A general overview of support materials for enzyme immobilization: Characteristics, properties, practical utility

In recent years, enzyme immobilization has been presented as a powerful tool for the improvement of enzyme properties such as stability and reusability. However, the type of support material used plays a crucial role in the immobilization process due to the strong effect of these materials on the properties of the produced catalytic system. A large variety of inorganic and organic as well as hybrid and composite materials may be used as stable and efficient supports for biocatalysts. This review provides a general overview of the characteristics and properties of the materials applied for enzyme immobilization. For the purposes of this literature study, support materials are divided into two main groups, called Classic and New materials. The review will be useful in selection of appropriate support materials with tailored properties for the production of highly effective biocatalytic systems for use in various processes.

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Authors: Zdarta, J. (Intern), Meyer, A. S. (Intern), Jesionowski, T. (Ekstern), Pinelo, M. (Intern)
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BFI (2015): BFI-level 1
Cellulase production by white-rot basidiomycetous fungi: solid-state versus submerged cultivation

White-rot basidiomycetous (WRB) fungi are a group of wood-decaying fungi that are known to be endowed with the ability to secrete enzymes that can catalyze decomposition of a range of plant cell wall polysaccharides, including cellulose and lignin. Expression of these enzymes is induced by the substrate and the enzyme yields obtained depend on the growth of the fungi and thus the mode of cultivation. In order to exploit WRB fungi for local enzyme production for converting lignocellulosic materials in biorefinery processes, the fungi can principally be cultivated in either solid-state (SSC) or submerged cultivation (SmC) systems. In this review, we quantitatively assess the data available in the literature on cellulase production yields by WRB fungi cultivated by SSC or SmC. The review also assesses cellulolytic enzyme production rates and enzyme recovery when WRB fungi are cultivated on different biomass residues in SSC or SmC systems. Although some variation in cellulase production yields have been reported for certain substrates, the analysis convincingly shows that SmC is generally more efficient than SSC for obtaining high cellulase production yields and high cellulase production rates on the substrate used. However, the cultivation method also affects the enzyme activity profile obtained, and the resulting enzyme titers and significant dilution of the enzymes usually occurs in SmC. The review also highlights some future approaches, including sequential cultivations and co-cultivation of WRB fungi for improved enzyme expression, as well as on-site approaches for production of enzyme blends for industrial biomass conversion. The quantitative comparisons made have implications for selection of the most appropriate cultivation method for WRB fungi for attaining maximal cellulase production.

General information

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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Kwame Nkrumah University of Science and Technology
Authors: Bentil, J. A. (Intern), Thygesen, A. (Intern), Mensah, M. (Ekstern), Lange, L. (Intern), Meyer, A. S. (Intern)
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Compared leaf anatomy and water relations of commercial and traditional Prunus dulcis (Mill.) cultivars under rain-fed conditions

Leaf anatomy and water relations of seven almond (Prunus dulcis Mill.) cultivars, traditional (Bonita, Casanova, Parada, Pegarinhos and Verdeal) and commercial (Ferragnès and Glorieta), grown under rain-fed conditions, were studied. The performed measurements included thickness of leaf tissues, leaf area, leaf mass per unit area, density of leaf tissue, relative water content, succulence, water saturation deficit, water content at saturation and cuticular transpiration rate. Significant differences were observed in most of the studied parameters between cultivars. Overall results indicate that traditional cultivars Bonita, Casanova and Pegarinhos have developed more morphological and structural leaf adaptations to protect against water loss than the other cultivars. If Bonita cultivar relies on reduced leaf area and stomatal density, thicker cell wall and leaf density, Casanova has increased cuticle thickness, while Pegarinhos adds a thicker epidermis and palisade parenchyma to increase protection to water loss. These data is one of the first comparative approaches to the leaf characterization of these cultivars, and should now be combined with physiological and biochemical studies, to
further elucidate the adaptation processes of almond cultivars to harmful environments.

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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Universidade de Tras-os-Montes e Alto Douro
Authors: Oliveira, I. (Ekstern), Meyer, A. (Intern), Afonso, S. (Ekstern), Gonçalves, B. (Ekstern)
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Scopus rating (2009): SJR 0.789 SNIP 1.773
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Corrigendum to “Rheological properties of agar and carrageenan from Ghanaian red seaweeds” [Food Hydrocolloids 63 (2017) 50–58]

The authors regret that the <data published in Table 3> in the paper report slightly too high values for the 3,6-anhydrogalactose, which in some cases infer that the level of anhydro-galactose is higher than the level of galactose in the hydrocolloids. This is fact not correct. The corrected data differ by only 1–3% from the ones published, but show that in no case is the anhydro-galactose level higher than the level of galactose in the hydrocolloids. The 3,6-anhydro-galactopyranosyl moieties were initially determined by HPAEC-PAD using a CarboPac™ PA20 column following the reducing acid hydrolysis using TFA and MMB, as described by Jol et al. (1999). The procedure for the reducing acid hydrolysis includes three additions of the reducing agent MMB. To improve the subsequent HPAEC-PAD quantification, the third addition of MMB was initially left out, as it resulted in better retention and resolution in the HPAEC-PAD quantification. The experiments have since been repeated following the exact procedure for the reducing acid hydrolysis (Jol et al., 1999). Carbohydrate compositions have been determined using the CarboPac™ PA1 column with accompanying guard column. Elution was performed using 500 mM NaOH and an isocratic flow on 0.4 mL/min.

Quantification was performed with glucose, galactose, and 3,6-anhydro-galactose as sugar standards that had been reduced by the reductive acid hydrolysis as well. The new data are presented in the corrected Table 3 below. Reference: Jol, C. N., Neiss, T. G., Penninkhof, B., Rudolph, B., & De Ruiter, G. A. (1999). A novel high-performance anion-exchange chromatographic method for the analysis of carrageenans and agars containing 3,6-anhydrogalactose. Analytical Biochemistry, 268, 213-222. Table 3 Overview of seaweed type (hydrocolloid source), hydrocolloid extraction method (direct water-extraction or after alkali treatment), hydrocolloid and monomer1 yields, and sulfate levels [data given as means±SD]. Different roman superscript letters indicate significant differences (P<0.05) column-wise for carrageenans and agar yields, monosaccharides, and sulfate content by one-way ANOVA.

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Scopus rating (2014): SJR 2.251 SNIP 2.564 CiteScore 5.21
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BFI (2011): BFI-level 2
Hydrothermal Liquefaction of Enzymatic Hydrolysis Lignin: Biomass Pretreatment Severity Affects Lignin Valorization

Alkaline hydrothermal liquefaction (HTL) of lignin-rich enzymatic hydrolysis residues (EnzHR) from wheat straw and Miscanthus × giganteus was performed at 255, 300, and 345 °C to investigate valorization of this side-stream from second-generation bioethanol production. The EnzHR were from biomass hydrothermally pretreated at two different levels of severity (190 °C, 10 min or 195 °C, 15 min), and HTL at 300 °C of these EnzHR showed the most effective lignin depolymerization of the low severity EnzHR for both wheat straw and Miscanthus. The degree of depolymerization during HTL was temperature dependent and was not complete after 20 min at 255 °C, most distinctly for the Miscanthus EnzHR. The yields of 128 monomeric products quantified by gas chromatography–mass spectrometry were up to 15.4 wt % of dry matter. Principal component analysis of the quantified compounds showed that nonlignin HTL products are main contributors to the variance of the HTL products from the two biomasses. The chemically modified lignin polymer was found to have increased thermal stability after HTL. Analytical pyrolysis was applied to investigate the chemical composition of a larger fraction of the products. Analytical pyrolysis contributed with additional chemical information as well as confirming trends seen from quantified monomers. This work is relevant for future lignin valorization in biorefineries based on current second-generation bioethanol production.
Immobilization of alcohol dehydrogenase on ceramic silicon carbide membranes for enzymatic CH$_3$OH production

BACKGROUND Alcohol dehydrogenase (ADH; EC 1.1.1.1) catalyzes oxidation of CH$_3$OH to CHOH during NAD$^+$ reduction to NADH. ADH can also accelerate the reverse reaction, which is studied as part of cascading enzymatic conversion of CO$_2$ to CH$_3$OH. In the present study, immobilization of ADH onto macroporous membranes of silicon carbide (SiC) was investigated for CHOH to CH$_3$OH conversion.

RESULTS Immobilization techniques included physical adsorption directly to the membrane and functionalization of the membrane with polyethylenimine (PEI) or (3-aminopropyl)triethoxysilane (APTES) followed by glutaraldehyde (GA) cross-linking. Enzyme loadings, flux, NADH conversion, and overall ADH reusability were assessed. Enzyme loadings were similar, but substrate conversion was approximately 2 and 2.5 times higher for APTES-GA and PEI-GA, respectively, and the relative activity retention was better than for physical adsorption. Membrane surface treatment with NaOH prior to APTES-GA immobilization resulted in significant improvement in enzyme loading and a doubling of ADH activity as well as higher activity during recycling as the ADH destabilization rate was unaffected.

CONCLUSIONS The results provided proof-of-concept for the use of NaOH-treated SiC membranes for covalent enzyme immobilization and biocatalytic efficiency improvement of ADH during multiple reaction cycles. These data have implications for the development of robust extended enzymatic reactions.
Lignin from hydrothermally pretreated grass biomass retards enzymatic cellulose degradation by acting as a physical barrier rather than by inducing nonproductive adsorption of enzymes

Lignin is known to hinder efficient enzymatic conversion of lignocellulose in biorefining processes. In particular, nonproductive adsorption of cellulases onto lignin is considered a key mechanism to explain how lignin retards enzymatic cellulose conversion in extended reactions. Lignin-rich residues (LRRs) were prepared via extensive enzymatic cellulose degradation of corn stover (Zea mays subsp. mays L.), Miscanthus × giganteus stalks (MS) and wheat straw (Triticum aestivum L.) (WS) samples that each had been hydrothermally pretreated at three severity factors (log \(R_0\)) of 3.65, 3.83 and 3.97. The LRRs had different residual carbohydrate levels—the highest in MS; the lowest in WS. The residual carbohydrate was not traceable at the surface of the LRRs particles by ATR-FTIR analysis. The chemical properties of the lignin in the LRRs varied across the three types of biomass, but monolignols composition was not affected by the severity factor. When pure cellulose was added to a mixture of LRRs and a commercial cellulolytic enzyme preparation, the rate and extent of glucose release were unaffected by the presence of LRRs regardless of biomass type and severity factor, despite adsorption of the enzymes to the LRRs. Since the surface of the LRRs particles were covered by lignin, the data suggest that the retardation of enzymatic cellulose degradation during extended reaction on lignocellulosic substrates is...
due to physical blockage of the access of enzymes to the cellulose caused by the gradual accumulation of lignin at the surface of the biomass particles rather than by nonproductive enzyme adsorption. The study suggests that lignin from hydrothermally pretreated grass biomass retards enzymatic cellulose degradation by acting as a physical barrier blocking the access of enzymes to cellulose rather than by inducing retardation through nonproductive adsorption of enzymes.
Loop engineering of an α-1,3/4-L-fucosidase for improved synthesis of human milk oligosaccharides

The α-1,3/4-L-fucosidases (EC 3.2.1.111; GH29) BbAfcB from Bifidobacterium bifidum and CpAfc2 from Clostridium perfringens can catalyse formation of the human milk oligosaccharide (HMO) lacto-N-fucopentaose II (LNFP II) through regioselective transfucosylation of lacto-N-tetraose (LNT) with 3-fucosyllactose (3FL) as donor substrate. The current work exploits structural differences between the two enzymes with the aim of engineering BbAfcB into a more efficient transfucosidase and approaches an understanding of structure-function relations of hydrolytic activity vs. transfucosylation activity in GH29. Replacement of a 23 amino acids long α-helical loop close to the active site of BbAfcB with the corresponding 17-aminoacid α-helical loop of CpAfc2 resulted in almost complete abolishment of the hydrolytic activity on 3FL (6000 times lower hydrolytic activity than WT BbAfcB), while the transfucosylation activity was lowered only one order of magnitude. In turn, the loop engineering resulted in an α-1,3/4-l-fucosidase with transfucosylation activity reaching molar yields of LNFP II of 39±2% on 3FL and negligible product hydrolysis. This was almost 3 times higher than the yield obtained with WT BbAfcB (14±0.3%) and comparable to that obtained with CpAfc2 (50±8%). The obtained transfucosylation activity may expand the options for HMO production: mixtures of 3FL and LNT could be enriched with LNFP II, while mixtures of 3FL and lacto-N-neotetraose (LNnT) could be enriched with LNFP III.
Low energy recycling of ionic liquids via freeze crystallization during cellulose spinning

A new method for recycling ionic liquids (ILs) from a cellulose spinning process is suggested. The method involves the combination of freeze crystallization and evaporation of H₂O from IL + H₂O mixtures to recycle the ILs. Processes with EmimAc and EmimDep were used as references to develop this IL recycling method. EmimAc + 12.5 wt% H₂O and EmimDep + 4 wt% H₂O were selected for a quantitative mass and energy analysis of the cellulose spinning and IL recycling process (the maximal initial H₂O levels in the ILs + H₂O mixtures for cellulose dissolution were determined experimentally). The energy requirement for the freeze crystallization + evaporation method was compared to evaporation only for recycling EmimAc and EmimDep. To produce 1 kg dry cellulose fiber, 45.4 MJ and 62.6 MJ are required for recycling EmimAc and EmimDep respectively by the freeze crystallization + evaporation recycling method. Using evaporation only, 66.9 MJ is required for EmimAc recycling and 99.9 MJ for EmimDep recycling per kg cellulose fiber produced. Thus, to fabricate 1 kg dry cellulose fiber using freeze crystallization + evaporation rather than evaporation, 21.5 MJ can be saved for EmimAc and 37.3 MJ for EmimDep recycling. We also show that compared to a classical Lyocell fiber production method using N-methylmorpholine-N-oxide (NMMO) as solvent, use of ILs is energy saving in itself. Hence, significantly less H₂O is required in the cellulose spinning process with ILs than with NMMO, and in turn less H₂O has to be evaporated for the solvent recycling.

General information
Membrane separation of enzyme-converted biomass compounds: Recovery of xylose and production of gluconic acid as a value-added product

The purpose of the present study was to assess the efficiency of enzyme-assisted nanofiltration for separation of xylose from glucose present in genuine biorefinery liquors obtained from hydrothermal pretreatment of wheat straw, corn stover and Miscanthus stalks. Glucose oxidase and catalase were used to convert the glucose contained in the liquors into gluconic acid, so xylose could be more easily recovered in the subsequent nanofiltration. Subjecting the biomass liquors to dilute acid treatment and centrifugation before the enzymatic reaction and filtration led to maximum biocatalytic performance of the membrane bioreactor (neglectable fouling and no enzyme activity loss) during five consecutive reaction-filtration cycles. The best separation factor of gluconic acid over xylose in the subsequent nanofiltration was 2.7, 2.5 and 2.2 for wheat straw, corn stover and Miscanthus stalks, respectively. All represented a significant improvement compared to the benchmark separation of xylose and glucose, in which case the separation factor was only 1.4. However, the higher ionic strength of the biomass liquors compared to the pure model solution probably led to a less negative zeta potential of the nanofiltration membrane, which significantly reduced the xylose purification performance as compared to the model system, for which the separation factor was 34.

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- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): SJR 1.35 SNIP 1.64 CiteScore 3.48
The aim of this study was to evaluate morphological (of fruit and kernel), mechanical (namely shell rupture force) and antioxidant properties (including phenolics and flavonoid content) of five Portuguese almond cultivars, comparing them with two commercial cultivars (Glorieta and Ferragnès). Of the analyzed traits, nut and kernel dimensions varied substantially and were used to describe cultivars. However, some traditional cultivars recorded similar (Pegarinhos), or even higher (Amendoão, Casanova and Refêgo) nut and kernel weight than commercial cultivars. Furthermore, shelling percentage of traditional cultivar (Bonita) was higher than commercial cultivars. Rupture force necessary to break fruits of all traditional cultivars was higher than commercial ones, and was correlated to nut weight cultivars. The phenolics, flavonoids content and antioxidants were higher for Casanova. Parameters like high kernel weight, low percentages of double kernels or losses during shelling and considerable higher phenolics and flavonoids content may be considered by industry during selection of almond.
På vej mod bedre modermælkserstatning
Modermælk indeholder særlige kulhydrater, humane melkeoligosakkarider (HMO), som har afgørende betydning for spædbarnets sundhed. Modermælkserstatning baseret på komælk mangler disse unikke molekyler, hvorfor der er stor interesse for at fremstille HMO til industriel brug.

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Authors: Zeuner, B. (Intern), Meyer, A. S. (Intern)
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Substrate specificity and transfucosylation activity of GH29 α-l-fucosidases for enzymatic production of human milk oligosaccharides

Abstract Human milk oligosaccharides (HMOs) constitute a unique family of bioactive lactose-based molecules present in human breast milk. HMOs are of major importance for infant health and development but also virtually absent from bovine milk used for infant formula. Among the HMOs, the fucosylated species are the most abundant. Transfucosylation catalysed by retaining α-l-fucosidases is a new route for manufacturing biomimetic HMOs. Seven α-l-fucosidases from glycosyl hydrolase family 29 were expressed, characterized in terms of substrate specificity and thermal stability, and shown to be able to catalyse transfucosylation. The α-l-1,3/4-fucosidase CpAf2 from Clostridium perfringens efficiently catalysed the formation of the more complex human milk oligosaccharide structure lacto-N-fucopentaose II (LNFP II) using 3-fucosyllactose as fucosyl donor and lacto-N-tetraose as acceptor with a 39% yield. α-l-Fucosidases FgFCO1 from Fusarium graminearum and Mfuc5 from a soil metagenome were able to catalyse transfucosylation of lactose using citrus xyloglucan as fucosyl donor. FgFCO1 catalysed formation of 2′-fucosyllactose, whereas Mfuc5 catalysis mainly produced an unidentified, non-HMO fucosyllactose, reaching molar yields based on the donor substrate of 14% and 18%, respectively.

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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.069 SNIP 1.07 CiteScore 3.07
Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 0.994 SNIP 1.248 CiteScore 2.77
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.819 SNIP 0.988 CiteScore 2.5
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The natural catalytic function of CuGE glucuronoyl esterase in hydrolysis of genuine lignin-carbohydrate complexes from birch.

Glucuronoyl esterases belong to carbohydrate esterase family 15 and catalyze de-esterification. Their natural function is presumed to be cleavage of ester linkages in lignin-carbohydrate complexes particularly those linking lignin and glucuronoyl residues in xylans in hardwood. Here, we show for the first time a detailed product profile of aldouronic acids released from birchwood lignin by a glucuronoyl esterase from the white-rot fungus Cerrena unicolor (CuGE). CuGE releases substrate for GH10 endo-xylanase which results in significantly increased product release compared to the action
of endo-xylanase alone. CuGE also releases neutral xylo-oligosaccharides that can be ascribed to the enzymes feruloyl esterase side activity as demonstrated by release of ferulic acid from insoluble wheat arabinoxylan. The data verify the enzyme's unique ability to catalyze removal of all glucuronoxylan associated with lignin and we propose that this is a direct result of enzymatic cleavage of the ester bonds connecting glucuronoxylan to lignin via 4-O-methyl glucuronoyl-ester linkages. This function appears important for the fungal organism's ability to effectively utilize all available carbohydrates in lignocellulosic substrates. In bioprocess perspectives, this enzyme is a clear candidate for polishing lignin for residual carbohydrates to achieve pure, native lignin fractions after minimal pretreatment.
A comparative study on the activity of fungal lytic polysaccharide monooxygenases for the depolymerization of cellulose in soybean spent flakes

Lytic polysaccharide monooxygenases (LPMOs) are copper-dependent enzymes capable of the oxidative breakdown of polysaccharides. They are of industrial interest due to their ability to enhance the enzymatic depolymerization of recalcitrant substrates by glycoside hydrolases. In this paper, twenty-four lytic polysaccharide monooxygenases (LPMOs) expressed in Trichoderma reesei were evaluated for their ability to oxidize the complex polysaccharides in soybean spent flakes, an abundant and industrially relevant substrate. TrCel61A, a soy-polysaccharide-active AA9 LPMO from T. reesei, was used as a benchmark in this evaluation. In total, seven LPMOs demonstrated activity on pretreated soy spent flakes, with the products from enzymatic treatments evaluated using mass spectrometry and high performance anion exchange chromatography. The hydrolytic boosting effect of the top-performing enzymes was evaluated in combination with endoglucanase and beta-glucosidase. Two enzymes (TrCel61A and Aspte6) showed the ability to release more than 36% of the pretreated soy spent flake glucose - a greater than 75% increase over the same treatment without LPMO addition.

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Scopus rating (2014): SJR 0.638 SNIP 0.856 CiteScore 2.01
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ISI indexed (2013): ISI indexed yes
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ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.76 SNIP 1.062 CiteScore 2.43
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Glucuronoyl esterases are a novel type of enzymes believed to catalyze the hydrolysis of ester linkages between lignin and glucuronoxylan in lignocellulosic biomass, linkages known as lignin carbohydrate complexes. These complexes contribute to the recalcitrance of lignocellulose. Glucuronoyl esterases are a part of the microbial machinery for lignocellulose degradation and coupling their role to the occurrence of lignin carbohydrate complexes in biomass is a desired research goal. Glucuronoyl esterases have been assigned to CAZymes family 15 of carbohydrate esterases, but only few examples of characterized enzymes exist and the exact activity is still uncertain. Here peptide pattern recognition is used as a bioinformatic tool to identify and group new CE15 proteins that are likely to have glucuronoyl esterase activity. 1024 CE15-like sequences were drawn from GenBank and grouped into 24 groups. Phylogenetic analysis of these groups made it possible to pinpoint groups of putative fungal and bacterial glucuronoyl esterases and their sequence variation. Moreover, a number of groups included previously undescribed CE15-like sequences that are distinct from the glucuronoyl esterases and may possibly have different esterase activity. Hence, the CE15 family is likely to comprise other enzyme functions than glucuronoyl esterase alone. Gene annotation in a variety of fungal and bacterial microorganisms showed that coprophilic fungi are rich and diverse sources of CE15 proteins. Combined with the lifestyle and habitat of coprophilic fungi, they are predicted to be excellent candidates for finding new glucuronoyl esterase genes.
Biocatalysis
Biocatalysis is important for addressing global challenges: climate change, substitution of fossils, feeding a growing population—basically because bioprocessing in food, feed, and nonfood industries improves resource efficiency, getting more out of the raw biomaterials. Microbial enzymes are the active elements in biocatalysis. Enzymes are specific and efficient (not used up, but reusable). The small enzyme molecules contribute significantly to making industrial processes more sustainable, by changing from chemical processes to enzymatic (biocatalytic) processes, being milder, using less energy, producing less waste water. Enzymes and biocatalysis are key elements in sustainable production of biobased products in the new bioeconomy era.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, University of Delhi
Authors: Lange, L. (Intern), Parmar, V. (Ekstern), Meyer, A. (Intern)
Characterisation of Authentic Lignin Biorefinery Samples by Fourier Transform Infrared Spectroscopy and Determination of the Chemical Formula for Lignin

Efficient methods for lignin characterisation are increasingly important as the field of lignin valorisation is growing with the increasing use of lignocellulosic feedstocks, such as wheat straw and corn stover, in biorefineries. In this study, we characterised a set of authentic lignin biorefinery samples in situ with no prior purification and minimal sample preparation. Lignin chemical formulas and lignin Fourier transform infrared (FTIR) spectra were extracted from mixed spectra by filtering out signals from residual carbohydrates and minerals. From estimations of C, H and O and adjustment for cellulose and hemicelluloses contents, the average chemical formula of lignin was found to be C9H10.2O3.4 with slight variations depending on the biomass feedstock and processing conditions (between C9H9.5O2.8 and C9H11.1O3.6). Extracted FTIR lignin spectra showed many of the same characteristic peaks as organosolv and kraft lignin used as benchmark samples. Some variations in the lignin spectra of biorefinery lignin residue samples were found depending on biomass feedstock (wheat straw, corn stover or poplar) and on pretreatment severity, especially in the absorbance of bands at 1267 and 1032 cm⁻¹ relative to the strong band at ~1120 cm⁻¹. The suggested method of FTIR spectral analysis with adjustment for cellulose and hemicellulose is proposed to provide a fast and efficient way of analysing lignin in genuine lignin samples resulting from biorefineries.
A sialidase (EC 3.2.1.18; GH 33) from non-pathogenic Trypanosoma rangeli has been engineered with the aim of improving its transsialylation activity. Recently, two engineered variants containing 15 and 16 amino acid substitutions, respectively, were found to exhibit significantly improved transsialylation activity: both had a 14 times higher ratio between transsialylation and hydrolysis products compared to the first reported mutant TrSA5mut. In the current work, these two variants, Tr15 and Tr16, were characterized in terms of pH optimum, thermal stability, effect of acceptor-to-donor ratio, and acceptor specificity for transsialylation using casein glycomacropeptide (CGMP) as sialyl donor and lactose or other human milk oligosaccharide core structures as acceptors. Both sialidase variants exhibited pH optima around pH 4.8. Thermal stability of each enzyme was comparable to that of previously developed T. rangeli sialidase variants and higher than that of the native transsialidase from T. cruzi (TcTS). As for other engineered T. rangeli sialidase variants and TcTS, the acceptor specificity was broad: lactose, galactooligosaccharides (GOS), xylooligosaccharides (XOS), and human milk oligosaccharide structures lacto-N-tetraose (LNT), lacto-N-fucopentaose (LNFP V), and lacto-N-neofucopentaose V (LNNFP V) were all sialylated by Tr15 and Tr16. An increase in acceptor-to-donor ratio from 2 to 10 had a positive effect on transsialylation. Both enzymes showed high preference for formation α(2,3)-linkages at the non-reducing end of lactose in the transsialylation. Tr15 was the most efficient enzyme in terms of transsialylation reaction rates and yield of 3'-sialyllactose. Finally, Tr15 was immobilized covalently on glyoxyly-functionalized silica, leading to a 1.5-fold increase in biocatalytic productivity compared to free enzyme after 6 cycles of reuse. The use of glyoxyly-functionalized silica proved to be markedly better for immobilization than silica functionalized with (3-amino-propyl)triethoxysilane (APTES) and glutaraldehyde, which resulted in a biocatalytic productivity which was less than half of that obtained with free enzyme.

Characterization and immobilization of engineered sialidases from Trypanosoma rangeli for transsialylation

A sialidase (EC 3.2.1.18; GH 33) from non-pathogenic Trypanosoma rangeli has been engineered with the aim of improving its transsialylation activity. Recently, two engineered variants containing 15 and 16 amino acid substitutions, respectively, were found to exhibit significantly improved transsialylation activity: both had a 14 times higher ratio between transsialylation and hydrolysis products compared to the first reported mutant TrSA5mut. In the current work, these two variants, Tr15 and Tr16, were characterized in terms of pH optimum, thermal stability, effect of acceptor-to-donor ratio, and acceptor specificity for transsialylation using casein glycomacropeptide (CGMP) as sialyl donor and lactose or other human milk oligosaccharide core structures as acceptors. Both sialidase variants exhibited pH optima around pH 4.8. Thermal stability of each enzyme was comparable to that of previously developed T. rangeli sialidase variants and higher than that of the native transsialidase from T. cruzi (TcTS). As for other engineered T. rangeli sialidase variants and TcTS, the acceptor specificity was broad: lactose, galactooligosaccharides (GOS), xylooligosaccharides (XOS), and human milk oligosaccharide structures lacto-N-tetraose (LNT), lacto-N-fucopentaose (LNFP V), and lacto-N-neofucopentaose V (LNNFP V) were all sialylated by Tr15 and Tr16. An increase in acceptor-to-donor ratio from 2 to 10 had a positive effect on transsialylation. Both enzymes showed high preference for formation α(2,3)-linkages at the non-reducing end of lactose in the transsialylation. Tr15 was the most efficient enzyme in terms of transsialylation reaction rates and yield of 3'-sialyllactose. Finally, Tr15 was immobilized covalently on glyoxyly-functionalized silica, leading to a 1.5-fold increase in biocatalytic productivity (mg 3'-sialyllactose per mg enzyme) compared to free enzyme after 6 cycles of reuse. The use of glyoxyly-functionalized silica proved to be markedly better for immobilization than silica functionalized with (3-amino-propyl)triethoxysilane (APTES) and glutaraldehyde, which resulted in a biocatalytic productivity which was less than half of that obtained with free enzyme.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Universidad Rey Juan Carlos
Authors: Zeuner, B. (Intern), González-Delgado, I. (Ekstern), Holck, J. (Intern), Morales, G. (Ekstern), López-Muñoz, M. (Ekstern), Segura, Y. (Ekstern), Meyer, A. S. (Intern), Mikkelsen, J. D. (Intern)
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Characterization of alginates from Ghanaian brown seaweeds: Sargassum spp. and Padina spp

Alginates of four locally harvested Ghanaian brown seaweeds from the Sargassum and Padina genus were assessed for their rheological and chemical characteristics. The seaweeds contained 16–30% by weight of alginate assessed as the sum of d-mannuronic acid (M) and l-guluronic acid (G). In comparison, alginate samples from Laminaria digitata and Macrocystis pyrifera, used commercially for alginate extraction, contained 29% and 27% by weight of the two constituent uronic acids (M + G), respectively. Alginate extraction yields of the Ghanaian seaweeds ranged from 17 to 23% by weight of dry material; the corresponding yields from L. digitata and M. pyrifera were 26–29% by weight; these yields were equivalent to ~49–99% of the theoretical yields, but the purity of the extracted alginates varied, and were lowest for the Ghanaian seaweed alginates. 1H NMR analysis of the uronic acid block-structure in the alginates gave M/G ratios of 0.47 and 0.70 for the alginates extracted from Sargassum natans and Sargassum vulgare, while alginates from Padina gymnospora and Padina antillarum had M/G ratios of 1.75 and 1.85, respectively. The alginates from the two Ghanaian Sargassum spp. had high contents of dimeric and trimeric homoguluronate elements: FGG and FGGG values were 0.61 and 0.58 for S. natans and 0.49 and 0.44 for S. vulgare. The alginates from the two Padina spp. had gel strengths estimated as G’ surpassing those from the commercial alginates with G’ values after 4 h of rheological oscillation of 340 Pa (P. gymnospora) and 376 Pa (P. antillarum), whereas the gelling properties of the Sargassum spp. alginates were poor. The degree of polymerization of the acid tolerant alginate backbone fragments, but not M/G ratio or homoguluronate dimer and trimer element contents, appeared to correlate to the alginate gel strength. The study shows that notably Ghanaian Padina spp. hold alginate having desirable properties for high gel-strength applications.
Characterization of two novel bacterial type A exo-chitobiose hydrolases having C-terminal 5/12-type carbohydrate-binding modules

Type A chitinases (EC 3.2.1.14), GH family 18, attack chitin ((1 → 4)-2-acetamido-2-deoxy-β-D-glucan) and chito-oligosaccharides from the reducing end to catalyze release of chitobiose (N,N′-diacetylchitobiose) via hydrolytic cleavage of N-acetyl-β-D-glucosaminide (1 → 4)-β-linkages and are thus "exo-chitobiose hydrolases." In this study, the chitinase type A from Serratia marcescens (SmaChiA) was used as a template for identifying two novel exo-chitobiose hydrolase type A enzymes, FbalChi18A and MvarChi18A, originating from the marine organisms Ferrimonas balearica and Microbulbifer variabilis, respectively. Both FbalChi18A and MvarChi18A were recombinantly expressed in Escherichia coli and were confirmed to exert exo-chitobiose hydrolase activity on chito-oligosaccharides, but differed in temperature and pH activity response profiles. Amino acid sequence comparison of the catalytic β/α barrel domain of each of the new enzymes showed individual differences, but ~69% identity of each to that of SmaChiA and highly conserved active site residues. Superposition of a model substrate on 3D structural models of the catalytic domain of the enzymes corroborated exo-chitobiose hydrolase type A activity for FbalChi18A and MvarChi18A, i.e., substrate attack from the reducing end. A main feature of both of the new enzymes was the presence of C-terminal 5/12 type carbohydrate-binding modules (SmaChiA has no C-terminal carbohydrate binding module). These new enzymes may be useful tools for utilization of chitin as an N-acetylglucosamine donor substrate via chitobiose.

General information
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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Binti Jamek, S. (Intern), Nyffenegger, C. (Intern), Muschiol, J. (Intern), Holck, J. (Intern), Meyer, A. S. (Intern), Mikkelsen, J. D. (Intern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.57 SJR 1.177 SNIP 1.173
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.254 SNIP 1.217 CiteScore 3.43
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.327 SNIP 1.458 CiteScore 3.71
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.533 SNIP 1.432 CiteScore 4.3
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.507 SNIP 1.286 CiteScore 4
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.437 SNIP 1.232 CiteScore 3.72
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.381 SNIP 1.239
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.353 SNIP 1.062
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.224 SNIP 0.979
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.036 SNIP 1.021
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.131 SNIP 1.062
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.118 SNIP 1.201
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.169 SNIP 1.162
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.969 SNIP 1.24
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.941 SNIP 1.027
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.876 SNIP 1.038
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.834 SNIP 1.065
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.13 SNIP 1.253
Comparison of traditional field retting and Phlebia radiata Cel 26 retting of hemp fibres for fibre-reinforced composites

Classical field retting and controlled fungal retting of hemp using Phlebia radiata Cel 26 (a mutant with low cellulose degrading ability) were compared with pure pectinase treatment with regard to mechanical properties of the produced fibre/epoxy composites. For field retting a classification of the microbial evolution (by gene sequencing) and enzyme profiles were conducted. By phylogenetic frequency mapping, different types of fungi, many belonging to the Ascomycota phylum were found on the fibres during the first 2 weeks of field retting, and thereafter, different types of bacteria, notably Proteobacteria, also proliferated on the field retted fibres. Extracts from field retted fibres exhibited high glucanase activities, while extracts from P. radiata Cel 26 retted fibres showed high polygalacturonase and laccase activities. As a result, fungal retting gave a significantly higher glucan content in the fibres than field retting (77 vs. 67%) and caused a higher removal of pectin as indicated by lower galacturonan content of fibres (1.6%) after fibres were retted for 20 days with P. radiata Cel 26 compared to a galacturonan content of 3.6% for field retted fibres. Effective fibre stiffness increased slightly after retting with P. radiata Cel 26 from 65 to 67 GPa, while it decreased after field retting to 52 GPa. Effective fibre strength could not be determined similarly due to variations in fibre fracture strain and fibre-matrix adhesion. A maximum composite strength with 50 vol% fibres of 307 MPa was obtained using P. radiata Cel 26 compared to 248 MPa with field retting.

General information
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Scopus rating (2016): CiteScore 2.15 SJR 0.65 SNIP 0.799
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.698 SNIP 0.693 CiteScore 1.38
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.7 SNIP 1.008 CiteScore 1.37
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.589 SNIP 0.924 CiteScore 1.19
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Original language: English
Hemp fibre, Field retting, Phlebia radiata Cel 26, Microbial community, Enzyme profiling, Composite strength
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Compositional variations of brown seaweeds Laminaria digitata and Saccharina latissima in Danish waters

Around Denmark, Laminaria digitata and Saccharina latissima are particularly common macroalgae species and are considered as prospective candidates for biorefineries. In this study, the carbohydrate composition and protein levels of L. digitata and S. latissima from three different sites in Denmark were compared for 1 year, and compositional variations of wild L. digitata harvested in August from the North Sea was monitored for 3 years. Glucan levels of L. digitata were consistently higher than those of S. latissima irrespective of harvest site and time of the year. Glucan levels in wild L. digitata from Kattegat peaked in October with 37.0% by dry weight compared to 22.6% by dry weight in wild S. latissima (Kattegat) and were accompanied by lower ash contents (18.5% w/w in L. digitata versus 26.5% w/w in S. latissima). Alginate contents were almost constant throughout the year, but mannuronic/glucuronic acid ratios differed between species and location from 1.33 to 3.64. Wild L. digitata harvested from the North Sea in August contained >50% glucans by weight and had low ash contents for three consecutive years (2012-2014). Compositional variation of the seaweeds was mainly related to season but also varied with species, location, and within populations. Among environmental variables (temperature, salinity, phosphate, nitrate, ammonia), only temperature was found to correlate with the chemical composition of the seaweeds. Amino acid profiles were dominated by glutamic acid, aspartic acid, and alanine and varied with season, especially for L. digitata from the North Sea, and location. Total nitrogen contents fluctuated more between samples than the actual protein contents; hence, application of a common N-to-protein factor cannot be recommended.

General information

State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Aarhus University, University of Hamburg
Authors: Manns, D. M. (Intern), Nielsen, M. M. (Intern), Bruhn, A. (Ekstern), Saake, B. (Ekstern), Meyer, A. S. (Intern)
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Scopus rating (2016): CiteScore 2.46
Web of Science (2016): Indexed yes
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Scopus rating (2015): CiteScore 2.32
Web of Science (2015): Indexed yes
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Scopus rating (2014): CiteScore 2.88
Web of Science (2014): Indexed yes
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ISI indexed (2013): ISI indexed yes
Crude fucoidan content in two North Atlantic kelp species, Saccharina latissima and Laminaria digitata - seasonal variation and impact of environmental factors

Fucoidans are sulphated fucose-rich polysaccharides predominantly found in the cell walls of brown algae. The bioactive properties of fucoidans attract increasing interest from the medico-pharmaceutical industries and may drive an increase in demand of brown algae biomass. In nature, the biochemical composition of brown algae displays a seasonal fluctuation driven by environmental factors and endogenous rhythms. To cultivate and harvest kelps with high yields of fucoidans, knowledge is needed on seasonal variation and impact of environmental conditions on the fucoidan content of brown algae. The relations between the fucoidan content and key environmental factors (irradiance, nutrient availability, salinity and exposure) were examined by sampling natural populations of the common North Atlantic kelps, Saccharina latissima and Laminaria digitata, over a full year at Hanstholm in the North Sea and Aarhus in the Kattegat. In addition, laboratory experiments were carried out isolating the effects of the single factors. The results demonstrated that (1) seasonal variation alters the fucoidan content by a factor of 2±6; (2) interspecific differences exist in the concentrations of crude fucoidan (% of dry matter): L. digitata (11%) > S. latissima (6%); and (3) the effects of single environmental factors were not consistent between species or between different conspecific populations. The ambiguous response to single environmental factors complicates prospective directions for manipulating an increased content of fucoidan in a cultivation scenario and emphasizes the need for knowledge on performance of local kelp ecotypes.
Design of Trypanosoma rangeli sialidase mutants with improved trans-sialidase activity

A sialidase (EC 3.2.1.18) from the non-pathogenic Trypanosoma rangeli, TrSA, has been shown to exert trans-sialidase activity after mutation of five specific amino acids in the active site (M96V, A98P, S120Y, G249Y, Q284P) to form the so-called TrSA5mut enzyme. By computational and hypothesis-driven approaches, additional mutations enhancing the trans-sialidase activity have been suggested. In the present work, we made a systematic combination of these mutations leading to seven new variants of the T. rangeli sialidase, having 6-16 targeted amino acid mutations. The resulting enzyme variants were analyzed via kinetics for their ability to carry out trans-sialidase reaction using CGMP and D-lactose as substrates. The sialidase variants with 15 and 16 mutations, respectively, exhibited significantly improved trans-sialidase activity for D-lactose sialylation. Our results corroborate that computational studies of trans-glycosylation can be a valuable input in the design of novel trans-glycosidases, but also highlight the importance of experimental validation in
order to assess the performance. In conclusion, two of the seven mutants displayed a dramatic switch in specificity from hydrolisis towards trans-sialylation and constitute the most potent trans-sialidase mutants of TrSA described in literature to date.

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Scopus rating (2016): CiteScore 3.11 SJR 1.201 SNIP 1.092
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.414 SNIP 1.131 CiteScore 3.32
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.545 SNIP 1.141 CiteScore 3.54
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.74 SNIP 1.147 CiteScore 3.94
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.945 SNIP 1.142 CiteScore 4.15
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.369 SNIP 1.23 CiteScore 4.58
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 2.631 SNIP 1.161
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.473 SNIP 0.985
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.323 SNIP 0.96
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.289 SNIP 0.525
Web of Science (2006): Indexed yes
Original language: English
Electronic versions:
Direct rate assessment of laccase catalysed radical formation in lignin by electron paramagnetic resonance spectroscopy

Laccases (EC 1.10.3.2) catalyse removal of an electron and a proton from phenolic hydroxyl groups, including phenolic hydroxyls in lignins, to form phenoxy radicals during reduction of O$_2$. We employed electron paramagnetic resonance spectroscopy (EPR) for real time measurement of such catalytic radical formation activity on three types of lignin (two types of organosolv lignin, and a lignin rich residue from wheat straw hydrolysis) brought about by two different fungal laccases, derived from Trametes versicolor (Tv) and Myceliophthora thermophila (Mt), respectively. Laccase addition to suspensions of the individual lignin samples produced immediate time and enzyme dose dependent increases in intensity in the EPR signal with g-values in the range 2.0047–2.0050 allowing a direct quantitative monitoring of the radical formation and thus allowed laccase enzyme kinetics assessment on lignin. The experimental data verified that the laccases acted upon the insoluble lignin substrates in the suspensions. When the action on the lignin substrates of the two laccases were compared on equal enzyme dosage levels (by activity units on syringaldazine) the Mt laccase exerted a significantly faster radical formation than the Tv laccase on all three types of lignin substrates. When comparing the equal laccase dose rates on the three lignin substrates the enzymatic radical formation rate on the wheat straw lignin residue was consistently higher than those of the organosolv lignins. The pH-temperature optimum for the radical formation rate in organosolv lignin was determined by response surface methodology to pH 4.8, 33 °C and pH 5.8, 33 °C for the Tv laccase and the Mt laccase, respectively. The results verify direct radical formation action of fungal laccases on lignin without addition of mediators and the EPR methodology provides a new type of enzyme assay of laccases on lignin.
Elemental analysis of various biomass solid fractions in biorefineries by X-ray fluorescence spectrometry

Elemental analysis by X-ray fluorescence spectrometry (XRF) of solid samples from a biorefinery process was performed to study the behaviour of mineral elements in a process involving hydrothermal pretreatment of biomass (wheat straw, corn stover, sugarcane bagasse, palm oil empty fruit bunches, poplar) followed by enzymatic hydrolysis and fermentation. For all the different biomasses, the biorefinery process concentrated silicon, aluminium, and calcium in the solid fraction, while potassium and magnesium were solubilised in the process and removed from the solid fraction. Sodium concentrations were in general low and they only increased in case of addition during the process. No general tendencies were observed for phosphorus, sulphur, and iron concentrations. A prerequisite for XRF elemental analysis was defining an average chemical formula for the organic matrix of process biomass samples. Based on ultimate elemental analysis of all biomasses, the formula for biomass was $C_{6}H_{8.4}O_{3.5}$, which was used for all types of samples (raw biomass, pretreated biomass, and lignin residue) and can be used in future XRF analysis of samples of similar process and biomass feedstock as those used in this study.

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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, DONG Energy A/S
Enzymatic conversion of CO2 to CH3OH via reverse dehydrogenase cascade biocatalysis: Quantitative comparison of efficiencies of immobilized enzyme systems

A designed biocatalytic cascade system based on reverse enzymatic catalysis by formate dehydrogenase (EC 1.2.1.2), formaldehyde dehydrogenase (EC 1.2.1.46), and alcohol dehydrogenase (EC 1.1.1.1) can convert carbon dioxide (CO2) to methanol (CH3OH) via formation of formic acid (CHOH) and formaldehyde (CHOH) during equimolar cofactor oxidation of NADH to NAD+. This reaction is appealing because it represents a double gain: (1) reduction of CO2 and (2) an alternative to fossil fuel based production of CH3OH. The present review evaluates the efficiency of different immobilized enzyme systems and reaction designs that have been explored for optimizing this sequential enzymatic conversion of CO2 to CH3OH, including multilayer microcapsules, bead scaffolds, cationic nanofibers, and membrane systems. The recent progress within efficient cofactor regeneration, protein engineering of the enzymes for robustness, and advanced uses of membrane systems for enzyme reuse and product separation are assessed for large scale implementation of this biocatalytic reaction cascade. Industrial realization of enzymatic CO2 to CH3OH conversion including the option for reaping of formaldehyde and formate during the reaction warrants innovative development. There is a particular need for development of i) better enzymes; ii) improved understanding of enzyme structure function aspects of reverse catalysis by dehydrogenases, iii) quantitative kinetic models of the enzymatic cascade reaction during simultaneous cofactor regeneration, iv) robust systems for regeneration of reducing equivalents.
This study examines enzymatic production of linear xylooligosaccharides (XOS) and branched arabinoxylooligosaccharides (AXOS) from monocotyledonous biomass, wheat straw and ryegrass, and compares the in vitro effects of these XOS and AXOS on pig gut microbiota. XOS and AXOS were obtained from the biomass by treatment with different endo-1,4-β-xylanases. XOS of DP2-6 from wheat straw, obtained after treatment with Aspergillus niger endo GH11, suppressed growth of Clostridium perfringens and resulted in a high level of lactic acid production when fermented in vitro by pig fecal microbiota. Analogously, XOS ryegrass produced in the same way also suppressed Cl. perfringens growth, and more so than the corresponding ryegrass AXOS, but AXOS exhibited a more pronounced stimulation of lactic acid bacteria growth than XOS. The prebiotic potential, i.e., suppression of Cl. perfringens and stimulation of lactic acid bacteria, for the ryegrass oligosaccharides was as follows: XOS, produced by A. niger endo-1,4-β-xylanase (GH11) > AXOS, produced by Thermotoga maritima and Cellvibrio mixtus endo-1,4-β-xylanase s (GH10) > AXOS, produced by Trichoderma viride and Aspergillus aculeatus endo-1,4-β-xylanase s (GH11). These results indicate that wheat straw as well as green grass biomass such as ryegrass have potential as new sources of putative prebiotics for pig feed.
Enzyme discovery for tuber processing pulps

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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Barrett, K. (Intern), Meyer, A. S. (Intern), Lange, L. (Intern)
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Freezing Point Determination of Water–Ionic Liquid Mixtures

Freezing points of aqueous solutions of HOEtPyBr, HOEtMimBr, AmimCl, EtOMmimCl, EmimDep, and EmimAc were measured using a modified Beckmann apparatus with automatic data logging. The ionic liquids (ILs) in this study exhibited features similar to those of inorganic salts in depressing the freezing point of water. On the basis of the cryoscopic behavior recorded, the solid phases formed at higher IL contents were presumed to be hydrates of the form IL·nH2O. The HOEtPyBr+H2O and HOEtMimBr+H2O systems formed simple eutectic systems. The eutectic points were found to be at a water mole fraction of 0.617 and 219.841 K in the first system and at a water mole fraction of 0.657 and 202.565 K in the second system. Water activities in aqueous IL solutions were predicted by COSMO-RS and COSMO-SAC and compared to water activities derived from the experimentally determined freezing points. The COSMO-RS predictions were closer to the experimental water activities than the COSMO-SAC predictions. The experimental results indicate that the freezing points of IL+H2O systems are affected by the nature of both cations and anions. However, according to the COSMO-RS excess enthalpy prediction results, the anions have a relatively higher influence than cations on the IL+H2O interaction.

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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, CERE – Center for Energy Ressources Engineering, Chinese Academy of Sciences
Authors: Liu, Y. (Intern), Meyer, A. S. (Intern), Nie, Y. (Ekstern), Zhang, S. (Ekstern), Zhao, Y. (Ekstern), Fosbøl, P. L. (Intern), Thomsen, K. (Intern)
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BFI (2016): BFI-level 1
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BFI (2015): BFI-level 1
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.021 SNIP 1.208 CiteScore 2.22
Web of Science (2014): Indexed yes
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.141 SNIP 1.103 CiteScore 2.01
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
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ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.054 SNIP 1.299
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BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.313 SNIP 1.037
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BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.505 SNIP 1.186
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Web of Science (2007): Indexed yes
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Web of Science (2006): Indexed yes
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Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.897 SNIP 1.205
Scopus rating (2003): SJR 1.054 SNIP 1.157
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.661 SNIP 1.062
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.978 SNIP 1.234
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.735 SNIP 1.16
Scopus rating (1999): SJR 0.891 SNIP 1.249

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Functional hydrocolloids from seaweeds

The global production of seaweeds continues to grow for production of food hydrocolloids, i.e. carbohydrate polymers that form viscous suspensions and gels in water. Because of their unique gelling properties seaweed hydrocolloids are used in various food and pharmaceutical applications. Asian countries and Tanzania are currently the main producers of seaweed hydrocolloids based on cultivation of seaweeds such as Kappaphycus alvarezii, Gracilaria spp. and Laminaria spp. that hold carrageenan, agar, and alginate, respectively. In this review we summarize the chemistry, food uses, and gelling mechanisms of carrageenan, agar, and alginate, and describe the key techniques and principles for their extraction from seaweeds. We also discuss the options for local seaweed manufacturing as a business opportunity in countries along the West African coast.

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Authors: Rhein-Knudsen, N. (Intern), Meyer, A. S. (Intern)
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Scopus rating (2016): CiteScore 0.33 SJR 0.193 SNIP 0.137
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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.161 SNIP 0.176 CiteScore 0.24
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Scopus rating (2014): SJR 0.152 SNIP 0.147 CiteScore 0.22
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ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.159 SNIP 0.096 CiteScore 0.19
ISI indexed (2012): ISI indexed yes
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ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.147 SNIP 0.091
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.158 SNIP 0.088
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.133 SNIP 0.084
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.123 SNIP 0.094
High-performance removal of acids and furans from wheat straw pretreatment liquid by diananofiltration

Two model solutions and a real stream from the hydrothermal pretreatment of wheat straw were subjected to nanofiltration, and permeate flux, retention and resistance to fouling were evaluated. Three commercial NF membranes were tested, and a pressure of 4 bars (range: 1–20 bars) and a temperature of 20°C (range: 20–50°C) were found to provide the best results in terms of retention. A subsequent nanodiafiltration consisting of five cycles enabled one to recover 90% of the monosaccharides (purity >99%). This result showed that diananofiltration could be a promising strategy for the recovery of high-purity streams of monosaccharides from pretreatment liquids.
Homology to peptide pattern for annotation of carbohydrate-active enzymes and prediction of function

Background: Carbohydrate-active enzymes are found in all organisms and participate in key biological processes. These enzymes are classified in 274 families in the CAZy database but the sequence diversity within each family makes it a major task to identify new family members and to provide basis for prediction of enzyme function. A fast and reliable method for de novo annotation of genes encoding carbohydrate-active enzymes is to identify conserved peptides in the curated enzyme families followed by matching of the conserved peptides to the sequence of interest as demonstrated for the glycosyl hydrolase and the lytic polysaccharide monooxygenase families. This approach not only assigns the enzymes to families but also provides functional prediction of the enzymes with high accuracy.

Results: We identified conserved peptides for all enzyme families in the CAZy database with Peptide Pattern Recognition. The conserved peptides were matched to protein sequence for de novo annotation and functional prediction of carbohydrate-active enzymes with the Hotpep method. Annotation of protein sequences from 12 bacterial and 16 fungal genomes to families with Hotpep had an accuracy of 0.84 (measured as F1-score) compared to semiautomatic annotation by the CAZy database whereas the dbCAN HMM-based method had an accuracy of 0.77 with optimized parameters. Furthermore, Hotpep provided a functional prediction with 86% accuracy for the annotated genes. Hotpep is available as a stand-alone application for MS Windows.

Conclusions: Hotpep is a state-of-the-art method for automatic annotation and functional prediction of carbohydrate-active enzymes.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Busk, P. K. (Intern), Pilgaard, B. (Intern), Lezyk, M. J. (Intern), Meyer, A. S. (Intern), Lange, L. (Intern)
Impact of the fouling mechanism on enzymatic depolymerization of xylan in different configurations of membrane reactors

In order to maximize enzymatic xylan depolymerization while simultaneously purifying the resulting monosaccharide (xylose), different ultrafiltration (UF) membrane reactor configurations were evaluated. Initial results showed that the two hydrolytic enzymes required for complete depolymerization of xylan, endo-1,4-β-xylanase and β-xylosidase, promoted different types of fouling, which had a direct impact on the extent of xylan hydrolysis achieved during reaction. Endo-1,4-β-xylanase generated DP 1-6 xylo-oligomers. These products contributed to partial pore blocking of the 1 kDa polysulfone membrane and caused irreversible flux loss (~20%). The presence of β-xylosidase could not prevent deposition of xylan and xylooligomers on the UF membrane surface. Mulder’s modelling of the filtration parameters affirmed that this xylan and xylooligosaccharide deposition formed a cake layer on the membrane which hindered enzymatic attack in addition to fouling. Reaction with both enzymes followed by UF was found to be the optimal configuration, providing at least 40% higher xylan hydrolysis than the cascade configuration (involving sequential reaction with each of the enzymes separately) and the simultaneous reaction-filtration with both enzymes, respectively. This study thus confirmed that the reactor configuration has a crucial impact on the performance of both the reaction and the separation process of xylose during enzymatic xylan degradation, and that the type of fouling mechanism varies in response to the type of enzyme treatment.

General information

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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.257 SNIP 1.54 CiteScore 3.5
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Kinetics based reaction optimization of enzyme catalyzed reduction of formaldehyde to methanol with synchronous cofactor regeneration

Enzymatic reduction of carbon dioxide (CO₂) to methanol (CH₃OH) can be accomplished using a designed set-up of three oxidoreductases utilizing reduced pyridine nucleotide (NADH) as cofactor for the reducing equivalents electron supply. For this enzyme system to function efficiently a balanced regeneration of the reducing equivalents during reaction is required. Herein, we report the optimization of the enzymatic conversion of formaldehyde (CHOH) to CH₃OH by alcohol dehydrogenase, the final step of the enzymatic redox reaction of CO₂ to CH₃OH, with kinetically synchronous enzymatic cofactor regeneration using either glucose dehydrogenase (System I) or xylose dehydrogenase (System II). A mathematical model of the enzyme kinetics was employed to identify the best reaction set-up for attaining optimal cofactor recycling rate and enzyme utilization efficiency. Targeted process optimization experiments were conducted to verify the kinetically modelled results. Repetitive reaction cycles were shown to enhance the yield of CH₃OH, increase the total turnover number (TTN) and the biocatalytic productivity rate (BPR) value for both system I and II whilst minimizing the exposure of the enzymes to high concentrations of CHOH. System II was found to be superior to System I with a yield of 8 mM CH₃OH, a TTN of 160 and BPR of 24 μmol CH₃OH/U·h during 6 hours of reaction. The study demonstrates that an optimal reaction set-up could be designed from rational kinetics modelling to maximize the yield of CH₃OH, whilst simultaneously optimizing cofactor recycling and enzyme utilization efficiency. This article is protected by copyright. All rights reserved.
Laccase catalyzed grafting of-N-OH type mediators to lignin via radical-radical coupling

Lignin is an underexploited resource in biomass refining. Laccases (EC 1.10.3.2) catalyze oxidation of phenolic hydroxyls using O2 as electron acceptor and may facilitate lignin modification in the presence of mediators. This study assessed the reactivity of four different synthetic mediators by laccases from Trametes versicolor and Pleurotus ostreatus by quantitative analysis of the reaction outcome by pyrolysis gas chromatography mass spectroscopy. The two laccases were equally efficient in catalyzing grafting, but only-N-OH type mediators grafted. HPI (N-hydroxyacetanilide) grafted 7-10 times better than HBT (1-hydroxybenzotriazole). Three different mechanisms are suggested to explain the grafting of HPI and HBT, all involving radical-radical coupling to produce covalent bonding to lignin. Lignin from exhaustive cellulase treatment of wheat straw was more susceptible to grafting than beech organosolv lignin with the relative abundance of grafting being 35% vs. 11% for HPI and 5% vs. 1% for HBT on these lignin substrates. The data imply that lignin can be functionalized via laccase catalysis with-N-OH type mediators.

General information
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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Wageningen University
Authors: Munk, L. (Intern), Punt, A. M. (Ekstern), Kabel, M. A. (Ekstern), Meyer, A. S. (Intern)
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Web of Science (2016): Indexed yes
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Scopus rating (2014): SJR 1.114 SNIP 0.965 CiteScore 3.87
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Municipal Solid Waste Management in a Low Income Economy Through Biogas and Bioethanol Production

The biodegradable fraction of municipal solid wastes generated from households in Ghana has favourable characteristics worth considering for bioenergy production. The suitability of this biodegradable portion for biogas and bioethanol production was assessed in this study. The assessment was performed on both untreated and hydrothermally treated unsorted and sorted fractions of the waste using standard methods for biomass conversion to bioenergy. Compositional analysis of the waste indicated that unsorted biodegradable municipal solid wastes (BMSW) consisted of 38.7 % dry matter (DM) glucan, 8.3 % DM hemicellulose, 10.1 % DM lignin and 7.6 % DM ash. The sorted fractions with the highest glucan but least lignin and hemicellulose were the pool of cassava, yam and plantain peeling wastes (CYPPW) with 84 % DM glucan much of which was starch, 5.6 % DM lignin and 0.5 % DM hemicellulose. The highest ethanol yield of 0.29 l/kg DM was measured from this same CYPPW while fruit wastes (FW) had the highest biomethane potential of 408 ml CH4/g VS. The BMSW had ethanol yield of 0.17 l/kg DM and biogas 369 ml CH4/g VS. The hydrothermally pretreated wastes had marginal increases in glucose and ethanol yield except the treated yard waste which significantly increased by 54 % in glucose over the untreated waste. The most promising waste fractions were FW, CYPPW and mixed paper wastes. Careful selection of these fractions in feedstock for biofuel production would reduce generation of the waste, improve the quality and effectively lead to higher yield of biofuel over the unsorted form.

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Web of Science (2016): Indexed yes
Scopus rating (2015): SJR 0.396 SNIP 0.515 CiteScore 1.08
Web of Science (2015): Indexed yes
Scopus rating (2014): SJR 0.455 SNIP 1.004 CiteScore 1.25
Scopus rating (2013): SJR 0.731 SNIP 1.074 CiteScore 2.01
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.691 SNIP 1.27 CiteScore 1.86
New degradation compounds from lignocellulosic biomass pretreatment: routes for formation of potent oligophenolic enzyme inhibitors

In this study 26 new oligophenol cellulase inhibitors were discovered from wheat straw pretreatment liquors. By consideration of the reaction mechanisms for their formation it is proposed that these oligophenols are formed during hydrothermal biomass pretreatment by pentose self-condensation reactions involving aldol condensations, 1,4 additions to α,β unsaturated carbonyl compounds, 3-keto acid decarboxylations and oxidations. Furthermore, pentose reactions with phenolic lignin components are suggested. The identification of the central role of xylose in the reaction routes for oligophenolic inhibitor formation led to the solution to protect the reactive anemic center in xylose. It is shown that protection of the anemic center in in situ generated xylose with ethylene glycol monobutyl ether, during pretreatment of wheat straw, reduces the level of oligophenols by 73%. The results pave the way for implementation of new types of reactions that hinder inhibitor formation in lignocellulosic biomass processing.

General information
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Organisations: Department of Chemistry, Organic Chemistry, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, DONG Energy AS, DONG Energy A/S
Authors: Rasmussen, H. (Ekstern), Tanner, D. A. (Intern), Sørensen, H. R. (Ekstern), Meyer, A. S. (Intern)
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Main Research Area: Technical/natural sciences

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Scopus rating (2016): CiteScore 8.86 SJR 2.564 SNIP 2.019
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.477 SNIP 1.901 CiteScore 8.21
Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 2.398 SNIP 2.007 CiteScore 8.05
Web of Science (2014): Indexed yes
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Scopus rating (2013): SJR 2.266 SNIP 1.815 CiteScore 7.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.439 SNIP 1.709 CiteScore 6.64
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
New pentose dimers with bicyclic moieties from pretreated biomass

In lignocellulosic biorefinery processes involving enzyme catalysed reactions it is a challenge that enzyme inhibiting compounds are generated and liberated during pretreatment of the biomass. In this study the contribution to cellulase inhibition from xylooligosaccharides and newly discovered oligophenolic compounds from pilot scale pretreated wheat straw was assessed at two different pretreatment severities. An increase in severity of the pretreatment led to more oligophenol compounds and in turn the total overall cellulase inhibition increased. When the xylooligosaccharides were enzymatically degraded prior to cellulose hydrolysis, a relief in cellulase inhibition was observed, but some inhibition remained, suggesting that other components also played a role in inhibition. We propose that these components include dipentoses with bicyclic moieties and feruloylated tripentoses, because LC-MS/MS analysis revealed the presence of these components in the liquid from hydrothermal pretreated wheat straw after enzymatic treatment. The reaction mechanisms for synthesis of the new dipentoses having hydroxylated oxane bicyclic residues are considered and they are proposed to be formed as reaction products from either xylose or glucose reacting with glyceraldehyde during pretreatment. The data show that the main cellulase inhibition from hydrothermally pretreated wheat straw liquors is due to xylooligosaccharides followed by oligophenolic compounds and the newly discovered dipentose with bicyclic moieties and feruloylated tripentoses. The relative amounts and hence contribution to inhibition from each class of compounds changes with severity of the pretreatment.

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Authors: Rasmussen, H. (Ekstern), Sørensen, H. R. (Ekstern), Tanner, D. A. (Intern), Meyer, A. S. (Intern)
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Oxidation of lignin in hemp fibres by laccase: effects on mechanical properties of hemp fibres and unidirectional fibre/epoxy composites

Laccase activity catalyzes oxidation and polymerization of phenols. The effect of laccase treatment on the mechanical properties of hemp fibres and hemp fibre/epoxy composites was examined. Laccase treatment on top of 0.5% EDTA + 0.2% endo-polygalacturonase (EPG) treatments increased the mechanical properties of hemp fibres and fibre/epoxy composites. Comparing all fibre treatments, composites with 0.5% EDTA + 0.2% EPG + 0.5% laccase treated fibres had highest stiffness of 42 GPa and highest ultimate tensile strength (UTS) of 326 MPa at a fibre volume content of 50%. The thermal resistance of hemp fibres increased after laccase treatments, as the maximum degradation temperature increased about 5 °C. Oxidation of phenolic hydroxyls in lignin by laccase was observed. Cross-linking of hydroxycinnamates by laccase was not observed. We suggest that the increased mechanical properties of laccase treated hemp fibres and their composites were due to laccase catalyzed polymerization of lignin moieties in hemp fibres.

General information
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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, The Danish Polymer Centre, University of Hamburg
Authors: Liu, M. (Intern), Baum, A. (Intern), Odermatt, J. (Ekstern), Berger, J. (Ekstern), Yu, L. (Intern), Zeuner, B. (Intern), Thygesen, A. (Intern), Holck, J. (Intern), Meyer, A. S. (Intern)
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Oxidative cleavage and hydrolytic boosting of cellulose in soybean spent flakes by Trichoderma reesei Cel61A lytic polysaccharide monooxygenase

The auxiliary activity family 9 (AA9) copper-dependent lytic polysaccharide monoxygenase (LPMO) from Trichoderma reesei (EG4; TrCel61A) was investigated for its ability to oxidize the complex polysaccharides from soybean. The substrate specificity of the enzyme was assessed against a variety of substrates, including both soy spent flake, a by-
product of the soy food industry, and soy spent flake pretreated with sodium hydroxide. Products from enzymatic
treatments were analyzed using mass spectrometry and high performance anion exchange chromatography. We
demonstrate that TrCel61A is capable of oxidizing cellulose from both pretreated soy spent flake and phosphoric acid
swollen cellulose, oxidizing at both the C1 and C4 positions. In addition, we show that the oxidative activity of TrCel61A
displays a synergistic effect capable of boosting endoglucanase activity, and thereby substrate depolymerization of soy
cellulose, by 27%.

General information
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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, DuPont
Nutrition Biosciences Aps
Authors: Pierce, B. (Intern), Wittrup Agger, J. (Intern), Wichmann, J. (Ekstern), Meyer, A. S. (Intern)
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Web of Science (2016): Indexed yes
Scopus rating (2016): CiteScore 2.83 SJR 0.759 SNIP 1.025
Web of Science (2015): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.85 SNIP 0.969 CiteScore 2.63
Web of Science (2014): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.061 SNIP 1.214 CiteScore 3.12
Web of Science (2013): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.165 SNIP 1.376 CiteScore 3.2
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.204 SNIP 1.281 CiteScore 2.78
ISI indexed (2012): ISI indexed yes
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Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.201 SNIP 1.565
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.305 SNIP 1.504
Web of Science (2009): Indexed yes
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Prebiotic potential of pectin and pectic oligosaccharides to promote anti-inflammatory commensal bacteria in the human colon

Dietary plant cell wall carbohydrates are important in modulating the composition and metabolism of the complex gut microbiota, which can impact on health. Pectin is a major component of plant cell walls. Based on studies in model systems and available bacterial isolates and genomes, the capacity to utilize pectins for growth is widespread among colonic Bacteroidetes but relatively uncommon among Firmicutes. One Firmicutes species promoted by pectin is *Eubacterium eligens*. *E. eligens* DSM3376 utilizes apple pectin and encodes a broad repertoire of pectinolytic enzymes, including a highly abundant pectate lyase of around 200 kDa that is expressed constitutively. We confirmed that certain *Faecalibacterium prausnitzii* strains possess some ability to utilize apple pectin and report here that *F. prausnitzii* strains in common with *E. eligens*, can utilize the galacturonide oligosaccharides DP4 and DP5 derived from sugar beet pectin. *F. prausnitzii* strains have been shown previously to exert anti-inflammatory effects on host cells, but we show here for the first time that *E. eligens* strongly promotes the production of the anti-inflammatory cytokine IL-10 in in vitro cell-based assays. These findings suggest the potential to explore further the prebiotic potential of pectin and its derivatives to rebalance the microbiota towards an anti-inflammatory profile.

**General information**

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**Organisations:** Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, University of Aberdeen, Wageningen University  
**Authors:** Chung, W. S. F. (Ekstern), Meijerink, M. (Ekstern), Zeuner, B. (Intern), Holck, J. (Intern), Louis, P. (Ekstern), Meyer, A. S. (Intern), Wells, J. M. (Ekstern), Flint, H. J. (Ekstern), Duncan, S. H. (Ekstern)  
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  Scopus rating (2016): CiteScore 3.85
Prediction of Pectin Yield and Quality by FTIR and Carbohydrate Microarray Analysis

Pectin production is complex, and final product quality assessment is generally accomplished at the end of the process using time-consuming off-line laboratory analysis. In this study, pectin was extracted from lime peel either by acid or by enzymes. Fourier transform infrared spectroscopy and carbohydrate microarray analysis were performed directly on the crude lime peel extracts during the time course of the extractions. Multivariate analysis of the data was carried out to predict final pectin yields. Fourier transform infrared spectroscopy (FTIR) was found applicable for determining the optimal extraction time for the enzymatic and acidic extraction processes, respectively. The combined results of FTIR and carbohydrate microarray analysis suggested major differences in the crude pectin extracts obtained by enzymatic and acid extraction, respectively. Enzymatically extracted pectin, thus, showed a higher degree of esterification (DE 82 %) than pectin extracted by acid (DE 67 %) and was moreover found to be more heterogeneously esterified when probed with the monoclonal antibodies JIM5, JIM7, and LM20. The data infer that enzymatic pectin extraction allows for extraction of complex, high DE pectin, and that FTIR and carbohydrate microarray analysis have potential to be developed into online process analysis tools for prediction of pectin extraction yields and pectin features from measurements on crude pectin extracts.

General information
Antibodies, Chemometrics, Enzymatic extraction, Multivariate analysis, Online monitoring, PLS

Pre-process desilication of wheat straw with citrate

Effects of treatment time, citrate concentration, temperature, and pH on Si extraction from wheat straw prior to hydrothermal pretreatment were investigated for maximising Si removal and biomass recovery before biomass refining. With citrate, an almost linear negative correlation between Si content in the residual biomass and treatment temperature was observed up to 170 degrees C, yielding a Si removal of up to 97.7%. This high Si removal came at the expense of a low mass yield (down to 45%) in the insoluble lignocellulosic fraction. Optimum process conditions for high Si removal and high total mass yield were: 100mM sodium citrate, 130 degrees C, 60 min, 2% w/v solids, and pH of similar to 6.5 during extraction. Using the proposed process conditions, silica removal of up to 77% was achieved with a mass yield of 72.8%. This Si removal from the insoluble lignocellulosic fraction did not affect the enzymatic cellulose hydrolysis, neither negatively nor positively.
Rheological properties of agar and carrageenan from Ghanaian red seaweeds

Red seaweeds contain unique galactose-rich hydrocolloids, carrageenans and agar, which find use as gelling agents in high value applications. This study examined the chemical and rheological properties of hydrocolloids from selected wild red seaweed species collected in Ghana: Hypnea musciformis and Cryptonemia crenulata, expected to hold carrageenan, contained 21–26% by weight of galactose. A commercial Kappaphycus alvarezii carrageenan sample had 30% galactose residues by weight. Hydropuntia dentata, expected to contain agar, contained 15% by weight of galactose-monomers. Fourier transform infrared spectroscopy (FTIR) analysis on the hydrocolloids extracted from H. musciformis (and K. alvarezii) indicated κ-carrageenan, C. crenulata hydrocolloids were mainly ι-carrageenan, and the H. dentata hydrocolloids were agar. Gelling temperatures ranged from 32 to 36 °C for the κ-carrageenan hydrocolloid samples. The ι-carrageenan and agar samples had gelling temperatures of 70–74 °C and 38–52 °C, respectively. Gel strengths, G’ at 25 °C, of carrageenan samples extracted via alkali-treatment were 4000–6500 Pa. The agar gel strength was 287 Pa. The rheological properties of the H. musciformis κ-carrageenans were comparable with κ-carrageenan from K. alvarezii, whereas the H. dentata agar properties were different from those of a commercial agar sample. This work shows that certain red seaweed species in Ghana contain hydrocolloids with desirable properties for high value applications.

