Oxidative burst and nitric oxide responses in carp macrophages induced by zymosan, MacroGard® and selective dectin-1 agonists suggest recognition by multiple pattern recognition receptors

β-Glucans are glucose polymers that are found in the cell walls of plants, bacteria, certain fungi, mushrooms and the cell wall of baker's yeast. In mammals, myeloid cells express several receptors capable of recognizing β-glucans, with the C-type lectin receptor dectin-1 in conjunction with Toll-like receptor 2 (TLR2), considered key receptors for recognition of β-glucan. In our studies to determine the possible involvement of these receptors on carp macrophages a range of sources of β-glucans were utilized including particulate β-glucan preparations of baker's yeast such as zymosan, which is composed of insoluble β-glucan and mannan, and MacroGard®, a β-glucan-based feed ingredient for farmed animals including several fish species. Both preparations were confirmed TLR2 ligands by measuring activation of HEK293 cells transfected with human TLR2 and CD14, co-transfected with a secreted embryonic alkaline phosphatase (SEAP) reporter gene. In addition, dectin-1-specific ligands in mammals i.e. zymosan treated to deplete the TLR-stimulating properties and curdian, were monitored for their effects on carp macrophages by measuring reactive oxygen and nitrogen radicals production, as well as cytokine gene expression by real-time PCR. Results clearly show the ability of carp macrophages to strongly react to particulate β-glucans with an increase in the production of reactive oxygen and nitrogen radicals and an increase in cytokine gene expression, in particular il-1β, il-6 and il-11. We identified carp il-6, that was previously unknown. In addition, carp macrophages are less, but not unresponsive to selective dectin-1 agonists, suggesting recognition of β-glucans by multiple pattern recognition receptors that could include TLR but also non-TLR receptors. Candidate receptors for recognition of β-glucans are discussed.