Евіталія – це ліофільно висушені спеціальні штами молочнокислих мікроорганізмів та продуценти вітамінів В1,В2, В6, В12, А, Е, С, фоліва кислота, мікроелементи заліза, кальцію, магнію.

Висушені мікроорганізми в шлунково-кишковому тракті відновлюють свою активність. Евіталія-Вет рекомендується для відновлення імунної системи та нормалізації шлунково-кишкового тракту, підвищення рівня гемоглобіну й активізації білкового обміну.

Бетаїн – біологічно активна речовина, екстракт із рослинної сировини. За хімічною структурою являє собою триметилгліцин. Кормова добавка, яка використовується для збагачення раціонів і є добрим замінником холіну, хлориду і метіоніну. Препарат бетаїну у кормах є інтерним по відношенню до інших компонентів, активно впливає на зменшення жирової інфільтрації печінки.

Дослідження впливу пробіотичних препаратів на імунний стан та продуктивність свиней є актуальним питанням при виробництві свинини.

Метою досліджень є вивчення доцільності та ефективності застосування евіталії та бетаїну, як кормових добавок при вирощуванні свиней.

Матеріал та методика досліджень. Досліди проведені на поголів'ї підсвинків великої білої породи за умов їх відгодівлі в період з трьохмісячного до восьмимісячного віку. Було сформовано три групи піддослідних тварин по 15 голів в кожній за принципом аналогів за масою тіла, віком, статтю та походженням. Перша (І) група – контрольна (без застосування) препаратів. Друга (ІІ) – дослідна з застосуванням евіталії та третя(ІІІ) – дослідна група з застосуванням бетаїну.

Результати досліджень. За період відгодівлі середньодобові прирости відповідно становили: І – 593,4 ± 12,8 г, ІІ – 620,4 ± 17,8 г і ІІІ - 617,9 ± 18,4 г. Збереженість тварин за період відгодівлі була наступною: І – 86,7 %; ІІ – 100,0 %; ІІІ – 93,3 %.

Рівень продуктивності підсвинків, яким застосовували пробіотичні препарати в середньому була вищою від тварин контрольної групи на 4,3 %.

Життєздатність тварин визначається рівнем імунного стану. Отримані результати за показниками бактерицидної активності сироватки крові, лізоцимної та компліментарної активності підтверджують, що застосування пробіотичних компонентів в раціонах свиней на відгодівлі суттєво впливає на їх життєздатність та продуктивність. Показники бактерицидної активності по групам були такими: І – 53,8 ± 0,12; ІІ – 58,1 ± 0,08; ІІІ – 56,9 ± 0,24. Лізоцимна і компліментарна активність сироватки крові відповідно становили: І – 39,8±0,19 і 12,7±0,11; ІІ – 41,8 ± 0,22 і 13,4 ± 0,17; ІІІ – 43,2 ± 0,17 і 13,8 ± 0,21.

В підсумку можна констатувати, що пробіотичні та біологічно-активні речовини, як евіталія-Вет та бетаїн є ефективними компонентами кормових сумішей раціону свиней на відгодівлі, позитивно впливають на стабілізацію імунної системи тварин, сприяють підвищенню енергії їх росту і розвитку. Застосування зазначених компонентів в раціонах свиней при відгодівлі є доцільним та рекомендується для широкого практичного впровадження.

BETA-GLUCANS AS IMMUNOSTIMULANTS IN SALMON AQUACULTURE

H. Tkaczenko, N. Kurhaluk

Institute of Biology, Pomeranian University, Słupsk, Poland,
halina.tkaczenko@upsl.edu.pl, natalia.kurhaluk@upsl.edu.pl

