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PROSPECTS OF SHRIMP FEED PRODUCTION

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Aquaculture is food sector, which is growing rapidly in the last 25 years with annual growth of 8,2 %. One of the most perspective branches of aquaculture is shrimp farming. The theoretical research was devoted to the problem of compound shrimp feed production. In order to satisfy shrimp requirements, shrimp feeding systems were shown. Features of the nutritional standards for freshwater and saltwater shrimps were analyzed. Nutrient requirements of shrimp have been changed through fish life-cycle. Also features of feed mill scheme and modern technologies for shrimp feed manufacture were shown. Undoubtedly, extrusion is the main process for shrimp feed production. As well new ingredients as food by-products, beans, etc. are used more for shrimp feed recipes. As the result of the paper, recommendation for shrimp feeding manufacture was created.

***Keywords**: compound feed for shrimp, feed manufacture technology for shrimp feed, requirements for shrimp feed.*

INTRODUCTION

Aquaculture has seen tremendous growth since 2011, increasing market share by as much as 17% per year. The Food and Agriculture Organization of the United Nations (FAO) has released data indicating that trends in global consumption of farmed fish and shellfish exceeds that of beef on a weight basis (Alltech, 2013). Shrimp (or prawn) culture is widespread throughout the tropical world. It is in an industry set for a period of strongly growing demand, and is currently worth around US$10 billion.

This article is intended to provide some detailed discussion, and information references where possible, on the perspectives and features of shrimp feed production.

Farming system and feeding strategies vary with shrimp size (larval, nursery, juvenile, adult), species and country. Framing and feeding strategies used by farmers include (Albert G.J. Tacon, 2004):

- Extensive outdoor farming system with no additional nutrient input through fertilization or feeding (L. vannamei, P. monodon, P. chinensis, P. indicus.).
- Extensive tidal/ running water outdoor farming system with fertilizer and / or complete / supplementary diet feeding (L. vannamei, P. monodon, P. chinensis, P. indicus).
- Semi-intensive static / running water outdoor farming system with fertilizer and / or complete / supplementary diet feeding. (P. monodon, P. chinensis, L. vanname).
- Intensive outdoor running / static water farming system with fertilizer and / or complete / supplementary diet feeding (P. monodon, L. vanname, F. dorarum, P.aztecus, F. merguensis).
- Intensive indoor farming system with fertilizer and / or complete / supplementary diet feeding (*P. monodon*, *L.vanname*, *P.indicus*, *P.esculentus*).

Production cost depends on farming system and vary from 1-2 US dollar per kilogram of live shrimp to 5 US dollar (Albert G.J. Tacon, 2004) with feed conversation range from 0,9 kg/kg to 3,0 kg/kg. While some 20 species are cultured in various parts of the world, the majority of production is based on six species (Figure 1). For the eastern hemisphere, the fast growing giant tiger shrimp Penaeus monodon is the most important, while in the western hemisphere, the white shrimp Litopenaeus vannamei is the leading production species. Feed most often

represents the greatest percentage of the total cost of raising fish and shrimp. Therefore, correct requirements are necessary for feed production.
Shrimp have a complicated life cycle (Figure 2, Akiyama, D.M., 1992). Eggs from the female are broadcast into the environment. Hatching from the egg, the larvae pass through three distinct stages, nauplius, zoea and mysis, before assuming the distinctive adult morphology as post-larval or juvenile shrimp.

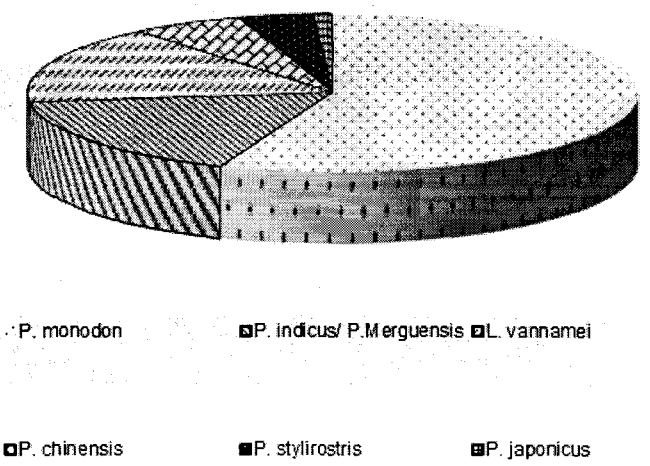

Figure 1. Relative importance of shrimp species to global aquaculture production. (Rosenberry 1999)