General information

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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, National Food Institute, Research Group for Nano-Bio Science, The Danish Polymer Centre
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Scopus rating (2013): SJR 2.1 SNIP 2.292 CiteScore 4.81
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Selection of Bacillus species for targeted in situ release of prebiotic galacto-rhamnogalacturonan from potato pulp in piglets

We have previously shown that galacto-rhamnogalacturonan fibers can be enzymatically extracted from potato pulp and that these fibers have potential for exerting a prebiotic effect in piglets. The spore-forming Bacillus species are widely used as probiotics in feed supplements for pigs. In this study, we evaluated the option for further functionalizing Bacillus feed supplements by selecting strains possessing the enzymes required for extraction of the potentially prebiotic fibers. We established that it would require production and secretion of pectin lyase and/or polygalacturonase but no or limited secretion of galactanase and β-galactosidase. By screening a library of 158 Bacillus species isolated from feces and soil, we demonstrated that especially strains of Bacillus amyloliquefaciens, Bacillus subtilis, and Bacillus mojavensis have the necessary enzyme profile and thus the capability to degrade polygalacturonan. Using an in vitro porcine gastrointestinal model system, we revealed that specifically strains of B. mojavensis were able to efficiently release galacto-rhamnogalacturonan from potato pulp under simulated gastrointestinal conditions. The work thus demonstrated the feasibility of producing prebiotic fibers via a feed containing Bacillus spores and potato pulp and identified candidates for future in vivo evaluation in piglets.

General information

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Organisations: Department of Biotechnology and Biomedicine, Infection Microbiology, Novo Nordisk Foundation Center for Biosustainability, Research Groups, Bacterial Signal Transduction, National Veterinary Institute, Bacteriology & Parasitology, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Chr. Hansen A/S Authors: Jers, C. (Intern), Strube, M. L. (Intern), Cantor, M. D. (Ekstern), Nielsen, B. K. K. (Ekstern), Sørensen, O. B. (Ekstern), Boye, M. (Intern), Meyer, A. S. (Intern)
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Separation of xylose and glucose using an integrated membrane system for enzymatic cofactor regeneration and downstream purification

Mixtures of xylose, glucose, and pyruvate were fed to a membrane bioreactor equipped with a charged NF membrane (NTR 7450). Value-added products were obtained in the reactor via enzymatic cofactor-dependent catalysis of glucose to gluconic acid and pyruvate to lactic acid, respectively. The initial cofactor (NADH) concentration could be decreased to 10% of the stoichiometric value (relative to glucose) without compromising process time and substrate conversion via i) efficient cofactor regeneration and ii) high retention of cofactor (R=0.98) in the membrane bioreactor. Furthermore, accumulation of xylose (R...
Membrane separation of xylose and glucose can be accomplished via oxidation of glucose to gluconic acid by enzymatic glucose oxidase catalysis. Oxygen for this reaction can be supplied via decomposition of hydrogen peroxide by enzymatic catalase catalysis. In order to maximize the biocatalytic productivity of glucose oxidase and catalase (gluconic acid yield per total amount of enzyme) the following system set-ups were compared: immobilization of glucose oxidase alone; co-immobilization of glucose oxidase and catalase; glucose oxidase and catalase free in the membrane bioreactor. Fouling-induced enzyme immobilization in the porous support of an ultrafiltration membrane was used as strategy for entrapment of glucose oxidase and catalase. The biocatalytic productivity of the membrane reactor was found to be highly related to the oxygen availability, which in turn depended on the reactor configuration, hydrogen peroxide concentration and catalase origin. When glucose oxidase and catalase (from Aspergillus niger) were free in the membrane bioreactor a total biocatalytic productivity of 122 mg gluconic acid/mg enzyme was obtained after five consecutive reaction cycles. The free enzymes showed superior performance compared to the immobilized systems as a result of limited substrate and product diffusion in the latter case.
Structural Characterization and Enzymatic Modification of Soybean Polysaccharides

The work in this thesis explores the structure of soybean polysaccharides, and examines approaches for the chemical and enzymatic degradation and solubilization of this material. Soybean polysaccharides are produced in large quantities globally as a by-product of various soy production processes. The work presented in this text focuses on the insoluble cell wall polysaccharides produced during the manufacture of soy protein isolate. Soybean polysaccharides are water insoluble and feature an approximate carbohydrate composition (by weight) of 35% galactose, 20% glucose, 20% arabinose, 10% galacturonic acid, 8% xylose, 3% rhamnose, and 3% fucose. Currently, the majority of this material is disposed of as waste, increasing production costs. Opportunities exist for the development of novel functional ingredients from this abundant and underutilized material; however, efforts in this area are currently limited by the material's insolubility. A central hypothesis of this work was that by obtaining a more complete understanding of the structure of this material, chemical and enzymatic approaches could be developed to modify the polysaccharides, creating soluble polysaccharide fractions that could provide improved functionality in industrial...
To address this hypothesis, structural information was obtained through HPAEC compositional analysis and GC-MS linkage analysis. This work was conducted on the whole soybean polysaccharide fraction, instead of only chemically extracted portions of this material like those analyzed in previous studies. Using this linkage data, the polysaccharide classes in soybean were quantified for the first time, with the results (by weight) identifying the primary constituents as: type I arabinogalactan (27.8%), cellulose (23.5%), (glucurono)arabinobioxyan (14.4%), arabinan (8.1%), rhamnogalacturonan I (6.2%), xyloglucan (2.7%), type II arabinogalactan (2.0%), and homogalacturonan (1.6%). Using this compositional data, a novel chemical solubilization process was developed utilizing hydrogen peroxide at elevated temperatures. This treatment resulted in the release of more than 70% of the original insoluble material as high molar mass, water-soluble polysaccharides. This solubilized fraction is significantly enriched in the non-cellulosic polysaccharides of soy-bean such as arabinogalactan, homogalacturonan, rhamnogalacturonan, arabinan, xyloglucan, and (glucurono)arabinobioxyan. These results demonstrate that it is possible to solubilize significant portions of the soybean polysaccharide using a one-step chemical treatment, which opens new possibilities for the expanded utilization of this material going forward.

Building upon these observations, twenty-three additional LPMOs from seven fungal sources were evaluated (using TrCel61A as a benchmark), with none showing oxidative activity on native soybean polysaccharides. However, significant oxidative degradation was observed on NaOH pretreated soybean polysaccharides. The oxidation products were evaluated using HPAEC and MS, with the results showing oxidation at both the C1 and C4 positions of cellulose. In addition, a synergistic effect between TrCel61A and a GH5 endo-β-1,4-glucanase was discovered, boosting the glucose release from NaOH pretreated soybean polysaccharides.

Overall, the research conducted in this project has demonstrated the utility of structure-based modification approaches and suggests that the insolubility of soybean polysaccharides is primarily conferred by the cellulosic components. In addition, the results obtained suggest several new opportunities for direct chemical or enzymatic solubilization and degradation of insoluble soybean polysaccharides, paving the way for the improved utilization of this material in the future.
Miscanthus × giganteus, and wheat straw (Triticum aestivum L.) were systematically hydrothermally pretreated; each at three different severities of 3.65, 3.83, and 3.97, respectively, and the enzymatic digestibility was assessed. Pretreated samples of Miscanthus × giganteus stalks were the least digestible among the biomass feedstocks producing 24 to 66.6% lower glucose yields than the other feedstocks depending on pretreatment severity and enzymedosage. Bulk biomass composition analyses, 2D nuclear magnetic resonance, and comprehensive microarray polymer profiling were not able to explain the observed differences in recalcitrance among the pretreated feedstocks. However, methods characterizing physical and chemical features of the biomass surfaces, specifically contact angle measurements (wettability) and attenuated total reflectance-Fourier transform infrared (ATR-FTIR) spectroscopy (surfacebiopolymer composition) produced data correlating pretreatment severity and enzymatic digestibility, and they also revealed differences that correlated to enzymatic glucose yield responses among the three different biomass types.

Conclusion: The study revealed that to a large extent, factors related to physico-chemical surface properties, namely surface wettability as assessed by contact angle measurements and surface content of hemicellulose, lignin, and waxs assessed by ATR-FTIR rather than bulk biomass chemical composition correlated to the recalcitrance of the tested biomass types. The data provide new insight into how hydrothermal pretreatment severity affects surface properties of key Poaceae lignocellulosic biomass and may help design new approaches to overcome biomass recalcitrance.
Global interest in the use of plant fibres in natural fibre reinforced composites (NFCs) is growing rapidly. The increased interest is primarily due to the advantageous properties of natural fibres including biodegradability, low cost, low density and high stiffness and strength to weight ratio. In order to achieve strong NFCs, well separated and cellulose-rich fibres are required. Hemp is taking a center stage in this regard as a source of suitable natural plant cellulose fibres because natural hemp bast fibres are long and inherently possess high strength. Classical field and water retting methods have been used for centuries for removal of non-cellulosic components from fibrous plant stems including from hemp, but carries a risk of reducing the mechanical properties of the fibres via damaging the cellulose. For NFCs new targeted fibre pre-treatment methods are needed to selectively and effectively remove non-cellulosic components from the plant fibres to produce cellulose rich fibres without introducing any damage to the fibres. A key feature for successful use of natural fibres such as hemp fibres in composite materials is optimal interfacial contact between the fibres and the hydrophobic composite matrix material. Targeted modification of natural fibres for NFCs must also be targeted to optimize the fibre surface properties. Consequently, improved interfacial bonding between fibres and hydrophobic polymers, reduced moisture uptake, increased microbial degradation resistance, and prolonged durability of NFCs can be achieved. This review, using hemp bast fibres as an example, critically and comprehensively assesses the targeted pretreatment technologies and data available for producing well separated cellulose bast fibres having optimal chemical and physical properties for maximizing the mechanical performance and durability of NFCs.
Whole grain-rich diet reduces body weight and systemic low-grade inflammation without inducing major changes of the gut microbiome: a randomised cross-over trial

Objective To investigate whether a whole grain diet alters the gut microbiome and insulin sensitivity, as well as biomarkers of metabolic health and gut functionality. Design 60 Danish adults at risk of developing metabolic syndrome were included in a randomised cross-over trial with two 8-week dietary intervention periods comprising whole grain diet and refined grain diet, separated by a washout period of ≥6 weeks. The response to the interventions on the gut microbiome composition and insulin sensitivity as well on measures of glucose and lipid metabolism, gut functionality, inflammatory markers, anthropometry and urine metabolomics were assessed. Results 50 participants completed both periods with a whole grain intake of 179±50 g/day and 13±10 g/day in the whole grain and refined grain period, respectively. Compliance was confirmed by a difference in plasma alkylresorcinols (p<0.0001). Compared with refined grain, whole grain did not significantly alter glucose homeostasis and did not induce major changes in the faecal microbiome. Also, breath hydrogen levels, plasma short-chain fatty acids, intestinal integrity and intestinal transit time were not affected. The whole grain diet did, however, compared with the refined grain diet, decrease body weight (p<0.0001), serum inflammatory markers,
interleukin (IL)-6 (p=0.009) and C-reactive protein (p=0.003). The reduction in body weight was consistent with a reduction in energy intake, and IL-6 reduction was associated with the amount of whole grain consumed, in particular with intake of rye. Conclusion Compared with refined grain diet, whole grain diet did not alter insulin sensitivity and gut microbiome but reduced body weight and systemic low-grade inflammation.

**General information**

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Organisations: National Food Institute, Research Group for Gut Microbiology and Immunology, Department of Bio and Health Informatics, Metagenomics, Disease Intelligance and Molecular Evolution, Department of Biotechnology and Biomedicine, Disease Systems Immunology, Department of Chemical and Biochemical Engineering, Organic Chemistry, Center for BioProcess Engineering, DTU Multi Assay Core, Research Group for Analytical Food Chemistry, Copenhagen Center for Health Technology, University of Copenhagen, Chalmers University of Technology, Chalmers University of Technology, Bispebjerg University Hospital, Herlev and Gentofte Hospital, University of Auckland


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4-Hydroxybenzoic acid from hydrothermal pretreatment of oil palm empty fruit bunches - Its origin and influence on biomass conversion

An unknown major compound, characteristically occurring during processing of oil palm empty fruit bunches was identified with LC-DAD-ESI-MS/MS to be 4-hydroxybenzoic acid. Lignin from oil palm empty fruit bunches contains 4-hydroxybenzoic acid so a tempting conclusion was that the 4-hydroxybenzoic acid originated from lignin. However, another hypothesis to its origin was also tested. The route considered involves degradation of rhamnose to 5-methylfuran-2-carbaldehyde followed by reaction with formic acid. Experimental hydrothermal pretreatment of pure rhamnose in the presence of formic acid revealed that 5-methylfuran-2-carbaldehyde is in fact a degradation product from rhamnose, analogous to glucose degradation to 5-(hydroxymethyl)-2-furaldehyde. However, the subsequent step of carboxylation with formic acid to form 4-hydroxybenzoic acid was found not to take place in practice at realistic biomass hydrothermal pretreatment conditions. 5-methylfuran-2-carbaldehyde only differs from furfural by having an extra methyl group and the degradation route indicates that it may be a new important degradation compound to consider in other biomass feedstocks rich in deoxysugars such as rhamnose or fucose, e.g. pectin rich biomasses. Assessment of the influence of 4-hydroxybenzoic acid in the enzymatic hydrolysis of pretreated oil palm empty fruit bunches as well as its presence during fermentation showed that 4-hydroxybenzoic acid is not inhibiting or mediating neither on the enzymatic hydrolysis or fermentation in the quantified range from 0.1 g/L to 1 g/L, indicating an option for reaping the 4-hydroxybenzoic acid from the biomass liquor directly after hydrothermal pretreatment for biorefinery value-addition. (C) 2016 Elsevier Ltd. All rights reserved.
An Aspergillus nidulans GH26 endo-β-mannanase with a novel degradation pattern on highly substituted galactomannans

The activity and substrate degradation pattern of a novel Aspergillus nidulans GH26 endo-β-mannanase (AnMan26A) was investigated using two galactomannan substrates with varying amounts of galactopyranosyl residues. The AnMan26A was characterized in parallel with the GH26 endomannanase from Podospora anserina (PaMan26A) and three GH5 endomannanases from A. nidulans and Trichoderma reesei (AnMan5A, AnMan5C and TrMan5A). The initial rates and the maximal degree of enzymatically catalyzed conversion of locust bean gum and guar gum galactomannans were determined. The hydrolysis product profile at maximal degree of conversion was determined using DNA sequencer-Assisted Saccharide analysis in High throughput (DASH). This is the first reported use of this method for analyzing galactomannooligosaccharides. AnMan26A and PaMan26A were found to have a novel substrate degradation pattern on the two galactomannan substrates. On the highly substituted guar gum AnMan26A and PaMan26A reached 35-40% as their maximal degree of conversion whereas the three tested GHS endomannanases only reached 8-10% as their maximal degree of conversion. α-Galactosyl-mannose was identified as the dominant degradation product resulting from...
AnMan26A and PaMan26A action on guar gum, strongly indicating that these two enzymes can accommodate galactopyranosyl residues in the -1 and in the +1 subsite. The degradation of α-6-4-63-di-galactosyl-mannopentaose by AnMan26A revealed accommodation of galactopyranosyl residues in the -2, -1 and +1 subsite of the enzyme. Accommodation of galactopyranosyl residues in subsites -2 and +1 has not been observed for other characterized endomannanases to date. Docking analysis of galactomannooligosaccharides in available crystal structures and homology models supported the conclusions drawn from the experimental results. This newly discovered diversity of substrate degradation patterns demonstrates an expanded functionality of fungal endomannanases, than hitherto reported.

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Web of Science (2016): Indexed yes
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Web of Science (2015): Indexed yes
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ISI indexed (2011): ISI indexed yes
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Scopus rating (2010): SJR 1.201 SNIP 1.565
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.305 SNIP 1.504
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
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Brown seaweed processing: enzymatic saccharification of Laminaria digitata requires no pre-treatment

This study assesses the effect of different milling pre-treatments on enzymatic glucose release from the brown seaweed Laminaria digitata having high glucan (laminarin) content. Wet refiner milling, using rotating disc distances of 0.1–2 mm, generated populations of differently sized pieces of lamina having decreasing average surface area (100–0.1 mm²) with increased milling severity. Higher milling severity (lower rotating disc distance) also induced higher spontaneous carbohydrate solubilization from the material. Due to the seaweed material consisting of flat blades, the milling did not increase the overall surface area of the seaweed material, and size diminution of the lamina by milling did not improve the enzymatic glucose release. Milling was thus not required for enzymatic saccharification because all available glucose was released even from unmilled material. Treatment with a mixture of alginate lyase and a cellulase preparation (Cellic®CTec2) on large-sized milled material released all available glucose within 8 h. Application of the cellulase preparation alone released only half of the available glucose. The alginate lyase catalysis apparently induced selective removal of alginate to improve the cellulase catalyzed degradation of laminarin and cellulose in the material.

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Authors: Manns, D. (Intern), Andersen, S. K. (Intern), Saake, B. (Ekstern), Meyer, A. S. (Intern)
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Carbohydrate degradation mechanisms and compounds from pretreated biomass

The formation of inhibitors during pretreatment of lignocellulosic feedstocks is a persistent problem, and notably the compounds that retard enzymatic cellulose conversion represent an obstacle for achieving optimal enzymatic productivity and high glucose yields. Compounds with many chemical functionalities are formed during biomass pretreatment, which gives possibilities for various chemical reactions to take place and hence formation of many new potential inhibitor compounds. This somehow overlooked contemplation formed the basis for the main hypothesis investigated in this work:

Hypothesis 1) Liquors from biomass pretreatment contain an array of hitherto unidentified cellulase inhibitors that are believed to be reaction products from carbohydrate degradation.

(*cellulases include endo-cellulases, cellobiohydrolases, LPMO, and beta-glucosidase enzyme activities)

Furthermore the two following two hypotheses were tested.

Hypothesis 2). Formation of these inhibitor compounds can be prevented by protection of reactive chemical functionalities as revealed from their mechanisms for formation.

Hypothesis 3) Process parameters influence the amount and type of reaction products (from hypothesis 1) that are formed and in turn change inhibition.

In order to point out potent cellulase inhibitors, a solvent extraction based fractionation method was developed to separate compounds in liquid from pilot plant hydrothermal pretreatment of wheat straw. Via 2-butanol extraction a group of potent cellulase inhibitors were identified with LC-MS/MS to be oligophenolic compounds. 26 of the compounds were new and by considering the reaction mechanisms and synthesis routes for their formation it was revealed that xylose was heavily involved in their formation. The new oligophenolic cellulase inhibitors were suggested to be formed during hydrothermal pretreatment by xylose self-condensation reactions involving aldol condensations, 1,4 additions to α,β unsaturated carbonyl compounds, 3-keto acid decarboxylations and oxidations. In addition xylose reactions with phenolic lignin components were suggested.

The identification of the central role of xylose in the reaction routes for oligophenolic inhibitor formation led to the solution
to protect the reactive anemic center in xylose. Protection of the anemic center in in situ generated xylose with ethylene glycol monobutyl ether, during pretreatment of wheat straw, reduced the level of oligophenolic compounds with 73 % compared to the original pretreatment and 41 % compared to the control.

When pretreatment severity was increased the amount of xylooligosaccharides decreased whereas the amount of oligophenolic compounds increased. No new degradation compounds were formed although the profile of the oligophenolic inhibitors changed. New dipentoses with hydroxylated oxane bicyclic moieties and feruloylated tripentoses are suggested also to play a role in inhibition, because LC-MS/MS analysis revealed the presence of these components in the liquid from hydrothermal pretreated wheat straw after enzymatic treatment.

It was found that formation of the oligophenolic degradation compounds were common across biomass sources as sugar cane bagasse and oil palm empty fruit bunches. These findings were in line with that the oligophenolic compounds arise from reactions involving xylose from hemicellulose in the biomass. Even though oligophenolic degradation compounds were common across biomasses, variations were found in biomass structural elements that were released during pretreatment. Pentoseoligosaccharides from sugar cane bagasse had a more acetylated substitution pattern than wheat straw, and in oil palm empty fruit bunches 4-hydroxybenzoic acid was identified to be a variation from a lignin structural elements released during pretreatment.

In conclusion it was found that the reactions taking place during pretreatment of biomass are complex and involve both degradation compounds and biomass structural elements. The present work has shed some light over the reactions and from this new insight a new type of pretreatment with anemic protection was proposed and tested. The results open up for implementation of new types of pretreatments that hinder monosaccharide degradation to inhibitor compounds in lignocellulosic biomass processing.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, DONG Energy A/S
Authors: Rasmussen, H. (Intern), Meyer, A. S. (Intern), Sørensen, H. R. (Ekstern)
Number of pages: 152
Publication date: 2016

Cathode Assessment for Maximizing Current Generation in Microbial Fuel Cells Utilizing Bioethanol Effluent as Substrate
Implementation of microbial fuel cells (MFCs) for electricity production requires effective current generation from waste products via robust cathode reduction. Three cathode types using dissolved oxygen cathodes (DOCs), ferricyanide cathodes (FeCs) and air cathodes (AiCs) were therefore assessed using bioethanol effluent, containing 20.5 g/L xylose, 1.8 g/L arabinose and 2.5 g/L propionic acid. In each set-up the anode and cathode had an electrode surface area of 88 cm(2), which was used for calculation of the current density. Electricity generation was evaluated by quantifying current responses to substrate loading rates and external resistance. At the lowest external resistance of 27 and highest substrate loading rate of 2 g chemical oxygen demand (COD) per L/day, FeC-MFC generated highest average current density (1630 mA/m(2)) followed by AiC-MFC (802 mA/m(2)) and DOC-MFC (184 mA/m(2)). Electrochemical impedance spectroscopy (EIS) was used to determine the impedance of the cathodes. It was thereby confirmed that the FeC-MFC produced the highest current density with the lowest internal resistance for the cathode. However, in a setup using bioethanol effluent, the AiC-MFC was concluded to be the most sustainable option since it does not require ferricyanide. The data offer a new add-on option to the straw biorefinery by using bioethanol effluent for microbial electricity production.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Department of Systems Biology
Authors: Sun, G. (Intern), Thygesen, A. (Intern), Meyer, A. S. (Intern)
Number of pages: 11
Publication date: 2016
Main Research Area: Technical/natural sciences
Combination of ensiling and fungal delignification as effective wheat straw pretreatment

Background: Utilization of lignocellulosic feedstocks for bioenergy production in developing countries demands competitive but low-tech conversion routes. White-rot fungi (WRF) inoculation and ensiling are two methods previously investigated for low-tech pretreatment of biomasses such as wheat straw (WS). This study was undertaken to assess whether a combination of forced ensiling with Lactobacillus buchneri and WRF treatment using a low cellulase fungus, Ceriporiopsis subvermispora, could produce a relevant pretreatment effect on WS for bioethanol and biogas production. Results: A combination of the ensiling and WRF treatment induced efficient pretreatment of WS by reducing lignin content and increasing enzymatic sugar release, thereby enabling an ethanol yield of 66 % of the theoretical max on the WS glucan, i.e. a yield comparable to yields obtained with high-tech, large-scale pretreatment methods. The pretreatment effect was reached with only a minor total solids loss of 5 % by weight mainly caused by the fungal metabolism. The combination of the biopretreatments did not improve the methane potential of the WS, but improved the initial biogas production rate significantly. Conclusion: The combination of the L. buchneri ensiling and C. subvermispora WRF treatment provided a significant improvement in the pretreatment effect on WS. This combined biopretreatment produced particularly promising results for ethanol production.

General information
Controlled retting of hemp fibres: Effect of hydrothermal pre-treatment and enzymatic retting on the mechanical properties of unidirectional hemp/epoxy composites

The objective of this work was to investigate the use of hydrothermal pre-treatment and enzymatic retting to remove non-cellulosic compounds and thus improve the mechanical properties of hemp fibre/epoxy composites. Hydrothermal pre-treatment at 100 kPa and 121 °C combined with enzymatic retting produced fibres with the highest ultimate tensile strength (UTS) of 780 MPa. Compared to untreated fibres, this combined treatment exhibited a positive effect on the mechanical properties of hemp fibre/epoxy composites, resulting in high quality composites with low porosity factor ($\alpha_{pf}$) of 0.08. Traditional field retting produced composites with the poorest mechanical properties and the highest $\alpha_{pf}$ of 0.16. Hydrothermal pretreatment at 100 kPa and subsequent enzymatic retting resulted in hemp fibre composites with the highest UTS of 325 MPa, and stiffness of 38 GPa with 50% fibre volume content, which was 31% and 41% higher, respectively, compared to field retted fibres.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Department of Wind Energy, Composites and Materials Mechanics, Technical University of Denmark, Swedish University of Agricultural Sciences
Authors: Liu, M. (Intern), Silva, D. A. S. (Ekstern), Fernando, D. (Ekstern), Meyer, A. S. (Intern), Madsen, B. (Intern), Daniel, G. (Ekstern), Thygesen, A. (Intern)
Pages: 253–262
Publication date: 2016
Main Research Area: Technical/natural sciences

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Journal: Composites Part A: Applied Science and Manufacturing
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.67 SNIP 2.538 CiteScore 4.08
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.59 SNIP 2.828 CiteScore 3.92
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Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
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ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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Scopus rating (2011): SJR 1.443 SNIP 2.499 CiteScore 3.23
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.553 SNIP 2.241
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.536 SNIP 1.976
BFI (2008): BFI-level 2
DNA-Based Identification and Chemical Characteristics of *Hypnea musciformis* from Coastal Sites in Ghana

This work reveals new, important insights about the influence of broad spatial variations on the phylogenetic relationship and chemical characteristics of Ghanaian *Hypnea musciformis*—acarrageenan-containing red seaweed. DNA barcoding techniques alleviate the difficulty for accurate morphological identification. COI barcode sequences of the Ghanaian *H. musciformis* showed <0.7% intraspecies divergence, indicating no distinct phylogenetic variation, suggesting that they actually belong to the same species. Thus, the spatial distribution of the sampling sites along the coast of Ghana did not influence the phylogenetic characteristics of *H. musciformis* in the region. The data also showed that the Ghanaian Hypnea sp. examined in this work should be regarded as the same species as the *H. musciformis* collected in Brazilian Sao Paulo (KP725276) with only 0.8%–1.3% intraspecies divergence. However, the comparison of COI sequences of Ghanaian *H. musciformis* with the available COI sequence of *H. musciformis* from other countries showed intraspecies divergences of 0%–6.9% indicating that the COI sequences for *H. musciformis* in the GenBank may include different subspecies. Although samples did not differ phylogenetically, the chemical characteristics of the *H. musciformis* differed significantly between different sampling locations in Ghana. The levels of the monosaccharides, notably galactose (20%–30% dw) and glucose (10%–18% dw), as well as the seawater inorganic salt concentration (21–32 mg/L) and ash content (19%–33% dw), varied between *H. musciformis* collected at different coastal locations in Ghana. The current work demonstrated that DNA-based identification allowed a detailed understanding of *H. musciformis* phylogenetic characteristics and revealed that chemical compositional differences of *H. musciformis* occur along the Ghanaian coast which are not coupled with genetic variations among those samples.

**General information**

State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, CSIR Water Research Institute
Number of pages: 14
Publication date: 2016
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Diversity and Distributions
Volume: 8
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 2.651 SNIP 1.542 CiteScore 4.64
DNA barcodes, LSU, UPA, COI, Hypnea musciformis, Marine biodiversity, Carrageenan, Spatial variation, Seaweed, Phylogenetic, Ghana

Electronic versions:

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Relations
Activities:
Seaweed Biorefinery in Ghana (SeaBioGha) (External organisation)

Source: FindIt
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Publication: Research - peer-review › Journal article – Annual report year: 2016

Effect of pectin and hemicellulose removal from hemp fibers on the mechanical properties of unidirectional hemp fiber/epoxy composites

General information
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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Swedish University of Agricultural Sciences
Number of pages: 1
Publication date: 2016
Effect of pectin and hemicellulose removal from hemp fibres on the mechanical properties of unidirectional hemp/epoxy composites

The objective of this study was to investigate the effect of pectin and hemicellulose removal from hemp fibres on the mechanical properties of hemp fibre/epoxy composites. Pectin removal by EDTA and endo-polygalacturonase (EPG) removed epidermal and parenchyma cells from hemp fibres and improved fibre separation. Hemicellulose removal by NaOH further improved fibre surface cleanliness. Removal of epidermal and parenchyma cells combined with improved fibre separation decreased composite porosity factor. As a result, pectin removal increased composite stiffness and ultimate tensile strength (UTS). Hemicellulose removal increased composite stiffness, but decreased composite UTS due to removal of xyloglucans. In comparison of all fibre treatments, composites with 0.5% EDTA + 0.2% EPG treated fibres had the highest tensile strength of 327 MPa at fibre volume content of 50%. Composites with 0.5% EDTA + 0.2% EPG → 10% NaOH treated fibres had the highest stiffness of 43 GPa and the lowest porosity factor of 0.04.
Enzyme discovery for fucoidan modification

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Thi Thuy Cao, H. (Intern), Dalgaard Mikkelsen, M. (Intern), Meyer, A. S. (Intern)
Number of pages: 1
Publication date: 2016
Main Research Area: Technical/natural sciences
Links:
http://www.sustain.dtu.dk/

Bibliographical note
Sustain Abstract R-9
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Formation of water-soluble soybean polysaccharides from spent flakes by hydrogen peroxide treatment
In this paper we propose a novel chemical process for the generation of water-soluble polysaccharides from soy spent flake, a by-product of the soy food industry. This process entails treatment of spent flake with hydrogen peroxide at an elevated temperature, resulting in the release of more than 70% of the original insoluble material as high molar mass soluble polysaccharides. A design of experiment was used to quantify the effects of pH, reaction time, and hydrogen peroxide concentration on the reaction yield, average molar mass, and free monosaccharides generated. The resulting product is low in protein, fat, and minerals and contains predominantly water-soluble polysaccharides of high molar mass, including arabinan, type I arabinogalactan, homogalacturonan, xyloglucan, rhamnogalacturonan, and (glucurono)arabinoxylan. This treatment provides a straightforward approach for generation of soluble soy polysaccharides and opens a new range of opportunities for this abundant and underutilized material in future research and industrial applications.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, DuPont Nutrition Biosciences Aps, DuPont Protein Solutions, University of Melbourne, University of Melbourne
Authors: Pierce, B. (Intern), Wichmann, J. (Ekstern), Tran, T. H. (Ekstern), Cheetamun, R. (Ekstern), Bacic, A. (Ekstern), Meyer, A. S. (Intern)
Hydrogen peroxide, Soluble fiber, Soy polysaccharides, Spent flakes
Impact of different alginate lyases on combined cellulase–lyase saccharification of brown seaweed

Two bacterial polysaccharide lyase (PL) family 7 alginate lyases (EC 4.2.2.-) from Sphingomonas sp. (SALy) and Flavobacterium sp. (FALy), respectively, were selected for heterologous, monocomponent expression in Escherichia coli. The thermal stability, pH, and temperature reaction optima and substrate preferences of the enzymes on different alginate polymers were assessed and compared to those of a commercially available microbial alginate lyase (SigmALy). The optimal pH range for SALy was pH 5.5–7.0; for FALy and SigmALy it was pH 7.5. Reaction temperatures of 30–50 °C had no influence on the activity of any of the enzymes, but the thermal stability was reduced above 50 °C. The FALy enzyme preferred poly-mannuronic acid as substrate, but exhibited activity also on poly-guluronic acid, whereas the SALy had highest activity on poly-guluronic acid, and the SigmALy was active only on poly-guluronic acid. When applied together with a fungal cellulase preparation (Cellic®CTec2) at pH 6 and 40 °C on a glucan rich brown seaweed Laminaria digitata the viscosity decreased in the initial minutes while measurable alginate degradation occurred primarily within the first 1–2 hours of reaction. Whereas FALy and SALy addition catalyzed degradation of more alginate in L. digitata than SigmALy addition, only the SigmALy enabled release of 90% of the available glucose within 8 hours of combined enzyme treatment. The level of mannuronic acid moieties released was inversely proportional to the glucose release, indicating that the degradation of mannuronic acid blocks inhibited cellulase catalyzed glucose release from L. digitata. Nevertheless, combined alginate lyase and cellulase treatment for 24 hours released all potential glucose regardless of the applied lyase. The enzymatic treatment moreover induced solubilization of sulfated fucoidan, whereas most of the nitrogen was recovered in the residual seaweed solids.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, University of Hamburg
Authors: Manns, D. M. (Intern), Nyffenegger, C. (Intern), Saake, B. (Ekstern), Meyer, A. S. (Intern)
Pages: 45392-45401
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Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.06 SJR 0.875 SNIP 0.743
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.959 SNIP 0.837 CiteScore 3.42
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.114 SNIP 0.965 CiteScore 3.87
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.117 SNIP 0.903 CiteScore 3.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.863 SNIP 0.603 CiteScore 2.4
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Original language: English
Inocula selection in microbial fuel cells based on anodic biofilm abundance of *Geobacter sulfurreducens*

Microbial fuel cells (MFCs) rely on microbial conversion of organic substrates to electricity. The optimal performance depends on the establishment of a microbial community rich in electrogenic bacteria. Usually this microbial community is established from inoculation of the MFC anode chamber with naturally occurring mixed inocula. In this study, the electrochemical performance of MFCs and microbial community evolution were evaluated for three inocula including domestic wastewater (DW), lake sediment (LS) and biogas sludge (BS) with varying substrate loading ($L_{\text{sub}}$) and external resistance ($R_{\text{ext}}$) on the MFC. The electrogenic bacterium *Geobacter sulfurreducens* was identified in all inocula and its abundance during MFC operation was positively linked to the MFC performance. The LS inoculated MFCs showed highest abundance (18% ± 1%) of *G. sulfurreducens*, maximum current density ($I_{\text{max}} = (690 \pm 30) \text{ mA} \cdot \text{m}^{-2}$) and coulombic efficiency (CE = 29% ± 1%) with acetate as the substrate. $I_{\text{max}}$ and CE increased to (1780 ± 30) mA.m$^{-2}$ and 58% ± 1%, respectively, after decreasing the $R_{\text{ext}}$ from 1000 Ω to 200 Ω, which also correlated to a higher abundance of *G. sulfurreducens* (21% ± 0.7%) on the MFC anodic biofilm. The data obtained contribute to understanding the microbial community response to $L_{\text{sub}}$ and $R_{\text{ext}}$ for optimizing electricity generation in MFCs.
It All Starts with a Sandwich: Identification of Sialidases with Trans-Glycosylation Activity

Sialidases (3.2.1.18) may exhibit trans-sialidase activity to catalyze sialylation of lactose if the active site topology is congruent with that of the Trypanosoma cruzi trans-sialidase (EC 2.4.1.-). The present work was undertaken to test the hypothesis that a particular aromatic sandwich structure of two amino acids proximal to the active site of the T. cruzi trans-sialidase infers trans-sialidase activity. On this basis, four enzymes with putative trans-sialidase activity were identified through an iterative alignment from 2909 native sialidases available in GenBank, which were cloned and expressed in Escherichia coli. Of these, one enzyme, SialH, derived from Haemophilus parasuis had an aromatic sandwich structure on the protein surface facing the end of the catalytic site (Phe168; Trp366), and was indeed found to exhibit trans-sialidase activity. SialH catalyzed production of the human milk oligosaccharide 3'-sialyllactose as well as the novel trans-sialylation product 3-sialyllactose using casein glycomacropeptide as sialyl donor and lactose as acceptor. The findings corroborated that Tyr119 and Trp312 in the T. cruzi trans-sialidase are part of an aromatic sandwich structure that confers trans-sialylation activity for lactose sialylation. The in silico identification of trans-glycosidase activity by rational active site topology alignment thus proved to be a quick tool for selecting putative trans-sialidases amongst a large group of glycosyl hydrolases. The approach moreover provided data that help understand structure-function relations of trans-sialidases.

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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Aarhus University
Number of pages: 16
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: P L o S One
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Issue number: 7
Article number: e0158434
Modelling of volumetric composition and mechanical properties of unidirectional hemp/epoxy composites - Effect of enzymatic fibre treatment

The objective of the present study is to assess the effect of enzymatic fibre treatments on the fibre performance in unidirectional hemp/epoxy composites by modelling the volumetric composition and mechanical properties of the composites. It is shown that the applied models can well predict the changes in volumetric composition and mechanical
properties of the composites when differently treated hemp fibres are used. The decrease in the fibre correlated porosity factor with the enzymatic fibre treatments shows that the removal of pectin by pectinolytic enzymes results in a better fibre impregnation by the epoxy matrix, and the mechanical properties of the composites are thereby increased. The effective fibre stiffness and strength established from the modelling show that the enzymatic removal of pectin also leads to increased mechanical properties of the fibres. Among the investigated samples, the composites with hydrothermally pre-treated and enzymatically treated fibres have the lowest porosity factor of 0.08 and the highest mechanical properties. In these composites, the effective fibre stiffness and strength are determined to be 83 GPa and 667 MPa, respectively, when the porosity efficiency exponent is set equal to 2. Altogether, it is demonstrated that the applied models provide a concept to be used for the evaluation of performance of treated fibres in composites.

General information
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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Department of Wind Energy, Composites and Materials Mechanics
Authors: Liu, M. (Intern), Thygesen, A. (Intern), Meyer, A. S. (Intern), Madsen, B. (Intern)
Number of pages: 11
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Main Research Area: Technical/natural sciences

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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.172 SNIP 0.281 CiteScore 0.22
Scopus rating (2014): SJR 0.186 SNIP 0.306 CiteScore 0.18
Scopus rating (2013): SJR 0.183 SNIP 0.256 CiteScore 0.16
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.161 SNIP 0.203 CiteScore 0.14
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.155 SNIP 0.149 CiteScore 0.1
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Molecular and biochemical characterization of a new thermostable bacterial laccase from *Meiothermus ruber* DSM 1279
A new laccase gene (mrlac) from *Meiothermus ruber* DSM 1279 was successfully overexpressed to produce a laccase (Mrlac) in soluble form in *Escherichia coli* during simultaneous overexpression of a chaperone protein (GroEL/ES). Without the GroEL/ES protein, the Mrlac overexpressed in *E. coli* constituted a huge amount of the total cellular protein, but the enzyme was localized in the insoluble fraction with no activity in the soluble fraction. Co-expression of the Mrlac with the *E. coli* GroEL/ES drastically improved proper folding and expression of active Mrlac in the soluble fraction. Spectroscopic
analysis of the purified enzyme by UV/visible and electron paramagnetic resonance spectroscopy confirmed that the Mrlac was a multicopper oxidase. The Mrlac had a molecular weight of ~50 kDa and exhibited activity towards the canonical laccase substrates 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS), syringaldazine (SGZ), and 2,6-dimethoxyphenol (2,6-DMP). Kinetic constants $K_m$ and $k_{cat}$ were 27.3 µM and 325 min$^{-1}$ on ABTS, 4.2 µM and 106 min$^{-1}$ on SGZ, and 3.01 µM and 115 min$^{-1}$ on 2,6-DMP, respectively. Maximal enzyme activity was achieved at 70°C with ABTS as substrate. In addition, Mrlac exhibited a half-life for deactivation at 70°C and 75°C of about 120 min and 67 min, respectively, indicating that the Mrlac is intrinsically thermostable. Finally, Mrlac was efficient in catalyzing the removal of 2,4-dichlorophene (DCP) in aqueous solution, a trait which makes the enzyme potentially useful for environmentally friendly applications.

**General information**

State: Published  
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering  
Authors: Kalyani, D. C. (Intern), Munk, L. (Intern), Mikkelsen, J. D. (Intern), Meyer, A. S. (Intern)  
Pages: 3910-3918  
Publication date: 2016  
Main Research Area: Technical/natural sciences

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Web of Science (2016): Indexed yes  
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Scopus rating (2014): SJR 1.114 SNIP 0.965 CiteScore 3.87  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 1  
Scopus rating (2013): SJR 1.117 SNIP 0.903 CiteScore 3.74  
ISI indexed (2013): ISI indexed yes  
Web of Science (2013): Indexed yes  
Scopus rating (2012): SJR 0.863 SNIP 0.603 CiteScore 2.4  
ISI indexed (2012): ISI indexed no  
Web of Science (2012): Indexed yes  
Original language: English  
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Source: FindIt  
Source-ID: 2289943804  
Publication: Research - peer-review › Journal article – Annual report year: 2016
Phytase application in chewing gum - A technical assessment

Phytase catalysis has been shown to improve iron absorption by dephosphorylation of the potent iron chelator, phytic acid, found in high amounts in cereals. Recently, the World Health Organization evaluated the phytase from Aspergillus niger as safe for use in human food. The phytase may work either prior to ingestion, i.e. in the food, or post ingestion, i.e. in the human gastrointestinal tract. We have assessed the technical aspects of formulation and release of phytase added to chewing gum as a delivery vehicle. Phytases from Aspergillus niger and Escherichia coli incorporated into chewing gum were released quantitatively upon chewing and retained phytase activity (50-80% of the enzyme activity added was released within 10 minutes). Initial evaluations of phytase chewing gum shelf life showed good stability after 48 days of storage of the chewing gum at ambient conditions.
Phytase-mediated mineral solubilization from cereals under in vitro gastric conditions: Phytase-mediated mineral release

BACKGROUND
Enzymatic dephosphorylation of phytic acid (inositol hexakisphosphate) in cereals may improve mineral bioavailability in humans. This study quantified enzymatic dephosphorylation of phytic acid by measuring inositol tri- to hexakisphosphate (InsP3-6) degradation and iron and zinc release during microbial phytase action on wheat bran, rice bran and sorghum under simulated gastric conditions.

RESULTS
InsP3-6 was depleted within 15–30 min of incubation using an Aspergillus niger phytase or Escherichia coli phytase under simulated gastric conditions with the two enzymes dephosphorylating cereal phytic acid at similar rates and to similar extents. Microbial phytase-catalysed phytate dephosphorylation was accompanied by increased iron and zinc release from the cereal substrates. For wheat bran at pH 5, the endogenous wheat phytase activity produced mineral release equal to or better than that of the microbial phytases. No increases in soluble cadmium, lead or arsenic were observed with microbial phytase-catalyzed phytate dephosphorylation.

CONCLUSION
Microbial phytase treatment abated phytate chelation hence enhanced the release of iron and zinc from the phytate-rich cereals at the simulated gastric conditions. The data infer that acid stable microbial phytases can help improve iron bioavailability from phytate-rich cereal substrates via post-ingestion activity.

General information
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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Nielsen, A. V. F. (Intern), Meyer, A. S. (Intern)
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Main Research Area: Technical/natural sciences

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
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Scopus rating (2016): CiteScore 2.48 SJR 0.87 SNIP 1.222
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.813 SNIP 1.088 CiteScore 2.11
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.819 SNIP 1.153 CiteScore 2.1
Phytases for improved iron absorption

Phytase enzymes present an alternative to iron supplements, because they have been shown to improve iron absorption by means of catalysing the degradation of a potent iron absorption inhibitor: phytic acid. Phytic acid is a hexaphosphate of inositol and is particularly prevalent in cereal grains, where it serves as a storage molecule for phosphorous. Phytic acid is also associated with minerals. The minerals are bound by chelation to the negatively charged phosphate groups in phytic acid. Phytases catalyse the dephosphorylation of phytic acid, thus releasing bound minerals to make them available for absorption. This article presents research on phytase catalysis in gastric conditions and considers potential benefits and drawbacks for using phytases as a food supplement.
Predictive screening of ionic liquids for dissolving cellulose and experimental verification

In this work, 357 ionic liquids (ILs) formed from 17 cations and 21 anions were selected for evaluation of their ability to dissolve cellulose by COSMO-RS. In order to evaluate the predictive model and method, experimental measurements of the solubility of microcrystalline cellulose (MCC) in 7 of these ILs were also conducted. Predicted results from logarithmic activity coefficients were generally in good agreement with the experimental results. Three different models were used for describing cellulose, and the mid-monomer part of the cellotriose model was found to be closer to the experimental results than a neat glucose model and the model of the mid-dimer part of cellotetraose. Excess enthalpy calculations indicated that hydrogen-bond (H-bond) interactions between cellulose (i.e. the three cellulose models) and the 7 studied ILs are key factors for the solubility of cellulose, and the anions play a crucial role in the cellulose dissolution process. Importantly, the cations of methylimidazolium\(^+\), pyridinium\(^+\), ethylmorpholinium\(^+\) and methylpyrrolidinium\(^+\) structured with functional groups including ethyl, allyl, 2-hydroxyethyl, 2-methoxyethyl and acryloyloxypropyl, combined with anions Ac\(^-\), Dec\(^-\), HCOO\(^-\), Cl\(^-\), BEN\(^-\), DMPO4\(^-\), DEP\(^-\), DBP\(^-\) and Br\(^-\) were predicted to be the best for dissolving cellulose.

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Pretreatment of hemp fibers for utilization in strong bio composite materials

Hemp is the common name for Cannabis sativa cultivated for industrial use. Compared to synthetic fibers (e.g., glass fiber), hemp fibers have many advantages such as low cost, low density (1.5 g/cm³) and high specific strength and stiffness. As a result of increasing environmental awareness, interest in hemp fiber reinforced composites is increasing because of a high potential of manufacturing hemp fiber reinforced polymer composites with acceptable mechanical properties at low cost. In order to expedite the application of natural fibers in polymer composites, hemp fibers need to be treated before being incorporated in matrix polymers to optimize the properties of fibers and fiber reinforced composites. The overall objective of this study was therefore to focus on understanding the correlation between chemical composition and morphology of hemp fibers and mechanical properties of hemp fibers, and furthermore to establish the relationship between the mechanical properties of hemp fiber reinforced composites and the chemical composition and morphology of hemp fibers after different fiber treatments.

The first part of this study investigated the effect of harvest time and stem sections on mechanical properties of hemp fibers in order to correlate the mechanical properties of hemp fibers to their chemical composition and morphology. Harvest time (or growth stage) and stem sections were found to have an effect on the mechanical properties of hemp fibers. The variations in mechanical properties of hemp fibers can be explained by the differences in chemical composition and morphology. Untreated hemp bastfibers with high cellulose content had high stiffness and tensile strength. In addition, the presence of secondary fibers was found to reduce the favorable mechanical properties of hemp fibers. It was our intention to find the key factors that damage fiber properties during traditional field retting. In order to compare and demonstrate the significant effect of the targeted factors, controlled fungal retting was performed using P. radiata Cel 26 and C. subvermispora. Controlled fungal retting with P. radiata Cel 26 and C. subvermispora removed pectin more efficiently than traditional field retting. Fibers with the highest mechanical properties were obtained by controlled fungal retting with P. radiata Cel 26. As a result, composites with P. radiata Cel 26 retted fibers had higher mechanical properties regarding stiffness and tensile strength compared with composites with field retted fibers. The differences in mechanical properties of fibers and fiber reinforced composites were presumably due to the effect of cellulase enzymes activity, which can degrade the cellulose and damage fibers.

Further work was conducted to examine the presence of different enzymes activity during field retting and controlled fungal retting with white rot fungi P. radiata Cel 26 and C. subvermispora. Controlled fungal retting with P. radiata Cel 26 and C. subvermispora removed pectin more efficiently than traditional field retting. Fibers with the highest mechanical properties were obtained by controlled fungal retting with P. radiata Cel 26. As a result, composites with P. radiata Cel 26 retted fibers had higher mechanical properties regarding stiffness and tensile strength compared with composites with field retted fibers. The differences in mechanical properties of fibers and fiber reinforced composites were presumably due to the effect of cellulase enzymes activity, which can degrade the cellulose and damage fibers.

It is certain that cellulase has a negative impact on fiber properties. Mono-component pectinase enzymes were thereby tested on hemp bast fibers combined with hydrothermal pre-treatment. Enhanced removal of pectin from hemp fibers was found to produce a positive impact on hemp fiber reinforced composites. Further work was performed to understand the role of different cell wall components (i.e., pectin, hemicellulose and lignin) in contributing to tensile properties of fiber.
reinforced composites. Pectin removal was found to increase both composite stiffness and UTS. Hemicellulose removal increased composite stiffness, but decreased composite UTS due to the removal of xyloglucans. The changes in mechanical properties of fiber reinforced composites correlated with chemical composition of differently treated hemp fibers via composite porosity. This may provide a way to reshape and optimize the natural cellulose fibers for composite use.

Oxidation of lignin using laccase after treatment with EDTA and EPG increased the mechanical properties of fibers and fiber/epoxy composites. It is suggested that the improvement in mechanical properties was due to polymerization of lignin by laccase resulting in hemp fibers with a stiffer structure. Once part of lignin was removed prior to laccase treatment, a less marked increase in mechanical properties was observed. Modelling of the changes in mechanical properties and physical properties of composites made with differently treated hemp fibers improved understanding of the effect of composite porosity on mechanical properties of unidirectional (UD) hemp fiber/epoxy composites. It was demonstrated that the applied pretreatment of hemp fibers for utilization in strong biocomposite material models provide a concept to be used for the evaluation of performance of differently treated fibers in composites. This study has resulted in improved understanding of the role of different components in contributing to the tensile properties of hemp fibers and of fiber treatments to improve the mechanical properties of natural fiber reinforced composites.

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Quantitative enzymatic production of sialylated galactooligosaccharides with an engineered sialidase from Trypanosoma rangeli

Sialylated galactooligosaccharides (GOS) represent a potential infant formula ingredient, which is believed to contribute with a combination of the beneficial properties of the prebiotic GOS as well as of sialylated human milk oligosaccharides. Sialylated GOS do not exist in natural milk, but can be produced from κ(kappa)-casein glycomacropeptide (CGMP), a sialylated side stream component from cheese-making, by sialidase-catalyzed transsialylation. Using a rationally designed mutant of the sialidase from Trypanosoma rangeli, Tr13, with enhanced transsialylation activity, six different GOS preparations with a varying degree of polymerization (DP) were effectively sialylated with molar yields of 20-30% on the CGMP sialyl in batch reactions. The rate of sialylation of the individual DPs was largely dependent on the DP distribution in each GOS preparation, and Tr13 catalysis did not discriminate against large GOS molecules, providing the novelty point that GOS molecules are sialylated independently of their size by Tr13. Using CGMP, GOS, and Tr13, the production of gram-scale quantities of sialyl-GOS was achieved in 20L volume reactions. Compared to the benchmark transsialidase from pathogenic Trypanosoma cruzi, the Tr13 was significantly more thermostable. By employing an enzymatic membrane reactor, Tr13 could be recycled and after seven consecutive 1-h reaction cycles, the biocatalytic productivity of the enzyme was increased 7-fold compared to the batch reaction. Assuming that the enzyme may be specific for α-2,3-bound sialyl moieties only, and that only 50% of sialyl linkages in CGMP are α-2,3-linked, the molar yield of sialyl-GOS on the available α-2,3-bound sialyl moieties in CGMP reached 80% in the enzymatic membrane reactor system.

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Rhamnogalacturonan I modifying enzymes: an update

Rhamnogalacturonan I (RGI) modifying enzymes catalyse the degradation of the RGI backbone and encompass enzymes specific for either the α1,2-bond linking galacturonic acid to rhamnose or the α1,4-bond linking rhamnose to galacturonic acid in the RGI backbone. The first microbial enzyme found to be able to catalyse the degradation of the RGI backbone, an endo-hydrolase (EC 3.2.1.171) derived from Aspergillus aculeatus, was discovered 25 years ago. Today the group of RGI modifying enzymes encompasses endo- and exo-hydrolases as well as lyases. The RGI hydrolases, EC 3.2.1.171–EC 3.2.1.174, have been described to be produced by Aspergillus spp. and Bacillus subtilis and are categorized in glycosyl hydrolase families 28 and 105. The RGI lyases, EC 4.2.2.23–EC 4.2.2.24, have been isolated from different fungi and bacterial species and are categorized in polysaccharide lyase families 4 and 11. This review brings together the available knowledge of the RGI modifying enzymes and provides a detailed overview of biocatalytic reaction characteristics, classification, structure-function traits, and analyses the protein properties of these enzymes by multiple sequence alignments in neighbour-joining phylogenetic trees. Some recently detected unique structural features and dependence of calcium for activity of some of these enzymes (notably the lyases) are discussed and newly published results regarding improvement of their thermostability by protein engineering are highlighted. Knowledge of these enzymes is important for understanding microbial plant cell wall degradation and for advancing enzymatic processing and biorefining of pectinaceous plant biomass.
Sourcing and bioprocessing of brown seaweed for maximizing glucose release

The research undertaken for this PhD thesis has been part of a larger research program “The MacroAlgaeBiorefinery – sustainable production of third generation (3G) bioenergy carriers and high value aquatic fish feed from macroalgae (MAB3)”. The research has been based on the overall hypothesis that brown seaweeds represent a huge unexploited bioresource of the sea which can be upgraded to energy carriers via degradation to fermentable sugars. The research in the PhD thesis has aimed at optimizing pretreatment and enzymatic saccharification of Saccharina latissima and Laminaria digitata to release maximum levels of glucose. The first requirement was to develop a robust methodology, including acid hydrolysis and analytical composition analysis, to quantitatively estimate the carbohydrate composition of the brown seaweeds. The monosaccharide composition of four different samples of brown seaweeds Laminaria digitata and Saccharina latissima were compared by different high performance anion exchange chromatography (HPAEC) methods after 3 different acid hydrolysis treatments or a cellulase treatment. HPAEC analysis with pulsed amperometric detection (PAD) preceded 2-step pretreatment with 72 % sulfuric acid (H2SO4) for 1 h at 30 °C and followed by 4 % H2SO4 at 120 °C for 40 min allowed quantitative determination of the carbohydrate composition of brown seaweed. The use of guluronic, glucuronic and galacturonic acid standards enabled quantification of the uronic acids. The variation in the biochemical composition of four populations of Saccharina latissima and Laminaria digitata from three different locations from Danish waters was documented. The chemical composition of brown seaweed varied mainly in regard to the season but differed also with respect to species, location, between the years and even within the population. Concentrations of ash and protein levels varied inversely to the carbohydrate levels, and total carbohydrate concentration varied seasonally, in particular through the storage of carbohydrates glucose and mannitol. Generally, alginate was the most abundant carbohydrate at all sites from December to summer with up to 36 % w/wDM by weight before glucose levels were at least at the same magnitude. Total alginate concentration was relatively independent of seasonal changes but mannuronic (M) and guluronic acid (G) differed strongly throughout the year. M/G ratios varied according to species and location from 1.3 to 3.6 but without a general pattern. The highest concentrations of glucan were found in August for wild growing L. digitata from the North Sea, with the glucose potential lying >50 % w/wDM for three sequential years (2012-2014) accompanied by mannitol levels of about 10 % w/wDM and low ash levels of 10-11 % w/wDM. Generally spoken, glucose levels of L. digitata appeared to be superior to those of S. latissima. Cultivation of S. latissima in the Limfjorden, Denmark to obtain high glucan levels was not possible due to the incidence of biofouling in the summer. The average N-to-protein conversion factor was 3.7 but ranged from 2.1 to 5.9. Hence, application of a common factor cannot be recommended since total nitrogen content was more variable than the protein content. Post washing L. digitata harvested from the Danish North Sea in August 2012 had a total organic matter of 84 % mostly accounted for glucose (51 % w/wDM), including a smaller contribution of mannitol (8 % w/wDM), making this material an ideal feedstock for biocatalytical processing to achieve maximum glucose release. The influence of milling as pretreatment to enhance enzymatic degradation was studied on the glucan rich L. digitata (North Sea, August 2012). Wet refiner milling, using rotating disc distances of 0.1-2 mm, generated differently sized particle populations with particles having decreasing average surface area (100-0.1 mm²) with increased milling severity. Milling with disc distances below the thickness of the algae (≤1 mm) increased the particle volume of the milled seaweed slurries and higher milling severity (lower rotating disc distance) also induced higher carbohydrate solubilization from the material, particularly for glucan and mannitol. However, particle size

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diminution did not improve the enzymatic glucose release. Milling was thus not required for enzymatic saccharification because all available glucose was released even from unmilled material during the combined treatment of alginate lyase and the cellulase preparation Cellic®CTec2. Apparently, the alginate lyase (Sigma Aldrich) activity catalyzed the cleavage of alginate on the substrate, which both decreases the viscosity of the substrate alginate and catalytically solubilizes the alginate to provide access to the glucan in the brown seaweed cell wall matrix. The impact of alginate lyase in addition to cellulase on the brown seaweed degradation was studied further for L. digitata degradation. Therefore, two bacterial alginate endo-lyases (EC 4.2.2.-) from Sphingomonas sp. (SALy) and Flavobacterium sp. (FALy) were selected for heterologous, monocomponent expression in Escherichia coli. The optimal pH range for SALy was pH 5.5-7.0 with optimum at pH 6. The optimum for FALy and the commercially available alginate lyase from Sigma Aldrich (SigmALy) was pH 7.5. The investigated reaction temperatures of 50-50 °C had no influence on the activity. The thermal stability was reduced above 50 °C, for SigmALy above 40 °C. The FALy preferred poly-mannuronic acid as substrate, but also exhibited activity on poly-guluronic acid, whereas SALy had higher activity on poly-guluronic acid and SigmALy was only active on poly-guluronic acid. Subsequently, the alginate lyases were applied together with the commercial, fungally derived cellulase preparation Cellic®CTec2 at pH 6 and 40 °C on the glucan rich L. digitata. A decrease in viscosity decrease ensued in the initial minutes while alginate degradation occurred primarily within the first 1-2 hours of reaction. The level of released mannuronic acid blocks was inversely proportional to the glucose release indicating that the degradation of mannuronic acid blocks inhibited the cellulase catalyzed glucose release from L. digitata. Only the selective activity of SigmALy on guluronic acid enabled a 90 % glucose release within 8 hours by the cellulase preparation Cellic®CTec2. Nevertheless, combined alginate lyase and cellulase treatment for 24 hours released all potential glucose regardless of the applied lyase. Treatment with a mixture of 1 % w/wDM SigmALy and 10 % v/vDM Cellic®CTec2 at pH 5 and 40 °C released the available glucose during 8 hours. Two-thirds of the glucose was released with lower enzyme loading. Simple application of only the cellulase preparation enabled the release of only half of the present glucose after 8 h. Analysis after the enzymatic treatment indicated a potential extraction of proteins from the solid residue and the sulfated polysaccharide fucoidan solubilized in the saccharified liquid. The results of this PhD study demonstrated that brown seaweed can be completely degraded enzymatically by combined cellulase and alginate lyase treatment after milling. The work also showed, that biorefining of brown seaweed with current state of art technology is highly dependent on the cultivation, in particular growth site and season, of a suitable feedstock for achieving maximal glucan content and in turn allowing maximum glucose release.

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Structure, functionality and tuning up of laccases for lignocellulose and other industrial applications
Laccases (EC 1.10.3.2) are copper-containing oxidoreductases that have a relatively high redox potential which enables them to catalyze oxidation of phenolic compounds, including lignin-derived phenolics. The laccase-catalyzed oxidation of phenolics is accompanied by concomitant reduction of dioxygen to water via copper catalysis and involves a series of electron transfer reactions balanced by a stepwise re-oxidation of copper ions in the active site of the enzyme. The reaction details of the catalytic four-copper mechanism of laccase-mediated catalysis are carefully re-examined and clarified. The substrate range for laccase catalysis can be expanded by means of supplementary mediators that essentially function as vehicles for electron transfer. Comparisons of amino acid sequences and structural traits of selected laccases reveal conservation of the active site trinuclear center geometry but differences in loop conformations. We also evaluate the features and regions of laccases in relation to modification and evolution of laccases for various industrial applications including lignocellulosic biomass processing.

General information
Thermostable β-galactosidases for the synthesis of human milk oligosaccharides

Human milk oligosaccharides (HMOs) designate a unique family of bioactive lactose-based molecules present in human breast milk. Using lactose as a cheap donor, some β-galactosidases (EC 3.2.1.23) can catalyze transgalactosylation to form the human milk oligosaccharide lacto- N-neotetraose (LNnT; Gal-β(1,4)-GlcNAc-β(1,3)-Gal-β(1,4)-Glc). In order to reduce reaction times and be able to work at temperatures, which are less welcoming to microbial growth, the current
study investigates the possibility of using thermostable β-galactosidases for synthesis of LNnT and N-acetyllactosamine (LacNAc; Gal-β(1,4)-GlcNAc), the latter being a core structure in HMOs. Two hyperthermostable GH 1 β-galactosidases, Ttβ-gly from *Thermus thermophilus* HB27 and CelB from *Pyrococcus furiosus*, were codon-optimized for expression in *Escherichia coli* along with BgaD-D, a truncated version of the GH 42 β-galactosidase from *Bacillus circulans* showing high transgalactosylation activity at low substrate concentrations. The three β-galactosidases were compared in the current study in terms of their transgalactosylation activity in the formation of LacNAc and LNnT. In all cases, BgaD-D was the most potent transgalactosidase, but both thermostable GH 1 β-galactosidases could catalyze formation of LNnT and LacNAc, with Ttβ-gly giving higher yields than CelB. The thermal stability of the three β-galactosidases was elucidated and the results were used to optimize the reaction efficiency in the formation of LacNAc, resulting in 5-6 times higher reaction yields and significantly shorter reaction times.

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Scopus rating (2006): SJR 0.752 SNIP 0.898  
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Viden er den vigtigste ingrediens

Acetate is a superior substrate for microbial fuel cell initiation preceding bioethanol effluent utilization

This study assessed cell voltage development, electricity recovery, and microbial community composition in response to initial substrate including acetate, xylose, acetate/xylose 1:1 mixture (ace/xyl), and bioethanol effluent (BE) during microbial fuel cell (MFC) operation at 1000Ω external resistance. The BE mainly contained 20.5 g/L xylose, 1.8 g/L arabinose, and 2.5 g/L propionic acid. The MFCs initially fed with acetate showed shorter initiation time (1 day), higher average cell voltage (634±9 mV), and higher coulombic efficiency (31.5±0.5 %) than those initially fed with ace/xyl or xyl. However, BE-initiated MFCs only generated 162±1 mV. The acetate-initiated MFCs exhibited longer adaptation time (21 h) and lower cell voltage (645±10 mV) when the substrate was switched to xylose, whereas substrate switching to BE produced the highest voltage (656 mV), maximum power density (362±27 mW/m2), maximum current density (709±27 mA/m2), and coulombic efficiency (25±0.5 %) in the acetate-initiated MFCs. The microbial community in acetate-initiated MFCs was less diverse and contained more electrogenic bacteria (13.9±0.4 %) including Geobacter sulfurreducens and Desulfuromonas acetoxidans than the MFCs initially fed with ace/xyl, xylose, and BE. After switching the substrate to xylose and subsequently to BE, the microbial community in the acetate-initiated MFCs became more diverse, while no significant changes were observed in ace/xyl-, xylose-, and BE-initiated MFCs. The results showed that initial substrate affected the power generation and the capability to adapt to the substrate alteration in MFCs. Acetate-initiated MFCs showed best performance utilizing BE.
Backbone structures in human milk oligosaccharides: trans-glycosylation by metagenomic β-N-acetylhexosaminidases

This paper describes the discovery and characterization of two novel β-N-acetylhexosaminidases HEX1 and HEX2, capable of catalyzing the synthesis of human milk oligosaccharides (HMO) backbone structures with fair yields using chitin oligomers as β-N-acetylglucosamine (GlcNAc) donor. The enzyme-encoding genes were identified by functional screening of a soil-derived metagenomic library. The β-N-acetylhexosaminidases were expressed in Escherichia coli with an N-terminal His6-tag and were purified by nickel affinity chromatography. The sequence similarities of the enzymes with their respective closest homologues are 59 % for HEX1 and 51 % for HEX2 on the protein level. Both β-N-acetylhexosaminidases are classified into glycosyl hydrolase family 20 (GH 20) are able to hydrolyze para-nitrophenyl-β-N-acetylglucosamine (pNP-GlcNAc) as well as para-nitrophenyl-β-N-acetylgalactosamine (pNP-GalNAc) and exhibit pH optima of 8 and 6 for HEX1 and HEX2, respectively. The enzymes are able to hydrolyze N-acetylchitooligosaccharides with a degree of polymerization of two, three, and four. The major findings were, that HEX1 and HEX2 catalyze trans-glycosylation reactions with lactose as acceptor, giving rise to the human milk oligosaccharide precursor lacto-N-triose II (LNT2) with yields of 2 and 8 % based on the donor substrate. In total, trans-glycosylation reactions were tested with the disaccharide acceptors β-lactose, sucrose, and maltose, as well as with the monosaccharides galactose and glucose resulting in the successful attachment of GlcNAc to the acceptor in all cases. © Springer-Verlag Berlin Heidelberg 2015.

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Can laccases catalyze bond cleavage in lignin?

Modification of lignin is recognized as an important aspect of the successful refining of lignocellulosic biomass, and enzyme-assisted processing and upcycling of lignin is receiving significant attention in the literature. Laccases (EC 1.10.3.2) are taking the center stage of this attention, since these enzymes may help degrading lignin, using oxygen as the oxidant. Laccases can catalyze polymerization of lignin, but the question is whether and how laccases can directly catalyze modification of lignin via catalytic bond cleavage. Via a thorough review of the available literature and detailed illustrations of the putative laccase catalyzed reactions, including the possible reactions of the reactive radical intermediates taking place after the initial oxidation of the phenol-hydroxyl groups, we show that i) Laccase activity is able to catalyze bond cleavage in low molecular weight phenolic lignin model compounds; ii) For laccases to catalyze inter-unit bond cleavage in lignin substrates, the presence of a mediator system is required. Clearly, the higher the redox potential of the laccase enzyme, the broader the range of substrates, including o- and p-diphenols, aminophenols, methoxy-substituted phenols, benzenethiols, polyphenols, and polyamines, which may be oxidized. In addition, the currently available analytical methods that can be used to detect enzyme catalyzed changes in lignin are summarized, and an improved nomenclature for unequivocal interpretation of the action of laccases on lignin is proposed. (C) 2015 Elsevier Inc. All rights reserved.
Cascade catalysis in membranes with enzyme immobilization for multienzymatic conversion of CO₂ to methanol

Facile co-immobilization of enzymes is highly desirable for bioconversion methods involving multienzymatic cascade reactions. Here we show for the first time that three enzymes can be immobilized in flat-sheet polymeric membranes simultaneously or separately by simple pressure-driven filtration (i.e. by directing membrane fouling formation), without any addition of organic solvent. Such coimmobilization and sequential immobilization systems were examined for the production of methanol from CO₂ with formate dehydrogenase (FDH), formaldehyde dehydrogenase (FaldDH) and alcohol dehydrogenase (ADH). Enzyme activity was fully retained by this non-covalent immobilization strategy. The two immobilization systems had similar catalytic efficiencies because the second reaction (formic acid ↔ formaldehyde) catalyzed by FaldDH was found to be the cascade bottleneck (a threshold substrate concentration was required). Moreover, the trade-off between the mitigation of product inhibition and low substrate concentration for the adjacent enzymes probably made the coimmobilization meaningless. Thus, sequential immobilization could be used for multienzymatic cascade reactions, as it allowed the operational conditions for each single step to be optimized, not only during the enzyme immobilization but also during the reaction process, and the pressure-driven mass transfer (flow-through mode) could overcome the diffusion resistance between enzymes. This study not only offers a green and facile immobilization method for multi-enzymatic cascade systems, but also reveals the reaction bottleneck and provides possible solutions for the bioconversion of CO₂ to methanol.
Characterization and biological depectinization of hemp fibers originating from different stem sections

The wide variation of mechanical properties of natural fibers limits their applications in matrix composites. The aim of this study is to evaluate the properties of hemp fibers from different stem sections (top, middle and bottom) and to assess fungal retting pretreatment of hemp from different stem sections with the white rot fungi Phlebia radiata Cel 26 and Ceriporiopsis subvermispora. For the untreated hemp fibers, no apparent difference in tensile behavior for fiber bundles from different stem sections was observed, and more than 90% tested samples demonstrated plastic flow behavior. Fiber strength and stiffness were highest for the fibers from the top and middle stem sections. These properties were related to the compositional make up and morphological properties of hemp fibers, notably the secondary fiber cell contents. In fungal retting, there was a strong dependence of depectinization selectivity on stem section, which decreased from bottom to top presumably due to the significantly higher lignin content in the bottom section than in the top section (middle section was in between). Consequently, the fungal retting caused a lower reduction in strength of fibers from the bottom section than in those from the top stem section, and essentially reversed the influence of stem section on fiber tensile strength through depectinization selectivity. At whole hemp stem level, the fungal retting with P. radiata Cel 26 exhibited better mechanical properties with an ultimate tensile strength, strain and stiffness of 736 MPa, 2.3% and 42 GPa, respectively, while fibers treated with C. subvermispora exhibited lower mechanical properties of 573 MPa, 1.9% and 40 GPa, respectively. The study thus also showed that less variable and high strength fibers may be produced using the dependence of depectinization selectivity on stem section for composite application.

