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ORGANIC AQUACULTURE AS PROMISING TREND OF THE FISH INDUSTRY DEVELOPMENT

(review)

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Abstract

The status of organic aquaculture which presents production (cultivation) aquatic species (fish, crustaceans, molluscs, sea plants etc.) and guarantees high quality and safety of the product in accordance with specific principles is evaluated on the base of a large amount of statistical data. The main limiting factor of the development of aquaculture, in particular organic aquaculture, in Russia and in the world is deficiency of feeds (L.Yu. Lagutkina, 2017). Feed production is constrained by the deficit, expensiveness, and low ecological safety of fish meal which is a traditional raw material. The incentives of the development of aquaculture are changes in the culture of food consumption especially among young people, and willingness of the consumers to pay for the ecological safety of the products. The new formats of production (P. Edwards, 2015) based on technologies of sustainable, effective, integrated and organic production will contribute to the development of an aquaculture. Organic projects of aquaculture (S. Begleiter et al., 2015) become more attractive for investors. One of the first specialized venture capital funds, Aqua-Spark (Netherlands), has invested $7 mln in organic projects in Mozambique, Iceland and Norway since 2014. Global organic aquaculture production in 2015 is evaluated as 400 thousand tons that is about 0.54 % of the overall aquaculture production (without water plants) but twice as much as overall volume of Russian aquaculture production. Production of organic aquaculture is focused on rearing salmon (10 %), molluscs (5 %), carp (1 %), shrimp (1 %), trout (0.3 %), and sturgeons (0.3 %). Major part of organic products is produced in China (304 thousand tons, or 80 %) and in Europe (76 thousand tons, 19 %). Among manufacturers (about 1 thousand) those who are certified (200 in China, 465 in Europe) are of our particular interest. European manufacturers are certified according to the European (in fact, the international) standards, Chinese manufacturers are mainly certified according to national organic standard which is not identical to the international standards. Russian manufacturers will be certified with regard to the Russian and (or) international certification systems. Since 2011, the pilot introduction of organic aquaculture in Russia occurs in the Astrakhan region at a small innovative enterprise Modern Fishery Complex "Sharapovskii" where aquaculture is combined with crop rotation. "Vitality Leaf. Organic" of Saint-Petersburg Ecological Union (the Russian system for voluntarily ecological certification of international level) is acknowledged as congruent to European standards. To date, the development of organic aquaculture in Russia corresponds neither to natural potential of the country, nor to world average indicators of the industry. A way to solve the problem may lay in the development of feeds which will correspond to base requirements of organic standards.

Keywords: organic aquaculture, principles of organic production, organic standards, fish food products, consumer culture, certification, feeds

Global population growth necessitates rapid development of agriculture and growth of production output. This could be achieved by relying upon the intensive animal breeding, poultry breeding, and fishery forms. Aquaculture is going to play an enormous role in development of agriculture. By 2050, 9.8 billions of people shall be provided with food, i.e. growth of food production by 60 % as

compared to recent food production rates. Aquaculture, as a technological process, may warrant transparency and manageability of production that serves the basis for improvement of the safety and ecological compatibility. Contribution of the Russian aquaculture to the total volume of domestic fish products remains small – slightly over 4 % [1]. Conversely, it is aquaculture that produces more fish products than pisciculture in the global context starting from 2014 [2]. It is expected that by 2030 aquaculture would yield $^3/_4$ of fish products to be consumed by humans in the world [3]. Apparently, development of aquaculture in Russia is still not in line with natural potentials of the country and with mean global indicators of industrial development. Such low aquaculture production volumes could be, in particular, explained by the fact that until present time the national demand for fish protein was satisfied by sufficiently high pisciculture production volumes, which is in stagnation state in foreign countries.

In present paper we assess global development of organic aquaculture: production of fish, shell fish, mollusk, sea plants, and other consumable goods according to certain ("organic") principles based on statistical data provided in the available literature sources.

According to statistics, $^3/_4$ of the total aquaculture production volume is represented by hydrobionts, and $^1/_4$ — sea weed (*Algae*) [2]. In 2014, global aquaculture industry had produced 73.8 million of hydrobions (USD 160.2 billion in producer prices), of which 49.8 million tons of bony fishes (*Teleostei*) (USD 99.2 billion); 16.1 million tons of mollusks (USD 19 billion); 6.9 million tons of shell fishes *Crustacea* (USD 36.2 billion); 7.3 million tons of other sea animals, including semi-aquatic animals (*Amphibia*) (USD 3.7 billion). Volume of raised aquatic plants comprised 27.3 million tons (USD 5.6 billion) [2]. By dominant growth objects, modern global aquaculture may be defined as limnobiotic extensive, warm-water culture based on species of south-eastern faunal complex [4].

