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Review Article

Feed palatability and the alternative protein sources in shrimp feed

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Abstract

Feed palatability in carnivorous aquaculture species, shrimps in particular, has been crucially related to the presence of compounds acting as attractants that are commonly associated with the prey components under wild conditions. Thus a nutritionally adequate and organoleptically-pleasing diet is essential to achieve satisfactory intake and growth in shrimps. Historically, fishmeal has been an essential dietary component of intensive shrimp cultures because of its nutrient composition and compounds of high attractability. However, in recent years the fishmeal supplies have been dwindling due to over hunting, a diminishing natural fish-stock, elevating prices and market volatility. This has led to search for cheaper sources of suitable protein as fishmeal substitutes. To improve the palatability of diets, various substances have been investigated for their effectiveness in aqua-feed including natural feed ingredients and synthetic flavor substances. For crustacean, attractants characteristically are of low molecular weight, water and ethanol soluble, and amphoteric or basic compounds that are released from potential prey items. Compounds such as free amino acids, especially taurine, hydroxyproline, glycine, arginine, glutamic acid and alanine have been identified to stimulate feeding in shrimps. The same has been identified with organic acids, nucleotides and nucleosides, betaine, and some small peptides. Palatability also has been associated with animal's past experience with the feed. Understanding the factors that regulate feed palatability is therefore primary for successful shrimp culture.

Keywords: palatability, shrimp feed, alternative protein sources

1. Introduction

In aqua feed, particularly the one for carnivorous species, fishmeal will be on formulation because of its excellent properties as protein source and for other beneficial effects on growth promotion. However, the supply of fishmeal has been fluctuating due to a reduced natural fish stock and a high demand leading to growing prices and market volatility (Figure 1) as reported by the World Bank (World Bank Commodity Price Data, 2012). With the growing demand for marine protein for human consumption, it is

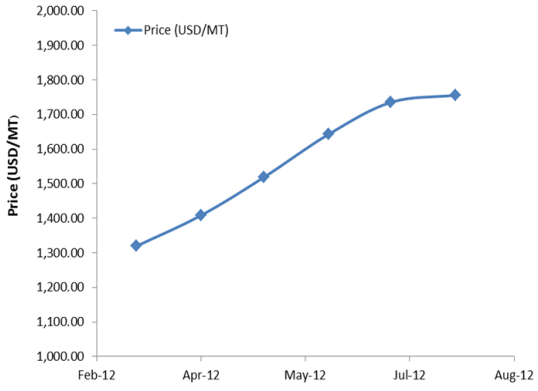

Figure 1. Fishmeal, Peru Fish meal/pellets 65% protein, US Dollars per Metric Ton (World Bank Commodity Price Data, 2012)

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forecasted that world aquaculture, the reliable aquatic animal mass production, will be increasing to meet the demand in contrast to commercial fisheries which have been decreasing over the past decades.

The static and/or diminishing global supplies of wild forage fish are destined for reduction into fish meal. The cost of fishmeal is currently escalating as a result of the increase of energy costs and of the processing and shipping/ transportation costs (Tacon and Metian, 2008). These factors have led research institutions and aquaculture feed industries to search for cheaper suitable protein sources with a sufficient supply to substitute fishmeal. In the past 13 years, fishmeal inclusion in major aqua-diets has declined considerably (Table 1). At a species level, fish meal use from 2006 to 2020 is expected to decrease by 37.7% for shrimp, 31.3% for marine fish, 47.2% for salmon, 44.1% for trout, 57.0% for carp, 0% for catfish, 48,0% for eel, 26.2% for freshwater crustaceans, 34.1% for tilapia and 34.5% for milkfish (Tacon and Metian, 2008). The FAO technical paper predicts that in 2020 fishmeal inclusion in the diets of carnivorous fish and crustacean species will be reduced to as low as 1-2 percent in diets for some major freshwater fish species (FAO, 2012a).

2. Protein Sources to Replace Fishmeal

In the animal feed production, there is a number of available protein sources, mostly animal and plant by-products, varying in the protein contents and amino acid profile. Animal protein sources contain considerably high protein contents such as meat and bone meal, blood meal and hydrolysed feather meal. Despite their good amino acid profile, meat and bone meal cannot be incorporated in the feed as a result of implementation of the ban by European Union on their use in any animal production (Chadd *et al.,* 2004), while blood meal and hydrolysed feather meal present inferior properties of imbalanced amino acid profile and low digestibility.

