Emulsifier type, metal chelation and pH affect oxidative stability of n-3-enriched emulsions

Recent research has shown that the oxidative stability of oil-in-water emulsions is affected by the type of surfactant used as emulsifier. The aim of this study was to evaluate the effect of real food emulsifiers as well as metal chelation by EDTA and pH on the oxidative stability of a 10% n-3-enriched oil-in-water emulsion. The selected food emulsifiers were Tween 80, Citrem, sodium caseinate and lecithin. Lipid oxidation was evaluated by determination of peroxide values and secondary volatile oxidation products. Moreover, the zeta potential and the droplet sizes were determined. Tween resulted in the least oxidatively stable emulsions, followed by Citrem. When iron was present, caseinate-stabilized emulsions oxidized slower than lecithin emulsions at pH 3, whereas the opposite was the case at pH 7. Oxidation generally progressed faster at pH 3 than at pH 7, irrespective of the addition of iron. EDTA generally reduced oxidation, as evaluated by volatiles formation in all emulsions, irrespective of pH and emulsifier type, except in the lecithin and caseinate emulsions where a pro-oxidative effect was observed for some volatiles. The different effects of the emulsifier types could be related to their ability to chelate iron, scavenge free radicals, interfere with interactions between the lipid hydroperoxides and iron as well as to form a physical barrier around the oil droplets.
Interactions between iron, phenolic compounds, emulsifiers, and pH in omega-3-enriched oil-in-water emulsions

The behavior of antioxidants in emulsions is influenced by several factors such as pH and emulsifier type. This study aimed to evaluate the interaction between selected food emulsifiers, phenolic compounds, iron, and pH and their effect on the oxidative stability of n-3 polyunsaturated lipids in a 10% oil-in-water emulsion. The emulsifiers tested were Tween 80 and Citrem, and the phenolic compounds were naringenin, rutin, caffeic acid, and coumaric acid. Lipid oxidation was evaluated at all levels, that is, formation of radicals (ESR), hydroperoxides (PV), and secondary volatile oxidation products. When iron was present, the pH was crucial for the formation of lipid oxidation products. At pH 3 some phenolic compounds, especially caffeic acid, reduced Fe\(^{3+}\) to Fe\(^{2+}\), and Fe\(^{2+}\) increased lipid oxidation at this pH compared to pH 6. Among the evaluated phenols, caffeic acid had the most significant effects, as caffeic acid was found to be prooxidative irrespective of pH, emulsifier type, and presence of iron, although the degrees of lipid oxidation were different at the different experimental conditions. The other evaluated phenols were prooxidative at pH 3 in Citrem-stabilized emulsions and had no significant effect at pH 6 in Citrem- or Tween-stabilized emulsions on the basis of the formation of volatiles. The results indicated that phenol-iron complexes/nanoparticles were formed at pH 6.
Flavor release measurement from gum model system
Flavor release from a mint-flavored chewing gum model system was measured by atmospheric pressure chemical ionization mass spectroscopy (APCI-MS) and sensory time-intensity (TI). A data analysis method for handling the individual curves from both methods is presented. The APCI-MS data are ratio-scaled using the signal from acetone in the breath of subjects. Next, APCI-MS and sensory TI curves are smoothed by low-pass filtering. Principal component analysis of the individual curves is used to display graphically the product differentiation by APCI-MS or TI signals. It is shown that differences in gum composition can be measured by both instrumental and sensory techniques, providing comparable information. The peppermint oil level (0.5-2% w/w) in the gum influenced both the retronasal concentration and the perceived peppermint flavor. The sweeteners' (sorbitol or xylitol) effect is less apparent. Sensory adaptation and
sensitivity differences of human perception versus APCI-MS detection might explain the divergence between the two
dynamic measurement methods.