There are several stimuli for rapid development of aquaculture. First of all, it is growth of demand for aquaculture products [5] caused by growth in consumption rates of food products due to growth of the number of population and transformation of product consumption models. In 2009-2014, total consumption of fish products in humans had increased by 18 % (from 123.8 to 146.3 million tons), and consumption per capita — from 18 to 20 kg [2]. Practically all fish produced by aquaculture, as apart from fish produced by pesciculture, is used for such purpose. The second factor is inability to satisfy the growing global demand for fish products by traditional pesciculture without a threat to destruction of the natural ecosystems. Achievement of the fishing margin is indicated by the fact that during 2009-2014 global fishing volumes had increased by only 3 %, while aquaculture production volumes — by 32 % [2]. According to forecasts, by 2030 global consumption of fish caught by pesciculture would be reduced from 65 million tons (in 2006) to 58 million tons [6], and consumption volumes of fish produced by aquaculture would, conversely, grow from 47 to 94 million tons [7]. The third factor is lack of fish product safety warranties [8]. Fishing industry (first of all, pesciculture) does not always warrant ecologic compatibility of products served on the table, due to complexity of supply chains. Sometimes it is hard to validly establish the origin of fish, how it was caught and how it was shipped. Relevance of the issue of increasing the transparency and traceability of fish products had resulted in implementation of relevant international and national programs [9-12]. The fourth factor is increasing the effectiveness [13], as well as technological accessibility and feasibility of creation and development of aquaculture objects, first of all, for small and middle entrepreneurships. In 2000-2014, number of enterprises and farmers dealing with aquaculture had increased by 49 % — from 12.63 to 18.75 million [2].

Aquaculture development is also promoted by rapid spread of both new and known, and technologically realized production methods. These are technologies of stable [14, 15], resource effective [16], and integrated [17], as well as organic [18] agriculture, re-circulating aquaculture systems (RAS) [19], and aquaponics [20].

By 2050, 70 % of global population would live in the cities and, thus, in the next decade an explosive growth of demand for technologies of the urbanized agriculture allowing producing food ingredients and products in the closed controlled environment is expected [21]. These technologies allow improving the production safety by extending the access to food products by the citizens [22]. Reduction of the traditional logistics supply chain of products that recently increases the cost of food products by 40-100 % as compared to "farm gate" prices and in which 20-40 % of products are disposed to waste would become the basis for price affordability. One of such technologies is aquaponics [23-26] that is based on closed cycle aquaculture. It becomes popular around the world, especially in the cities, since people become more interested in fresh domestic food products. Aquaponics extending in closed urban premises [27] promotes rapid supply of fresh fish, vegetables, and plants to the consumers and more often requires less space and water for production purpose than pond aquaculture [28]. Aquaponics is effective even in countries with cold climate. Recently, there are 20 thousand farming units dealing with aquaponics in the world, and volume of aquaponics market comprises USD 409 million. By 2021 volume of the market would increase up to USD 907 million (http://industryarc.com).

Since 1999, area of agricultural lands certified by organic standards had increased from 11 to 51 million ha in the world; number of certified producers of organic products had increased from 200 thousand to 2.4 million; 87 countries enforced statutory regulation of the organic production and consumption [29]. Experts forecast rapid growth of global market of organic products from USD 81.6 billion in 2015 [29] to USD 238.4 billion in 2022 (http://www.marketresearchstore.com). In absolute figures (total sales of organic products), most developed markets are US (EUR 35.8 billion), Germany (EUR 8.6 billion), France (EUR 5.5 billion), China (EUR 4.7 billion), Canada (EUR 2.8 billion), and United Kingdom (EUR 2.6 billion) [29]. In relative figures, "organics" market (share of organic products in the total volume of sold products) in mostly developed in the following European countries: Denmark (8.4 %), Switzerland (7.7 %), Luxemburg (7.5 %), Sweden (7.3 %), and Austria (6.5 %). European producers of organics get significant state support [30].

