Using quality function deployment for improving fish preserves technology

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Abstract. Modern market-driven economy requires manufacturing high-quality and competitive products to make enterprises successful. The present paper analyzes the works on fishing industry in Russia and the qualitative indicators of fish preserves, identifies the main consumer properties and the main characteristics of the products studied, and constructs a matrix for planning the quality of preserves made from pond fish.

1. Introduction

The popularity of fish products is increasing in our country. Nowadays, fish is increasingly replacing meat in the Russian menu. Today, a lot of people keep Orthodox fasts. At this time, fish sales have increased by several times [1].

The structure of Russian fish production is characterized by the overwhelming majority of frozen products, specifically over 60%. The second place in terms of volume is occupied by live fish, which makes 20%, while fresh and chilled fish account for only 6%, fish products and canned fish make 10% and mollusks make only 4% [2].

![Figure 1. Structure of Russian fish products market](image)

The dynamics of the Russian economy declares that the 5-6% increase production of fish products...
every year over the coming years. In terms of fish and fish products consumption, Russia is gradually approaching European countries, where about 21 kg of fish products per year are per capita [3].

Literature review [4] has showed that the fishing industry in Russia is mainly oriented to the ocean industry (more than 90%). At the same time, it is necessary to pay attention to the growth of commercial aquaculture: in 2018 compared with 2017 it increased by more than 50%.

2. Problem setting

Currently, the Russian fish and seafood market is not at the peak of its development due to a controversial situation characterized by a general deficit of fish products in the Russian market while the most domestic enterprises use less than 50% of their facilities. In 2014-2015 there was a decrease in the market sales as a result of a drop in consumer purchasing power, limited availability of imports and a significant increase in the prices for fish and seafood. Due to the embargo, the imports of fresh and chilled fish decreased by 83% by 2017 in comparison with the year 2013 [5].

In 2017, imports grew for the first time in recent years. The growth was triggered by an increase in shipments from the Faeroes and Turkey and these two countries became the pivotal suppliers of fresh and chilled fish to Russia after the introduction of the food embargo [6].

The analysis showed that since 2015, there have been positive trends in fishing industry, which is stipulated by the food embargo (Figure 2). As a result, Russian manufacturers managed to increase production by replacing imports significantly.

![Figure 2. Fish catch structure (commercial aquaculture) in physical terms by species, 2015-2018](image)

In general, the indicators of 2016-2017 provide an opportunity to conclude that there is a tendency to reduce the amount of fish imported into the Russian Federation and increase domestic production. A promising and high-demand area is pond fish production. Modern consumers are increasingly opting for the cooled products of local origin. At the same time, currently the consumers are being saturated with cooled pond fish and are increasingly paying attention to preserves being non-traditional products made from pond fish.

The scientific and technical literature review [7] has showed that fresh pond fish and preserves made from it are very popular among Russian consumers and are consumed with the ratio of 35 and 23%, respectively. Cooled fish fillet with a 16% consumption share is also popular. Balyk products and dried fish make only 11% of consumption. Thus, the market of preserves made from pond fish is quite promising.
In order to study consumer preferences [8] of pond fish preserves, a sociological survey on organoleptic indicators was conducted and the most important quality indicators of fish preserves established by consumers were named. They are as follows: condition of fish and gravy, consistency, smell, fish color, taste and the presence of scales (Figure 4).

Analysis of the diagram of fish preserves organoleptic indicators showed that respondents pay special attention to the consistency of fish preserves, the fish color as well as taste and smell.

**3. Results and discussion**
Production that can satisfy all consumer preferences is of paramount importance for modern processing enterprises. The quality of finished products can be anticipated by applying the method of
Quality Function Deployment (QFD) for the qualimetric prediction of fish preserves properties with allowance for the consumers’ requirements [9].

The method of Quality Function Deployment (QFD) is used at all stages of manufacturing: product planning, product design, processing and production, and the results of applying QFD at all stages are interrelated.

