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Organic Aquaculture and Organic Feeds

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ABSTRACT

Environmental awareness is increasing around the world, however, the production of eco-friendly food products has started to gain importance in order to protect nature and reduce dependence on it. In addition, due to the awareness of people, it increases the demand for healthy foods. As a result, organic farming is developing and the number of organic product farms is increasing. Organic aquaculture products have also started to take their place in this big market. Although many of the rules and standards applied in organic agriculture are similar, the rules of organic aquaculture products contain differences on the basis of species. Significant progress has been made with the organic aquaculture production standards determined by international organizations and each country. Organic aquaculture defines organic aquatic organisms that are fed with organic feeds approved by authorized organizations and grown in accordance with all organic farming standards. The main principles of organic culture; health, ecology, fairness and care. Therefore, these basic principles are adhered to when determining organic aquaculture standards. In this review, general and current information were given about the organic aquaculture and organic feeds.

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Introduction

The aquaculture industry is one of the fastest growing industries in the world, especially the most important in the food sector (Yılmaz et al., 2022). The amount of aquaculture production has developed rapidly in recent years with the increasing demand for quality food products. While the aquaculture production was 21.8 million tons in the 1990s, it reached 87.5 million tons according to the data of 2020, and this has increased by 4 times over the past 30 years (FAO, 2022).

In recent years, it is known that the sources of feed raw materials are decisive in sustainable aquaculture. Aquaculture needs new raw material needs due to decreasing natural fisheries resources (Demirak et al., 2006; Nizza, 2012). While the amount of aquaculture is increasing rapidly day by day, its effects on the environment are inevitable and poses risks to food security (Holmer et al., 2008; Tacon and Metian, 2008). For this reason, it has become important how compatible the feeds used are with the aquaculture environment and healthy food for the human consumption.

The International Federation of Organic Agriculture Movements (IFOAM) stated that the four main principles of organic agriculture are health, ecology, fairness and care (IFOAM, 2014; Lembo et al., 2018; Gould et al., 2019).

Considering the principles of organic farming; animal welfare, adding value to products, traceability, environmentally friendly practices (especially feeds), eco-labeling and consumer acceptance have come to the fore, which has led to the emergence of organic aquaculture (Aarset et al. 2004; Cottee and Petersan 2009; Perdikaris and Paschos, 2010; Censkowsky and Altena 2013; Xie et al. 2013; Lembo and Mente, 2019; Mente et al., 2019; Ahmed et al., 2020). Researchers have stated that especially consumer demands play an important role in making organic aquaculture production mainstream (Bulis, 2004; Boehmer, et al., 2005; Datta, 2012; Lembo and Mente, 2019; Mente et al., 2019; Ahmed et al., 2020).

Organic aquaculture provides socially, ecologically and economically sustainable production methods. Therefore, organic aquaculture considers the health and well-being of cultured organisms and includes various elements that ensure that farming activities are in harmony with nature (Anonymous, 2011). Due to the difficulties in the supply of organic feed and feedstuffs, differences in consumer preferences and market uncertainty, organic fish production has shown a slow development compared to organic agriculture (Prein et al., 2012), but it has gained a significant momentum by eliminating the above-mentioned negativities.

Organic feed and feed raw materials play a key role in the development of organic aquaculture. Today, the diversity of organic feed sources is increasing and its supply is getting easier. In this review, detailed information were given about the feeds used in organic aquaculture.

Organic Aquaculture and the Standards

Historically, the basis of organic aquaculture comes from the organic farming movement and this continues to shape organic aquaculture in many ways (IFOAM EU Group, 2010; Ahmed et al., 2020).

Organic aquaculture is an integrated approach to production management systems that support and improve ecosystem health. Organic production in general; It is based on specific and precise production standards aimed at realizing production systems that are socially, ecologically and economically sustainable. Therefore, organic products differ from commercially produced products (INFOFISH, 2011). Organic farm management relies on natural or traditional production methods. Organic aquaculture is based on ecology, human and animal health, just like in organic agriculture systems (Gould et al., 2019; Ahmed et al., 2020). Therefore, organic aquaculture can be defined as an eco-friendly sustainable aquaculture model that does not use synthetic raw materials. (Datta, 2012; IFOAM, 2014; Naturland, 2020; Ahmed et al., 2020).

The first known standard for organic aquaculture was established in Austria for carp (*Cyprinus carpio*) in the beginning of 1990's and then continued in Ireland with the organic salmon project. The first national general standards organic fishery products were established in 2000 by France and the United Kingdom. In addition, the first global organic aquaculture criteria were established in 2000 by the International Federation of Organic Agriculture Movement (IFOAM) (Prein et al., 2012; Lembo et al., 2018).