Production of organics is not merely market niche or sustainable growth technology [31], but also a reaction of society, producers to the changing social and economic and social and cultural human behavior [32] as regards to consumption of food products. This trend is recently observed not only in developed, but also in developing countries [33]. People perceive "food", its quality, ecologic compatibility, and safety, and "health" as a whole concept.

Development of organics market is an innovative, but already sustainable global trend [34]. It is supported by growth of human awareness in influence of food on health, physical form, well-being; popularity of healthy life style, strive to diet individualization (functional and personalized diet) [21]; frequent incidents in many countries of the world associated with safety of food products; increase of the national wealth of developed countries and human readiness to pay for ecologic compatibility of the products. It is demands of the young generation that define the successful development of organics production industry. That is, in 2016 sales volumes in USA had exceeded USD 43.3 billion, and the most from 18 to 34 years. In average, 45 % Americans are attempting to actively

include organic products in their diet, regardless of the fact that their cost is by 20-100 % higher than the cost of regular food products.

In Russia, civil society is also concerned about safety and ecological compatibility of food products [35]. They are ready to pay more for ecologically compatible products and for increased costs, by purchasing fresh, not frozen, non-processed products free from genetically modified organisms (GMO). First certified (primarily by European systems) Russian producers of organic products face an unfair competition [36]. Over half of products marked by "eco", "bio", and "organic" are not related to organic production, thus, negatively affecting development of organic production in Russia. Fair market participants (not only producers, but also associations, certification operators) are forced to compete for positive image of organic products: mobile applications "Ecopolka" (http://ecopolka.ru) and "Navigator of Farm Products" (https://inter-start.ru/project85) are realized for information of consumers on verified organic products.

Importance of organics production in Russia and development of relevant technologies [37] was not left unnoticed by state bodies and development institutes. As it was noted in "Forecast of scientific and technological development of agro-industrial complex of the Russian Federation by 2030", this is one of the key factors securing access of the national producers to international markets [21]. Within the scope of the National Technological Initiative, organics production in Russia is considered as one of the key segments of perspective food product market (Road Map "Foonet", http://www.nti2035.ru). However the national regulatory framework for development of the organics market is not fully formed [38], first of all, due to absence of the federal law governing relations associated with production and turnover of organic products.

It terms of technology and its statutory regulation, the organics production shall comply with several principles which are recently articulated by the International Federation of Organic Agriculture Movements (IFOAM) [39]. These health principles (support and improvement of the health of ecosystems, soils, animals, humans, and planet); ecology (coexistence with essential ecologic systems and cycles; maintenance of the natural cycles and balances); fairness (protection of environment, humanity to humans and animals; assurance of conditions and opportunities for life which accord with physiology, essential behavior and health of live organism); care (preventative and responsible management of organic agriculture for protection of health of the existing and future generations and environment; use of new methods and technologies which may improve the production efficiency, and shall not jeopardize the health and well-being of humans).

Practically, it means meeting of the basic requirements of organic standards. For crop growing it is a conversion (transit) period; use of natural fertilizers; ban on use of chemical crop protection agents (except for the permitted list of agents), on treatment of seeds by chemical preparations and use of genetically modified seed material. For animal breeding it means natural feeds (the following content is permitted: 70 % organics, 30 % organics in conversion); ban on use of antibiotics, GMOs; animal packing density no more than permitted and their loose keeping. For processed products it means use of at least 95 % of organic raw materials and ban on use of artificial additives.

Different certification systems of organics production and products may impose adapted and additional requirements. Thus, Russian system for voluntarily ecological certification of international level "Vitality Leaf. Organic" (Ecologic Union of Saint Petersburg, member of IFOAM) imposes the following basic requirements for the crop raising: ban on seed treatment by chemical preparations; ban on use of GMOs; ecologically compatible raising methods (use of permitted fertilizers and crop protection means, crop rotation) [40]; laborato-

ry tests of soil for content of oil products, benzpyrene, heavy metals, persistent organic pollutants (POP); laboratory tests of products by extended list of indicators (pesticides, polyaromatic hydrocarbons, POPs, heavy metals); adherence to statutory regulations on waste disposals, discharges, and waste treatment.