The eight stages are applied for implementing the QFD method. The result is the construction of a quality house ensuring the products competitiveness (Figure 5).

The main goal at the stage of constructing the planning matrix is to interpret the qualitative and informal requests and wishes of consumers into their quantitative assessments [10].

![Figure 5. Typical structure and configuration of the QFD matrix (quality house)](image)

Consumer requirements were ranked by the importance on the basis of the results of applying statistical methods in quality management. All basic organoleptic indicators and product safety indicators were specified in State standard 7453-86 and TR TS 040/2016 “On the safety of fish and fish products”.

At the next stage, the degree of consumer satisfaction with fish preserves in oil made from carp, manufactured in accordance with the requirements of State standard 7453-86 was analyzed. This is necessary for understanding the advantages of the studied products in comparison with the analogue ones.

As a result of constructing the planning matrix [11] (Figure 6), the analysis of the quality of fish preserves from the pond was carried out and the highest priority technical characteristics for further research were identified. As well, the recommendations for quality improvement were developed. To improve these characteristics, it was decided to add an enzyme complex at the stage of putting salt, which will reduce the time of fish salting and, accordingly, this will affect the rate of salting substances distribution (fish salinity) in the fish and its consistency.
The preserves presented in Table 1 were proposed taking into account fish ripening time. The II stage of fish stiffening is recommended for fish preserves production, since the day of salting will contribute to its ripening. The fish, previously chopped in fillet, was salted, cut into pieces, laid in jars and put in gravy. The preserves from pond fish were proposed forming the matrix of planning fish preserves from pond fish. The preserves presented in Table 1 were proposed taking into account fish ripening time. The II stage of fish stiffening is recommended for fish preserves production, since the day of salting will contribute to its ripening. The fish, previously chopped in fillet, was salted, cut into pieces, laid in jars and put in gravy.

Table 1. Recipe for fish preserves

| Raw products, spices and materials | Raw products, g | Unsalted raw products, g |
|-----------------------------------|----------------|-------------------------|
| Carp in oil                        | 500            |                         |
| Salt                              | 35             |                         |
| Enzyme complex (cathepsin)        | 0.03           |                         |
| Vegetable oil                     | 200            |                         |
| Corn                              | 75             |                         |
| Black peppercorns                 | 0.6            |                         |
| Ground black pepper               | 0.5            |                         |
| Ground coriander                  | 0.5            |                         |
| Bay leaf                          | 0.5            |                         |
| Whole cloves                      | 0.5            |                         |
| Sodium benzoate                   | 0.65           |                         |

Figure 6. Matrix of planning fish preserves from pond fish
We have developed a modified technological scheme for the production of preserves from pond fish. At the stage of brine preparation, an enzyme complex, specifically, cathepsin extracted from the muscle tissue of carp is added, due to which the duration of salting process was reduced by 3 times.

![Technological scheme for fish preserves production](image)

*Figure 7. Technological scheme for fish preserves production*

The process of enzyme complex introduction at the stage of brine preparation, which increased the salting speed, was studied.

Live fish was used as the main raw product for preserves manufacture. At the same time, the possibility of using mechanically damaged fish (with the damaged parts being removed) corresponding to the rest of the indicators of the 1st grade was studied [11].

Raw and additional materials must be of the quality corresponding to the 1st grade and meet the requirements of the relevant regulatory documentation. Sauces and brines were added through a dispenser or measuring device. In this case, the mass fraction of fish should be at least 60-70%, sauce or pouring mass of at least 30-40%. After pouring, preserves were corked with lids and kept for 2–5 days to form flavor characteristics [12].

Based on the review of the available literature [13], the following most important groups of properties for all meat and fish objects can be named: organoleptic characteristics, indicators of...
biological value and fitness for storage as well as safety characteristics. The state of the product is described by a complex set of chemical, biochemical, physico-chemical, histological, rheological and other characteristics. To make an objective description of their entire set, the simultaneous and interconnected use of a number of characteristics and methods for their determination on the basis of various principles is required [14].

