Bioactive based feed formulation for aquaculture applications

Tejpal C. S.[1*], Lekshmi R.G. Kumar[1], Elavarasan K.[2], Renuka V. [1] and Anas K.K. [1]
[1]Biochemistry & Nutrition Division
[2] Fish Processing Division
ICAR- Central Institute of Fisheries Technology, Cochin
*tejpal.arun@rediffmail.com

Introduction

Worldwide the demand for the fish and fishery product is continuously increasing due to many health beneficial aspects (Delgado et al. 2003, FAO 2010). Concerns about food security are of significant importance to emerging nations like India, where a substantial percentage of its population lives in poverty and where a large portion of total family expenditure is spent on food (Pradeepkiran, 2019). Fish and fishery product are known for the protein sources with all the essential micronutrients. To meet the present and future demand the culture sector has adopted innovative intensive and super intensive farming techniques. However, intensified farming has improved the production and productivity of fish, on the other side, risk of disease outbreaks in the culture system is also higher and leads to production and economic losses. As the sector has adopted intensification, requirement of quality feed ingredient for feed formulation has increased. As per the recent survey, the aquaculture sector in India is facing serious crisis with abrupt increase in cost of shrimp and fish feed due to unexpected increase in the prices of the key feed ingredients such fishmeal, soyameal, fish oil etc. The prime ingredient in the aqua feed sector is fishmeal, the cost has gone up due to non-availability of fish preparation of fishmeal. Fishmeal is being considered as one the gold standard ingredient due to the presence of quality protein with all essential micronutrients and also known to have unknown growth promoters which helps fish and shellfish growth. As the cost of all the essential feed ingredients are going up and anticipating the adverse effect of intensification in culture system, bioactive compound isolated from marine and agri based source having bio function properties like antioxidant, antimicrobial, growth promoters and immune system modulators have been used in the aquaculture system.

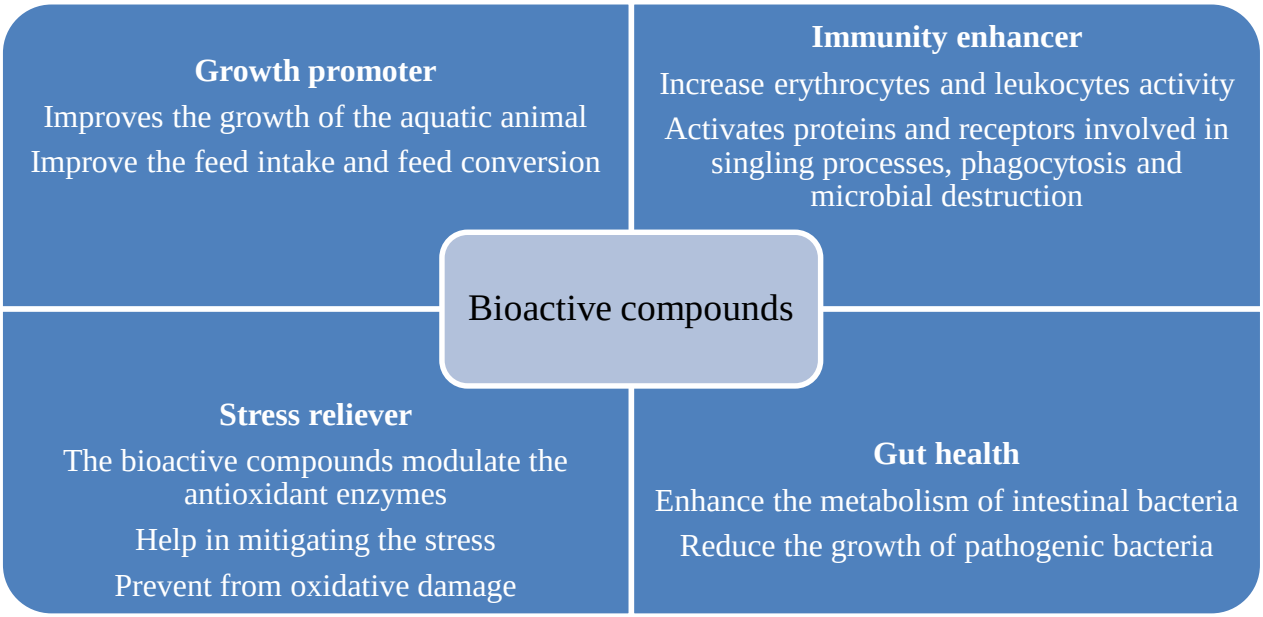
Bioactive ingredients obtained from agri source

Huge amount of waste is being generated from the cultivation and processing of agricultural products. Waste generated from the source includes husk, seeds, leaves, roots and stems, these can be considered as source of bioactive compounds (Veneziani et al., 2017). Bioactive compounds such as phenolic complexes (flavonoids, coumarins, xanthones, chalcones, stilbenes, lignins), terpenes (essential oils and carotenoids), dietary fiber (β-glucans, fructooligosaccharides, galactooligosaccharides), glucosinolates, etc (Vermerris and Nicholson, 2008, Ferreira et al., 2017, Leyva-López et al., 2020). These bioactive compounds are proven to have several biological properties, such as antioxidants, immunostimulants, and microbiota modulators. In addition, they also have properties like antibacterial, antiparasitic, antiviral, anti-inflammatory, anticancer, and antihypertensive effects (Leyva-López et al., 2020).

