Use of innovative technological solutions in the development of the fish products market

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Abstract. As fishery activities is a significant producer of vital food products (17\% of the world’s protein consumption), the problem of including illegal and adulterated products in the supply chain, which can be solved with the help of innovative technology – blockchain, is of significant importance. Conducting this review, it is important to understand how the blockchain can act as a unifying structure for various international stakeholders to solve the problem of the fish products market. Based on the conducted economic analysis of various information technologies using methods of analysis and synthesis, experimentation, graphic images, as well as the use of official reports of the FAO (Food Organization of the United Nations), Rospotrebnadzor, Rosrybolovstvo, scientific and expert assessments and calculations of the implementation of information technologies in fishery activities of Russian and foreign scientists, it was proposed to introduce a technology of an effective mechanism for limiting the blockchain for fishery activities, where the result is the exclusion of “falsified information”, “illegal” and “low-quality” fish products from the moment they are caught to the moment they are put on sale.

1. Introduction
To achieve one of the goals of the state program for the development of agriculture and regulation of markets for agricultural products, food and raw materials in the short term and in strategic direction, ensuring the financial stability of agricultural producers – the innovative approach to the development of competitiveness in both domestic and foreign markets is essential.

In ensuring global food security, the problem of including illegal and adulterated products in the supply chain, which can be solved with the help of innovative technologies, is of particular importance.

Fishery activities (FA), also known as fishing, fish farming (catching and aquaculture), and fish processing, is a significant producer of vital foods that currently account for 17\% of global protein consumption [1]. In terms of profitability and tax burden, FA is one of the most profitable in the most advanced sectors of the economy in Russia in 2019. (figure 1).
As the world’s population grows exponentially, the demand for fish products becomes the highest in history. The capacity of this market exceeds the total capacity of the rubber, banana and coffee markets [2]. In addition, the rapid expansion of developing countries gradually leads to an increase in the income of the population, while at the same time certain elements of Western culture, including its characteristic cult of consumption, are penetrating even into traditional Asian societies. There is an increase in demand for high-quality products, and the consumption of delicacies from valuable fish species, shrimp, crabs, and caviar is increasing. In 2016, the total volume of fish production in the world was 175.2 million tons and demand for it shows no signs of slowing down [8].

The UN Food and Agriculture Organization (FAO-Food and Agriculture Organization) expects that by 2030, an additional 27 million tons of products will be needed to maintain the current level of fish consumption per capita (20 kg per year). In these circumstances, ensuring a high-quality, stable, uninterrupted and sufficient supply of fish products is an important condition for global food security figure 2.

![Figure 2. Forecast of growth of average fish consumption per capita in the world from 2019 to 2050, kg/person](image)

However, the global trade in fish products faces challenges from the penetration of “falsified”, “illegal” and “low-quality” products throughout the global supply chain, including on vessels engaged in illegal, unreported and unregulated (IUU) fishery (IUU-Illlegal, Unreported and Unregulated fishing), on fish processing plants that purchase unrecorded raw materials, on the shelves of retail stores that sell falsified products, and on informal markets. The impact of these products is huge, because they not only have a significant negative impact on the safety of consumption, but also lead to overexploitation of aquatic biological resources, reduction of their reserves, and environmental problems. The shadow economy leads to the leakage of currency abroad, evading taxation and customs control, which significantly complicates the financing of the fishing industry, hinders economic growth and seriously threatens the provision of fair, safe and resilient access to the most marketable food commodity in the world – fish [Ошибка! Источник ссылки не найден.2; Ошибка! Источник ссылки не найден.10].

The fight against the global trade in “falsified” and “illegal” fish products creates a need for innovative technological solutions for supply chain management. One of these solutions may be the...
blockchain industry, which has grown from a small but bold idea to multibillion-dollar volumes over the past few years. This technology has not only changed the economic environment, but also defined new approaches to business management.