Organic aquaculture was included in the European Council Regulation for the first time in 2007 with the regulation EC No 884/2007, which provides the general principles guiding the sustainable development of organic production (EC, 2007). Regulation (EC) No 834/2007 determines aims and principles for organic production, labelling, controls and international trade of organic products. The Regulation is composed of 40 recitals, 7 titles with 42 articles and 1 annex (Busacca and Lembo, 2019). As a following regulation, a Commission Regulation addressing the rules for implementing organic farming (Commission Regulation EC No 889/2008) (EC, 2008) was adopted, but without the section on aquaculture. Finally, to streamline a number of different organic standards and national certification schemes in Europe, Reg. EC No 889/2008 was amended by the Reg. EC No 710/2009, detailed rules have been introduced for organic aquaculture animal and seaweed production (EC, 2009). After 2009, Also Reg. EC No 889/2008 was amended and integrated by the other Commission regulations which were especially on aquaculture; Reg. (EU) No 505/2012; Reg. (EU) No 1030/2013; Reg. (EU) No 1364/2013; Reg. (EU) No 1358/2014; Reg. (EU) 2016/673; Reg. (EU) No 2017/838 and Reg. (EU) 2018/1584 (Busacca and Lembo, 2019).

Organic Aquaculture Production Amount

The amount of organic aquaculture production and the diversity of species are increasing day by day. Organic aquaculture, which started with carp production in the early 1990s, continues with many different fish species and other aquatic species.

According to the latest data, the distribution of the world's total organic aquaculture production by continents and the top 10 countries with the highest production are given below (Figure 1). (FiBL and IFOAM, 2022).

The distribution of the world's total organic aquaculture production by species and key species are given below (Figure 2). (FiBL and IFOAM, 2022).

Total organic aquaculture volume was more than 306000 metric tons by 2020. While 51% of the total production was concentrated in the Asian continent, the European continent followed with 31%. The country with the highest production was China with 169,400 metric tons, followed by Ecuador (almost 43000 metric tons) and Ireland (more than 30000 metric tons). The most produced species were salmon (over 25500 metric tons), followed by mussels (25400 metric tons) and sturgeon (over 2500 metric tons) (FAO, 2022) (Table 1.)

According to the latest data, the main EU organic fisheries producers are; Ireland (salmon and mussels), Italy (mussels and finfish), France (oysters, mussels and trout), the Netherlands (mussels), Spain (mussels and sturgeon), Germany, Denmark and Bulgaria (mussel) (EUMOFA, 2022).

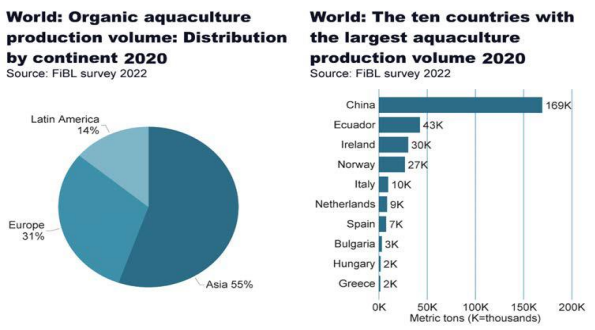

Figure 1. World organic aquaculture production volume: Distribution by continent and top 10 countries 2020
(FiBL and IFOAM, 2022)

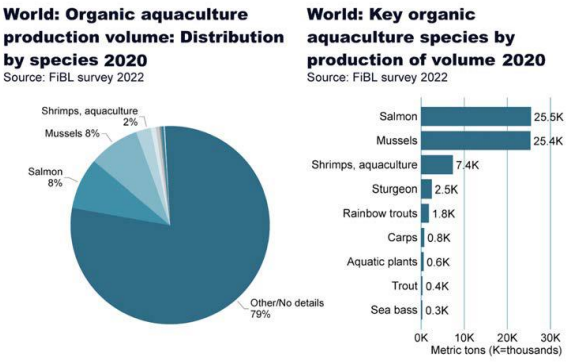

Figure 2. World organic aquaculture production volume: Distribution by species and key species 2020
(FiBL and IFOAM, 2022).

Table 1. Organic aquaculture: Production volume by species 2020 (FAO, 2022).

Species	Production (Metric Tons)
Other/no detais	241112
Salmon	25546
Mussels	25419
Shrimps	7382
Sturgeon	2520
Rainbow trout	1821
Carps	761
Trout	643
Aquatic plants	611
Sea bass	310
Sea bream	269
Bream	54
Bass	44
Oysters	37
Total	306.528

General Principles of Organic Aquaculture and Organic Feeds

Although the basic principles for organic aquaculture and organic agriculture are similar, there are some differences in organic aquaculture according to aquatic species.