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Effect of harvest time and field retting duration on the chemical composition, morphology and mechanical properties of hemp fibers

The large variability in the mechanical properties of hemp fibers is an issue in relation to their use in high-grade composites. The objective of the present study was to determine the optimal growth stage for harvesting hemp fibers for use in composites and to evaluate the effect of field retting time on mechanical performance of the fibers. Reduction in bast content and thickness of the primary bast fiber layer in stems were found to be highly significant (P < 0.01) with plant maturity. A significant increase in the secondary fiber fraction occurred with maturity, reaching a maximum value of 10% at seed maturity. A highly significant reduction in cellulose deposition in fiber cell walls was reflected by reduced fiberwall thickness with plant maturity and was related to the development and ripening of hemp seeds. A statistically significant increase in lignin deposition and a slight decrease in pectins in hemp fiber cell walls were also noted with stem maturity. Microscopy observations and histochemical analyzes corroborated the results from the chemical analyzes and revealed variations in morphological aspects and spatial micro-distributions of carbohydrates and lignin within the cell structure of the hemp stems between early- and late growth phases. Fibers harvested at the beginning of flowering exhibited high tensile strength and strain, which decreased with plant maturity. Reduction in strength was related to the increase in proportion of secondary fibers and decrease in cellulose deposition leading to inferior properties of fibers. A negative effect of field retting occurred only after extended field retting (i.e., 70 days) which was presumably due to accelerated degradation of cellulose by the action of microorganisms.

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High performance separation of xylose and glucose by enzyme assisted nanofiltration
An integrated membrane system was investigated for the separation of mixtures of xylose and glucose. Separation of these sugars is extremely challenging due to their similar structure, size and charge. In order to enhance the xylose separation factor in nanofiltration (NF), we present an enzymatic process for converting glucose to gluconic acid followed by separation of xylose from gluconic acid by nanofiltration. Process conditions which favored the negative charge repulsions between gluconic acid and the NF270 membrane were examined. At the best conditions (9:1 feed molar ratio of
xylose to gluconic acid, 0.15M total feed concentration, pH 9.5, 25°C and 4bar), we achieved a xylose separation factor of 34 and a throughput of 18.7Lm⁻²h⁻¹. In comparison, the separation factor was only 1.4 for solutions of xylose and glucose at the same process conditions, thus demonstrating the huge potential of the integrated system. Full conversion of glucose to gluconic acid assisted by glucose oxidase (GOD) could be achieved by coupling a parallel reaction catalyzed by catalase (CAT), where H₂O₂ (GOD-inhibitor formed in the first reaction) was decomposed to water and oxygen. GOD has a high oxygen-demand and it was demonstrated that sufficient oxygen could be obtained by controlling the CAT-catalyzed reaction through initial H₂O₂ addition. The new strategy suggested in this study, integrating reaction and nanofiltration to enhance separation while obtaining another value-added stream, presents new options for separating compounds with similar molecular weights by nanofiltration.

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Implications of silica on biorefineries – interactions with organic material and mineral elements in grasses

Biorefineries aim to convert low value biomasses into high value products. The feedstock biomasses are often high-silica agricultural waste products such as rice straw, wheat straw, corn stover, sugarcane bagasse, or empty fruit bunches. This causes challenges, since silica is problematic in industrial processes, where it forms water-insoluble precipitates that are hard to remove, block filtration systems, and cause instrumental defects. In this paper we review various industries that experience issues with silica. These include paper pulping and waste-water treatment, where they try to solve their problems with silica in different ways. High pH and co-precipitation with mineral elements are some common ways of alleviating silica problems. Reviewing the literature for the fundamentals of silica revealed a complex chemistry that is not yet fully understood. Much is still to be learned about the interactions between silica and organic material as well as the mechanisms of silica precipitation and dissolution. Understanding the fundamental and complex chemistry of silica might help developing better solutions than those existing today, allowing efficient use of high silica biomasses in biorefineries.

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in Situ Formation of a Biocatalytic Alginate Membrane by Enhanced Concentration Polarization

A thin alginate layer induced on the surface of a commercial polysulfone membrane was used as a matrix for noncovalent immobilization of enzymes. Despite the expected decrease of flux across the membrane resulting from the coating, the initial hypothesis was that such a system should allow high immobilized enzyme loadings, which would benefit from the decreased flux in terms of increased enzyme/substrate contact time. The study was performed in a sequential fashion: first, the most suitable types of alginate able to induce a very thin, sustainable gel layer by pressure-driven membrane filtration were selected and evaluated. Then, an efficient method to make the gel layer adhere to the surface of the membrane was developed. Finally, and after confirming that the enzyme loading could remarkably be enhanced by using this method, several strategies to increase the permeate flux were evaluated. Alcohol dehydrogenase (EC 1.1.1.1), able to catalyze the conversion of formaldehyde into methanol, was selected as the model enzyme. An enzyme loading of 71.4% (44.8 μg/cm²) was attained under the optimal immobilization conditions, which resulted in a 40% conversion to methanol as compared to the control setup (without alginate) where only 10.8% (6.9 μg/cm²) enzyme was loaded, with less than 5% conversion. Such conversion increased to 60% when polyethylene glycol (PEG) was added during the construction of the gel layer, as a strategy to increase flux. No enzyme leakage was observed for both cases (with/without PEG addition). Modeling results showed that the dominant fouling mechanism during gel layer induction (involving enzyme entrapment) was cake layer formation in the initial and intermediate phases, while pore blocking was the dominant mechanism in the final phase. Such mechanisms had a direct consequence on the type of immobilization promoted in each phase. The results suggested that the strategy proposed could be efficiently used to enhance the enzyme loading on polymer membranes.
In situ prebiotics: enzymatic release of galacto-rhamnogalacturonan from potato pulp in vivo in the gastrointestinal tract of the weaning piglet

Prebiotics may be efficient for prevention of intestinal infections in humans and animals by increasing the levels of beneficial bacteria and thereby improving gut health. Using purified prebiotics may however not be cost-effective in the livestock production industry. Instead, prebiotic fibres may be released directly in the gastro-intestinal tract by feeding enzymes with a suitable substrate and allowing the prebiotics to be produced in situ. Using low doses, 0.03 % enzyme-to-substrate ratio, of the enzymes pectin lyase and polygalacturonase in combination with potato pulp, a low-value industrial by-product, we show that high molecular weight galacto-rhamnogalacturonan can be solubilized in the stomach of weaning piglets. The release of this fiber is in the order of 22–38 % of the theoretical amount, achieved within 20 min. The catalysis takes place mainly in the stomach of the animal and is then followed by distribution through the small intestines. To our knowledge, this is the first paper describing targeted production of prebiotics in an animal model.
In situ prebiotics for weaning piglets: In vitro production and fermentation of potato galactorhamnogalacturonan

Post weaning diarrhea (PWD) in pigs is a leading cause of economic loss in pork production worldwide. The current practice of using antibiotics and zinc to treat PWD is unsustainable due to the potential of antibiotic resistance and ecological disturbance, and novel methods are required. In this study, an in vitro model was used to test the possibility of producing prebiotic fiber in situ in the gastro-intestinal tract (GI-tract) of the piglet and the prebiotic activity of the resulting fiber in the terminal ileum. Soluble fiber were successfully produced from potato pulp, an industrial waste product, with a minimal enzyme dose in a simulated upper GI-model extracting 26.9 % of initial dry matter. The fiber was rich in galactose and galacturonic acid and was fermented at 2.5, 5 or 10 g/L in a glucose-free media inoculated with the gut contents of piglet terminal ileum. Fermentations of 5 g/L inulin or 5 g/L of a purified potato fiber were used as controls. The fibers showed high fermentability, evident by a dose-dependent drop in pH and increase in organic acids, with lactate in particularly being increased. Deep sequencing showed a significant increase in Lactobacillus and Veillonella and an insignificant increase in Clostridium as well as a decrease in Streptococcus. Multivariate analysis showed clustering of the treatment groups, with the purified potato fiber being clearly separated from the other groups as the microbiota composition was 60 % Lactobacillus and almost free of Clostridium. For animal studies, a dosage corresponding to the 5 g/L treatment is suggested.

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Mathematical modelling of membrane separation

This thesis concerns mathematical modelling of membrane separation. The thesis consists of introductory theory on membrane separation, equations of motion, and properties of dextran, which will be the solute species throughout the thesis. Furthermore, the thesis consist of three separate mathematical models, each with a different approach to membrane separation.

The first model is a statistical model investigating the interplay between solute shape and the probability of entering the membrane. More specific the transition of solute particles from being spherical to becoming more elongated as prolate ellipsoids with the same volume. The porous membrane is assumed isotropic such that the model reduces to a two dimensional model. With this assumption ellipsoids with the same volume reduces to ellipses with the same area. The model finds the probability of entering the pore of the membrane. It is found that the probability of entering the pore is highest when the largest of the radii in the ellipse is equal to half the radius of the pore, in case of molecules with circular radius less than the pore radius. The results are directly related to the macroscopic distribution coefficient and the rejection coefficient.

The second model is a stationary model for the flux of solvent and solute in a hollow fibre membrane. In the model we solve the time independent equations for transport of solvent and solute within the hollow fibre. Furthermore, the flux of solute and solvent through the membrane is coupled through the boundary conditions. The model investigates how the true and observed rejection coefficient depends on the transmembrane pressure, the average inlet velocity, and the molecular weight. Furthermore, the effect of concentration dependent viscosity on the rejection coefficients is investigated. The results show that the true rejection coefficient is increasing as a function of increasing transmembrane pressure, increasing inlet velocity, and decreasing molecular weight. Furthermore, it is found that a concentration dependent viscosity decreases the true rejection. The observed rejection is increasing for decreasing molecular weight and increasing inlet velocities. The observed rejection can be either increasing or decreasing as a function of increasing transmembrane pressure. Moreover, the observed rejection is reduced when the viscosity depends on the concentration. The study is a time dependent model of back-shocking. During back-shocking the pressure difference across the membrane is reversed for a given time. This implies that the concentration polarization at the membrane surface is flushed away. When the pressure is reversed back to normal the membrane performs better resulting in an increased average flux. Two models models of the problem was made.

In a two dimensional model, limited to capture the dynamics close to the membrane, a positive effect was observed on both the observed rejection and the average solvent flux. Furthermore, an analytical upper estimate for the optimal back-shock time is given. In a three dimensional model, where the flow within the entire hollow fibre is modelled, the mentioned upper estimate is used to obtain a positive effect on both the observed rejection and the average solvent flux. Moreover, the effect of a concentration dependent viscosity was investigated. It was found that the average flux compared to the steady-state solution increased when the viscosity depends on the concentration.

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Modulating the regioselectivity of a *Pasteurella multocida* sialyltransferase for biocatalytic production of 3'- and 6'-sialyllactose

Several bacterial sialyltransferases have been reported to be multifunctional also catalysing sialidase and trans-sialidase reactions. In this study, we examined the trans-sialylation efficacy and regioselectivity of mutants of the multifunctional *Pasteurella multocida* sialyltransferase (PmST) for catalysing the synthesis of 3'- and 6'-sialyllactose using casein glycomacropeptide as sialyl-donor and lactose as acceptor. The mutation P34H led to a 980-fold increase in α-2,6-sialyltransferase activity (with cytidine-5'-monophospho-N-acetylneuraminic acid as donor), while its α-2,3-sialyltransferase activity was abolished. Histidine in this position is conserved in α-2,6-sialyltransferases and has been suggested, and recently confirmed, to be the determinant for strict regiospecificity in the sialyltransferase reaction. Our data verified this theorem. In trans-sialidase reactions, the P34H mutant displayed a distinct preference for 6'-sialyllactose synthesis but low levels of 3'-sialyllactose were also produced. The sialyllactose yield was however lower than when using PmSTWT under optimal conditions for 6'-sialyllactose formation. The discrepancy in regiospecificity between the two reactions could indicate subtle differences in the substrate binding site in the two reactions. In contrast, the two mutations E271F and R313Y led to preferential synthesis of 3'-sialyllactose over 6'-sialyllactose and the double mutant (PmSTE271F/R313Y) exhibited the highest α-2,3-regioselectivity via reduced sialidase and α-2,6-trans-sialidase activity. The double mutant PmSTE271F/R313Y thus showed the highest α-2,3-regioselectivity and constitutes an interesting enzyme for regioselective synthesis of α-2,3-sialylated glycans. This study has expanded the understanding of the structure-function relationship of multifunctional, bacterial sialyltransferases and provided new enzymes for regioselective glycan sialylation.
Microbial phytases catalyze dephosphorylation of phytic acid, thereby potentially releasing chelated iron and improving human iron absorption from cereal-based diets. For this catalysis to take place in vivo, the phytase must be robust to low pH and proteolysis in the gastric ventricle. This study compares the robustness of five different microbial phytases, evaluating thermal stability, activity retention, and extent of dephosphorylation of phytic acid in a simulated low-pH/pepsin gastric environment and examines secondary protein structural changes at low pH via circular dichroism. The Peniophora lyici phytase was found to be the most thermostable, but the least robust enzyme in gastric conditions, whereas the Aspergillus niger and Escherichia coli phytases proved to be most resistant to gastric conditions. The phytase from Citrobacter braakii showed intermediate robustness. The extent of loss of secondary structure at low pH correlated positively with the extent of activity loss at low pH.

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Predicting optimal back-shock times in ultrafiltration hollow fiber modules II: Effect of inlet flow and concentration dependent viscosity

This paper concerns mathematical modeling and computational fluid dynamics of back-shocking during hollow fibre ultrafiltration of dextran T500. In this paper we present a mathematical model based on first principles, i.e., solving the Navier-Stokes equation along with the continuity equation for both the solute and the solvent. We investigate the validity of the estimate on the optimal back-shock time, i.e., the back-shock time needed to achieve the highest permeate flux, published in a previous paper by the authors (Vinther et al., Predicting optimal back-shock times in ultrafiltration hollow fibre membranes, J. Membr. Sci. 470 (2014) 275-293 [33]). Furthermore, the simulations have been performed with two different inlet velocities, i.e., crossflow velocities and are clone with and without a concentration dependent viscosity. This enables us, for the first time, to investigate the effect of different inlet velocities and the effect of a concentration polarization on the observed rejection and the permeate flux, as a function of different back-shock times. In all cases the average permeate flux and the observed rejection during one period of back-shocking were found to be higher than the steady-state values - representing the long time behavior of a similar separation process performed without back-shocking - when using the optimal back-shock time. It is concluded that the estimate of the optimal back-shock time is in good agreement with the optimal time found in the simulations performed in this paper. Furthermore, it is found that the optimal back-shock time increases when the viscosity is allowed to depend on the concentration. It is found that this can be explained by a decrease in the velocity tangential to the membrane due to the increase in viscosity where the concentration is high - resulting in a longer time for the concentration polarization to be convected tangentially along the membrane surface. The ratio between the average flux over a back-shock cycle and the steady-state flux is found to increase with increasing inlet velocity. Furthermore, this ratio increases when the viscosity depends on the concentration. This is due to the relatively lower steady-state value when the viscosity depends on the concentration. Moreover, an increase in observed rejection is found when using back-shocking. The increase in observed rejection is found to be largest when the inlet velocity is high and the viscosity depends on the concentration. (C) 2015 Elsevier B.V. All rights reserved.

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Scopus rating (2014): SJR 2.433 SNIP 1.935 CiteScore 5.42
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Producion af humane mælkeoligosakkarider
Humane mælkeoligosakkarider er særlige kulhydrater i mælk, som har stor betydning for den nyfødtes helbred og udvikling. Disse molekyler mangler i modermælkserstatninger. Enzymer kan producere humane mælkeoligosakkarider, men der kræves optimering af både enzym og reaktionsbetingelser for at opnå et tilfredsstillende udbytte.

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Seaweed Hydrocolloid Production: An Update on Enzyme Assisted Extraction and Modification Technologies

Agar, alginate, and carrageenans are high-value seaweed hydrocolloids, which are used as gelation and thickening agents in different food, pharmaceutical, and biotechnological applications. The annual global production of these hydrocolloids has recently reached 100,000 tons with a gross market value just above US$ 1.1 billion. The techno-functional properties of the seaweed polysaccharides depend strictly on their unique structural make-up, notably degree and position of sulfation and presence of anhydro-bridges. Classical extraction techniques include hot alkali treatments, but recent research has shown promising results with enzymes. Current methods mainly involve use of commercially available enzyme mixtures developed for terrestrial plant material processing. Application of seaweed polysaccharide targeted enzymes allows for selective extraction at mild conditions as well as tailor-made modifications of the hydrocolloids to obtain specific functionalities. This review provides an update of the detailed structural features of κ-, ι-, λ- carrageenans, agars, and alginate, and a thorough discussion of enzyme assisted extraction and processing techniques for these hydrocolloids.

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Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.888 SNIP 1.605 CiteScore 4.16
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Separation of phenolic acids from monosaccharides by low-pressure nanofiltration integrated with laccase pre-treatments

Separation of phenolic acids from monosaccharides is required for detoxification of lignocellulosic hydrolysates. For the first time, a low-pressure nanofiltration (NF) process was used to retain phenolic acids (vanillic acid, p-coumaric acid and ferulic acid) and at the same time permeate monosaccharides (xylose, arabinose, glucose). Four commercial NF membranes (NF270, NP030, NTR7450 and NP010) were evaluated at different pH values and with various laccase pre-treatments (for polymerization of phenolic acids). The results showed that with increasing pH, the retentions of phenolic acids by NF increased, reaching 86–88% for NTR7450 and 90–94% for NF270 at pH 9.55. The retentions of monosaccharides kept almost constant (<10%) for NP030, NTR7450 and NP010 membranes at different pH but significantly increased at pH 9.55 for the NF270 membrane due to enhancement of solute interactions. Phenolic acids could be polymerized by laccase and then completely retained by the NF membranes via size exclusion at pH 5.15. The formation of large polymeric products by laccase could alleviate the irreversible fouling in/on a NF membrane and decrease the monosaccharide retention, while the small polymeric products (e.g. dimers and trimers) were mainly responsible for the adsorption fouling. Free laccase treatment was preferred since it was prone to produce large polymeric products while the biocatalytic membrane with immobilized laccase was not suitable as it generated smaller polymers by in-situ product removal. Furthermore, the NF membranes with more charge and higher hydrophilicity were more resistant to the irreversible fouling caused by hydrophobic adsorption of phenolic acids and their polymers. This work not only provides fundamental data for removal of phenolic acids from lignocellulosic hydrolysates, but also opens a new gate for separation of small solutes with similar molecular weight by NF integrated with enzymatic conversion.

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Thermostability enhancement of an endo-1,4-β-galactanase from Talaromyces stipitatus by site-directed mutagenesis

Enzymatic conversion of pectinaceous biomasses such as potato and sugar beet pulp at high temperatures is advantageous as it gives rise to lower substrate viscosity, easier mixing, and increased substrate solubility and lowers the risk of contamination. Such high-temperature processing requires development of thermostable enzymes. Talaromyces stipitatus was found to secrete endo-1,4-β-galactanase when grown on sugar beet pectin as sole carbon source. The mature protein contained 353 AA and the MW was estimated to 36.5 kDa. It was subjected to codon optimization and pro-
duced in Pichia pastoris in 2 l scale yielding 5.3 g. The optimal reaction condition for the endo-1,4-β-galactanase was
determined to be 46 °C at pH 4.5 at which the specific activity was estimated to be 6.93 μ mol/min/mg enzyme with half-
lives of 13 and 2 min at 55 and 60 °C, respectively. For enhancement of the half-life of TSGAL, nine single amino acid
residues were selected for site-directed mutagenesis on the basis of semi-rational design. Of these nine mutants, G305A
showed half-lives of 114 min at 55 °C and 15 min at 60 °C, respectively. This is 8.6-fold higher than that of the TSGAL at
55 °C, whereas the other mutants displayed mod- erate positive to negative changes in their half-lives.
Time of harvest affects the yield of soluble polysaccharides extracted enzymatically from potato pulp

Potato pulp is a co-processing product from potato starch production. The pulp mainly consists of the tuber cell walls, which are rich in pectin and cellulose. The potato pulp pectin is dominated by galactan branched rhamnogalacturonan 1 which after enzymatic solubilization has shown promising properties as bifidogenic prebiotic fibers. The potato starch processing campaign is based on processing of fresh potatoes (in Denmark the campaign lasts from September to December). This study examines the effect of time of harvest and processing during the campaign on the yield of enzymatically solubilized potato polysaccharides applying a recently developed enzymatic process using 1.0\% (w/w) [enzyme/substrate (E/S)] pectin lyase from Aspergillus nidulans and 1.0\% (w/w) [E/S] polygalacturonase from A. aculeatus at 60 °C, 100 mM citric acid, pH 6.0 for 1 min. Seven samples drawn within the potato starch campaign of 2011 were characterized: the yields of enzymatically solubilized potato polysaccharides and the solubilized galactan proportion increased during the potato starch campaign. The data thus suggest that potato pulp produced late in the campaign would be preferable for upgrading to the bifidogenic fibers; this outcome may be the result of an inherent effect of the higher maturity of the potatoes late in the campaign.
A Novel Laccase from Ganoderma Lucidum Capable of Enhancing Enzymatic Degradation of Lignocellulolytic Biomass

The invention addresses the need for enzymes that can enhance the yield of fermentable sugar from the hydrolysis of lignocellulose biomass, for example sugar cane bagasse, barley straw and wheat straw, such that the use of this biomass can become economically viable. The invention provides methods for the hydrolysis of biomass using a laccase derived from Ganoderma lucidum. Further, the invention provides an enzyme composition comprising a laccase derived from Ganoderma lucidum which may be combined with one or more cellulases, and for its use in enhancing lignocellulose biomass hydrolysis.

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A combined metabolomic and phylogenetic study reveals putatively prebiotic effects of high molecular weight arabino-oligosaccharides when assessed by in vitro fermentation in bacterial communities derived from humans

Prebiotic oligosaccharides are defined by their selective stimulation of growth and/or activity of bacteria in the digestive system in ways claimed to be beneficial for health. However, apart from the short chain fatty acids, little is known about bacterial metabolites created by fermentation of prebiotics, and the significance of the size of the oligosaccharides remains largely unstudied.

By in vitro fermentations in human fecal microbial communities (derived from six different individuals), we studied the effects of high-mass (HA, >1 kDa), low-mass (LA, <1 kDa) and mixed (BA) sugar beet arabino-oligosaccharides (AOS) as carbohydrate sources. Fructo-oligosaccharides (FOS) were included as reference. The changes in bacterial communities and the metabolites produced in response to incubation with the different carbohydrates were analyzed by quantitative PCR (qPCR) and Liquid Chromatography–Mass Spectrometry (LC–MS), respectively.

All tested carbohydrate sources resulted in a significant increase of Bifidobacterium spp. between 1.79 fold (HA) and 1.64 fold (FOS) in the microbial populations after fermentation, and LC–MS analysis suggested that the bifidobacteria contributed to decomposition of the arabino-oligosaccharide structures, most pronounced in the HA fraction, resulting in release of the essential amino acid phenylalanine. Abundance of Lactobacillus spp. correlated with the presence of a compound, most likely a flavonoid, indicating that lactobacilli contribute to release of such health-promoting substances from plant structures.

Additionally, the combination of qPCR and LC–MS revealed a number of other putative interactions between intestinal microbes and the oligosaccharides, which contributes to the understanding of the mechanisms behind prebiotic impact on human health.
A Dynamic Model for Cellulosic Biomass Hydrolysis: a Comprehensive Analysis and Validation of Hydrolysis and Product Inhibition Mechanisms

The objective of this study is to perform a comprehensive enzyme kinetics analysis in view of validating and consolidating a semimechanistic kinetic model consisting of homogeneous and heterogeneous reactions for enzymatic hydrolysis of lignocellulosic biomass proposed by the U.S. National Renewable Energy Laboratory (Kadam et al., Biotechnol Prog 20(3):698–705, 2004) and its variations proposed in this work. A number of dedicated experiments were carried out under a range of initial conditions (Avicel® versus pretreated barley straw as substrate, different enzyme loadings and different product inhibitors such as glucose, cellobiose and xylose) to test the hydrolysis and product inhibition mechanisms of the model. A nonlinear least squares method was used to identify the model and estimate kinetic parameters based on the experimental data. The suitable mathematical model for industrial application was selected among the proposed models based on statistical information (weighted sum of square errors). The analysis showed that transglycosylation plays a key role at high glucose levels. It also showed that the values of parameters depend on the selected experimental data used for parameter estimation. Therefore, the parameter values are not universal and should be used with caution. The model proposed by Kadam et al. (Biotechnol Prog 20(3):698–705, 2004) failed to predict the hydrolysis phenomena at high glucose levels, but when combined with transglycosylation reaction(s), the prediction of cellulose hydrolysis behaviour over a broad range of substrate concentrations (50–150 g/L) and enzyme loadings (15.8–31.6 and 1–5.9 mg protein/g

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cellulose for Celluclast and Novozyme 188, respectively) was possible. This is the first study introducing transglycosylation into the semimechanistic model. As long as these type of models are used within the boundary of their validity (substrate type, enzyme source and substrate concentration), they can support process design and technology improvement efforts at pilot and full-scale studies.
An integrated membrane system for the biocatalytic production of 3′-sialyllactose from dairy by-products

An integrated membrane system was investigated for the production of 30-sialyllactose by an engineered sialidase using casein glycomacropeptide (CGMP) and lactose as substrates. CGMP was purified by ultrafiltration (UF) to remove any small molecules present and then an enzymatic membrane reactor (EMR) was used to separate the product and reuse the enzyme. A PLCC regenerated cellulose membrane was found to be the most suitable for both the UF purification and EMR. Subsequently, nanofiltration (NF) was conducted to increase the purity of the 30-sialyllactose by removing the excess lactose present. The NTR7450 membrane outperformed others in NF due to its high retention of 30-sialyllactose (98%) and relatively low rejection of lactose (40%). The lactose in the permeate could be concentrated by the NF45 membrane and recycled into the EMR. The described integrated membrane system enables a more economic and efficient enzymatic production of 30-sialyllactose.

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Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
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A Pasteurella multocida sialyltransferase displaying dual trans-sialidase activities for production of 3′-sialyl and 6′-sialyl glycans

This study examined a recombinant Pasteurella multocida sialyltransferase exhibiting dual trans-sialidase activities. The enzyme catalyzed trans-sialylation using either 2-O-(p-nitrophenyl)--d-N-acetylneuraminic acid or casein glycomacropeptide (whey protein) as the sialyl donor and lactose as the acceptor, resulting in production of both 3-sialyllactose and 6-sialyllactose. This is the first study reporting -2,6-trans-sialidase activity of this sialyltransferase (EC 2.4.99.1 and 2.4.99.4). A response surface design was used to evaluate the effects of three reaction parameters (pH, temperature, and lactose concentration) on enzymatic production of 3- and 6-sialyllactoses using 5% (w/v) casein glycomacropeptide (equivalent to 9 mM bound sialic acid) as the donor. The maximum yield of 3-sialyllactose(2.75 ± 0.35 mM) was achieved at a reaction condition with pH 6.4, 40°C, 100 mM lactose after 6 h; and the largest concentration of 6-sialyllactose (3.33 ± 0.38 mM) was achieved under a condition with pH 5.4, 40°C, 100 mM lactose after 8 h. 6-sialyllactose was presumably formed from -2,3 bound sialic acid in the casein glycomacropeptide as well as from 3-sialyllactose produced in the reaction. The kcat/Km value for the enzyme using 3-sialyllactose as the donor for 6-sialyllactose synthesis at pH 5.4 and 40°C was determined to be 23.22 ± 0.7 M−1s−1. Moreover, the enzyme was capable of catalyzing the synthesis of both 3- and 6-sialylated galactooligosaccharides, when galactooligosaccharides served as acceptors.
The appearance and distribution of monoester regioisomers were investigated in the virtually irreversible acylation of sucrose with the enol ester, vinyl laurate, as acyl donor catalysed by serine proteases and a metalloprotease in the hydrophilic, aprotic solvent N,N-dimethylformamide. Sucrose laurate was obtained in yields from 12 to 53% after 48 h under different catalytic conditions. The serine protease ALP-901, derived from a Streptomyces sp., produced the highest yield at this reaction time, while reaction with the zinc-protease thermolysin achieved the overall highest yield (63%) after 6 h, with only monoesters synthesised. The total conversion of sucrose after 48 h ranged from 19 to 96%. The highest degree of conversion was observed in the reaction with thermolysin, while the reactions without protein and with ALP-901 resulted in 82% and 66% sucrose conversion, respectively. 2-O-Lauroyl sucrose was the most abundant monoester regioisomer synthesised and the highest concentration observed was 23.7 mM after 24 h in the thermolysin-catalysed reaction. The highest concentration of 2-O-lauroyl sucrose detected in the reaction catalysed by ALP-901 was 19.0 mM, while it was 17.0 mM in the reaction without protein, both after 48 h. The detected appearance of the sucrose laurate regioisomers largely corresponded to the apparent rates of formation, and 2-O-lauroyl sucrose was among the first regioisomers to appear in all reactions. The observed sucrose laurate regioisomeric distribution after 48 h (2:3:4:6:1:3) was 72:5:2:1:7:14 in the reaction catalysed by ALP-901, and 74:5:2:1:7:13 in the reaction without protein. In the reaction catalysed by thermolysin the distribution was 71:5:2:--:9:13 after 6 h and 86:8:--:--:4:3 after 48 h of reaction. The esterification of sucrose with vinyl laurate without protein in the reaction mixture appeared to be catalysed in the presence of aluminosilicate molecular sieves. Non-catalytic protein in the reaction medium seemed to lower the catalytic activity of the molecular sieves.
Application of enzymes for efficient extraction, modification, and development of functional properties of lime pectin

The objective of the present study was to transform "Waste to Food" using enzymes to recover value-added food ingredients from biomass. Six commercial cellulases were screened to generate proof of concept that enzymes are selective and efficient catalysts for opening of lime peel biomass to recover pectin. The most efficient enzyme preparation was Laminex C2K derived from Penicillium funiculosum which, during 4 h treatment at pH 3.5, 50 °C, released pectin with similar yield (23% w/w), molecular weight (69 kDa), and functional properties e.g. gelling, stabilization of acidified milk drinks and viscosity as the classically acid-extracted pectins (8 h treatment at 70 °C, pH < 2). Carbohydrate microarray analysis showed that enzymatically extracted pectin mainly contained highly methylated pectin (chemical compositional analysis indicated degree of esterification up to 82%), whereas acidically extracted pectins were more heterogeneous with regard to degree of esterification and had lower degrees of esterification (67–74%). A high degree of esterification in enzymatically extracted pectin may be directly exploited commercially as the so-called Ultra-Rapid-Set pectin, which gels particularly fast at higher temperatures. The Laminex CK2 extracted pectin polymers were not sensitive to the presence of Ca2+ ions, they formed a gel at low pH in the presence of sugar and were able to stabilize acidified milk drinks. Further modification by enzymatic de-esterification of the pectin extracted with Laminex C2K improved its calcium sensitivity and ability to stabilize acidified milk drinks. The present study demonstrates that it is possible to substitute classical acid-based
extraction by enzymatic catalysis and obtain pectin products with desirable functional properties.

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Authors: Dominiak, M. M. (Intern), Marie Søndergaard, K. (Ekstern), Wichmann, J. (Ekstern), Vidal-Melgosa, S. (Ekstern), Willats, W. G. (Ekstern), Meyer, A. S. (Intern), Mikkelsen, J. D. (Intern)
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Scopus rating (2011): SJR 1.615 SNIP 1.921 CiteScore 3.57
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Scopus rating (2009): SJR 1.728 SNIP 1.781
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Scopus rating (2008): SJR 1.484 SNIP 1.654
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Scopus rating (2001): SJR 0.728 SNIP 0.915
Assessing Effects and interactions among key variables affecting the growth of mixotrophic microalgae: pH, inoculum volume, and growth medium composition.
A 2(3) + 3 full factorial experimental design was used to evaluate growth rate and biomass productivity of four selected, high-biomass-yielding microalgae species, namely, Chlorella vulgaris (CV), Scenedesmus acutus (SA), Chlamydomonas reinhardtii (CR), and Chlamydomonas debaryana (CD), in mixtures of growth medium (MWC) and wastewater at different proportions (from 20 to 50% of MWC) and at different pH (from 7 to 9). Multilinear regression analysis of the biomass productivity data showed that for SA and CD the biomass productivity was independent of the proportion of medium (MWC), while the growth of CV and CR slowed down in mixtures with high proportions of wastewater. However, the biomass productivity of SA was dependent on pH, while the growth of the other microalgae was independent of pH (7-9). When evaluating the influence of pH and proportion of medium, CD appeared most robust among the algae species, despite its lower biomass productivity. All the four species reduced 80-90% of the nitrate [Formula: see text] and 60-70% of the ammonia [Formula: see text] initially present in the wastewater:medium mixture, although the extent of the reduction was dependent on the initial [Formula: see text] ratio. Both SA and CV reduced ∼20-25% of the chemical oxygen demand (COD) contained in the wastewater. This study shows the remarkable influence of certain variables that are often ignored in the search for optimal conditions of microalgal growth and also reveals the importance of considering interactions among growth variables in potential applications at large scale, particularly in the field of bioremediation.
Biocatalytic production of 3′-sialyllactose by use of a modified sialidase with superior trans-sialidase activity

Casein glycomacropeptide (cGMP) and lactose, which are purified (or semi-purified) components obtained from side streams from dairy industry operations, were used as substrates for enzyme catalyzed production of 3′-sialyllactose, a model case compound for human milk oligosaccharides (HMOs). The enzyme employed was a mutated sialidase, Tr6, derived from Trypanosoma rangeli, and expressed in Pichia pastoris after codon-optimization. The Tr6 contained 6 point mutations and exhibited trans-sialidase activity. The Tr6 trans-sialidase reaction conditions were tuned for maximizing Tr6 catalyzed 3′-sialyllactose production by optimizing pH, temperature, acceptor, and donor concentrations using response surface designs. At the optimum reaction conditions, the Tr6 catalyzed the transfer of sialic acid from cGMP to lactose at high efficiency without substantial hydrolysis of the 3′-sialyllactose product. The robustness of the Tr6 catalyzed reaction was verified at 5L-scale providing a yield of 3.6g 3′-sialyllactose at an estimated molar trans-sialylation yield of 50% on the 3′-sialyl in cGMP. Lacto-N-tetraose and lacto-N-fucopentaoses also functioned as acceptor molecules demonstrating the versatility of the Tr6 trans-sialidase for catalyzing sialyl-transfer for generating different HMOs. The data signify the applicability of enzymatic trans-sialylation on dairy side-stream components for production of human milk oligosaccharides.

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Biorefining of wheat straw: accounting for the distribution of mineral elements in pretreated biomass by an extended pretreatment – severity equation

Background: Mineral elements present in lignocellulosic biomass feedstocks may accumulate in biorefinery process streams and cause technological problems, or alternatively can be reaped for value addition. A better understanding of the distribution of minerals in biomass in response to pretreatment factors is therefore important in relation to development of new biorefinery processes. The objective of the present study was to examine the levels of mineral elements in pretreated wheat straw in response to systematic variations in the hydrothermal pretreatment parameters (pH, temperature, and treatment time), and to assess whether it is possible to model mineral levels in the pretreated fiber fraction. Results: Principal component analysis of the wheat straw biomass constituents, including mineral elements, showed that the recovered levels of wheat straw constituents after different hydrothermal pretreatments could be divided into two groups: 1) Phosphorus, magnesium, potassium, manganese, zinc, and calcium correlated with xylose and arabinose (that is, hemicellulose), and levels of these constituents present in the fiber fraction after pretreatment varied depending on the pretreatment-severity; and 2) Silicon, iron, copper, aluminum correlated with lignin and cellulose levels, but the levels of these constituents showed no severity-dependent trends. For the first group, an expanded pretreatment-severity equation, containing a specific factor for each constituent, accounting for variability due to pretreatment pH, was developed. Using this equation, the mineral levels could be predicted with $R^2 > 0.75$; for some with $R^2$ up to 0.96. Conclusion: Pretreatment conditions, especially pH, significantly influenced the levels of phosphorus, magnesium, potassium, manganese, zinc, and calcium in the resulting fiber fractions. A new expanded pretreatment-severity equation is proposed to model and predict mineral composition in pretreated wheat straw biomass.

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Authors: Le, D. M. (Intern), Sørensen, H. R. (Ekstern), Knudsen, N. O. (Ekstern), Schjoerring, J. K. (Ekstern), Meyer, A. S. (Intern)
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A xyloglucan-specific endo-1,4β-glucanase (XcXGHA) from Xanthomonas citri pv. mangiferaeindicae has been cloned, expressed in Escherichia coli, purified and characterised. The XcXGHA enzyme belongs to CAZy family GH74 and has catalytic site residues conserved with other xyloglucanases in this family. At its optimal reaction conditions, pH 7.0 and 40 °C, the enzyme has a kcat/KM value of 2.2 × 107 min−1 M−1 on a tamarind seed xyloglucan substrate. XcXGHA is relatively stable within a broad pH range (pH 4–9) and up to 50 °C (t1/2, 50 °C of 74 min). XcXGHA is proven to be xyloglucan-specific, and a glycan microarray study verifies that XcXGHA catalyses cleavage of xyloglucan extracted from both monocot and dicot plant species. The enzyme catalyses hydrolysis of tamarind xyloglucan in a unique way by cleaving XXXG into XX and XG (X is xylosyl-substituted glucose; G is unsubstituted glucose), is able to degrade more complex xyloglucans and notably is able to cleave near more substituted xyloglucan motifs such as L [i.e. α-l-Fucp-(1 → 2)-β-d-Galp-(1 → 2)-α-d-Xylp-(1 → 6)-β-d-Glcp]. LC-MS/MS analysis of product profiles of tamarind xyloglucan which had been catalytically degraded by XcXGHA revealed that XcXGHA has specificity for X in subsite −1. The 3D model suggests that XcXGHA consists of two seven-bladed β-propeller domains with the catalytic center formed by the interface of these two domains, which is conserved in xyloglucanases in the GH74 family. However, the XcXGHA has two amino acids (D264 and R472) that differ from the conserved residues of other GH74 xyloglucanases. These two amino acids were predicted to be located on the opposite side of the active site pocket, facing each other and forming a closing surface above the active site pocket. These two amino acids may contribute to the unique substrate specificity of the XcXGHA enzyme.
Characterization of an extensin-modifying metalloprotease: N-terminal processing and substrate cleavage pattern of Pectobacterium carotovorum Prt1

Compared to other plant cell wall-degrading enzymes, proteases are less well understood. In this study, the extracellular metalloprotease Prt1 from Pectobacterium carotovorum (formerly Erwinia carotovora) was expressed in Escherichia coli and characterized with respect to N-terminal processing, thermal stability, substrate targets, and cleavage patterns. Prt1 is an autoprocessing protease with an N-terminal signal pre-peptide and a pro-peptide which has to be removed in order to activate the protease. The sequential cleavage of the N-terminus was confirmed by mass spectrometry (MS) fingerprinting and N-terminus analysis. The optimal reaction conditions for the activity of Prt1 on azocasein were at pH 6.0, 50 °C. At these reaction conditions, KM was 1.81 mg/mL and kcat was 1.82 × 107 U M⁻¹. The enzyme was relatively stable at 50 °C with a half-life of 20 min. Ethylenediaminetetraacetic acid (EDTA) treatment abolished activity; Zn2+ addition caused regain of the activity, but Zn2+ addition decreased the thermal stability of the Prt1 enzyme presumably as a result of increased proteolytic autolysis. In addition to casein, the enzyme catalyzed degradation of collagen, potato lectin, and plant extensin. Analysis of the cleavage pattern of different substrates after treatment with Prt1 indicated that the protease had a substrate cleavage preference for proline in substrate residue position P1 followed by a hydrophobic residue in residue position P1′ at the cleavage point. The activity of Prt1 against plant cell wall structural proteins suggests that this enzyme might become an important new addition to the toolbox of cell-wall-degrading enzymes for biomass processing. © 2014 Springer-Verlag Berlin Heidelberg.

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Chelating agents improve enzymatic solubilization of pectinaceous co-processing streams

This study investigates the hypothesis that loosening of the egg-box structure by presence of divalent ion chelating agents during enzymatic degradation of homogalacturonan (HG) can improve enzymatic polysaccharide solubilization on pectinaceous, agro-industrial co-processing streams. The influence of different levels of ethylene-diaminetetraacetic acid (EDTA), citric acid, oxalic acid, and phosphate was assessed in relation to enzymatic solubilization of isopropanol precipitatable oligo- and polysaccharides from sugar beet pulp, citrus peel, and two types of potato pulp. The two types of potato pulp were FiberBind 400, a dried commercial potato pulp product, and PUF, a dried calcium reduced product, respectively. The enzymatic treatment consisted of 1% (w/w) of substrate treated with pectin lyase from Aspergillus nidulans and polygalacturonase from A. aculeatus [each dosed at 1.0% (w/w) enzyme/substrate] at 60 °C, pH 6.0 for 1 min. Characterization of the released fractions demonstrated a significantly improved effect of chelating agents for polysaccharide solubilization from FiberBind 400, PUF, and citrus peel, whereas only low amounts of polysaccharides were solubilized from the sugar beet pulp. The results substantiated the importance of chelating agents during enzymatic extraction of pectinaceous polysaccharides. Lower levels of chelating agents were required for the calcium-reduced potato pulp substrate (PUF) indicating the significance of calcium cross-linking in HG in relation to the enzymatic solubilization yields. The effect of the chelating agents correlated to their dissociation constants (pKa values) and calcium binding constants and citric acid and EDTA exerted highest effects. Maximum polysaccharide yield was obtained for FiberBind 400 where the enzymatic treatment in presence of citric acid yielded 22.5% (w/w) polysaccharides of the initial substrate dry matter.

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Chemical characterization and hydrothermal pretreatment of *Salicornia bigelovii* straw for enhanced enzymatic hydrolysis and bioethanol potential

*Salicornia bigelovii* straw was characterized and evaluated as a potential lignocellulosic bioethanol feedstock. *S. bigelovii* used in the study was grown in the United Arab Emirates using saltwater (40 ppt) for irrigation. Salt removal was performed prior to pretreatment to protect the processing equipment and avoid inhibition of enzymes and yeast. Composition of the washed biomass was comparable to traditional lignocellulosic biomasses with relatively high glucan and xylan content (26 and 22 g/100 gDM, respectively) but with lower lignin content (7 g/100 gDM). The washed feedstock was subjected to hydrothermal pretreatment, producing highly digestible (up to 92% glucan-to-glucose conversion) and fermentable (up to 100% glucose-to-ethanol conversion) fiber fractions. Liquid fractions obtained in the pretreatment did not show inhibition towards *Saccharomyces cerevisiae*. No significant differences among the enzymatic convertibility and microbial fermentability of the fibers as well as low xylose recoveries suggest that lower severity pretreatment conditions could be exploited for *S. bigelovii*. © 2013 Elsevier Ltd.
Bioethanol, Enzymatic hydrolysis, Enzyme inhibition, Feedstocks, Glucose, Yeast, Ethanol

Design of thermostable rhamnogalacturonan lyase mutants from *Bacillus licheniformis* by combination of targeted single point mutations

Rhamnogalacturonan I lyases (RGI lyases) (EC 4.2.2.7) catalyze cleavage of α-1,4 bonds between rhamnose and galacturonic acid in the backbone of pectins by β-elimination. In the present study, targeted improvement of the thermostability of a PL family 11 RGI lyase from *Bacillus licheniformis* (DSM 13/ATCC14580) was examined by using a combinatorial protein engineering approach exploring additive effects of single amino acid substitutions. These were selected by using a consensus approach together with assessing protein stability changes (PoPMuSiC) and B-factor iterative test (B-FIT). The second-generation mutants involved combinations of two to seven individually favorable single mutations. Thermal stability was examined as half-life at 60 °C and by recording of thermal transitions by circular dichroism. Surprisingly, the biggest increment in thermal stability was achieved by producing the wild-type RGI lyase in *Bacillus subtilis* as opposed to in *Pichia pastoris*; this effect is suggested to be a negative result of glycosylation of the *P. pastoris* expressed enzyme. A ~ twofold improvement in thermal stability at 60 °C, accompanied by less significant increases in Tm of the enzyme mutants, were obtained due to additive stabilizing effects of single amino acid mutations (E434L, G55V, and G326E) compared to the wild type. The crystal structure of the *B. licheniformis* wild-type RGI lyase was also determined; the structural analysis corroborated that especially mutation of charged amino acids to hydrophobic ones in surface-exposed loops produced favorable thermal stability effects. © 2014 Springer-Verlag Berlin Heidelberg.

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Directing filtration to optimize enzyme immobilization in reactive membranes

In this work, fouling principles in force in ultrafiltration were deployed to understand the role of selected variables-applied pressure (1-3 bar), enzyme concentration (0.05-0.2 gL⁻¹), pH (5-9) and membrane properties-on fouling-induced enzyme immobilization. The immobilization and subsequent enzymatic reaction efficiency were evaluated in terms of enzyme loading, conversion rate and biocatalytic stability. Alcohol dehydrogenase (ADH) was selected as a model enzyme. Lower pressure, higher enzyme concentration and lower pH resulted in higher irreversible fouling resistance and lower permeate flux. High pH during immobilization produced increased permeate flux but declines in conversion rates, likely because of the weak immobilization resulting from strong electrostatic repulsion between enzymes and membrane. The results showed that pore blocking as a fouling mechanism permitted a higher enzyme loading but generated more permeability loss, while cake layer formation increased enzyme stability but resulted in low loading rate. Low pH (near isoelectric point) favored hydrophobic and electrostatic adsorption of enzymes on the membrane, which reduced the enzyme stability. Neutral pH, however, promoted entrapment and hydrogen bonding of enzymes on the membrane, which improved the enzyme stability. This study suggests that a compromise between different fouling/immobilization mechanisms must be found in order to maximize the immobilization performance, both in terms of enzyme loading and also of enzyme activity.

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Engineering aspects of enzymatic fiber solubilization from potato pulp

Potato pulp is a low-value by-product of the potato starch production. However, it contains valuable fibers consisting of rhamnogalacturonan I (RGI) with large galactan and arabinan side chains that can be extracted using a combination of polygalacturonase (PG) and pectin lyase (PL) which degrades the surrounding homogalacturonan (HG). The RGI backbone is linked by glycosidic bonds to HG and by degradation of HG the target carbohydrate is solubilized and thereby recoverable. Due to the complex structure of RGI with large galactan and arabinan side chains – also known as hairy-RGI – the fiber has the potential to act as a prebiotic. Prebiotics are especially valuable to the swine industry where post weaning diarrhea is problematic. When piglets are separated from the sow they are subjected to a critical transition from milk onto a diet based on plant polysaccharides causing imbalance in the intestinal system. Prebiotics can counteract this imbalance by maintaining a healthy microbiota in weaning piglets.

Fast enzymatic release of the potential prebiotic hairy-RGI fiber from potato pulp demanded excessive availability of HG. However, at pH 6.0 the availability of HG was strongly affected by the presence of calcium as calcium forms gels by interacting with protonated low-methoxylated (LM) HG hindering enzyme attacks and degradation of the HG. Initially, two types of potato pulp FiberBind, a dried commercial potato pulp product containing ~7000 ppm of calcium, and PUF, a dried calcium reduced product containing ≤200 ppm of calcium, were tested for precipitable dry matter after a 1 min reaction at 60°C and pH 6.0 using 1% substrate and with or without enzymes. The enzymes were PL from Emericella nidulans and PG from Aspergillus aculeatus each dosed at 1.0% (w/w) enzyme/substrate [E/S]. The study was carried out at various concentrations of ethylenediaminetetraacetic acid (EDTA) or phosphate. EDTA is a known calcium chelating
agent.
Assessment of the dosage-response effects of phosphate and EDTA on the two potato pulp substrates indicated a need for a significant molar surplus of the chelating agent for maximal effect on polysaccharide release induced by enzymatic cleavage of HG. To get a more generic understanding of the calcium gel formation four potential chelating agents were tested for their effect on inducing high yields of precipitatable oligo- and polysaccharides from sugar beet pulp, citrus peel, FiberBind and PUF. The results revealed a correlation between degree of protonation at pH 6.0 and yield of fibers.

Maximum polysaccharide yield was obtained for FiberBind where the enzymatic treatment in presence of citric acid yielded 22.5% of initial dry matter. Besides the effect from the applied chelating agent other factors such as production date of potato pulp also had an effect on the yields of fibers from potato pulp. Seven samples drawn within the potato starch campaign of 2011 were characterized according to monosaccharide compositions, degree of methylation (DM) and acetylation (DAc), and content of the glycoalkaloids α-solanine and α-chaconine. The monosaccharide composition, DM, and content of α-solanine remained rather unchanged, whereas DAc and content of α-chaconine decreased significantly during the campaign.

The seven samples were subjected to the same enzymatic treatment as described above and the precipitated polysaccharides were characterized based on their monosaccharide compositions and molecular size distribution. The yields of enzymatically solubilized potato polysaccharides and the solubilized galactan proportion increased during the potato starch campaign. The data suggested that potato pulp produced late in the campaign would be preferable to upgrade, due to the higher yield and lower risk of toxicity from glycoalkaloids. The outcome may be the result of an inherent effect of the higher ripeness of the potatoes late in the campaign.

Producing fibers from potato pulp, i.e. FiberBind, is more profitably done at dry matter contents of more than 1% (w/w). However, increased dry matter content can lead to highly viscous suspensions and inefficient mixing. To investigate practical processing of FiberBind suspensions viscosity studies were performed in a Rapid-ViscoAnalyzer (RVA, Newport Scientific, NSW, Australia) examining the viscosity reducing effect of enzyme activities, which included PL and PG from E. nidulans both dosed at 1% (w/w) [E/S] and tested at 60°C, as well as two commercial α-amylases Termamy® SC and Fungamy® 800L dosed at 0.2% (w/w) [E/S] tested at 60°C and 70°C. Especially, PL was efficient for viscosity reduction possibly due to the high DM (~70%) of FiberBind hindering PG attacks on the HG backbone. Starch degradation at 60°C and 70°C did not cause viscosity reduction to the same extent as pectinases, suggesting, if necessary, starch removal contemporary with release of polysaccharides by PL and PG. Scaling up the enzymatic extraction of polysaccharides using 3% (w/w) dry matter to 4L gave 29.7% (of initial dry matter) which was comparable to lab. scale enzymatic extraction using 1% (w/w) dry matter.

The enzymatically extracted polysaccharides produced in 4L as well as polysaccharides produced in pilot plant scale were structurally characterized through linkage analysis producing partially methylated alditol acetates (PMAA) analyzed via gas chromatography (GC) mass spectroscopy (MS). The two products showed almost identical linkage patterns. As expected, large galactan and arabinan chains made up most of the polysaccharides. ~50% of the glycosidic linkages in the extracted products were (1→4) galactopyranosyl (Galp) linkages with a low degree of branching: a branch point was observed for every 30 (1→4) Galp residue. High contents (~23%) of (1→4) arabinofuranosyl (Araf) residues was detected as well, but no branch points were observed. Lower contents of rhampyranosyl (Rhap) and galactopyranosyl uronic acid (Gal pA) were observed as well the structure to be hairy-RGI.

The prebiotic effect of the fiber was tested in weaning piglets a minimal basal medium containing 5 g/L of the polysaccharides and inoculated with content from the terminal ileum of piglets. Hereafter the suspension was incubated anaerobically for 24 hours at 37.5°C. The microbiota composition was analyzed by extracting DNA, amplifying 16S rRNA variable regions by PCR, and taxonomically classification against the Ribosomal Database Project II. After 24 hours incubation the pH had dropped and the concentration of short chain fatty acids (SCFA) had increased. The microbiota was dominated by the phylum Firmicutes. In particular, the proportion of Clostridia, decreased significantly, whereas the proportion of Lactobacillus was increased significantly. In piglets Lactobacillus is associated with a healthy microbiota suggesting a prebiotic effect of the enzymatically extracted polysaccharides.

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**Engineering of pectinolytic enzymes for enhanced thermostability**

Conversion of waste materials into valuable compounds is promising concerning transformation of byproduct streams such as sugar beet and potato pulp. In order to obtain those compounds with reduced energy consumption, carbohydrate active enzymes can be used as catalysts. Sugar beet and potato pulp consist of pectin that can be converted into beneficial polymeric and oligomeric carbohydrates requiring enzymes such as pectin lyases, rhamnogalacturonan I (RGI) lyases, polygalacturonases and galactanases. Enzymatic conversion of such pectinaceous biomasses at high
Ensiling and hydrothermal pretreatment of grass: Consequences for enzymatic biomass conversion and total monosaccharide yields

Ensiling may act as a pretreatment of fresh grass biomass and increase the enzymatic conversion of structural carbohydrates to fermentable sugars. However, ensiling does not provide sufficient severity to be a standalone pretreatment method. Here, ensiling of grass is combined with hydrothermal treatment (HTT) with the aim of improving the enzymatic biomass convertibility and decrease the required temperature of the HTT. Results: Grass silage (Festuca rubra) was hydrothermally treated at temperatures of 170, 180, and 190°C for 10 minutes. Relative to HTT treated dry grass, ensiling increased the solubilization of dry matter (DM) during HTT and gave increased glucan content, but lower lignin in the insoluble fiber fraction. Ensiling improved glucose yields in the enzymatic hydrolysis of the washed solid fiber fraction at the lower HTT temperatures. At 170°C glucose yield improved from 17 to 24 (w/w)% (45 to 57% cellulose convertibility), and at 180°C glucose yield improved from 22 to 29 (w/w)% (54 to 69% cellulose convertibility). Direct HTT of grass at 190°C gave the same high glucose yield as for grass silage (35 (w/w)% (77% cellulose convertibility)) and improved xylan yields (27% xylan convertibility). The effect of ensiling of grass prior to HTT improved the enzymatic conversion of cellulose for HTT at 170 and 180°C, but the increased glucose release did not make up for the loss of water soluble carbohydrates (WSC) during ensiling. Overall, sugar yields (C6 + C5) were similar for HTT of grass and grass silage at both 170 and 180°C, but at 190°C the overall sugar yield was better for HTT of dry grass. Conclusions: This study unequivocally establishes that ensiling of grass as a biomass pretreatment method comes with a loss of WSC. The loss of WSC by ensiling is not necessarily compensated for by providing a lower temperature requirement for HTT for high enzymatic monosaccharide release. However, ensiling can be an advantageous storage method prior to grass processing.
Ensiling as pretreatment of grass for lignocellulosic biomass conversion

Development of sound technologies of biomass conversion will be increasingly important for many years to come as planetary boundaries drive the development towards a biobased society. Pretreatment of lignocellulosic biomass is, in this regard, an essential technology. Current pretreatment methods, based on severe physio-chemical processes, are effective, however, they are also costly and energy demanding. An alternative biological pretreatment method, based on the well-known biomass preservation of ensiling, has been proposed. Ensiling holds potential as an integrated storage and pretreatment method with low cost and low energy requirements, plus brings about multiple advantages with regards to agricultural management. However, the pretreatment effect of ensiling, and the overall effects for further conversion are limited.

In this study, ensiling was evaluated as a method of pretreatment for subsequent enzymatic saccharification of cellulose and hemicellulose, by using the temperate grass Festulolium Hykor. The method was additionally combined with hydrothermal treatment, in order to decrease the required severity of an industrial applied pretreatment method. The first part of the project was devoted to method development. This resulted in the development of a simple and flexible standard method for laboratory ensiling with a high reproducibility, which is well suited for high-throughput experiments.

A comprehensive study on important parameters in ensiling was conducted to find optimal conditions providing the best possible pretreatment effect. The parameters were biomass composition, varied by ensiling of four seasonal cuts of grass, different dry matter (DM) content at ensiling, and an addition of different lactic acid bacteria species. First of all, the study confirmed that ensiling can act as a method of pretreatment and improve the enzymatic cellulose convertibility of grass. Furthermore, low DM ensiling was found to improve the effects of pretreatment due to a higher production of organic acids in the silage. The effect of applied lactic acid bacteria species was, however, insignificant. Cellulose conversion was noted to be largely determined by the stage of maturity of the four different cuts of grass. Less mature grass had high convertibility but less amount of cellulose and vice versa. This led to the conclusion that an optimal maturity of grass can be found, which gives an optimal glucose release. However, limitations of the method were also noted. The ensiling of grass came with a considerable loss of water soluble carbohydrates (WSC), which was in fact higher than the improved glucose release. Furthermore, the amount of released glucose was not adequate to support an efficient production of ethanol. Lastly, the conversion of xylan was extremely low in both grass and grass silage.

Optimization of the enzymatic saccharification of grass was attempted through improvement of the hemicellulose content in the enzyme blend. However, neither additional xylanases (Cellic HTec2® and β-xylanase) nor hemicellulose degrading esterases (acetyl xylan esterase and ferulic acid esterase) showed any improvements of xylan or glucan convertibility. Furthermore, hemicellulases were added before ensiling in order to assist and improve the pretreatment effect. This resulted in, however, the undesired effect that additionally released monosaccharides were utilized during storage and had a negative impact on sugar release after enzymatic saccharification. In both of the above mentioned experiments on optimization of sugar release by means of enzymes, it was noted that the hemicellulose structure of Festulolium Hykor appeared unusually resistant to enzymatic degradation. Due to the low conversion results on Festulolium Hykor, the last part of the project was based on a new tenet: Ensiling can not provide sufficient pretreatment effect to be a stand-alone pretreatment method.

Ensiling was therefore combined with hydrothermal treatment (HTT), and the pretreatment combination was applied to both grass (Festulolium Hykor) and wheat straw, in order to compare the effect upon two categorically different biomasses.

For wheat straw, it was found that ensiling in combination with HTT increased the severity of HTT and facilitated a reduction in optimum HTT temperature of 10 to 20 °C. This could, however, not be proven for grass, since the overall release of mono- and oligosaccharides for the combined pretreatment of grassdid not exceed HTT of grass alone. This was due to a combination of high loss of WSC during silage storage of grass and only minor improvements of HTT induced by ensiling. In comparison, the ensiling of wheat straw improved cellulose convertibility by a maximum factor of 1.9 at 170 °C, where the ensiling of grass only improved cellulose convertibility by a maximum factor of 1.3. Furthermore, the HTT pretreatment of both grass and grass silage gave considerably lower xylan convertibility than HTT of wheat straw and wheat straw silage. The reason for the inaccessible xylan in grass is believed to be found in a high complexity of branching and cross linkages creating a heterogeneous and resistant grass hemicellulose. However, further studies are necessary.

The study concludes that ensiling may provide a pretreatment effect in itself, depending on the silage conditions and the recalcitrance of the biomass. However, ensiling will always be at the expense of an amount of WSC; and the significance of the gain from the pretreatment effect versus the loss of WSC will again depend on the silage conditions and the nature of the biomass. Ensiling was proven not to be a stand-alone pretreatment of Festulolium Hykor and should instead be considered as a sound method for biomass storage with possible benefits to biomass conversion. On the other hand, ensiling provided significant improvements to a combined pretreatment of ensiling and HTT. However, the improvements largely depend on the loss of WSC and the type of biomass in question. In this regard, it should be duly stressed that ensiling is not merely a pretreatment method, but an integrated storage and pretreatment method with effects on both agricultural management, biomass feedstock logistics, and biomass conversion. This thesis aimed to study only the last issue of biomass conversion.

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Enzymatic Cellulose Hydrolysis: Enzyme Reusability and Visualization of beta-Glucosidase Immobilized in Calcium Alginate

The high cellulase enzyme dosages required for hydrolysis of cellulose is a major cost challenge in lignocellulosic ethanol production. One method to decrease the enzyme dosage and increase biocatalytic productivity is to re-use beta-glucosidase (BG) via immobilization. In the present research, glutaraldehyde cross-linked BG was entrapped in calcium alginate gel particles. More than 60% of the enzyme activity could be recovered under optimized conditions, and glutaraldehyde cross-linking decreased leakage of BG from the calcium alginate particles. The immobilized BG aggregates were visualized by confocal laser scanning microscopy (CLSM). The CLSM images, which we believe are the first to be published, corroborate that more BG aggregates were entrapped in the matrix when the enzymes were cross-linked by glutaraldehyde as opposed to when they are not cross-linked. The particles with the immobilized BG were recycled for cellulase catalyzed hydrolysis of Avicel. No significant loss in BG activity was observed for up to 20 rounds of reaction recycle steps of the BG particles of 48 h each, verifying a significant stabilization of the BG by immobilization. Similar high glucose yields were obtained by one round of enzymatic hydrolysis of hydrothermally pretreated barley straw during a 72 h reaction with immobilized BG and free BG.
Enzymatic production of human milk oligosaccharides

Human milk oligosaccharides (HMOs) are a group of complex glycans that are abundant in human breastmilk. Breastfeeding infants is linked to several beneficial effects like promotion of bifidogenic growth, anti-adhesive effects by blocking pathogens, and sialylated HMOs are moreover involved in infant brain development. Only trace amounts of these oligosaccharides are present in bovine milk-based infant formula. In order to produce genuine HMOs, this project explores a sustainable way to develop an enzymatic process capable of converting certain kinds of food materials into the desired products.

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Enzymatic production of polysaccharides from gum tragacanth

Plant polysaccharides, relating to the field of natural probiotic components, can comprise structures similar to human milk oligosaccharides. A method for enzymatic hydrolysis of gum tragacanth from the bush-like legumes of the genus Astragalus, using a combination of pectin hydrolases and a xylogalacturonan hydrolase, is described. Fractions with different oligo- and/or polysaccharide compositions and structure are separated according to molecular weight.

General information
Enzyme catalysed production of sialylated human milk oligosaccharides and galactooligosaccharides by Trypanosoma cruzi trans-sialidase

A Trypanosoma cruzi trans-sialidase (E.C. 3.2.1.18) was cloned into Pichia pastoris and expressed. The pH and temperature optimum of the enzyme was determined as pH 5.7 and 30°C. Using casein glycomacropeptide (CGMP) and lactose as sialyl-donor and acceptor respectively, the optimal donor/acceptor ratio for the trans-sialidase catalysed 3′-sialyllactose production was found to be 1:4. Quantitative amounts of 3′-sialyllactose were produced from CGMP and lactose at a yield of 40mg/g CGMP. The 3′-sialyllactose obtained exerted a stimulatory effect on selected probiotic strains, including different Bifidobacterium strains in single culture fermentations. The trans-sialidase also catalysed the transfer of sialic acid from CGMP to galacto-oligosaccharides (GOS) and to the human milk oligosaccharide (HMO) backbone lacto-N-tetraose (LNT) to produce 3′-sialyl-GOS, including doubly sialylated GOS products, and 3′-sialyl-LNT, respectively. This work thus provides proof of the concept of producing 3′-sialyllactose and potentially other sialylated HMOs as well as sialylated GOS enzymatically by trans-sialidase activity, while at the same time providing valorisation of CGMP, a co-processing product from cheese manufacture.

General information

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Enzyme immobilization by fouling in ultrafiltration membranes: Impact of membrane configuration and type on flux behavior and biocatalytic conversion efficacy
Enzyme-immobilization in membranes accomplished by fostering membrane fouling was evaluated. Four different membrane configurations and five membranes were compared for immobilization of alcohol dehydrogenase (ADH) in terms of enzyme loading, permeate flux and final biocatalytic conversion. The membrane configuration impacted the efficiency of the enzyme-immobilization as well as the biocatalytic-membrane reaction, and the "sandwich mode", with an extra polypropylene support above the membrane skin layer, worked best due to its high flux and stable conversion. Among the membranes, a GR51PP polysulphone membrane allowed for the highest flux during the reaction with the enzyme-immobilized membrane. At the same time, the lowest enzyme loading and low reaction stability were achieved for this membrane. Satisfactory enzyme loadings, stable conversions, but low flux rates were obtained for the PLTK and PLGC regenerated cellulose membranes. With these two highly hydrophilic membranes, the ADH enzyme activity was fully retained even after 24h of storage of the membrane. Filtration blocking and resistance models were used to analyze the fouling/immobilization mechanisms and give explanations for the different results. The work confirms that fouling-induced enzyme immobilization is a promising option for enhancing biocatalytic productivity, and highlights the significance of the membrane type and configuration for optimal performance.

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Enzyme technology: Key to selective biorefining

Development of selective biomass upgrading processes is a crucial prerequisite for unfolding the potential of biomass in biorefinery processes. The biorefinery concept designates that different value-added compounds are produced from the same crop or biomass stream. Selectivity with respect to the reaction is a unique trait of enzyme catalysis. Since enzyme selectivity means that a specific reaction is catalysed between particular species to produce definite products, enzymes are particularly fit for converting specific compounds in mixed biomass streams. Since enzymes are protein molecules their rational use in biorefinery processes requires an understanding of the basic features of enzymes and reaction traits with respect to specificity, kinetics, reaction optima, stability and structure-function relations – we are now at a stage where it is possible to use nature’s enzyme structures as starting point and then improve the functional traits by targeted mutation of the protein. The talk will display some of our recent hypotheses related to enzyme action, recently obtained results within knowledge-based enzyme improvements as well as cast light on research methods used in optimizing enzyme catalysed biomass conversion processes.
Filtration behavior of casein glycomacropeptide (CGMP) in an enzymatic membrane reactor: fouling control by membrane selection and threshold flux operation

Sialylated human milk oligosaccharides (HMOs) can be produced by enzymatic trans-sialidation using casein glycomacropeptide (CGMP) as the substrate. By performing the reaction in an enzymatic membrane reactor (EMR), simultaneous separation of the HMOs from CGMP and enzyme reuse can be achieved. In this study, the filtration performance and fouling behavior during ultrafiltration (UF) of CGMP for the enzymatic production of 3′-sialyllactose were investigated. A 5kDa regenerated cellulose membrane with high anti-fouling performance, could retain CGMP well, permeate 3′-sialyllactose, and was found to be the most suitable membrane for this application. Low pH increased CGMP retention but produced more fouling. Higher agitation and lower CGMP concentration induced larger permeate flux and higher CGMP retention. Adsorption fouling and pore blocking by CGMP in/on membranes could be controlled by selecting a highly hydrophilic membrane with appropriate pore size. Operating under threshold flux could minimize the concentration polarization and cake/gel/scaling layers, but might not avoid irreversible fouling caused by adsorption and pore blocking. The effects of membrane properties, pH, agitation and CGMP concentration on the threshold flux were studied based on the resistance-in-series model. Higher hydrophilicity of the membrane, elevated pH and agitation, and lower CGMP concentration were found to increase the threshold flux and decrease membrane fouling.
The degradation compounds formed during pretreatment when lignocellulosic biomass is processed to ethanol or other biorefinery products include furans, phenolics, organic acids, as well as mono- and oligomeric pentoses and hexoses. Depending on the reaction conditions glucose can be converted to 5-(hydroxymethyl)-2-furaldehyde (HMF) and/or levulinic acid, formic acid and different phenolics at elevated temperatures. Correspondingly, xylose can follow different reaction mechanisms resulting in the formation of furan-2-carbaldehyde (furfural) and/or various C-1 and C-4 compounds. At least four routes for the formation of HMF from glucose and three routes for furfural formation from xylose are possible. In addition, new findings show that biomass monosaccharides themselves can react further to form pseudo-lignin and humins as well as a wide array of other compounds when exposed to high temperatures. Hence, several aldehydes and ketones and many different organic acids and aromatic compounds may be generated during hydrothermal treatment of lignocellulosic biomass. The reaction mechanisms are of interest because the very same compounds that are possible inhibitors for biomass processing enzymes and microorganisms may be valuable biobased chemicals. Hence a new potential for industrial scale synthesis of chemicals has emerged. A better understanding of the reaction mechanisms and the impact of the reaction conditions on the product formation is thus a prerequisite for designing better biomass processing strategies and forms an important basis for the development of new biorefinery products from lignocellulosic biomass as well.
High permeability, high enzyme loading, and strong antifouling ability are the desired features for a biocatalytic membrane to be used in an enzymatic membrane reactor (EMR). To achieve these goals, the membrane sublayer was enriched with laccase by reverse filtration in this case, and the resulting enzyme-loaded sublayer was covered with a dopamine coating. After membrane reversal, the virgin membrane skin layer was facing the feed and the enzymes were entrapped by a polydopamine network in the membrane sublayer. Thus, the membrane sublayer was functionalized as a catalytically active layer. The effects of the original membrane properties (i.e., materials, pore size, and structure), enzyme type (i.e., laccase and alcohol dehydrogenase), and coating conditions (i.e., time and pH) on the resulting biocatalytic membrane permeability, enzyme loading, and activity were investigated. Using a RC10 kDa membrane with sponge-like sublayer to immobilize laccase with dopamine coating, the trade-off between permeability and enzyme loading was broken, and enzyme loading reached 44.5% without any permeability loss. After 85 days of storage and reuse 14 times, more than 80% of the immobilized laccase activity was retained for the membrane with a dopamine coating, while the relative activity was less than 40% without the coating. The resistance to high temperature and acidic/alkaline pH was also improved by the dopamine coating for the immobilized laccase. Moreover, this biocatalytic membrane could resist mild hydrodynamic cleaning (e.g., back-flushing), but the catalytic ability was reduced by chemical cleaning at extreme pH (e.g., 1.5 and 11.5). Since the immobilized enzyme is not directly facing the bulk of EMRs and the substrate can be specifically selected by the separation skin layer, this biocatalytic membrane is promising for cascade catalytic reactions.
Improvement of trans-sialylation versus hydrolysis activity of an engineered sialidase from Trypanosoma rangeli by use of co-solvents.