2. Materials and methods
A review of various information technologies and general academic literature revealed that blockchain technology is an effective mechanism for restricting access of illegal and falsified fish products to commodity markets as an additional solution that improves information exchange and data collection.

It is important to understand how the blockchain can act as a unifying structure for various international stakeholders to solve the problem of the fish market based on the economic analysis of various information technologies using methods of analysis and synthesis, experimentation, graphic images. The use of official reports of the FAO (Food and Agriculture Organization of the United Nations), Rospotrebnadzor, Rosrybolovstvo, scientific and expert assessments and calculations of the introduction of information technologies in the fisheries activities of Russian and foreign scientists was the information base.

3. Results
“Blockchain (originally block chain) is a continuous sequential chain of blocks (a connected list) containing information built according to certain rules. The connection between blocks is provided not only by numbering, but also by the fact that each block contains its own hash sum and the hash sum of the previous block. To change the information in a block, you will also need to edit all subsequent blocks. Most often, copies of block chains are stored on many different computers independently of each other. This makes it extremely difficult to make changes to information already included in blocks” [4] (figure 3).

According to the results of the study, this new-generation technology is still at the stage of maturation and its implementation is associated with many problems, such as heterogeneity of participation in global value chains, high cost of implementation, the risk of vulnerabilities in software, and uncertain regulatory status in many countries. However, the features and prospects of blockchain, as well as the presence of successful cases in the analyzed area, confirmed the need for blockchain for the supply ecosystem and the interest of the fishing industry in investing in new digital technologies based on distributed registries and their integration into the business processes of global market participants.

Figure 3. Scheme for obtaining the hash of the transaction.
will go hand in hand with elements such as Advanced tracking and tracing (T&T) technologies, Big data analytics, Industry 4.0, Additive manufacturing (3D printing), etc.

In the context of “falsified” and “illegal” fish products, the use of blockchain can be used for:

1. Tracking raw materials and finished products from the fish producer to the end user in an unaltered and shared electronic database based on e-book;
2. Ensuring greater transparency in identifying unrecorded products in the supply chain by enabling all participants to verify the accuracy of the data;
3. Integration into the “Internet of things” and better detection and authentication of unaccounted fish products;
4. Expanding information exchange between unrelated databases and various supply chain participants.

This could potentially transform the global fish product supply chain into a more reliable, accountable and transparent data architecture that can cross multiple entities and jurisdictions.

Intel has already been using the Sawtooth Lake platform on an open-source blockchain being developed for seafood deliveries. Due to blockchain technology, buyers can track the entire process of delivery of goods.

Internet of things (IoT) sensors help track recorded delivery data in the blockchain. These sensors also contain information about the owner of the property, its location in real time, as well as the environment in which products are stored (temperature, humidity).

IBM and Wal-Mart are exploring how to improve food safety using blockchain technology. In practice, new cloud analytics platforms such as SupplyOn Industry 4.0 Sensor Clouds allow managing the supply chains in real time, as well as planning and configuring processes using the latest information. Just by clicking on the container type, you can find out from the graphs whether there was a violation of certain limits of temperature or humidity along the time axis [4].

The technology of distributed registries can help to displace producers of falsified and unrecorded fish products from the local market if, for example, data fusion and QR-code systems are integrated, combined with blockchain technology and implemented in the state electronic system for controlling the movement of products (in Russia, this is the “Mercury” system). At the same time, each product should be assigned a unique code containing information about production: from the moment of catching to going on sale, and the buyer will be able to get acquainted with this information using an app on a mobile phone.

The blockchain will also help identify anomalies in the production and consumption process automatically. For example, an importer of frozen fillets will know that raw fish is pumped with water and chemicals to increase significantly its weight, and fish cutlets on the counter in a supermarket will “say” that illegal raw materials were used in their production. Manufacturers of crab sticks will no longer be able to add to the product banned in many countries Pangasius caught in the most polluted river on the planet – the Mekong. All parties, including control authorities, will have access to this data. Automation will reduce the number of documents and allow more time for value-adding activities.