The graphical dependence of the functional and technological properties of salted fish flesh is presented in Figure 4.8.

**Figure 8.** Functional and technological properties of salted fish

Having determined the functional and technological properties of end product, we can say that all the main characteristics show positive results, which may indicate that the consistency of the product corresponds to State standard 7453-86.

The application of enzymes in the food industry is possible only if it is completely inactivated in the finished product since the fact that active enzymes in food can negatively affect the walls of the
digestive tract, which is impermissible. Therefore, a study on the biological safety and biological activity of the obtained product using the rapid biotest on a unicellular culture Paramecium caudatum was conducted. The express biotest reacts quite sensitively to the active substances contained in the test objects and reflects their relation to the organism viability [15].

The biological activity was assessed by the resolving method with the objective to identify the biological effect of the obtained enzyme complex on the mechanism of Paramecium caudatum cells adaptation and resistance with the help of an additional resolving unfavorable factor.

Table 2. Change in the index of cell multiplication intensity depending on the breeding

| Sample                                              | Breeding facility |
|-----------------------------------------------------|-------------------|
|                                                      | 1:100             |
|                                                      | 1:1000            |
|                                                      | 1:10000           |
| Preserves “Carp in oil” with an enzyme complex       | 0.75              |
| Preserves “Carp in oil” without enzyme complex       | 0.60              |
|                                                      | 0.76              |
|                                                      | 0.72              |
|                                                      | 0.81              |
|                                                      | 0.79              |

Notes:
- CPII is Cell Propagation Intensity Index;
- CPII is 1.0 means the object is biologically inactive;
- CPII is >1.0 means the object stimulates cell reproduction;
- CPII is <1.0 means the object inhibits the reproduction of cells.

Thus, it can be seen from the data in Table 4.2 that the Paramecium caudatum culture is viable, which proves that the enzyme complex is completely inactivated while cooking, therefore, the finished products are safe.

We analyzed the organoleptic and physico-chemical characteristics of fish preserves with the objective to expand the recommendations for usage and development of salted products.

Table 3 Physico-chemical characteristics of the finished product

| Indicator                                      | Norm for preserves | Preserves “Carp in oil” |
|-----------------------------------------------|--------------------|-------------------------|
| Mass fraction of protein,%                   | Not less than 12   | 16.5                    |
| Mass fraction of salt,%                      | 4.0-6.0            | 5.6                     |
| Mass fraction of sodium benzoate,%           | 0.1-0.15           | 0.1                     |
| Mass fraction of gravy,%                     | 31.5               | thirty                  |
| Acidity in terms of acetic acid              | 0.2-1.2            | 0.5                     |

Analysis of the data presented in table 4.3 showed that the physico-chemical parameters of fish preserves coincide with the norms specified in the regulatory documentation.

We conducted a survey of respondents with the purpose to compare the organoleptic characteristics of preserves from pond fish with traditional preserves from herring. In the questionnaire, the following major organoleptic indicators of the quality of fish preserves, which are most important for consumers, were taken into account: appearance, texture, taste, smell, color of fish (Figure 10). 50 people belonging to the age category from 18 to 25 took part in the survey. The main participants of the survey were university students.
Having analyzed the data of organoleptic evaluation, we can conclude that preserves from pond fish are not worse than traditional ones and even surpass them in consistency.

4. Conclusion

Thus, we can conclude that the proposed technology for the production of preserves from pond fish can intensify the process, reduce time and energy costs, improve their organoleptic characteristics, do not have any toxic effects and are harmless to humans.

The application of the method of quality function deployment makes it possible to transfer consumer requirements into a set of controlled characteristics and requirements for the methods of implementing technological operations, to form a continuous information flow that ensures that all elements of the production system are aimed to meet consumer requirements

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