Aquaculture is food sector, which is growing rapidly in the last 25 years with annual growth rate 8.2 %. One of the most perspective branches of aquaculture is shrimp farming. The cost of feeds is up to 80% of the cost of shrimp breeding, so providing the industry with high-quality feeds is the important goal of the feed industry in all over the world. The theoretical research was devoted to the task of compound shrimp feed production. In order to satisfy shrimp requirements, shrimp feeding systems were shown. Existing shrimp breeding systems are shown as different from the type of reservoirs (static / running water, indoor or outdoor), feeding systems, and the species of grown shrimp. Features of the nutritional standards for freshwater and saltwater shrimps were analyzed. Nutrient requirements of shrimp have been changed through shrimp life-cycle. The shrimp life-cycle was shown.

World producers of compound mixed feeds for shrimps were shown. The analysis of pellet size and nutritional value of compound mixed feeds of crude protein content in prestart, starter, grower and finish periods of cultivation and in accordance with the system of cultivation and feeding shrimp (intensive, extensive, semi-intensive) is carried out. The requirements for the content of main minerals, vitamins and restrictions to the content of crude fiber are given. Traditional ingredients are described. Binders and preservatives, which are used for shrimp feeds, are shown and subscribed. In raw material the main problem is the need to ensure high protein content in the shrimp feed recipes. Because of many factors, fish meal quantity should be reduced in recipes. 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.

The features of technological lines and processes of production of mixed feeds for shrimp are shown. The advantages and disadvantages of using the two most common processes of production of shrimp feeds (pelleting and extrusion), despite the relatively high cost extrusion, undoubtedly, is the main process of shrimp feed production.

At the same time, there are challenges, which need to be overcome by the industry for effective further development: to produce environmentally friendly feeds, to conduct further studies in order to clarify the required nutritional value of shrimp feed and add amino acids, feed enzymes, chemo-attractants, probiotics, and immunostimulants, to provide the necessary water stability of pellets, and to increase feed conversion rate, develop regional, national, or international guidelines and codes of practices for both feed manufacturing practices and feed management practices, reduce fish meal in shrimp feed recipes.

Despite the existence of problems, shrimp production is growing and the production of feed for their feeding has a great potential as an important source of animal protein in human nutrition.

**Key words:** compound feed for shrimp, feed manufacture technology for shrimp feed, requirements for shrimp feed.
P. aztecs, F. merguensis).

- intensive indoor farming system with fertilizer and / or complete / supplementary diet feeding (P. monodon, L. vannamei, 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 [2] with feed conversion 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) [3]. 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.

Figure 1. Relative importance of shrimp species to global aquaculture production. Source Rosenberry, 1999 [3].

Shrimp have a complicated life cycle (Figure 2, [4]). 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.

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. Using 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.

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 (amino acids), lipids (fats, oils, fatty acids), carbohydrates (sugars, starch), vitamins and minerals.

**Table 1** Protein level in practical shrimp feed

<table>
<thead>
<tr>
<th>Cultural system</th>
<th>Crude protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensive</td>
<td>23, 25</td>
</tr>
<tr>
<td>Semi-intensive</td>
<td>30, 35</td>
</tr>
<tr>
<td>Intensive</td>
<td>40, 45</td>
</tr>
</tbody>
</table>

**Lipids.** Oils from marine fish, such as menhaden, and vegetable oils from canola, sunflower, and lin-
seed, are common sources of lipids in shrimp feeds. Important topic is ensuring necessary w-3: w-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 antimicrobials 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 [6]. Recommended mineral levels in commercial shrimp feeds are shown in the table 2.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Quantity per kg of feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium, maximum</td>
<td>2.3 %</td>
</tr>
<tr>
<td>Phosphorus, available</td>
<td>0.8 %</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.9 %</td>
</tr>
<tr>
<td>Iron maximum</td>
<td>200 mg</td>
</tr>
<tr>
<td>Copper</td>
<td>35 mg</td>
</tr>
<tr>
<td>Zinc</td>
<td>150 mg</td>
</tr>
<tr>
<td>Manganese</td>
<td>20 mg</td>
</tr>
<tr>
<td>Selenium</td>
<td>1 mg</td>
</tr>
<tr>
<td>Cobalt</td>
<td>0.05 mg</td>
</tr>
</tbody>
</table>

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, 1g/cm³).