Thus, the global trade in fish products faces the challenges of infiltrating “adulterated” and “illegal” products throughout the global supply chain. Consumers and marine ecosystems bear the burden at the expense of health, finance, and security. As criminals become more sophisticated and supply chains become more complex and diverse, new technologies to prevent, respond to, and eliminate counterfeit and illegal products must go through a continuous process of development and implementation. Blockchain stands out as a potential revolutionary technology for better enabling the modernization and digitalization of the fish product supply chain, which will be more reliable, accountable, transparent and protected from counterfeiting.

In a number of European countries, enterprises have been established for the centralized production of a substrate for the cultivation of champignon and other types of mushrooms. The substrate is the
most important product of the mushroom growing industry and is supplied to a wide range of consumers-mushroom producers [17].

In Russia, organic fertilizers are applied at only 7.5% of the total fertilized area. The volume of organic fertilizer exports from Russia in 2014 amounted to 876 tons, which is 116% higher than in 2012. The growth in exports of organic fertilizers indicates that in foreign countries, fertilizers of this type are gaining popularity as the most environmentally friendly. The import of organic fertilizers to the domestic market continues to be relatively high. Thus, according to 2015 data, the import amounted to 22 thousand tons. The study of the capacity of foreign markets showed that the leader in the consumption of organic fertilizers is the UAE (United Arab Emirates), Uzbekistan, and Tajikistan, which indicates a high potential for selling organic fertilizers to the territory of these countries (table 1) [18,19].

Table 1. Actual capacity of the organic fertilizer market abroad, 2015.

| Region  | Actual capacity of the market, thousand tons |
|---------|--------------------------------------------|
| UAE     | 32081.25                                    |
| Kazakhstan | 85244.63                                   |
| Mongolia | 24695.04                                    |
| Tajikistan | 50482.00                                   |
| Uzbekistan | 896720.00                                 |

The use of modern nano-and biotechnologies for fermentation and granulation makes it possible to process poultry droppings into granular organic fertilizers that increase the yield of vegetables in the open ground by 20-30%. The cost is 2-3 times lower. The size of the granules allows applying fertilizer to the soil simultaneously with sowing, using existing equipment, and the soil fertility increases for up to 3 years [20]. The production of biohumus based on the processing of fungal waste substrate using California worm is also effective. It is produced from the waste of the substrate after the cultivation of mushrooms. It has a high demand in the world and can be exported. One of the largest consumers of biohumus on the world market is the United Arab Emirates and Saudi Arabia, which use biohumus in national projects to transform the environment (turning sandy deserts into flowering oases). Therefore, the world prices for biohumus are dictated by the Arab countries (their only requirement is not to produce compost based on pig manure). The demand for high-quality organic fertilizers in the world is extremely high and continues to grow, according to experts, by 20-30% annually, because environmentally friendly food remains a large deficit. In addition, in Russia, this market is very far from being saturated. Only Russian gardeners (without taking into account the needs of the agricultural industry) need more than 2 million tons of biohumus annually. Biohumus is effective in solving a number of tasks for agricultural producers: reducing the cost of fertilizers (chemical fertilizers and pesticides are more expensive); improving the quality and shelf life of vegetables; production of environmentally friendly agricultural products; reducing the incidence of plant diseases. The calculated values of only the substrates used in the production cycle are about 188 thousand tons [21, 22]. The presented calculation is based on the study of the substrate metabolism processes that take place from the moment of mixing the initial materials to the end of harvesting the mushroom fruit bodies. It shows the potential for high yield and the final yield of the spent substrate at the end of the crop rotation when using intensive multi-zone technology for growing the main mushroom crops: champignon and oyster mushrooms (table 2).