Within the scope of aquaculture, organics direction has also been intensively developing during the last years [41, 42]. Organic aquaculture is defined as production (growing) of aquaculture objects (fish, shell fish, mollusk, and sea weed) and crop growing (in case of realization of mixed technology, aquaponics) according to the above-listed principles. Special requirements are also imposed in organic aquacultural production: renunciation of use of pesticides, fertilizers and GMOs, stepwise renunciation of fish flour, strict limiting the use of antibiotics and hormones [43]. Organic aquaculture is a production certified by organic standards, verified at each stage from raising (young animals, feed, and techniques) to treatment and delivery to consumer, and warranting high quality and safety of products.

Organics aquaculture is a new, extremely perspective and rapidly developing market niche satisfying the growing demand of humans for safe, ecologically compatible products in the context of stagnation in the global pesciculture [44, 45]. Organic projects within the scope of aquaculture become more appealing for investors. Thus, one of the first specialized venture funds in this domain is "Aqua-Spark" (Netherlands, founded in 2014), that invested USD 7 million in organic projects, of which USD 2 million were invested in project "Chicoa Fish Farm" (Mozambique, year 2014): ecologically compatible, vertically integrated, rapidly extendable technology of fresh-water raising of *Tilapia*; own incubator; production of planting material and feeds. It is forecasted that this production model would effectively operate in all countries of Africa to the south of Sahara desert. USD 2.5 million was invested in project "Matorka" (Island, 2015) (ecologically compatible production of *Salvelinus alpinus* from feeds to end product; recovered energy sources); USD 2.5 million was invested in project "Sogn Aqua" (Northway, 2015) (raising of *Hippoglossus*, patented water supply system with intensive aeration of purest deep water of fiords allowing renouncing of chemicals and antibiotics, low operating costs, practically complete absence of environmental impact, since 95 % of used materials are suitable for secondary processing, as well as possibility of production transfer on shore) (http://www.aqua-spark.nl).

In 2017 the Research Institute of Organic Agriculture, FiBL, Switzerland (http://www.fibl.org) and IFOAM (International Federation of Organic Agriculture Movements) (https://www.ifoam.bio) in their annual report "Global Organic Agriculture" [29] had for the first time summarized information on development of organic aquaculture in the world. Estimated global volume of organic aquaculture production in 2015 comprised 400 thousand tons (that is only 0.54 % of the total volume of aquaculture products, without sea weed), that is 2 times more than production volume of the Russian aquaculture, in general. Most part of organic products is produced in China — 304 thousand tons (80 %) and in Europe — 76 thousand tons (19 %), including Ireland — 31 thousand tons (mainly Atlantic salmon or *Salmo salar*), Northway — 17 thousand tons (salmon), Romania — 6.4 thousand tons (carp, salmon), Italy — 5.5 thousand tons (mollusks, *Dicen-trarchus labrax*, Black Sea salmon, or *Salmo trutta*, *Oncorhynchus mykiss*), Denmark — 4.1 thousand tons (mollusks), Hungary — 3.5 thousand tons, Spain — 2.7 thousand tons (mollusks, white mullet, bull trout, rainbow trout). From the other countries, the group of large producers is presented (mainly produced product is indicated) by Vietnam — 3.3 thousand tons (shrimps), Costa-Rica — 3.2 thousand tons (shrimp), Lithuania — 2.7 thousand

tons (carp), Indonesia — 1.9 thousand tons (shrimp), Ecuador — 1.8 thousand tons (shrimp), Thailand — 1.5 thousand tons. Significantly smaller production volumes of organic products are in Croatia— 1.4 thousand tons (mollusks, white mullet), in Greece — 1.1 thousand tons (white mullet), in Germany — 1.0 thousand tons (rainbow trout), as well as in Honduras — 0.6 thousand tons (shrimps) [46]. There is still no information on volumes of organic production in many countries with developed aquaculture (for instance, in Brazil). It could be expected that following such information, the adjusted global production volume of organic aquaculture would be higher.

Regardless of the fact that there is no available information on structure of the most part of organic aquaculture products, the available information reflect its specificity: production of organic aquaculture is focused on raising of salmons (10 %), mollusks (5 %), carp (1 %), shrimp (1 %), trout (0.3 %) and sturgeon (0.3 %).

Number of organic aquaculture producers constantly grows. There are 200 certified producers [47] in China, 465 — in Europe (most of all in Germany — 160) (http://ec.europa.eu/euro-stat/web/agriculture/data/database). European producers are certified according to European (in fact international) standards, Chinese − mainly according to the national organic standard which is not yet identical to the international standards. Generally, at present there are nearly 1 thousand of producers of organic aquaculture objects, and their number would grow.