In order to be carried out of organic aquaculture the most important condition is to have an organic farming certificate and to make all conditions suitable according to the standards.

Basic principles in organic aquaculture; applied aquaculture systems and their environments (land, closed system, water and etc.), species, breeding, animal health and welfare, feeds. However, none of these general principles are separate from each other, they follow an integrated path.

Aquaculture systems and their environment

Organic aquaculture methods depend on the species being cultured, its age, biology, etc. differ according to the features. Therefore, systems such as ponds, tanks, raceway systems, net cages and recirculating aquaculture systems (RAS) can be used (Gould et al., 2019; Ahmed et al., 2020).

Within the framework of this principle, no matter which system is applied, its compatibility with the environment or the minimum impact it has on the environment is important. The system should operate in a way that respects ecological health in accordance with the word "organic".

The main production rules of aquaculture animals are set in Article 15 of the Reg. EC no 834/2007 (EC, 2007). According to this, the stock densities of fish in aquaculture conditions vary according to the species, but are between 10-25 kg/m^3. Only in sturgeon this rate is applied as 30 kg/m^3. The main purpose here is to ensure the health and welfare conditions of the fish.

At the same time, all water quality parameters should be monitored in aquaculture systems. Lighting should never exceed 16 hours a day, except during production period conditions. The use of oxygen is permitted under conditions such as the health of the fish, the breeding season and transport. To ensure fish welfare, the handling of aquaculture animals should be minimized and all operations should be carried out with the minimum requirement. If production is to be carried out at sea, the places where the water flow, depth and exchange of water body are most suitable should be selected (EC, 2007; Busacca and Lembo, 2019).

RAS facilities are prohibited in organic aquaculture with the exception in hatcheries, nurseries and production of some organic feed organisms (Busacca and Lembo, 2019).

One of the most controversial issues in organic aquaculture has been related to the use of RAS. When it comes to the Ecology Principle of organic farming, RAS has both advantages and disadvantages.

The limited use of water is one of the most important issues today. Therefore, RAS systems are successfully used in aquaculture. In fact, these systems have ecological advantages. A lower amount of water is used and the water is easier to clean and disinfect (Gould et al., 2019). In this case, RAS systems can be seen as environmentally friendly.

On the other hand, the biggest disadvantage of RAS is the high energy consumption. In particular, obtaining this energy from non-renewable or greenhouse gas-emitting sources is seen as one of the negative effects for the environment. (Busacca and Lembo, 2019; Gould et al., 2019; Ahmed et al., 2020). From this perspective, RAS cannot be seen as environmentally friendly.

RAS has a great impact on proper stocking density, animal health and welfare (Meisch and Stark 2019). However, RAS, which is completely disconnected from natural conditions, does not comply with the Fairness principle of organic farming (Kerr and Potthast 2018). For this reason, there has been an intense opinion about the rejection of RAS.

At its 2017 General Assembly, IFOAM International has reached the following decision regarding system boundaries for organic aquaculture systems:

"Organic aquaculture can include an environmentally integrated recirculation system only if it is based primarily on a natural environment and is located in a natural environment. It routinely does not rely on external inputs such as oxygen, allows cultivated species to spend most of their lives in outdoor facilities, and preferably uses renewable energy" (IFOAM, 2017; Gould et al., 2019).

Animal Origin and Breeding

The species of animal is important for the breeding model. Because semi-intensive, intensive, extensive or polyculture organic farming models can be applied.

Another issue is reproduction. In this regard, the use of hormones and hormone derivatives is prohibited.

Local species should be preferred. Organic stock should be used for breeding. The origin of the animals must be from individuals who are healthy and benefit from good feed resources. The entire life stage of the harvested product must pass in organic conditions.

Artificial hybridization, non-manual means of creating monosex populations and polyploidy is prohibited.

There is also restriction of manuplation or ablation of eyestalks in crustaceans (Prein et al., 2012; Busacca and Lembo, 2019).

Health

Fish health and diseases are the most important issues to be considered. The treatment methods to be applied should be done within the framework of organic aquaculture rules.

According to regulation EC No 710/2009, with regard to animal health, disease prevention should be a priority (EC, 2009).

The measures provided for in this Regulation should be without prejudice to Council Directive 2006/88/EC of 24 October 2006 (EC, 2006) on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals in case of veterinary treatment.

Certain substances for cleaning, antifouling treatment and disinfection of production equipment and facilities should be allowed under defined conditions.

In the presence of live animals the use of disinfection substances requires particular care and measures to ensure that the application is not harmful. Such substances should be authorised according to Article 16(1) of Regulation (EC) No 834/2007 (EC, 2007).

Also, ozone and ultraviolet lights can only be used in hatcheries and nurseries.