Biocatalytic trans-sialylation is relevant for the design of biomimetic oligosaccharides such as human milk oligosaccharides. t-Butanol and ionic liquids, EAN (ethylammonium nitrate), [MMIm][MeSO4] (1,3-dimethylimidazolium methyl sulfate), and [C2OHMIm][PF6] (1-(2-hydroxyethyl)-3-methylimidazolium hexafluorophosphate), were examined as co-solvents for the improvement of the synthesis versus hydrolysis ratio in the trans-sialylation of lactose, catalysed by an engineered sialidase from Trypanosoma rangeli. The use of 25 % (v/v) t-butanol as co-solvent significantly increased 3’-sialyllactose production by 40 % from 1.04 ± 0.09 to 1.47 ± 0.01 mM. The synthesis versus hydrolysis ratio increased correspondingly by 1.2-times. 1-2.5 % (v/v) EAN or [C2OHMIm][PF6] improved the synthesis versus hydrolysis ratio up to 2.5-times but simultaneously decreased the 3’-sialyllactose yield, probably due to enzyme inactivation caused by the ionic liquid. [MMIm][MeSO4] had a detrimental effect on the trans-sialylation yield and on the ratio between synthesis and hydrolysis.
Mathematical modelling of dextran filtration through hollow fibre membranes

In this paper we present a mathematical model of an ultrafiltration process. The results of the model are produced using standard numerical techniques with Comsol Multiphysics. The model describes the fluid flow and separation in hollow fibre membranes. The flow of solute and solvent within the hollow fibre is modelled by solving the Navier-Stokes equation along with the continuity equation for both the solute and the solvent. The flux of solute and solvent through the membrane are given by the solution diffusion model, since ultrafiltration occurs at high rejections. For a given set of parameters describing the characteristics of the membrane, effect on the observed and the intrinsic rejection of the membrane are investigated for the different working parameters: inlet velocity, molecular weight, and transmembrane pressure. Furthermore, the model investigates the effect of a concentration dependent viscosity. The model shows that both the observed and intrinsic rejection increase when the inlet velocity increases. Moreover, the intrinsic rejection increases as a function of transmembrane pressure, but the observed rejection has a characteristic maximum. Therefore, the observed
rejection can either increase or decrease as a function of pressure. The influence of a concentration dependent viscosity is to increase the concentration on the membrane surface. This leads to a decrease in both the observed and the intrinsic rejection, when compared to a constant viscosity. For small values of the solute permeability the concentration dependent viscosity decreases the volumetric flux through the membrane at high pressures. This effect is due to a very high concentration at the membrane surface. The model is related to experimental data. There is a good qualitative and a reasonable quantitative agreement between simulations and experimental data.

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Methodology for quantitative determination of the carbohydrate composition of brown seaweeds (Laminariaceae)

The monosaccharide composition of four different samples of brown seaweeds Laminaria digitata and Saccharina latissima were compared by different high performance anion exchange chromatography (HPAEC) methods after different acid hydrolysis treatments or a cellulase treatment. A two-step treatment of 72% (w/w) H2SO4 + 4% (w/w) H2SO4 performed best, but cellulase treatment released more glucose than acid treatments. HPAEC with pulsed amperometric detection (PAD) allowed quantification of all present neutral sugars and the sugar alcohol mannitol. Furthermore, the use of guluronic, glucuronic, and galacturonic acid as standards enabled quantification of the uronic acids. A complete map of amino acids, fatty compounds, minerals, and ash was also achieved. L. digitata and S. latissima harvested in Denmark April (Baltic Sea, 2012) were dominated by alginic acid and ash (each ~30% by weight (w/w) of the dry matter) and 10% (w/w) protein. In contrast, the dominant compound of L. digitata harvested in August (North Sea, 2012) was glucose constituting 51% w/w of the dry matter, and with 16% w/w alginic acid. Washing prior to analysis mainly removed salts. © the Partner Organisations 2014.
Methods for Improving Enzymatic Trans-glycosylation for Synthesis of Human Milk Oligosaccharide Biomimetics

Recently, significant progress has been made within enzymatic synthesis of biomimetic, functional glycans, including, for example, human milk oligosaccharides. These compounds are mainly composed of N-acetylglucosamine, fucose, sialic acid, galactose, and glucose, and their controlled enzymatic synthesis is a novel field of research in advanced food ingredient chemistry, involving the use of rare enzymes, which have until now mainly been studied for their biochemical significance, not for targeted biosynthesis applications. For the enzymatic synthesis of biofunctional glycans reaction parameter optimization to promote “reverse” catalysis with glycosidases is currently preferred over the use of glycosyl transferases. Numerous methods exist for minimizing the undesirable glycosidase-catalyzed hydrolysis and for improving the trans-glycosylation yields. This review provides an overview of the approaches and data available concerning optimization of enzymatic trans-glycosylation for novel synthesis of complex bioactive carbohydrates using sialidases, α-l-fucosidases, and β-galactosidases as examples. The use of an adequately high acceptor/donor ratio, reaction time control, continuous product removal, enzyme recycling, and/or the use of cosolvents may significantly improve trans-glycosylation and biocatalytic productivity of the enzymatic reactions. Protein engineering is also a promising technique for obtaining high trans-glycosylation yields, and proof-of-concept for reversing sialidase activity to trans-sialidase action has been established. However, the protein engineering route currently requires significant research efforts in each case because the structure–function relationship of the enzymes is presently poorly understood.

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Optimizing the biocatalytic productivity of an engineered sialidase from Trypanosoma rangeli for 3′-sialyllactose production

An engineered sialidase, Tr6, from Trypanosoma rangeli was used for biosynthetic production of 3′-sialyllactose, a human milk oligosaccharide case compound, from casein glycomacropeptide (CGMP) and lactose, components abundantly present in industrial dairy side streams. Four different enzyme re-use methods were compared to optimize the biocatalytic productivity, i.e. 3′-sialyllactose formation per amount of Tr6 employed: (i) His-tag immobilization on magnetic Cu2+-
iminodiacetic acid-functionalized nanoparticles (MNPs), (ii) membrane immobilization, (iii) calcium alginate encapsulation of cross-linked Tr6, and (iv) Tr6 catalysis in a membrane reactor. Tr6 immobilized on MNPs gave a biocatalytic productivity of 84 mg 3'-sialyllactose/mg Tr6 after seven consecutive reaction runs. Calcium-alginate and membrane immobilization were inefficient. Using free Tr6 in a 10kDa membrane reactor produced a 9-fold biocatalytic productivity increase compared to using free Tr6 in a batch reactor giving 306 mg 3'-sialyllactose/mg Tr6 after seven consecutive reaction runs. The 3'-sialyllactose yield on α-2,3-bound sialic acid in CGMP was 74%. Using circular dichroism, a temperature denaturation midpoint of Tr6, Tm, of 57.2°C was determined. The thermal stability of free Tr6 was similarly high and the Tr6 was stable at the reaction temperature (25°C) for at least 24h.
Phytases for Improved Iron Absorption

Microbial phytases (EC 3.1.3.8) catalyse dephosphorylation of phytic acid, which is the primary storage compound for phosphorous in cereal kernels. The negatively charged phosphates in phytic acid chelate iron (Fe^{3+}) and thus retard iron bioavailability in humans 1. Supplementation of microbial phytase can improve iron absorption from cereal-based diets 2. In order for phytase to catalyse iron release in vivo, the phytase must be robust to low pH and proteolysis in the gastric ventricle. Our work has compared the robustness of five different microbial phytases, evaluating thermal stability, activity retention, and extent of dephosphorylation of phytic acid in a simulated low pH/pepsin gastric environment. The five phytases responded differently to the robustness parameters: The Peniophora lycii phytase (Ronozyme NP) was the most thermostable, but the least robust enzyme at low pH, whereas the two tested Aspergillus niger phytases (SukaPhy phytase and a cloned A. niger enzyme), and an Escherichia coli phytase proved to be most resistant to low pH and pepsin hydrolysis. The phytase from Citrobacter braakii (Ronozyme HiPhos) showed intermediate robustness.

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Predicting optimal back-shock times in ultrafiltration hollow fibre modules through path-lines

This paper presents a two dimensional mathematical model of back-shocking in ultrafiltration. The model investigates the effect of back-shocking on concentration polarization. The model shows a positive effect on both the volumetric flux and the observed rejection when back-shocking is applied as compared to the steady-state solution. Furthermore, the effect of changing different parameters such as inlet velocity, forward and backwards pressure on the back-shock time, the increase in volumetric flux and observed rejection, is presented. Moreover, two analytical estimates for the optimal back-shock time derived from calculating the path-lines during a back-shock cycle are presented. Both of these expressions are in good agreement with the results obtained from the mathematical model and data collected from the literature. Based on this, a simple expression for an optimal back-shock time in a multi-parameter problem is provided.
Rational Design of a New Trypanosoma rangeli Trans-Sialidase for Efficient Sialylation of Glycans

This paper reports rational engineering of Trypanosoma rangeli sialidase to develop an effective enzyme for a potentially important type of reactivity: production of sialylated prebiotic glycans. The Trypanosoma cruzi trans-sialidase and the homologous T. rangeli sialidase has previously been used to investigate the structural requirements for trans-sialidase activity. We observed that the T. cruzi trans-sialidase has a seven-amino-acid motif (197–203) at the border of the substrate binding cleft. The motif differs substantially in chemical properties and substitution probability from the homologous sialidase, and we hypothesised that this motif is important for trans-sialidase activity. The 197–203 motif is strongly positively charged with a marked change in hydrogen bond donor capacity as compared to the sialidase. To investigate the role of this motif, we expressed and characterised a T. rangeli sialidase mutant, Tr13. Conditions for efficient trans-sialylation were determined, and Tr13’s acceptor specificity demonstrated promiscuity with respect to the acceptor molecule enabling sialylation of glycans containing terminal galactose and glucose and even monomers of glucose and fucose. Sialic acid is important in association with human milk oligosaccharides, and Tr13 was shown to sialylate a number of established and potential prebiotics. Initial evaluation of prebiotic potential using pure cultures demonstrated, albeit not selectively, growth of Bifidobacteria. Since the 197–203 motif stands out in the native trans-sialidase, is markedly different from the wild-type sialidase compared to previous mutants, and is shown here to confer efficient and broad trans-sialidase activity, we suggest that this motif can serve as a framework for future optimization of trans-sialylation towards prebiotic production.

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Reactive membrane technology: Two case studies

Enzymatic processes are generally sustainable processes that use mild conditions and natural substrates. Membrane technology can be employed for enzyme immobilization as well as for recycling free enzymes. Using alcohol dehydrogenase (ADH) as part of a process to recycle CO2 to methanol, we investigated the effect of applied pressure, enzyme concentration, pH, and membrane properties on fouling-induced enzyme immobilization. In another study, the production of the human milk oligosaccharide 3'-sialyllactose by an engineered sialidase from *Trypanosoma rangeli* (Tr6) was significantly improved in an enzymatic membrane reactor. The entire process can be improved by employing a series of ultra- and nanofiltrations.
Separation of 3′-sialyllactose and lactose by nanofiltration: A trade-off between charge repulsion and pore swelling induced by high pH

Separation of 3′-sialyllactose (SL) and lactose is an essential final step for the production of the next generation of infant formulas containing sialylated prebiotics. Due to the difference in molecular weight (MW) between SL and lactose and the charge density of SL, nanofiltration could provide a rapid, inexpensive alternative for the separation of SL and lactose compared to traditional chromatography. The performance of four commercial nanofiltration membranes (NF45, DSS-ETNA01PP, NTR-7540 and NP010) for the separation of SL and lactose was assessed at various pH. The difference in retention between SL and lactose was only significant in the NP010 and NTR-7450 membranes, whereas the NF45 and DSS ETNA01PP membranes exhibited either too high lactose retention (i.e. insufficient separation) or too low SL retention (i.e. losing the target SL compound), respectively. Operation at increased pH did not affect SL retention significantly. The expected increase in retention levels of SL at high pH - due to repulsion between the negative charge of the membrane and the charged SL - was apparently offset by pore swelling of the NF membranes at high pH. The water permeability was measured before and after a membrane was used for filtration of a mixture of lactose and SL. For the NP010 and DSS-ETNA membranes, the decline in water permeability was lower when the experiments were conducted at high pH, which is ascribed to the electrostatic repulsion of SL by the membrane. Further improvements in the ratio of retention of SL and lactose were achieved by changing the operational pressure. The best suited membrane was used in a final 10-rounds diafiltration, which enabled total separation of SL and lactose. The study also reveals that while charge differences between solutes can be utilized during nanofiltration, the trade-off between electrostatic repulsion and pore swelling must be addressed when optimizing the nanofiltration process.

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Solvent engineering and other reaction design methods for favouring enzyme-catalysed synthesis

This thesis investigates different methods for improving reaction yields of enzyme-catalysed synthesis reactions. These methods include the use of non-conventional media such as ionic liquids (ILs) and organic solvents as main solvents or as co-solvents as well as the use of more classical reaction design methods, i.e. enzyme immobilization and the use of an enzymatic membrane reactor. Two different enzyme classes, namely feruloyl esterases (FAEs) and sialidases are employed.

Using sinapoylation of glycerol as a model reaction it was shown that both the IL anion nature and the FAE structure were important for FAE activity and stability in IL-buffer (15% v/v) systems. The quantum chemistry-based COSMO-RS method was applied for explaining the IL anion effect in terms of hydrogen bonding capacity. Furthermore, the usefulness of COSMO-RS and other thermodynamically based tools in solvent selection for FAE-catalysed acylation reactions was reviewed. FAE type A from Aspergillus niger and an FAE from a commercial preparation from Humicola insolens, Depol 740L, could not catalyse the esterification of arabinose or xylose with hydroxycinnamates in IL-buffer systems or in surfactantless microemulsion. However, both FAEs catalysed the feruloylation and/or sinapoylation of solvent cation C2OHIm+, thus underlining the broad acceptor specificity of FAEs and their potential for future solvent reactions.

An engineered sialidase from Trypanosoma rangeli, Tr6, catalyses trans-sialylation but the yield is hampered by substrate and product hydrolysis. The formation of 3'-sialyllactose from lactose and casein glycomacropeptide was used as a model reaction. Addition of 20-25% (v/v) t-butanol improved the trans-sialylation yield 1.4-fold and the synthesis/hydrolysis ratio 1.2-fold. Using ILs as co-solvents, the synthesis/hydrolysis ratio was also improved, but the trans-sialylation yield decreased, probably due to destabilization of Tr6 caused by the ILs. Returning to the conventional aqueous medium, immobilization of Tr6 on magnetic nanoparticles improved the synthesis/hydrolysis ratio 2.1-fold and increased the biocatalytic productivity of 2.5-fold. However, the recyclability of the immobilized enzyme was low. Reusing Tr6 seven times in a membrane reactor increased the trans-sialylation yield on the limiting substrate 1.3-fold, emphasizing the importance of the continuous product removal. Furthermore, the biocatalytic productivity was increased more than 9-fold as a result of the enzyme recovery.

In conclusion, where the use of non-conventional media is required for catalysis, e.g. in the thermodynamically controlled FAE-catalysed esterification, careful selection of both solvent system and the FAE itself is required to obtain adequate reaction yields. In contrast, for Tr6 the most promising results were obtained when keeping the reaction in aqueous medium and employing other reaction design methods such as continuous product removal and enzyme immobilization.
The significance of the initiation process parameters and reactor design for maximizing the efficiency of microbial fuel cells

Microbial fuel cells (MFCs) can be used for electricity generation via bioconversion of wastewater and organic waste substrates. MFCs also hold potential for production of certain chemicals, such as H2 and H2O2. The studies of electricity generation in MFCs have mainly focused on the microbial community formation, substrate effect on the anode reaction, and the cathode’s catalytic properties. To improve the performance of MFCs, the initiation process requires more investigation because of its significant effect on the anodic biofilm formation. This review explores the factors which affect the initiation process, including inoculum, substrate, and reactor configuration. The key messages are that optimal performance of MFCs for electricity production requires (1) understanding of the electrogenic bacterial biofilm formation, (2) proper substrates at the initiation stage, (3) focus on operational conditions affecting initial biofilm formation, and (4) attention to the reactor configuration.
Enhanced enzymatic cellulose degradation by cellobiohydrolases via product removal

Product inhibition by cellobiose decreases the rate of enzymatic cellulose degradation. The optimal reaction conditions for two Emericella (Aspergillus) nidulans-derived cellobiohydrolases I and II produced in Pichia pastoris were identified as CBHII: 52 °C, pH 4.5–6.5, and CBHII: 46 °C, pH 4.8. The optimum in a mixture of the two was 50 °C, pH 4.9. An almost fourfold increase in enzymatic hydrolysis yield was achieved with intermittent product removal of cellobiose with membrane filtration (2 kDa cut-off): The conversion of cotton cellulose after 72 h was ~19 % by weight, whereas the conversion in the parallel batch reaction was only ~5 % by weight. Also, a synergistic effect, achieving ~27 % substrate conversion, was obtained by addition of endo-1,4-β-d-glucanase. The synergistic effect was only obtained with product removal. By using pure, monoactive enzymes, the work illustrates the profound gains achievable by intermittent product removal during cellulose hydrolysis.

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Authors: Ahmadi Gavlighi, H. (Intern), Meyer, A. S. (Intern), Mikkelsen, J. D. (Intern)
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Enhancing RGI lyase thermostability by targeted single point mutations

Rhamnogalacturonan I lyase (RGI lyase) (EC 4.2.2.-) catalyzes the cleavage of rhamnogalacturonan I in pectins by β-elimination. In this study the thermal stability of a RGI lyase (PL 11) originating from Bacillus licheniformis DSM 13/ATCC14580 was increased by a targeted protein engineering approach involving single amino acid substitution. Nine individual amino acids were selected as targets for site-saturated mutagenesis by the use of a predictive consensus approach in combination with prediction of protein mutant stability changes and B-factor iteration testing. After extensive experimental verification of the thermal stability of the designed mutants versus the original wild-type RGI lyase, several promising single point mutations were obtained, particularly in position Glu434 on the surface of the enzyme protein. The best mutant, Glu434Leu, produced a half-life of 31 min at 60 °C, corresponding to a 1.6-fold improvement of the thermal stability compared to the original RGI lyase. Gly55Val was the second best mutation with a thermostability half-life increase of 27 min at 60 °C, and the best mutations following were Glu434Trp, Glu434Phe, and Glu434Tyr, respectively.

The data verify the applicability of a combinatorial predictive approach for designing a small site saturation library for improving enzyme thermostability. In addition, new thermostable RGI lyases suitable for enzymatic upgrading of pectinaceous plant biomass materials at elevated temperatures were produced.
Ensiling as biological pretreatment of grass (Festulolium Hykor): The effect of composition, dry matter, and inocula on cellulose convertibility

Grass biomass is a prospective type of lignocellulosic biomass for bioenergy and fuel production, but the low dry matter in grass at harvest calls for new pretreatment strategies for cellulosic conversion. In this study, ensiling was tested as a biological pretreatment method of the high yielding grass variety Festulolium Hykor. The biomass was harvested in four cuts over a growing season. Three important factors of ensiling: biomass composition, dry matter (DM) at ensiling, and inoculation of lactic acid bacteria, were assessed in relation to subsequent enzymatic cellulose hydrolysis. The organic acid profile after ensiling was dependant on the composition of the grass and the DM, rather than on the inocula. High levels of organic acids, notably lactic acid, produced during ensiling improved enzymatic cellulose convertibility in the grass biomass. Ensiling of less mature grass gave higher convertibility. Low DM at ensiling (<25%) resulted in the highest cellulose convertibilities, which ranged from 32 to 70% of the available cellulose in the four cuts after ensiling. The study confirms that ensiling can enhance cellulose convertibility of green biomass, and provides new insight to ensiling as a biological pretreatment method for green biomass conversion.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Novozymes A/S, DLF-TRIFOLIUM A/S
Ensiling of wheat straw decreases the required temperature in hydrothermal pretreatment

BACKGROUND: Ensiling is a well-known method for preserving green biomasses through anaerobic production of organic acids by lactic acid bacteria. In this study, wheat straw is subjected to ensiling in combination with hydrothermal treatment as a combined pretreatment method, taking advantage of the produced organic acids. 

RESULTS: Ensiling for 4 weeks was accomplished in a vacuum bag system after addition of an inoculum of Lactobacillus buchneri and 7% w/w xylose to wheat straw biomass at 35% final dry matter. Both glucan and xylan were preserved, and the DM loss after ensiling was less than 0.5%. When comparing hydrothermally treated wheat straw (170, 180 and 190°C) with hydrothermally treated ensiled wheat straw (same temperatures), several positive effects of ensiling were revealed. Glucan was up-concentrated in the solid fraction and the solubilisation of hemicellulose was significantly increased. Subsequent enzymatic hydrolysis of the solid fractions showed that ensiling significantly improved the effect of pretreatment, especially at the lower temperatures of 170 and 180°C. The overall glucose yields after pretreatments of ensiled wheat straw were higher than for non-ensiled wheat straw hydrothermally treated at 190°C, namely 74-81% of the theoretical maximum glucose in the raw material, which was ~1.8 times better than the corresponding yields for the non-ensiled straw pretreated at 170 or 180°C. The highest overall conversion of combined glucose and xylose was achieved for ensiled wheat straw hydrothermally treated at 180°C, with overall glucose yield of 78% and overall conversion yield of xylose of 87%.

CONCLUSIONS: Ensiling of wheat straw is shown to be an effective pre-step to hydrothermal treatment, and can give rise to a welcomed decrease of process temperature in hydrothermal treatments, thereby potentially having a positive effect on large scale pretreatment costs.

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Enzymatic depolymerization of gum Tragacanth: Bifidogenic potential of low molecular weight oligosaccharides

Gum tragacanth derived from the plant “goat’s horn” (Astragalus sp.) has a long history of use as a stabilizing, viscosity-enhancing agent in food emulsions. The gum contains pectinaceous arabinogalactans and fucose-substituted xylogalacturonans. In this work, gum tragacanth from Astragalus gossypinus was enzymatically depolymerized using Aspergillus niger pectinases (Pectinex® BE Colour). The enzymatically degraded products were divided into three molecular weight fractions via membrane separation: HAG1 <2 kDa; 2 kDa <HAG2 <10 kDa; HAG3 > 10 kDa. Compositional and linkage analyses showed that these three fractions also varied with respect to composition and structural elements: HAG1 and HAG2 were enriched in arabinose, galactose, and galacturonic acid, but low in fucose and xylose; whereas HAG3 was high in (terminal) xylose, fucose and 1,4-bonded galacturonic acid, but low in arabinose and galactose content. The growth-stimulating potential of the three enzymatically produced gum tragacanth fractions was evaluated via growth assessment on seven different probiotic strains in single culture fermentations on: Bifidobacterium longum subsp. longum (2 strains), B. longum subsp. infantis (3 strains), Lactobacillus acidophilus, B. lactis, and on one pathogenic strain of Clostridium perfringens. The fractions HAG1 and HAG2 consistently promoted higher growth of the probiotic strains than HAG3, especially of the three B. longum subsp. infantis strains, and the growth promotion on HAG1 and HAG2 was better than that on galactan (control). HAG3 completely inhibited the growth of the Cl. perfringens strain. Tragacanth gum is thus a potential source of prebiotic carbohydrates that exert no viscosity effects and which may find use as natural functional food ingredients.
Enzymatic lignocellulose hydrolysis: Improved cellulase productivity by insoluble solids recycling.

To take advantage of this effect, the amount of solids recycled should be maximized, based on a given processes ability to deal with higher solids concentrations and volumes. Recycling of enzymes by recycling the insoluble solids fraction was thus shown to be an effective method to decrease enzyme usage, and research should be continued for its industrial application.
Enzyme activity measurement via spectral evolution profiling and PARAFAC

The recent advances in multi-way analysis provide new solutions to traditional enzyme activity assessment. In the present study, enzyme activity has been determined by monitoring spectral changes of substrates and products in real time. The method relies on measurement of distinct spectral fingerprints of the reaction mixture at specific time points during the course of the whole enzyme catalyzed reaction and employs multi-way analysis to detect the spectral changes. The methodology is demonstrated by spectral evolution profiling of Fourier Transform Infrared (FTIR) spectral fingerprints using parallel factor analysis (PARAFAC) for pectin lyase, glucose oxidase, and a cellulase preparation.

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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Technical University of Denmark, FOSS Analytical A/S
Authors: Baum, A. (Intern), Meyer, A. S. (Intern), Garcia, J. L. (Ekstern), Egebo, M. (Forskerdatabase), Hansen, P. W. (Ekstern), Mikkelsen, J. D. (Intern)
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Fouling-induced enzyme immobilization for membrane reactors

A simple enzyme immobilization method accomplished by promoting membrane fouling formation is proposed. The immobilization method is based on adsorption and entrapment of the enzymes in/on the membrane. To evaluate the concept, two membrane orientations, skin layer facing feed (normal mode) and support layer facing feed (reverse mode), were used to immobilize alcohol dehydrogenase (ADH, EC 1.1.1.1) and glutamate dehydrogenase (GDH, EC 1.4.1.3), respectively. The nature of the fouling in each mode was determined by filtration fouling models. The permeate flux was larger in the normal mode, but the reverse mode allowed for higher enzyme loading and stability, and irreversible fouling (i.e. pore blocking) developed more readily in the support structure than in the skin layer. Compared with an enzymatic membrane reactor (EMR) with free enzymes, the novel EMR with enzymes immobilized in membrane support improved the enzyme reusability (especially for ADH), and reduced the product inhibition (especially for GDH). © 2013 Elsevier Ltd.

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Fucoidans from brown seaweeds: An update on structures, extraction techniques and use of enzymes as tools for structural elucidation

Fucoidan or fucoidans cover a family of sulfated fucose-rich polysaccharides, built of a backbone of L-fucose units, and characteristically found in brown seaweeds. Fucoidans have potential therapeutic properties, including anti-inflammatory and anti-coagulant activities, as well as anti-proliferative effects on cancer cells. Recent work has revealed distinct
structural features of fucoidans obtained from different brown seaweed sources. Fucoidans are classically obtained from brown seaweeds by multi-step, hot acid extraction, but the structural and compositional traits, and possibly the bioactivity, of the fucoidan polysaccharides are significantly influenced by the extraction parameters. This review discusses the structural features of fucoidans, the significance of different extraction technologies, and reviews enzymatic degradation of fucoidans and the use of fucoidan-modifying enzymes for elucidating structural details of fucoidans. Mild extraction techniques coupled with the use of new tools such as enzymes can provide the much needed knowledge about structural characteristics of different fucoidan molecules and thus pave the way for a better understanding of the structural chemistry and bioactivities of fucoidans.

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Hemp fibres: Enzymatic effect of microbial processing on fibre bundle structure
The effects of microbial pretreatment on hemp fibres were evaluated after microbial retting using the white rot fungi Ceriporiopsis subvermispora and Phlebia radiata Cel 26 and water retting. Based on chemical composition, P. radiata Cel 26 showed the highest selectivity for pectin and lignin degradation and lowest cellulose loss (14%) resulting in the highest cellulose content (78.4%) for the treated hemp fibres. The pectin and lignin removal after treatment with P. radiata Cel 26 were of the order 82% and 50%, respectively. Aligned epoxy-matrix composites were made from hemp fibres defibrated
Identification of a laccase from Ganoderma lucidum CBS 229.93 having potential for enhancing cellulase catalyzed lignocellulose degradation

Based on a differential pre-screening of 44 white-rot fungi on a lignocellulose-supplemented minimal medium, four basidiomycetes were selected for further study: Ganoderma lucidum, Polyporus brumalis, Polyporus ciliatus and Trametes versicolor. Only G. lucidum was able to grow vividly on malt extract or minimal media supplemented with alkali lignin. When grown on malt extract or minimal medium supplemented with lignocellulose (sugar cane bagasse), the crude G. lucidum protein extract exhibited high laccase activity, ~3U/mL toward syringaldazine. This activity was 13–17 fold higher than the corresponding activities of the crude protein extracts of P. brumalis, P. ciliatus and T. versicolor. Native PAGE electrophoresis of the crude G. lucidum extract confirmed the presence of an active laccase. The G. lucidum laccase had a molecular weight of ~62.5kDa, and a Km value of 0.107mM (determined on ABTS). A partial amino acid sequence analysis of four short de novo sequenced peptides, defined after trypsin digest analysis using MALDI-TOF MS/MS analysis, revealed 64–100% homology to sequences in related laccases in the UniProt database, but also indicated that certain sequence stretches had low homology. Addition of the laccase-rich G. lucidum broth to lignocellulosic biomass (pretreated sugar cane bagasse) together with a state-of-the-art cellulase enzyme preparation (Cellic™CTec1) produced significantly increased cellulolytic yields, which were also better than those obtained with a T. versicolor laccase addition, indicating that the laccase from G. lucidum has unique properties that may be momentous in lignocellulosic biomass conversion.

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with the microbial retting to evaluate the effects on their ultrastructure. SEM microscopy of the composites showed low porosity on the fibre surfaces after defibration with P. radiata Cel 26 and C. subvermispora indicating good epoxy polymer impregnation. In contrast, fibres treated by water retting and the raw hemp fibres were badly impregnated due to porosity caused by surface impurities such as epidermis and other pectin rich plant cells. The pectin and lignin mainly located in the outer part of the fibres were assumed to be extracted and degraded by pectinase and peroxidase enzymes produced by the fungi.

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In vitro growth of four individual human gut bacteria on oligosaccharides produced by chemoenzymatic synthesis.

The present study aimed at examining oligosaccharides (OS) for potential stimulation of probiotic bacteria. Nineteen structurally well-defined candidate OS covering groups of β-glucosides, α-glucosides and α-galactosides with degree of polymerization 2-4 were prepared in >100 mg amounts by chemoenzymatic synthesis (i.e. reverse phosphorolysis or transglycosylation). Fourteen of the OS are not naturally occurring and five (β-d-glucosyl-fructose, β-d-glucosyl-xylitol, α-glucosyl-(1,4)-d-mannose, α-glucosyl-(1,4)-d-xylose; α-glucosyl-(1,4)-l-fucose) have recently been synthesized for the first time. These OS have not been previously tested for effects of bacterial growth and here the ability of all 19 OS to support growth of four gastrointestinal bacteria: three probiotic bacteria Bifidobacterium lactis, Bifidobacterium longum, and Lactobacillus acidophilus, and one commensal bacterium, Bacteroides vulgatus has been evaluated in monocultures. The disaccharides β-d-glucosyl-xylitol and β-d-glucosyl-(1,4)-xylose noticeably stimulated growth yields of L. acidophilus NCFM, and additionally, β-d-glucosyl-(1,4)-xylose stimulated B. longum Bl-05. α-Glucosyl-(1,4)-glucosamine and α-glucosyl-(1,4)-N-acetyl-glucosamine enhanced the growth rate of B. animalis subsp. lactis and B. longum Bl-05, whereas L. acidophilus NCFM and Bac. vulgatus did not grow on these OS. α-Galactosyl-(1,6)-α-galactosyl-(1,6)-glucose advanced the growth rate of B. animalis subsp. lactis and L. acidophilus NCFM. Thus several of the structurally well-defined OS supported growth of beneficial gut bacteria. This reflects a broad specificity of their sugar transporters for OS, including specificity for non-naturally occurring OS, hence showing promise for design of novel prebiotics.
Laccase Enzymology in Relation to Lignocellulose Processing

Several studies have indicated that cellulase action on cellulose fibers and their conversion to glucose is inhibited by lignin and lignin-derived phenolic substances, which are released during the pretreatment of lignocellulosic biomass. A prerequisite for optimization of the cellulose-to-glucose conversion is to either get rid of the inhibitory substances or to alter them in a way, so they no longer decrease the action of cellulases.

The main focus in the present work was the investigation of the influence of the enzymes that are being expressed from the white-rot fungi when lignin was present in the cultivation broth, on the cellulase catalyzed hydrolysis of pretreated biomass, and to understand the mechanism of their action on phenolic substances.

In this thesis, 44 fungi from the genus Alternaria, Fusarium, Memnoniella, Stemphylium, Ulocladium, Ganoderma, Trametes, and Polyporus were evaluated for their ability to grow on lignocellulosic material, such as sugarcane bagasse – a competitive substrate for grain bioethanol. From this investigation, four white-rot fungi (Ganoderma lucidum, Trametes versicolor, Polyporus brumalis, and Polyporus ciliatus), were selected for the growth on lignin (lignin alkaline) and investigated for production of enzymes under such conditions (Paper I).

G. lucidum was found to produce high amounts of laccase which corresponded to its exceptional growth on lignocellulosic substrate and lignin. This observation led to a hypothesis that this particular laccase might act in a synergistic way with cellulase preparations and yield in higher cellulose-to-glucose catalyzed hydrolysis. To test this hypothesis the laccase-rich crude extract from G. lucidum was added to the cellulase catalyzed hydrolysis of cellulose from the pretreated sugarcane bagasse (Paper I). A positive outcome of this reaction, a 17% increase in the total glucose yields during cellulase catalyzed hydrolysis of cellulose, led to amplification of laccase gene and its expression in Pichia pastoris (Paper II). This approach was directed into obtaining a monocomponent laccase enzyme and to prove that the higher yields of cellulose-to-glucose conversion are partly due to the presence of laccase, and are not caused by the other proteins, present in the laccase-rich crude protein extract.

The addition of the laccase from G. lucidum, expressed in P. pastoris resulted in a total increase in the glucose yields by 20 and 33% depending on the cellulase cocktail preparation. This discovery is significant considering the fact that the cellulase cocktail preparations, namely Cellic®CTec1 and Cellic®CTec2, are improved in respect to phenolic-derived, and end-substrate inhibitors.

Additionally, the molecular dynamics simulations (MD) of the obtained amino acid sequence of the laccase from G. lucidum highlighted a potential mechanism of laccase detoxification of the cellulase-pretreated-biomass-derived inhibitors (Paper II).

The mechanism of laccase reaction on the phenolic substrates was further evaluated by the literature study of the reactions that take place in the catalytic pocket of this oxidoreductases and the structural alteration that can lead to a more robust, or completely inactive, laccase (Review paper).

Mechanisms controlling retention during ultrafiltration of charged saccharides: Molecular conformation and electrostatic forces

Separation of different biomass components in solution, including charged saccharides, is one of the key challenges in biorefining of plant biomass. Ultrafiltration is one of the potential processes that could cope with such separation. Electrostatic interactions between solute molecules and between solute molecules and membrane material are amongst the key factors determining the separation efficiency during ultrafiltration of charged saccharides. Our hypothesis is that the manipulation of pH in addition to the classic pressure control should enhance the ultrafiltration performance for charged saccharides in terms of permeate flux and observed retention of the target molecules. Series of batch ultrafiltrations with carboxy-methyl-cellulose (CMC) showed that an increase of transmembrane pressure (from 2 to 4bars)
resulted in higher permeate fluxes and lower observed retentions. These results were explained by the cake-layer model. An increase of pH from 2.0 to 7.4 caused an increase in flux and we propose that this effect was due to a conformation change in the CMC molecules from an entangled, globular shape to a more linear one in response to repulsion amongst the negative charges on the molecules at higher pH. The results obtained in this work demonstrate that it is possible to control the observed retention of charged saccharides during ultrafiltration by manipulating pH and transmembrane pressure. Therefore, beyond operational conditions, specific molecular mechanisms must be taken into account when it comes to optimizing ultrafiltration of such species.

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- Scopus rating (2007): SJR 1.015 SNIP 1.457
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Mini Review: Basic Physiology and Factors Influencing Exogenous Enzymes Activity in the Porcine Gastrointestinal Tract

The addition of exogenous enzymes to pig feed is used to enhance general nutrient availability and thus increase daily weight gain per feed unit. The enzymes used are mainly beta-glucanase (EC 3.2.1.4) and xylanase (EC 3.2.1.8) and phytase (EC 3.1.3.8). Although in vivo data assessing feed enzyme activity during intestinal transit are few, it is known that the enzymes, being protein molecules, can be negatively affected by the gastrointestinal proteolytic enzymes and the low pH in the stomach ventricle. In this review, the pH-values, endogenous proteases and other factors native to the digestive tract of the adult pig and the piglet are discussed in relation to the stability of exogenous feed enzymes. Development of more consistent assessment methods which acknowledge such factors is warranted both in vitro and in vivo for proper evaluation and prediction of the efficiency of exogenous enzymes in the porcine gastrointestinal tract.

General information
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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, National Veterinary Institute, Section for Bacteriology, Pathology and Parasitology
Authors: Strube, M. L. (Intern), Meyer, A. S. (Intern), Boye, M. (Intern)
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Scopus rating (2012): SJR 0.348 SNIP 0.901 CiteScore 0.44
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Scopus rating (2011): SJR 0.36 SNIP 0.77 CiteScore 0.28
ISI indexed (2011): ISI indexed yes
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Oxidative enzymatic gelation of sugar beet pectin for emulsion stabilization

Pectin from sugar beet is derived from the sugar beet pulp residue which results when sugar beets are processed for sucrose extraction. The sugar beet pectin has poor gelation ability by the classic divalent cation molecular mechanism because of a relatively high acetylation degree and short polygalacturonate backbone chain length. However, due to the feruloyl-substitutions on the side chains, the sugar beet pectic polysaccharides can be cross-linked via enzyme catalyzed oxidation. The enzyme kinetics and functionality of such oxidatively cross-linked sugar beet pectin, in relation to stabilizing emulsions, has recently been investigated in model food emulsions. This paper reviews the pectin chemistry, enzymatic oxidative gelation mechanisms, interaction mechanisms of the sugar beet pectin with the emulsion droplets, and explores how the gelation affects the rheology and stability of emulsion systems. The applied biotechnology concept of enzymatic gelation provides an array of opportunities for upgrading of low-value pectins for new food and non-food uses.

Potential of phytase-mediated iron release from cereal-based foods: a quantitative view.

The major part of iron present in plant foods such as cereals is largely unavailable for direct absorption in humans due to complexation with the negatively charged phosphate groups of phytate (myo-inositol (1,2,3,4,5,6)-hexakisphosphate). Human biology has not evolved an efficient mechanism to naturally release iron from iron phytate complexes. This narrative review will evaluate the quantitative significance of phytase-catalysed iron release from cereal foods. In vivo studies have shown how addition of microbially derived phytases to cereal-based foods has produced increased iron absorption via enzyme-catalysed dephosphorylation of phytate, indicating the potential of this strategy for preventing and treating iron deficiency anaemia. Despite the immense promise of this strategy and the prevalence of iron deficiency worldwide, the number of human studies elucidating the significance of phytase-mediated improvements in iron absorption and ultimately in iron status in particularly vulnerable groups is still low. A more detailed understanding of (1) the uptake mechanism for iron released from partially dephosphorylated phytate chelates, (2) the affinity of microbially derived phytases towards insoluble iron phytate complexes, and (3) the extent of phytate dephosphorylation required for iron release from inositol phosphates is warranted. Phytase-mediated iron release can improve iron absorption from plant foods. There is a need for development of innovative strategies to obtain better effects.
Simultaneous measurement of two enzyme activities using infrared spectroscopy: A comparative evaluation of PARAFAC, TUCKER and N-PLS modeling

Enzymes are used in many processes to release fermentable sugars for green production of biofuel, or the refinery of biomass for extraction of functional food ingredients such as pectin or prebiotic oligosaccharides. The complex biomasses may, however, require a multitude of specific enzymes which are active on specific substrates generating a multitude of products. In this paper we use the plant polymer, pectin, to present a method to quantify enzyme activity of two pectolytic enzymes by monitoring their superimposed spectral evolutions simultaneously. The data is analyzed by three chemometric multway methods, namely PARAFAC, TUCKER3 and N-PLS, to establish simultaneous enzyme activity assays for pectin lyase and pectin methyl esterase. Correlation coefficients $R^2$ for prediction test sets are 0.48, 0.96 and 0.96 for pectin lyase and 0.70, 0.89 and 0.89 for pectin methyl esterase, respectively. The retrieved models are compared and prediction test sets show that especially TUCKER3 performs well, even in comparison to the supervised regression method N-PLS.
Fourier transform infrared spectroscopy, Enzyme activity, Spectral evolution profiles, Multiway, Second-order calibration

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Stabilization of emulsions by gum tragacanth (Astragalus spp.) correlates to the galacturonic acid content and methoxylation degree of the gum

Gum tragacanth samples from six species of Iranian Astragalus bush plants ("goat's-horn") were evaluated for their emulsion stabilizing effects and their detailed chemical composition in order to examine any possible correlation between the make-up and the emulsion stabilizing properties of gum tragacanth. The six gum tragacanth samples were exudates from the species Astragalus parrowianus, Astragalus fluccosus, Astragalus rahensis, Astragalus gossypinus, Astragalus microcephalus, and Astragalus compactus. The six gum samples varied with respect to their levels and ratios of water-soluble (tragacanthin) and water-swellable (bassorin) fractions, their monosaccharide composition, methoxylation, and acetylation degrees. The gums from A. parrowianus and A. fluccosus had relatively high tragacanthin:bassorin ratios of ~66:34 and ~75:25, respectively, whereas in the other gums this ratio approached 50:50 (A. rahensis, A. microcephalus, A. compactus) or tipped toward higher bassorin than tragacanthin (A. gossypinus). The monosaccharide make-up of the six gums also varied, but all the gums contained relatively high levels of galacturonic acid (~100–330 mg/g), arabinose (50–360 mg/g), xylose (~150–270 mg/g), and galactose (~40–140 mg/g), and also contained fucose, rhamnose, and glucose. The ability of the gums to act as stabilizers in whey protein isolate based emulsions varied. The best emulsion stabilization effect, measured as lowest creaming index ratio after 20 days, was obtained with the A. fluccosus gum. The emulsion stabilization effect correlated linearly and positively to the methoxylation degree, and galacturonic acid content of the gums, but not to acetyl or fucose content. A particularly high correlation was found between methoxyl level in the soluble gum part and emulsion stabilization. The work provides some important clues to the emulsion stabilization mechanisms in relation to the monosaccharide composition of tragacanth gums.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Shahid Beheshti University of Medical Sciences
Authors: Ahmadi Gavlighi, H. (Intern), Meyer, A. S. (Intern), Abang Zaidel, D. N. (Intern), Mohammadifar, M. A. (Intern), Mikkelsen, J. D. (Intern)
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Stabilization of oil-in-water emulsions by enzyme catalyzed oxidative gelation of sugar beet pectin

Enzyme catalyzed oxidative cross-linking of feruloyl groups can promote gelation of sugar beet pectin (SBP). It is uncertain how the enzyme kinetics of this cross-linking reaction are affected in emulsion systems and whether the gelation affects emulsion stability. In this study, SBP (2.5% w/v) was mixed into an oil-in-water emulsion system (4.4% w/w oil, 0.22% w/w whey protein, pH 4.5). Two separate, identically composed, emulsion systems were prepared by different methods of preparation. The emulsions prepared separately and subsequently mixed with SBP (referred as Mix A) produced significantly larger average particle sizes than the emulsions in which the SBP was homogenized into the emulsion system during emulsion preparation (referred as Mix B). Mix B type emulsions were stable. Enzyme catalyzed oxidative gelation of SBP helped stabilize the emulsions in Mix A. The kinetics of the enzyme catalyzed oxidative gelation of SBP was evaluated by small angle oscillatory measurements for horseradish peroxidase (HRP) (EC 1.11.1.7) and laccase (EC 1.10.3.2) catalysis, respectively. HRP catalyzed gelation rates, determined from the slopes of the increase of elastic modulus (G0) with time, were higher (P < 0.05) than the corresponding laccase catalyzed rates, but the final G0 values were higher for laccase catalyzed gels, regardless of the presence of emulsions or type of emulsion preparation (Mix A or Mix B). For both enzymes, rates of gelation in Mix A were higher (P < 0.05) than in Mix B, and higher stress was needed to break the gels in Mix A than in Mix B at similar enzyme dosage levels. These differences may be related to a lower availability of the feruloyl groups for cross-linking when the SBP was homogenized into the emulsion system during preparation.

General information

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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, National Food Institute, Division of Industrial Food Research
Authors: Abang Zaidel, D. N. (Intern), Chronakis, I. S. (Intern), Meyer, A. S. (Intern)
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Tragacanth gum: Functionality and prebiotic potential

Tragacanth gum is a plant-derived hydrocolloid that has a long history of use in food, pharma, and cosmetics. The gum is mainly produced in the Middle East and permitted for food use in the US and Europe. Tragacanth gum consists of complex, heterogeneous polysaccharides, which contain different highly substituted pectin-like structural elements. Enzymatically produced low molecular-weight fractions of tragacanth gum exhibit potential prebiotic activity by promoting growth in vitro of Bifidobacterium longum subsp. infantis strains. These findings may lead to new uses of this gum for production of value-added prebiotic compounds for functional foods.
Tragacanth Gum: Structural Composition, Natural Functionality and Enzymatic Conversion as Source of Potential Prebiotic Activity

Gum tragacanth derived from the plant (Astragalus sp.) has a long history of use as a stabilizing, viscosity-enhancing agent in food emulsions. The gum is mainly produced in the Middle East, and permitted for food use in the US as well as in Europe (E-number E413). Gum tragacanth is known to confer very high viscosities when in aqueous solution, and is described as a complex, highly branched, heterogeneous hydrophilic polysaccharide. The gum contains pectinaceous arabinogalactans and fucose-substituted xylogalacturonans. The objective of this PhD study was to evaluate tragacanth samples from six species of Iranian Astragalus for their emulsion stabilizing effects and their detailed chemical composition in order to examine any possible correlation between the make-up and the emulsion stabilizing properties of gum tragacanth. Also, enzymatic modification of highly fucose content of tragacanth gum and separation via membrane technique to get different molecular size. Furthermore, examination of compositional structure and effect of different molecular size on potential prebiotic was evaluated.

The first part of the present study was selected of six different species of Astragalus and exudates of gum and fractionated by centrifugation to soluble and insoluble. To examine correlation between composition structure, sugar composition and methoxyl and acetyl content was determined. The six gum samples varied with respect to their levels and ratios of water-soluble and water-swellable fractions, their monosaccharide composition, methoxylation, and acetylation degrees. Emulsion and rheological properties of different gum solution was assessed with WPI as an emulsifier in protein base emulsion and correlation of each composition on emulsion stability was established. Tragacanth gum solution added in emulation and without emulation showed shear thinning properties in all gums. The emulsion stabilization effect correlated linearly and positively to the methoxylation degree, and galacturonic acid content of the gums, but not to acetyl or fucose content. A particularly high correlation was found between methoxyl level in the soluble gum part and emulsion stabilization.

The results of this work provide some important clues to the emulsion stabilization mechanisms in relation to the structure composition of tragacanth gums. From our knowledge and many research for application of this gum in food industry and unique properties of this gum with arabinogalactan and fucoxylogalacturonans in the structure of we decided to evaluate bioactivity of this gum. To date, different commercial of prebiotic compound available but still new compound is needed and interested. The main process for the production of prebiotic is enzymatic process. Thus, the next study of work was using commercial pectinolytic enzyme to get different molecular size and purified with membrane technique and get three different fraction: HAG1 < 2 kDa; 2 kDa< HAG2 < 10 kDa; HAG3 > 10 kDa. HPAEC results shown that these three fractions varied with respect to composition and HAG1 and HAG2 were enriched in arabinose, galactose, and galacturonic acid, but low in fucose and xylose; whereas HAG3 was high in xylose, fucose and galacturonic acid, but low in arabinose and galactose. The structural composition of different fractions with linkage analysis shown that the structure of gum tragacanth fractions was different and included 1,4-bonded galacturonic acid backbone with terminally linked fucose and (1,2)-linked xylose, as well as terminally linked xylose called fucoxylogalacturonan. In addition, the presence of (1,4)-galactose linkages and 1,5 Ara linkage presumably correspond to arabinogalactan-derived galactan.

Determination of prebiotic effect of different fraction in vitro were assessed on seven different probiotic strains in single culture fermentations on: Bifidobacterium longum subsp. longum (2 strains), B. longum subsp. infantis (3 strains), Lactobacillus acidophilus, B. lactis, and on one pathogenic strain of Clostridium perfringens. The fractions HAG1 and HAG2 consistently promoted higher growth of the probiotic strains than HAG3, especially of the three B. longum subsp. infantis strains, and the growth promotion on HAG1 and HAG2 was better than that on galactan (control). HAG3 completely inhibited the growth of the Cl. perfringens strain.

In summary of this study:
- Emulsion stabilization of the gum is related to the gum composition and structure, and mainly galacturonic acid content and degree of esterification are important
- low molecular size oligosaccharides produced enzymatically has higher potential prebiotic activity than longer chain gum saccharides
- Tragacanth gum can be a new source for development of innovative functional foods with health claims

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Ahmadi Gavilighi, H. (Intern), Mikkelsen, J. D. (Intern), Meyer, A. S. (Intern)
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A framework for model-based optimization of bioprocesses under uncertainty: Lignocellulosic ethanol production case

This study presents the development and application of a systematic model-based framework for bioprocess optimization. The framework relies on the identification of sources of uncertainties via global sensitivity analysis, followed by the quantification of their impact on performance evaluation metrics via uncertainty analysis. Finally, stochastic programming is applied to drive the process development efforts forward subject to these uncertainties. The framework is evaluated on four different process configurations for cellulosic ethanol production including Simultaneous Saccharification and Co-Fermentation and Separate Hydrolysis and Co-Fermentation (SSCF and SHCF, respectively) technologies in different operation modes (continuous and continuous with recycle). The results showed that parameters related to pretreatment (e.g. activation energy of the reaction for glucose production, order of reaction, etc.), hydrolysis (inhibition constant for xylose on conversion of cellulose and cellobiose, etc) and co-fermentation (ethanol yield on xylose, inhibition constant on microbial growth, etc.), are the most significant sources of uncertainties affecting the unit production cost of ethanol with a standard deviation of up to 0.13 USD/gal-ethanol. Further stochastic optimization demonstrated the options for further reduction of the production costs with different processing configurations, reaching a reduction of up to 28% in the production cost in the SHCF configuration compared to the base case operation. Further, the framework evaluated here for uncertainties in the technical domain, can also be used to evaluate the impact of market uncertainties (feedstock prices, selling price of ethanol, etc) and political uncertainties (such as subsidies) on the economic feasibility of lignocellulosic ethanol production.

General information
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Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Center for Process Engineering and Technology
Authors: Morales Rodriguez, R. (Intern), Meyer, A. S. (Intern), Gernaey, K. (Intern), Sin, G. (Intern)
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Altering of biomass composition in response to changing substrate particle size and the consequences for enzymatic hydrolysis of corn bran

Corn bran is a by-product from corn starch processing. This work examined the effects of changing substrate particle size on enzymatic hydrolysis of both raw and pretreated destarched corn bran. The biomass composition of the corn bran varied between particle size fractions: The largest particles ([1000;710]μm) were richer in cellulose and in (arabino)xylan with a relatively low degree of arabinofuranosyl substitutions, whereas the smaller particles ([250;150]μm) contained less cellulose, but arabinoxylan with higher arabinofuranosyl substitution (higher A:X ratio). Enzymatic hydrolysis yields improved with decreasing substrate particle size, particularly for the raw corn bran. The increased enzymatic yields obtained with decreasing substrate particle sizes were related to the increased substrate surface area but also to the biomass composition. Theoretical estimations of enzymatic reaction efficiency supported that biomass composition affected the enzymatic reaction yields and provided new insight into the impact of substrate particle size on enzymatic biomass hydrolysis.

General information
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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Agger, J. (Intern), Meyer, A. S. (Intern)
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Biocatalytic cross-linking of pectic polysaccharides for designed food functionality: Structures, mechanisms, and reactions

Recent research has demonstrated how cross-linking of pectic polysaccharides to obtain gel formation can be promoted by enzymatic catalysis reactions, and provide opportunities for functional upgrading of pectic polysaccharides present in agro-industrial sidestreams. This review highlights the mechanisms of formation of functional pectic polysaccharide cross-links, including covalent cross-links (notably phenolic esters and uronyl ester linkages) and non-covalent, ionic cross-links (which involve calcium and borate ester links). The treatise examines how such cross-links can be designed via specific enzymatic reactions, and highlights the most recent data concerning enzyme catalyzed engineering of cross-links for in situ structural design of functional properties of foods.

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Bioethanol from lignocellulose - pretreatment, enzyme immobilization and hydrolysis kinetics

Pretreatment and enzymatic hydrolysis are two of the processes involved in the production of cellulosic ethanol. Several pretreatment methods were proposed, however new pretreatment strategies to increase enzymatic hydrolysis efficiency are still under investigation. For enzymatic hydrolysis, the cost of enzyme is still the bottle neck, re-using the enzyme is possible way to reduce the input of enzyme in the process. In the point view of engineering, the prediction of enzymatic hydrolysis kinetics under different substrate loading, enzyme combination is useful for process design. Therefore, several kinetic models were proposed previously. In view of the connection between pretreatment and enzymatic hydrolysis. The hypotheses and objective of this PhD study consists of three parts:

1. Pretreatment of barley straw by 1-ethyl-3-methylimidazolium acetate ([EMIM]Ac), which was done during 2009. Ionic liquid had been reported to be able to dissolve lignocellulose. However, as our knowledge, in all published researches, the concentration of lignocellulose in ionic liquid were low (5~10%). Besides, pretreatment time were long (from 1 hr to 1 day). Based on the hypothesis that the amount of ionic liquid and pretreatment time can be reduced, the influence of substrate concentration, pretreatment time and temperature were investigated and optimized.

2. Immobilization of β-glucosidase (BG), which was done during 2010. One of the major bottlenecks in production of ethanol from lignocellulose is the required high cellulase enzyme dosages that increase the processing costs. One method to decrease the enzyme dosage is to re-use BG, which hydrolyze the soluble substrate cellobiose. Based on the hypothesis that immobilized BG can be re-used, how many times the enzyme could be recycled and how coupling with glutaraldehyde affected enzyme recovery after immobilization were investigated.

3. Validation and modification of a semimechanistic model, which was done during 2010 ~ 2012. A number of cellulosic hydrolysis kinetic models were proposed. Among the models, a simple and useful mathematical model proposed by Kadam et al. (2004) has potential for supporting process design. However, like the other models, it was not validated intensively, especially under high glucose concentration background and high substrate loading. Thus, the role of transglycosylation was not considered in previous reports. Based on the hypothesis that transglycosylation plays an important role under these conditions, the influence of transglycosylation was introduced into the model and evaluated.

The semimechanistic multi-reaction kinetic model consists of homogeneous and heterogeneous reaction proposed by Kadam et al. (2004) was systematically validated and modified under a step by step analysis. The objective is to perform a comprehensive analysis in view of validating and further consolidating the model. A number of dedicated experiments were carried out under a wide range of initial conditions (Avicel versus pretreated barley as substrate, different enzyme loadings, and different product inhibitors such as glucose, cellobiose and xylose) to test the hydrolysis and product inhibition mechanism of the model. Nonlinear least squares method was used to identify the model and estimate kinetic parameters based on the experimental data. The analysis showed that transglycosylation reaction at high glucose level play a key role in the model. Therefore with the introduction of transglycosylation into the model, prediction of cellulose hydrolysis behavior over a broad range of substrate loading is possible. It also revealed that the experimental data used for parameters estimation or different estimation strategies influence the values of parameters and performance of the model. The revised model structure can now be used to support process design and technology improvement efforts at pilot and full-scale studies especially under high cellulose loading.

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Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Novozymes A/S
Authors: Tsai, C. T. (Intern), Meyer, A. S. (Intern), Johansen, K. S. (Ekstern)
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Controlling the rejection of protein during membrane filtration by adding selected polyelectrolytes

Electrostatic interactions among the charged groups on proteins and/or between proteins and other solutes significantly affect the aggregation/deposition phenomena that induce fouling and decrease permeate flux during membrane purification of proteins. Such interactions can be turned into an advantage by e.g. addition of new charged species that are able to destabilize the interactions causing aggregation or by controlling the charges via pH. The present study examined the effect of (1) addition of polyelectrolytes-polystyrene-co-acrylic acid (PS-co-AA) and pectin-, respectively, and (2) changing the pH, on the permeate flux and membrane transmission of bovin serum albumina (BSA) through a PVDF membrane. The addition of PS-co-AA to the feed solution resulted in significant increases of the BSA transmission at pH 7.4 as compared to the transmission of a pure BSA solution (1g/L). The addition of pectin to BSA at pH 7.4 also resulted in higher permeate fluxes and improved BSA transmission, as compared to the individual solution of pectin or BSA. The BSA transmission decreased at lower pHs i.e. at 4.7 (isoelectric point of BSA) and 2 with each polyelectrolyte as the apparent interactions between the BSA and the polyelectrolyte favoured deposition and aggregation phenomena, resulting in higher fouling. The results suggest that the addition of a polyelectrolyte to a protein solution at a certain pH can dramatically modify the profile of electrostatic interactions causing fouling, and can help enhance the performance of membrane filtration for fractionation/purification of a target protein by significantly reducing fouling and modifying rejection/selectivity.
Designed optimization of a single-step extraction of fucose-containing sulfated polysaccharides from Sargassum sp.

Fucose-containing sulfated polysaccharides can be extracted from the brown seaweed, Sargassum sp. It has been reported that fucose-rich sulfated polysaccharides from brown seaweeds exert different beneficial biological activities including anti-inflammatory, anticoagulant, and anti-viral effects. Classical extraction of fucose-containing sulfated polysaccharides from brown seaweed species typically involves extended, multiple-step, hot acid, or CaCl₂ treatments, each step lasting several hours. In this work, we systematically examined the influence of acid concentration (HCl), time, and temperature on the yield of fucose-containing sulfated polysaccharides (FCSPs) in statistically designed two-step and single-step multifactorial extraction experiments. All extraction factors had significant effects on the fucose-containing sulfated polysaccharides yield, with the temperature and time exerting positive effects, and the acid concentration having a negative effect. The model defined an optimized single-step FCSPs extraction procedure for Sargassum sp. (a brown seaweed). A maximal fucose-containing sulfated polysaccharides yield of ~7% of the Sargassum sp. dry matter was achieved by the optimal extraction procedure of: 0.03 M HCl, 90°C, 4 h. HPAECPAD analysis confirmed that fucose, galactose, and glucuronic acid were the major constituents of the polysaccharides obtained by the optimized method. Lower polysaccharide yield, but relatively higher fucose content was obtained with shorter extraction time. The data also revealed that classical multi-step extraction with acid ≥0.2 M HCl at elevated temperature and extended time had a detrimental effect on the FCSPs yield as this treatment apparently disrupted the structural integrity of the polymer and evidently caused degradation of the carbohydrate chains built up of fucose residues.

General information
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Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Ale, M. T. (Intern), Mikkelsen, J. D. (Intern), Meyer, A. S. (Intern)
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Authors: Pinelo, M. (Intern), Prado, O. (Ekstern), Møller, V. (Intern), Meyer, A. (Intern), Jonsson, G. (Intern), Nicola Marsh (Ekstern)
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Enzyme catalyzed oxidative cross-linking of feruloylated pectic polysaccharides from sugar beet: Kinetics and rheology

Sugar beet pulp is a byproduct from sugar production consisting mainly of cellulose and pectic polysaccharide. Its utilization has been mostly as feedstock due to its high content of energy and fiber. This study emphasizes on the utilization of the pectin and arabinan fractions extracted from sugar beet pulp as a potential starting material for production of pectin derived products which could help maintain the competitiveness of the sugar beet based industry. The overall objective of this study has been focusing on understanding the kinetics of enzyme catalyzed oxidative crosslinking of feruloylated polysaccharide from sugar beet and relating the kinetics of this crosslinking to the properties of the crosslinked products. Several hypotheses have been formulated in order to accomplish our objective.

The first part of the study utilized arabinan-oligosaccharide fraction from sugar beet pulp byproduct. In this study we investigated the effect of arabinans backbone length on the kinetics of horseradish peroxidase (EC 1.11.1.7) (HRP) catalyzed oxidative cross-linking of ferulic acid (FA) moieties esterified to 3-(1,5)-linked arabinans; taking into account that FA can be oxidatively cross-linked by HRP catalysis in the presence of hydrogen peroxide (H2O2) to form ferulic acid dehydrodimers (diFAs). The composition of the substrate was analyzed by HPAEC, HPLC and MALDI-TOF, confirming the structural make up of the arabinan-oligosaccharide (Arabinose: 2.9- 3.4 mmol?g-1 DM; FA: 2.5-7.0 mg?g-1 DM) and verifying the formation of diFAs as a result of the enzyme catalyzed cross-linking reaction. The result demonstrates the influence of arabinans backbone length on the rates of FA cross-linking; longer arabinans exhibit a slower cross-linking rate than shorter, all other things being equal.

It has been our intention to study the rheological properties of cross-linked feruloylated arabinanoligosaccharide, however the attempt has not been fully achieved. It might be due to small molecular weight of the arabinan (71.3 kDa) which prevented the measurement of the rheological properties since the change in viscosity resulting from the cross-linking was insignificant. Therefore, the next part of the work presented in this thesis utilized sugar beet pectin (SBP) solid fraction extracted from sugar beet pulp which has molecular weight >100 kDa. The compositional analysis of the substrate shows abundant amount of FA (7.3 mg?g-1 DM) in SBP which can be oxidatively cross-linked via enzyme catalyzed reaction by oxidoreductase enzymes. We hypothesized that different mechanisms of two oxidoreductase enzymes, i.e. HRP and laccase (EC 1.10.3.2), might influence the kinetics of the oxidative cross-linking and consequently the properties of the gels formed. The kinetics of oxidative gelation of SBP, taking place via enzyme catalyzed cross-linking of FA, was evaluated by small angle oscillatory measurements. The result indicates a significant difference between the SBP gels produced from the catalysis of HRP and laccase, that is, laccase catalysis produced stronger SBP gels albeit slower rates of gelation than the HRP catalysis. Statistically design experiment has been constructed to investigate the effect of several reaction factors which might influence the rates of gelation of SBP catalyzed by HRP or laccase, particularly the pectin level, temperature, enzyme dosage, pH and, for HRP, the H2O2 concentration. The result reveals that these reaction factors could be tuned in order to adjust the enzyme catalyzed gelation and the properties of the gels produced. Moreover,
positive correlation between the rates of gelation and gel strengths was obtained for laccase catalyzed gels, but no such correlation exists for HRP catalyzed gels. Chemical analysis confirmed the formation of diFAs in the cross-linked products by both enzymes catalysis supporting that the gelation was a result of oxidative cross-linking of FA.

It is uncertain how the kinetics of enzyme catalyzed oxidative cross-linking of SBP and the gels properties are affected in emulsion systems. Thus, investigation on the enzyme catalyzed oxidative gelation of SBP was further performed on the SBP in emulsion systems. In this study, we have formulated two separate, identically composed, oil-in-water emulsion systems to study the effect of different methods of emulsion preparation on the emulsion stability in the presence of SBP and the kinetics of enzyme catalyzed oxidative gelation of SBP. The result shows that the different methods of emulsion preparation affect the emulsion stability and the rates of gelation of SBP in emulsion systems, and stronger gels were produced in the SBP containing emulsions as compared to the SBP without emulsions.

From this study, we have shown that arabinan-oligosaccharide and SBP solid fractions extracted from sugar beet pulp byproduct could undergo oxidative cross-linking of the feruloyl group, which abundantly esterified to the arabinan side-chains, through enzyme catalyzed reaction. Our study provides the insight into the relationship between the kinetics of the oxidative cross-linking of FA with the structural characteristic of the oligosaccharide, and the correlation between the rates of enzyme catalyzed oxidative gelation of feruloylated polysaccharide and the rheological properties of the gels produced. This knowledge could be useful for designing application of sugar beet pectin in food technology or similar application.
Enzyme kinetics and identification of the rate-limiting step of enzymatic arabinoxylan degradation

This study investigated the kinetics of multi-enzymatic degradation of soluble wheat arabinoxylan by monitoring the release of xylose and arabinose during designed treatments with mono-component enzymes at different substrate concentrations. The results of different combinations of α-l-arabinofuranosidases (EC 3.2.1.55), one derived from *Aspergillus niger* (AFAn) and one from *Bifidobacterium adolescentis* (AFBa), respectively, a β-xylosidase (EC 3.2.1.37) from *Trichoderma reesei*, and an engineered D11F/R122D variant of *Bacillus subtilis* XynA endo-1,4-β-xylanase (EC...
3.2.1.8) were examined. The two selected α-l-arabinofuranosidases catalyze liberation of arabinose residues linked 1→3 to singly (AF<sub>An</sub>) or doubly (AF<sub>Ba</sub>) substituted xyloses in arabinoxylan, respectively. When added to arabinoxylan at equimolar levels, the AF<sub>Ba</sub> enzyme catalyzed the release of more arabinose, i.e. had a higher rate constant than AF<sub>An</sub>, but with respect to the xylose release, AF<sub>An</sub> – as expected – exhibited a better synergistic effect than AF<sub>Ba</sub> with β-xylosidase. This synergistic effect with AF<sub>An</sub> was estimated to increase the number of β-xylosidase catalyzed cuts from ~3 (with β-xylosidase alone) to ~7 in each arabinoxylan substrate molecule. However, the synergistic effects between β-xylosidase and the α-l-arabinofuranosidases on the xylose release were low as compared to the effect of xylanase addition with β-xylosidase, which increased the xylose release by ~25 times in 30min, to a yield equivalent to ~104 β-xylosidase catalyzed cuts in each arabinoxylan substrate molecule. At equimolar addition levels of the four enzymes, the xylanase activity was thus rate-limiting for the β-xylosidase catalyzed depolymerization to release xylose from arabinoxylan. The work provides clues to design efficient enzymatic degradation of arabinoxylan into fermentable monosaccharides.

**General information**

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**Organisations:** Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Danisco AS  
**Authors:** Rasmussen, L. E. (Intern), Xu, C. (Intern), Sørensen, J. (Forskerdatabase), Nielsen, M. K. (Intern), Meyer, A. S. (Intern)  
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Expression and characterization of an endo-1,4-β-galactanase from Emericella nidulans in Pichia pastoris for enzymatic design of potentially prebiotic oligosaccharides from potato galactans

Potato pulp is a high-volume side-stream from industrial potato starch manufacturing. Enzymatically solubilized β-1,4-galactan-rich potato pulp polysaccharides of molecular weights >100kDa (SPPP) are highly bifidogenic in human fecal sample fermentations in vitro. The objective of the present study was to use potato β-1,4-galactan and the SPPP as substrates for enzymatic production of potentially prebiotic compounds of lower and narrower molecular weight. A novel endo-1,4-β-galactanase from Emericella nidulans (anamorph Aspergillus nidulans), GH family 53, was produced in a recombinant Pichia pastoris strain. The enzyme was purified by Cu2+ affinity chromatography and its optimal reaction conditions were determined to pH 5 and 49°C via a statistical experimental design. The specific activity of the E. nidulans enzyme expressed in P. pastoris was similar to that of an endo-1,4-β-galactanase from Aspergillus niger used as benchmark. The E. nidulans enzyme expressed in P. pastoris generated a spectrum poly- and oligo-saccharides which were fractionated by membrane filtration. The potential growth promoting properties of each fraction were evaluated by growth of beneficial gut microbes and pathogenic bacteria. All the galactan- and SPPP-derived products promoted the growth of probiotic strains of Bifidobacterium longum and Lactobacillus acidophilus and generally did not support the propagation of Clostridium perfringens in single culture fermentations. Notably the growth of B. longum was significantly higher (p
The single-step extraction of FCSPs from Sargassum sp. was carried out. The effects of the different extraction parameters on structural properties, yield, and compositional attributes. In this study, statistically designed, optimized extraction of a natural killer cell activity in mice. Tumor activity of crude fucoidan seems to be associated with an enhanced immune response as depicted by an increase in vitro proliferation of Lewis lung carcinoma and melanoma B16 cell lines by induction of apoptosis. Moreover, the anti-acquiring precise quantitative growth data for Ulva lactuca. This study exhibits the applicability of a photoscanning approach for response to different nitrogen-based nutrient sources. The results also showed a favorable growth response to ammonium nitrate. This study proved that unfractionated FCSPs hinder the growth of Lewis lung carcinoma and melanoma B16 cell lines by induction of apoptosis. Moreover, the anti-tumor activity of crude fucoidan seems to be associated with an enhanced immune response as depicted by an increase in natural killer cell activity in mice. The classical extraction of FCSPs involving long, repetitive, multi-step acid and alkaline treatments is detrimental to its structural properties, yield, and compositional attributes. In this study, statistically designed, optimized extraction of a single-step extraction of FCSPs from Sargassum sp. was carried out. The effects of the different extraction parameters on the natural chemical composition of the isolated sulfated polysaccharides were also investigated. The data showed that classical multi-step extraction using ≥0.2 M HCl at elevated temperature and extended time had a detrimental effect on the FCSPs yield, as this treatment apparently disrupted the structural integrity of the polymer and evidently degraded carbohydrate chains of fucose residues during extraction. The results also revealed a maximal FCSPs yield of approximately 7% dry weight with Sargassum sp. using 0.03 M HCl at 90°C and 4-h extraction conditions. Accurate monitoring of the differential growth response of seaweed to nutrient assimilation was also developed. Moreover, to assess the potential of seaweed to assimilate nitrogen-based nutrients, a technology for accurate monitoring of differential seaweed growth responses to nutrient assimilation was also developed. Accurate monitoring of the differential growth response of seaweed to nutrient assimilation is crucial to explore various applications of seaweed resources, such as biomass for bioenergy production and source of functional healthy components and bioactive compounds. A major prerequisite for the successful exploitation of cultivated seaweed like Ulva lactuca for commercial purposes is that the growth rate and yields should be optimized. In this study, the growth response of U. lactuca to ammonium and nitrate assimilation was investigated using a photoscanning technique to monitor the growth kinetics in Ulva lactuca. Photoscanning images revealed differential increases in the surface area of Ulva lactuca discs over time in response to different nitrogen-based nutrient sources. The results also showed a favorable growth response to ammonium as a nitrogen source, and the presence of ammonium discriminated the nitrate uptake by Ulva lactuca upon exposure to ammonium nitrate. This study exhibits the applicability of a photoscanning approach for acquiring precise quantitative growth data for Ulva lactuca. In conclusion, we demonstrated that nuisance seaweed can be a potential source of biomass and bioactive compound notably FCSPs. This study proved the hypotheses that different extraction conditions have crucial influenced to the chemical nature of FCSPs. The study also demonstrated that unfractionated FCSPs are able to exert bioactive actions such as anti-tumor and immune-modulating properties in both in vitro and in vivo studies. This study illustrates the Fucose-containing sulfated polysaccharides from brown seaweed: Extraction technology and bioactivity assessment

Marine seaweed that is washed up on the coastline is a nuisance as its degradation produces a foul smell and generates waste problems. Exploitation of coastline-polluting seaweeds such as Sargassum sp., Ulva sp., and other beach-cast seaweed species for various commercial applications will generate new valuable products that may help lessen coastal pollution by seaweeds and create new seaweed-based resources. Thus, utilization of these natural resources is of great importance. The objectives of this PhD study were to develop a technology to extract bioactive compounds from nuisance brown seaweeds, and investigate their bioactivity. To this effect, designed optimized extraction of fucose-containing sulfated polysaccharides (FCSPs) and/or crude fucoidan from brown seaweed were performed, and the bioactivity of the isolated FCSPs was investigated. Moreover, to assess the potential of seaweed to assimilate nitrogen-based nutrients, a technology for accurate monitoring of differential seaweed growth responses to nutrient assimilation was also developed.

