Alternative sources of aquaculture feed in the context of organic production priorities

R R Isyakaeva\textsuperscript{1}, L Yu Lagutkina\textsuperscript{2}, A B Akhmedzhanova\textsuperscript{2}, E V Golubkina\textsuperscript{1}, M T Kaplanov\textsuperscript{1} and N A Khazova\textsuperscript{3}

\textsuperscript{1}Astrakhan State Medical University, 121, Bakinskaya ave., Astrakhan, 414000, Russia
\textsuperscript{2}Astrakhan State Technical University, 16, Tatishehev ave., Astrakhan, 414056, Russia
\textsuperscript{3}LLC "NUTRISHN", 73/3, Kulikova ave., Astrakhan, 414041, Russia

E-mail: Lagutkina_lina@mail.ru

Abstract. The article presents data on alternative feed sources composition for thermophilic freshwater crustaceans and cyprinids. We found that the implementation of an agriculture component in the feed is quite capable of replacing the regular parts. Studies have shown that the addition of new elements allows modifying the previously used feed with a positive effect on the potential growth rate of cultivated thermophilic objects. The presented food additives from local, raw materials not only correspond to the food preferences of the cultivated objects but also reduce the cost of feed, thereby increasing its competitiveness in the aquaculture feed market. Based on the detailed study of nutritional characteristics of alternative sources of feed raw materials, effective doses of the compounds have been developed. A partial replacement of scarce fish meal was made with the useful addition of local raw materials- an alternative component of the source of protein from pond ecosystems - 50%, which provides a high growth rate of cultivated objects. A consistent rejection of antibiotics dictated the conditions for the study of the addition of the probiotics into feed (0.3%-0.5%) that increase the body's resistance under farm conditions and 100% survival during cultivation. The proposed alternative is the taste addition of a local halophyte plant - 0.1% increase feeding attractiveness, active and united response to the recommended feed, which reduce its conversion. Replacement with alternative sources of feed was made under the basic requirements of organic production of aquaculture products.

1. Introduction

The implementation of standards and technologies of organic agriculture in aquaculture production forms a new direction in output – organic aquaculture, which is a promising direction of the industry development [1, 2, 3]. We are confident that it is organic aquaculture can be a big part of sustainable agri-food industry production [4].

Organic aquaculture aims at meeting the demands of people for safe, environmentally friendly food in a time of stagnation in world fisheries [5, 6, 7, 8].

For the first time, certification of aquaculture products (carp) was implemented in 1995 in Germany (Naturland certifier, according to the German national standard). And only a decade later – in 2005 – IFOAM approved the final version of the international standard for organic aquaculture.

Today, the total volume of aquaculture products certified by organic standards is about 400 thousand tons per year (although it is probably higher because some countries with well-developed aquacultures,
such as Brazil, Indonesia, Thailand, do not publish statistics) [9]. It’s known that 77% of organic aquaculture products are produced in Asia (mainly in China ≈ 300 thousand tons) [10], 22% - in Europe. European countries with the most massive production volumes are Ireland (41 thousand tons, mainly mussels, oysters, salmon), Norway (17.2 thousand tons, salmon), Romania (10.8 thousand tons).

Implementation of the principles of organic production in aquaculture involves combining the cultivation of aquaculture objects (fish, crustaceans, shellfish, algae) and output within a uniform agricultural complex on the principle of a cyclic ecosystem.

Such production, when properly organized, seems to be the most environmentally friendly since it can save the natural conservation and increase of fertility of the restored land involved in an economic turnover.

Certification of such productions according to organic standards means that the manufactured products meet the highest requirements of quality and safety. Since the accredited certification body carefully and continuously checks the product itself at every stage of aquaculture farming (receiving juveniles, used feed, the technique used) before processing the final product and delivery to the consumer.

The organic direction of aquaculture in Russia is associated with the certification of producers according to the organic standard, various types of certification (international or national Russian) and the certification system (GOST, ECO-PRODUCT and another). Russian national certification of organic production is regulated by the relevant law and regulatory documents, including GOST R 57022-2016 [11]. The production of organic products has been regulated since January 1, 2020, by the Federal Law "Organic Products and on Amending Certain Legislative Acts of the Russian Federation" dated 08.08.2018 N 280-FL.

The development of organic aquaculture is the basis for increasing the competitiveness of fisheries, creating safe and quality food products in the Astrakhan region and the Russian Federation.

The main requirements for organic aquaculture production include the rejection of the use of pesticides, fertilizers and GMOs, the consistent rejection of the use of fish meal, the strictly limited use of antibiotics and hormones in the production of fish feed [12, 13, 14, 15, 16].

In connection with the exclusion of the above components, the main task is to find alternative sources in the composition of feed for aquaculture facilities.

2. Materials and methods
The objects of study were crustaceans (*Cheraxquadricarinatus*, *Macrobrachiumrosenbergii*) and cyprinids, tench and Romanian carp (*Tincatinca*, *Cyprinuscarpio*). Following the goals and objectives of this work, research is based on a program-targeted approach.

The objects were grown in the “Bio-Aquapark – Scientific and Technical Center for Aquaculture” of Department of Aquaculture and Aquatic Bioresources of the Astrakhan State Technical University. Feed was developed strictly under the food preferences of the grown organisms. The prepared feed mixture from homogenized components was and moistened with 20% mineral water. Dried feed was turned into granules with the necessary length to diameter ratio. The daily feeding rate corresponded to the bodyweight of the aquaculture and the temperature of the water. Efficiency determined by the main indicator – the average daily growth rate. A set of methods used in fisheries research – variation statistics, fish-biological, morphological, hydrobiological, physiological and biochemical tests was used. The physiological and biochemical status of the grown objects was determined according to the guidelines for haematological examination; hemolymph was taken from the caudal vein of the crayfish with a disposable syringe; fish blood was taken in vivo.