**General information**

**State:** Published

**Organisations:** National Institute of Aquatic Resources, Department of Systems Biology

**Authors:** Ovejero-López, I. (Ekstern), Haahr, A. (Intern), van den Berg, F. W. (Intern), Bredie, W. (Ekstern)

**Pages:** 8119-8126

**Publication date:** 2004

**Main Research Area:** Technical/natural sciences

**Publication information**

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- 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
- Web of Science (2015): Indexed yes
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- 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
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- 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
Release of peppermint flavour compounds from chewing gum: effect of oral functions

During chewing, the oral cavity functions like a bellow, forcing volatile flavour compounds into the exhaling air to the nasal compartment. Accordingly, we hypothesised that flavour release from chewing gum is predominantly governed by chewing frequency (CF), although other oral functions, like masseter muscle activity (MMA), chewing force (CFO), and saliva flow rate (SFR), may also play a role. In 10 healthy young males, the retronasal expired air of menthol and menthone from peppermint-flavoured (2%) chewing gum was determined as functions of CF, SFR, MMA, and CFO. The experimental setup comprised three separate series of a 4-min chewing period. These series differed only with respect to CF, i.e., habitual frequency, and 60 and 88 strokes/min. Results showed that more than 50% of the released menthol and menthone could be retrieved in the expired air and saliva. After 2-min of chewing, the concentration of flavour compounds in the expired air depended primarily on MMA and CF, becoming higher with increased MMA and CF. The concentration of flavour compounds in saliva depended primarily on SFR and the duration of the chewing task, becoming lower with high SFR and prolonged chewing duration. An increased volume of saliva in the mouth seemed to keep more flavour compounds in the aqueous phase, thereby diminishing the release via the retronasal route. In conclusion, flavour release to the retronasal compartment was dependent on MMA and CF and influenced by the volume of saliva present in the mouth.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Department of Systems Biology
Authors: Haahr, A. (Intern), Bardow, A. (Ekstern), Thomsen, C. (Ekstern), Jensen, S. (Ekstern), Nauntofte, B. (Ekstern), Bakke, M. (Ekstern), Adler-Nissen, J. (Intern), Bredie, W. (Ekstern)
Pages: 531-540
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Journal: Physiology & Behavior
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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 2.53 SJR 1.05 SNIP 0.856
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.286 SNIP 1.006 CiteScore 2.92
Web of Science (2015): Indexed yes
Effect of sweetener on release of flavour compounds from chewing gum

General information
State: Published
Organisations: National Institute of Aquatic Resources, Department of Biotechnology
Authors: Haahr, A. (Intern), Pilsgaard, C. (Ekstern), Stahnke, L. H. (Intern), Bredie, W. (Ekstern), Refsgaard, H. (Intern)
Number of pages: 780
Pages: 224-228
Publication date: 2003

Host publication information
Title of host publication: Flavour Research at the Dawn of the Twenty-first Century, Proceedings of the 10th Weurman Flavour Research Symposium, Dijon, 2002
Place of publication: London
Publisher: Intercept
Main Research Area: Technical/natural sciences
Conference: Flavour Research at the Dawn of the Twenty-first Century, 10th Weurman Flavour Research Symposium, Dijon, 01/01/2002
Source: orbit
Source-ID: 155527
Publication: Research - peer-review › Journal article – Annual report year: 2004
Flavor release measurement by atmospheric pressure chemical ionization ion trap mass spectrometry, construction of interface and mathematical modeling of release profiles