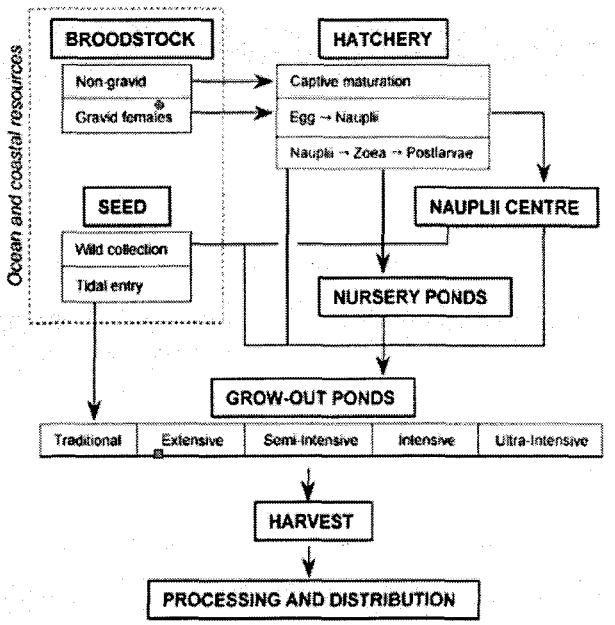

Figure 2. Production cycle for the cultured organism in industrial shrimp aquaculture. (Fast & Lester, 1992)

Formulated diets are available for post-larval and juvenile stages, enabling the farmer to rear the shrimp to maturity. Diets for broodstock shrimp typically include fresh or frozen supplements to the formulated diets. The bulk of feed used in the shrimp industry is the formulated feed used in the growout of juveniles to market size. These feeds for growout of shrimp typically contain high levels of protein. Use of sources such as high quality fish,

shrimp and squid meal, protein levels in the feed range from 30% to 50%, depending on the shrimp species and culture strategy (Table 1). Lower levels of protein are used when shrimp are reared under extensive conditions.

Table 1. Protein level in practical shrimp feed

Culture system	Crude protein (%)
Extensive	23 25
Semi-intensive	30 35 40
Intensive	40 45

The factors which determine the quality of a feed are its nutrient profile, anti-nutrient status, particle size, texture, stability of nutrients, attractability, digestibility, anabolic efficiency and shelf-life.

Nutrients essential to fish are the same as those required by most other animals. These include water, proteins (aminoacids), lipids (fats, oils, fatty acids), carbohydrates (sugars, starch), vitamins and minerals.

Proteins and Amino Acids. Fish meal, soybean meal, grain by-products, skim milk powder, legumes, and wheat gluten are excellent sources of protein. Additionally, the building blocks of proteins (free amino acids) such as lysine and methionine are commercially available to supplement the diet. One of the most important issue in shrimp feed production is alternatives of animal protein sources. Several factors have stimulated efforts to find alternatives for marine protein sources in manufactured shrimp feeds. Certainly, price is the key reason to look for replacement. The supply and price of high quality fish meal, as well as shrimp and squid meals, fluctuate dramatically from year to year. There is also a general concern of the potential negative impact that fish meal production might have on natural fisheries (Naylor et al., 2000). Because of its attractive amino acid content, availability and relatively affordable price, soybean meal and soy concentrates have received increasing attention as substitutes for marine animal meals.

Lipids. Oils from marine fish, such as menhaden, and vegetable oils from canola, sunflower, and linseed, are common sources of lipids in shrimp feeds. Important topic is ensuring necessary omega-3:omega-6 relation.

Carbohydrates. Cooked carbohydrates, from flours of corn, wheat and other cereals, are relatively inexpensive sources of energy that may spare protein (which is more expensive) from being used as an energy source

Vitamins and Minerals. The variety and amount of vitamins and minerals are so complex that they are usually prepared synthetically and are available commercially as a balanced and pre-measured mixture known as a vitamin or mineral premix. This premix is added to the diet in amounts to ensure that adequate levels of vitamins and minerals are supplied to meet dietary requirements.

Binding Agents. Another important ingredient in shrimp diets is a binding agent to provide stability to the pellet and reduce leaching of nutrients into the water. Carbohydrates (starch, cellulose, pectin) and various other polysaccharides, such as extracts or derivatives from animals (gelatin), plants (locust bean), and seaweeds (agar and other alginates) are also popular binding agents.