Organic trend in China is deemed to be one of the key trends in development of aquaculture. About 60 % of the total volume of global aquaculture objects is produced there, of which fish products make 26 million tons, mollusks make 13.4 million tons, shell fish make 4 million tons, sea weed makes 13.3 million tons. This volume generates total 27 % (5.12 million) of the global number of producers — enterprises and farmers dealing with aquaculture [48]. Chinese aquaculture yields 540 fish, mollusk, shell fish, and other invertebrate species, several species of amphibians and aquatic reptilians, nearly 30 species of limnetic macrophytes, over 50 species of micro-seaweed and invertebrate animals. China remains the global leader in production of sturgeon roe. Experts forecast growth of Chinese aquaculture market volume by 2020 up to USD 103 billion mainly due to increase of organic aquaculture production volumes and demand for "premium" seafood.

In China, 400 thousand ha of agricultural lands (mainly in Zhejiang, Hainan, Mongol, Jiangsu, Xinjiang, Liaoning, Hunan, Anhui, Fujian, and Shandong provinces) are used for organic aquacultural production purposes. Main production technology at organic aquaculture farms in China is raised in polyculture. The most used production objects are fish, shrimp, *Pectinidae*, sea cucumber (trepan) (*Holothurioidea*), crab (*Brach-yura*), mollusks, and eel (*Monopterus albus*) [49].

Pilot region for implementation of organic aquaculture in Russia is Astrakhan Region [50, 51]. Aquaculture production in combination with crop rotation is in place here since 2011 at small innovative enterprise "Modern Fishery Complex "Sharapovskii". Production process by organic technology includes alternating growing of aquaculture objects (carp, herbivorous fish) and agricultural species (melons, grains, vegetables) without the use of substances containing synthetic materials and chemical agents that allows ensuring production safety of products. Preparation program of stagnal areas increases in 2 times the crop yields of agricultural products following predecessor (aquaculture objects), fish yields in 1.5 times [52]. Organic technology in combination with methods of adaptive agricultural production [53] and production of ecologically compatible

products [54] had shown high effectiveness in the context suitable for stagnal culture [55] that makes its large-scale application possible in fishery basins of arid area of Russia. Diagnostic audit of the food product safety management system was conducted at fishery complex “Sharapovskiy” for compliance with requirements of the state standard GOST P ISO 22000-2007 [56] and organic production by program “ECO-PRODUCT” adopted in “R-Standard” voluntary certification system [57] that confirmed development of organic aquaculture and readiness to further certification.

Effective development of organic aquaculture direction in China, as well as in Russia, suppresses the deficit of organic feeds [58] and lack of organic certification in majority of producers. Certification of organic aquaculture production and products in Russia would be done within the limits of the Russian and international certification systems and governed by relevant law and statutory regulations, including GOST P 57022-2016 [59]. Cost of certification would vary depending on the number of types of certified products, production volume, and etc. Most probably, it would be compatible with certification cost of agricultural production. Cost of certification of compliance to GOST P 56508-2015 [60] would comprise 70 thousand rubles/ year (GOST presupposes only nearly 70 % requirements of European organic standards); by European organic standards through European operators — USD 10 thousand [61]. Cost of certification for compliance to standard “Vitality Leaf. Organic” of the Ecologic Union of Saint Petersburg, recognized as compliant to the European standards, in average comprise 150 thousand rubles/year.

Therefore, aquaculture production industry is ready for radical changes, which would be associated with new formats of organic production and which would also change the food product consumption picture. Large global venture funds have been already included in investment organic aquaculture projects, and these projects are accounted for at conduction of scientific researches. Innovative developments are supported by governments of many countries, international organizations, and private investors. Perspectives of aquaculture changes are associated with practical realization of organic technologies promoted by both growth of the number of issues related to safety of food products and ecologic threats, as well as by growth of population of organic food products. For effective development of organic aquaculture direction in the world and in Russia, in particular, it is necessary to overcome a number of barriers, in particular deficit of organic feed and lack of international certification in majority of organic aquaculture operators. All these facts and factors shall be accounted for in the domestic aquaculture development strategy to enable the Russian producers to compete at the global market for a few years.

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