Ohly Application Note

Benefits of Nucleotide Supplementation in Aquaculture: Shrimps

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Abstract: Nucleotides are semi-essential nutrients: under conditions of rapid growth, stress and disease the own synthesis capacity of animals is not sufficient. Supplementation of feed with nucleotides improves productivity with respect to body weight gain and feed conversion ratio. This effect is especially pronounced in the first weeks of life. This is because due to the fact that nucleotides supplementation especially results in an improved innate and adaptive immune system, reducing the impact of pathogenic infections. Consequently, dietary nucleotides provide a valuable tool to the aquaculture producer as an alternative to antibiotics.

Keywords: Nucleotides, Aquaculture, Crustacean, Antibiotic replacement

Introduction

Aquaculture is the global fastest growing animal food-producing sector. Intensive culture has led to serious problems with diseases and pathogen infections and negatively affected the growth of crustaceans (Bonato, 2014). Traditionally, antibiotics were used sub-therapeutically by the aquaculture industry to reduce the impact of bacterial infections. However, there are increasing consumer concerns about drug residues in food products and the rise of antibiotic resistance of pathogenic bacteria. As a result, many countries have banned the inclusion of antibiotics in crustaceans' diets as a routine means of growth promotion. Consequently, there is an increasing demand for alternatives to antibiotics (Ringo *et al*., 2012).

Nucleotides play a major role in almost every biological process. They are the building blocks of DNA and RNA and play a central role in cellular metabolism, i.e. as energy carriers (i.e. ATP), in cell signaling (i.e. cAMP) and are a building block for important cofactors (i.e. NAD+). In crustaceans, it is however not known whether nucleotides can be synthesized de novo. It is assumed they have limited capacity to produce nucleotides and therefore would benefit highly from dietary supplementation (Devresse, 2000). After decades of studies, the health benefits of nucleotides have in the meantime been well established in humans (Grimble &

Westwood, 2001), and they have therefore been added to human infant formulas for decades (Boza & Martinez-Augustin, 2002). Although the use of nucleotides is relatively new in aquaculture, there is an increasing body of evidence showcasing their benefits (Do Huu, 2016).

Enhancing disease resistance

Crustaceans lack an adaptive immune system and are thus entirely dependent on the non-specific (innate) immune system to fight pathogenic infections (Hertrampf & Mishra, 2006). The innate immune response of crustaceans is mainly mediated by hemocytes (blood cells) to fight pathogens. However, their count decreases dramatically during infections or environment stress (Wu *et al*., 2008). Ancieta-Probstl *et al.* (2005) demonstrated that the hemocyte counts increased by more than 100% in juvenile shrimps and by 30% in larger shrimps after nucleotide supplementation. Survival rates of various species were significantly better after nucleotides supplementation. For example, shrimps had up to 66% higher survival rates against bacterial infections (Biswas *et al*., 2012; Guo *et al*., 2016) viral infections (Andrino *et al*., 2012) or environmental stress like changing salinities (Hertrampf, 2003); Artemia had 38% higher survival rates against *Vibrio proteolyticus* infections (Madalla *et al*., 2013). Juvenile crayfish had a significantly higher survival rate and a much faster immune response against an air stress challenge (Safari *et al*., 2014). Nucleotide inclusion also provided long term effects. Juvenile shrimps fed nucleotides in the larval stage had higher survival rates (Hertrampf *et al*., 2006).

Enhancing gut intestinal structure and integrity

A proper functioning intestine is of key importance to enhance the growth of animals as it results in a more efficient nutrient digestion and absorption (Xu *et al*., 2015). Dietary nucleotides have a positive effect on intestinal growth and maturation (Do Huu, 2016). Intestinal villi height, an indicator for gut performance, in shrimps fed nucleotides was up to 30% higher (Abedian-Kenari & Oujifard, 2013; Guo *et al*., 2016), while the jejunum wall thickness was also significantly improved (Guo *et al*., 2016) resulting in an increase in the total gut mucosal surface (Burrells *et al*., 2001).

Improving reproductive performance

Commercially pond-reared shrimps are generally unpredictable in their reproductive performance due to their specific rearing conditions. Nucleotide supplementation resulted in an improved reproductive performance (including absolute fecundity, egg diameter and latency period) of female Pacific shrimp (Arshadi *et al*., 2018).

Boosting animal growth and performance

Supplementation of diets with nucleotides has been demonstrated to improve growth performance of crustaceans in the younger life stages (Do Huu *et al*., 2012). Nucleotide supplementation early on also carried long term effects, since the weight gain and specific growth rates of juveniles fed nucleotides in the larval stage was significantly better (Hertrampf *et al*., 2006). The growth rate of shrimps (Ancieta-Probstl *et al*., 2005; Hertrampf & Mishra, 2006), crayfish (Safari *et al*., 2014) and Artemia (Madalla *et al*., 2013) was significantly improved due to nucleotides, indicated by increased growth rate, higher final weights and/or higher body length. Moreover, nucleotide-fed crustaceans had better feed conversion rates and utilize proteins and lipids more efficiently (Andrino *et al*., 2012; Hertrampf & Mishra, 2006; Safari *et al*., 2014).

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