An instrumental on-line retronasal flavor analysis was developed to obtain information about the release of flavor compounds in expired air from humans during eating. The volatile flavor compounds were measured by ion trap mass spectrometry with an atmospheric pressure chemical ionization source (APCI). An interface was designed to sample the breath directly from the nose. The repeat-ability in vitro for seven different flavor compounds came out with relative standard derivation less than 10% in most cases, which is acceptable. In vitro quantification was carried out by a determination of the concentration in the gas phase over a flavor solution by GC/MS, followed by measurements of intensities by the APCI ion trap. Ion suppression by acetone in the breath was negligible at concentration levels relevant in these experiments. The instrumental limits of detection for menthone and menthol coincide with that of the flavor detection threshold. An application study on the release of menthone and menthol from chewing gum by a group of six test persons was performed. Flavored chewing gum was used as a model matrix because of the long chewing periods and the simplicity of the system. It is concluded that the interface and the method can be used to measure breath from the nose. A mathematical model of the data was developed to give a quantitative method for description and characterization of the release of flavor compounds. The release profiles consisted of two sequences, one for a chewing period, and one for a phasing out process. The proposed method for modeling provided a reasonable description of the release process. In addition to flavor compounds, this new interface and mathematical application could provide information on chemicals in the human breath which could be interesting, for example, within medical diagnosis.
Stability to oxidation of spray-dried fish oil powder microencapsulated using milk ingredients

Microencapsulation of fish oil was achieved by spray-drying homogenized emulsions of fish oil using 3 different types of casein as emulsifier and lactose as filler. As the degree of aggregation of the casein emulsifier increased, the vacuole volume of the microencapsulated powders decreased. The shelf life of the powders increased as the degree of aggregation of the casein emulsifier increased at the high homogenization conditions. When micellar casein was used as emulsifier, the shelf life also increased as homogenization conditions increased. Free fat but not surface fat was inversely related to shelf life. Since the type of casein used was confounded with the powder vacuole volume, the increased shelf life may have been due to either factor.
Flavour release of aldehydes and diacetyl in oil/water systems
The concentration- and time-dependent release of three C-6-aldehydes, six C-9-aldehydes and diacetyl was studied in model systems. The systems were water, rapeseed oil and oil-in-water emulsions. Dynamic headspace sampling was used to collect the volatile compounds. In the concentration-dependent release experiment, the C-6-aldehydes were released in equal proportions from the aqueous and the emulsion systems, but in lower amounts from the pure oil. The amounts of C-9-aldehydes released decreased with increasing oil content. All aldehydes were released more rapidly from the aqueous system than from the pure oil. The release over time for diacetyl and (E,E)-2,4-hexadienal showed a linear relationship in all systems. The other compounds followed an exponential relationship between the time and the fraction released in the aqueous systems. It was demonstrated that the release of the volatile compounds was dependent on the chain length, the degree of unsaturation as well as the characteristics of the model system. (C) 2000 Elsevier Science Ltd. All rights reserved.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Department of Biotechnology
Authors: Haahr, A. (Intern), Bredie, W. L. P. (Ekstern), Stahnke, L. H. (Intern), Jensen, B. (Ekstern), Refsgaard, H. (Intern)
Pages: 355-362
Protection of fish oil from oxidation by microencapsulation using freeze-drying techniques

(N-3)-Polyunsaturated fatty acids (PUFAs) reduce the risk of coronary heart disease. Cold sea water plankton and plankton-consuming fish are known sources of (n-3)-PUFAs. Enriching normal food components with fish oil is a tool for increasing the intake of (n-3)-PUFAs. Due to the high sensitivity of fish oil with respect to oxidation, it has to be protected from oxygen and light. The investigations presented demonstrate the microencapsulation of fish oil using freeze-drying techniques. Emulsions containing 10% fish oil, 10% sodium caseinate, 10% carbohydrate and 70% water were frozen using different freezing techniques and subsequently freeze-dried. Several parameters regarding formulation and process (addition of antioxidants to the fish oil, use of carbohydrates, homogenisation and freezing conditions, initial freeze-drying temperature, grinding) were varied to evaluate their influence on the oxidative stability of dried microencapsulated fish oil. The shelf life of the produced samples was determined by measuring the development of volatile oxidation products vs. storage time. It could be shown that the addition of antioxidants to fish oil was necessary to produce dried microencapsulated fish oil with an adequate shelf life. The best shelf life was achieved for the dried product which was frozen with a slow freezing rate.