Aquaculture, the farming of aquatic organisms, plays a crucial role in meeting the growing global demand for seafood (Verdegem et al., 2023). However, the sustainable growth of this industry faces significant challenges, mainly due to disease outbreaks and environmental stressors that can affect the health and productivity of farmed fish, crustaceans and molluscs. Traditional approaches to disease management often rely on antibiotics and chemical treatments, raising concerns about antimicrobial resistance and environmental impacts (Martinez-Porchas and Martinez-Cordova, 2012). In recent years, there has been increasing interest in exploring alternative strategies to enhance the immune response of aquatic organisms in aquaculture systems. Immunostimulants, substances capable of enhancing the innate immune system, have emerged as promising candidates for reducing disease risk and promoting the overall health of farmed species (Semple and Dixon, 2020). The use of immunostimulants as dietary supplements can enhance the innate defences of animals and provide resistance to pathogens during periods of high stress such as grading, reproduction, sea transfer and vaccination (Bricknell and Dalmo, 2005). Among these immunostimulants, β-glucans, which are homopolysaccharides of glucose molecules linked by glycoside bonds, have received considerable attention for their potential applications in aquaculture (Meena et al., 2013).

Beta-glucans are a group of polysaccharides found in the cell walls of various microorganisms, fungi, algae and plants. They are known for their immunomodulatory properties, in particular their ability to activate innate immune cells such as macrophages and neutrophils, and to stimulate the production of cytokines and other immune mediators (Meena et al., 2013). Through these mechanisms, β-glucans may enhance the host's ability to recognise and respond to pathogens, thereby improving resistance to infectious diseases (Goodridge et al., 2009). The use of β-glucans as immunostimulants in aquaculture offers several potential advantages. Unlike antibiotics, β-glucans do not contribute to antimicrobial resistance and pose minimal environmental risks. Additionally, they can be administered orally or incorporated into feed formulations, making them convenient and cost-effective for large-scale production systems (Bashir and Choi, 2017).

Glucan administration by various routes, including immersion, feed or injection, has been found to enhance many types of immune responses, resistance to bacterial and viral infections and resistance to environmental stress (Vetvicka et al., 2013; Rodrigues et al., 2020). Although the efficacy of glucan varies to some extent with the mode and route of administration, glucan used as an immunomodulatory additive has been found to be active in inducing immunity in commercial aquaculture and is currently used routinely in commercial farming (Dalmo and Bøgwald, 2008). Researchers have shown that β-glucans increase the resistance of fish to infectious diseases mainly by enhancing their non-specific defence mechanisms. Some studies in fish have also shown evidence for the development of specific defences (Siwicki et al., 2004). β-Glucans provide the host with improved protection against several diseases such as Aeromonas salmonicida and viral haemorrhagic septicemia virus (VHSV) (Douxfils et al., 2017; Cornet et al., 2021). A recent study in rainbow trout examined the effect of a β-glucan diet on fish infected with *A. salmonicida* and showed that several immunostimulatory pathways were upregulated to a greater extent in fish fed the β-glucan-supplemented diet after infection, with complement and coagulation, PI3K-AKT signalling, platelet activation and T-cell receptor pathways all being enriched in fish fed the β-glucan-supplemented diet (Ji et al., 2020). In carp head kidney macrophages, C-type lectin type 4 was suggested as a novel β-glucan receptor, possibly leading to direct activation of the C-type lectin signalling pathway. Other pathways involved in the proinflammatory response, cytokine-cytokine receptor interactions, apoptosis, NOD-like receptor signalling pathway and ECM receptor interaction were also upregulated in this species (Petit et al., 2019).

One of the first studies on the protective effects of β-glucans, which described that intraperitoneal injection of a β-1,3/1,6 'M' glucan from *Saccharomyces cerevisiae* increased resistance to two different bacterial pathogens, was carried out in Atlantic salmon (Robertsen et al., 1990). It is perhaps not surprising that subsequent studies investigating the immunomodulatory effects of β-glucans have been carried out in salmonids. β-1,3/1,6-glucan (lentinan) from the fungus *Lentinula edodes* reduced the expression of pro-inflammatory genes in response to bacterial lipopolysaccharide (LPS) (studied by microarray) in rainbow trout (*Oncorhynchus mykiss*). A group of genes involved in acute inflammatory responses included IFN-related and TNF-dependent genes (galectins and receptors, signal transducers and transcription factors), genes involved in MHC class

I antigen presentation and leukocyte recruitment. A similar trend was observed in iron and xenobiotic metabolism, markers of oxidative and cellular stress (Djordjevic et al., 2009).