Preservatives. Preservatives, such as antimicrobials and antioxidants, are often added to extend the shelf-life of shrimp diets and reduce the rancidity of the fats. Vitamin E is an effective, but expensive, antioxidant that can be used in laboratory prepared formulations. Commonly available commercial antioxidants are butylated hydroxyanisole (BHA), or butylated hydroxytoluene (BHT), and ethoxyquin. BHA and BHT are added at 0.005% of dry weight of the diet or no more than 0.02% of the fat content in the diet, while ethoxyquin is added at 150 mg/kg of the diet. Sodium and potassium salts of propionic, benzoic or sorbic acids, are commonly available antimicrobials added at less than 0.1% in the manufacture of shrimp feeds

Minerals are inorganic components of the feed, which are components of hard and soft tissues, cofactors and/or activators of enzymes, also they have function in acid – base balance in production of membrane potentials and osmoregulation (O'Keefe, 2011). Recommended mineral levels in commercial shrimp feeds are shown in the table 2.

Table 2. Recommended mineral levels in commercial shrimp feed

Mineral	Quantity per kg of feed
Calcium, maximum	2,3 %
Phosphorus, available	0,8 %
Magnesium	0,2 %
Potassium	0,9 %
Iron maximum	200 mg
Copper	35 mg
Zinc	150 mg
Manganese	20 mg
Selenium	1 mg
Cobalt	0,05 mg

Physical properties of shrimp feed depend on shrimp feeding habits. For slow-feeding species such as shrimp good pellet stability is required. Also shrimp prefer sinking pellets (density greater than that of water, 1 g/cm^3).

The feed production involves grinding of raw materials (by hammer mill and micropulverizer, particle size up to 300 micron), mixing, steam condition, pelleting (extrusion), drying (to moisture below 10%) for good shelf-life of feed).

Pelleting and extrusion are two most popular processes which are used for shrimp feed production. Both of them have pros and cons (Kearns, 2010, Riaz, 2007). The most important advantages of extrusion cooking of shrimp feed are: reduced feed ingredient costs, improved feed water stability, reduced nutrient leaching, improved nutrient digestibility, increased oil and energy addition, higher starch gelatinization, increased feed efficiency, increased potential shrimp growth and profit per unit of feed intake. Also extrusion causes potential savings in recipe costs (extruded recipes reported to have $20-$100/ton potential savings over pelleted recipes, extrusion process allows reduction or elimination of special binders and extrusion process can use less expensive starch sources. However, extrusion has higher operating costs (operating costs for extrusion typically reported to be $20-25/ton higher than for pelleting).

The most current challenges of shrimp farming are (Tacon, A.G.J., 2002):

Production eco-friendly shrimp feed (minimum faecal and metabolic wastes).

1. The dietary nutrient requirements of shrimp under practical farming conditions, particularly in outdoor ponds, are not well understood. Aquafeeds and feeding strategies suited to the farming system need to be developed in order to reduce feed costs and avoid unnecessary nutrient input, feed wastage, and environmental pollution.

2. The potential value of feed additives such as free amino acids, feed enzymes, chemo-attractants and feeding stimulants, probiotics, and immunostimulants for farmed shrimp needs to be recognized, and practical application technologies for their successful incorporation in manufactured aquafeeds need to be developed.
3. Shrimp farmers may deficiency of understanding of the major nutritional role played by natural food organisms (including microorganisms) in the overall diet of shrimp raised under practical farming conditions.
4. There is an urgent need to maximize dietary nutrient utilization efficiency and minimize nutrient loss and feed wastage resulting from pellet disintegration, nutrient leaching, and/or overformulation.
5. The industry needs to recognize the increased dietary nutrient requirements of shrimp for the maintenance of optimum health and disease resistance under practical farming conditions.
6. The farmed shrimp industry needs to reduce its dependence on wild-caught seed and broodstock by developing improved processing and manufacturing techniques for the production of larval, nursery, and broodstock feeds.
7. Shrimp farmers need to maximize feed conversion efficiency and minimize feed losses and related deleterious environmental impacts by developing improved on-farm feed handling and management methods.
8. Aquaculture feed manufacturers and shrimp farmers must develop regional, national, or international guidelines and codes of practices for both feed manufacturing practices and feed management practices.

CONCLUSIONS

Even through there are many challenges, shrimp feed production has great potential as important source of animal protein. The article shows farming system and feeding strategies of shrimp production. Feeds are major part of shrimp production cost. Ingredients which can be used for feed preparation were shown. Features of feed processes were discusses.

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