Due to rapid growth and huge demand for the fish and fishery product, the farming communities across the globe have adopted intensification in the culture system. Additionally,

other farming factors, including poor diet, poor water quality, changes in temperature and pH, may leads to stress resulted in reduced immunity in the aquatic animals, further may lead to rapid spread of infectious diseases. In the recent past, the aquaculture sector started using the bioactive compounds from medicinal plants as feed additives to enhance the immune response in the fish and shellfish. Most consumed cereals across the globe are corn, rice, wheat, and sorghum. As the waste generated from the cereal processing sector is huge and contain valuable bioactive compounds. Lot of researchers are working on converting bio-waste into functional feed ingredients. Corn and sorghum residues have been used a dietary supplement to boost the antioxidant efficiency in fish. Corn silk extract is good source of flavonoids such as luteolin, formononetin, maizine, and apigenin, incorporation of corn silk extract as feed additive as proven to lower the lipid peroxidation in the liver of Nile tilapia. In general, these polyphenolic compounds have ability to neutralizing reactive oxygen species and modulates antioxidant enzyme activities in the living system.

Role of Bioactive compounds in aqua feed



Bioactive compounds from marine source

Fish, shellfish, macroalgae, microalgae, and other varied organisms make up marine ecosystems (Thorpe et al., 2000). Marine habitats are frequently referred to as one of the richest treasure houses of biomolecules and these biomolecules from marine habitats may possess bioactive properties like antioxidant, antimicrobial, antiviral, antiparasitic, anti-inflammatory, antifibrotic, and anticancer activity. Due to their bio-functional properties, these bioactive compounds find its applications in field of pharmaceutical, nutraceutical, biomedical, and cosmetic industries (Barrow and Shahidi, 2007). As the demand for the fish is increasing constantly and culture sector are adopting new methods of farming to meet the present and future requirements. Meanwhile, fish processing sector tends to generate huge quantity of waste which includes head, skin, trimmings, fins, frames and viscera, and these generated biomasses can be utilized for the extraction of bioactive compounds (Dekkers et al., 2011).

Fish protein hydrolysate: Fish protein hydrolysates find application as fish feed ingredient or as a supplement to replace fishmeal. Fish protein hydrolysate are found to have desirable bio-functional properties like antihypertensive, antithrombotic, immune modulatory and

antioxidative properties. Various studies have shown that dietary supplementation of fish protein hydrolysate had positive influence on growth performance and immunity parameter in fish and shellfish (Quinto et al., 2018, Tejpal et al., 2021).

Chitin and chitosan

Chitin is natural biopolymer and it is a cationic amino polysaccharide composed of *N*-acetyl-d-glucosamine with β (1 → 4) glycosidic bonds between each monomer. Similar to chitin, chitosan is also a biopolymer and it consists of d-glucosamine units obtained during the deacetylation of chitin by adopting hot alkali treatment (Beaney et al., 2005, Se-Kwon, 2010). Chitin and chitosan are mainly present in many aquatic, terrestrial organisms and also found in some of the microorganisms. Bio-waste generated from aquatic and terrestrial source can be used as raw material for production of chitin and chitosan (Tokura and Tamura, 2007 and Se-Kwon, 2010). These biomaterials are reported to have wide range of applications. The chitin was found to improve the growth performance, feed conversion and modulates the immunity of the aquatic animals. However, inclusion of chitin at excess in feed had adverse influence in the aquatic animals. Whereas chitosan, an interesting bioactive polymer, found to have application in aqua feed sector as biomaterial for encapsulation of bioactive compounds. In addition, chitosan supplementation in the feed improves growth performance in aquatic animals.

Pigments

Pigments such as astaxanthin, fucaxanthin, melanin etc. are available in the marine source and found to have bio-functional properties. Generally, waste generated from the shellfish processing waste contain good amount of carotenoid pigments such as astaxanthin and canthaxanthin. The supplementation of these pigments will increase the palatability of the feed and improve the immunity of aquatic animals. Carotenoids, caramel, curcumin, and spirulina are feed pigments that are majorly available in the market.

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