Refstie and co-workers (2010) evaluated the effects of a highly purified immunomodulating beta-1,3/1,6-glucan product (BG) and a putative receptor blocking mannan oligosaccharide-rich product (MOS) in Atlantic salmon fed extruded diets containing extracted soybean meal (SBM) or a combination of SBM and extracted sunflower meal (SFM). Supplementation with BG and MOS did not alter the effects of the 32 % SBM diet. However, BG enhanced the salmon lice control effect of the SFM diet. When MOS was added to the 14 % SFM + 14 % SBM diet, the SBM-induced enteritis was eliminated and the diarrhoea-like condition improved. This did not affect appetite, but was followed by improved feed conversion and faster growth, demonstrating that gut health is an important production parameter for Atlantic salmon (Refstie et al., 2010).

β-Glucans should not be seen as a magic bullet that can increase resistance to all pathogens at all levels of infection. For example, β-glucan treatment appears to increase resistance of Atlantic salmon to sea lice of the species *Lepeophtheirus salmonis*, but not to *Caligus elongates* (Refstie et al., 2010), for which β-glucan treatment may actually lead to higher infestation (Covello et al., 2012). Sea lice (*Lepeophtheirus salmonis*) are the most economically important ectoparasites affecting Atlantic salmon (*Salmo salar*) farming worldwide. The ability of three orally administered immunostimulants to reduce the number of lice successfully infecting post-smolts of Atlantic salmon was investigated by Covello and co-workers (2012). The five treatment groups in the study were: control diet (uninfected), control diet (infected with *L. salmonis*), ProVale™ (400 g/1000 kg diet; infected with *L. salmonis*), CpG ODN 1668 (20 g/1000 kg diet; infected with *L. salmonis*) and ABN (4 kg/1000 kg AllBrew + 1 kg/tone NuPro; infected with *L. salmonis*). It was found that the β-glucan (ProVale) fed group actually maintained more sea lice than the control group (24 % increase). However, both the CpG ODN (31-46%) and AllBrew NuPro (11-31 %) fed groups showed reduced infection levels compared to the control group. Histopathological and differential gene expression analyses suggest that local and systemic inflammatory mechanisms may be transiently altered by these immunostimulatory diets, resulting in increased host resistance to sea lice (Covello et al., 2012).

Potential immunostimulatory effects of orally administered β-glucan were investigated by Skov and co-workers (2012) in combination with immersion vaccination against enteric redmouth disease caused by *Yersinia ruckeri* in rainbow trout (*Oncorhynchus mykiss*). A linear, unbranched and pure (purity ≥ 98 %) β-1,3-glucan (syn. paramylon) from the alga *Euglena gracilis* was applied at an inclusion level of 1 % β-glucan in the diet, administered at a rate of 1 % biomass day-1 for 84 consecutive days. Fish were vaccinated after two weeks of experimental feeding and challenged with live *Y. ruckeri* in the pond six weeks after vaccination. Blood and head kidney samples were collected on days 0, 13 (1 day before vaccination), 15, 55, 59 (3 days after challenge (p.c.)), 70 and 84. Vaccination induced a significant increase in p.c. survival, whereas β-glucan had no effect on survival in either unvaccinated or vaccinated fish. Head kidney expression of acute phase response related genes, i.e. interleukin-1β (IL-1β), serum amyloid A (SAA), precerebellin and hepcidin, was significantly different in vaccinated fish receiving β-glucan compared to vaccinated controls at day 3 p.c., whereas no effect of β-glucan was observed in unvaccinated fish. A significant interaction between β-glucan and vaccination was found for the regulation of IL-1β, tumour necrosis factor-α, interferon-γ, SAA, precerebellin and hepcidin p.c. For SAA, the significant effect of β-glucan in vaccinated fish persisted at day 14 p.c. and 28 p.c. The difference in gene expression between vaccinated fish was mainly observed as down-regulation in vaccinated, β-glucan-fed fish compared to up-regulation or no regulation in vaccinated controls. Slightly elevated levels of plasma lysozyme activity were found in fish (both unvaccinated and vaccinated) fed β-glucan on day 3 p.c. compared to the control groups. This was associated with faster clearance of *Y. ruckeri* in unvaccinated fish receiving β-glucan. In contrast to the trend towards a beneficial effect of β-glucan on plasma lysozyme activity, a trend towards suppression of plasma antibodies was observed in both unvaccinated and vaccinated fish receiving β-glucan. However, the effects of β-glucan were not reflected in the survival curves, and the differences seen in plasma lysozyme activity and antibody levels may have cancelled each other out, as well as any potential effect represented by the differences in gene expression found (Skov et al., 2012).