3. Discussion of the results
Focusing on previously experimental compounds feed formulations, new alternative feeding components (AFC) of plant and animal origin were developed, which were used for achieving efficient cultivation at 100% survival and maximize the use of the growth potential of aquaculture in Table 1.
Table 1. The range of proposed components for compounding feed

| Amino acid name                        | Mass fraction in dry matter, % | Mass fraction in dry matter, % | Growth rate, % |
|----------------------------------------|--------------------------------|--------------------------------|----------------|
| **ASP+ASN**                            | 3.71                           | 3.71                           | AFC 0.19       |
| **Cheraxquadricarinatus**              |                                |                                | Control 0.1    |
| salt, mineral complex                  |                                |                                |                |
| **Macrobrachiumrosenbergii**           |                                |                                |                |
| salt, mineral complex                  |                                |                                |                |
| **Cheraxquadricarinatus**              |                                |                                |                |
| Fish flour                             | 50% replaced by zooplankton    |                                |                |
|                                        | of pond ecosystems             |                                |                |
| **Macrobrachiumrosenbergii**           |                                |                                |                |
| Fish flour                             | 50% replaced by zooplankton    |                                |                |
|                                        | of pond ecosystems             |                                |                |
| **Tincatinca**                         |                                |                                |                |
| Fish flour                             | 50% replaced by zooplankton    |                                |                |
|                                        | of pond ecosystems             |                                |                |
| **Cyprinuscarpio (fresinet)**         | subtilis                       |                                |                |
|                                        | 0.5% *Bacillus subtilis*       |                                |                |
|                                        | (VKPM 10172), *Bacillus*       |                                |                |
|                                        | *licheniformis* (VKPM 10135)  |                                |                |
| **Cyprinuscarpio (fresinet)**         | subtilis                       |                                |                |
|                                        | 0.3% *Bacillusamyloliquefaciens* |                                |                |

When feeding tropical freshwater crayfish and shrimp, experimental formulations were used with the addition of a plant-based food supplement, saltwort (Salicorniaperennans Willd), which causes a salty taste of the feed. The growth rate compared to the control feed without additives was doubled. The quantitative content of sodium, potassium, magnesium and calcium ions in the aqueous extract of the herb *Salicorniaperennans* Willd was carried out by capillary electrophoresis on a Capel 104 T device (Lumex, Russia), the quantitative content of zinc was determined by the atomic absorption method (atomic absorption spectrometer, cont AA 300, Analytik Jena AG, Germany). The results of the content of the primary ions of the feed additive are presented in Table 2.

As can be seen from the table 2 herb *Salicorniaperennans* Willd is a good nutritional component for crustaceans and cyprinids, and can be used as an additional component to the compounding of the feed, as an additive for the content of the main mineral components. The harvesting time affects the content of ions in the grass; the difference between the harvesting was 8.9 in percentage.

Presented test feed sources of nutrients expand the range of feed components, improve the quality of feed for cultivated objects, and local raw materials reduce its cost [17,18, 19, 20, 21].
Table 2. The ionic composition of SalicorniaperennansWilld, dry matter (%)

| Chemical composition | Harvesting time |
|----------------------|-----------------|
|                      | August 2017     | September 2018 |
| Concentration of Na⁺ in the extract, mg / dm³ | 3813.8          | 4188.0          |
| The content of Na⁺ in the grass, %                | 10.0            | 11.1            |
| K⁺ concentration in extract, mg / dm³              | 245.0           | 462.4           |
| The content of K⁺ in the grass, %                  | 0.6             | 1.2             |
| Concentration of Mg²⁺ in the extract, mg / dm³    | 1977.9          | 2098.3          |
| The content of Mg²⁺ in the grass, %                | 5.2             | 5.6             |
| Concentration Ca²⁺ in the extract, mg / dm³       | 609.1           | 613.1           |
| The content of Ca²⁺ in the grass, %                | 1.6             | 1.6             |
| Concentration Cl⁻ in the extract, mg / dm³        | 10900           | 6690            |
| The content of Cl⁻ in the grass, %                 | 28.5            | 17.5            |
| Concentration Zn²⁺ in the extract, mg / dm³       | 0.25            | 0.47            |
| The content of Zn²⁺ in the grass, %                | 0.0006          | 0.0012          |

4. Conclusion

According to the basic principles of organic farming, the proportion of fishmeal in feed should be steadily reduced, up to a complete rejection of its use by replacing with alternative sources of raw minerals. A feed additive of natural origin based on biomass of plant and zooplankton of pond ecosystems, provided 50% replacement of minerals and organic substances, contains: up to 60% protein, 4.4% fat, 11.9% minerals, 19.6% essential fatty acid-sesonolic acids in total lipids, up to 35% phospholipids, a high level of essential amino acids - lysine (9.0%), arginine (5.2%), tryptophan (0.9%) and methionine (2.0%), high amounts of vitamin E. Moreover, for 1 year, the feed retains its productive properties without the manifestation of toxic effect.

The probiotic additive caused a positive effect on the grow process. It is proposed to use the probiotic Olin, which includes Bacillus subtilis (VKPM 10172) and Bacillus licheniformis (VKPM 10135), for inclusion in the analytical work and recommendations as a component that increases the immunity of objects, providing a growth rate of 3 times more than the control group.

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