General information
State: Published
Organisations: National Institute of Aquatic Resources
Authors: Heinzelmann, K. (Ekstern), Franke, K. (Ekstern), Jensen, B. (Intern), Haahr, A. (Intern)
Pages: 114-121
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Main Research Area: Technical/natural sciences

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Journal: European Journal of Lipid Science and Technology
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Scopus rating (2016): CiteScore 2.06 SJR 0.71 SNIP 1.024
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.642 SNIP 0.881 CiteScore 1.85
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.737 SNIP 1.051 CiteScore 1.98
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.852 SNIP 1.124 CiteScore 2.16
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
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Scopus rating (2012): SJR 0.873 SNIP 1.207 CiteScore 2.06
Flavour release of aldehydes and diacetyl in oil/water systems

General information
State: Published
Organisations: Department of Biotechnology, National Institute of Aquatic Resources, Royal Veterinary and Agricultural University
Authors: Haahr, A. (Intern), Bredie, W. L. (Ekstern), Stahnke, L. H. (Intern), Jensen, B. (Intern), Refsgaard, H. (Intern)
Publication date: 1999

Host publication information
Title of host publication: Proceedings of the Food and flavour COST 96 Symposium
Main Research Area: Technical/natural sciences
Conference: Food and flavour COST 96 Symposium, Udine, 01/01/1999
Source: orbit
Source-ID: 174863
Publication: Research › Article in proceedings – Annual report year: 1999

Isolation and quantification of volatiles in fish by dynamic headspace sampling and mass spectrometry
A dynamic headspace sampling method for isolation of volatiles in fish has been developed. The sample preparation involved freezing of fish tissue in liquid nitrogen, pulverizing the tissue, and sampling of volatiles from an aqueous slurry of the fish powder. Similar volatile patterns were determined by use of this sample preparation method and for samples chewed for 10 s. Effects of sampling time, temperature, and purge flow on level of volatiles were tested. Purging at 340 mL/min for 30 min at 45 degrees C was found to be optimal. Detection Emits for a number of aldehydes were 0.2-2.7 mu
g/kg. Levels of volatiles are given for fresh salmon, cod, saithe, mackerel, and redfish.

**General information**

State: Published
Organisations: Department of Biotechnology, National Institute of Aquatic Resources
Authors: Refsgaard, H. (Intern), Haahr, A. (Intern), Jensen, B. (Intern)
Pages: 1114-1118
Publication date: 1999
Main Research Area: Technical/natural sciences

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- 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
Aromadannelse i et "functional ingredients" produkt

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State: Published
Organisations: National Institute of Aquatic Resources
Authors: Haahr, A. (Intern)
Pages: 63-67
Publication date: 1997
Main Research Area: Technical/natural sciences

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Journal: Fisk & Hav
Volume: 48
Issue number: 1997/98
ISSN (Print): 0105-9211
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ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: English
Source: orbit
Source-ID: 167327
Publication: Research › Journal article – Annual report year: 1999

Forprojekt oxidationsmekanismer i fiskeolieholdigt mayonnaise

General information
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Organisations: National Institute of Aquatic Resources
Authors: Hartvigsen, K. (Ekstern), Kaaber, M. (Ekstern), Haahr, A. (Intern)
Publication date: 1996

Publication information
Place of publication: Lyngby, Afdeling for Fiskeindustriel Forskning
Publisher: Danmarks Fiskeriundersøgelser
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 225704
Publication: Research › Report – Annual report year: 1996

Projects:
Flavour Release from Model Systems - In Vitro and In Vivo Instrumental Measurements

Department of Systems Biology
Period: 01/06/1999 → 08/06/2005
Number of participants: 7
Phd Student: Haahr, Anne-Mette (Intern)
Supervisor: Bredie, Wender (Ekstern)
Stahnke, Louise Heller (Intern)
Main Supervisor: Adler-Nissen, Jens (Intern)
Examiner: Nielsen, Kristian Fog (Intern)
Jørgensen, Bo Munk (Intern)
Marcussen, Jørn (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Kandidatstipendium ansat på DT
Project: PhD

Retronasal flavour measurement and perception of foods
The aim of this project is to explore and understand factors of importance for flavour release and flavour perception and the relations between flavour release and perception. A thorough understanding of this relationship is essential, in order to develop better methods for collecting and analysing flavour for routine measurements of food quality and in order to develop instrumentation –an artificial mouth- for simulating flavour release.