Fucoidan is a term used to describe a class of sulfated polysaccharides extracted from brown seaweed, which contains substantial amounts of fucose; varying amounts of galactose, xylose, and glucuronic acid; and differing glycosidic linkages, and are variously substituted with sulfate and acetyl groups and side branches containing fucose or other glycosyl units. These FCSPs principally consist of a backbone of (1→3)- and/or (1→4)-linked α-L-fucopyranose residues that may be substituted with sulfate (SO3−) on C-2, C-3, or C-4 and acetyl groups at C-4 on the main chain or may have short fucoside side chains that are usually linked from the O-4 of one or several of the fucopyranose backbone residues. FCSPs are known to exhibit crucial biological activities including anti-tumor activity. Although differently extracted, purified, fucose-rich, modified fucoidans have been reported to exert bioactive properties such as anti-coagulant and enhance immune response activity, few studies have investigated the bioactivity of unfractionated FCSPs, notably FCSPs extracted using milder and fewer processing steps. Crude fucoidan from Sargassum sp. and Fucus vesiculosus were examined for their bioactivity against lung and skin cancer cell lines in both in vitro and in vivo studies. This study showed that unfractionated FCSPs hinder the in vitro proliferation of Lewis lung carcinoma and melanoma B16 cell lines by induction of apoptosis. Moreover, the anti-tumor activity of crude fucoidan seems to be associated with an enhanced immune response as depicted by an increase in natural killer cell activity in mice.

The classical extraction of FCSPs involving long, repetitive, multi-step acid and alkaline treatments is detrimental to its structural properties, yield, and compositional attributes. In this study, statistically designed, optimized extraction of a single-step extraction of FCSPs from Sargassum sp. was carried out. The effects of the different extraction parameters on the natural chemical composition of the isolated sulfated polysaccharides were also investigated. The data showed that classical multi-step extraction using ≥0.2 M HCl at elevated temperature and extended time had a detrimental effect on the FCSPs yield, as this treatment apparently disrupted the structural integrity of the polymer and evidently degraded carbohydrate chains of fucose residues during extraction. The results also revealed a maximal FCSPs yield of approximately 7% dry weight with Sargassum sp. using 0.03 M HCl at 90°C and 4-h extraction conditions. Accurate monitoring of the differential growth response of seaweed to different nutrient assimilation is crucial to explore various applications of seaweed resources, such as biomass for bioenergy production and source of functional healthy components and bioactive compounds. A major prerequisite for the successful exploitation of cultivated seaweed like Ulva lactuca for commercial purposes is that the growth rate and yields should be optimized. In this study, the growth response of U. lactuca to ammonium and nitrate assimilation was investigated using a photoscanning technique to monitor the growth kinetics in Ulva lactuca. Photoscanning images revealed differential increases in the surface area of Ulva lactuca discs over time in response to different nitrogen-based nutrient sources. The results also showed a favorable growth response to ammonium as a nitrogen source, and the presence of ammonium discriminated the nitrate uptake by Ulva lactuca upon exposure to ammonium nitrate. This study exhibits the applicability of a photoscanning approach for acquiring precise quantitative growth data for Ulva lactuca.

In conclusion, we demonstrated that nuisance seaweed can be a potential source of biomass and bioactive compound notably FCSPs. This study proved the hypotheses that different extraction conditions have crucial influenced to the chemical nature of FCSPs. The study also demonstrated that unfractionated FCSPs are able to exert bioactive actions such as anti-tumor and immune-modulating properties in both in vitro and in vivo studies. This study illustrates the
importance of a precise monitoring technique of the growth of *U. lactuca* in order to successfully exploit it for commercial application.

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Authors: Ale, M. T. (Intern), Meyer, A. S. (Intern), Mikkelsen, J. D. (Intern)
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In vitro fermentation of sugar beet arabino-oligosaccharides by fecal microbiota obtained from patients with ulcerative colitis to selectively stimulate the growth of *Bifidobacterium* spp. and *Lactobacillus* spp.

The commensal bacteria found in the human gut are important for host health, and an unfavorable composition of the gut microbiota can affect the synergistic interaction that exists between microbes and their host. An altered microbial composition is suggested to play a pivotal role in the pathogenesis of ulcerative colitis (UC), an inflammatory bowel disease, and compositional changes have been observed in the colonic microbiota by us as well as by other research groups 1-3. Since bifidobacteria and lactobacilli may exert anti-inflammatory effects, a reduced level of these commensal bacteria may compromise the colon health and favor intestinal inflammation.

In this study, selective stimulation of fecal bifidobacteria and lactobacilli from healthy subjects and UC patients in remission or with active disease were investigated using arabino-oligosaccharides (AOS; DP2-10) derived from sugar beet pulp. The fermentative-induced changes were compared to those for fructo-oligosaccharides (FOS), which are known to have a prebiotic effect. The fermentation studies were carried out using a validated small-scale static batch system, and changes in the fecal microbial communities and metabolites were monitored after 24 h by quantitative real-time PCR and short-chain fatty acid analysis. With a few minor exceptions, AOS affected the communities similarly to what was seen for FOS. Quantitative real-time PCR revealed that *Bifidobacterium* spp. and *Lactobacillus* spp. were selectively increased after fermentation of AOS or FOS by fecal microbiota derived from UC patients. The stimulation of growth of *Lactobacillus* spp. and *Bifidobacterium* spp. was accompanied by a high production of acetate and hence a decrease of pH. The fermentation of AOS may thus help improve the inflammatory conditions in UC patients through stimulation of bacteria eliciting anti-inflammatory responses and through production of acetate.

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In this study, selective stimulation of fecal bifidobacteria and lactobacilli from healthy subjects and UC patients in remission or with active disease were investigated using arabino-oligosaccharides (AOS; DP2-10) derived from sugar beet pulp. The fermentative-induced changes were compared to those for fructo-oligosaccharides (FOS), which are known to have a prebiotic effect. The fermentation studies were carried out using a validated small-scale static batch system, and changes in the fecal microbial communities and metabolites were monitored after 24 h by quantitative real-time PCR and short-chain fatty acid analysis. With a few minor exceptions, AOS affected the communities similarly to what was seen for FOS. Quantitative real-time PCR revealed that Bifidobacterium spp. and Lactobacillus spp. were selectively increased after fermentation of AOS or FOS by fecal microbiota derived from UC patients. The stimulation of growth of Lactobacillus spp. and Bifidobacterium spp. was accompanied by a high production of acetate and hence a decrease of pH. The fermentation of AOS may thus help improve the inflammatory conditions in UC patients through stimulation of bacteria eliciting anti-inflammatory responses and through production of acetate.

Optimization of reaction parameters for enzymatic glyceride synthesis from fish oil: Ethyl esters versus free fatty acids
Enzymatic conversion of fish oil free fatty acids (FFA) or fatty acid ethyl esters (FAE) into glycerides via esterification or transesterification was examined. The reactions catalyzed by Lipozyme™ 435, a Candida antarctica lipase, were optimized. Influence on conversion yields of fatty acid chain length, saturation degree, temperature, enzyme dosage, molar ratio glycerol:fatty acids, acyl source composition (w/w ratio FFA:FAE), and reaction time was evaluated collectively by multiple linear regression. All reaction variables influenced the conversion into glycerides. Transesterification of FAE produced the highest yields of 94–95% (w/w) conversion yield at 1:3 glycerol:FAE, 25h, 66°C, enzyme dosage 3.1%w/w.

Optimization of reaction parameters for enzymatic glyceride synthesis from fish oil: Ethyl esters versus free fatty acids

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Product inhibition of enzymatic hydrolysis of cellulose: are we running the reactions all wrong?

Enzyme catalyzed deconstruction of cellulose to glucose is an important technology step in lignocellulose-to-ethanol processing as well as in the future biorefinery based production of novel products to replace fossil oil based chemistry. The main goals of the enzymatic biomass saccharification include high substrate conversion (maximal yields), maximal enzyme efficiency, maximal volumetric reactor productivity, minimal equipment investment, minimal size, and short reaction time. The classic batch type STR reactions used for enzymatic cellulose hydrolysis prevent these goals to be fulfilled. This is because the currently used Trichoderma reesei derived cellulases, i.e. exoglucanases (mainly the cellobiohydrolases Cel7A and Cel6A), endo-1,4-β-glucanases, and now boosted with β-glucosidase and other enzymes, now considered the "industry standard" enzymes, are significantly inhibited by the products cellobiose and glucose. The reported KI for glucose on the T. reesei cellulases and β-glucosidase varies from 0.04 to 5 g/L. The type of inhibition is debated, and probably varies for different β-glucosidases, but with a required goal of sufficient glucose concentration to support ethanol concentrations of minimum ~5–6% v/v, the glucose product concentrations exceed the critical limit for product inhibition. Hence, regardless of the recent progress in enzyme development for cellulose hydrolysis, the glucose product inhibition remains an issue, which is exacerbated as the reaction progresses, especially at high substrate loadings in batch reactions. Hence in addition to understanding product inhibition and develop new cellulolytic enzymes that are more resistant to product inhibition, much can be gained from proper reaction design and continuous removal of the product(s) in enzymatic cellulose hydrolysis. Based on cellulose inhibition kinetics the talk will illustrate the suitability of membrane reactor technology for improving cellulose substrate conversion efficiency.
Production of Monascus-like pigments

The present invention relates to a method for producing one or more Monascus-like pigment composition from Penicillium species comprising: a) providing a cultivation medium comprising a high concentration of C-and N-sources and a high C/N molar ratio, b) adjusting pH to about 5 to 8, c) inoculating the cultivation medium with an inoculum of Penicillium to form a cultivation composition; d) cultivating the inoculated cultivation composition of (c); e) separating the one or more produced pigment compositions. The method of the invention may be used for producing Monascus-like pigment compositions for use as colouring agents in food items or non food items. The inventions further relates to Monascus-like pigment composition obtainable by a method of the inventions as well as use of the pigments.

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Authors: Frisvad, J. C. (Intern), Meyer, A. S. (Intern), Mapari, S. S. (Forskerdatabase), Thrane, U. (Intern)
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Rapid near infrared spectroscopy for prediction of enzymatic hydrolysis of corn bran after various pretreatments

Efficient generation of a fermentable hydrolysate is a primary requirement in the utilization of fibrous plant biomass as feedstocks in bioethanol processes. The first biomass conversion step usually involves a hydrothermal pretreatment before enzymatic hydrolysis. The purpose of the pretreatment step is to increase the responsivity of the substrate to enzymatic attack and the type of pretreatment affects the enzymatic conversion efficiency. Destarched corn bran is a fibrous, heteroxylan-rich side-stream from the starch industry which may be used as a feedstock for bioethanol production or as a source of xylose for other purposes. In the present study we demonstrate the use of diffuse reflectance near infrared spectroscopy (NIR) as a rapid and non-destructive analytical tool for evaluation of pretreatment effects on destarched corn bran. NIR was used to achieve classification between 43 differently pretreated corn bran samples using principal component analysis (PCA) and hierarchal clustering algorithms. Quantification of the enzymatically released monosaccharides by HPLC was used to design multivariate calibration models (biPLS) on the NIR spectra. The models could predict the enzymatic release of different levels of arabinose, xylose and glucose from all the differently pretreated destarched corn bran samples. The present study also demonstrates a generic, non-destructive solution to determine the enzymatic monosaccharide release from polymers in biomass side-streams, thereby potentially replacing the cumbersome HPLC analysis.

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Statistical modelling of the interplay between solute shape and rejection in porous membranes

The structural conformation of complex molecules, e.g., polymers and proteins, is determined by several factors like composition of the basic structural units, charge, and properties of the surrounding solvent. In absence of any chemical or physical interaction solute–solute and/or solute–membrane, it can be expected that the possibility for a solute particle to enter the membrane pore will only depend upon the relation between such molecular conformation and pore size. The objective of the present study is to use geometric and statistical modelling to determine the effect of particle elongation – from spherical to being increasingly prolate ellipsoidal – on the possibility of entering the pore, and, in turn, on the macroscopic distribution coefficient, K, and overall retention during filtration. The model showed that the value of K was maximal when the longer of the radii in the prolate ellipsoid was approximately equal to the radius of the pores, in case the spherical size of the particle was smaller than the membrane pore. Furthermore, for spherical particles larger than the pore, such a maximum was found to occur after the smaller of the radii was smaller than the pore radius. Either for spherical particles bigger or smaller than the pore radius, K was monotonically decreasing towards zero as the particles became more elongated. When relating the values of K to the friction model, the maximal rejection coefficient was found to reach a characteristic minimum when changing shape. The results suggested that the retention during porous membrane filtration can be manipulated when working with solute particles prone to alter conformation via, e.g., adding proper functional groups to the molecule, or modifying charge density/distribution by varying pH.

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Organisations: Department of Mathematics, Applied functional analysis, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Dynamical systems, Computer Aided Process Engineering Center, Membrane Technology group
Authors: Vinther, F. (Intern), Pinelo, M. (Intern), Brøns, M. (Intern), Jonsson, G. (Intern), Meyer, A. S. (Intern)
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Strategies for Controlling the Rejection of Charged Oligosaccharides During Ultrafiltration: Modification of Molecular Shape, Operational Pressure and Membrane Cutoff

General information
Thermodynamically based solvent design for enzymatic saccharide acylation with hydroxycinnamic acids in non-conventional media

Enzyme-catalyzed synthesis has been widely studied with lipases (EC 3.1.1.3), but feruloyl esterases (FAEs; EC 3.1.1.73) may provide advantages such as higher substrate affinity and regioselectivity in the synthesis of hydroxycinnamate saccharide esters. These compounds are interesting because of their amphiphilicity and antioxidative potential. Synthetic reactions using mono- or disaccharides as one of the substrates may moreover direct new routes for biomass upgrading in the biorefinery. The paper reviews the available data for enzymatic hydroxycinnamate saccharide ester synthesis in organic solvent systems as well as other enzymatic hydroxycinnamate acylations in ionic liquid systems. The choice of solvent system is highly decisive for enzyme stability, selectivity, and reaction yields in these synthesis reactions. To increase the understanding of the reaction environment and to facilitate solvent screening as a crucial part of the reaction design, the review explores the use of activity coefficient models for describing these systems and – more importantly – the use of group contribution model UNIFAC and quantum chemistry based COSMO-RS for thermodynamic predictions and preliminary solvent screening. Surfactant-free microemulsions of a hydrocarbon, a polar alcohol, and water are interesting solvent systems because they accommodate different substrate and product solubilities and maintain enzyme stability. Ionic liquids may provide advantages as solvents in terms of increased substrate and product solubility, higher reactivity and selectivity, as well as tunable physicochemical properties, but their design should be carefully considered in relation to enzyme stability. The treatise shows that thermodynamic modeling tools for solvent design provide a new toolbox to design enzyme-catalyzed synthetic reactions from biomass sources.

General information
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Organisations: Center for Energy Resources Engineering, BioChemical Engineering, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, CERE – Center for Energy Ressources Engineering, Centre for Catalysis and Sustainable Chemistry, Department of Chemistry
Authors: Zeuner, B. (Intern), Kontogeorgis, G. (Intern), Risager, A. (Intern), Meyer, A. S. (Intern)
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Controlled enzyme catalyzed heteropolysaccharide degradation: Xylans

The work presented in this PhD thesis has provided a better understanding of the enzyme kinetics and quantitative phenomena of the hydrolysis of xylan substrates by selected pure enzyme preparations. Furthermore, the options for producing specific substituted xylooligosaccharides from selected substrates by specific xylanase treatment have been examined. The kinetics of the enzymatic degradation of water-extractable wheat arabinoxylan (WE-AX) during designed treatments with selected monocomponent enzymes was investigated by monitoring the release of xylose and arabinose. The results of different combinations of α-L-arabinofuranosidases (EC 3.2.1.55), one derived from Aspergillus niger (AFAn) and one from Bifidobacterium adolescentis (AFAβ), a β-xylosidase (EC 3.2.1.37) from Trichoderma reesei, and a D11F/R122D variant of an endo-1,4-β-xylanase (EC 3.2.1.8) from Bacillus subtilis (Bsxmut) were examined. The selected arabinofuranosidases catalyze liberation of arabinofuranosyl residues linked 1→3 to singly (AFAn) or doubly (AFAβ) substituted xylopyranosyl in arabinoxylan, respectively. AFAn catalyzed the release of more arabino, i.e. had a higher rate constant than AFAn, when added to arabinoxylan at equimolar levels. With respect to the xylose release, AFAn exhibited a better synergistic effect than AFAβ with β-xylosidase. The differences in the synergistic effect could be related to the different mode of action for the two arabinofuranosidases: AFAn enhanced the probability of more unsubstituted xyloses at (or near) the non-reducing ends for β-xylosidase to attack. AFAn catalyzed the removal of 1→3 linked arabinofuranosyl, but the β-xylosidase still could not work on the xylan backbone, because there was a 1→2 linked arabinofuranosyl blocking the binding site. However, the synergistic effects between -xylosidase and the α-L-arabinofuranosidases on the xylose release were low as compared to the effect of xylanase addition with β-xylosidase, which increased the xylose release by ~25 times in 30 minutes. At equimolar addition levels of the four enzymes, the xylanase activity was thus rate-limiting for the -xylosidase catalyzed depolymerization to release xylose from arabinoxylan. Thus, the provision of more (unsubstituted) non-reducing ends resulting from xylanase action was more efficient to boost the -xylosidase activity than provision of more (randomly) unsubstituted xyloses in the arabinoxylan backbone. The kinetics and substrate selectivity of the B. subtilis wildtype xylanase, BsX, which is sensitive to inhibition by TAXI, and the engineered variant, BsXmut, which is much less inhibited by TAXI, was examined in order to elucidate the influence of the structural point mutations. Three dimensional structures of both xylanases were superimposed to elucidate the structural basis for differences in their hydrolytic properties. The comparison showed that the D11F mutation appeared to cause a slight narrowing of the entrance to the active site cleft because the phenylalanine was more bulky than the aspartic acid. The two xylanases were incubated individually with WEAX, water-unextractable arabinoxylan (WUAX), birchwood xylan, and wheat bran, respectively. At equimolar addition, the activity of BsXmut was lower than that of BsX with respect to both the initial rate and the product yields obtained after prolonged reaction on the xylan substrates. The lower activity could be related to steric hindrance caused by the D11F mutation. The calculated substrate selectivity factors indicated that BsX and BsXmut both had higher catalytic rate on WUAX than on WEAX. Addition of a 100:1 (TAXI:xylanase) molar ratio of the inhibitor confirmed the significantly decreased inhibition of BsXmut by TAXI. Addition of TAXI also influenced the xylanases’ selectivity factor differently. In order to assess the heterogenous structure of the substrate matrix and the change occurring during the xylanolytic reaction, the possibilities for using high-performance size exclusion chromatography (HPSEC) as a quantitative method to assess xylo-oligosaccharide profiles was examined. HPSEC is a widely used method for the qualitative profiling of oligosaccharide mixtures. A novel method employing HPSEC for the quantitative analytical profiling of the progress of enzymatic hydrolysis of different xylan substrates was developed. The method relies on dividing the HPSEC elution profiles into fixed time intervals and utilizing the linear refractive index response (area under the curve) of defined standard compounds. In order to obtain optimal high-performance size exclusion chromatography profiles, the method was designed using 0.1 M CH₃COONa in both the mobile phase and as the sample solution. This was based on the systematic evaluation of the influence of the mobile phase, including the type, ionic strength and pH, on the refractive index detector response. A time study of the enzyme catalyzed hydrolysis of birchwood xylan and wheat bran by BsX was used as an example to demonstrate the workability of the new HPSEC method for obtaining progress curves describing the evolution in the product profile during enzyme catalysis. Flaxseed mucilage (FM) has recently been reported to contain an interesting structure, notable a mixture of highly doubly substituted arabinoxylan as well as rhamnogalacturonan I (RGI) with unusual side group substitutions. This substrate was therefore evaluated as a potential substrate for the production of xylo-oligosaccharides catalyzed by BsX. Treatment of FM with BsX resulted in limited depolymerization, but when BsX and FM were incubated together on WE-AX, WUAX and birchwood xylan, significant amounts of xylose were released. Moreover, arabinose was released from both WE-AX and WU-AX. Since no xylose or arabinose was released by Bh addition alone on these substrates, nor without FM or Bh addition, the results indicate the presence of endogenous β-D-xylosidase and α-Larabinofuranosidase activities in FM. FM also exhibited activity on both p-nitrophenyl α-Larabinofuranoside (pNPa) and p-nitrophenyl β-D-xylopyranoside (pNPX). The potential of producing glucurono-xylo-oligosaccharides (GXOS) from wheat bran via specific treatment with BsXmut was investigated. After the enzyme catalyzed hydrolysis by BsXmut, the GXOS were isolated by anion exchange chromatography and the fractions obtained were analyzed for the presence of uronic acid, and by High Performance Anion Exchange Chromatography (HPEC) and LC/MS for structural verification. Since phosphate also co-eluted during the anion exchange chromatography, the amount of phosphate in the fractions was also determined. LC/MS analysis showed that GXOS was isolated from wheat bran but an even larger amount of RGI was present in the obtained samples together with phosphate. Therefore, further purification has to be made in order to obtain GXOS.
Enzymatic hydrolysis of corn bran arabinoxylan: - theory versus practice

This thesis concerns enzymatic hydrolysis of corn bran arabinoxylan. The work has focused on understanding the composition and structure of corn bran with specific interest in arabinoxylan with the main purpose of targeting enzymatic hydrolysis for increased yields. Corn bran has been used as a model substrate because it represents a readily available agroindustrial side product with upgrading potentials. Corn bran originates from the wet-milling process in corn starch processing, is the outmost layers of the corn kernel and is particularly rich in pentose monosaccharides comprising the major components of arabinoxylan. Corn bran is one of the most recalcitrant cereal byproducts with arabinoxylans of particular heterogeneous nature. It is also rich in feruloyl derived substitutions, which are responsible for extensive cross-linking between arabinoxylan molecules and thereby participate in a complex and rigid cell wall structure. This thesis contains a thorough examination of the monosaccharide and structural composition of corn bran, which is used to assess and apply the relevant mono component enzyme preparations. In this way, the aim is to obtain the most effective minimal enzymatic requirements for hydrolyzing corn bran. The off set of the work has been a basic set of four hemicellulases consisting of an endo-β-1,4-xylanase (GH10 from H. insolens), a β-xylanosidase (GH3 from T. reesei) and two α-L-arabinofuranosidases (GH43 and GH51 from H. insolens and M. giganteus respectively). This set of enzymes have proven efficient in degrading arabinoxylan structures from wheat arabinoxylan and it is also verified in this study that it probably is among the best available hemicellulases for increasing the hydrolysis of corn bran arabinoxylan at present. This set of enzymes creates a solid starting point for hydrolysis of the arabinoxylan structure but is not alone capable of catalyzing complete hydrolysis. Auxiliary enzyme activities that catalyse the hydrolysis of various substitutions are also necessary and several of such enzymes are investigated. This results in the identification of a suitable feruloyl esterase from A. niger (FAE-III) for catalyzing the release of free ferulic acid and diferulic acids to a certain extent. Furthermore, a novel acetyl xylan esterase from Flavolaschia sp. is also found to be important for obtaining higher release of xylose from the arabinoxylan structure. Structural analysis of a soluble fraction of corn bran also confirms the presence of highly acetylated pento-oligosaccharides. All these enzymes together with a commercial cellulase preparation (Cellic™ CTec) are capable of catalyzing the release of up to 36% xylose from a soluble fraction of hydrothermally pretreated corn bran. Yet enzymatic hydrolysis of corn bran is far from complete and in order to improve the yields, this thesis has thoroughly investigated the need and impact of different pretreatment conditions. Corn bran is a special substrate when it comes to pretreatment conditions because the biomass is mainly composed by heat, acid and alkaline linkages in arabinoxylan. It therefore becomes a balancing task to find optimum conditions that compromise the advantages and disadvantages. Acidic pretreatments (pH 1.5-2) are found to be particularly effective in promoting the enzymatic hydrolysis, especially with respect to xylose and glucose release, but vast amounts of the valuable monosaccharides are lost during this pretreatment and this is especially evident for arabinose. From a scientific point of view acid catalysed pretreatment renders the substrate in a state of disruption where assessment of correct enzyme administration becomes difficult and enzymatic hydrolysis becomes a secondary route to disintegration. Alkaline pretreatments are less efficient in promoting the enzymatic hydrolysis, but still serve an academic purpose because those conditions chemically remove diferulate cross-linkings between arabinoxylans, which have been believed to be a major obstical for enzymatic hydrolysis. The chemical removal of these cross-links allows for the interpretation of hindering effects of cross-linking and it is concluded that they do not pose a significant barrier for enzymatic hydrolysis. By this conclusion a major hypothesis of this thesis is rejected. Because chemically catalysed pretreatments has obvious disadvantages, milder mechanical pretreatments has also be investigated and results show that decreasing the particle size of the insoluble substrate renders it more accessible to enzymatic hydrolysis. The hydrolysis improves with a factor of 3-8 for xylose, arabinose and glucose when comparing the yields in the largest particle size fraction to the yields in the smallest size fraction for native destarched corn bran. This is related to an increased substrate surface area, but it is also observed that different particle size fractions from corn bran are not uniformly composed. The content of monosaccharides varies and results in differences in content and composition of cellulose and arabinoxylan. These differences in biomass composition may very well also be part of the explanation why increased enzymatic hydrolysis is obtained. To further investigate the influence of particle size and other physical parameters on enzymatic hydrolysis, theoretic estimations of how changing particle size influences the enzymatic hydrolysis is made. These estimations point to the observation that other factors than particle size alone governs the enzymatic hydrolysis. It is observed that enzymatic hydrolysis is promoted in certain particle size fractions and inhibited in others. This is likely to be related to the biomass composition. Corn bran is a recalcitrant substrate and complete hydrolysis is not achieved in this thesis. Instead explanations as to what causes the recalcitance are sought and it most likely lies within a combination of factors. Firstly, corn bran has an exceptional rigid and tight exterior that leaves it virtually impenetrable to enzymes. Disruption of this outside structure is important if the hydrolysis is at all to commence. In that sense it is important to obtain a higher understanding of the cell wall matrix, the packing of polysaccharides and how they interact with other polymeric structures in the cell wall, eg proteins and lignin. Especially proteins associated with the cell wall may play a significant role in maintaining cell wall strength and preventing enzymatic hydrolysis. Secondly, the
heterogeneous nature of arabinoxylan from corn bran makes it difficult even for the correct enzymes to catalyse complete hydrolysis as observed for hydrolysis in a soluble corn bran fraction. Once the arabinoxylan structure is free of the cell wall matrix the hydrolysis seem to be restricted due to steric hinderance or lack of additional enzymes to catalyse the hydrolysis of certain unusual bonds. In particular, it is of outmost importance to target arabinosyl substitutions of arabinoxylan and other possible configurations of arabinose, as this in particular may hold part of the reason for corn bran recalcitrance. Generally, increased arabinose release will most likely also lead to increase in the overall release of xylose. Obstructions by heterogeneous arabinoxylan may be overcome by completing the knowledge about corn bran arabinoxylan, which can then lead to the identification of missing, central enzyme activities, and thereby also make the work on corn bran generic. The thesis is based upon the scientific publications produced during the last four years and they represent the development and achievements of this work. To ease the reading the thesis will highlight some of the findings and interpretations from the publications, but also from unpublished work and thereby establish the mindset and progress behind the project.

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Authors: Agger, J. (Intern), Meyer, A. S. (Intern)
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A continuous membrane microbioreactor system for development of integrated pectin modification and separation processes
Evaluation of novel enzyme reactions and reactor systems is often hampered by costs related to obtaining sufficient amounts of enzymes. In this respect, it will be advantageous to assess new enzymatic processes in microbioreactors designed to resemble genuine reactor systems. In this work, we present a continuous membrane microbioreactor prototype for development of enzyme catalyzed degradation of pectin. Membrane reactors are becoming increasingly important for the novel ‘biorefining’ type of processes that either require product removal to avoid product inhibition or rest on partial hydrolysis of the substrate to obtain e.g. value-added oligosaccharides from complex biopolymers. The microbioreactor prototype was fabricated from poly(methylmethacrylate) (PMMA) and poly(dimethylsiloxane) (PDMS) and designed as a loop reactor (working volume approximately 190μL) integrated with a regenerated cellulose membrane for separation of low molecular weight products. The main technical considerations and challenges related to establishing the continuous membrane microbioreactor are discussed. The workability of the prototype was validated by comparing the process data at microscale to those obtained using a lab-scale membrane reactor system. The prototype presented here is easy to handle, has a low complexity – thus a relatively simple fabrication process – and can be used to study extended enzymatic reactions.

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BFI (2017): BFI-level 2
Activity and stability of feruloyl esterase A from Aspergillus niger in ionic liquid systems

Feruloyl esterases (FAEs; EC 3.1.1.73) are accessory plant cell wall-degrading enzymes, which catalyse the hydrolysis of the ester bond between ferulic acid and the monosaccharide to which it is covalently linked. FAEs can however also be brought to catalyse the (trans)esterification reaction in solvents that favour synthesis over hydrolysis, i.e. systems with low water content such as organic solvents or ionic liquids (ILs). The esterification of sinapic acid with glycerol catalysed by FAE A from Aspergillus niger (AnFaeA) in a series of ILs containing 15% (v/v) buffer showed that AnFaeA stability – and hence activity – was highly dependent on the anion nature: AnFaeA was stable and active for more than 2 hours in [PF6]−-based ILs, but rapidly lost activity in [BF4]−-based systems. This effect can be explained in terms of hydrogen bonding capacity of the two anions: As predicted by the quantum chemistry-based COSMO-RS method, [BF4]- has a tendency to form hydrogen bonds and thus interfere with the secondary structure of the enzyme, while [PF6]-is unlikely to form hydrogen bonds and therefore does not cause denaturation of the enzyme. Similar results have been obtained for lipases [1], but this is the first report on FAE stability in ILs [2]. COSMO-RS, which is now widely used for solvent screening in the complex IL systems [3], may be a valuable tool for fast enzyme stability predictions and/or solvent screening in the future.
**Advances in the effective application of membrane technology in the food industry**

This chapter focuses on the recent advances in the use of membrane technology for efficient separation and concentration of solutes in the dairy and fruit juice industry, as well as in the purification of bioactive compounds to be used as food additives. The importance of fouling reduction is emphasized because this is necessary for membrane processes to become economically feasible.

**A framework for model-based optimization of bioprocesses under uncertainty: Identifying critical parameters and operating variables**

This study presents the development and application of a systematic model-based framework for bioprocess optimization, evaluated on a cellulosic ethanol production case study. The implementation of the framework involves the use of dynamic simulations, sophisticated uncertainty analysis (Monte-Carlo technique) and sensitivity analysis (such as global techniques). The results of the case study point towards the enzyme loading as the most significant variable influencing the operational cost of additives in the conversion of lignocellulose to ethanol. Moreover, the results also show that there is an opportunity for further process optimization of bioethanol production from lignocellulose.
A framework for model-based optimization of bioprocesses under uncertainty: Identifying critical parameters and operating variables

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Authors: Morales Rodriguez, R. (Intern), Meyer, A. S. (Intern), Gernaey, K. (Intern), Sin, G. (Intern)
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A Framework for Optimization of Bioprocess Operation under Uncertainties: A lignocellulosic Ethanol Production Case Study

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Authors: Morales Rodriguez, R. (Intern), Mauricio Iglesias, M. (Intern), Meyer, A. S. (Intern), Gernaey, K. (Intern), Sin, G. (Intern)
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A Laboratory Exercise To Understand the Importance of Enzyme Technology in the Fruit-Processing Industry: Viscosity Decrease and Phenols Release from Apple Mash

In a 4-h laboratory exercise, students accomplish a series of enzymatic macerations of apple mash, assess the viscosity of the mash during the maceration, extract the juice by centrifugation, and measure the levels of antioxidant phenols extracted into the juice after different enzyme treatments. The exercise shows the impact of enzyme-catalyzed plant cell-wall degradation on the viscosity of apple fruit mash and on the extraction of antioxidant phenols into experimentally prepared apple juice. The exercise also demonstrates that pectinolytic and cellulolytic enzymes have different effects on the viscosity of apple mash. Depending on the academic skills and background of the students, various aspects of quantitative enzyme activity assessment and advanced data analysis of decay curves can be included in the postexercise discussions and reporting of the data.
A Mathematical Model for Simultaneous Saccharification and Co-fermentation (SSCF) of C6 and C5 Sugars
Reliable production of biofuels and specifically bioethanol has attracted a significant amount of research recently. Within this context, this study deals with dynamic simulation of bioethanol production processes and in particular aims at developing a mathematical model for describing simultaneous saccharification and co-fermentation (SSCF) of C6 and C5 sugars. The model is constructed by combining existing mathematical models for enzymatic hydrolysis and co-fermentation. An inhibition of ethanol on cellulose conversion is introduced in order to increase the reliability. The mathematical model for the SSCF is verified by comparing the model predictions with experimental data obtained from the ethanol production based on kraft paper mill sludge. When fitting the model to the data, only the yield coefficients for glucose and xylose metabolism were fine-tuned, which were found to be 0.43 g·g⁻¹ (ethanol/glucose) and 0.35 g·g⁻¹ (ethanol/xylose) respectively. These promising validation results encourage further model application to evaluate different process configurations for lignocellulosic bioethanol technology.

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Web of Science (2016): Indexed yes
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BFI (2014): BFI-level 1
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Scopus rating (2010): SJR 0.493 SNIP 0.747
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Web of Science (2008): Indexed yes
The objective of this paper is to assess if a membrane microbioreactor system could potentially be used to diagnose consequences of different process design and reactor operation options relevant for larger-scale enzymatic degradation of pectin reactions. The membrane microbioreactor prototype was fabricated from poly(methylmethacrylate) (PMMA) and poly(dimethylsiloxane) (PDMS) with a working volume of ∼190 μL. The prototype also contained the necessary sensors and actuators, i.e., pressure transducer, mixing via magnetic stirrer bar and a temperature controller. The functionality of the prototype was demonstrated by performing a continuous enzymatic degradation of pectin experiment for a range of reactor conditions: different membrane molecular weight cutoff (MWCO) values, enzyme-to-substrate ratios (E/S), and substrate feeding rates (F) were assessed. Based on the experimental data, it was found that the apparent reaction rate increased from 0.11 μmol/h to 0.13 μmol/h when the E/S ratio was doubled from 0.2% (g/g) to 0.4% (g/g). In contrast, when the substrate feeding rate was reduced from 200 μL/h to 100 μL/h (i.e., longer residence time), a higher yield was achieved (producing a pectin fragment concentration of 0.82 mM in the permeate) and the apparent reaction rate increased by ∼50% (i.e., from 0.11 μmol/h to 0.17 μmol/h). Clearly, this signifies that the substrate feeding rate is a critical variable that influences the conversion rate and the process yield. The data also showed that the process design affected the membrane rejection profile. The results obtained thus underlined the suitability of a miniature membrane reactor system for evaluating different process design options that are relevant for larger-scale reactions of enzymatic pectin degradation.
An integral analysis for second generation bioethanol production via a dynamic model-based simulation approach: stochastic nonlinear optimisation

There are different technological routes to biofuels production such as, biohydrogen, biomethane, biobutanol, among others. Bioethanol production from lignocellulosic feedstock has acquired special attention, and its feasibility has been demonstrated at laboratory, pilot and demo-plant scale[1,2,3]. Despite the reported progress and the promising results, however, at present this technology is not cost-competitive compared with first generation bioethanol production or fossil-fuels. Therefore, there is further room for optimisation of the technology and improvement of its cost-effectiveness. The objective of this study is to perform an integral analysis for bioethanol production from lignocellulosic feedstock using a rigorous dynamic modelling approach for the whole process. The bioethanol production includes different sections such as, pre-treatment of the substrate, enzymatic hydrolysis of cellulose, co-fermentation of sugars and downstream processes for purification and recovery of most value-added products. The dynamic model involves both the mass and energy balances coupled with constitutive dynamic equations to assess the process yield and energy efficiency of different bioethanol processes. This study employs the Dynamic Lignocellulosic Bioethanol (DLB 1.0) modelling platform[4], which has demonstrated to describe accurately the dynamics of the pre-treatment, enzymatic hydrolysis and co-fermentation. Moreover, DLB 1.0 is complemented by downstream process models. The results will show and provide further analysis for 2G bioethanol production, aiming to decrease and find a competitive bioethanol production cost that recently was set on $2.35 USD/gallon[5]. Thus, the application of the constructed modelling platform will allow and support the analysis and search of a more reliable and feasible bioethanol production route.

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Definition and characterization of enzymes for maximal biocatalytic solubilization of prebiotic polysaccharides from potato pulp

Potato pulp is a high-volume co-processing product resulting from industrial potato starch manufacturing. Potato pulp is particularly rich in pectin, notably galactan branched rhamnogalacturonan I polysaccharides, which are highly bifidogenic when solubilized. The objective of the present study was to characterize and compare four homogalacturonan degrading enzymes capable of catalyzing the required solubilization of these pectinaceous polysaccharides from potato pulp in a 1min reaction. An additional purpose was to assess the influence of the pH and the potential buffer chelating effects on the release of these polysaccharides from the potato pulp. The pH and temperature optima of two selected pectin lyases from Emericella nidulans (formerly known as Aspergillus nidulans) and Aspergillus niger were determined to 8.6 and 4.0, respectively, at ≥100°C within 1min of reaction. The optima for the two selected polygalacturonases from E. nidulans and Aspergillus aculeatus were determined to pH 4.4 and 46°C, and pH 3.7 and ≥80°C, respectively. The polygalacturonase from A. aculeatus was 4–42 times more heat-resistant than the other enzymes. The difference in pH optima of the pectin lyases and the exceptional thermal stabilities of some of the enzymes are proposed to be related to specific amino acid substitutions, stabilizing hydrogen bonding and structural traits of the enzymes. The KM and Vmax values ranged from 0.3–0.6g/L and 0.5–250.5U/mg protein, respectively. Phosphate buffer induced release of a higher amount of dry matter than Tris–acetate buffer at pH 6, indicating a chelating effect of the phosphate. Moreover, the phosphate had a higher chelating effect at pH 6 than at pH 4. The optimal conditions for a high yield of polysaccharides from potato pulp were therefore: 1% (w/w) potato pulp treated with 1% (w/w) enzyme/substrate (E/S) pectin lyase from E. nidulans and 1% (w/w) E/S polygalacturonase from A. aculeatus at pH 6.0 and 60°C for 1min.

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Journal: Enzyme and Microbial Technology
Dependency of the hydrogen bonding capacity of the solvent anion on the thermal stability of feruloyl esterases in ionic liquid systems

Three feruloyl esterases, EC 3.1.1.73, (FAEs), namely FAE A from Aspergillus niger (AnFaeA), FAE C from Aspergillus nidulans (AndFaeC), and the FAE activity in a commercial β-glucanase mixture from Humicola insolens (Ultraflo L) were tested for their ability to catalyse esterification of sinapic acid with glycerol in four ionic liquid (IL) systems. The IL systems were systematically composed of two selected pairs of cations and anions, respectively: [BMIm][PF6], [C2OHMIm][PF6], [BMIm][BF4], and [C2OHMIm][BF4]. AnFaeA had activity in [PF6]–based ILs, whereas the AndFaeC and the FAE in Ultraflo L had no appreciable activities and were generally unstable in the IL systems. FAE stability in the IL systems was apparently highly dependent on enzyme structure, and notably AnFaeA’s similarity to IL-compatible lipases may explain its stability. The thermal stability of AnFaeA was higher in buffer than in the IL systems, but at 40 °C and below there was no significant difference in AnFaeA stability between the buffer and the [PF6]–based systems: AnFaeA was stable in the [BMIm][PF6] and [C2OHMIm][PF6] systems for 2 h at 40 °C. However, the IL anion had a major effect on stability: [BF4]–caused rapid inactivation of AnFaeA, while [PF6]–did not. The cation did not have a similar effect. These observations could be explained in terms of the hydrogen bonding capacity of IL cations and anions via COSMO-RS simulations.

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Scopus rating (2016): CiteScore 8.86 SJR 2.564 SNIP 2.019
Web of Science (2016): Indexed yes
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.398 SNIP 2.007 CiteScore 8.05
Web of Science (2014): Indexed yes
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Differential growth response of Ulva lactuca to ammonium and nitrate assimilation

Controlled cultivation of marine macroalgal biomass such as Ulva species, notably Ulva lactuca, is currently studied for production of biofuels or functional food ingredients. In a eutrophic environment, this macrophyte is exposed to varying types of nutrient supply, including different and fluctuating levels of nitrogen sources. Our understanding of the influences of this varying condition on the uptake and growth responses of U. lactuca is limited. In this present work, we examined the growth response of U. lactuca exposed to different sources of nitrogen (NH4+; NO3−; and the combination NH4NO3) by using photo-scanning technology for monitoring the growth kinetics of U. lactuca. The images revealed differential increases of the surface area of U. lactuca disks with time in response to different N-nutrient enrichments. The results showed a favorable growth response to ammonium as the nitrogen source. The NH4Cl and NaNO3 rich media (50 μM of N) accelerated U. lactuca growth to a maximum specific growth rate of 16.4 ± 0.18% day−1 and 9.4 ± 0.72% day−1, respectively. The highest biomass production rate obtained was 22.5 ± 0.24 mg DW m−2·day−1. The presence of ammonium apparently discriminated the nitrate uptake by U. lactuca when exposed to NH4NO3. Apart from showing the significant differential growth response of U. lactuca to different nitrogen sources, the work exhibits the applicability of a photo-scanning approach for acquiring precise quantitative growth data for U. lactuca as exemplified by assessment of the growth response to two different N-sources.

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Web of Science (2018): Indexed yes
In this study a number of different process flowsheets were generated and their feasibility evaluated using simulations of dynamic models. A dynamic modeling framework was used for the assessment of operational scenarios such as, fed-batch, continuous and continuous with recycle configurations. Each configuration was evaluated against the following benchmark criteria, yield (kg ethanol/kg dry-biomass), final product concentration and number of unit operations required in the different process configurations. The results show that simultaneous saccharification and co-fermentation (SSCF) operating in continuous mode with a recycle of the SSCF reactor effluent, results in the best productivity of bioethanol among the proposed process configurations, with a yield of 0.18 kg ethanol/kg dry-biomass.
Scopus rating (2002): SJR 0.882 SNIP 1.3
Web of Science (2002): Indexed yes
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Scopus rating (2000): SJR 0.464 SNIP 1.049
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Extraction and Bioactivity assessment of Fucoidan from Brown seaweed
Fucoidan is a term used for a class of sulfated, fucose rich, polysaccharides extracted from brown seaweeds. These fucose-containing sulfated polysaccharides (FCSPs) principally consist of a backbone of (1→3)- and (1→4)- α-linked -L-fucopyranose residues, that may be organized in stretches of (1→3)-α-fucan or of alternating α(1→3)- and α(1→4)-bonded L-fucopyranose residues with sulfate on C-2 or C-4 and rarely on C-3. A range of biological activities have been attributed to FCSPs including anti-tumoral, anti-viral, anti-inflammatory, and notably anticoagulant effects. Therefore special interest for potential pharmaceutical, medical, cosmetics and food applications of FCSPs and/or Fucoidan. Therefore special interest for potential pharmaceutical, medical, cosmetics and food applications of FCSPs and/or Fucoidan.
Keyword: Fucoidan, extraction, seaweed, anti-cancer, bioactivity

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Feruloylated and Nonferuloylated Arabino-oligosaccharides from Sugar Beet Pectin Selectively Stimulate the Growth of Bifidobacterium spp. in Human Fecal in Vitro Fermentations

The side chains of the rhamnogalacturonan I fraction in sugar beet pectin are particularly rich in arabinan moieties, which may be substituted with feruloyl groups. In this work the arabinan-rich fraction resulting from sugar beet pulp based pectin production was separated by Amberlite XAD hydrophobic interaction and membrane separation into four fractions based on feruloyl substitution and arabinono-oligosaccharide chain length: short-chain (DP 2–10) and long-chain (DP 7–14) feruloylated and nonferuloylated arabinono-oligosaccharides, respectively. HPAEC, SEC, and MALDI-TOF/TOF analyses of the fractions confirmed the presence of singly and doubly substituted feruloylated arabinono-oligosaccharides in the feruloyl-substituted fractions. In vitro microbial fermentation by human fecal samples (n = 6 healthy human volunteers) showed a selective stimulation of bifidobacteria by both the feruloylated and the nonferuloylated long-chain arabinono-oligosaccharides to the same extent as the prebiotic fructo-oligosaccharides control. None of the fractions stimulated the growth of the potential pathogen Clostridium difficile in monocultures. This work provides a first report on the separation of potentially bioactive feruloylated arabinono-oligosaccharides from sugar beet pulp and an initial indication of the potentially larger bifidogenic effect of relatively long-chain arabinono-oligosaccharides as opposed to short-chain arabinono-oligosaccharides.
Fucoidan from Sargassum sp. and Fucus vesiculosus reduces cell viability of lung carcinoma and melanoma cells in vitro and activates natural killer cells in mice in vivo

Fucoidan is known to exhibit crucial biological activities, including anti-tumor activity. In this study, we examined the influence of crude fucoidan extracted from Sargassum sp. (MTA) and Fucus vesiculosus (SIG) on Lewis lung carcinoma cells (LCC) and melanoma B16 cells (MC). In vitro studies were performed using cell viability analysis and showed that SIG and MTA fucoidans significantly decreased the viable number of LCC and MC cells in a dose-response fashion. Histochemical staining showed morphological changes of melanoma B16 cells after exposure to fucoidan. The observed changes were indicative of crude fucoidan induced apoptosis. Male C57BL/6JCL mice were subjected to daily i.p. injections over 4 days with either SIG or MTA fucoidan (50 mg/kg body wt.). The cytolytic activity of natural killer (NK) cells was enhanced by crude fucoidan in a dose-dependent manner as indicated by 51Cr labeled YAC-1 target cell release.

This study provides substantial indications that crude fucoidan exerts bioactive effects on lung and skin cancer model cells in vitro and induces enhanced natural killer cell activity in mice in vivo.

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Fucose-Containing Sulfated Polysaccharides from Brown Seaweeds Inhibit Proliferation of Melanoma Cells and Induce Apoptosis by Activation of Caspase-3 in Vitro

Fucose-containing sulfated polysaccharides (FCSPs) extracted from seaweeds, especially brown macro-algae, are known to possess essential bioactive properties, notably growth inhibitory effects on tumor cells. In this work, we conducted a series of in vitro studies to examine the influence of FCSPs products from Sargassum henslowianum C. Agardh (FSAR) and Fucus vesiculosus (FVES), respectively, on proliferation of melanoma B16 cells and to investigate the underlying apoptosis promoting mechanisms. Cell viability analysis showed that both FCSPs products, i.e., FSAR and FVES, decreased the proliferation of the melanoma cells in a dose-response fashion, with FSAR being more potent at lower dosages, and FVES being relatively more anti-proliferative than FSAR at higher dosages. Flow cytometric analysis by Annexin V staining of the melanoma cells exposed to the FCSPs products confirmed that both FSAR and FVES induced apoptosis. The FCSPs-induced apoptosis was evidenced by loss of plasma membrane asymmetry and translocation of the cell membrane phospholipids and was accompanied by the activation of caspase-3. The FCSPs bioactivity is proposed to be attributable to distinct structural features of the FCSPs, particularly the presence of sulfated galactofucans (notably in S. henslowianum) and sulfated fucans (notably in F. vesiculosus). This study thus indicates that unfractionated FCSPs may exert bioactive effects on skin cancer cells via induction of apoptosis through cascades of reactions that involve activation of caspase-3.
Identification, expression, and characterization of a novel bacterial RGI Lyase enzyme for the production of bio-functional fibers

A gene encoding a putative rhamnogalacturonan I (RGI) Lyase (EC 4.2.2.-) from Bacillus licheniformis (DSM13) was selected after a homology search and phylogenetic analysis and optimized with respect to codon usage. The designed gene was transformed into Pichia pastoris and the enzyme was produced in the eukaryotic host with a high titer in a 5l bioreactor. The RGI Lyase was purified by Cu2+ affinity chromatography and 1.1g pure enzyme was achieved pr. L. When the denatured protein was deglycosylated with EndoH, the molecular weight of the protein decreased to 65kDa, which correlated with the predicted molecular weight of the mature RGI Lyase of 596 amino acids. By use of a statistical design approach, with potato rhamnogalacturonan as the substrate, the optimal reaction conditions for the RGI Lyase were established to be: 61°C, pH 8.1, and 2mM of both Ca2+ and Mn2+ (specific activity 18.4U/mg; KM 1.2mg/ml). The addition of both Ca2+ and Mn2+ was essential for enzyme activity. The enzyme retained its catalytic activity at higher temperatures and the enzyme has a half life at 61°C of 15min. The work thus demonstrated the workability of in silico based screening coupled with a synthetic biology approach for gene synthesis for identification and production of a thermostable enzyme.
Seaweeds—or marine macroalgae—notably brown seaweeds in the class Phaeophyceae, contain fucoidan. Fucoidan designates a group of certain fucose-containing sulfated polysaccharides (FCSPs) that have a backbone built of (1→3)-linked α-L-fucopyranosyl or of alternating (1→3)- and (1→4)-linked α-L-fucopyranosyl residues, but also include sulfated galactofucans with backbones built of (1→6)-β-D-galacto- and/or (1→2)-β-D-mannopyranosyl units with fucose or fucogalactosaccharide branching, and/or glucuronic acid, xylose or glucose substitutions. These FCSPs offer several potentially beneficial bioactive functions for humans. The bioactive properties may vary depending on the source of seaweed, the compositional and structural traits, the content (charge density), distribution, and bonding of the sulfate substitutions, and the purity of the FCSP product. The preservation of the structural integrity of the FCSP molecules essentially depends on the extraction methodology which has a crucial, but partly overlooked, significance for obtaining the relevant structural features required for specific biological activities and for elucidating structure-function relations. The aim of this review is to provide information on the most recent developments in the chemistry of fucoidan/FCSPs emphasizing the significance of different extraction techniques for the structural composition and biological activity with particular focus on sulfate groups.
In Vitro Fermentation of Sugar Beet Arabino-Oligosaccharides by Fecal Microbiota Obtained from Patients with Ulcerative Colitis To Selectively Stimulate the Growth of Bifidobacterium spp. and Lactobacillus spp.

The potential prebiotic properties of arabino-oligosaccharides (AOS) derived from sugar beet pulp was studied using mixed cultures of human fecal bacteria from patients with ulcerative colitis (UC), in remission or with active disease, and in healthy controls. These results were compared to those for fructo-oligosaccharides (FOS), which are known to have a prebiotic effect. Fermentation studies were carried out using a small-scale static batch system, and changes in the fecal microbial communities and metabolites were monitored after 24 h by quantitative real-time PCR and short-chain fatty acid analysis. With a few minor exceptions, AOS affected the communities similarly to what was seen for FOS. Quantitative real-time PCR revealed that Bifidobacterium spp. and Lactobacillus spp. were selectively increased after fermentation of AOS or FOS by fecal microbiota derived from UC patients. The stimulation of growth of Lactobacillus spp. and Bifidobacterium spp. was accompanied by a high production of acetate and hence a decrease of pH. The fermentation of AOS may help improve the inflammatory conditions in UC patients through stimulation of bacteria eliciting anti-inflammatory responses and through production of acetate. AOS may therefore represent a new prebiotic candidate for reduction of the risk of flare-ups in UC patients. However, human trials are needed to confirm a health-promoting effect.

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Kinetics of enzyme-catalyzed cross-linking of feruloylated arabinan from sugar beet

Ferulic acid (FA) groups esterified to the arabinan side chains of pectic polysaccharides can be oxidatively crosslinked in vitro by horseradish peroxidase (HRP) catalysis in the presence of hydrogen peroxide (H2O2) to form ferulic acid dehydrodimers (diFAs). The present work investigated whether the kinetics of HRP catalyzed cross-linking of FA esterified to α-(1,5)-linked arabinans are affected by the length of the arabinan chains carrying the feruloyl substitutions. The kinetics of the HRP-catalyzed cross-linking of four sets of arabinan samples from sugar beet pulp, having different molecular weights and hence different degrees of polymerization, were monitored by the disappearance of FA absorbance at 316 nm. MALDI-TOF/TOF-MS analysis confirmed that the sugar beet arabinans were feruloyl-substituted, and HPLC analysis verified that the amounts of diFAs increased when FA levels decreased as a result of the enzymatic oxidation treatment with HRP and H2O2. At equimolar levels of FA (0.0025–0.05 mM) in the arabinan samples, the initial rates of the HRP-catalyzed cross-linking of the longer chain arabinans were slower than those of the shorter chain arabinans. The lower initial rates may be the result of the slower movement of larger molecules coupled with steric phenomena, making the required initial reaction of two FAs on longer chain arabinans slower than on shorter arabinans.
Low temperature lignocellulose pretreatment: effects and interactions of pretreatment pH are critical for maximizing enzymatic monosaccharide yields from wheat straw

Background: The recent development of improved enzymes and pentose-using yeast for cellulosic ethanol processes calls for new attention to the lignocellulose pretreatment step. This study assessed the influence of pretreatment pH, temperature, and time, and their interactions on the enzymatic glucose and xylose yields from mildly pretreated wheat straw in multivariate experimental designs of acid and alkaline pretreatments. Results: The pretreatment pH was the most significant factor affecting both the enzymatic glucose and xylose yields after mild thermal pretreatments at maximum 140 degrees C for 10 min. The maximal enzymatic glucose and xylose yields from the solid, pretreated wheat straw fraction were obtained after pretreatments at the most extreme pH values (pH 1 or pH 13) at the maximum pretreatment temperature of 140 degrees C. Surface response models revealed significantly correlating interactions of the pretreatment pH and temperature on the enzymatic liberation of both glucose and xylose from pretreated, solid wheat straw. The influence of temperature was most pronounced with the acidic pretreatments, but the highest enzymatic monosaccharide yields were obtained after alkaline pretreatments. Alkaline pretreatments also solubilized most of the lignin. Conclusions: Pretreatment pH exerted significant effects and factor interactions on the enzymatic glucose and xylose releases. Quite extreme pH values were necessary with mild thermal pretreatment strategies (T

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Authors: Pedersen, M. (Intern), Johansen, K. S. (Ekstern), Meyer, A. S. (Intern)
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Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 2.414 SNIP 1.722 CiteScore 5.86
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.17 SNIP 1.815 CiteScore 6.21
Maximal release of highly bifidogenic soluble dietary fibers from industrial potato pulp by minimal enzymatic treatment

Potato pulp is a poorly utilized, high-volume co-processing product resulting from industrial potato starch manufacturing. Potato pulp mainly consists of the tuber plant cell wall material and is particularly rich in pectin, notably galactan branched rhamnogalacturonan I type pectin which has previously been shown to exhibit promising properties as dietary fiber. The objective of this study was to solubilize dietary fibers from potato pulp by a one-step minimal treatment procedure and evaluate the prebiotic potential of the fibers. Statistically designed experiments were conducted to investigate the influence of enzyme type, dosage, substrate level, incubation time, and temperature on the enzyme catalyzed solubilization to define the optimal minimal enzyme treatment for maximal fiber solubilization. The result was a method that within 1 min released 75% [weight/weight (w/w)] dry matter from 1% (w/w) potato pulp treated with 1.0% (w/w) [enzyme/substrate (E/S)] pectin lyase from Aspergillus nidulans and 1.0% (w/w) E/S polygalacturonase from Aspergillus aculeatus at pH 6.0 and 60 °C. Molecular size fractionation of the solubilized fibers revealed two major fractions: one fraction rich in galacturonic acid of 10–100 kDa indicating mainly homogalacturonan, and a fraction >100 kDa rich in galactose, presumably mainly made up of β-1,4-galactan chains of rhamnogalacturonan I. When fermented in vitro by microbial communities derived from fecal samples from three healthy human volunteers, both of the solubilized fiber fractions were more bifidogenic than fructo-oligosaccharides (FOS). Notably the fibers having molecular masses of >100 kDa selectively increased the densities of Bifidobacterium spp. and Lactobacillus spp. 2–3 times more than FOS.

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BFI (2013): BFI-level 1
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Scopus rating (2012): SJR 1.507 SNIP 1.286 CiteScore 4
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BFI (2011): BFI-level 1
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Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.353 SNIP 1.062
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Web of Science (2008): Indexed yes
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Web of Science (2006): Indexed yes
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Modelling Framework for the Identification of Critical Variables and Parameters under Uncertainty in the Bioethanol Production from Lignocellulose

This study presents the development of a systematic modelling framework for identification of the most critical variables and parameters under uncertainty, evaluated on a lignocellulosic ethanol production case study. The systematic framework starts with: (1) definition of the objectives; (2) Collection of data and the implementation of dynamic models for each unit operation in the process; (3) Uncertainty and sensitivity analysis, performed to identify the critical operational variables and parameters in the process. The uncertainty analysis is carried out using the Monte-Carlo technique. Sensitivity analysis employs the standardized regression coefficient (SRC) method, which provides a global sensitivity measure, $\beta_i$, thereby showing how much each parameter contributes to the variance (uncertainty) of the model predictions. Thus, identifying the most critical parameters involved in the process, suitable for further analysis of the bioprocess. The uncertainty and sensitivity analysis identified the following most critical variables and parameters involved in the lignocellulosic ethanol production case study. For the operating cost, the enzyme loading showed the strongest impact, while reaction volume showed a significant impact on the ethanol/biomass ratio. The results showed also that it is possible to find a better alternative operation of the plant in comparison with the base case.

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**pH catalyzed pretreatment of corn bran for enhanced enzymatic arabinoxylan degradation**

Corn bran is mainly made up of the pericarp of corn kernels and is a byproduct stream resulting from the wet milling step in corn starch processing. Through statistic modeling this study examined the optimization of pretreatment of corn bran for enzymatic hydrolysis. A low pH pretreatment (pH 2, 150°C, 65min) boosted the enzymatic release of xylose and glucose and maximized biomass solubilization. With more acidic pretreatment followed by enzymatic hydrolysis the total xylose release was maximized (at pH 1.3) reaching ~50% by weight of the original amount present in destarched corn bran, but the enzyme catalyzed xylose release was maximal after pretreatment at approx. pH 2. The total glucose release peaked after pretreatment of approx. pH 1.5 with an enzymatic release of approx. 68% by weight of the original amounts present in destarched corn bran. For arabinose the enzymatic release was negatively affected by the acidic pretreatment as labile arabinosyl-linkages were presumably hydrolysed directly during the pretreatment. A maximum of 60% arabinose release was achieved directly from the optimal (acidic) pretreatment. The total content of diferulic acids, supposedly involved in the cross-linking of the arabinoxylan polymers, decreased by both alkaline and acidic pretreatment pH, with the loss by alkaline pretreatments being highest. No direct correlation between the enzymatic release of xylose and the content of diferulic acids in the substrate could be verified. On the contrary the enzymatic release of xylose was significantly correlated to the total release of arabinose, indicating that the degree of arabinosyl-substitutions on the xylan backbone is an essential parameter for enzymatic hydrolysis of corn bran arabinoylan.

**General information**

State: Published  
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Novozymes A/S  
Authors: Agger, J. (Intern), Johansen, K. S. (Ekstern), Meyer, A. S. (Intern)  
Pages: 125-135  
Publication date: 2011  
Main Research Area: Technical/natural sciences

**Publication information**

Journal: New Biotechnology  
Volume: 28  
Issue number: 2  
ISSN (Print): 1871-6784  
Ratings:  
BFI (2018): BFI-level 1  
Web of Science (2018): Indexed yes  
BFI (2017): BFI-level 1  
Web of Science (2017): Indexed Yes  
BFI (2016): BFI-level 1  
Scopus rating (2016): CiteScore 3.67 SJR 1.065 SNIP 1.269  
Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 1  
Scopus rating (2015): SJR 1.069 SNIP 1.07 CiteScore 3.07  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 1  
Scopus rating (2014): SJR 0.994 SNIP 1.248 CiteScore 2.77  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 1  
Scopus rating (2013): SJR 0.819 SNIP 0.988 CiteScore 2.5  
ISI indexed (2013): ISI indexed yes  
BFI (2012): BFI-level 1  
Scopus rating (2012): SJR 0.788 SNIP 0.836 CiteScore 2.12  
ISI indexed (2012): ISI indexed yes  
Web of Science (2012): Indexed yes  
BFI (2011): BFI-level 1  
Scopus rating (2011): SJR 0.934 SNIP 0.952 CiteScore 2.13  
ISI indexed (2011): ISI indexed yes  
Web of Science (2011): Indexed yes  
BFI (2010): BFI-level 1  
Scopus rating (2010): SJR 0.89 SNIP 1.023  
BFI (2009): BFI-level 1
Reactor selection for multi-enzymatic processes

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Xue, R. (Intern), Mikkelsen, J. D. (Intern), Meyer, A. S. (Intern), Woodley, J. (Intern)
Publication date: 2011
Event: Poster session presented at Biotrans 2011, Giardini Naxos, Italy.
Main Research Area: Technical/natural sciences

Recovery of volatile fruit juice aroma compounds by membrane technology: Sweeping gas versus vacuum membrane distillation

The influence of temperature (10–45°C), feed flow rate (300–500L/h) and sweeping gas flow rate (1.2–2m3/h) on the recovery of berry fruit juice aroma compounds by sweeping gas membrane distillation (SGMD) was examined on an aroma model solution and on black currant juice in a lab scale membrane distillation set up. The data were compared to recovery of the aroma compounds by vacuum membrane distillation (VMD). The flux of SGMD increased with an increase in temperature, feed flow rate or sweeping gas flow rate. Increased temperature and feed flow rate also increased the concentration factors (Cpermeate/Cfeed) of the aroma compounds. At 45°C the most volatile and hydrophobic aroma compounds obtained the highest concentration factors: 12.1–9.3 (black currant juice) and 17.2–12.8 (model solution). With black currant juice a volume reduction of 13.7% (vol.%) at 45°C, 400L/h, resulted in an aroma recovery of 73–84vol.% for the most volatile compounds. Compared to VMD, the aroma recovery with SGMD was less influenced by the feed flow rate but more influenced by the temperature. Higher fluxes were achieved during concentration by VMD and this reduced the operation time, which in turn reduced the degradation of anthocyanins and polyphenolic compounds in the juice. Industrial relevance: High temperature evaporation is the most widely used industrial technique for aroma recovery and concentration of juices, but membrane distillation (MD) may provide for gentler aroma stripping and lower energy consumption. This study gives important clues about the fate of berry juice aroma compounds and polyphenols during concentration by MD, and identifies the main factors influencing the aroma recovery efficiency with MD. Both SGMD and VMD are promising techniques for gentle stripping of berry juice aroma compounds and deserve further consideration as alternative techniques for gentle aroma stripping in industrial fruit juice processing.

General information
State: Published
Organisations: Department of Chemistry, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Membrane Technology group, University of Copenhagen
Pages: 388-397
Anthocyanins, Vacuum membrane distillation, Polyphenols, Black currant juice, Sweeping gas membrane distillation, Aroma recovery

DOIs:
10.1016/j.ifset.2011.02.005

Source: orbit
Source-ID: 318422
Publication: Research - peer-review › Journal article – Annual report year: 2012
Tailored enzymatic production of oligosaccharides from sugar beet pectin and evidence of differential effects of a single DP chain length difference on human faecal microbiota composition after in vitro fermentation

Sugar beet pectin was degraded enzymatically and separated by ion exchange chromatography into series of highly purified homogalacturonides and rhamnogalacturonides. MALDI-TOF/TOF mass-spectrometry was used to determine sizes and structural features. The methodology was based on the sequential use of monocomponent enzymes that were selected to target specific substructures in the sugar beet pectin. Notably pectin lyase and rhamnogalacturonan I lyase were used, which allowed detection of the resulting cleavage products by UV spectroscopy. Seven different homogalacturonides (HG) with degrees of polymerization (DP) from 2 to 8 and six different rhamnogalacturonide (RGI) structures, ranging from DP4 to 6 with defined galactose substitutions were purified. Total recoveries of 200 mg homogalacturonides and 67 mg rhamnogalacturonides per gram sugar beet pectin were obtained. This integrated biorefining method provides an option for advanced upgrading of sugar beet pectin into HG and RGI oligosaccharides of defined size and structure. In vitro microbial fermentation by human faecal samples (n = 9) showed a different response to the DP4 and DP5 HG structures on the ratio between Bacteroidetes and Firmicutes. This indicates that pectic oligosaccharides with only slightly different structures have significantly different biological effects. This is the first report of pectic oligosaccharide activity on gut bacterial populations related to the metabolic syndrome associated with obesity.

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Division of Microbiology and Risk Assessment, National Food Institute, BioChemical Engineering, University of Southern Denmark
Pages: 1039-1049
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: Process Biochemistry
Volume: 46
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ISSN (Print): 1359-5113
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.819 SNIP 1.075 CiteScore 2.87
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.923 SNIP 1.234 CiteScore 3.01
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.989 SNIP 1.438 CiteScore 3.05
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.994 SNIP 1.493 CiteScore 3.06
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.191 SNIP 1.455 CiteScore 2.93
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.165 SNIP 1.419 CiteScore 3.05
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
An assessment of a number of different process flowsheets for bioethanol production was performed using dynamic model-based simulations. The evaluation employed diverse operational scenarios such as, fed-batch, continuous and continuous with recycle configurations. Each configuration was evaluated against the following benchmark criteria, yield (kg ethanol/kg dry-biomass), final product concentration and number of unit operations required in the different process configurations. The results has shown the process configuration for simultaneous saccharification and co-fermentation (SSCF) operating in continuous mode with a recycle of the SSCF reactor effluent, results in the best productivity of bioethanol among the proposed process configurations, with a yield of 0.18 kg ethanol /kg dry-biomass.

General information
State: Published
Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Morales Rodriguez, R. (Intern), Meyer, A. S. (Intern), Gernaey, K. (Intern), Sin, G. (Intern)
Publication date: 2011

Host publication information
Title of host publication: 32. National Meeting and First International Congress AMIDIQ
Main Research Area: Technical/natural sciences
Conference: AMIDIQ 32nd National Meeting and 1st International Congress, Riviera Maya, Mexico, 03/05/2011 - 03/05/2011
Electronic versions:
PEC11-43.pdf
Links:
http://www.amidiq.com/congreso/info-ing.htm

Bibliographical note
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Validation of Inhibition Effect in the Cellulose Hydrolysis: a Dynamic Modelling Approach

Enzymatic hydrolysis is one of the main steps in the processing of bioethanol from lignocellulosic raw materials. However, complete understanding of the underlying phenomena is still under development. Hence, this study has focused on validation of the inhibition effects in the cellulosic biomass hydrolysis employing a dynamic mathematical model. A systematic framework for parameter estimation is used for model validation, which helps overcome the problem of parameter correlation. Data sets obtained from carefully designed enzymatic cellulose and cellobiose hydrolysis experiments, were used for parameter estimation (calibration) and validation purposes. The model predictions using calibrated parameters have shown good agreement with the validation data sets, which provides credibility to the model structure and the parameter values.