Table 2. Substrate mass loss during preparation and growing of mushroom fruit bodies (2015-2018) depending on the growing system.

| Indicators         | Two zone system | Three zone system |
|--------------------|-----------------|-------------------|
| Phase Ph1, 14 days | 32-35           | 32-35             |
| Phase Ph2, 7-10 days | 25-30         | 25-28             |
| Phase Ph3, 35/25 days | 29-35         | 8-10              |
Phase of fruiting and picking up mushroom, 35/14 days, %
Specific consumption of the substrate
Total substrate mass loss, kg/m²
Number of crop rotations per year, vol.

| Indicator                          | Standard          | 50-55 | 28-30 |
|------------------------------------|-------------------|-------|-------|
| Appearance                         | loose in structure product with strongly decomposed components: straws, sawdust, other cellulose-containing materials, with an admixture of cover material, peat, interspersed with white mycellial hyphae of edible mushrooms |       |       |
| Color                              | from light brown to dark brown, almost black |       |       |
| Smell                              | humus, fungal substrate, peat mixture |       |       |
| pH of the medium (acidity of the water extract) | 5.5 – 6.8 |       |       |
| Mass fraction of moisture, W, %    | 30 - 50           |       |       |
| Mass fraction of total nitrogen, N, % | 0.6 – 2.9       |       |       |
| Mass fraction of total phosphorus, P, at least,% | 0.6 |       |       |
| Mass fraction of total potassium, K, at least, % | 0.5 |       |       |
| Mass fraction of organic matter, % | 66 - 70       |       |       |
| Ratio of C:N                        | 6 - 25            |       |       |
| Volume weight, g/cm³               | 0.9 – 2.15        |       |       |
| Nutrient content, % of dry matter: |                    |       |       |
| - mobile potassium (K₂O)           | 0.3 – 1.0         |       |       |
| - mobile phosphorus (P₂O₅)         | 0.15 – 0.4        |       |       |
| - ammonia nitrogen (NH₄)⁺           | 0.3 – 0.8         |       |       |
| - exchange calcium (CaO)            | 0.5 – 2.0         |       |       |

To produce the volumes of fresh fruit bodies of mushrooms specified as indicators of the state program (140 thousand tons per year), it will be necessary to produce 470 thousand tons of phase 3 substrate in accordance with the introduction of a three-zone intensive cultivation system. The planned yield is 30 kg/m² per crop rotation. The yield of the spent substrate will be 188 thousand tons per year with a number of positive properties that allow it to be used as a concentrated organic fertilizer for both open and protected soil. In technological terms, after the culture turnover, the substrate is subjected to steam heat treatment at a temperature of +70°C (table 3).

Table 3. Physical and chemical indicators of the spent substrate (2015-2018).

4. Summary
The main idea is to develop new architecture in which all market participants will work with a common set of data. Blockchain does not work in isolation, it uses supporting digital technologies (for example, mobile technologies). Therefore, the evolution of design and conceptualization of anti-counterfeit solutions will go hand in hand with elements such as Advanced tracking and tracing (T&T) technologies, Big data analytics, Industry 4.0, Additive manufacturing (3D printing), etc.

Currently, many forms of anti-counterfeit technologies based on blockchain cannot be implemented or scaled due to inherent limitations, such as heterogeneity of participation in global value chains, high
implementation costs, the risk of vulnerabilities in software, and uncertain regulatory status in many countries.

Thus, by implementing the technology of an effective mechanism for restricting the blockchain in the fishing industry, the company will completely exclude “falsified”, “illegal” and “low-quality” fish products from the moment of catch to sale. This contributes to an increase in the index of consumer confidence in the organization and, accordingly, an increase in demand for the organization products and, correspondingly, an increase in the company’s profit indicator, which is the main task of any business. The introduction of blockchain contributes to an additional means of attracting investment in the organization, which generally contributes to economic development.

In the near future, it is pointless and risky to resist the penetration of the blockchain. In order to ensure global food security, the world community will have to adopt new technological solutions, considered in this study, sooner or later.

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