Organic Feeds

Feeds have always been an issue that should be emphasized in aquaculture. Because one of the biggest expense items of a fish farm is the cost of feed. In addition to the importance of the subject, the biggest problem in organic aquaculture is the supply of certified organic feed and feed raw materials.

According to Regulation EU 2018/848 (EU, 2018) of the European Parliament and of the Council of May 2018, on organic production and labelling of organic products and repealing Council Regulation EC No 834/2007 (EC, 2007), in Chapter 2 (Objectives and Principles of Organic Production) and in Article 8 (Specific Principles Applicable to the Processing of Organic Feed);

The production of processed organic feed shall be based, in particular, on the following specific principles:

- the production of organic feed from organic feed materials;
- the restriction of the use of feed additives and processing aids, so that they are used to a minimum extent and only in cases of essential technological or zootechnical needs or for particular nutritional purposes;
- the exclusion of substances and processing methods that might be misleading as regards the true nature of the product;
- the processing of organic feed with care, preferably through the use of biological, mechanical and physical methods.

On the other hand, organic standards in the feed of carnivorous species should be as follows (EU Reg. 710/2009 art. 25k, as amended by EU Reg. 1358/2014) (EU, 2014):

- the source of organic feed products must be of aquaculture origin,
- fish meal and fish oil from organic aquaculture trimmings
- fishmeal and fish oil and ingredients of fish origin derived from trimmings of fish already caught for human consumption in sustainable fisheries;
- organic feed materials of plant origin and of animal origin;
- Feed products obtained from all fish caught in fisheries certified to be sustainable under a program recognized by the competent authority in line with the principles set out in Regulation (EU) No 1380/2013 European Parliament and Council (EU 2013).

The feed ration may comprise a maximum of 60 % organic plant products.

Mainly astaxanthin from organic sources and histidine produced by fermentation can be used in feed ration for salmonid.

Conventional phytoplankton and zooplankton can be used as feed for larval rearing of organic fry (EU, 2014).

All synthetic ingredients such as color additives, growth promoters and stimulants, attractants, antioxidants, none-protein nitrogen, solvent extracted feedstuff, chemically extracted amino acid genetically modified organisms (GMOs) and derivatives are not permitted as feed additives for the organic aquaculture feeds (Xie et al., 2013).

Nutritional characteristics of fish cultured under organic aquaculture conditions may differ. The feed of fish with herbivorous, omnivorous or carnivorous feeding habits should also be formulated in a balanced and appropriate way according to the species' wishes. As mentioned above, the ratio of vegetable protein sources in the feed of carnivorous fish should not exceed 60%. In recent years, alternative vegetable sources have been used instead of fish meal and fish oil in order to reduce dependence on nature. Especially in organic aquaculture feeds, researches are carried out to select organic vegetable protein sources that meet the standards (Li et al., 2006; Lunger et al., 2006; Tusche et al., 2011).

In addition to plant organic protein sources, animal organisms (organic certified) can be used instead of fish meal. In recent years, insects and worms have been used extensively. In particular, companies that only organically produce these products have been established and started to contribute to the feed sector.

It has been stated in many studies that insect flours can be used as an alternative sustainable protein source to fishmeal in aquaculture due to their advantages such as balanced essential amino acid content, high feed conversion ratio, and fast and easy production. (Belforti et al., 2015 ; Halloran et al., 2016; Piccolo et al., 2017; Ido et al., 2019 ; Rema et al., 2019 , Stejskal et al., 2020).

There are many different species of Coleoptera and Diptera, including BSF (*H. illucens*) (Newton et al., 2005), houseflies (*Musca domestica*) (Awomyi, 2007), and insects (*Tenebrio molitor*) (Li et al., 2013). These produced species are transformed into high quality proteins and take their place in aquaculture feeds instead of fish meal. (Nairuti et al., 2022).

The natural productivity of water can be enhanced by external inputs, such as livestock manure, plant products, inorganic phosphate, nitrogen and potassium products (Mente et al., 2011).

Fertilizers, as external inputs, can be used only if they are sourced from certified organic farming operations, and are natural or naturally derived substances (EC, 2007).

Conclusion

As it is known, aquaculture industry has gained a significant momentum around the world in recent years. It is inevitable to increase aquaculture production in order to reduce our dependence on nature. In addition, aquaculture products, which are products with a quality and balanced nutritional content, are an indispensable food for human consumption. In parallel with this situation, with the increase in people's preferences for organic products, the amount of organic aquaculture production has started to increase day by day in the last 30 years. In the first years of organic aquaculture production, the difficulties and economic problems in the supply of feed and raw materials began to be overcome, and even great progress was made in organic feed. For this reason, despite all the difficulties experienced, it is thought that the acceleration of organic aquaculture and organic feed production will continue in the future without slowing down.

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