Department of Biotechnology
Department of Systems Biology
Royal Veterinary and Agricultural University
Period: 01/02/1999 → 01/02/2002
Number of participants: 4
Project participant: Haahr, Anne-Mette (Intern)
Stahnke, Louise Heller (Intern)
Bredie, Wender (Ekstern)
Project Manager, organisational: Refsgaard, Hanne (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 2,000,000.00 Danish Kroner
Project

NUTRIFISH - Nutritional Studies on Dried Functional Ingredients Containing n-3 Polyunsaturated Fatty Acids
1998: The project objectives are to define the lowest intake of n-3 PUFA which will exert a positive nutritional effect against biomarkers of chronic diseases in humans; to design high quality bioavailable fish oil-enriched ingredients; to incorporate these novel dried ingredients in a range of consumer food products. The tasks at FF are to provide fish oil for powder-production, to set up quality specifications for fish oil, to prepare antioxidant formulations and to test their efficiencies, and to study formation and identity of volatile oxidation products formed in spray-dried fish oil powders during storage. Fish oil was refined and deodorized for production of microencapsulated fish oil and for a storage experiment. The fish oil was protected against oxidation by adding an antioxidant system prepared at FF. The shelf-life of commercial powders have been compared with the shelf-life of powders produced in this project. The dynamic headspace method develop at FF, applying analysis of the volatiles by gas chromatography-mass spectrometry (GC-MS),was used to evaluate sensorially significant volatiles formed by lipid oxidation. Compounds with a characteristic and easily detectable odour were selected by GC sniffing analyses. The amount of the volatiles were calculated using calibration curves, that were determined by quantitative GC-MS analysis of standards. The amounts of volatiles were found in levels of microgram volatiles / g powder (ppm).

National Institute of Aquatic Resources
Analytical Chemistry

Analytical Chemistry at FF is a basic activity, aimed at maintaining the chemical-analytical know-how, which is necessary for carrying out general analytical tasks, e.g. analyses for salt, crude protein, and TVB-N. In addition, newer instrumental methods may be part of this general project area, though usually such analyses are developed within specific projects (analysis of peptides, proteins, microbial metabolites, autolytic breakdown-products). The available instrumentation include i.a. 4 HPLC-instruments (UV, DAD, ELSD, RI, fluorescence detection), 3 GC instruments (MS, PFD, FID, olfactory detection), 2 scanners for 2-D-gel electropherograms, NIR, low-resolution NMR, differential scanning calorimeter. The Analytical Quality Group follows up on developments and trends in analytical principles and in analytical quality control that may be relevant for analytical chemistry at FF. This group carries out updating of standard procedures and method descriptions for the purpose of improving quality assurance and minimizing environmental effects, and occasionally manages participation in national and international inter-laboratory tests. Safety activities have been strengthened by the employment of a safety officer. Also, within this project area are placed advisory activities towards internal and external questions on analytical problems. A central theme of present and planned activities is quality assurance and quality control of standard analytical methods. External cooperation in the field of chemical analysis of fish with WEFTA Working Group on Analytical Methods (WEFTA = [West] European Fish Technologists’ Association. The basal chemistry activities, comprising approx. 1 person/year, are financed by the running costs of the department.

National Institute of Aquatic Resources

Period: 01/06/1989 → 31/12/2013
Number of participants: 7
Project participant:
Berner, Lis (Intern)
Stampe-Villadsen, Hanne Lilian (Intern)
Jørgensen, Bo Munk (Intern)
Olsen, Lone Rosenkær (Intern)
Reimers, Karin (Intern)
Haahr, Anne-Mette (Intern)
Project Manager, organisational:
Jensen, Benny (Intern)