Because of their low price and their relatively consistent nutrient composition and supply, plant proteins, such as oil seed cakes, are often economically and nutritionally valuable sources of protein. However, potential problems associated with insufficient levels of indispensable amino acids (particularly lysine and methionine), anti-nutritional factors and poor palatability are the main concerns for feed formulators. Among plant protein sources, soybean products are the most suitable sources to replace fishmeal in aquatic feed because of its protein levels as well as amino acid profile that match the animal's requirements except for the low methionine level (Lim *et al.*, 1998; Hardy, 1999; Samocha *et al.*, 2004, NRC, 2011). With available pretreatment and processing technologies, properly processed plant ingredients containing high protein content with high digestibility of crude protein and low anti-nutritional components are potential protein sources for the replacement of fish meal in fish and shrimp diets (Dersjant-Li, 2002). For example, extrusion is widely used in manufacturing shrimp feeds, having the advantage of inactivating and/or destroying endogenous heat-sensitive anti-nutritional factors commonly found in soybean meal and gelatinizing starch granules (Amaya, 2006).

Presently, feed manufacturers are faced with increasing prices of almost all imported feedstuff. Efforts therefore have been made to study the feasibility of utilizing potential local ingredients which will depend on the sufficient supply, cost and ability to compete with human food supplements. These include different agriculture by-products, oil crop by-products (Hardy, 2010) and fisheries by-products (Hernández *et al*., 2004). Progress has also been made on finding various novel protein sources such as microalgae meal of different species , bioflocs (microbial flocs) (Burford *et al*., 2004; Schryver *et al*., 2008; Kuhn *et al*., 2009), single cell proteins (McLean *et al*., 2006), and co-products from biofuel production (FAO, 2012b).

In comparison with terrestrial animal feeds, shrimp feeds are protein-rich. Practical formulation for these species

Table 1. Reduction in fishmeal inclusion in compound aquafeed of different species groups

Species/species group	Fishmeal inclusion in compound aquafeed (%)		
	1995	2008	2020*
Tilapias	10	5	1
Catfishes	5	7	2
Milkfish	15	5	2
Salmons	45	25	12
Trouts	40	25	12
Marine fishes	50	29	12
Marine shrimps	28	20	8
Freshwater crustaceans	25	18	8

* Projected.
Source: FAO (2012a)

is the blend of a variety of plant and animal sources or other local protein sources based on their nutritional value and availability. Such blends would more closely accommodate the amino acid profile of fishmeal than any single protein source. However, partial or total fishmeal replacement although with supplementation of essential nutrients to meet the animal requirements often causes reduced growth in several aquatic species, particularly carnivorous groups (Tantikitti *et al*., 2005; Chookird *et al*., 2010; Zhou *et al*., 2011). The reduced shrimp growth when fed on diets with alternative protein sources is caused by reduced protein digestibility as compared to that of fishmeal (Brunson *et al*., 1997), amino acid deficiency and/or imbalance and unavailability (Richard *et al*., 2011), existing anti-nutritional factors (Francis *et al*., 2001), toxic substances (Laohabanjong *et al*., 2009) and unpalatable properties of diets (Nunes *et al*., 2006).

3. Nutrition and Feeding Management in Aquatic Animal Production

On top of the nutritionally balanced formulations, the most important factor determining the success of the feed manufacture is palatability and attractiveness of the feed that promotes ingestion leading to utilization of available nutrients. Diet palatability and attractiveness would help to reduce the time that shrimp spend approaching the feed and it would limit nutrient leaching and feed loss which in turn reduce deterioration of rearing pond environments from overloaded nutrient input. Feed and feeding management, therefore, constitute an immense element in the success of the shrimp culture production in terms of both growth promotion and cost (Figure 2). This is because feed takes up approximately 30-60% of variable cost in shrimp culture. As with any animal production system, reducing feed loss - which is directly related to reducing costs - whilst maintaining a desirable level of output is the prime concern.