The immunomodulatory properties of host defence peptides (HDPs) expressed in rainbow trout intestinal epithelial cells in response to the β-glucan, zymosan, were assessed by Schmitt and co-workers (2015). The results showed that zymosan increased the production of HDP, cathelicidin and the cytokine IL-1β in the intestinal epithelial cell line RTgutGC at the transcript and protein levels. Cathelicidin-2 variants were produced and shown to (i) induce IL-1β production in RTgutGC cells and (ii) have a synergistic effect with zymosan in IL-1β upregulation. Importantly, colocalisation of both rtCATH-2 and IL-1β was detected in the intestinal epithelial cells of rainbow trout fed a diet supplemented with 0.3 % zymosan. The researchers proposed that trout cathelicidins are expressed by intestinal epithelial cells and exert immunomodulatory effects to enhance the local intestinal immune response induced by immunostimulants (Schmitt et al., 2015).

Studies investigating the effects of β-glucans on maintaining gut integrity have found no adverse effects and provide evidence for a presumed beneficial increase in the frequency of mucus-secreting cells in the epithelial barrier (Covello et al., 2012, Schmitt et al., 2015). Of interest, oral administration of rainbow trout with β-glucans appears to downregulate the expression of immunoregulatory genes (e.g. IL-1β and lysozyme) in the presence of a microbial stimulus (Djordjevic et al., 2009, Skov et al., 2012), but upregulate the expression of such genes (e.g. IL-1β and cathelicidins (host defence peptides)) in the absence of a microbial stimulus (Schmitt et al., 2015, Skov et al., 2012). To verify and explain the initial field observations, the number of laboratory-based studies aimed at gaining more detailed knowledge of the immunostimulatory effects of β-glucans in salmonids has increased considerably. It has become clear that the immunomodulatory effects of β-glucans on the immune system of salmonids should be considered stimulatory. Although the degree of disease protection afforded by β-glucans clearly depends, among other things, on the infectious agent, it should be noted that oral administration of β-glucans to salmonid species has great potential as a prophylactic measure (Petit and Wiegertjes, 2016).

In conclusion, the use of β-glucans as immunostimulants in aquaculture holds great promise for improving the health and disease resistance of farmed aquatic organisms. Through their ability to modulate the innate immune response, β-glucans offer a sustainable alternative to traditional antibiotics and chemical treatments, addressing concerns related to antimicrobial resistance and environmental impact. The literature reviewed suggests that β-glucans can enhance the immune response of aquatic organisms, resulting in improved resistance to a wide range of pathogens, including bacteria, viruses and parasites. In addition, β-glucans have been shown to have positive effects on growth performance, feed efficiency and stress tolerance in farmed species.

However, several knowledge gaps and challenges remain. Further research is needed to optimise the dosage, timing and duration of β-glucan supplementation and to explore potential synergies with other immunostimulants or dietary supplements. In addition, further studies are needed to elucidate the mechanisms underlying the immunomodulatory effects of β-glucans in different species of fish, crustaceans and molluscs. Despite these challenges, the evidence presented in this review supports the continued research and implementation of β-glucans as part of integrated disease management strategies in aquaculture. By promoting the health and resilience of farmed aquatic species, β-glucans have the potential to contribute to the sustainability and profitability of the aquaculture industry, while reducing reliance on antibiotics and chemical treatments.

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