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 [7, 10]. 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 [8, 12]:

1. Production eco-friendly shrimp feed (minimum faecal and metabolic wastes).
2. 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.
3. 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.
4. 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.
5. 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.
6. 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.
7. 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.
8. Shrimp farmers need to maximize feed conversion efficiency and minimize feed losses and related
The biggest shrimp feed producers are: «Growel», Waterbase Ltd, Hoc Po Feeds Corporation, Hocpo, Rangen, «Anand», «Nutrimo», «Skretting», «BioMar Group» etc. Crude protein content of shrimp feed depends on feeding period and differs from 34% to 42% (table 3), crude fat is 2…3% and crude fiber content is not more than 3%. Also there are different sizes of feed pellets for shrimp. It is 0,1…0,3 mm for pre-start, 0,6…1,0 mm for start shrimp, 1,0…2,0 mm for grower, finisher feed – 2,3 mm and bigger.

**CONCLUSION**

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, as well as chemical composition of most popular shrimp feeds.

**REFERENCES**

появившись і порівняно доступною ціною, соєсійшуції та соєсійним концентратам приділяють все більшу увагу як замінникам морских тваринних продуктів.

Показано особливості ліній та технологічних процесів виробництва комбікормів для креветок. Наведено переваги і недоліки використання двох найпоширеніших процесів виробництва комбікормів для креветок - гранулювання та екструзія, екструзія незначною значною частинкою, так і екструзії, безусловно, саме екструзія є основним процесом виробництва комбікормів. Разом з тим відзначено високі, які потрібно подолати галузі для ефективного подальшого розвитку: використання екологічно чисті корми, зменшувати кількість рибної муки у рецептах, продовживати подальше дослідження з утворення необхідної кількості комбікормів для креветок та використання різних амінокислот, кормових ферментів, хемоатраактантів, пробіотиків та іншого.

Головні ключові слова: комбікорми для креветок, технологія виробництва комбікормів, відходи лущення-шліфування ячменю для креветок.

Результати лущення-шліфування ячменю в абразивно-дисковій машині А1-ЗШН-3

Анотація

На підставі роботи провідника кущі групи широко застосовуються лущильно-шліфувальні машини типу А1-ЗШН-3 та їх аналіз, що відображається розрізнення робочої зони та відповідність продуктивності. Основними недоліками цих машин є низька ефективність лущення-шліфування та високі питомі енерговитрати. Забезпечення якості обробки поверхні крупів досягається багатократними послідовними пропусками крізь однотипні машини. Підвищення ефективності використання машин можливо на основі закономірностей, отриманих під час випробувань на виробництві.

В статті наведені результати виробництва виробів на лущильно-шліфувальні машини типу А1-ЗШН-3 при попередній якість різної ковоші. В першій серії дослідів використовували ячмінь золотистого гострого W=13,8%, в другій W=10,1%, в третьій W=12,6%. Під час досліджень визначали наступні показники: продуктивність машини Q, кг/год, потужність, що витрачається електродвигуном N, кВт, кількість відходів лущення-шліфування у вигляді лузги та мучи Q/1000, % (визначали як різницю між масами ячмінь до обробки і після, поділену на масу до обробки), коефіцієнт відвідування лузги і мучи в машині К, % (відношення відходів лущення-шліфування вибіркових системою аспірації в машині до повної кількості витроених відходів лущення-шліфування). Контролювали кількість дробки Dr., %, що утворюється у машині. Розраховували питому енергоспоживання виробництва відходів лущення-шліфування як відношення потужності, що витрачається електродвигуном N,