General information
State: Published
Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Morales Rodriguez, R. (Intern), Tsai, C. (Intern), Meyer, A. S. (Intern), Gernaey, K. (Intern), Sin, G. (Intern)
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Main Research Area: Technical/natural sciences
Conference: AMIDIQ 32nd National Meeting and 1st International Congress, Riviera Maya, Mexico, 03/05/2011 - 03/05/2011
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Validation of Inhibition Effect in the Cellulose Hydrolysis: a Dynamic Modelling Approach

General information
State: Published
Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Morales Rodriguez, R. (Intern), Meyer, A. S. (Intern), Gernaey, K. (Intern), Sin, G. (Intern)
Publication date: 2011
Event: Poster session presented at AMIDIQ 32nd National Meeting and 1st International Congress, Riviera Maya, Mexico.
Main Research Area: Technical/natural sciences
Electronic versions:
RMR_AMIDIQ-2011_Poster3.pdf

Bibliographical note
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Publication: Research - peer-review › Poster – Annual report year: 2011

Technology Evaluation of Process Configurations for Second Generation Bioethanol Production using Dynamic Model-based Simulations

General information
State: Published
Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Morales Rodriguez, R. (Intern), Meyer, A. S. (Intern), Gernaey, K. (Intern), Sin, G. (Intern)
Publication date: 2011
Event: Poster session presented at AMIDIQ 32nd National Meeting and 1st International Congress, Riviera Maya, Mexico.
Main Research Area: Technical/natural sciences
Electronic versions:
RMR_AMIDIQ-2011_Poster3.pdf
A Dynamic Model for Cellulosic Biomass Hydrolysis: Validation of Hydrolysis and Product Inhibition Mechanism

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center, Center for BioProcess Engineering
Authors: Eeclo, J. (Ekstern), Tsai, C. (Intern), Morales Rodriguez, R. (Intern), Gernaey, K. (Intern), Meyer, A. S. (Intern), Sin, G. (Intern)
Publication date: 2010

Assessing Reliability of Cellulose Hydrolysis Models to Support Biofuel Process Design – Identifiability and Uncertainty Analysis

The reliability of cellulose hydrolysis models is studied using the NREL model. An identifiability analysis revealed that only 6 out of 26 parameters are identifiable from the available data (typical hydrolysis experiments). Attempting to identify a higher number of parameters (as done in the original NREL model publication) results in significant errors on the parameter estimates. The reasons for this poor identifiability are related to (i) model structure complexity, inherently containing correlated parameters due to Michaelis–Menten type kinetics, and (ii) the available data, which are not informative enough (sensitivities of 16 parameters were insignificant). This indicates that the NREL model has severe parameter uncertainty, likely to be the case for other hydrolysis models as well since similar kinetic expressions are used. To overcome this impasse, we have used the Monte Carlo procedure to analyze the uncertainty of model predictions. This allows judging the fitness of the model to the purpose under uncertainty. Hence we recommend uncertainty analysis as a proactive solution when faced with model uncertainty, which is the case for biofuel process development research.

General information
State: Published
Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Sin, G. (Intern), Meyer, A. S. (Intern), Gernaey, K. (Intern)
Pages: 1385-1392
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Computers & Chemical Engineering
Volume: 34
Issue number: 9
ISSN (Print): 0098-1354
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Continuous membrane microbioreactor for integrated pectin degradation and separation

General information
Development of a mathematical model describing hydrolysis and co-fermentation of C6 and C5 sugars

Reliable production of biofuels and specifically bioethanol has attracted a significant amount of research recently. Within this context, this study deals with dynamic simulation of bioethanol production processes and in particular aims at developing a mathematical model for describing simultaneous saccharification and co-fermentation (SSCF) of C6 and C5 sugars. Model construction has been carried out by combining existing mathematical models for enzymatic hydrolysis on the one hand and co-fermentation on the other hand. An inhibition of ethanol on cellulose conversion was introduced in order to increase the degree of reliability. The mathematical model for the SSCF has been tested for a modified version of the process flowsheet proposed by the National Renewable Energy Laboratory (NREL). The model can now be used to evaluate different process configurations for 2G bioethanol production using corn stover as a feedstock.

Discriminated release of phenolic substances from red wine grape skins (Vitis vinifera L.) by multicomponent enzymes treatment

Detailed insight into the effects of enzymatic treatments on grape phenolics is of significant importance for grape processing for wine making. This study examined the release of phenols during enzymatic (pectinolytic and cellulolytic) degradation of the cell wall polysaccharides in skins of Merlot and Cabernet Sauvignon wine grapes (Vitis vinifera L.). Anthocyanins were released from skins during the early phases of the enzymatic treatments, but were then degraded
during further enzymatic treatment; flavonols underwent transformation from glycosylated (rutin) to deglycosylated (quercetin) during the enzymatic treatment; phenolic acids, including hydroxybenzoic acids and hydroxycinnamic acids, were released as a function of monosaccharides liberation, i.e. as a function of the enzyme catalyzed cell wall degradation of the skins, and with some of the phenolic acids perhaps released from the lignin. The data moreover suggest that p-coumaric acid was also released during enzyme catalyzed degradation of acylated anthocyanins, probably as a result of cinnamate esterase activity. The data thus provided unexpected new clues as to how the enzymatic treatment with multicomponent pectinolytic enzymes may promote (a) discriminated release of phenols from grape skins, and (b) molecular changes in the phenols.

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Arnous, A. (Intern), Meyer, A. S. (Intern)
Pages: 68-77
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Biochemical Engineering Journal
Volume: 49
Issue number: 1
ISSN (Print): 1369-703X
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.16
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.75
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.72
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.03
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.15
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.95
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Web of Science (2008): Indexed yes
Web of Science (2007): Indexed yes
Web of Science (2005): Indexed yes
Web of Science (2003): Indexed yes
Web of Science (2001): Indexed yes
Effect and Modeling of Glucose Inhibition and In Situ Glucose Removal During Enzymatic Hydrolysis of Pretreated Wheat Straw

The enzymatic hydrolysis of lignocellulosic biomass is known to be product-inhibited by glucose. In this study, the effects on cellulytic glucose yields of glucose inhibition and in situ glucose removal were examined and modeled during extended treatment of heat-pretreated wheat straw with the cellulolytic enzyme system, Celluclast (R) 1.5 L, from Trichoderma reesei, supplemented with a beta-glucosidase, Novozym (R) 188, from Aspergillus niger. Addition of glucose (0-40 g/L) significantly decreased the enzyme-catalyzed glucose formation rates and final glucose yields, in a dose-dependent manner, during 96 h of reaction. When glucose was removed by dialysis during the enzymatic hydrolysis, the cellulose conversion rates and glucose yields increased. In fact, with dialytic in situ glucose removal, the rate of enzyme-catalyzed glucose release during 48-72 h of reaction recovered from 20-40% to become approximate to 70% of the rate recorded during 6-24 h of reaction. Although Michaelis-Menten kinetics do not suffice to model the kinetics of the complex multi-enzymatic degradation of cellulose, the data for the glucose inhibition were surprisingly well described by simple Michaelis-Menten inhibition models without great significance of the inhibition mechanism. Moreover, the experimental in situ removal of glucose could be simulated by a Michaelis-Menten inhibition model. The data provide an important base for design of novel reactors and operating regimes which include continuous product removal during enzymatic hydrolysis of lignocellulose.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Applied Biochemistry and Biotechnology
Volume: 160
Issue number: 1
ISSN (Print): 0273-2289
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.81 SJR 0.559 SNIP 0.738
Web of Science (2016): Indexed yes
Effects of specific carbohydrates on the intestinal microbiota

The current screening study aimed at testing a set of well-characterized carbohydrates derived from pectic oligosaccharides (POS) from sugar beet for their specific effect on intestinal microbiotas derived from healthy people and from patients suffering from the inflammatory bowel disease designated Ulcerative Colitis (UC). Two such oligosaccharides having different degrees of polymerization, in the following designated S1 and S2, respectively, were tested. Small scale anaerobic fermentation studies were performed to test the effect of S1 and S2 on the composition of the intestinal microbiotas. Changes in the microbial composition were addressed by Denaturing Gradient Gel
Electrophoresis, DGGE, using Fructo- Oligosaccharides (FOS, a goldenstandard prebiotic) and glucose as reference substrates. Comparison between the DGGE profiles obtained by fermentations of S1, S2 and FOS showed that S2 produced a DGGE profile different from fermentations of S1 and the control substrate FOS in a Pearson correlation cluster analysis, indicating that the degree of polymerization (DP) was decisive for which bacteria were stimulated by the oligosaccharides. Additionally, DGGE results of this screening study showed that there were no significant differences between the numbers of bands in the fermentations of all four substrates, indicating that S1, S2 and FOS had similar degrees of selectivity.

Enzymatic modifications of grape skin phenolics A new look at wine maceration?
Phenolic compounds are decisive for the colour and sensory properties of wines. Especially in the making of red wines, the optimal retrieval of phenolics from the grape skins is crucial for obtaining wines having optimal colour, flavour, and mouth feel properties. Exogenous enzymes are widely used during the wine grape maceration to obtain high juice yield and initial extraction of flavour components, and in the case of red wines for obtaining better initial extraction of colour. Until now, this maceration has mainly been considered as an extraction step. Recent data have shown that significant changes of the phenolics may occur via enzyme catalyzed reactions already during the maceration. These recent findings provide a new base for understanding and promoting phenolic conversions during wine making, and may lead to new enzymatic maceration strategies and novel grape pomace valorisation processes in the wine industry.
Enzymatic Xylose Release from Pretreated Corn Bran Arabinoxylan: Differential Effects of Deacetylation and Deferuloylation on Insoluble and Soluble Substrate Fractions

In the present work enzymatic hydrolysis of arabinoxylan from pretreated corn bran (190 °C, 10 min) was evaluated by measuring the release of xylose and arabinose after treatment with a designed minimal mixture of monocomponent enzymes consisting of α-L-arabinofuranosidases, an endoxylanase, and a β-xylosidase. The pretreatment divided the corn bran material 50:50 into soluble and insoluble fractions having A:X ratios of 0.66 and 0.40, respectively. Addition of acetyl xylan esterase to the monocomponent enzyme mixture almost doubled the xylose release from the insoluble substrate fraction and gave release of 1 mol of xylose/mol of acetic acid released, whereas addition of feruloyl esterase promoted release of only 0.4 mol of xylose/mol of ferulic acid released. For the soluble substrate fraction up to 36% of the xylose could be released by the enzymatic treatment. Acetyl xylan esterase addition on top of the minimal monocomponent enzyme mixture resulted in liberation of up to 0.5 mol of xylose/mol of acetic acid released, whereas feruloyl esterase addition released 1 mol of xylose/mol of ferulic acid released from the soluble substrate. The results imply that on the insoluble material the acetyl xylan esterase was more important for the enzymatic degradation than feruloyl esterase, whereas on soluble arabinoxylan the feruloyl esterase seemed to be more important for the release of xylose.
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.408 SNIP 1.392
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.317 SNIP 1.303
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.361 SNIP 1.324
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.249 SNIP 1.439
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.358 SNIP 1.418
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.286 SNIP 1.521
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.316 SNIP 1.496
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.158 SNIP 1.479
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.236 SNIP 1.537
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.066 SNIP 1.255
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.091 SNIP 1.312
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.859 SNIP 1.256
Original language: English
DOIs:
10.1021/jf100633f
Enzyme technology for precision functional food ingredient processes

A number of naturally occurring dietary substances may exert physiological benefits. The production of enhanced levels or particularly tailored versions of such candidate functional compounds can be targeted by enzymatic catalysis. The recent literature contains examples of enhancing bioavailability of iron via enzyme-catalyzed degradation of phytate in wheat bran, increasing diacyl-glycerol and conjugated linoleic acid levels by lipase action, enhancing the absorption of the citrus flavonoid hesperetin via rhamnosidase treatment, and obtaining solubilized dietary fiber via enzymatic modification of potato starch processing residues. Such targeted enzyme-catalyzed reactions provide new invention opportunities for designing functional foods with significant health benefits. The provision of well-defined naturally structured compounds can, moreover, assist in obtaining the much-needed improved understanding of the physiological benefits of complex natural substances.

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Meyer, A. S. (Intern)
Pages: 126-132
Publication date: 2010
Conference: Conference on Foods for Health in the 21st Century : A Road Map for the Future, Univ Calif Davis, Davis, CA, 01/01/2008
Main Research Area: Technical/natural sciences

Publication information
Volume: 1190
ISSN (Print): 0077-8923
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 2.183 SNIP 1.393 CiteScore 4.42
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.38 SNIP 1.388 CiteScore 4.42
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.281 SNIP 1.446 CiteScore 4.37
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.137 SNIP 1.477 CiteScore 4.56
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.636 SNIP 1.198 CiteScore 3.61
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.533 SNIP 1.097 CiteScore 3.41
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.321 SNIP 0.905
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.17 SNIP 0.847
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.957 SNIP 0.758
Scopus rating (2007): SJR 0.879 SNIP 0.67
Scopus rating (2006): SJR 0.923 SNIP 0.696
From lab experiments to plant operation and design: Bioethanol production from lignocellulose using different enzyme technologies

General information
State: Published
Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Morales Rodriguez, R. (Intern), Meyer, A. S. (Intern), Gernaey, K. (Intern), Sin, G. (Intern)
Publication date: 2010

Fungal polyketide azaphilone pigments as future natural food colorants?
The recent approval of fungal carotenoids as food colorants by the European Union has strengthened the prospects for fungal cell factories for the production of polyketide pigments. Fungal production of colorants has the main advantage of making the manufacturer independent of the seasonal supply of raw materials, thus minimizing batch-to-batch variations. Here, we review the potential of polyketide pigments produced from chemotaxonomically selected non-toxicogenic fungal strains (e.g. Penicillium and Epicoccum spp.) to serve as food colorants. We argue that the production of polyketide azaphilone pigments from such potentially safe hosts is advantageous over traditional processes that involve Monascus spp., which risks co-production of the mycotoxin citrinin. Thus, there is tremendous potential for the development of robust fungal production systems for polyketide pigments, both to tailor functionality and to expand the color palette of contemporary natural food colorants.

General information
State: Published
Organisations: Center for Microbial Biotechnology, Department of Systems Biology, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Mapari, S. S. (Intern), Thrane, U. (Intern), Meyer, A. S. (Intern)
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Main Research Area: Technical/natural sciences
Integrated Dynamic Plant-Wide Model-Based Simulation of Bioethanol Production from Lignocellulose

General information
State: Published
Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Authors: Morales Rodriguez, R. (Intern), Gernaey, K. (Intern), Meyer, A. S. (Intern), Sin, G. (Intern)

DOI: 10.1016/j.tibtech.2010.03.004
Source: orbit
Source-ID: 268247
Publication: Research - peer-review › Journal article – Annual report year: 2010
Juice clarification by protease and pectinase treatments indicates new roles of pectin and protein in cherry juice turbidity

Industrial juice clarification is accomplished by a combination of enzymatic depectinization, gelatin–silica sol, and/or bentonite treatment. The gelatin–silica sol treatment step is particularly slow, mischievous, and requires comprehensive downstream processing to obtain clarified juice. In this work, alternative, enzymatic clarification strategies of industrially pressed cherry juice were evaluated in a 24−1 factorial design set-up with addition of a pectinase, Pectinex Smash®, a protease, Enzeco, both enzyme preparations derived from Aspergillus spp., gallic acid, and tannic acid as factors, and determination of turbidity, protein, pectin, and phenolics as responses. The effects of the alternative clarification treatments were assessed immediately after the particular clarification treatment (immediate turbidity) and during 14 days of cold storage (turbidity development). The protease treatment resulted in significant reduction of immediate turbidity, but effectively decreased the turbidity development during storage. The phenolic acid additions contributed to reduce turbidity when added together with the pectinase or the protease. However, when gallic acid and tannic acid were added together they induced enhanced turbidity formation. Conventionally, immediate turbidity is presumed to be caused by pectin, while turbidity development during cold storage (haze formation) is assumed to be due to protein–phenol interactions. Our results suggest that proteins play a decisive role in the formation of immediate turbidity in cherry juice, and point to that pectin may contribute to turbidity development during cold storage of cherry juice. The data may thus pave the way for development of improved, alternative procedures for cherry juice clarification.
Kinetics and substrate selectivity of a Triticum aestivum xylanase inhibitor (TAXI) resistant D11F/R122D variant of Bacillus subtilis XynA xylanase

This study examined the kinetics and substrate selectivity of a GH11 Bacillus subtilis XynA xylanase (BsX) sensitive to inhibition by TAXI and an engineered variant, which is much less inhibited by TAXI (BsX(mut)). The main purpose of the work was to elucidate any influence of the structural point mutations on the kinetics and substrate selectivity of the enzyme. Three-dimensional structures of both xylanases were superimposed to elucidate the structural basis for differences in their hydrolytic properties. The two xylanases were incubated individually with water-extractable arabinoxylan (WEAX), water-unextractable arabinoxylan (WUAX), birchwood xylan, and wheat bran. Both the BsX and the BsX(mut) catalyzed the release of xylo-oligosaccharides with higher degree of polymerization from WUAX than from WEAX. At equimolar addition levels the activity of the BsX(mut) was lower than that of the BsX with respect to both the initial rate and the product yields obtained after prolonged reaction on the xylan substrates. The calculated substrate selectivity factors indicated that the BsX and the BsX(mut) both had higher catalytic rate on WUAX than on WEAX. Addition of a 100:1 (TAXI:xylanase) molar ratio of inhibitor confirmed the significantly decreased inhibition of BsX(mut) by TAXI. Addition of TAXI also influenced the xylanases' selectivity factor differently.

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Rasmussen, L. E. (Intern), Sørensen, J. F. (Ekstern), Meyer, A. S. (Intern)
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.88 SJR 0.978 SNIP 0.937
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.068 SNIP 0.987 CiteScore 2.87
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.113 SNIP 1.144 CiteScore 2.95
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.173 SNIP 1.188 CiteScore 3.22
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Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.255 SNIP 1.312 CiteScore 3.4
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.157 SNIP 1.064 CiteScore 2.87
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.126 SNIP 1.18
Web of Science (2010): Indexed yes
Lignocellulose pretreatment severity – relating pH to biomatrix opening

In cellulose-to-ethanol processes a physico-chemical pretreatment of the lignocellulosic feedstock is a critical prerequisite for increasing the amenability of the cellulose to enzymatic attack. Currently published pretreatment strategies span over a wide range of reaction conditions involving different pH values, temperatures, types of catalysts, and holding times. The consequences of the pretreatment on lignocellulosic biomass are described with special emphasis on the chemical alterations of the biomass during pretreatment, especially highlighting the significance of the pretreatment pH. We present a new illustration of the pretreatment effects encompassing the differential responses to the pH and temperature. A detailed evaluation of the use of severity factor calculations for pretreatment comparisons signifies that the multiple effects of different pretreatment factors on the subsequent monosaccharide yields after enzymatic hydrolysis cannot be reliably compared by a one-dimensional severity factor, even within the same type of pretreatment strategy. However, a quantitative comparison of published data for wheat straw pretreatment illustrates that there is some correlation between the hydrolysis yields (glucose, xylose) and the pretreatment pH, but no correlation with the pretreatment temperature (90–200 °C). A better recognition and understanding of the factors affecting biomatrix opening, and use of more standardized evaluation protocols, will allow for the identification of new pretreatment strategies that improve biomass utilization and permit rational enzymatic hydrolysis of the cellulose.

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Pedersen, M. (Intern), Meyer, A. S. (Intern)
Pages: 739-750
Publication date: 2010
Main Research Area: Technical/natural sciences

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Journal: New Biotechnology
Volume: 27
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ISSN (Print): 1871-6784
Ratings:
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Membrane Microbioreactor for Enzyme-Catalyzed Degradation of Pectin

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Department of Systems Biology, Center for BioProcess Engineering, Computer Aided Process Engineering Center
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Publication information
Membrane microbioreactor prototype for enzyme-catalyzed degradation of pectin

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Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 268898
Publication: Research › Sound/Visual production (digital) – Annual report year: 2010

Monosaccharide yields and lignin removal from wheat straw in response to catalyst type and pH during mild thermal pretreatment

The influence of various low temperature (140 °C) pretreatments, using different acid and alkaline catalysts and different pH values, was studied for enzymatic hydrolysis of wheat straw. The pretreated wheat straw was treated by a standard blend of Celluclast 1.5 L and Novozym 188. While pretreatment at pH 1 gave the highest yield of saccharides in the liquid fraction, the solid fraction was more susceptible to enzymatic attack when pretreated at pH 13. The highest yields were obtained after pretreatment with hydrochloric acid at pH 1, and with sodium hydroxide at pH 13 when enzymatic hydrolysis was employed. A two-step pretreatment strategy at pH 1 (hydrochloric acid) and subsequently at pH 13 (sodium hydroxide) released 69 and 95% of the theoretical maximal amounts of glucose and xylose, respectively. Furthermore, this two-step pretreatment removed 68% of the lignin from the straw with only minor losses of monosaccharides, and production of only low amounts of inhibitors. Type of catalyst and pH indeed influenced the monosaccharide yields and lignin removal from wheat straw, and need more attention in the choice of pretreatment strategy.

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Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Novozymes A/S
Authors: Pedersen, M. (Intern), Viksø-Nielsen, A. (Ekstern), Meyer, A. S. (Intern)
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Journal: Process Biochemistry
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.819 SNIP 1.075 CiteScore 2.87
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.923 SNIP 1.234 CiteScore 3.01
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.989 SNIP 1.438 CiteScore 3.05
N-uptake and growth monitoring of the macrophyte Ulva lactuca by photo-scanning technology

General information
State: Published
Organisations: BioChemical Engineering
Authors: Ale, M. T. (Intern), Mikkelsen, J. D. (Intern), Meyer, A. S. (Intern)
Publication date: 2010
Event: Poster session presented at 20th International Seaweed Symposium, Ensenada, Mexico.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 262616
Publication: Research - peer-review › Journal article – Annual report year: 2010
Reactors design for minimizing product inhibition during enzymatic lignocellulose hydrolysis II. Quantification of inhibition and suitability of membrane reactors

Product inhibition of cellulytic enzymes affects the efficiency of the biocatalytic conversion of lignocellulosic biomass to ethanol and other valuable products. New strategies that focus on reactor designs encompassing product removal, notably glucose removal, during enzymatic cellulose conversion are required for alleviation of glucose product inhibition. Supported by numerous calculations this review assesses the quantitative aspects of glucose product inhibition on enzyme-catalyzed cellulose degradation rates. The significance of glucose product inhibition on dimensioning of different ideal reactor types, i.e. batch, continuous stirred, and plug-flow, is illustrated quantitatively by modeling different extents of cellulose conversion at different reaction conditions. The main operational challenges of membrane reactors for lignocellulose conversion are highlighted. Key membrane reactor features, including system set-up, dilution rate, glucose output profile, and the problem of cellbiose are examined to illustrate the quantitative significance of the glucose product inhibition and the total glucose concentration on the cellulolytic conversion rate. Comprehensive overviews of the available literature data for glucose removal by membranes and for cellulose enzyme stability in membrane reactors are given. The treatise clearly shows that membrane reactors allowing continuous, complete, glucose removal during enzymatic cellulose hydrolysis, can provide for both higher cellulose hydrolysis rates and higher enzyme usage efficiency (kg(product)/kg(enzyme)). Current membrane reactor designs are however not feasible for large scale operations. The report emphasizes that the industrial realization of cellulosic ethanol requires more focus on the operational feasibility within the different hydrolysis reactor designs, notably for membrane reactors, to achieve efficient enzyme-catalyzed cellulose degradation. (C) 2010 Elsevier Inc. All rights reserved.
Reactor design for minimizing product inhibition during enzymatic lignocellulose hydrolysis: I. Significance and mechanism of cellobiose and glucose inhibition on cellulytic enzymes

Achievement of efficient enzymatic degradation of cellulose to glucose is one of the main prerequisites and one of the main challenges in the biological conversion of lignocellulosic biomass to liquid fuels and other valuable products. The specific inhibitory interferences by cellobiose and glucose on enzyme-catalyzed cellulose hydrolysis reactions impose significant limitations on the efficiency of lignocellulose conversion especially at high-biomass dry matter conditions. To provide the base for selecting the optimal reactor conditions, this paper reviews the reaction kinetics, mechanisms, and significance of this product inhibition, notably the cellobiose and glucose inhibition, on enzymatic cellulose hydrolysis. Particular emphasis is put on the distinct complexity of cellulose as a substrate, the multi-enzymatic nature of the cellulytic degradation, and the particular features of cellulase inhibition mechanisms and kinetics. The data show that new strategies that place the bioreactor design at the center stage are required to alleviate the product inhibition and in turn to enhance the efficiency of enzymatic cellulose hydrolysis. Accomplishment of the enzymatic hydrolysis at medium substrate concentration in separate hydrolysis reactors that allow continuous glucose removal is proposed to be the way forward for obtaining feasible enzymatic degradation in lignocellulose processing. (C) 2010 Elsevier Inc. All rights reserved.
Size exclusion chromatography for the quantitative profiling of the enzyme-catalyzed hydrolysis of xylo-oligosaccharides

High-performance size exclusion chromatography (HPSEC) is a widely used method for the qualitative profiling of oligosaccharide mixtures, including, for example, enzymatic hydrolysates of plant biomass materials. A novel method employing HPSEC for the quantitative analytical profiling of the progress of enzymatic hydrolysis of different xylan substrates was developed. The method relies on dividing the HPSEC elution profiles into fixed time intervals and utilizing the linear refractive index response (area under the curve) of defined standard compounds. To obtain optimal HPSEC profiles, the method was designed using 0.1 M CH₃COONa both in the mobile phase and as the sample solution matrix, after systematic evaluation of the influence of the mobile phase, including the type, ionic strength, and pH, on the refractive index detector response. A time study of the enzyme-catalyzed hydrolysis of birchwood xylan and wheat bran by a Bacillus subtilis XynA xylanase (GH 11) was used as an example to demonstrate the workability of the HPSEC method for obtaining progress curves describing the evolution in the product profile during enzyme catalysis.
Potato pulp is a high-volume, low-value byproduct stream resulting from the industrial manufacture of potato starch. The pulp is a rich source of biologically functional dietary fibers, but the targeted valorisation of the fibers requires removal of the residual starch from the pulp. The objective of this study was to release the residual starch, making up 21-22% by weight of the dry matter, from the potato pulp in a rational way employing as few steps, as few enzyme activities, as low enzyme dosages, as low energy input (temperature and time), and as high pulp dry matter as possible. Starch removal to obtain dietary fibers is usually accomplished via a three step, sequential enzymatic treatment procedure using a heat stable alpha-amylase, protease, and amylglucosidase. Statistically designed experiments were performed to investigate the influence of enzyme dose, amount of dry matter, incubation time and temperature on the amount of starch released from the potato pulp. The data demonstrated that all the starch could be released from potato pulp in one step when 8% (w/w) dry potato pulp was treated with 0.2% (v/w) (enzyme/substrate (E/S)) of a thermostable Bacillus licheniformis alpha-amylase (Termamyl(R) SC) at 70 degrees C for at least 65 min. The study also indicated that the amount of other carbohydrates released from the pulp during the release of starch was less than using the AOAC Official Method 985.29 and another recently published starch release method employed as a pretreatment for enzymatic upgrading of a pectinaceous potato pulp fiber. (C) 2009 Elsevier Inc. All rights reserved.
Enzymatic release of phenolics from fruit skins: With grape as the main model

General information
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Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Arnous, A. (Intern), Meyer, A. S. (Intern)
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Source-ID: 259736
Publication: Research › Ph.D. thesis – Annual report year: 2009

Chemotaxonomic Exploration of Fungal Biodiversity for Polyketide Natural Food Colorants...

General information
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Organisations: Center for Microbial Biotechnology, Department of Systems Biology, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Mapari, S. S. (Intern), Meyer, A. S. (Intern), Thrane, U. (Intern)
Publication date: Apr 2009

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General information
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Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Sin, G. (Intern), Meyer, A. S. (Intern), Gernaey, K. (Intern)
Publication date: 2009

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 248177
Publication: Research › Sound/Visual production (digital) – Annual report year: 2009
Enzymatic solubilization of a pectinaceous dietary fiber fraction from potato pulp: Optimization of the fiber extraction process

Upgrading of potato pulp, a byproduct stream from industrial manufacture of potato starch, is important for the continued economic competitiveness of the potato starch industry. The major part of potato pulp consists of the tuber plant cell wall material which is particularly rich in galactan branched rhamnogalacturonan I type pectin. In the work reported here, the release of high-molecular weight pectinaceous dietary fiber polysaccharides from starch free potato pulp was accomplished by use of a multicomponent pectinase preparation from Aspergillus aculeatus (Viscozyme® L). The enzyme reaction conditions for the solubilization were optimized via a surface response design to be addition of 0.27% Viscozyme® L by weight of potato pulp substrate dry matter, 1 h treatment at pH 3.5, 62.5 °C. Analysis of the molecular size and monomer composition of the enzymatically released fibers showed that they were rich in galactose and uronic acid indicating that the solubilized fibers were mainly made up of galactan branched rhamnogalacturonan I type pectin polymers.
European Nutrition and Health

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, National Food Institute, FoodDTU
Publication date: 2009

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Publisher: Forum Nutr
Original language: English
Main Research Area: Technical/natural sciences
Grape skins (Vitis vinifera L.) catalyze the in vitro enzymatic hydroxylation of p-coumaric acid to caffeic acid

The ability of grape skins to catalyze in vitro conversion of p-coumaric acid to the more potent antioxidant caffeic acid was studied. Addition of different concentrations of p-coumaric to red grape skins (Cabernet Sauvignon) resulted in formation of caffeic acid. This caffeic acid formation (Y) correlated positively and linearly to p-coumaric acid consumption (X): Y = 0.5 X + 9.5; R² = 0.96, P < 0.0001. The kinetics of caffeic acid formation with time in response to initial p-coumaric acid levels and at different grape skin concentrations, indicated that the grape skins harboured an α-hydroxylation activity, presumably a monophenol- or a flavonoid 3′-monooxygenase activity (EC 1.14.18.1 or EC 1.14.13.21). The K_m of this crude α-hydroxylation activity in the red grape skin was 0.5 mM with p-coumaric acid.

General information
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Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Arnous, A. (Intern), Meyer, A. S. (Intern)
Pages: 1953-1960
Publication date: 2009
Main Research Area: Technical/natural sciences

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Journal: Biotechnology Letters
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Web of Science (2018): Indexed yes
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Web of Science (2017): Indexed Yes
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Scopus rating (2016): CiteScore 1.89 SJR 0.61 SNIP 0.721
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.591 SNIP 0.673 CiteScore 1.66
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.627 SNIP 0.809 CiteScore 1.75
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.713 SNIP 0.941 CiteScore 2.03
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.758 SNIP 0.949 CiteScore 2.03
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.722 SNIP 0.912 CiteScore 1.97
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.698 SNIP 0.894
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.707 SNIP 0.816
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.628 SNIP 0.778
Identification of potentially safe promising fungal cell factories for the production of polyketide natural food colorants using chemotaxonomic rationale

Background: Colorants derived from natural sources look set to overtake synthetic colorants in market value as manufacturers continue to meet the rising demand for clean label ingredients-particularly in food applications. Many ascomycetous fungi naturally synthesize and secrete pigments and thus provide readily available additional and/or alternative sources of natural colorants that are independent of agro-climatic conditions. With an appropriately selected fungus; using in particular chemotaxonomy as a guide, the fungal natural colorants could be produced in high yields by using the optimized cultivation technology. This approach could secure efficient production of pigments avoiding use of genetic manipulation. Results: Polyketide pigment producing ascomycetous fungi were evaluated for their potential as production organisms based on a priori knowledge on species-specific pigment and potential mycotoxin production and BioSafety level (BSL) classification. Based on taxonomic knowledge, we pre-selected ascomycetous fungi belonging to Penicillium subgenus Biverticillium that produced yellow, orange or red pigments while deselecting Penicillium marneffei; a well known human pathogen in addition to other mycotoxigenic fungi belonging to the same group. We identified 10 strains belonging to 4 species; viz. P. purpurogenum, P. aculeatum, P. funiculosum, and P. pinophilum as potential pigment producers that produced Monascus-like pigments but no known mycotoxins. The selection/deselection protocol was illustrated in the pigment extracts of P. aculeatum IBT 14259 and P. crateriforme IBT 5015 analysed by HPLC-DAD-MS. In addition, extracellular pigment producing ability of some of the potential pigment producers was evaluated in liquid media with a solid support and N-glutarylmonascorubramine was discovered in the partially purified pigment extract of P. purpurogenum IBT 11181 and IBT 3645. Conclusion: The present work brought out that the use of chemotaxonomic tools and a priori knowledge of fungal extrolites is a rational approach towards selection of fungal polyketide pigment producers considering the enormous chemical diversity and biodiversity of ascomycetous fungi. This rationale could be very handy for the selection of potentially safe fungal cell factories not only for polyketide pigments but also for the other industrially important polyketides; the molecular and genetic basis for the biosynthesis of which has not yet been examined in detail. In addition, 4 out of the 10 chemotaxonomically selected promising Penicillium strains were shown to produce extracellular pigments in the liquid media using a solid support indicating future cell factory possibilities for polyketide natural food colorants.
Influence of Substrate Particle Size and Wet Oxidation on Physical Surface Structures and Enzymatic Hydrolysis of Wheat Straw

In the worldwide quest for producing biofuels from lignocellulosic biomass, the importance of the substrate pretreatment is becoming increasingly apparent. This work examined the effects of reducing the substrate particle sizes of wheat straw by grinding prior to wet oxidation and enzymatic hydrolysis. The yields of glucose and xylose were assessed after treatments with a benchmark cellulase system consisting of Celluclast 1.5 L (Trichoderma reesei) and Novozym 188-glucosidase (Aspergillus niger). Both wet oxidized and not wet oxidized wheat straw particles gave increased glucose release with reduced particle size. After wet oxidation, the glucose release from the smallest particles (53-149 μm) reached 90% of the theoretical maximum after 24 h of enzyme treatment. The corresponding glucose release from the wet oxidized reference samples (2-4 cm) was 65% of the theoretical maximum. The xylose release only increased (by up to 39%) with particle size decrease for the straw particles that had not been wet oxidized. Wet oxidation pretreatment increased the enzymatic xylose release by 5.4 times and the glucose release by 1.8 times across all particle sizes. Comparison of scanning electron microscopy images of the straw particles revealed edged, nonspherical, porous particles with variable surface structures as a result of the grinding. Wet oxidation pretreatment tore up the surface structures of the particles to retain vascular bundles of xylem and phloem. The enzymatic hydrolysis left behind a significant amount of solid, apparently porous structures within all particles size groups of both the not wet oxidized and wet oxidized particles. © 2009 American Institute of Chemical Engineers Biotechnol. Prog., 2009.
In vitro fermentation of arabinoxylan-derived carbohydrates by Bifidobacteria and mixed fecal microbiota

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Pastell, H. (Ekstern), Westermann, P. (Ekstern), Meyer, A. S. (Intern), Tuomainen, P. (Ekstern), Tenkanen, M. (Ekstern)
Pages: 8598-8606
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Main Research Area: Technical/natural sciences

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
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particle size, enzymatic hydrolysis, pretreatment, bioethanol, particle surface, wet oxidation, SEM, wheat straw

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Source-ID: 222443
Publication: Research - peer-review » Journal article – Annual report year: 2009
Membrane technology for purification of enzymatically produced oligosaccharides: Molecular and operational features affecting performance

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center
Photostability of Natural Orange-Red and Yellow Fungal Pigments in Liquid Food Model Systems

The variation in the photostability among the currently authorized natural pigments limits their application span to a certain type of food system, and more robust alternatives are being sought after to overcome this problem. In the present study, the photostability of an orange-red and a yellow fungal pigment extract produced by ascomycetous fungi belonging to the genera Penicillium and Epicoccum, respectively, were studied in a soft drink model medium and in citrate buffer at low and neutral pH. The quantitative and qualitative color change pattern of the fungal pigment extracts indicated an enhanced photostability of fungal pigment extracts compared to the commercially available natural colorants Monascus Red and turmeric used as controls. Yellow components of the orange-red fungal pigment extract were more photostable than the red components. Chemistry of the photodegradation of the orange-red pigment extract was studied by high-performance liquid chromatography-diode array detection-mass spectrometry (HPLC-DAD-MS), and a light-induced formation of a structural analogue of sequoiamonascin C, a Monascus-like polyketide pigment discovered in the extract of Penicillium aculeatum IBT 14263 on yeast extract sucrose (YES) medium, was confirmed in the soft drink medium at pH 7.

General information
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Organisations: Center for Microbial Biotechnology, Department of Systems Biology, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Mapari, S. S. (Intern), Meyer, A. S. (Intern), Thrane, U. (Intern)
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Publication date: 2009
Main Research Area: Technical/natural sciences
Process design and production of chemicals. Food ingredients, fuels and pharmaceuticals

General information
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Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center
Authors: Meyer, A. S. (Intern), Woodley, J. (Intern), Gani, R. (Intern)
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ISBN (Print): 978-87-985544-4-8
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Main Research Area: Technical/natural sciences

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Engineering_challenges_2009.pdf
PRODUCTION OF MONASCUS-LIKE AZAPHILONE PIGMENT
The present invention relates to the field of biotechnological production of polyketide based colorants from filamentous fungi, in particular a method for preparing a biomass comprising a Monascus-like pigment composition from a nontoxicogenic and non-pathogenic fungal source. The present invention further relates to use of the Monascus-like pigment composition as a colouring agent for food items and/or non-food items, and a cosmetic composition comprising the Monascus-like pigment composition.

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State: Published
Organisations: Center for Microbial Biotechnology, Department of Systems Biology, Center for BioProcess Engineering
Authors: Mapari, S. S. (Intern), Thrane, U. (Intern), Meyer, A. S. (Intern), Frisvad, J. C. (Intern)
Publication date: 2009

Publication information
Patent number: WO2009026923
Date: 05/03/2009
Original language: English

Bibliographical note
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Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 266117
Publication: Research › Patent – Annual report year: 2009

Quantitative Prediction of Cell Wall Polysaccharide Composition in Grape (Vitis vinifera L.) and Apple (Malus domestica) Skins from Acid Hydrolysis Monosaccharide Profiles
On the basis of monosaccharide analysis after acid hydrolysis of fruit skin samples of three wine grape cultivars, Vitis vinifera L. Cabernet Sauvignon, Merlot, and Shiraz, and of two types of apple, Malus domestica Red Delicious and Golden Delicious, an iterative calculation method is reported for the quantitative allocation of plant cell wall monomers into relevant structural polysaccharide elements. By this method the relative molar distribution (mol %) of the different polysaccharides in the red wine grape skins was estimated as 57-62 mol % homogalacturonan, 6.0-14 mol % cellulose, 10-11 mol % xyloglucan, 7 mol % arabinan, 4.5-5.0 mol % rhamnogalacturonan I, 3.5-4.0 mol % rhamnogalacturonan II, 3 mol % arabinogalactan, and 0.5-1.0 mol % mannans; the ranges indicate minor variations in the skin composition of the three different cultivars. These cell wall polysaccharides made up similar to 43-47% by weight of the skins (dry matter), the rest mainly being lignin. The predicted relative molar levels of the polysaccharide elements in the apple skins, which made up similar to 49-64% by weight of the skins (dry matter), appeared to be similar to those of the grape skins. The apple skins were estimated to be relatively richer than grape skins in arabinan, total levels 10-13 mol %, and relatively lower in mannann content, total levels.

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Arnous, A. (Intern), Meyer, A. S. (Intern)
Pages: 3611-3619
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 57
Issue number: 9
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
The minimal enzyme cocktail concept for biomass processing

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, BioGasol ApS, University of Copenhagen
Authors: Meyer, A. S. (Intern), Rosgaard, L. (Ekstern), Sørensen, H. R. (Ekstern)
Pages: 337-344
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Cereal Science
Volume: 50
ISSN (Print): 0733-5210
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.65 SJR 1.004 SNIP 1.331
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.259 SNIP 1.366 CiteScore 2.51
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.176 SNIP 1.463 CiteScore 2.59
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.008 SNIP 1.436 CiteScore 2.41
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.31 SNIP 1.611 CiteScore 2.61
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.226 SNIP 1.529 CiteScore 2.46
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.739 SNIP 1.725
BFI (2009): BFI-level 2
Antioxidant strategies for preventing oxidative flavour deterioration of foods enriched with n-3 polyunsaturated lipids: a comparative evaluation

The aim of this review is to provide a better base for predicting the ability of antioxidants to prevent lipid oxidation in food emulsions in general and in functional food systems enriched with n-3 PUFA in particular. Therefore, the antioxidant efficacies of a range of commercially available antioxidants in a number of fish oil enriched real food emulsions (milk, milk drink, salad dressing, mayonnaise and selected model emulsions) are compared. This comparison clearly shows that the same antioxidant exerts different effects in different systems. EDTA is a very efficient antioxidant in salad dressing and mayonnaise, but not in milk, while ascorbyl palmitate efficiently reduces oxidation in milk. Furthermore, the comparative data evaluation confirms that the same antioxidant in some cases may exert opposite effects on peroxide levels and on formation of individual volatiles and fishy odour and flavours. Therefore, antioxidant effects should always be evaluated by more than one method.

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Jacobsen, C. (Intern), Let, M. (Ekstern), Nielsen, N. S. (Intern), Meyer, A. S. (Intern)
Pages: 76-93
Bioprodukter bliver til gavnlige kostfibre

General information
State: Published
Organisations: Division of Food Production Engineering, National Food Institute, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Jørgensen, S. B. (ed.) (Intern), Meyer, A. S. (Intern)
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: FoodDTU Midt i Ugen
Original language: Danish
Source: orbit
Source-ID: 258260
Publication: Communication › Journal article – Annual report year: 2008

Comparison of methods for compositional characterisation of grape (Vitis vinifera) and apple (Malus domestica) skins

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Arnous, A. (Intern), Meyer, A. S. (Intern)
Pages: 79-86
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Food and Bioproducts Processing
Volume: 86
Issue number: 2
ISSN (Print): 0960-3085
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.881 SNIP 1.178 CiteScore 2.59
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.182 SNIP 1.87 CiteScore 3.44
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.236 SNIP 2.098 CiteScore 3.24
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.932 SNIP 1.951 CiteScore 2.92
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.787 SNIP 1.703 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Computerized screening for novel producers of Monascus-like food pigments in Penicillium species

Monascus pigments have been used as natural food colorants in Asia for centuries. They are not authorized for use in the European Union and the United States mainly due to the risk of coproduction of the mycotoxin citrinin by Monascus slop. In the present study, we screened for novel producers of Monascus-like pigments from ascomycetous filamentous fungi belonging to Penicillium subgenus Biverticillium that are not reported to produce citrinin or any other known mycotoxins. The screening was carried out using the X-hitting algorithm as a tool to quickly screen through chromatographic sample data files of 22 different Penicillium extracts with 12 Monascus pigment extracts as controls. The algorithm searched for the most similar UV-vis spectra of the metabolites (cross hits) present in the pigment extracts to those of the selected reference metabolites viz. monascin, rubropunctatin, rubropunctamine, and citrinin. The cross hits were then manually identified on the basis of their UV-vis and mass spectra. X-hitting was found to be a good tool in the rapid screening of crude pigment extracts. Monascus pigments were discovered in the extracts of two closely related species of Penicillium that were only distantly related to the genus Monascus. Monascorubrin, xanthomonasin A, and threonine derivatives of rubropunctatin were identified in the extract of Penicillium aculeatum IBT 14263, and monascorubrin was identified in the extract of Penicillium pinophilum IBT 13104. None of the tested Penicillium extracts showed the presence of citrinin. Thus, the present study brought out two novel promising sources of yellow, orange, and purple-red Monascus-like food pigments in the species of Penicillia that do not produce citrinin and opened the door to look for several more new promising sources of natural food colorants in the species of Penicillia.
Effect of wine dilution on the reliability of tannin analysis by protein precipitation

A reported analytical method for tannin quantification relies on selective precipitation of tannins with bovine serum albumin. The reliability of tannin analysis by protein precipitation on wines having variable tannin levels was evaluated by measuring the tannin concentration of various dilutions of five commercial red wines. Tannin concentrations of both very diluted and concentrated samples were systematically underestimated, which could be explained by a precipitation threshold and insufficient protein for precipitation, respectively. Based on these findings, we have defined a valid range of the tannin response in the protein precipitation-tannin assay, which suffers minimally from these problems.
Enzyme-assisted extraction of antioxidants: Release of phenols from vegetal matrixes

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Pinelo-Jiménez, M. (Intern), Meyer, A. S. (Intern)
Pages: 3217-3220
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Electronic Journal of Environmental, Agricultural and Food Chemistry
Volume: 7
Issue number: 8
ISSN (Print): 1579-4377
Ratings:
Scopus rating (2015): SJR 0.141 SNIP 0.644
Scopus rating (2014): SJR 0.16 SNIP 0.466
Scopus rating (2013): SJR 0.172 SNIP 0.523
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.244 SNIP 0.484
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.25 SNIP 0.438
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.224 SNIP 0.521
Scopus rating (2009): SJR 0.184 SNIP 0.362
Scopus rating (2008): SJR 0.112 SNIP 0.089
Original language: English
Source: orbit
Source-ID: 221809
Publication: Research - peer-review › Journal article – Annual report year: 2008
Evaluation of Epicoccum nigrum for growth, morphology and production of natural colorants in liquid media and on a solid rice medium

Four nonpathogenic and nontoxigenic Epicoccum nigrum strains were evaluated for their growth, morphology and pigment producing ability in three complex and one defined liquid media. Epicoccum nigrum IBT 41028 produced pigments in all the four media tested with a maximum pigment of 3.68 AU at 410 nm in M1 medium (unoptimized) containing 5 g/l yeast autolysate. The color hue of the crude pigment extracts ranged from 74 to 102 exhibiting dark orange to green-yellow color. Pelleted morphology was shown to have a positive influence on the pigment production by E. nigrum strain IBT 41028 in the liquid media, and the use of Bis-tris buffer was found to diminish or reduce the pellet formation. Since Monascus is a well known pigment producer on rice. Pigment producing ability of E. nigrum IBT 41028 was tested on rice and compared to liquid media with Monascus ruber IBT 7904 as control. Though, both genera preferred rice but E. nigrum produced 4.6 folds higher pigment in the liquid unoptimized fermentation medium compared to M. ruber. Solid phase extraction and subsequently HPLC-DAD analysis of the crude pigment extracts showed qualitative as well as quantitative variation in the pigment composition under solid and liquid cultivations.
Identification of Spectral Regions for Quantification of Red Wine Tannins with Fourier Transform Mid-Infrared Spectroscopy

Accomplishment of fast tannin measurements is receiving increased interest as tannins are important for the mouthfeel and color properties of red wines. Fourier transform mid-infrared spectroscopy allows fast measurement of different wine components, but quantification of tannins is difficult due to interferences from spectral responses of other wine components. Four different variable selection tools were investigated for the identification of the most important spectral regions which would allow quantification of tannins from the spectra using partial least-squares regression. The study included the development of a new variable selection tool, iterative backward elimination of changeable size intervals PLS.

The spectral regions identified by the different variable selection methods were not identical, but all included two regions (1485−1425 and 1060−995 cm⁻¹), which therefore were concluded to be particularly important for tannin quantification. The spectral regions identified from the variable selection methods were used to develop calibration models. All four variable selection methods identified regions that allowed an improved quantitative prediction of tannins (RMSEP = 69−79 mg of CE/L; r = 0.93−0.94) as compared to a calibration model developed using all variables (RMSEP = 115 mg of CE/L; r = 0.87). Only minor differences in the performance of the variable selection methods were observed.

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, FOSS
Authors: Jensen, J. S. (Intern), Egebo, M. (Ekstern), Meyer, A. S. (Intern)
Pages: 3493-3499
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 56
Issue number: 10
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
|------------|----------------------------|------------|----------------------|----------------------------|------------|----------------------|----------------------------|------------|----------------------|----------------------------|------------|----------------------|-------------------|----------------------------|------------|----------------------|-------------------|----------------------------|------------|----------------------|-------------------|----------------------------|------------|----------------------|-------------------|----------------------------|------------|----------------------|-------------------|----------------------------|------------|----------------------|-------------------|----------------------------|------------|----------------------|-------------------|----------------------------|------------|----------------------|-------------------|----------------------------|------------|----------------------|-------------------|----------------------------|------------|----------------------|-------------------|----------------------------|------------|----------------------|-------------------|----------------------------|
Influence of substrate particle size and wet oxidation on physical surface structures and enzymatic hydrolysis of wheat straw

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Novozymes A/S
Authors: Pedersen, M. (Intern), Viksø-Nielsen, A. (Ekstern), Meyer, A. S. (Intern)
Publication date: 2008

Phytate: impact on environment and human nutrition. A challenge for molecular breeding
Phytic acid (PA) is the primary storage compound of phosphorus in seeds accounting for up to 80% of the total seed phosphorus and contributing as much as 1.5% to the seed dry weight. The negatively charged phosphate in PA strongly binds to metallic cations of Ca, Fe, K, Mg, Mn and Zn making them insoluble and thus unavailable as nutritional factors. Phytate mainly accumulates in protein storage vacuoles as globoids, predominantly located in the aleurone layer (wheat, barley and rice) or in the embryo (maize). During germination, phytate is hydrolysed by endogenous phytase(s) and other phosphatases to release phosphate, inositol and micronutrients to support the emerging seedling. PA and its derivatives are also implicated in RNA export, DNA repair, signalling, endocytosis and cell vesicular trafficking. Our recent studies on purification of phytate globoids, their mineral composition and dephytinization by wheat phytase will be discussed. Biochemical data for purified and characterized phytases isolated from more than 23 plant species are presented, the dephosphorylation pathways of phytic acid by different classes of phytases are compared, and the application of phytase in food and feed is discussed.

General information
State: Published
Organisations: Department of Systems Biology, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Bohn, L. (Ekstern), Meyer, A. S. (Intern), Rasmussen, S. K. (Ekstern)
Pages: 165-191
Publication date: 2008
Main Research Area: Technical/natural sciences

Prediction of wine color attributes from the phenolic profiles of red grapes (Vitis vinifera)

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, FOSS
Authors: Jensen, J. S. (Intern), Demiray, S. (Intern), Egebo, M. (Ekstern), Meyer, A. S. (Intern)
Pages: 1105-1115
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 56
Issue number: 3
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Selection of the elderberry (Sambucus nigra L.) genotypes best suited for the preparation of juice

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Kaack, K. (Ekstern), Fretté, X. (Ekstern), Christensen, L. (Ekstern), Landbo, A. R. (Intern), Meyer, A. B. S. (Intern)
Pages: 843-855
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: European Food Research and Technology
Volume: 226
Issue number: 4
ISSN (Print): 1438-2377
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Selective release of phenols from apple skin: Mass transfer kinetics during solvent and enzyme extraction
Enzymatic hydrolysis of pretreated barley and wheat straw

The work carried out during the Ph. D. project was part of the European research project called the Babilafuente Bioethanol Project and was focussed on meeting challenges arising from this project in relation to the enzymatic saccharification of pretreated substrates relevant for the project. The work involved evaluation of 1) possible ways to increase the glucose release from the commercial cellulase product Celluclast by boosting with other enzyme activities to increase the enzymatic hydrolysis, 2) comparing differently pretreated feedstock substrates and 3) evaluating a fed-batch substrate feeding strategy to increase the substrate loading in the hydrolysis reaction. The substrate for the enzymatic hydrolysis was primarily steam pretreated wheat and barley straw since these substrates were the primary feedstocks for the Babilafuente Bioethanol process. The initial work showed that there was indeed potential to boost the enzyme activities in Celluclast (arising from Trichoderma reesei) by addition of small amounts of fermentation broth from fungal sources other than T. reesei at optimal reaction conditions for Celluclast, pH 5, 50 °C. The activity(ies) related to the boosting effect were indicated to arise from more efficient or different endoglucanase activities than those found in Celluclast. Evaluating of the extent of hydrolysis using the 4 major enzyme activities in Celluclast, which constituted a complete set of enzymes for hydrolysis of cellulose, showed that the most efficient mixture resulted in a glucose release corresponding to ~84% of the glucose release from Celluclast. It was therefore suggested that other enzyme activities than the 4 four main cellulase activities in Celluclast are necessary for optimal hydrolysis of lignocellulose. Even though Celluclast is a multicomponent cellulase mixture, there are still possibilities for further improvement in terms of providing the most efficient cellulase mixture for lignocellulose hydrolysis. It was shown that substrates evaluated all had some residual hemicellulose in the solid cellulose fraction after pretreatment. This residual hemicellulose was speculated to be interlocking the cellulose moiety wherefore hemicellulolytic activities might benefit the glucose release from cellulose hydrolysis. It is therefore suggested that the boosting effect of enzymes in the fungal fermentation broth might to some extent account for the boosting effect and that the hemicellulolytic activities (and remaining cellulolytic activities not evaluated) might account for the lower glucose release obtained with monocomponent activities from T. reesei compared to Celluclast. Evaluation of barley and wheat straw substrates subjected to different pretreatment conditions; hot water extraction and acid- or water impregnation followed by steam explosion showed there were slight differences between the effect of pretreatment conditions in relation to the overall yield from enzymatic hydrolysis. The highest glucose concentration was found for barley straw subjected to acid impregnation followed by steam explosion; however when the glucose concentration was related to the glucose potential in the substrates, the highest yield was obtained with hot water extracted. Analysis of the supernatants from the pretreatments by mass spectrometry showed that the water impregnated straw contained primarily pentose oligomers arising from hemicellulose solubilisation in contrast to the supernatants from acid impregnation. A substrate fed-batch strategy, that is, sequential addition of substrate or substrate + enzymes during the enzymatic hydrolysis was evaluated in terms of viscosity of the reaction mixture, the glucose release, and overall yield. The fed-batch reactions consistently provided lower concentrations of glucose and yield compared to reaction where all substrate was added at the beginning of the hydrolysis. In terms of glucose release and cellulose conversion it a compromise was necessary to achieve high glucose release and high cellulose conversion. In terms of keeping the viscosity of the substrate slurry at a low level throughout the enzymatic hydrolysis reaction the strategy proved effective; the reactions which were added substrate during the hydrolysis had consistently lower viscosity. The low level of viscosity was thought suggest that mixing of substrate and enzyme would be more efficient. The work showed that the commercial cellulase product Celluclast can be improved with enzyme activities from other fungal sources and suggested that supplementation of the current multicomponent cellulase product is feasible as a first step to identify promising enzyme activities for lignocellulose hydrolysis. The importance of other enzyme activities other than the main cellulase components was indicated suggesting that increasing the hydrolytic performance could involve addition of hemicellulase activities to complement the cellulase activities found in Celluclast. Further improving the hydrolysis process in relation to the Babilafuente Bioethanol process might be achieved applying a substrate fed-batch strategy, if optimised in relation to timing of the substrate addition, to achieve high substrate loading since this would ensure a low level of viscosity to ensure efficient mixing of substrate and enzymes.

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Technical University of Denmark
Authors: Rosgaard, L. (Ekstern), Meyer, A. S. (Intern)
Publication date: Aug 2007
Production of oxidatively stable fish oil enriched food emulsions

Purpose: The objective of the project is to determine how a number of selected fish oil enriched foods can be protected against oxidation by the right choice of antioxidants, emulsifiers and optimal process conditions. Furthermore the influence of antioxidant addition to the fish oil itself on the effect of antioxidants added to the foods will also be investigated.

Background: Fish oils are rich sources of the long-chain polyunsaturated fatty acids EPA and DHA of which DHA is a vital component of the phospholipids of human cellular membranes, especially those in the brain and retina. Fish oils have many other health benefitting properties such as preventing heart diseases. Addition of fish oils to foods is therefore of interest. The many double bonds in the fatty acids are however susceptible to oxidation. Collaboration partners: The project is a collaborative project between DFU-FF, BioCentrum-DTU, Arla Foods and Maritex A/S.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Department of Chemical and Biochemical Engineering
Authors: Bruni Let, M. (Intern), Meyer, A. S. (Intern), Jacobsen, C. (Intern)
Number of pages: 83
Publication date: May 2007

Ascorbyl palmitate, gamma-tocopherol, and EDTA affect lipid oxidation in fish oil enriched salad dressing differently

The aim of the study was to investigate the ability of γ-tocopherol, ethylenediaminetetraacetate (EDTA), and ascorbyl palmitate to protect fish oil enriched salad dressing against oxidation during a 6 week storage period at room temperature. The lipid-soluble γ-tocopherol (220 and 880 µg g⁻¹ of fish oil) reduced lipid oxidation during storage by partly retarding the formation of lipid hydroperoxides (PV) and by decreasing the concentrations of individual volatile oxidation products by 34-39 and 42-66%, respectively. EDTA (10 and 50 µg g⁻¹ of dressing) was the most efficient single antioxidant, and overall peroxide values and volatiles were reduced by approximately 70 and 77-86%, respectively. Conversely, prooxidant effects were observed with a high concentration of ascorbyl palmitate (300 µg g⁻¹ of fish oil), whereas a low concentration was slightly antioxidative (50 µg/g of fish oil). Finally, a combination of all three antioxidants completely inhibited oxidation during storage, indicating that the prooxidant effects of ascorbyl palmitate were reverted or overshadowed by EDTA and γ-tocopherol.

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Technical University of Denmark
Authors: Let, M. (Ekstern), Jacobsen, C. (Intern), Meyer, A. S. (Intern)
Pages: 2369-2375
Publication date: 2007
Main Research Area: Technical/natural sciences
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.408 SNIP 1.392
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.317 SNIP 1.303
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.361 SNIP 1.324
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.249 SNIP 1.439
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.358 SNIP 1.418
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.286 SNIP 1.521
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.316 SNIP 1.496
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.158 SNIP 1.479
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.236 SNIP 1.537
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.066 SNIP 1.255
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.091 SNIP 1.312
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.859 SNIP 1.256

Original language: English
Fish oil, Lipid oxidation, Antioxidants, omega-3 PUFA, Ascorbyl palmitate, Tocopherol, EDTA, salad dressing
DOIs:
10.1021/jf062675c
Source: orbit
Source-ID: 197563
Comparison of different pretreatment strategies for enzymatic hydrolysis of wheat and barley straw

In biomass-to-ethanol processes a physico-chemical pretreatment of the lignocellulosic biomass is a critical requirement for enhancing the accessibility of the cellulose substrate to enzymatic attack. This report evaluates the efficacy on barley and wheat straw of three different pretreatment procedures: acid or water impregnation followed by steam explosion versus hot water extraction. The pretreatments were compared after enzyme treatment using a cellulase enzyme system, Celluclast 1.5 L (R) from Trichoderma reesei, and a beta-glucosidase, Novozyme 188 from Aspergillus niger. Barley straw generally produced higher glucose concentrations after enzymatic hydrolysis than wheat straw. Acid or water impregnation followed by steam explosion of barley straw was the best pretreatment in terms of resulting glucose concentration in the liquid hydrolysate after enzymatic hydrolysis. When the glucose concentrations obtained after enzymatic hydrolyses were related to the potential glucose present in the pretreated residues, the highest yield, similar to 48% (g g⁻¹), was obtained with hot water extraction pretreatment of barley straw; this pretreatment also produced highest yields for wheat straw, producing a glucose yield of similar to 39% (g g⁻¹). Addition of extra enzyme (Celluclast 1.5 L (R)+Novozyme 188) during enzymatic hydrolysis resulted in the highest total glucose concentrations from barley straw, 32-39 g L⁻¹, but the relative increases in glucose yields were higher on wheat straw than on barley straw. Maldi-TOF MS analyses of supernatants of pretreated barley and wheat straw samples subjected to acid and water impregnation, respectively, and steam explosion, revealed that the water impregnated + steam-exploded samples gave a wider range of pentose oligomers than the corresponding acid-impregnated samples.

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Novozymes A/S
Authors: Rosgaard, L. (Ekstern), Pedersen, S. (Ekstern), Meyer, A. B. S. (Intern)
Effect of Cellulases, Solvent Type and Particle Size Distribution on the Extraction of Chlorogenic Acid and Other Phenols from Spent Coffee Grounds

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Technical University of Denmark
Pages: 641-651
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: American Journal of Food Technology
Volume: 2
Issue number: 7
ISSN (Print): 1557-4571
Ratings:
Scopus rating (2016): SJR 0.246 SNIP 0.545
Scopus rating (2015): SJR 0.218 SNIP 0.516 CiteScore 0.52
Scopus rating (2014): SJR 0.509 SNIP 1.069 CiteScore 0.99
Scopus rating (2013): SJR 0.349 SNIP 0.852 CiteScore 0.86
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.545 SNIP 1.203 CiteScore 1.55
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.376 SNIP 1.217 CiteScore 1.38
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.23 SNIP 0.474
Scopus rating (2009): SJR 0.189 SNIP 0.258
Scopus rating (2008): SJR 0.159 SNIP 0.196
Original language: English
Source: orbit
Source-ID: 201403
Publication: Research - peer-review › Journal article – Annual report year: 2007

Effect of ripeness and postharvest storage on the evolution of color and anthocyanins in cherries (Prunus avium L.),

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Goncalves, B. (Ekstern), Silva, A. (Ekstern), Moutinho-Pereira, J. (Ekstern), Bacelar, E. (Ekstern), Rosa, E. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 976-984
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Food Chemistry
Volume: 103
Issue number: 3
Enzymatic Hydrolysis of Wheat Arabinoxylan by a Recombinant "Minimal" Enzyme Cocktail Containing beta-Xylosidase and Novel endo-1,4-beta-Xylanase and alpha-L-Arabinofuranosidase Activities

This study describes the identification of the key enzyme activities required in a "minimal" enzyme cocktail able to catalyze hydrolysis of water-soluble and water-insoluble wheat arabinoxylan and whole vinasse, a fermentation effluent resulting from industrial ethanol manufacture from wheat. The optimal arabinose-releasing and xylan-depolymerizing enzyme activities were identified from data obtained when selected, recombinant enzymes were systematically supplemented to the different arabinoxylan substrates in mixtures; this examination revealed three novel alpha-L-arabinofuranosidase activities: (i) one GH51 enzyme from Meripilus giganteus and (ii) one GH51 enzyme from Humicola insolens, both able to catalyze arabinose release from singly substituted xylose; and (iii) one GH43 enzyme from H. insolens able to catalyze the release of arabinose from doubly substituted xylose. Treatment of water-soluble and water-insoluble wheat arabinoxylan with an enzyme cocktail containing a 20%:20%:20%:40% mixture and a 25%:25%:25%:25% mixture, respectively, of the GH43 alpha-L-arabinofuranosidase from H. insolens (Abf II), the GH51 alpha-L-arabinofuranosidase from M. giganteus (Abf III), a GH10 endo-1,4-beta-xylanase from H. insolens (Xyl III), and a GH3 beta-xylosidase from Trichoderma reesei (beta-xyl) released 322 mg of arabinose and 512 mg of xylose per gram of water-soluble wheat arabinoxylan dry matter and 150 mg of arabinose and 266 mg of xylose per gram of water-insoluble wheat arabinoxylan dry matter after 24 h at pH 5, 50 degrees C. A 10%:40%:50% mixture of Abf II, Abf III, and beta-xyl released 56 mg of arabinose and 91 mg of xylose per gram of vinasse dry matter after 24 h at pH 5, 50 degrees C. The optimal dosages of the "minimal" enzyme cocktails were determined to be 0.4, 0.3, and 0.2 g enzyme protein per kilogram of substrate dry matter for the water-soluble wheat arabinoxylan, the water-insoluble wheat arabinoxylan, and the vinasse, respectively. These enzyme protein dosage levels were similar to 14, similar to 18, and similar to 27 times lower than the dosages used previously, when the same wheat arabinoxylan substrates were hydrolyzed with a combination of Ultraflo L and Celluclast 1.5 L, two commercially available enzyme preparations produced by H. insolens and T. reesei.
Evaluation of Minimal Trichoderma reesei Cellulase Mixtures on Differently Pretreated Barley Straw Substrate

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Novozymes A/S
Authors: Rosgaard, L. (Ekstern), Pedersen, S. (Ekstern), Langston, J. (Ekstern), Akerhielm, D. (Ekstern), Cherry, J. (Ekstern), Meyer, A. S. (Intern)
Pages: 1270-1276
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Biotechnology Progress
Volume: 23
ISSN (Print): 8756-7938
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
Evaluation of minimal Trichoderma reesei cellulase mixtures on differently pretreated barley straw substrates

The commercial cellulase product Celluclast 1.5, derived from Trichoderma reesei (Novozymes A/S, Bagsvaerd, Denmark), is widely employed for hydrolysis of lignocellulosic biomass feedstocks. This enzyme preparation contains a broad spectrum of cellulolytic enzyme activities, most notably cellobiohydrolases (CBHs) and endo-1,4-beta-glucanases (EGs). Since the original T. reesei strain was isolated from decaying canvas, the T reesei CBH and EG activities might be present in suboptimal ratios for hydrolysis of pretreated lignocellulosic substrates. We employed statistically designed combinations of the four main activities of Celluclast 1.5, CBHI, CBHII, EGI, and EGII, to identify the optimal glucose-
releasing combination of these four enzymes to degrade barley straw substrates subjected to three different pretreatments. The data signified that EGII activity is not required for efficient lignocellulose hydrolysis when addition of this activity occurs at the expense of the remaining three activities. The optimal ratios of the remaining three enzymes were similar for the two pretreated barley samples that had been subjected to different hot water pretreatments, but the relative levels of EGI and CBHII activities required in the enzyme mixture for optimal hydrolysis of the acid-impregnated, steam-exploded barley straw substrate were somewhat different from those required for the other two substrates. The optimal ratios of the cellulolytic activities in all cases differed from that of the cellulases secreted by T. reesei. Hence, the data indicate the feasibility of designing minimal enzyme mixtures for pretreated lignocellulosic biomass by careful combination of monocomponent enzymes. This strategy can promote both a more efficient enzymatic hydrolysis of (ligno)cellulose and a more rational utilization of enzymes.

General information
State: Published
Organisations: Department of Chemistry, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Rosgaard, L. (Ekstern), Pedersen, S. (Intern), Langston, J. (Ekstern), Akerhielm, D. (Ekstern), Cherry, J. R. (Ekstern), Meyer, A. S. (Intern)
Pages: 1270-1276
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Biotechnology Progress
Volume: 23
Issue number: 6
ISSN (Print): 8756-7938
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.12 SJR 0.668 SNIP 0.762
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.727 SNIP 0.825 CiteScore 2.07
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.808 SNIP 0.931 CiteScore 2.2
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.764 SNIP 0.847 CiteScore 2.16
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.84 SNIP 0.868 CiteScore 2.35
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.918 SNIP 0.956 CiteScore 2.4
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.988 SNIP 0.947
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.965 SNIP 1.047
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Fødevarer i en rationel helhedsbetragtning

General information
State: Published
Organisations: Division of Food Production Engineering, National Food Institute, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Jørgensen, S. B. (ed.) (Intern), Meyer, A. S. (Intern)
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: FoodDTU Midt i Ugen
Original language: Danish
Source: orbit
Source-ID: 221550
Publication: Research - peer-review › Journal article – Annual report year: 2007

Homogenization conditions affect the oxidative stability of fish oil enriched milk emulsions: Lipid oxidation

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Aquatic Lipids and Oxidation, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Bruni Let, M. (Intern), Jacobsen, C. (Intern), Sørensen, A. M. (Intern), Meyer, A. S. (Intern)
Pages: 1773-1780
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 55
Issue number: 5
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
Identification of thermostable beta-xylosidase activities produced by Aspergillus brasiliensis and Aspergillus niger

Twenty Aspergillus strains were evaluated for production of extracellular cellulolytic and xylanolytic activities. Aspergillus brasiliensis, A. niger and A. japonicus produced the highest xylanase activities with the A. brasiliensis and A. niger strains producing thermostable beta-xylosidases. The beta-xylosidase activities of the A. brasiliensis and A. niger strains had similar temperature and pH optima at 75 degrees C and pH 5 and retained 62% and 99%, respectively, of these activities over 1 h at 60 degrees C. At 75 degrees C, these values were 38 and 44%, respectively. Whereas A. niger is a well known enzyme producer, this is the first report of xylanase and thermostable beta-xylosidase production from the newly identified, non-ochratoxin-producing species A. brasiliensis.