4. Palatability of the Diet

Palatability is influenced by the nutrient and toxin content of the food, the nutritional needs of the animal, and the animal's past experience with the food. Animals use all senses (smell, taste, sight) to discriminate among foods that provide pleasant or unpleasant feelings associated with eating. Whether or not an animal readily eats a food is not determined by flavor alone, rather it is determined by the experiences associated with eating the food (Provenza, 1995). Since palatability is based on feedback from foods, the alertness towards feeding stimuli increases with the degree of starvation up to certain levels and thereafter it decreases due to the physical weakness of the animal (Fernandez, 1995).

In order to improve palatability of shrimp feed, attractants/stimulants have drawn serious attention especially when the plant proteins are included at a high level. For crustacean, attractants/stimulants characteristically are low molecular weight, water/ ethanol soluble, and amphoteric or basic compounds that released from potential prey items. Thus, substances that elicit strong feeding behaviour responses are free amino acids, especially taurine, hydroxyproline, glycine, arginine, glutamic acid and alanine, and other low molecular weight organic compounds such as organic acids, nucleotides and nucleosides, betaine or small peptides (Lee and Myer, 1997). Fernandez (1995) reported that the threshold concentration of L-amino acids ranged between 4 x 10-2M and 1 x 10-10M for *Peneaus. indicus* and at the same concentration L-Amino acids were more stimulatory than the corresponding DL-amino acid. Furthermore, lysine, methionine, glycine, alanine and proline produced maximum feeding response and feed ingestion. Floreto *et al*. (2001) used krill hydrolysate to enhance the acceptance of soybean-based feeds for the American lobster, *Homarus americanus*, and found that soybean could provide almost 90% of the dietary protein with no adverse effects on growth relative to feeding mussels. Smith *et al*. (2005) attributed the enhanced growth of juvenile *Peneaus monodon* in their studies to krill meal and krill hydrolysate being included in the diet as a rich source of small peptides and free amino acids. Protein hydrolysate produced from tuna viscera was also found to improve pellet stability and attractability and palatability of diet without fishmeal which result in improved feed intake of giant fresh water prawn, *Macrobrachium rosenbergii* (Sae-alee and Tantikitti, 2008)

However, the size of the pellet in relation to the size of the animal and perhaps the texture of the feed may be considerably important to maximize feed consumption and to minimize feed wastage (Sheppard *et al*., 2002). Despite good diet palatability, environmental parameters like pH and salinity have pronounced influence on the chemoreception and feeding response in the shrimps, being chemotactically more active at pH between 7.0 and 9.0 and salinity between 15 and 25%. The shrimp feed intake was observed to decline by 50% at pH 6.0 and 10.0 (Fernandez, 1995).

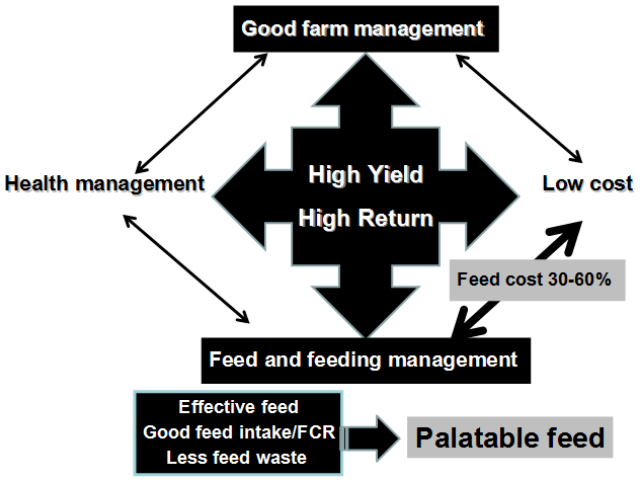

Figure 2. Key factors in aquatic animal production

5. Conclusion

The situation of limited fishmeal supply and increasing feedstuff price worldwide has caused feed industry to adapt by searching for alternative protein sources for effective least-cost formulations. The success of such feed will depend on key properties including nutritionally complete formulation, nutrient availability and feed palatability. Feed palatability is the prime concerns especially for shrimps because of their habitats and potential loss of sensory stimuli leading to feed wastage which directly affects growth and production cost. The palatability property of a diet is very crucial for feeding management of shrimp which is the lowest group of economically important culture aquatic species with a unique feeding habit. There have therefore been several studies world wide to investigate shrimp feeding behavior, effective feed attractant/stimulant and palatable feed formulations. The success of such investigations will result in a sustainable shrimp culture industry that can meet the protein demand for the growing world population.

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