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Center for Microbial Biotechnology, Department of Systems Biology
Authors: Pedersen, M. (Intern), Lauritzen, H. (Ekstern), Frisvad, J. C. (Intern), Meyer, A. S. (Intern)
Pages: 743-748
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Biotechnology Letters
Volume: 29
Issue number: 5
ISSN (Print): 0141-5492
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.89 SJR 0.61 SNIP 0.721
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.591 SNIP 0.673 CiteScore 1.66
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.627 SNIP 0.809 CiteScore 1.75
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.713 SNIP 0.941 CiteScore 2.03
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.758 SNIP 0.949 CiteScore 2.03
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.722 SNIP 0.912 CiteScore 1.97
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.698 SNIP 0.894
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.707 SNIP 0.816
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.628 SNIP 0.778
Identification of thermostable β-xylosidase activities produced by Aspergillus brasiliensis and Aspergillus niger

Twenty Aspergillus strains were evaluated for production of extracellular cellulolytic and xylanolytic activities. Aspergillus brasiliensis, A. niger and A. japonicus produced the highest xylanase activities with the A. brasiliensis and A. niger strains producing thermostable beta-xylosidases. The beta-xylosidase activities of the A. brasiliensis and A. niger strains had similar temperature and pH optima at 75 degrees C and pH 5 and retained 62% and 99%, respectively, of these activities over 1 h at 60 degrees C. At 75 degrees C, these values were 38 and 44%, respectively. Whereas A. niger is a well known enzyme producer, this is the first report of xylanase and thermostable beta-xylosidase production from the newly identified, non-ochratoxin-producing species A. brasiliensis.
Lipid oxidation in milk, yoghurt, and salad dressing enriched with neat fish oil or pre-emulsified fish oil

Abstract: This study compared the oxidative stabilities of fish-oil-enriched milk, yoghurt, and salad dressing and investigated the effects on oxidation of adding either neat fish oil or a fish-oil-in-water emulsion to these products. Milk emulsions had higher levels of a fishy off-flavor and oxidized faster, as determined by the peroxide value and volatile oxidation products, than fish-oil-enriched yoghurt and dressing, despite the fact that dressings had a higher fish oil content and were stored at room temperature. Additionally, fish-oil-enriched yoghurt generally had higher oxidative stability than fish-oil-enriched dressings, irrespective of the mode of fish oil addition. Yoghurt thus seemed to be a good delivery system of lipids containing n-3 polyunsaturated fatty acids. Different effects of adding fish oil either as neat fish oil or as a fish-oil-in-water emulsion were observed for milk, yoghurt, and dressing. Yoghurt and dressing enriched with neat fish oil were more stable than those enriched with a fish-oil-in-water emulsion, whereas milk enriched with neat fish oil was less stable than milk enriched with the fish-oil-in-water emulsion. Overall, it seemed that application of neat fish oil was a good option for preserving the final quality in yoghurt and dressings, but a pre-emulsion may still be considered for the fish oil enrichment of certain food products, for example, milk. Keywords: Fish oil; lipid oxidation; oil-in-water emulsion; n-3 PUFA; milk; yoghurt; salad dressing.
Optimisation of oxidative stability of omega-3 enriched milk

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Jacobsen, C. (Intern), Bruni Let, M. (Intern), Meyer, A. S. (Intern)
Publication date: 2007
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 226438
Publication: Research - peer-review › Journal article – Annual report year: 2007

Predictions of flavonoid solubility in ionic liquids by COSMO-RS: experimental verification, structural elucidation, and solvation characterization

Predictions of the solubility of flavonoids in a large variety of ionic liquids (ILs) with over 1800 available structures were examined based on COSMO-RS computation. The results show that the solubilities of flavonoids are strongly anion-dependent. Experimental measurement of the solubilities of esculin and rutin in 12 ILs with varying anions and cations show that predicted and experimental results generally have a good agreement. Based on the sound physical basis of COSMO-RS, the solubility changes of flavonoids were quantitatively associated with solvation interactions and structural characteristics of ILs. COSMO-RS derived parameters, i.e. misfit, H-bonding and van der Waals interaction energy, are shown to be capable of characterizing the complicated multiple interactions in the IL system effectively. H-bonding interaction is the most dominant interaction for ILs (followed by misfit and van der Waals interactions) to determine the solubility of flavonoids, and the anionic part has greater effect on the overall H-bonding capability of the IL. Based on basicity of anions, ILs were categorized into 3 groups, corresponding to the classification of the solubility of flavonoid. COSMO sigma-moment descriptors, which roughly denote the characteristic properties of the ILs, might be of general value to have a fast estimation for the solubilities of flavonoids as well as those compounds with massive moieties as H-bonding donors. The results obtained in this work may be important for achieving an improved understanding of IL solvations and the tailoring of the desired structures of ILs used as the media for efficient enzymatic esterification of flavonoids.

General information
State: Published
Organisations: Department of Systems Biology, Center for Phase Equilibria and Separation Processes, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Food Production Engineering, Center for Energy Resources Engineering
Authors: Guo, Z. (Intern), Lue, B. (Intern), Thomsen, K. (Intern), Meyer, A. S. (Intern), Xu, X. (Intern)
Pages: 1362-1373
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Green Chemistry
Volume: 9
Product inhibition of cellulases during enzymatic hydrolysis of the pre-treated ligno-cellulose

General information
State: Published
Organisations: CHEC Research Centre, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Publication date: 2007
Event: Poster session presented at Book of Abstracts, European Congress of Chemical Engineering (ECCE-6),
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 210996
Publication: Research - peer-review › Poster – Annual report year: 2007

Quantification of glucose inhibition of enzymatic cellulose degradation in pre-treated wheat straw

General information
State: Published
Organisations: CHEC Research Centre, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Publication date: 2007
Host publication information
Title of host publication: Book of abstracts and oral presentation
Main Research Area: Technical/natural sciences
Conference: NordForsk 3rd workshop, 01/01/2007
Source: orbit
Source-ID: 210998
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

Quantitative analysis of phytate globoids isolated from wheat bran and characterization of their sequential dephosphorylation by wheat phytase

Wheat phytase was purified to investigate the action of the enzyme toward its pure substrate (phytic acid - myo-inositol hexakisphosphate) and its naturally occurring substrate (phytate globoids). Phytate globoids were purified to homogeneity from wheat bran, and their nutritionally relevant parameters were quantified by ICP-MS. The main components of the globoids were phytic acid (40% w/w), protein (46% w/w), and several minerals, in particular, K > Mg > Ca > Fe (in concentration order). Investigation of enzyme kinetics revealed that Km and V-max decreased by 29 and 37%, respectively, when pure phytic acid was replaced with phytate globoids as substrate. Time course degradation of phytic acid or phytate globoids using purified wheat phytase was followed by HPIC identification of inositol phosphates appearing and disappearing as products. In both cases, enzymatic degradation initiated at both the 3- and 6-positions of phytic acid and end products were inositol and phosphate.

General information
State: Published
Organisations: Department of Systems Biology, Risø National Laboratory for Sustainable Energy, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Bohn, L. (Ekstern), Josefsen, L. (Intern), Meyer, A. S. (Intern), Rasmussent, S. (Ekstern)
Pages: 7547-7552
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 55
Issue number: 18
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Triticum aestivum, phytate globoids, inositol phosphates, kinetics, minerals, wheat bran, wheat phytase

DOIs:
10.1021/jf071191t

Source: orbit
Source-ID: 214697
Rapid extraction of polyphenols from red grapes

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Technical University of Denmark, FOSS
Authors: Jensen, J. S. (Intern), Blachez, B. (Ekstern), Egebo, M. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 451-461
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: American Journal of Enology and Viticulture
Volume: 58
Issue number: 4
ISSN (Print): 0002-9254
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.017 SNIP 1.052 CiteScore 1.86
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.828 SNIP 1.131 CiteScore 1.99
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.798 SNIP 1.06 CiteScore 1.65
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.253 SNIP 1.599 CiteScore 2.15
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.302 SNIP 1.516 CiteScore 2.24
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.116 SNIP 1.625 CiteScore 2.11
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.763 SNIP 1.136
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.877 SNIP 1.165
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.337 SNIP 1.319
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.023 SNIP 1.201
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.663 SNIP 1.029
Scopus rating (2005): SJR 0.726 SNIP 0.942
Scopus rating (2004): SJR 1.088 SNIP 1.509
Scopus rating (2003): SJR 0.814 SNIP 1.133
Scopus rating (2002): SJR 1.027 SNIP 1.188
Scopus rating (2001): SJR 0.773 SNIP 1.149
Scopus rating (2000): SJR 0.787 SNIP 1.067
Scopus rating (1999): SJR 1.038 SNIP 1.406
Original language: English
Source: orbit
Soluble fiber extracted from potato pulp is highly fermentable but has no effect on risk markers of diabetes and cardiovascular disease in Goto-Kakuzaki rats

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Lærke, H. (Ekstern), Meyer, A. B. S. (Intern), Kaack, K. (Ekstern), Larsen, T. (Ekstern)
Pages: 152-160
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Nutrition Research
Volume: 27
Issue number: 3
ISSN (Print): 0271-5317
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.03 SJR 1.095 SNIP 1.002
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.208 SNIP 1.062 CiteScore 3.12
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.081 SNIP 1.074 CiteScore 2.95
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.998 SNIP 1.175 CiteScore 3.05
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.83 SNIP 0.994 CiteScore 2.55
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.802 SNIP 1.073 CiteScore 2.51
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.645 SNIP 0.802
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.418 SNIP 0.55
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.334 SNIP 0.426
Scopus rating (2007): SJR 0.347 SNIP 0.5
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.338 SNIP 0.473
Scopus rating (2005): SJR 0.373 SNIP 0.503
Scopus rating (2004): SJR 0.294 SNIP 0.398
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.331 SNIP 0.463
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.328 SNIP 0.457
Web of Science (2002): Indexed yes
Statistically designed two step response surface optimization of enzymatic prepress treatment to increase juice yields and lower turbidity of elderberry juice

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, BioChemical Engineering, Danish Institute of Agricultural Sciences
Authors: Landbo, A. R. (Intern), Kaack, K. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 135-142
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Innovative Food Science and Emerging Technologies
Volume: 8
Issue number: 1
ISSN (Print): 1466-8564
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.54 SJR 1.412 SNIP 1.381
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.664 SNIP 1.463 CiteScore 3.48
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.621 SNIP 1.688 CiteScore 3.67
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.372 SNIP 1.653 CiteScore 3.16
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.745 SNIP 1.906 CiteScore 3.45
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.699 SNIP 1.865 CiteScore 3.65
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.546 SNIP 1.482
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.228 SNIP 1.095
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.153 SNIP 1.196
Synergistic enzymatic interactions and effects of sequential enzyme additions during hydrolysis of wheat arabinoxylan

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Sørensen, H. (Ekstern), Pedersen, S. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 908-918
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Enzyme and Microbial Technology
Volume: 40
ISSN (Print): 0141-0229
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.83 SJR 0.759 SNIP 1.025
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.85 SNIP 0.969 CiteScore 2.63
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.061 SNIP 1.214 CiteScore 3.12
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.165 SNIP 1.376 CiteScore 3.2
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.204 SNIP 1.281 CiteScore 2.78
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.062 SNIP 1.27 CiteScore 2.74
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.201 SNIP 1.565
Targeted isolation of constituents of Hubertia species by HPLC-SPE-NMR

General information

State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Pages: 1472-1477
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information

Journal: Journal of Natural Products
Volume: 70
Issue number: 9
ISSN (Print): 0163-3864
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.41 SJR 1.22 SNIP 1.408
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.395 SNIP 1.758 CiteScore 4.14
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.333 SNIP 1.827 CiteScore 3.68
Targeted natural product isolation guided by HPLC-SPE-NMR: Constituents of Hubertia species

The hyphenated technique, high-performance liquid chromatography-solid-phase extraction-nuclear magnetic resonance spectroscopy (HPLC-SPE-NMR), has been applied for rapid identification of novel natural products in crude extracts of Hubertia ambavilla and Hubertia tomentosa. The technique allowed full or partial identification of all major extract constituents and demonstrated the presence of unusual quinic acid derivatives containing the (1-hydroxy-4-oxocyclohexa-2,5-dienyl)acetyl residue that exhibit strongly coupled ABXY patterns, the parameters of which were obtained by spin simulations. Using homo- and heteronuclear 2D NMR data acquired in the HPLC-SPE-NMR mode, complete structure determination of three new natural products, i.e., 3,5-di-O-caffeoyl-4-O-[(1-hydroxy-4-oxocyclohexa-2,5-dienyl)acetyl]quinic acid (1), its 2-hydroxy derivative (2), and 3,5-di-O-caffeoyl-4-O-[(4-hydroxyphenyl)acetyl]quinic acid (3), was performed. Finally, targeted isolation of 1 was achieved by SPE fractionation and preparative HPLC, followed by evaluation of its antioxidant and antimicrobial activity. In contrast to chlorogenic acid and 3,5-di-O-caffeoylquinic acid, which act as antioxidants, compound 1 proved at the same conditions to possess prooxidant activity in an assay evaluating the oxidation of human low-density lipoprotein induced by Cu2+.

General information
State: Published
Organisations: National Veterinary Institute, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Wine dilution affects the reliability of tannin analysis by protein precipitation

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Jensen, J. S. (Intern), Werge, H. H. M. (Ekstern), Egebo, M. (Ekstern), Meyer, A. B. S. (Intern)
Publication date: 2007
Event: Poster session presented at American Society of Enology and Viticulture Annual Meeting, Reno, Nevada, USA
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 214686
Publication: Research - peer-review › Journal article – Annual report year: 2007

A novel GH43 α-L-arabinofuranosidase from Humicola insolens: mode of action and synergy with GH51 α-L-arabinofuranosidases on wheat arabinoxylan

General information
State: Published
Organisations: Department of Systems Biology
Authors: Sørensen, H. R. (Ekstern), Jørgensen, C. (Ekstern), Hansen, C. (Ekstern), Jørgensen, C. (Ekstern), Pedersen, S. (Ekstern), Meyer, A. S. (Intern)
Pages: 850-861
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Applied Microbiology and Biotechnology
Volume: 73
Issue number: 4
ISSN (Print): 0175-7598
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.57 SJR 1.177 SNIP 1.173
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.254 SNIP 1.217 CiteScore 3.43
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.327 SNIP 1.458 CiteScore 3.71
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.533 SNIP 1.432 CiteScore 4.3
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Colorimetric Characterization for Comparative Analysis of Fungal Pigments and Natural Food Colorants

General information
State: Published
Organisations: Center for Microbial Biotechnology, Department of Systems Biology, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Mapari, S. S. (Intern), Meyer, A. B. S. (Intern), Thrane, U. (Intern)
Pages: 7027-7035
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 54
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Effect of enzymatic clarification and rat intestinal extracts incubation on phenolic composition and antioxidant activity of black currant juice

**General information**
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Department of Chemistry
Pages: 6564-6571
Publication date: 2006
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Journal of Agricultural and Food Chemistry
Volume: 54
Issue number: 18
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.408 SNIP 1.392
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.317 SNIP 1.303
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.361 SNIP 1.324
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.249 SNIP 1.439
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.358 SNIP 1.418
Efficiency of new fungal cellulase systems in boosting enzymatic degradation of barley straw lignocellulose

This study examined the cellulytic effects on steam-pretreated barley straw of cellulose-degrading enzyme systems from the five thermophilic fungi Chaetomium thermophilum, Thielavia terrestris, Thermoascus aurantiacus, Corynascus thermophilus, and Myceliophthora thermophila and from the mesophile Penicillium funiculosum. The catalytic glucose release was compared after treatments with each of the crude enzyme systems when added to a benchmark blend of a commercial cellulase product, Celluclast, derived from Trichoderma reesei and a P-glucosidase, Novozym 188, from Aspergillus niger. The enzymatic treatments were evaluated in an experimental design template comprising a span of pH (3.5-6.5) and temperature (35-65 degrees C) reaction combinations. The addition to Celluclast + Novozym 188 of low dosages of the crude enzyme systems, corresponding to 10 wt % of the total enzyme protein load, increased the catalytic glucose yields significantly as compared to those obtained with the benchmark Celluclast + Novozyme 188 blend. A comparison of glucose yields obtained on steam-pretreated barley straw and microcrystalline cellulose, Avicel, indicated that the yield improvements were mainly due to the presence of highly active endoglucanase activity/activities in the experimental enzyme preparations. The data demonstrated the feasibility of boosting the widely studied T reesei cellulase enzyme system with additional enzymatic activity to achieve faster lignocellulose degradation. We conclude that this supplementation strategy appears feasible as a first step in identifying truly promising fungal enzyme sources for fast development of improved, commercially viable, enzyme preparations for lignocellulose degradation.

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Rosgaard, L. (Ekstern), Pedersen, S. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 493-498
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Biotechnology Progress
Volume: 22
Issue number: 2
ISSN (Print): 8756-7938
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.12 SJR 0.668 SNIP 0.762
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.727 SNIP 0.825 CiteScore 2.07
Hvordan påvirker hydrokolloider aromafrigivelse fra fødevarer?

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Bylaite, E. (Intern), Meyer, A. B. S. (Intern), Adler-Nissen, J. (Intern)
Pages: 34-36
Publication date: 2006
Main Research Area: Technical/natural sciences

Liver paté enriched with dietary fibre extracted from potato fibre as fat substitute

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Kaack, K. (Ekstern), Lærke, H. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 267-272
Publication date: 2006
Main Research Area: Technical/natural sciences
New potato fibre for improvement of texture and colour of wheat bread

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Kaack, K. (Ekstern), Pedersen, L. (Ekstern), Lærke, H. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 199-207
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: European Food Research and Technology
Volume: 224
Issue number: 2
Optimization of reaction conditions for enzymatic viscosity reduction and hydrolysis of wheat arabinoxylan in an industrial ethanol fermentation residue

This study examined enzyme-catalyzed viscosity reduction and evaluated the effects of substrate dry matter concentration on enzymatic degradation of arabinoxylan in a fermentation residue, "vinasse", resulting from industrial ethanol manufacture on wheat. Enzymatic catalysis was accomplished with a 50:50 mixture of an enzyme preparation from Humicola insolens, Ultraflo L, and a cellulolytic enzyme preparation from Trichoderma reesei, Celluclast 1.5 L. This enzyme mixture was previously shown to exhibit a synergistic action on arabinoxylan degradation. The viscosity of vinasse decreased with increased enzyme dosage and treatment time at pH 5, 50 degrees C, 5 wt % vinasse dry matter. After 24 h, 76-84%, 75-80%, and 43-47%, respectively, of the theoretically maximal arabinose, xylose, and glucose releases were achieved, indicating that the viscosity decrease was a result of enzyme-catalyzed hydrolysis of arabinoxylan, beta-glucan, and cellulose. In designed response surface experiments, the optimal enzyme reaction conditions with respect to pH and temperature of the vinasse, the vinasse supernatant (mainly soluble material), and the vinasse sediment (mainly insoluble substances) varied from pH 5.2-6.4 and 41-49 degrees C for arabinose release and from pH 4.9-5.3 and 42-46 degrees C for xylose release. Even though only limited hydrolysis of the arabinoxylan in the vinasse sediment fraction was obtained, the results indicated that the same enzyme activities acted on the arabinoxylan in the different vinasse fractions irrespective of the state of solubility of the substrate material. The levels of liberated arabinose and xylose increased with increased dry matter concentration during enzymatic hydrolysis in the vinasse and the vinasse supernatant, but at the same time, increased substrate dry matter concentrations gave corresponding linear decreases in the hydrolytic efficiency as evaluated from levels of monosaccharide release per weight unit dry matter. The study thus documents that enzymatic arabinoxylan hydrolysis of the vinasse significantly decreases the vinasse viscosity and that a compromise in the dry matter must be found if enzymatic efficiency must be balanced with monosaccharide yields.

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Novozymes A/S
Authors: Sørensen, H. (Ekstern), Pedersen, S. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 505-513
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Biotechnology Progress
Volume: 22
Issue number: 2
ISSN (Print): 8756-7938
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.12 SJR 0.668 SNIP 0.762
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.727 SNIP 0.825 CiteScore 2.07
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.808 SNIP 0.931 CiteScore 2.2
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.764 SNIP 0.847 CiteScore 2.16
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.84 SNIP 0.868 CiteScore 2.35
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Oxidative Stability of fish enriched yoghurts

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Jacobsen, C. (Ekstern), Let, M. (Ekstern), Andersen, G. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 71-86
Publication date: 2006

Host publication information
Title of host publication: Seafood research from fish to dish Quality, Safety and processing af wild and farmed fish
Place of publication: Wageningen, Holland
Publisher: Wageningen Academic Publishers
Main Research Area: Technical/natural sciences
Conference: Seafood research from fish to dish, 01/01/2006
Source: orbit
Source-ID: 183034
Publication: Research - peer-review › Journal article – Annual report year: 2006

Oxidative stability of fish oil enriched yoghurts

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering

Scopus rating (2011): SJR 0.918 SNIP 0.956 CiteScore 2.4
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.988 SNIP 0.947
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.965 SNIP 1.047
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.887 SNIP 0.992
Scopus rating (2007): SJR 1.011 SNIP 1.093
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.973 SNIP 1.108
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.905 SNIP 1.029
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.724 SNIP 0.966
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.736 SNIP 0.944
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.844 SNIP 1.075
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.923 SNIP 1.268
Scopus rating (2000): SJR 0.811 SNIP 1.203
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.012 SNIP 1.267
Original language: English
DOIs: 10.1021/bp050396o
Source: orbit
Source-ID: 183034
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006
Preventing oxidation in milk enriched with omega-3 fatty acids

General information
State: Published
Organisations: Department of Systems Biology, Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Bruni Let, M. (Intern), Jacobsen, C. (Intern), Meyer, A. S. (Intern)
Pages: 77-81
Publication date: 2006
Main Research Area: Technical/natural sciences
Publication information
Journal: Lipid Technology
Volume: 18
Issue number: 4
ISSN (Print): 0956-666x
Ratings:
Scopus rating (2016): SJR 0.224 SNIP 0.29 CiteScore 0.53
Scopus rating (2015): SJR 0.227 SNIP 0.278 CiteScore 0.64
Scopus rating (2014): SJR 0.287 SNIP 0.353 CiteScore 0.66
Scopus rating (2013): SJR 0.264 SNIP 0.311 CiteScore 0.43
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.323 SNIP 0.499 CiteScore 0.4
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.323 SNIP 0.368 CiteScore 0.39
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.197 SNIP 0.258
Web of Science (2002): Indexed yes
Original language: English
Source: orbit
Source-ID: 226440
Publication: Research › Journal article – Annual report year: 2006

Protease assisted clarification of black currant juice

General information
State: Published
Organisations: Department of Systems Biology, Department of Chemistry
Pages: 6554-6563
Publication date: 2006
Main Research Area: Technical/natural sciences
Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 54
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.408 SNIP 1.392
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.317 SNIP 1.303
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.361 SNIP 1.324
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.249 SNIP 1.439
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.358 SNIP 1.418
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.286 SNIP 1.521
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.316 SNIP 1.496
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.158 SNIP 1.479
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.236 SNIP 1.537
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.066 SNIP 1.255
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.091 SNIP 1.312
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.859 SNIP 1.256

Original language: English
Source: orbit
Separate and Simultaneous enzymatic hydrolysis and fermentation of wheat hemicellulose with recombinant xylose utilizing Saccharomyces cerevisiae

Fermentations with three different xylose-utilizing recombinant Saccharomyces cerevisiae strains (F12, CR4, and CB4) were performed using two different wheat hemicellulose substrates, unfermented starch free fibers, and an industrial ethanol fermentation residue, vinasse. With CR4 and F12, the maximum ethanol concentrations obtained were 4.3 and 4 g/L, respectively, but F12 converted xylose 15% faster than CR4 during the first 24 h. The comparison of separate hydrolysis and fermentation (SHF) and simultaneous saccharification and fermentation (SSF) with F12 showed that the highest, maximum ethanol concentrations were obtained with SSF. In general, the volumetric ethanol productivity was initially, highest in the SHF, but the overall volumetric ethanol productivity ended up being maximal in the SSF, at 0.013 and 0.010 g/Lh, with starch free fibers and vinasse, respectively.

General information
State: Published
Organisations: Center for Microbial Biotechnology, Department of Systems Biology
Authors: Olsson, L. (Intern), Sørensen, H. R. (Ekstern), Dam, B. P. (Ekstern), Krogh, K. B. R. M. (Intern), Meyer, A. B. S. (Intern)
Pages: 117-129
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Applied Biochemistry and Biotechnology
Volume: 129
Issue number: 1-3
ISSN (Print): 0273-2289
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.81 SJR 0.559 SNIP 0.738
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.57 SNIP 0.74 CiteScore 1.67
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.642 SNIP 0.939 CiteScore 1.92
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.744 SNIP 1.024 CiteScore 2.18
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.797 SNIP 1.034 CiteScore 2.04
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.8 SNIP 0.947 CiteScore 1.92
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.7 SNIP 0.905
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Synergistic enzyme mechanisms and effects of sequential enzyme additions on degradation of water insoluble wheat arabinoxylan

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Novozymes A/S
Authors: Sørensen, H. (Ekstern), Pedersen, S. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 908-918
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Enzyme Microbial. Technol
Volume: 40
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.83 SJR 0.759 SNIP 1.025
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.85 SNIP 0.969 CiteScore 2.63
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.061 SNIP 1.214 CiteScore 3.12
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.165 SNIP 1.376 CiteScore 3.2
Upgrading of grape skins: Significance of plant cell-wall structural components and extraction techniques for phenol release

General information
State: Published
Organisations: Department of Systems Biology, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Pinelo-Jiménez, M. (Intern), Arnous, A. (Intern), Meyer, A. B. S. (Intern)
Pages: 579-590
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Trends of Food Science & Technology
Volume: 17
Issue number: 11
Original language: English
Characterisation of volatile aroma compounds of orange juices by three dynamic and static headspace gas chromatography techniques

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Bylaite, E. (Intern), Meyer, A. B. S. (Intern)
Pages: 176-184
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: European Food Research and Technology
Volume: 222
ISSN (Print): 1438-2377
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.742 SNIP 0.882 CiteScore 1.81
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.732 SNIP 0.822 CiteScore 1.55
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.828 SNIP 0.908 CiteScore 1.71
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.791 SNIP 0.901 CiteScore 1.71
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.872 SNIP 1.038 CiteScore 1.68
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.009 SNIP 1.097 CiteScore 1.87
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.931 SNIP 0.901
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.917 SNIP 0.845
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.852 SNIP 0.849
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.707 SNIP 0.842
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.749 SNIP 0.824
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.723 SNIP 0.789
Effect of xanthan on flavor release from thickened viscous food model systems

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Bylaloe, E. (Intern), Adler-Nissen, J. (Intern), Meyer, A. B. S. (Intern)
Pages: 3577-3583
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 53
Issue number: 9
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
Efficiencies of designed enzyme combinations in releasing xylose and arabinose from wheat arabinoxylan in an industrial ethanol residue

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Sørensen, H. (Ekstern), Pedersen, S. (Ekstern), Viksø-Nielsen, A. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 773-784
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Enzyme Microbial. Technol
Issue number: 5-6
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.83 SJR 0.759 SNIP 1.025
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Enzymatic enhancement of anthocyanins and other phenolics in black currant juice

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Landbo, A. R. (Intern), Meyer, A. B. S. (Intern)
Number of pages: 17
Publication date: 2005
**Enzymatic hydrolysis of hemicellulose: Use of statistical designs for optimization of reactions and uncovering of synergy mechanisms**

**General information**
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Sørensen, H. (Ekstern), Meyer, A. B. S. (Intern), Pedersen, S. (Ekstern)
Pages: 26-29
Publication date: 2005
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Dansk Kemi
Volume: 86
Issue number: 3
ISSN (Print): 0011-6335
Ratings:
- ISI indexed (2013): ISI indexed no
- ISI indexed (2012): ISI indexed no
- ISI indexed (2011): ISI indexed no
- Web of Science (2007): Indexed yes
- Web of Science (2004): Indexed yes
Original language: English
Source: orbit
Source-ID: 183501
Publication: Communication › Journal article – Annual report year: 2005

**Enzymatic upgrading of antioxidant phenolics in berry juice and in press residues**

**General information**
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Meyer, A. B. S. (Intern)
Pages: 382-387
Publication date: 2005
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Fruit Processing
Volume: 6
ISSN (Print): 0939-4435
Ratings:
- BFI (2016): BFI-level 1
- BFI (2015): BFI-level 1
- BFI (2014): BFI-level 1
- BFI (2013): BFI-level 1
- ISI indexed (2013): ISI indexed no
- BFI (2012): BFI-level 1
- ISI indexed (2012): ISI indexed no
- BFI (2011): BFI-level 1
- ISI indexed (2011): ISI indexed no
- BFI (2010): BFI-level 1
- BFI (2009): BFI-level 1
Exploring fungal biodiversity for the production of water-soluble pigments as potential natural food colorants: Fungi as a source of natural food colorants

The production of many currently authorized natural food colorants has a number of disadvantages, including a dependence on the supply of raw materials and variations in pigment extraction. Fungi provide a readily available alternative source of naturally derived food colorants that could easily be produced in high yields. The recent authorization of a fungal food colorant has fuelled research to explore the extraordinary chemical diversity and biodiversity of fungi for the biotechnological production of pigments as natural food colorants. These studies require an appropriate use of chernotaxonomic tools and a priori knowledge of fungal metabolites to carry out intelligent screening for known or novel colorants as lead compounds. Such screening would result in the preselection of some potential pigment producers and the deselection of pathogenic strains and toxin producers. With advances in gene technology, in the future it should be possible to employ metabolic engineering to create microbial cell factories for the production of food colorants.

General information
State: Published
Organisations: Department of Systems Biology, Center for Microbial Biotechnology
Pages: 231-238
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Current Opinion in Biotechnology
Volume: 16
Issue number: 2
ISSN (Print): 0958-1669
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 8.55 SJR 3.331 SNIP 2.1
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.113 SNIP 2.143 CiteScore 7.99
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.271 SNIP 2.068 CiteScore 7.45
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 3.322 SNIP 2.198 CiteScore 7.93
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.508 SNIP 2.327 CiteScore 7.93
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.313 SNIP 2.089 CiteScore 7.76
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.56 SNIP 2.223
From straw to ethanol: The hunt for better enzymes for degradation of straw is part of the development of a new bioethanol process

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Rosgaard, L. (Ekstern), Pedersen, S. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 11-14
Publication date: 2005
Main Research Area: Technical/natural sciences

Influence of hydrocolloids and viscosity on aroma release

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Bylaite, E. (Intern), Meyer, A. B. S. (Intern), Adler-Nissen, J. (Intern)
Pages: 391-394
Publication date: 2005
Kan saftevand laves sundere ved hjælp af enzymere og ny prosøteknologi?

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Meyer, A. B. S. (Intern), Landbo, A. R. (Intern)
Pages: 10-11
Publication date: 2005
Main Research Area: Technical/natural sciences

Protection against oxidation of fish-oil-enriched milk emulsions through addition of rapeseed oil or antioxidants

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Aquatic Lipids and Oxidation, Center for BioProcess Engineering, Department of Biotechnology
Authors: Bruni Let, M. (Intern), Jacobsen, C. (Intern), Pham, K. A. (Ekstern), Meyer, A. S. (Intern)
Pages: 5429-5437
Publication date: 2005
Main Research Area: Technical/natural sciences
Sensory stability and oxidation of fish oil enriched milk is affected by milk storage temperature and oil quality

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Aquatic Lipids and Oxidation, Center for BioProcess Engineering, Department of Biotechnology
Authors: Brunet Let, M. (Intern), Jacobsen, C. (Intern), Meyer, A. S. (Intern)
Pages: 173-182
Publication date: 2005
Main Research Area: Technical/natural sciences
Synergistic antioxidative effects of alkamides, caffeic acid derivatives and polysaccharide fractions from Echinacea purpurea on in vitro oxidation of human low density lipoproteins
Chemical and olfactometric characterization of volatile flavor compounds in a fish oil enriched milk emulsion

Development of objectionable fishy off-flavors is an obstacle in the development of fish oil enriched foods. Only little is known about the sensory impact of specific volatile fish oil oxidation products in food emulsions. This study examined the volatiles profiles of fish oil enriched milk during cold storage (2 degreesC) for 14 days by dynamic headspace sampling followed by gas chromatography-mass spectrometry analyses. Different volatiles (n = 60) comprising alkenals, alkadienals, alkatrienals, and vinyl ketones were identified in the fish oil enriched milk. The potent odorants identified by gas chromatography-olfactometry were 1-penten-3-one, (Z)-4-heptenal, 1-octen-3-one, (Z)-1,5-octadien-3-one, (E,E)-2,4-heptadienal, and (E,Z)-2,6-nonadienal, but despite their potency, none of the separated volatiles imparted a fishy or metallic odor. Two isomers, (E,Z,Z) and (E,E,Z) of 2,4,7-decatrienal were identified in fish oil enriched milk emulsions with peroxide values 0.8 and 3.4 meq/kg, respectively. To our knowledge, this is the first report on appearance of these decatrienals in food emulsions having a relatively low peroxide value.
Effect of ripeness and postharvest storage on the phenolic profiles of cherries (Prunus avium L.)

The phenolic compounds hydroxycinnamates, anthocyanins, flavonols, and flavan-3-ols of sweet cherry cultivars Burial, Saco, Summit, and Van harvested in 2001 and 2002 were quantified by HPLC-DAD. Phenolics were analyzed at partially ripe and ripe stages and during storage at 15±5 degreesC (room temperature) and 1-2 degreesC (cool temperature). Neochlorogenic and p-coumaroylquinic acids were the main hydroxycinnamic acid derivatives, but chlorogenic acid was also identified in all cultivars. The 3-glucoside and 3-rutinoside of cyanidin were the major anthocyanins. Peonidin and pelargonidin 3-rutinosides were the minor anthocyanins, and peonidin 3-glucoside was also present in cvs. Burlat and Van. Epicatechin was the main monomeric flavan-3-ol with catechin present in smaller amounts in all cultivars. The flavonol rutin was also detected. Cultivar Saco contained the highest amounts of phenolics [227 mg/100 g of fresh weight (fw)] and cv. Van the lowest (124 mg/100 g of fw). Phenolic acid contents generally decreased with storage at 1-2 degreesC and increased with storage at 15±5 degreesC. Anthocyanin levels increased at both storage temperatures. In cv. Van the anthocyanins increased up to 5-fold during storage at 15±5 degreesC (from 47 to 230 mg/100 g of fw). Flavonol and flavan-3-ol contents remained quite constant. For all cultivars the levels of phenolic acids were higher in 2001 and the anthocyanin levels were higher in 2002, which suggest a significant influence of climatic conditions on these compounds.

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Goncalves, B. (Ekstern), Landbo, A. R. (Intern), Knudsen, D. (Ekstern), Silva, A. (Ekstern), Moutinho-Pereira, J. (Ekstern), Rosa, E. (Ekstern), Meyer, A. B. S. (Intern)
Effects of different enzymatic maceration treatments on enhancement of anthocyanins and other phenolics in black currant juice

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Landbo, A. R. (Intern), Meyer, A. B. S. (Intern)
Pages: 503-513
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Innovative Food Science and Emerging Technologies
Volume: 5
Issue number: 4
ISSN (Print): 1466-8564
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.54 SJR 1.412 SNIP 1.381
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.664 SNIP 1.463 CiteScore 3.48
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.621 SNIP 1.688 CiteScore 3.67
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.372 SNIP 1.653 CiteScore 3.16
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.745 SNIP 1.906 CiteScore 3.45
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.699 SNIP 1.865 CiteScore 3.65
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.546 SNIP 1.482
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.228 SNIP 1.095
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.153 SNIP 1.196
Scopus rating (2007): SJR 0.959 SNIP 1.302
Effects of different enzymatic pre-press maceration treatments on the release of phenols into blackcurrant juice

The effects of different pectinolytic enzyme treatments on the release of phenolic compounds from blackcurrant berry mash into juice in experimental blackcurrant juice production were examined. The influence of enzyme dose (0-0.1% by weight), degree of berry crushing, maceration time, and temperature on the total phenol concentration, the juice yield, and on polysaccharide degradation were evaluated for four commercial, fungal enzyme preparations in statistically designed experimental templates. In optimal experimental conditions, treatments with Macer8 [FJ] and Pectinex Ultra SP-L released ~6500 and 6650 mg gallic acid equivalents/L of total phenols, respectively. These levels correspond to increases of 14-15% compared to the juice extracted without enzymes, and were significantly higher than those achieved with Rapidase BE Super and Grindamyl pectinase treatments. Increased enzyme dosage gave larger juice yields and higher phenol concentrations. There was a positive, linear correlation between degradation of the substrate polysaccharides and the amount of phenols released. The juice samples inhibited the oxidation of human low-density lipoproteins in vitro in a dose-dependent manner. The non-enzyme-treated sample exhibited higher antioxidant activity than the enzyme-treated juices at equimolar test levels of phenols, presumably because of differences in their phenolic profiles.

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Bagger-Jørgensen, R. (Intern), Meyer, A. B. S. (Intern)
Pages: 620-629
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: European Food Research and Technology
Volume: 219
ISSN (Print): 1438-2377
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.742 SNIP 0.882 CiteScore 1.81
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.732 SNIP 0.822 CiteScore 1.55
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.828 SNIP 0.908 CiteScore 1.71
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.791 SNIP 0.901 CiteScore 1.71
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.872 SNIP 1.038 CiteScore 1.68
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Effects of fish oil type, lipid antioxidants and presence of rapeseed oil on oxidative flavour stability of fish oil enriched milk

General information
State: Published
Organisations: Department of Systems Biology, Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Department of Biotechnology
Authors: Bruni Let, M. (Intern), Jacobsen, C. (Intern), Meyer, A. S. (Intern)
Pages: 170-182
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: European Journal of Lipid Science and Technology
Volume: 106
Issue number: 3
ISSN (Print): 1438-7697
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.06 SJR 0.71 SNIP 1.024
Effects of lactoferrin, phytic acid, and EDTA on oxidation in two food emulsions enriched with long-chain polyunsaturated fatty acids

The influence of the addition of metal chelators on oxidative stability was studied in a milk drink and in a mayonnaise system containing highly polyunsaturated lipids. Milk drinks containing 5% (w/w) of specific structured lipid were supplemented with lactoferrin (6-24 M) and stored at 2 C for up to 9 weeks. Mayonnaise samples with 16% fish oil and 64% rapeseed oil (w/w) were supplemented with either lactoferrin (8-32 M), phytic acid (16-124 M), or EDTA (16-64 M) and were stored at 20 C for up to 4 weeks. The effect of the metal chelators was evaluated by determination of peroxide values, secondary volatile oxidation products, and sensory analysis. Lactoferrin reduced the oxidation when added in concentrations of 12 M in the milk drink and 8 M in the mayonnaise, whereas it was a prooxidant at higher concentrations.
in both systems. In mayonnaise, EDTA was an effective metal chelator even at 16 M, whereas phytic acid did not exert a distinct protective effect against oxidation. The differences in the equimolar effects of the metal chelators are proposed to be due to differences in their binding constants to iron and their different stabilities toward heat and low pH.

**General information**

State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Department of Biotechnology
Pages: 7690-7699
Publication date: 2004
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Journal of Agricultural and Food Chemistry
Volume: 52
Issue number: 25
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.408 SNIP 1.392
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.317 SNIP 1.303
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.361 SNIP 1.324
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.249 SNIP 1.439
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.358 SNIP 1.418
Functional foods 1: Definitioner og produktexempler

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Meyer, A. B. S. (Intern)
Pages: 25-28
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Dansk Kemi
Volume: 84
ISSN (Print): 0011-6335
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Web of Science (2007): Indexed yes
Web of Science (2004): Indexed yes
Original language: Danish
Source: orbit
Source-ID: 226929
Publication: Research - peer-review › Journal article – Annual report year: 2004

Functional foods 2: Nye processer til produktion af sundere frugtsaft

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Meyer, A. B. S. (Intern)
Pages: 2
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Dansk Kemi
Volume: 84
ISSN (Print): 0011-6335
Ratings:
ISI indexed (2013): ISI indexed no
Functional foods. What is that?

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Meyer, A. B. S. (Intern)
Pages: 2-3
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Laboranten
Volume: 48
Issue number: 12
Original language: Danish
Source-ID: 183503
Publication: Communication › Journal article – Annual report year: 2004

Generation of flavour compounds in fermented sausages–the influence of curing ingredients, Staphylococcus starter culture and ripening time

The volatile profiles of fermented sausages made with either Staphylococcus xylosus or Staphylococcus carnosus starter cultures were studied with regard to the influence of salt concentration, ripening time and three different combinations of curing ingredients-nitrate, nitrite or nitrite/ascorbate. Emphasis was laid on volatile compounds originating from degradation of branched-chain amino acids. Volatile compounds were collected using dynamic headspace sampling and were identified by gas chromatography/mass spectrometry (GC/MS). Development in water activity, water loss and pH was monitored throughout maturation. Curing salts had a pronounced effect on the level of volatile compounds. In particular, curing with nitrate instead of nitrite resulted in a striking difference. Generally, nitrate increased the level of volatile compounds compared to nitrite, whereas ascorbate had only a small influence. The concentration level of NaCl had a considerable effect on the amount of volatile compounds but the effect was highly related to the ripening stage. Most compounds, but not all, increased in concentration as ripening proceeded. Major differences in the development of volatile compounds were observed depending on whether S. xylosus or S. carnosus were used as starter culture. In particular the effects of nitrate was much more predominant in the sausages made with S. carnosus than S. xylosus.

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Olesen, P. T. (Intern), Meyer, A. B. S. (Intern), Stahnke, L. H. (Intern)
Pages: 675-687
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Meat Science
Volume: 66
ISSN (Print): 0309-1740
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.33 SJR 1.734 SNIP 1.945
Impact of Isolation Method on the Antioxidant Activity of Rapeseed Meal Phenolics

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Vuorela, S. (Ekstern), Meyer, A. B. S. (Intern), Heinonen, M. (Ekstern)
Pages: 8202-8207
Publication date: 2004
Main Research Area: Technical/natural sciences
Influence of lambda-carrageenan on the release of systematic series of volatile flavor compounds from viscous food model systems

The effect of lambda-carrageenan addition level (0.1, 0.25, 0.4, and 0.5% w/w) and viscosity on the release of systematic series of aroma compounds (aldehydes, esters, ketones, and alcohols) was studied in thickened viscous solutions containing lambda-carrageenan and 10 wt % of sucrose. Air-liquid partition coefficients $K$ ($37{\text{degrees}}\text{C}$) of a total of 43 aroma compounds were determined in pure water and in the lambda-carrageenan solutions by static headspace gas chromatography. Mass transfer of the aroma compounds in water and in the thickened lambda-carrageenan solutions which had a wide viscosity range was assessed by dynamic headspace gas chromatography. $K(37{\text{degrees}}\text{C})$ increased as the carbon chain increased within each homologous series. Esters exhibited the highest volatility, followed by aldehydes, ketones, and alcohols. Under equilibrium, no overall effect of lambda-carrageenan was found, except with the most hydrophobic compounds. Analysis of flavor release under nonequilibrium conditions revealed a suppressing effect of lambda-carrageenan on the release rates of aroma compounds, and the extent of decrease in release rates was dependent on the physicochemical characteristics of the aroma compounds, with the largest effect for the most volatile compounds. However, none of the effects was of a magnitude similar to the obtained changes in the macroscopic viscosity, and the suppressing effects are therefore attributable to the thickener and not the physical properties of the increasingly viscous systems.

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Bylaite, E. (Intern), Ilgunaite, Z. (Ekstern), Meyer, A. B. S. (Intern), Adler-Nissen, J. (Intern)
Pages: 3542-3549
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication Information
Journal: Journal of Agricultural and Food Chemistry
Volume: 52
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Modeling the sensory impact of defined combinations of volatile lipid oxidation products on fishy and metallic off-flavors

The volatiles (EZ)-2,6-nonadienal, 1-penten-3-one, (Z)-4-heptenal, and (EE)-2,4-heptadienal were added to milk containing 1.5% fat according to a central composite design, to evaluate the individual and combinatory effects of these volatiles on sensory properties. The milk samples with added volatiles were subjected to sensory descriptive analysis for fishy and metallic off-flavors. The data were analyzed using partial least-squares regression and multiple linear regression to develop mathematical models. The models revealed significant main effects of (EZ)-2,6-nonadienal and 1-penten-3-one and highlighted the importance of two-factor interactions for contribution toward off-flavors. The results suggest that (EZ)-2,6-nonadienal and 1-penten-3-one could be useful markers for fishy and metallic off-flavors in fish oil and fish oil enriched foods. Within the addition levels of the volatiles there was a curvature effect of (EZ)-2,6-nonadienal, a compensatory effect of (Z)-4-heptenal and (EE)-2,4-heptadienal, and a synergistic effect of (EZ)-2,6-nonadienal and (Z)-4-heptenal in the development of fishy off-flavors.

General information
State: Published
Organisations: Department of Systems Biology, National Institute of Aquatic Resources, Department of Biotechnology, Section for Aquatic Lipids and Oxidation
Pages: 1635-1641
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication Information
Journal: Journal of Agricultural and Food Chemistry
Recovery of volatile aroma compounds from black currant juice by vacuum membrane distillation

This study evaluated the recovery of seven characteristic black currant aroma compounds by vacuum membrane distillation (VMD) carried out at low temperatures (10-45 degreesC) and at varying feed flow rates (100-500 l/h) in a lab scale membrane distillation setup. VMD at feed flow from 100 to 500 l/h at 30 degreesC gave concentration factors, calculated for each aroma compound as C-permeate/C-feed: from similar to 4 to 15. The concentration factors increased with decreased juice temperature during VMD; at 10 degreesC concentration factors of 21-31 were obtained for the highly volatile aroma esters. The recovered levels of the highly volatile aroma compounds ranged from 68 to 83 vol.% with a feed volume reduction of 5 vol.% (10 degreesC, 400 l/h). The theoretically predicted aroma recovery as a function of the feed volume reduction was in accordance with the experimentally obtained values. VMD thus turned out to be a promising technique for gentle stripping of black currant juice aroma compounds.

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology, Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering
Pages: 23-31
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Food Engineering
Volume: 64
Issue number: 1
ISSN (Print): 0260-8774
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Web of Science (2016): Indexed yes
Scopus rating (2016): CiteScore 3.71 SJR 1.479 SNIP 1.842
Web of Science (2015): Indexed yes
Scopus rating (2015): SJR 1.467 SNIP 1.873 CiteScore 3.58
Web of Science (2014): Indexed yes
Scopus rating (2014): SJR 1.524 SNIP 1.975 CiteScore 3.44
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.348 SNIP 1.908 CiteScore 3.1
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.394 SNIP 1.993 CiteScore 2.84
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.329 SNIP 1.922 CiteScore 2.84
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.439 SNIP 1.793
Rye bran bread intake elevates urinary excretion of ferulic acid in humans, but does not affect the susceptibility of LDL to oxidation ex vivo

Background Rye bread contributes an important part of the whole grain intake in the Scandinavian diet. Ferulic acid is the major phenolic compound in rye bran and is an antioxidant in vitro and may, therefore, contribute to cardioprotective effects of whole grain consumption. Aim of study Firstly, to evaluate the bioavailability and potential antioxidative effects in humans of ferulic acid from rye. Secondly, to evaluate urine levels of ferulic acid as a possible biomarker of the ordinary dietary intake of ferulic acid. Methods We determined the urinary excretion of ferulic acid in 18 postmenopausal women after a dietary intake of rye bran or an inert wheat bran (control) in a crossover study (2 x 6 weeks with 4 weeks washout). The potential antioxidative effect of the rye bran intervention was investigated by measuring low-density lipoprotein (LDL) susceptibility to copper oxidation ex vivo. The subjects ingested rye bran enriched breads equivalent to similar to 10.2 mg ferulic acid per day. Results The urinary excretion of ferulic acid averaged similar to 4.8 mg per day during intervention with rye bran breads and similar to 1.9 mg per day on the control breads (P = 0.002). Rye bran intervention had no influence on lag time or propagation rate of the LDL oxidation ex vivo. Conclusions The present study demonstrated that ferulic acid from rye bran is bioavailable and that the urinary concentration of ferulic acid reflects the dietary intake of this hydroxycinnamic acid. Within the period of intervention, the elevated ferulic acid did not produce a measurable antioxidative effect on the subjects' LDL. It is suggested that the determination of ferulic acid in urine is a useful biomarker to assess the intake of ferulic acid from a regular diet.

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Harder, H. (Ekstern), Tetens, I. (Ekstern), Let, M. B. (Intern), Meyer, A. B. S. (Intern)
Pages: 230-236
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: European Journal of Nutrition
Volume: 43
ISSN (Print): 1436-6207
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Screening and identification of novel fungal pigments as potential natural food colorants

**General information**

State: Published
Organisations: Center for Microbial Biotechnology, Department of Systems Biology, Food Biotechnology and Engineering Group
Authors: Mapari, S. S. (Intern), Nielsen, K. F. (Intern), Meyer, A. B. S. (Intern), Thrane, U. (Intern)
Publication date: 2004
Event: Poster session presented at 3rd International congress on Pigments in Food, more than colours, Universite' de Bretagne Occidentale, Quimper, France, 14-17 June, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 155081
Storage affects the phenolic profiles and antioxidant activities of cherries (Prunus avium L) on human low-density lipoproteins

Four sweet cherry cultivars (cvs), Burlat, Saco, Summit and Van, were analysed at harvest and after storage at 2 and 15 degrees C for 30 and 6 days respectively. Phenolic profiles in methanolic extracts of freeze-dried samples of the fresh and differently stored cherries were quantified by high-performance liquid chromatography. Hydroxycinnamates dominated in all samples and represented 60-74% by weight of the phenols in the fresh and stored samples of the cvs Saco, Summit and Van, and 45% by weight of the phenols in the cv Burlat samples, which were richer in anthocyanins. The relative and total levels of hydroxycinnamates, anthocyanins, flavonols and flavan-3-ols varied among cultivars and during storage. Storage at 15 degrees C increased the phenol levels, particularly the cyanidin-3-rutinoside concentration. Cold storage induced decreased total phenol levels in the cvs Summit and Van but increased total phenol levels in the cvs Burlat and Saco. Phenolic cherry extracts inhibited low-density lipoprotein oxidation in vitro in a dose-dependent manner. Extracts of freshly harvested cherries exhibited significantly higher antioxidant activities than extracts of stored samples. The cv Summit samples had the highest antioxidant activity. Differences in the antioxidant effects of the cherry samples were positively correlated with their levels of p-coumaroylquinic acid (p <0.1) but negatively correlated with their cyanidin-3-rutinoside levels (p <0.05).
Antibacterial enzymes

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Meyer, A. B. S. (Intern)
Number of pages: 581
Pages: 42-56
Publication date: 2003

Changes in macroscopic viscosity do not affect the release of aroma aldehydes from a pectinaceous food model system of low sucrose content

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Bylaite, E. (Intern), Meyer, A. B. S. (Intern), Adler-Nissen, J. (Intern)
Pages: 8020-8026
Publication date: 2003
Main Research Area: Technical/natural sciences
Enzymatic hydrolysis of water-soluble wheat arabinoxylan. 1. Synergy between alpha-L-arabinofuranosidases, endo-1,4-beta-xylanases, and beta-xylosidase activities

Hydrolysis of arabinoxylan is an important prerequisite for improved utilization of wheat hemicellulose in the ethanol fermentation industry. This study investigates the individual and combined efficiencies of three commercial, cellulytic and hemicellulytic enzyme preparations, Celluclast 1.5 L, Ultraflo L, and Viscozyme L, in catalyzing the liberation of arabinose and xylose from water-soluble wheat arabinoxylan. Ultraflo L was the best enzyme preparation for releasing arabinose, liberating 53 wt% of the theoretical maximum after 48 h of reaction (10 wt% enzyme/substrate ratio, 40°C, pH 6). Celluclast 1.5 L was superior to the other enzyme preparations in releasing xylose, liberating 26 wt% of the theoretical maximum after 48 h of reaction (10 wt% enzyme/substrate ratio, 50°C, pH 5). The 50:50 mixtures of the enzyme preparations showed no synergistic cooperation in arabinose release, but a synergistic interaction in xylose release was found between Ultraflo L and Celluclast 1.5 L. On the basis of high-performance anion exchange chromatography (HPAEC) analysis of the hydrolysates after enzymatic reaction, we propose that the observed synergism between Celluclast 1.5 L and Ultraflo L is the result of positive interaction between alpha-L-arabinofuranosidase and endo-1,4-beta-xylanase activities present in Ultraflo L that released arabinose, xylobiose and xylotriose, and beta-xylosidase activities in Celluclast 1.5 L, capable of catalyzing the hydrolysis of xylobiose and xylotriose to xylose.

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Sørensen, H. (Ekstern), Meyer, A. B. S. (Intern), Pedersen, S. (Ekstern)
Pages: 726-731
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Journal: Biotechnology and Bioengineering
Volume: 81
Issue number: 6
ISSN (Print): 0006-3592
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.14 SJR 1.411 SNIP 1.163
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.613 SNIP 1.37 CiteScore 4.44
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.589 SNIP 1.401 CiteScore 4.16
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.621 SNIP 1.425 CiteScore 4.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.639 SNIP 1.366 CiteScore 4.04
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Oxidative flavour deterioration of fish oil enriched milk

The oxidative deterioration of milk emulsions supplemented with 1.5 wt-% fish oil was investigated by sensory evaluation and by determining the peroxide value and volatile oxidation products after cold storage. Two types of milk emulsions were produced, one with a highly unsaturated tuna oil (38 wt-% of n-3 fatty acids) and one with cod liver oil (26 wt-% of n-3 fatty acids). The effect of added calcium disodium ethylenediaminetetraacetate (EDTA) on oxidation was also investigated. Emulsions based on cod liver oil with a slightly elevated peroxide value (1.5 meq/kg) oxidised significantly faster than the tuna oil emulsions, having a lower initial peroxide value (0.1 meq/kg). In the tuna oil emulsions the fishy off-flavour could not be detected throughout the storage period. Addition of 5-50 ppm EDTA significantly reduced the development of volatile oxidation products in the cod liver oil emulsions, indicating that metal chelation with EDTA could inhibit the decomposition of lipid hydroperoxides in these emulsions. This study showed that an oxidatively stable milk emulsion containing highly polyunsaturated tuna fish oil could be prepared without significant fishy off-flavour development upon storage, provided that the initial peroxide value was sufficiently low.
Progress of lipid oxidation in different fish oil enriched milk emulsions supplemented with EDTA

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Aquatic Lipids and Oxidation, Department of Biotechnology
Authors: Bruni Let, M. (Intern), Jacobsen, C. (Intern), Frankel, E. (Ekstern), Meyer, A. S. (Intern)
Number of pages: 400
Publication date: 2003

Host publication information
Title of host publication: TAFT 2003 : First joint trans Atlantic fisheries technology conference, 10-14 June 2003 Reykjavik, Iceland : 33rd WEFTA meeting
Place of publication: Reykjavik
Publisher: The Icelandic Fisheries Laboratories
Main Research Area: Technical/natural sciences
Conference: 1st joint trans Atlantic fisheries technology conference: 33rd WEFTA meeting, Reykjavik, Iceland, 10/06/2003 - 10/06/2003
Source: orbit
Source-ID: 229360
Publication: Research › Article in proceedings – Annual report year: 2003

Quantitative analysis of the main phenolics in rapeseed meal and oils processed differently using enzymatic hydrolysis and HPLC

General information
State: Published
Organisations: Department of Systems Biology
Authors: Vuorela, S. (Ekstern), Meyer, A. B. S. (Intern), Heinonen, M. (Ekstern)
Pages: 517-523
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Journal: European Food Research and Technology
Volume: 217
Issue number: 6
ISSN (Print): 1438-2377
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.742 SNIP 0.882 CiteScore 1.81
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.732 SNIP 0.822 CiteScore 1.55
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.828 SNIP 0.908 CiteScore 1.71
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.791 SNIP 0.901 CiteScore 1.71
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.872 SNIP 1.038 CiteScore 1.68
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Antioxidants in fruits, berries and vegetables

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Heinonen, I. M. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 23-51
Publication date: 2002

Host publication information
Title of host publication: Fruit and Vegetable Processing
Volume: Chapter 3
Publisher: Woodhead Publishing/CRC Press
Editor: Jongen, W.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 46307
Publication: Research - peer-review › Journal article – Annual report year: 2003

Changes in dietary fibre, phenolic acids and activity of endogenous enzymes during rye bread-making

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology

Source: orbit
Source-ID: 183244
Publication: Research - peer-review › Book chapter – Annual report year: 2002
Effect of storage on phenolic profiles and antioxidant activity of cherries (Prunus avium L.)

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Gonçalves, B. (Ekstern), Landbo, A. R. (Intern), Let, M. (Ekstern), Silva, A. (Ekstern), Rosa, E. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 97-100
Publication date: 2002

Host publication information
Title of host publication: Health promoting compounds in vegetables and fruits : DIAS report, Plant production
Volume: 29
Publisher: Danish Institute of Agricultural Sciences
Editors: Brandt, K., Åkesson, B.
Series: DIAS Report, Plant Production
Number: 29
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 183248
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Enhance extraction og antioxidant phenols from wine and juice press residues via enzymatic polysaccharide hydrolysis

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Meyer, A. B. S. (Intern)
Pages: 29-33
Publication date: 2002
Main Research Area: Technical/natural sciences

Publication information
Journal: Fruit Processing
Volume: 12
ISSN (Print): 0939-4435
Ratings:
BFI (2016): BFI-level 1
BFI (2015): BFI-level 1
BFI (2014): BFI-level 1
BFI (2013): BFI-level 1
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
BFI (2009): BFI-level 1
BFI (2008): BFI-level 1
Enzymatic enhancement of anthocyanins and other phenolics in black currant juice

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Landbo, A. R. (Intern), Meyer, A. B. S. (Intern)
Pages: 109-112
Publication date: 2002

Host publication information
Title of host publication: Health promoting compounds in vegetables and fruits : DIAS report, Plant production
Volume: 29
Publisher: Danish Institute of Agricultural Sciences
Editors: Brandt, K., Åkesson, B.

Enzymatic extraction of antioxidative phenols from black currant juice pomace (Ribes nigrum)

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Landbo, A. R. (Intern), Meyer, A. B. S. (Intern)
Number of pages: 2
Publication date: 2002

Host publication information
Title of host publication: COST 916 Conference on Bioactive Compounds
ISBN (Print): 9282818160
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 183626
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Fate of anthocyanins in industrial clarification treatment of cherry and black currant juice and the effects on antioxidant activity on low density pipoprotein oxidation in vitro

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Meyer, A. B. S. (Intern), Let, M. (Ekstern), Landbo, A. R. (Intern)
Publication date: 2002

Host publication information
Title of host publication: COST 916 Conference on Bioactive Compounds
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 183633
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Inhibition of oxidation of human-low-density lipoprotein by phenolic extracts from rye and by pure monomeric and dimeric hydroxycinnamates
Microfiltration of red berry juice with thread filters: Effects of temperature, flow and filter pore size

A series of experiments was conducted to demonstrate the applicability of a new Filtomat(R) thread filtration principle for microfiltration of semiprocessed blackcurrant juice and cherry juice. The effect of juice temperature (3-20°C), flow (20-80 L/h), and filter pore size (3-10 μm) on the transmembrane pressure, juice turbidity, protein, sugar, and total phenols levels was evaluated in a lab scale microfiltration unit employing statistically designed factorial experiments. Thread microfiltration reduced significantly the turbidity of both juices. For blackcurrant juice, in all experiments, the turbidity was immediately reduced to the level required for finished juice without compromising either the protein, the sugar or the phenols content. High flow rates increased the turbidity in blackcurrant juice, but did not affect cherry juice quality. Filtomat(R) thread microfiltration therefore appears suitable as a novel technology for berry juice processing, especially for blackcurrant juice filtration.
Natural food preservation

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology, Center for Microbial Biotechnology
Authors: Meyer, A. B. S. (Intern), Suhr, K. I. (Intern), Nielsen, P. V. (Intern), Holm, F. (Ekstern)
Pages: 124-174
Publication date: 2002

Host publication information
Title of host publication: Minimal processing technologies in the food industry
Place of publication: Cambridge
Publisher: Woodhead Publishing
Editor: Ohlsson, T.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 155144
Publication: Research › Book chapter – Annual report year: 2002

Oxidative stability of fish and algae oils containing long-chain polyunsaturated fatty acids in bulk and in oil-in-water emulsions
The oxidative stability of long-chain polyunsaturated fatty acid (PUFA) and docosahexaenoic acid (DHA)-containing fish and algae oils varies widely according to their fatty acid composition, the physical and colloidal states of the lipids, the contents of tocopherols and other antioxidants, and the presence and activity of transition metals. Fish and algal oils were initially much more stable to oxidation in bulk systems than in the corresponding oil-in-water emulsions. The oxidative stability of emulsions cannot, therefore, be predicted on the basis of stability data obtained with bulk long-chain PUFA-containing fish oils and DHA-containing algal oils. The relatively high oxidative stability of an algal oil containing 42% DHA was completely lost after chromatographic purification to remove tocopherols and other antioxidants. Therefore, this evidence does not support the claim that DHA-rich oils from algae are unusually stable to oxidation. Addition of ethylenediaminetetraacetic acid (EDTA) prevented oxidation of both fish and algal oil emulsions without added iron and at low iron:EDTA molar concentrations. EDTA, however, promoted the oxidation of the corresponding emulsions that contained high iron:EDTA ratios. Therefore, to be effective as a metal chelator, EDTA must be added at molar concentrations higher than that of iron to inhibit oxidation of foods containing long-chain PUFA from either fish or algae and fortified with iron.
Retention of phenolic phytochemicals by new technological approaches in berry juice processing

Antioxidant activity of hydroxycinnamic acids on human low-density lipoprotein oxidation

Antioxidant effects of phenolic rye (Secale cereale L.) extracts, monomeric hydroxycinnamates, and ferulic acid dehydrodimers on human low-density lipoproteins
the monomeric hydroxycinnamates decreased in the following order: caffeic acid > sinapic acid > ferulic acid > p-coumaric acid. The antioxidant activity of rye extracts was significantly correlated with their total content of monomeric and dimeric hydroxycinnamates, and the rye bran extract was the most potent. The data suggest that especially rye bran provides a source of dietary phenolic antioxidants that may have potential health effects.

**General information**

State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Andreasen, M. (Ekstern), Landbo, A. R. (Intern), Christensen, L. (Ekstern), Hansen, A. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 4090-4096
Publication date: 2001
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Journal of Agricultural and Food Chemistry
Volume: 49
Issue number: 8
ISSN (Print): 0021-8561
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.408 SNIP 1.392
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.317 SNIP 1.303
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.361 SNIP 1.324
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.249 SNIP 1.439
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.358 SNIP 1.418
Ascorbic acid improves the antioxidant activity of European grape juices by improving the juices' ability to inhibit lipid peroxidation of human LDL in vitro

Antioxidant activities of red and white European grape juices towards copper induced lipid oxidation of human low-density lipoproteins (LDL) were examined in vitro. LDL lipid peroxidation was assessed spectrophotometrically by monitoring the development of conjugated lipid hydroperoxides at 234 nm. Red grape juice concentrate inhibited lipid peroxidation of LDL by prolonging the lag phase by 2.7 times relative to a control when evaluated at a total phenolic concentration of 10 μM gallic acid equivalents (GAE). Both red grape juices tested blocked lipid peroxidation of LDL at 20 μM GAE. White grape juice exerted prooxidant activity at 5–20 μM GAE. The antioxidant activity, inhibition of lipid peroxidation of LDL in vitro, was correlated with the juices' levels of total phenols (r > 0.98, P < 0.01), anthocyanins (r > 0.99, P < 0.01), flavan-3-ols (r > 0.97 P < 0.05), and hydroxybenzoates (r > 0.96, P < 0.05) when the phenolic composition of each grape juices was analysed by HPLC. 5 M ascorbic acid alone did not exert antioxidant activity towards LDL, but combinations of 5 μM ascorbic acid with 5 μM GAE juice phenols eliminated the prooxidant activity of white grape juice, and significantly improved the antioxidant activities of red grape juices.
Efficiency of enzymatic and other alternative clarification and fining treatments on turbidity and haze in cherry juice

Several alternative strategies were examined for improving conventional juice fining procedures for cherry juice clarification and fining in laboratory-scale experiments: Centrifugation of freshly pressed juice from 1000g to 35000g induced decreased turbidity according to a steep, negative power function. Individual and interactive effects on turbidity and haze formation in precentrifuged and uncentrifuged cherry juice of treatments with pectinase, acid protease, bromelain, gallic acid, and gelatin-silica sol were investigated in a factorial experimental design with 32 different parameter combinations. Gelatin-silica sol consistently had the best effect on juice clarity. Centrifugation of cherry juice (10000g for 15 min) prior to clarification treatment significantly improved juice clarity and diminished the rate of haze formation during cold storage of juice. Both treatment of precentrifuged cherry juice with Novozym 89L protease and co-addition of pectinase and gallic acid improved cherry juice clarity and diminished haze levels. None of the alternative treatments produced the unwieldy colloids notorious to gelatin-silica sol treatment. The data suggest that several alternative clarification strategies deserve further consideration in large-scale cherry juice processing. Precentrifugation of juice before clarification and fining is immediately recommended.

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Meyer, A. B. S. (Intern), Köser, C. (Ekstern), Adler-Nissen, J. (Intern)
Pages: 3644-3650
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 49
Issue number: 8
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Enzymatic enhancement and antioxidant activities of anthocyanins and other phenolic compounds in black currant juice

**General information**
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Landbo, A. R. (Intern), Meyer, A. B. S. (Intern)
Pages: 354-356
Publication date: 2001

**Host publication information**
Title of host publication: Biologically-active phytochemicals in food: analysis, metabolism, bioavailability and function
Place of publication: Cambridge
Publisher: Royal Society of Chemistry
Editors: Pfannhauser, W., Fenwick, G., Kokhar, S.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 155112
Publication: Research › Book chapter – Annual report year: 2001

Enzyme-assisted extraction of antioxidative phenols from black current juice press residues (Ribes nigrum)

Enzymatic release of phenolic compounds from pomace remaining from black currant (Ribes nigrum) juice production was examined. Treatment with each of the commercial pectinolytic enzyme preparations Grindamyl pectinase, Macer8 FJ, Macer8 R, and Pectinex BE, as well as treatment with Novozym 89 protease, significantly increased plant cell wall breakdown of the pomace. Each of the tested enzyme preparations except Grindamyl pectinase also significantly enhanced the amount of phenols extracted from the pomace. Macer8 FJ and Macer8 R decreased the extraction yields of anthocyanins, whereas Pectinex BE and Novozym 89 protease showed no effect. A decrease in pomace particle sizes from 500-1000 mum to <125 mum increased the phenol yields 1.6-5 times. Black currant pomace devoid of seeds gave significantly higher yields of phenols than pomace with seeds and seedless wine pomace. Four selected black currant pomace extracts all exerted a pronounced antioxidant activity against human LDL oxidation in vitro when tested at equimolar phenol concentrations of 7.5-10 muM.

**General information**
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Landbo, A. R. (Intern), Meyer, A. B. S. (Intern)
Pages: 3169-3177
Publication date: 2001

**Publication information**
Journal: Journal of Agricultural and Food Chemistry
Volume: 49
Issue number: 7
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Enzyme-assisted release of phenolic antioxidants from wine and juice press residues and their effect on human LDL oxidation in vitro

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Meyer, A. B. S. (Intern), Landbo, A. R. (Intern)
Pages: 300-302
Publication date: 2001

Host publication information
Title of host publication: Biologically-active phytochemicals in food : analysis, metabolism, bioavailability and function
Place of publication: Cambridge UK
Publisher: Royal Society of Chemistry
Editors: Phannhauser, W., Fenwick, G., Khokhar, S.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 183610
Publication: Research - peer-review › Book chapter – Annual report year: 2001

Lipid oxidation in fish oil enriched mayonnaise: Calcium disodium ethylenediaminetetraacetate, but not gallic acid, strongly inhibited oxidative deterioration
The antioxidative effects of gallic acid, EDTA, and extra emulsifier Panodan DATEM TR in mayonnaise enriched with 16% fish oil were investigated. EDTA reduced the formation of free radicals, lipid hydroperoxides, volatiles, and fishy and rancid off-flavors. The antioxidative effect of EDTA was attributed to its ability to chelate free metal ions and iron from egg yolk located at the oil-water interface. Gallic acid reduced the levels of both free radicals and lipid hydroperoxides but promoted slightly the oxidative flavor deterioration in mayonnaise and influenced the profile of volatiles. Gallic acid may therefore promote the decomposition of lipid hydroperoxides to volatile oxidation products. Addition of extra emulsifier reduced the lipid hydroperoxide levels but did not influence the level of free radicals or the oxidative flavor deterioration in mayonnaise; however, it appeared to alter the profile of volatiles. The effect of the emulsifier on the physical structure and rheological properties depended on the presence of antioxidants

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Department of Biotechnology, Department of Systems Biology, Department of Biochemistry and Nutrition
Authors: Jacobsen, C. (Intern), Hartvigsen, K. (Intern), Thomsen, M. H. (Ekstern), Hansen, L. (Ekstern), Lund, P. (Intern), Skibsted, L. (Ekstern), Holmer, G. K. (Intern), Adler-Nissen, J. (Intern), Meyer, A. S. (Intern)
Pages: 1009-1019
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 49
Issue number: 2
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Oxidation in fish oil-enriched mayonnaise 4: Effect of tocopherol concentration on oxidative deterioration

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Department of Biotechnology, Department of Systems Biology, Department of Biochemistry and Nutrition
Authors: Jacobsen, C. (Intern), Hartvigsen, K. (Intern), Lund, P. (Intern), Thomsen, M. (Ekstern), Skibsted, L. (Ekstern), Hølmer, G. K. (Intern), Adler-Nissen, J. (Intern), Meyer, A. S. (Intern)
Pages: 308-318
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: European Food Research and Technology
Volume: 212
Issue number: 3
ISSN (Print): 1438-2377
Ratings:
  BFI (2018): BFI-level 1
  Web of Science (2018): Indexed yes
  BFI (2017): BFI-level 1
  Web of Science (2017): Indexed yes
  BFI (2016): BFI-level 1
  Scopus rating (2016): SJR 0.742 SNIP 0.882 CiteScore 1.81
  Web of Science (2016): Indexed yes
  BFI (2015): BFI-level 1
  Scopus rating (2015): SJR 0.732 SNIP 0.822 CiteScore 1.55
  BFI (2014): BFI-level 1
  Scopus rating (2014): SJR 0.828 SNIP 0.908 CiteScore 1.71
  BFI (2013): BFI-level 1
  Scopus rating (2013): SJR 0.791 SNIP 0.901 CiteScore 1.71
  ISI indexed (2013): ISI indexed yes
  BFI (2012): BFI-level 1
  Scopus rating (2012): SJR 0.872 SNIP 1.038 CiteScore 1.68
  ISI indexed (2012): ISI indexed yes
  Web of Science (2012): Indexed yes
  BFI (2011): BFI-level 1
  Scopus rating (2011): SJR 1.009 SNIP 1.097 CiteScore 1.87
  ISI indexed (2011): ISI indexed yes
  Web of Science (2011): Indexed yes
  BFI (2010): BFI-level 1
  Scopus rating (2010): SJR 0.931 SNIP 0.901
  Web of Science (2010): Indexed yes
  BFI (2009): BFI-level 1
  Scopus rating (2009): SJR 0.917 SNIP 0.845
  Web of Science (2009): Indexed yes
  BFI (2008): BFI-level 1
  Scopus rating (2008): SJR 0.852 SNIP 0.849
  Web of Science (2008): Indexed yes
  Scopus rating (2007): SJR 0.707 SNIP 0.842
  Web of Science (2007): Indexed yes
  Scopus rating (2006): SJR 0.749 SNIP 0.824
  Web of Science (2006): Indexed yes
  Scopus rating (2005): SJR 0.723 SNIP 0.789
  Web of Science (2005): Indexed yes
  Scopus rating (2004): SJR 0.759 SNIP 0.827
  Web of Science (2004): Indexed yes
  Scopus rating (2003): SJR 0.758 SNIP 1.004
  Web of Science (2003): Indexed yes
  Scopus rating (2002): SJR 0.731 SNIP 0.88
  Web of Science (2002): Indexed yes
  Scopus rating (2001): SJR 0.514 SNIP 0.561
  Web of Science (2001): Indexed yes
  Scopus rating (2000): SJR 0.44 SNIP 0.446
  Web of Science (2000): Indexed yes
Oxidation in fish oil enriched mayonnaise: Ascorbic acid and low pH increase oxidative deterioration

The effect of ascorbic acid (0-4000 ppm) and pH (3.8-6.2) on oxidation and levels of iron and copper in various fractions of mayonnaise enriched with 16% fish oil was investigated. Ascorbic acid induced release of iron from the assumed oil-water interface into the aqueous phase at all pH levels, but this effect of ascorbic acid was strongest at low pH (pH 3.8-4.2). Ascorbic acid generally promoted formation of volatile oxidation compounds and reduced the peroxide value in mayonnaises. Peroxide values and total volatiles generally increased with decreasing pH values, suggesting that low pH promoted oxidation. It is proposed that iron bridges between the egg yolk proteins low-density lipoproteins, lipovitellin, and phosvitin at the oil-water interface are broken at low pH values, whereby iron ions become accessible as oxidation initiators. In the presence of ascorbic acid, oxidation is further enhanced due to the reduction of Fe3+ to Fe2+ that rapidly catalyzes lipid oxidation via lipid hydroperoxide decomposition at the oil-water interface in mayonnaise.

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Department of Biotechnology
Authors: Jacobsen, C. (Intern), Timm Heinrich, M. (Intern), Meyer, A. S. (Intern)
Pages: 3947-3956
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 49
Issue number: 8
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Rancidity in fish oil enriched foods

General information
State: Published
Organisations: Food Biotechnology and Engineering Group, Department of Systems Biology
Authors: Jacobsen, C. (Ekstern), Hartvigsen, K. (Intern), Meyer, A. B. S. (Intern)
Pages: 36-41
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: Dansk Kemi
Volume: 82
Issue number: 10
ISSN (Print): 0011-6335
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Web of Science (2007): Indexed yes
Web of Science (2004): Indexed yes
Original language: Danish
Source: orbit
Source-ID: 183505
Publication: Communication › Journal article – Annual report year: 2001
Content of phenolic acids and ferulic acid dehydrodimers in 17 rye (Secale cereale L.) varieties

General information
State: Published
Organisations: Department of Biotechnology
Authors: Andreasen, M. F. (Ekstern), Christensen, L. P. (Ekstern), Meyer, A. B. S. (Intern), Hansen, A. (Ekstern)
Pages: 2837-2842
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 48
Issue number: 7
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.408 SNIP 1.392
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.317 SNIP 1.303
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.361 SNIP 1.324
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.249 SNIP 1.439
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.358 SNIP 1.418
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.286 SNIP 1.521
Web of Science (2005): Indexed yes
Effect of ascorbic acid on iron release from the emulsifier interface and on the oxidative flavor deterioration in fish oil enriched mayonnaise

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Department of Biotechnology
Authors: Jacobsen, C. (Intern), Meyer, A. S. (Intern), Adler-Nissen, J. (Intern)
Pages: 4917-4926
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 47
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
ISI indexed (2011): ISI indexed yes
Enzyme assisted solubilization of beta-glucans from rye bran

General information
State: Published
Organisations: Department of Biotechnology
Authors: Meyer, A. B. S. (Intern), Hermannsdottir, F. (Ekstern), Bergsæe, M. N. (Intern)
Pages: 157-160
Publication date: 2000

Host publication information
Title of host publication: Proceedings 2nd European symposium on enzymes in grain processing
Publisher: Technical Research Centre of Finland
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 177442
Publication: Research - peer-review › Journal article – Annual report year: 2000

Ferulic acid dehydrodimers in rye (Secale cereale L)

General information
State: Published
Organisations: Department of Biotechnology, Årslev, Royal Veterinary and Agricultural University
Authors: Andreasen, M. (Ekstern), Christensen, L. (Ekstern), Meyer, A. M. B. S. (Intern), Hansen, Å. (Ekstern)
Pages: 303-307
Publication date: 2000
Main Research Area: Technical/natural sciences
Oxidation in fish-oil-enriched mayonnaise 2: Assessment of the efficacy of different tocopherol antioxidant systems by discriminant partial least squares regression analysis
Oxidative protection of mayonnaises with 16% fish oil was studied during cold storage (5 degrees C) after supplementation with different tocopherol systems: the ternary antioxidant system ascorbic acid, lecithin and tocopherol (A/L/T), and two commercial mixtures, an oil-soluble (Toco 70) preparation and a water-soluble (Grindox 1032) preparation. The physical structure of the fish-oil-enriched mayonnaise was manipulated by adding extra emulsifier (Panodan TR) with the purpose of investigating whether or not this affected the antioxidative activity of the tocopherol mixtures. A number of different analytical techniques HPLC (high-performance liquid chromatography), gas chromatography mass spectrometry (GC-MS), sensory analysis, confocal laser scanning microscopy and rheological measurements were employed to elucidate the chemical, sensory, structural and rheological aspects of the oxidation process. Discriminant partial least squares regression was used to analyse the data obtained. The three tocopherol preparations not only affected the oxidative stability of the mayonnaises differently they also influenced the rheological and structural properties of the mayonnaises in different ways. The rheological and structural properties of the mayonnaise were also affected by the addition of extra emulsifier, but this did not influence the formation of fishy and rancid off-flavours. Addition of the A system caused the immediate formation of distinct fish; and rancid off-flavours in the fresh mayonnaises. The volatile compounds trans-2-heptenal, 3-octen-3-one, 1-octen-3-ol, trans,cis-2, 4-heptadienal, trans,trans-2,4-heptadienal, trans-2-octenal, nonanal and trans,cis-3,6-nonadienal were thought to contribute to the fishy and rancid flavours. Addition of Toco 70 did not affect the sensory perception of mayonnaise nor the development of volatile of flavour compounds as evaluated by GC-MS, but the peroxide values were slightly increased in mayonnaise containing Toco 70 as compared to the other mayonnaises. Mayonnaise with Grinder 1032 seemed to have fewer fishy and rancid off-flavours than mayonnaises without antioxidant. This flavour-protective effect of Grindox 1032 was correlated to an increase in the size of the droplet diameter of mayonnaises supplemented with Grindox 1032

**General information**

State: Published

Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Department of Biotechnology, Department of Systems Biology, Department of Biochemistry and Nutrition


Pages: 242-257

Publication date: 2000

Main Research Area: Technical/natural sciences

**Publication information**

Journal: European Food Research and Technology

Volume: 210

Issue number: 4

ISSN (Print): 1438-2377

Ratings:

- BFI (2018): BFI-level 1
- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 1
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): SJR 0.742 SNIP 0.882 CiteScore 1.81
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 0.732 SNIP 0.822 CiteScore 1.55
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 0.828 SNIP 0.908 CiteScore 1.71
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 0.791 SNIP 0.901 CiteScore 1.71
- ISI indexed (2013): ISI indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 0.872 SNIP 1.038 CiteScore 1.68
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 1.009 SNIP 1.097 CiteScore 1.87
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
Oxidation in fish oil-enriched mayonnaise 3: Assessment of the influence of the emulsion structure on oxidation by discriminant partial least squares regression analysis

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Department of Biotechnology, Department of Systems Biology, Department of Biochemistry and Nutrition, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Authors: Jacobsen, C. (Intern), Hartvigsen, K. (Intern), Lund, P. (Intern), Thomsen, M. (Ekstern), Skibsted, L. (Ekstern), Adler-Nissen, J. (Intern), Hølmer, G. K. (Intern), Meyer, A. S. (Intern)
Pages: 86-98
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: European Food Research and Technology
Volume: 211
ISSN (Print): 1438-2377
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.742 SNIP 0.882 CiteScore 1.81
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
The problems of using one-dimensional methods to evaluate multifunctional food and biological antioxidants

General information
State: Published
Organisations: Department of Biotechnology
Authors: Frankel, E. N. (Ekstern), Meyer, A. B. S. (Intern)
Pages: 1925-1941
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Antioxidant activity of hydroxycinnamic acids on human LDL oxidation in vitro

General information
State: Published
Organisations: Department of Biotechnology
Authors: Meyer, A. M. B. S. (Intern), Andreasen, M. (Ekstern)
Pages: 197-199
Publication date: 1999

Host publication information
Title of host publication: Antioxidant activity of hydroxycinnamic acids on human LDL oxidation in vitro
Place of publication: Cambridge
Publisher: Royal Society of Chemistry
Main Research Area: Technical/natural sciences
Conference: Natural Antioxidants and anticarcinogens in nutrition, health, and disease, Helsinki, Finland, 01/01/1998
Source: orbit
Source-ID: 173148
Publication: Research - peer-review › Article in proceedings – Annual report year: 1999

Antioxidant activity of phenolic compounds in grape juice and prune juice on human low-density lipoproteins

General information
State: Published
Organisations: Department of Biotechnology
Authors: Meyer, A. M. B. S. (Intern)
Pages: 426-430
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication information
Journal: Fruit Processing
Volume: 9
ISSN (Print): 0939-4435
Ratings:
BFI (2016): BFI-level 1
BFI (2015): BFI-level 1
BFI (2014): BFI-level 1
BFI (2013): BFI-level 1
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
BFI (2009): BFI-level 1
BFI (2008): BFI-level 1
Original language: English
Source: orbit
Source-ID: 173155
Publication: Research - peer-review › Journal article – Annual report year: 1999

Enzymatic hydrolysis of plant material: Kinetics, reactions conditions and substrate effects

General information
State: Published
Organisations: Department of Biotechnology, Technical University of Denmark
Enzymatic hydrolysis of plant material: Synergism and antagonism among enzymes

General information
State: Published
Organisations: Department of Biotechnology, Technical University of Denmark
Authors: Meyer, A. M. B. S. (Intern), Landbo, K. (Ekstern)
Pages: 10-13
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication information
Journal: Alimenta
Volume: 22
Issue number: 10
Original language: Danish
Source: orbit
Source-ID: 173164
Publication: Research › Journal article – Annual report year: 1999

Oxidation in fish-oil-enriched mayonnaise 1: Assessment of propyl gallate as an antioxidant by discriminant partial least squares regression analysis

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Department of Biotechnology, Department of Systems Biology, Department of Biochemistry and Nutrition
Authors: Jacobsen, C. (Intern), Hartvigsen, K. (Intern), Lund, P. (Intern), Meyer, A. S. (Intern), Adler-Nissen, J. (Intern), Holstborg, J. (Ekstern), Hølmer, G. K. (Intern)
Pages: 13-20
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication information
Journal: European Food Research and Technology
Volume: 210
ISSN (Print): 1438-2377
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.742 SNIP 0.882 CiteScore 1.81
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.732 SNIP 0.822 CiteScore 1.55
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.828 SNIP 0.908 CiteScore 1.71
Oxidation mechanisms in real food emulsions: Oil-water partition coefficients of selected volatile off-flavor compounds in mayonnaise

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Department of Biotechnology
Authors: Jacobsen, C. (Intern), Meyer, A. S. (Intern), Adler-Nissen, J. (Intern)
Pages: 317-327
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication information
Journal: European Food Research and Technology: international journal of food research and technology
Partitioning of selected antioxidants in mayonnaise

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Department of Biotechnology
Authors: Jacobsen, C. (Intern), Schwarz, K. (Ekstern), Stockmann, H. (Ekstern), Meyer, A. S. (Intern), Adler-Nissen, J. (Intern)
Pages: 3601-3610
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 47
Issue number: 9
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.408 SNIP 1.392
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.317 SNIP 1.303
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.361 SNIP 1.324
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.249 SNIP 1.439
Web of Science (2007): Indexed yes
Plant cell wall degrading enzymes for fruit juice processing

General information
State: Published
Organisations: Department of Biotechnology, Technical University of Denmark
Authors: Landbo, K. (Ekstern), Meyer, A. M. B. S. (Intern)
Pages: 13-15
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication information
Journal: Alimenta
Volume: 22
Issue number: 8
Original language: Danish
Source: orbit
Source-ID: 173162
Publication: Research - peer-review › Journal article – Annual report year: 1999

Release of hydroxycinnamic and hydroxybenzoic acids in rye by commercial plant cell wall degrading enzyme preparations

General information
State: Published
Organisations: Department of Biotechnology, Årslev, Royal Veterinary and Agricultural University
Authors: Andreasen, M. (Ekstern), Christensen, L. (Ekstern), Meyer, A. M. B. S. (Intern), Hansen, Å. (Ekstern)
Pages: 411-413
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of the Science of Food and Agriculture
Volume: 79
ISSN (Print): 0022-5142
Ratings:
BFI (2018): BFI-level 1
The architecture of the plant plant wall: Fruits

General information
State: Published
Organisations: Department of Biotechnology, Technical University of Denmark
Authors: Landbo, K. (Ekstern), Meyer, A. M. B. S. (Intern)
Pages: 10-12
Publication date: 1999
Main Research Area: Technical/natural sciences

Antioxidant activity of berry phenolics on human low-density lipoprotein and liposome oxidation

General information
State: Published
Organisations: Department of Biotechnology
Authors: Heinonen, M. (Ekstern), Meyer, A. M. B. S. (Intern), Frankel, E. (Ekstern)
Pages: 4107-4112
Publication date: 1998
Main Research Area: Technical/natural sciences

Antioxidant activity of phenolic compounds in grapes

General information
State: Published
Organisations: Department of Biotechnology
Authors: Meyer, A. M. B. S. (Intern), Yi, O. (Ekstern), Frankel, E. (Ekstern)
Pages: 37-41
Publication date: 1998

Host publication information
Title of host publication: Proceedings 19th Nordic Lipid symposium
Place of publication: Bergen, Norway
Publisher: LipidForum
Main Research Area: Technical/natural sciences
Conference: 19th Nordic Lipid Symposium, Ronneby, Sweden, 15/06/1997 - 15/06/1997
Source: orbit
Source-ID: 173147
Publication: Research - peer-review › Article in proceedings – Annual report year: 1998

Antioxidant interactions of catechin, cyanidin, caffeic acid, quercetin, and ellagic acid on human LDL oxidation

General information
State: Published
Organisations: Department of Biotechnology
Authors: Meyer, A. M. B. S. (Intern), Heinonen, M. (Ekstern), Frankel, E. (Ekstern)
Pages: 71-75
Publication date: 1998
Antioxidants in grapes and grape juices and their potential health effects

General information
State: Published
Organisations: Department of Biotechnology
Authors: Frankel, E. (Ekstern), Meyer, A. M. B. S. (Intern)
Pages: 1-7
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: Pharmaceutical Biology
Volume: 36
Original language: English
Source: orbit
Source-ID: 173146
Publication: Research - peer-review › Journal article – Annual report year: 1998

Commercial grape juices inhibit the in vitro oxidation of human low-density lipoproteins

General information
State: Published
Organisations: Department of Biotechnology
Authors: Frankel, E. (Ekstern), Bosanek, C. (Ekstern), Meyer, A. M. B. S. (Intern), Silliman, K. (Ekstern), Kirk, L. (Ekstern)
Pages: 834-838
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agriculture and Food Chemistry
Volume: 46
Original language: English
Source: orbit
Source-ID: 173137
Publication: Research - peer-review › Journal article – Annual report year: 1998

Enzymatic release of antioxidants for human LDL from grape pomace

General information
State: Published
Organisations: Department of Biotechnology, Technical University of Denmark
Authors: Meyer, A. M. B. S. (Intern), Jepsen, S. M. (Intern), Sørensen, N. (Ekstern)
Pages: 2439-2446
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agriculture and Food Chemistry
Volume: 46
Original language: English
Source: orbit
Source-ID: 173143
Publication: Research - peer-review › Journal article – Annual report year: 1998
Enzymatic release of antioxidants for human low-density lipoprotein from grape pomace

General information
State: Published
Organisations: Department of Biotechnology, Department of Biochemistry and Nutrition
Authors: Meyer, A. M. B. (Intern), Jepsen, S. M. (Intern), Sørensen, N. S. (Intern)
Pages: 2439-2446
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agricultural and Food Chemistry
Volume: 46
Issue number: 7
ISSN (Print): 0021-8561
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.45 SJR 1.291 SNIP 1.344
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.236 SNIP 1.253 CiteScore 3.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.278 SNIP 1.421 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.423 SNIP 1.479 CiteScore 3.44
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.43 SNIP 1.471 CiteScore 3.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.408 SNIP 1.392
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.317 SNIP 1.303
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.361 SNIP 1.324
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.249 SNIP 1.439
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.358 SNIP 1.418
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.286 SNIP 1.521
Web of Science (2005): Indexed yes
Fruit hydroxycinnamic acids inhibit human LDL oxidation in vitro

General information
State: Published
Organisations: Department of Biotechnology
Authors: Meyer, A. M. B. S. (Intern), Donovan, J. (Ekstern), Pearson, D. (Ekstern), Waterhouse, A. (Ekstern), Frankel, E. (Ekstern)
Pages: 1783-1787
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agriculture and Food Chemistry
Volume: 46
Original language: English
Source: orbit
Source-ID: 173142
Publication: Research - peer-review › Journal article – Annual report year: 1998

Interactions between functional ingredients, antioxidants and off-flavour compounds in mayonnaise with fish oil

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, National Food Institute
Authors: Jacobsen, C. (Intern), Meyer, A. S. (Intern), Adler-Nissen, J. (Intern)
Publication date: 1998
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 229314
Publication: Research › Conference abstract for conference – Annual report year: 1998

Oxidation mechanisms in real food emulsions : Method for separation of mayonnaise by ultracentrifugation

General information
State: Published
Organisations: Section for Aquatic Lipids and Oxidation, National Institute of Aquatic Resources, Department of Biotechnology
Authors: Jacobsen, C. (Intern), Meyer, A. S. (Intern), Adler-Nissen, J. (Intern)
Pages: 87-101
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Phenolic composition and antioxidant activity of prunes and prune juice (Prunus domestica)

General information
State: Published
Organisations: Department of Biotechnology
Authors: Donovan, J. (Ekstern), Meyer, A. M. B. S. (Intern), Waterhouse, A. (Ekstern)
Pages: 1247-1252
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Agriculture and Food Chemistry
Volume: 46
Original language: English
Source: orbit
Source-ID: 173141
Publication: Research - peer-review › Journal article – Annual report year: 1998

Antioxidant activity of grape extracts in a lecithin liposome system

General information
State: Published
Organisations: Department of Biotechnology
Authors: Yi, O. (Ekstern), Meyer, A. M. B. S. (Intern), Frankel, E. (Ekstern)
Pages: 1301-1307
Inhibition of low-density lipoprotein oxidation in relation to composition of phenolic antioxidants in grapes

General information
State: Published
Organisations: Department of Biotechnology
Authors: Meyer, A. M. B. S. (Intern), Yi, O. (Ekstern), Pearson, D. (Ekstern), Waterhouse, A. (Ekstern), Frankel, E. (Ekstern)
Pages: 1638-1643
Publication date: 1997
Main Research Area: Technical/natural sciences

The effect of various food parameters on the activity and stability of catalase from Aspergillus niger and catalase from bovine liver

General information
State: Published
Organisations: Department of Biotechnology
Authors: Meyer, A. M. B. S. (Intern), Pedersen, L. H. (Ekstern), Isaksen, A. (Ekstern)
Pages: 137-142
Publication date: 1997
Main Research Area: Technical/natural sciences
Fate of the synergistic antioxidant system ascorbic acid, lecithin, and tocopherol in mayonnaise: Partition of ascorbic acid

General information
State: Published
Organisations: Department of Biotechnology
Authors: Meyer, A. M. B. (Intern), Jacobsen, C. M. (Intern)
Pages: 139-147
Publication date: 1996
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Food Lipids
Volume: 3
Ratings:
Scopus rating (2012): SJR 0.43 SNIP 0.918
Scopus rating (2011): SJR 0.609 SNIP 1.029
Oxidoreductases as food antioxidants

General information
State: Published
Organisations: Department of Biotechnology
Authors: Meyer, A. M. B. (Intern)
Pages: 343-345
Publication date: 1996

Host publication information
Title of host publication: Proceedings 21st World Congress of the International Society for Fat Research (ISF)
Publisher: PJ Barnes & Associates
Main Research Area: Technical/natural sciences
Conference: 21st World Congress of the ISF, Holland, 01/01/1995
Source: orbit
Source-ID: 167590
Publication: Research - peer-review » Article in proceedings – Annual report year: 1996

Critical Assessment of the Applicability of Superoxide Dismutase As An Antioxidant in Lipid Foods

General information
State: Published
Organisations: Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Department of Biotechnology, Food Production Engineering, Department of Systems Biology
Authors: Meyer, A. B. S. (Intern), Rørbaek, K. (Intern), Adler-Nissen, J. (Intern)
Pages: 171-175
Publication date: 1994
Main Research Area: Technical/natural sciences

Publication information
Journal: Food Chemistry
Volume: 51
ISSN (Print): 0308-8146
Ratings:
BFI (2018): BFI-level 2
Methods of Evaluating Food Antioxidants

General information
State: Published
Organisations: Department of Biotechnology
Authors: Meyer, A. B. S. (Intern)
Pages: 56-57
Publication date: 1994
Main Research Area: Technical/natural sciences

Publication information
Journal: Trends in Food Science and Technology
Volume: 5
Issue number: 2
ISSN (Print): 0924-2244
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6 SJR 2.279 SNIP 2.694
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.218 SNIP 2.6 CiteScore 5.51
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.183 SNIP 2.789 CiteScore 5.17
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.195 SNIP 2.679 CiteScore 4.83
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.098 SNIP 2.428 CiteScore 3.91
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.877 SNIP 2.623 CiteScore 3.81
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.729 SNIP 2.488
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.153 SNIP 2.574
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.794 SNIP 2.316
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.662 SNIP 2.298
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.163 SNIP 2.039
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.028 SNIP 1.927
Scopus rating (2004): SJR 1.031 SNIP 1.943
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.714 SNIP 1.416
The Combined Inhibitory Effect of Lysozyme and Low pH on Growth of Listeria Monocytogenes

**General information**
State: Published
Organisations: Department of Biotechnology, Department of Systems Biology, Department of Chemical and Biochemical Engineering
Authors: Johansen, C. (Intern), Gram, L. (Intern), Meyer, A. B. S. (Intern)
Pages: 561-566
Publication date: 1994
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Journal of Food Protection
Volume: 57
ISSN (Print): 0362-028X
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.68 SJR 0.759 SNIP 0.82
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.96 SNIP 1.031 CiteScore 2.03
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.91 SNIP 0.957 CiteScore 1.94
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.083 SNIP 1.087 CiteScore 2.11
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.09 SNIP 0.981 CiteScore 2.03
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.972 SNIP 0.963 CiteScore 1.96
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.006 SNIP 0.946
Web of Science (2010): Indexed yes
Inactivation of Copper, Zinc Superoxide Dismutase from Saccharomyces Cerevisiae in Lipid Food Model Systems

General information
State: Published
Organisations: Department of Systems Biology, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering, Food Production Engineering
Authors: Refsgaard, H. (Intern), Meyer, A. B. S. (Intern), Adler-Nissen, J. (Intern)
Pages: 564-568
Publication date: 1992
Main Research Area: Technical/natural sciences

Publication information
Journal: Lebensmittel-Wissenschaft und Technologie
Volume: 25
ISSN (Print): 0023-6438
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.31
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 3.11
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 3.12
Web of Science (2014): Indexed yes
Projects:

**Discovery and engineering of new enzymes for efficient enzymatic conversion of CO2 to CH2OH**

Department of Chemical and Biochemical Engineering  
**Period:** 01/04/2017 → 31/03/2020  
**Number of participants:** 4  
Phd Student:  
Nielsen, Christian Førgaard (Intern)  
Supervisor:  
Christensen, Jakob Munkholt (Intern)  
Lange, Lene (Intern)  
Main Supervisor:  
Meyer, Anne S. (Intern)  

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Samfinansieret - Andet  
Project: PhD

**Homology to peptide pattern for annotation of carbohydrate-active enzymes and prediction of function**

Department of Chemical and Biochemical Engineering  
**Center for BioProcess Engineering**  
**Period:** 14/12/2016 → 12/04/2017  
**Number of participants:** 5  
Acronym: Hotpep-carbohydrate  
Project participant:  
Busk, Peter Kamp (Intern)  
Pilgaard, Bo (Intern)  
Lezyk, Mateusz Jakub (Intern)
Production of alkali from cocoa husk ash and biological extraction of hydrocolloid from Sargassum sp.

Department of Chemical and Biochemical Engineering
Center for BioProcess Engineering
Period: 05/09/2016 → 06/02/2017
Number of participants: 4
Project participant:
Rhein-Knudsen, Nanna (Intern)
Bentil, Joseph Asankomah (Intern)
Supervisor:
Ale, Marcel Tutor (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)

Production of alkali from cocoa husk ash for extraction of hydrocolloid from biologically pretreated red seaweed

Department of Chemical and Biochemical Engineering
Center for BioProcess Engineering
Period: 05/09/2016 → 06/02/2017
Number of participants: 4
Phd Student:
Rhein-Knudsen, Nanna (Intern)
Bentil, Joseph Asankomah (Intern)
Supervisor:
Ale, Marcel Tutor (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)

Relations
Parent project:
Seaweed Biorefinery in Ghana

Systematic enzyme discovery, targeted to fungal and algal biomass

Department of Chemical and Biochemical Engineering
Period: 01/08/2016 → 30/07/2020
Number of participants: 4
Phd Student:
Pilgaard, Bo (Intern)
Supervisor:
Busk, Peter Kamp (Intern)
Meyer, Anne S. (Intern)
Main Supervisor:
Lange, Lene (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

PhD position in Valorization of Industrial Waste Streams from Tuber Processing - Sino Danish Center (SDC)

Department of Chemical and Biochemical Engineering
Enzymatic lignin biorefining by cleavage of lignin-carbohydrate complexes

Department of Chemical and Biochemical Engineering
Period: 15/05/2016 → 14/05/2019
Number of participants: 4
Phd Student: Mosbech, Caroline (Intern)
Supervisor: Wittrup Agger, Jane (Intern)
Busk, Peter Kamp (Intern)
Main Supervisor: Meyer, Anne S. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Energy production from seaweed and seaweed processing residues

Department of Chemical and Biochemical Engineering
Period: 15/12/2015 → 04/03/2016
Number of participants: 3
Phd Student: Iddrisu, Abdul-Mumeen (Ekstern)
Supervisor: Thygesen, Anders (Intern)
Main Supervisor: Meyer, Anne S. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Stipendie fra udlandet
Project: PhD

Laccase engineering and reaction analysis

Department of Chemical and Biochemical Engineering
Period: 01/12/2015 → 02/05/2019
Number of participants: 3
Phd Student: Perna, Valentina (Intern)
Supervisor: Wittrup Agger, Jane (Intern)
Main Supervisor: Meyer, Anne S. (Intern)
**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Samfinansieret - Andet  
Project: PhD

**Fractionation and enzymatic processing of biomass for biorefinery applications**

Department of Chemical and Biochemical Engineering  
Period: 01/02/2015 → 30/04/2018  
Number of participants: 7  
Phd Student:  
Djajadi, Demi Tristan (Intern)  
Supervisor:  
Jørgensen, Henning (Intern)  
Pinelo, Manuel (Intern)  
Main Supervisor:  
Meyer, Anne S. (Intern)  
Examiner:  
Thomsen, Kaj (Intern)  
Barsberg, Søren Talbro (Ekstern)  
Ragauskas, Arthur J. (Ekstern)

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Samfinansieret - Andet  
Project: PhD

**Study of Fixed Film Fixed Filter AD (4FAD) Biogas System Performance at High Suspende Solids and COD loads**

Department of Chemical and Biochemical Engineering  
Period: 01/02/2015 → 31/01/2019  
Number of participants: 5  
Phd Student:  
Gonzalez Londono, Jorge Enrique (Intern)  
Supervisor:  
Jensen, Anders Peter (Ekstern)  
Thomsen, Kaj (Intern)  
Uller, Bjarne (Ekstern)  
Main Supervisor:  
Meyer, Anne S. (Intern)

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Ansat eksternt  
Project: PhD

**Cellulase enzymology and production**

Department of Chemical and Biochemical Engineering  
Period: 01/01/2015 → 18/04/2018  
Number of participants: 8  
Phd Student:  
Bentil, Joseph Asankomah (Intern)  
Supervisor:  
Lange, Lene (Intern)  
Thygesen, Anders (Intern)  
Main Supervisor:  
Meyer, Anne S. (Intern)  
Examiner:  
Østergård, Hanne (Intern)
Jørgensen, Henning (Intern)
Jørgensen, Henning (Intern)
Polikarpoc, Igor (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Stipendie fra udlandet
Project: PhD

**Enzyme discovery for seaweed processing**
Department of Chemical and Biochemical Engineering
Period: 01/01/2015 → 16/04/2018
Number of participants: 4
Phd Student: Cao, Thi Thuy Hang (Intern)
Supervisor: Dalgaard Mikkelsen, Maria (Intern)
Mikkelsen, Jørn Dalgaard (Intern)
Main Supervisor: Meyer, Anne S. (Intern)

**Research of conductive spinning solution in ionic liquid and enzymatic modification cellulose system**
Department of Chemical and Biochemical Engineering
Period: 01/01/2015 → 31/12/2017
Number of participants: 7
Phd Student: Liu, Yanrong (Intern)
Supervisor: Thomsen, Kaj (Intern)
Zhang, Suo-Jiang (Ekstern)
Main Supervisor: Meyer, Anne S. (Intern)
Examiner: von Solms, Nicolas (Intern)
Chiappe, Cinzia (Ekstern)
Guo, Zheng (Intern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Stipendie fra udlandet
Project: PhD

**Seaweed polysaccharides production using enzymes technologies**
Department of Chemical and Biochemical Engineering
Period: 01/12/2014 → 22/05/2018
Number of participants: 7
Phd Student: Rhein-Knudsen, Nanna (Intern)
Supervisor: Holck, Jesper (Intern)
Dalgaard Mikkelsen, Maria (Intern)
Main Supervisor:
New fungal endomannanase diversity for mannan containing subrates in bioenergy

Department of Chemical and Biochemical Engineering
Period: 01/06/2014 → 08/10/2018
Number of participants: 4
Phd Student: von Freiesleben, Pernille (Intern)
Supervisor: Jørgensen, Henning (Intern)
Krogh, Kristian Bertel Rømer (Intern)
Main Supervisor: Meyer, Anne S. (Intern)

Integration between enzyme technology and membrane separation in biorefinery processes

Department of Chemical and Biochemical Engineering
Period: 01/05/2014 → 25/08/2017
Number of participants: 6
Phd Student: Morthensen, Sofie Thage (Intern)
Supervisor: Meyer, Anne S. (Intern)
Main Supervisor: Pinelo, Manuel (Intern)
Examiner: Hélix-Nielsen, Claus (Intern)
Christensen, Morten Lykkegaard (Ekstern)
Wallberg, Ola (Ekstern)

Biooxidation reactor and process design

Department of Chemical and Biochemical Engineering
Period: 01/04/2014 → 13/11/2017
Number of participants: 6
Phd Student: Pedersen, Asbjørn Toftgaard (Intern)
Supervisor: Krühne, Ulrich (Intern)
Main Supervisor: Woodley, John (Intern)
Biorefining of hemp seeds: Enzymatic assisted upgrading technology
Optimize the extraction conditions of hemp seed protein using different enzyme preparations. To evaluate statistically the effect of different defatting techniques on amino acid quality and quantity of hemp protein isolates (HPI). To study different cellular structure and composition [e.g. Protein, amino acid (e.g. cysteine and methionine) and carbohydrates] of different plant seed materials. To explore different extraction methods (experimental and industrial scale) for the production of protein from different plant seed materials.

Department of Chemical and Biochemical Engineering
Center for BioProcess Engineering
Period: 06/01/2014 → 24/01/2014
Number of participants: 3
Project participant:
Pinelo, Manuel (Intern)
Supervisor:
Meyer, Anne S. (Intern)
Main Supervisor:
Ale, Marcel Tutor (Intern)

Related projects:
Characterization and production of protein isolates from oil-cold-pressed hemp seed meal
Project
Lipid oxidation in skin care products

National Food Institute
Period: 01/01/2014 → 16/05/2018
Number of participants: 7
Phd Student:
Thomsen, Birgitte Raagaard (Intern)
Supervisor:
Hyldig, Grethe (Intern)
Taylor, Richard (Ekstern)
Main Supervisor:
Jacobsen, Charlotte (Intern)
Examiner:
Meyer, Anne S. (Intern)
Dalsgaard, Trine Kastrup (Ekstern)
Schwarz, Karin (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansierede - Virksomhed
Project: PhD

Developments in enzyme immobilization with downstream renewable energy applications

Department of Chemical and Biochemical Engineering
Period: 15/12/2013 → 25/08/2017
Number of participants: 6
Phd Student:
Mohd Sueb, Mohd Shafiq Bin (Intern)
Supervisor:
Meyer, Anne S. (Intern)
Main Supervisor:
Pinelo, Manuel (Intern)
Examiner:
Gavala, Hariklia N. (Intern)
Kádár, Zsófia (Intern)
Kroff, Pablo (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Stipendie fra udlandet
Project: PhD

Production of prebiotic oligosaccharides by biocatalysis

Department of Chemical and Biochemical Engineering
Period: 15/12/2013 → 13/11/2017
Number of participants: 7
Phd Student:
Binti Jamek, Shariza (Intern)
Supervisor:
Mikkelsen, Jørn Dalgaard (Intern)
Muschiol, Jan (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Lange, Lene (Intern)
Christensen, Morten Würtz (Ekstern)
Vaaje-Kolstad, Gustav (Ekstern)
Financing sources
Source: Internal funding (public)
Name of research programme: Stipendie fra udlandet
Project: PhD

Structural characterization and enzymatic modification of soy polysaccharides
Department of Chemical and Biochemical Engineering
Period: 15/11/2013 → 25/08/2017
Number of participants: 7
Phd Student:
Pierce, Brian (Intern)
Supervisor:
Mikkelsen, Jørn Dalgaard (Intern)
Wichmann, Jesper (Ekstern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Pinelo, Manuel (Intern)
Kabel, Mirjam Anna (Ekstern)
Pedersen, Lars Hastrup (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD

Relations
Publications:
Structural Characterization and Enzymatic Modification of Soybean Polysaccharides
Project: PhD

Pretreatment of hemp fibers for utilization in strong biocomposite materials
Department of Chemical and Biochemical Engineering
Period: 15/09/2013 → 25/01/2017
Number of participants: 6
Phd Student:
Liu, Ming (Intern)
Supervisor:
Thygesen, Anders (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Østergård, Hanne (Intern)
Hotchkiss, Jr., Arland Tillotson (Ekstern)
Tovborg, Morten (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Stipendie fra udlandet

Relations
Publications:
Pretreatment of hemp fibers for utilization in strong biocomposite materials
Project: PhD

Lignin processing within biorefining
Department of Chemical and Biochemical Engineering
Period: 15/12/2012 → 26/04/2017
Number of participants: 7
Phd Student:
Le, Duy Michael (Intern)
Supervisor:
Jensen, Anker Degn (Intern)
Serensen, Hanne Risbjerg (Ekstern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Skiadas, Ioannis V (Intern)
Johannsen, Ib (Ekstern)
Saake, Bodo (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt
Project: PhD

Carbohydrate degradation products within biorefining
Department of Chemical and Biochemical Engineering
Period: 01/11/2012 → 30/09/2016
Number of participants: 7
Phd Student:
Rasmussen, Helena (Intern)
Supervisor:
Egsgaard, Helge (Intern)
Serensen, Hanne Risbjerg (Ekstern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Gavala, Hariklia N. (Intern)
Taarning, Esben (Intern)
Willför, Stefan Mikael (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt

Relations
Publications:
Carbohydrate degradation mechanisms and compounds from pretreated biomass
Project: PhD

Enzymatic polishing and modification of lignin
Department of Chemical and Biochemical Engineering
Period: 01/10/2012 → 18/04/2018
Number of participants: 6
Phd Student:
Munk, Line (Intern)
Supervisor:
Mikkelsen, Jørn Dalgaard (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Kepp, Kasper Planeta (Intern)
Barsberg, Søren (Ekstern)
Polikarpov, Igor (Ekstern)

Financing sources
Enhancing micronutrient bioavailability via designed in situ enzyme catalysis

Department of Chemical and Biochemical Engineering
Period: 15/09/2012 → 02/12/2015
Number of participants: 5
Phd Student: Nielsen, Anne Veller Friis (Intern)
Main Supervisor: Meyer, Anne S. (Intern)
Examiner: Lange, Lene (Intern)
Hotchkiss, Jr., Arland Tillotson (Ekstern)
Skov, Lars Kobberøe (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Prebiotika til hindring af tarmssygdomme hos svin

National Veterinary Institute
Period: 01/07/2012 → 25/11/2015
Number of participants: 6
Phd Student: Strube, Mikael Lenz (Intern)
Supervisor: Meyer, Anne S. (Intern)
Main Supervisor: Boye, Mette (Intern)
Examiner: Licht, Tine Rask (Intern)
Hotchkiss, Jr., Arland Tillotson (Ekstern)
Thymann, Thomas (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

The MacroAlgaeBiorefinery 3G (MAB3) - sustainable production of 3G bioenergy carriers and high value aquatic fish feed from macroalgae

Department of Chemical and Biochemical Engineering
Period: 15/06/2012 → 18/08/2016
Number of participants: 6
Phd Student: Manns, Dirk Martin (Intern)
Supervisor: Saake, Bodo (Ekstern)
Main Supervisor: Meyer, Anne S. (Intern)
Examiner: Lange, Lene (Intern)
Horn, Svein Jarle (Ekstern)
SLET - Kádár, Zsófia (Ekstern)
Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.

Relations
Publications:
Sourcing and bioprocessing of brown seaweed for maximizing glucose release
Project: PhD

Extraction of protein and amino acid from hemp seed meal
Department of Chemical and Biochemical Engineering
Center for BioProcess Engineering
Period: 01/06/2012 → 30/06/2014
Number of participants: 3
Project participant:
Ale, Marcel Tutor (Intern)
Meyer, Anne S. (Intern)
Pinelo, Manuel (Intern)

Financing sources
Source: Other public support (public)
Name of research programme: GUDP projects
Project

Optimizing the anarobic digestion of manure
Department of Chemical and Biochemical Engineering
Period: 01/12/2011 → 01/07/2015
Number of participants: 6
Phd Student:
Sun, Guotao (Intern)
Supervisor:
Thygesen, Anders (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Jørgensen, Henning (Intern)
Jensen, Jens Oluf (Intern)
Kroff, Pablo (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Stipendie fra udlandet
Project: PhD

Lignin derived phenolics
Department of Chemical and Biochemical Engineering
Period: 01/11/2011 → 10/09/2012
Number of participants: 3
Phd Student:
Weiss, Noah Daniel (Intern)
Supervisor:
Sørensen, Hanne Risbjerg (Ekstern)
Main Supervisor:
Meyer, Anne S. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt
**Functional Electrospun Nanostructures and Microstructures for Food and Bioengineering Applications**

The objectives of this project is to generate the scientific and technological basis to: (i) develop new nano-microcarrier systems for bioactive compounds using electrospun nano-microstructures for their immobilization, (ii) develop new nano-microdelivery systems utilizing enzyme functionality and molecular imprinted polymers for controlled delivery/release of bioactives, (iii) study the structural and functional properties of nano-microstructures (NMS) as novel components of food and bioengineered products, (iv) evaluate their bioavailability and degradation/digestion in-vitro and in-vivo.

The overall aim is to create new functional systems that have a potential usage in foods/healthy foods, as nutritional supplements, as pharmaceutical products and for a range of other bioengineering applications. The project's ambition is also to contribute to research training in research institutes and industrial companies as well as education of industrial employees. We expect that the obtained knowledge will strengthen the Danish industry's potential to emerging nanomicrotechnologies and technologies of bioactives.

National Food Institute

Division of Industrial Food Research

Department of Chemical and Biochemical Engineering

Center for BioProcess Engineering

**Period: 01/05/2011 → 31/10/2015**

**Number of participants: 10**

**Acronym: FENAMI**

**Project participant:**

- Meyer, Anne S. (Intern)
- Qvortrup, Klaus (Ekstern)
- Ye, Lei (Ekstern)
- Goycoolea, F.M. (Ekstern)
- Nielsen, Kent Albin (Ekstern)
- Jessen, Flemming (Intern)
- Boutrup Stephansen, Karen (Intern)
- Jørgensen, Lars (Intern)
- Mendes, Ana Carina Loureiro (Intern)
- Project Manager, academic:
  - Chronakis, Ioannis S. (Intern)

**Financing sources**

**Source:** Public research council

**Name of research programme:** Danish Research Council/Programme Commission for "Sundhed, Fødevarer og Velfærd"

**Amount:** 14,866,637.00 Danish Kroner

**Relations**

**Activities:**

- FENAMI Project Course: Advances in Bioinspired Nanomaterials and Approaches in Life Sciences
- Project

**Large scale enzymatic production of bioactive fibers from potato pulp**

Department of Chemical and Biochemical Engineering

**Period: 01/12/2010 → 17/12/2014**

**Number of participants: 7**

**Phd Student:**

- Ravn, Helle Christine (Intern)

**Supervisor:**

- Kiørboe, Lars Georg (Intern)
- Sørensen, Ole Bandsholm (Ekstern)
- Main Supervisor:
  - Meyer, Anne S. (Intern)

**Examiner:**

- Mikkelsen, Jørn Dalgaard (Intern)
- Hotchkiss, Jr., Arland Tillotson (Ekstern)
Nielsen, Per Munk (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: 1/3 DTU-stip, 2/3 FUR/andet
Project: PhD

**Reactor and Process Design for Multi-enzymatic Synthesis**
Department of Chemical and Biochemical Engineering
Period: 01/12/2010 → 01/11/2016
Number of participants: 4
PhD Student:
Xue, Rui (Intern)
Supervisor:
Meyer, Anne S. (Intern)
Mikkelsen, Jørn Dalgaard (Intern)
Main Supervisor:
Woodley, John (Intern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

**Combined silage pretreatment and enzymatic hydrolysis of energy grasses for 2G bioethanol production**
Department of Chemical and Biochemical Engineering
Period: 01/11/2010 → 28/05/2014
Number of participants: 7
PhD Student:
Ambye-Jensen, Morten (Intern)
Supervisor:
Didion, Thomas (Ekstern)
Johansen, Katja Salomon (Ekstern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Jørgensen, Henning (Intern)
Galbe, Mats (Ekstern)
Larsen, Jan (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

**PhD Project in Membrane Technology**
Department of Chemical and Biochemical Engineering
Period: 01/08/2010 → 31/01/2012
Number of participants: 3
PhD Student:
Kulkarni, Anant (Ekstern)
Supervisor:
Pinelo, Manuel (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)

**Financing sources**
Source: Internal funding (public)
Matematisk modellering af membranseparation

Department of Informatics and Mathematical Modeling
Period: 01/04/2010 → 20/03/2014
Number of participants: 7
Phd Student:
Vinther, Frank (Intern)
Supervisor:
Meyer, Anne S. (Intern)
Sørensen, Mads Peter (Intern)
Main Supervisor:
Brøns, Morten (Intern)
Examiner:
Hassager, Ole (Intern)
Davis, Robert H. (Ekstern)
Jönsson, Ann-Sofi (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

SILP enzyme catalysis technology for upgrading of biomass C5 monomers

Department of Chemical and Biochemical Engineering
Period: 15/12/2009 → 23/04/2014
Number of participants: 7
Phd Student:
Zeuner, Birgitte (Intern)
Supervisor:
Pinelo, Manuel (Intern)
Riisager, Anders (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Jørgensen, Henning (Intern)
Christakopoulos, Paul (Intern)
Christensen, Morten Würtz (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 FUU, 1/3 inst 1/3 Andet
Project: PhD

Effekter af kulhydrater på tarmens mikrobiologi

National Food Institute
Period: 01/08/2009 → 31/07/2011
Number of participants: 4
Phd Student:
Hemmingsen, Lene (Intern)
Supervisor:
Meyer, Anne S. (Intern)
Wilcks, Andrea (Intern)
Main Supervisor:
Licht, Tine Rask (Intern)
Process development: Enzymatic upgrading of pectin from sugar beet pulp

Department of Chemical and Biochemical Engineering
Period: 01/06/2009 → 04/09/2013
Number of participants: 6
Phd Student:
Ahmadi Gavlighi, Hassan (Intern)
Supervisor:
Meyer, Anne S. (Intern)
Main Supervisor:
Mikkelsen, Jørn Dalgaard (Intern)
Examiner:
Chronakis, Ioannis S. (Intern)
Bergenståhl, Björn (Ekstern)
Juul, Anne Grete (Ekstern)

Discovery, Characterization and Design of a thermostable RGI Lyase for production of Bio-Functional Fibers

Department of Chemical and Biochemical Engineering
Period: 01/02/2009 → 18/12/2013
Number of participants: 6
Phd Student:
da Silva, Ines Isabel Cardoso Rodrigues (Intern)
Supervisor:
Meyer, Anne S. (Intern)
Main Supervisor:
Mikkelsen, Jørn Dalgaard (Intern)
Examiner:
Pinelo, Manuel (Intern)
Kragh, Karsten M. (Ekstern)
Visser, Jacob (Jaap) (Ekstern)

Enzymatic Production of Gut-functional Polysaccharides

Department of Chemical and Biochemical Engineering
Period: 01/08/2008 → 27/06/2012
Number of participants: 5
Phd Student:
Abang Zaidel, Dayang Norulfairuz Binti (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Mikkelsen, Jørn Dalgaard (Intern)
Bergenståhl, Björn (Ekstern)
Duus, Jens Ølgaard (Intern)
Financing sources
Source: Internal funding (public)
Name of research programme: Stipendie fra udlandet
Project: PhD

Enzymatic Upgrading of Plant Biomass
Department of Chemical and Biochemical Engineering
Period: 01/05/2008 → 30/09/2013
Number of participants: 6
Phd Student:
Tsai, Chien Tai (Intern)
Supervisor:
Johansen, Katja Salomon (Ekstern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Jensen, Peter Arendt (Intern)
Lidén, Gunnar (Ekstern)
Olsen, Hans Sejr (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU, Samfinansiering
Project: PhD

Enzymatic Production of Dietary Fibres and Prebiotics from Potato Pulp
Department of Chemical and Biochemical Engineering
Period: 01/04/2008 → 24/08/2011
Number of participants: 5
Phd Student:
Stouby, Lise (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Adler-Nissen, Jens (Intern)
Hotchkiss, Arland (Ekstern)
Laerke, Helle Nygaard (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 DTU-stip, 2/3 FUR/andet
Project: PhD

Biofuels from Nuisance Marine Algae
Department of Chemical and Biochemical Engineering
Period: 01/03/2008 → 18/04/2012
Number of participants: 5
Phd Student:
Ale, Marcel Tutor (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Jacobssen, Charlotte (Ekstern)
Saake, Bodo (Ekstern)
Troelsen, Jesper Thorvald (Ekstern)

Financing sources
Source: Internal funding (public)
Enzymatic Production of Prebiotics from Sugar Beet Pectin

Department of Chemical and Biochemical Engineering
Number of participants: 6
Phd Student: Holck, Jesper (Intern)
Supervisor: Mikkelsen, Jørn Dalgaard (Intern)
Main Supervisor: Meyer, Anne S. (Intern)
Examiner: Jonsson, Gunnar Eigil (Intern)
Hotchkiss, Arland (Ekstern)
Søndergaard, Karen Marie (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU, Samfinansiering
Project: PhD

Ethanol Production from Rapeseed Straw and Agricultural Residues

Department of Chemical and Biochemical Engineering
Period: 15/09/2007 → 18/04/2012
Number of participants: 6
Phd Student: Arvaniti, Efthalia (Intern)
Supervisor: SLET - Kádár, Zsófia (Ekstern)
Main Supervisor: Schmidt, Jens Ejbye (Intern)
Examiner: Meyer, Anne S. (Intern)
Girio, Francisco M. Ferreira (Ekstern)
Norddahl, Birgir (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Continuous Membrane Microbioreactors for Development of Integrated Pectin Modification and Separation Processes

Department of Chemical and Biochemical Engineering
Period: 01/07/2007 → 09/02/2011
Number of participants: 7
Phd Student: Zainal Alam, Muhd Nazrul Hisham Bin (Intern)
Supervisor: Jonsson, Gunnar Eigil (Intern)
Meyer, Anne S. (Intern)
Main Supervisor: Gernaey, Krist V. (Intern)
Examiner: Dufva, Martin (Intern)
Janssen, Anja E. M. (Ekstern)
Financing sources
Source: Internal funding (public)
Name of research programme: Stipendie fra udlandet
Project: PhD

The Cloning and Expression of Lignocellulose Degrading Enzymes in Thermophilic Bacteria
Department of Chemical and Biochemical Engineering
Period: 01/05/2007 → 19/04/2013
Number of participants: 6
Phd Student:
Sitarz, Anna Katarzyna (Intern)
Supervisor:
Mikkelsen, Jørn Dalgaard (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Jensen, Anker Degn (Intern)
Christensen, Morten Würtz (Ekstern)
Graff, Leendert H. de (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Lignocellulose Pretreatment for Lignin Removal and Maximal Enzymatic (Ligno) Cellulose Degradation
Department of Chemical and Biochemical Engineering
Period: 01/04/2007 → 01/09/2010
Number of participants: 7
Phd Student:
Pedersen, Mads (Intern)
Supervisor:
Johansen, Katja Salomon (Ekstern)
Pedersen, Sven (Ekstern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Jensen, Peter Arendt (Intern)
Larsen, Jan (Ekstern)
Zacchi, Guido N. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU, Samfinansiering
Project: PhD

Enzymatic Opening of Diferulate Cross-Links in Plant Cell Walls
Department of Chemical and Biochemical Engineering
Period: 15/03/2007 → 15/06/2011
Number of participants: 6
Phd Student:
Wittrup Agger, Jane (Intern)
Supervisor:
Johansen, Katja Salomon (Ekstern)
Main Supervisor:
Meyer, Anne S. (Intern)
Development of Quantitative Kinetic Models Describing Enzyme Catalyzed Heteropolysaccharide Degradation: Soluble Arabinoxylan
Department of Chemical and Biochemical Engineering
Period: 01/03/2007 → 31/07/2010
Number of participants: 2
Phd Student:
Xu, Cheng (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 DTU-stip, 2/3 FUR/andet
Project: PhD

Development of Quantitative Kinetic Models Describing Enzyme Catalysed Heteropolysaccharide Degradation: Insoluble Arabinoxylans
Department of Chemical and Biochemical Engineering
Period: 01/02/2007 → 15/06/2011
Number of participants: 6
Phd Student:
Rasmussen, Louise Enggaard (Intern)
Supervisor:
Sørensen, Jens Frisbak (Ekstern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Mikkelsen, Jørn Dalgaard (Intern)
Pettersson, Dan Robert (Ekstern)
Tenkanen, Maija (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 DTU-stip, 2/3 FUR/andet
Project: PhD

Workpackage 2 in Prebiotic Center: Gut microbiota and Immune Response Effects
The Prebiotic Center is a large research effort aiming to develop, synthesize and characterize new carbohydrates with beneficial effects on human health (e.g. prebiotics). This offers new possibilities for use of biological waste products. The Role of WP2 in Prebiotic Center is to reveal effects of putatively prebiotic carbohydrates on gut microbiota and immune function. We collaborate with Danisco and Herlev Hospital within this WP.

National Food Institute
Department of Chemical and Biochemical Engineering
Danisco AS
Period: 01/01/2007 → 31/12/2011
Number of participants: 9
WP2 in Prebiotic Center: Gut microbiota and Immune Response Effects
The Role of WP2 in Prebiotic center is to reveal effects of putatively prebiotic carbohydrates on gut microbiota and immune function. We collaborate with Danisco and Herlev Hospital within this WP.

National Food Institute
Period: 01/01/2007 → 31/12/2011
Number of participants: 3
Project participant:
Wilcks, Andrea (Intern)
Project Manager, organisational:
Licht, Tine Rask (Intern)
Meyer, Anne S. (Intern)

Financing sources
Source: Forskningsrådene - Andre
Name of research programme: Forskningsrådene - Andre
Amount: 3,436,000.00 Danish Kroner

Enzymatic Lipophilisation of Bioactive Compounds
National Food Institute
Period: 01/04/2006 → 30/06/2008
Number of participants: 7
Phd Student:
Lue, Bena-Marie (Intern)
Supervisor:
Guo, Zheng (Intern)
Jacobsen, Charlotte (Intern)
Jørgensen, Bo Munk (Intern)
Meyer, Anne S. (Intern)
Xu, Xuebing (Intern)
Main Supervisor:
Adler-Nissen, Jens (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Enzymatic catalysis for increased extraction and positive modulation of phenolic antioxidants in functional juice and wine production
Department of Systems Biology
Period: 01/10/2005 → 30/09/2007
Number of participants: 2
Contact person:
Pre-Treatment (and Enzymatic Hydrolysis) of Ligno-Cellulose

Department of Chemical and Biochemical Engineering
Period: 01/10/2005 → 21/12/2010
Number of participants: 7
Phd Student:
Andric, Pavle (Intern)
Supervisor:
Jensen, Peter Arendt (Intern)
Meyer, Anne S. (Intern)
Main Supervisor:
Dam-Johansen, Kim (Intern)
Examiner:
Villadsen, John (Intern)
Lidén, Gunnar (Ekstern)
Olsen, Hans Sejr (Ekstern)

Financing sources
Source: [Ordinær drift UK 10]
Name of research programme: [Ordinær drift UK 10]
Amount: 700,000.00 Danish Kroner
Project

Prediction of Wine Quality from Phenolic Profiles of Grapes, forkortet "Wine Quality"

Department of Chemical and Biochemical Engineering
Period: 01/02/2005 → 04/07/2008
Number of participants: 6
Phd Student:
Jensen, Jacob Skibsted (Intern)
Supervisor:
Egebo, Max (Ekstern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner: Eliasson Lantz, Anna (Intern)
Dietrich, Helmut (Ekstern)
Ridder, Carsten (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Fungal Pigments Potential Natural Food Colourants
Department of Systems Biology
Period: 01/09/2004 → 01/04/2009
Number of participants: 6
Phd Student: Mapari, Sameer Shamsuddin (Intern)
Supervisor: Meyer, Anne S. (Intern)
Main Supervisor: Thrane, Ulf (Intern)
Examiner: Kielland-Brandt, Morten (Intern)
Dufossé, Laurent (Ekstern)
Magan, Naresh (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 DTU-stip, 2/3 FUR/andet
Project: PhD

Optimizing Enzyme Catalyzed Phytate Degradation in Cereal Foods
Department of Systems Biology
Period: 01/05/2004 → 30/04/2005
Number of participants: 4
Phd Student: Bohn, Lisbeth (Ekstern)
Supervisor: Rasmussen, Søren Kjærgård (Intern)
Sørensen, Mikael B. (Ekstern)
Main Supervisor: Meyer, Anne S. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Risø (Løn)
Project: PhD

Post-translational Modifications of Proteins: Novel in Vitro Methods for their Study and Scale-up
Department of Chemical and Biochemical Engineering
Period: 01/04/2004 → 25/06/2007
Number of participants: 7
Phd Student: Maury, Trine Lütken (Intern)
Supervisor: Brask, Jesper (Intern)
Hobley, Timothy John (Intern)
Main Supervisor: Villadsen, John (Intern)
Examiner: 
Meyer, Anne S. (Intern)
Franzreb, Matthias (Ekstern)
Friedmann, Thomas (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: DTU, Samfinansiering
Project: PhD

**Development of Berry Fruit Juices with Improved Health Potential**
Department of Chemical and Biochemical Engineering
Number of participants: 5
Phd Student: Arnous, Anis (Intern)
Main Supervisor: 
Meyer, Anne S. (Intern)
Examiner: 
Mikkelsen, Jørn Dalgaard (Intern)
Dietrich, Helmut (Ekstern)
van den Brink, Hans (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: DTU, Samfinansiering
Project: PhD

**Enzymatisk Hydrolyse af Lignocellulose fra Byg, Strå og Skaller**
Department of Chemical and Biochemical Engineering
Number of participants: 6
Phd Student: Rosgaard, Lisa (Ekstern)
Supervisor: 
Pedersen, Sven (Ekstern)
Main Supervisor: 
Meyer, Anne S. (Intern)
Examiner: 
Villadsen, John (Intern)
Nielsen, Charles (Ekstern)
Tjerneld, Folke (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Ansat eksternt
Project: PhD

**Enzyme Catalysed Production of Phospholipids with Modified Fatty Acid Profile**
Department of Systems Biology
Period: 01/05/2003 → 04/12/2006
Number of participants: 7
Phd Student: Vikbjerg, Anders Falk (Intern)
Supervisor: 
Jonsson, Gunnar Eigil (Intern)
Mu, Huiling (Intern)
Main Supervisor: Xu, Xuebing (Intern)
Examiner:
Meyer, Anne S. (Intern)
Adlercreutz, Patrick (Ekstern)
Schneider, Michael (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Regulation and Characterization of Cellulases and Hemicellulases Produced by Penicillium
Department of Systems Biology
Period: 01/09/2002 → 26/06/2008
Number of participants: 5
Phd Student: Krogh, Kristian Bertel Rømer (Intern)
Main Supervisor: Olsson, Lisbeth (Intern)
Examiner:
Meyer, Anne S. (Intern)
Viikari, Liisa (Ekstern)
Visser, Jacob (Jaap) (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

New Thermostable Enzymes for Biomass Conversion
Department of Systems Biology
Period: 01/08/2002 → 01/09/2006
Number of participants: 5
Phd Student: Georgieva, Tania I. (Intern)
Main Supervisor: Ahring, Birgitte Kjaer (Intern)
Examiner:
Meyer, Anne S. (Intern)
Lange, Lene (Intern)
Zacchi, Guido N. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Enzymteknologi i frugtsaftprocesser
Department of Systems Biology
Period: 01/07/2002 → 31/08/2006
Number of participants: 3
Phd Student: Landbo, Anne-Katrine Regel (Intern)
Supervisor: Andersen, Keld Ejdrup (Ekstern)
Main Supervisor:
Meyer, Anne S. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Kandidatstipendium ansat på DT
Project: PhD

Diagnostiske tools for forståelse og afværgelse af procesproblemer i biogasanlæg

Department of Systems Biology
Period: 01/03/2002 → 10/03/2006
Number of participants: 5
Phd Student:
Bangsø Nielsen, Henrik (Intern)
Main Supervisor:
Ahring, Birgitte Kiær (Intern)
Examiner:
Meyer, Anne S. (Intern)
Møller, Henrik Bjarne (Intern)
Svensson, Bo Håkan (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Programbevilling
Project: PhD

Oxidationsbeskyttelse af fiskeolieholdige produkter

Department of Chemical and Biochemical Engineering
Period: 01/01/2002 → 18/05/2007
Number of participants: 6
Phd Student:
Bruni Let, Mette (Intern)
Supervisor:
Jacobsen, Charlotte (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Jørgensen, Bo Munk (Intern)
Andersen, Henrik Jørgen (Ekstern)
Nilsson, Astrid (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Offentlig finansiering
Project: PhD

Enzymatisk nedbrydning af arabinoxylan fra hvede

Department of Systems Biology
Period: 01/03/2001 → 28/08/2006
Number of participants: 7
Phd Student:
Sørensen, Hanne Risbjerg (Ekstern)
Supervisor:
Jørgensen, Christel Thea (Intern)
Pedersen, Sven (Ekstern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Olsson, Lisbeth (Intern)
Felby, Claus (Ekstern)
Tenkanen, T. Maija (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt
Project: PhD

Ulinær dynamik i biologiske reaktioner
Department of Systems Biology
Period: 01/03/2001 → 06/03/2006
Number of participants: 6
Phd Student:
Nordkvist, Mikkel (Intern)
Supervisor:
Nielsen, Jens (Intern)
Main Supervisor:
Villadsen, John (Intern)
Examiner:
Meyer, Anne S. (Intern)
Lidén, Gunnar (Ekstern)
Nienow, Alvin William (Ekstern)

Finance sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Nye Strategier til Forbedring af frugtsaftkvalitet
Department of Systems Biology
Period: 01/02/2001 → 15/11/2004
Number of participants: 6
Phd Student:
Bagger-Jørgensen, Rico (Intern)
Supervisor:
Adler-Nissen, Jens (Intern)
Jonsson, Gunnar Eigil (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Risum, Jørgen (Intern)
Kristensen, Steen (Ekstern)

Finance sources
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed
Project: PhD

Aroma formation by staphylococcus starter cultures - the influence of growth parameters
Department of Systems Biology
Period: 01/06/1999 → 24/06/2003
Number of participants: 7
Phd Student:
Olesen, Pelle Thonning (Intern)
Supervisor:
Stahnke, Louise Heller (Intern)
Vrang, Astrid (Intern)
Main Supervisor:
Meyer, Anne S. (Intern)
Examiner:
Martinussen, Jan (Intern)
Andersen, Henrik Jørgen (Ekstern)
Houlberg, Ulf (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt CAMP
Project: PhD

Funktionel kvalitet af hvede til produktion af kiks
Department of Systems Biology
Period: 01/06/1999 → 27/05/2003
Number of participants: 6
Phd Student:
Pedersen, Lene (Intern)
Supervisor:
Bergsæ, Merete Norsker (Intern)
Kaack, Karl (Ekstern)
Main Supervisor:
Adler-Nissen, Jens (Intern)
Examiner:
Meyer, Anne S. (Intern)
Hvidt, Søren (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskerakademiets Samfinansier
Project: PhD

Phenolic acids in rye
Department of Biotechnology
Department of Systems Biology
Period: 01/08/1997 → 31/03/2001
Number of participants: 2
Project participant:
Hansen, Åse (Ekstern)
Project Manager, organisational:
Meyer, Anne S. (Intern)

Oxidationsmekanismer i fiskeolieholdige
Department of Systems Biology
Period: 01/11/1996 → 21/06/1999
Number of participants: 4
Phd Student:
Jacobsen, Charlotte (Intern)
Supervisor:
Børresen, Torger (Intern)
Meyer, Anne S. (Intern)
Main Supervisor:
Adler-Nissen, Jens (Intern)

Financing sources
Oxidation mechanisms in fish oil enriched emulsions

The purpose of the project is to study the oxidation mechanisms in fish oil enriched emulsions in order to develop combined emulsifier and antioxidant systems which are more efficient in protecting fish oil enriched foods against oxidation than existing antioxidant systems. Results obtained in 1999 have shown that the low pH in mayonnaise is a very important factor for the initiation of the oxidation processes in mayonnaise. This is due to the fact that iron ions are released/loosened from the egg yolk components at the oil/water interface when pH is decreased to 4, which is the normal pH in mayonnaise. The released iron promotes decomposition of peroxides to volatiles, which are responsible for the off-flavour formation in mayonnaise. The metal chelator EDTA was observed to be a very efficient antioxidant in mayonnaise due to its ability to chelate iron. A HPLC method for determination of lipid peroxides has been further optimised and is now fully operational. By the aid of GC-MS a large number of volatiles that correlate to the fishy and rancid off-flavours in oxidised mayonnaise have been identified.

National Institute of Aquatic Resources

Department of Biochemistry and Nutrition

Department of Biotechnology

Danisco Ingredients

Association of Danish Fish Meal and Fish Oil Manufacturers

Royal Veterinary and Agricultural University

Period: 01/05/1996 → 31/12/1999

Number of participants: 11

Project participant:

Vu, Thi Thu Trang (Intern)
Jacobsen, Charlotte (Intern)
Hartvigsen, Karsten (Intern)
Lund, Pia (Intern)
Datta, Suvra (Intern)
Hølmer, Gunhild Kofoed (Intern)
Meyer, Anne S. (Intern)
Green, Else (Intern)
Reitz, Suzie (Intern)
Adler-Nissen, Jens (Intern)

Project Manager, organisational:

Børresen, Torger (Intern)

Financing sources

Source: Unknown

Name of research programme: Ukendt

Amount: 1,050,000.00 Danish Kroner

Source: Unknown

Name of research programme: Ukendt

Amount: 6,178,065.00 Danish Kroner

Application of enzymes for food protection

i) Enzymes as antioxidants

Enzyme catalysis can be employed as antioxidant principle by a) removal of active oxygen species, b) competitive removal of oxygen, c) reduction of lipid hydroperoxides. The effect of all three principles was tested by us in previous projects. we have thus shown that enzymatic removal of oxygen is an efficient and that reduction of lipid hydroperoxides is a workable principle. The present objectives are to study the efficacy of new oxidases and to continue the studies on application of peroxidases to reduce lipid hydroperoxides. ii) Inhibition of microbial growth by lytic enzymes

Lysozyme (EC 3.2.1.17) catalyses hydrolysis of peptidoglycan in bacterial cell walls. Lysozyme from hen egg white has been approved as a food additive in EU to inhibit late blowing of hard cheeses caused by Clostridium tyrobutyricum. We investigate the antibacterial effect of lysozyme. In particular the effects of various micro-enviromental food parameters on stability and activity of the enzymes.

Department of Biotechnology
Danisco Ingredients
Period: 01/01/1995 → 31/12/1997
Number of participants: 2
Project participant:
Adler-Nissen, Jens (Intern)
Project Manager, organisational:
Meyer, Anne S. (Intern)

**Application of plant cell wall degrading enzymes in food technology.**
The overall purpose is to develop new enzyme processes to produce new, natural food ingredients from vegetable material. Presently we investigate the possibilities for employing new, specific, so-called mono-component enzymes to release functional food ingredients from plant material: a) To solubilise dietary fibre from complex polysaccharides, b) to modify selected, functional properties (texture enhancers) from non-starch polysaccharide material, c) to release antioxidant phytochemicals from fruit byproducts. There is a strong collaboration with the Rheology Group, of which Merete Norsker is also a member.

Department of Biotechnology
Novo Nordisk A/S
Period: 01/01/1995 → 31/12/1996
Number of participants: 3
Project participant:
Adler-Nissen, Jens (Intern)
Bergsøe, Merete Norsker (Intern)
Project Manager, organisational:
Meyer, Anne S. (Intern)

**Activities:**

**Surface properties and chemistry correlate to the digestibility of biomass following hydrothermal pretreatment at different severities**
Period: 1 May 2017 → 4 May 2017
Demi Tristan Djajadi (Guest lecturer)
Aleksander R. Hansen (Guest lecturer)
Anders Jensen (Guest lecturer)
Lisbeth G. Thygesen (Guest lecturer)
Manuel Pinelo (Guest lecturer)
Anne S. Meyer (Guest lecturer)
Henning Jørgensen (Guest lecturer)

Department of Chemical and Biochemical Engineering
Center for BioProcess Engineering

**Description**
Poster presentation
Degree of recognition: International

**Related event**
**39th Symposium on Biotechnology for Fuels and Chemicals**
01/05/2017 → 04/05/2017
San Francisco, United States
Activity: Talks and presentations › Conference presentations