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Development of qualimetric model for predicting quality indicators of products from aquatic biological resources for school food rations

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Abstract. The analysis of school food rations was carried out in terms of satisfaction of schoolchildren and their legal representatives, as well as the state control bodies and representatives of the companies providing food services in schools in the quality, assortment, as well as in physiological needs. A questionnaire was developed to analyze the requests of potential consumers. The expert method of full pairwise comparison established the priority requirements of the consumers: the requirement not expressed during the survey regarding the absence of fish bones in the finished product and the expressed requirement about the presence of natural components in the food composition. The actual percentage consumption of school menu dishes was established on the example of schoolchildren in the Kaliningrad region. Based on the conducted qualimetric forecasting, recipes and technology for manufacturing a line of fish products were developed for including into the diet of schoolchildren both at school canteens and through a retail network for cooking at home.

Keywords: qualimetry, quality indicators, school meals, organoleptic evaluation, scoring

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Научная статья

Разработка квалиметрической модели прогнозирования показателей качества продукции из водных биологических ресурсов для рационов школьного питания

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Аннотация. Проведен анализ рационов школьного питания по уровню удовлетворенности школьников и их законных представителей, а также государственных органов контроля и представителей компаний, предоставляющих услугу питания в школах, качеством, ассортиментом и степенью удовлетворенности физиологических потребностей. Разработана анкета для анализа запросов потенциальных потребителей. Экспертным методом полного парного сопоставления установлены приоритетные требования потребителей: не высказанное ими при анкетировании требование в части отсутствия рыбных косточек в готовом изделии и высказанное – наличие в составе натуральных компонентов. Установлено фактическое процентное потребление блюд школьного меню на примере учащихся Калининградской области. На основе проведенного квалиметрического прогнозирования разработаны рецептуры и технология изготовления линейки продукции из рыбы для включения в рацион питания школьников – как в школьных столовых, так и через розничную сеть – для приготовления в домашних условиях для данной категории населения.

Ключевые слова: квалиметрия, показатели качества, школьное питание, органолептическая оценка, балльная оценка

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Introduction

A rapid growth, physical and mental development of children and adolescents, combined with a significant neuropsychic load due to an intensive learning process, which, starting from the age of 6, predetermine the need for a constant intake of a complex of all essential and nonessential nutrients with food, including proteins and amino acids, fats and fatty acids, various classes of carbohydrates, including dietary fiber, micronutrients (vitamins and vitamin-like substances, mineral salts and trace elements), bioflavonoids, nucleotides, etc. This requirement can only be met providing properly organized, rational (healthy, optimal, balanced) nutrition of children in preschool and school institutions and at home.

The rational nutrition of children and adolescents in organized groups is a system of requirements that can be briefly formulated as follows:

1. When forming school food rations, the energy value should be adequate to the energy consumption of modern children and adolescents.

2. Substantiation of the ratio for all nonessential and irreplaceable nutrients, including proteins and amino acids, dietary fats and fatty acids, various classes of carbohydrates, vitamins and vitamin-like substances, mineral salts and microelements according to the level of physiological needs of this age group.

3. Systematic intake with food of the most important minor components: natural antioxidants, nucleotides, etc.

4. Compliance with the principles of biodiversity in the preparation of the diet.

5. Compliance with the interval between meals.

6. Technological processing modes aimed at maximum preservation of the original nutritional value and high taste indicators.

7. Accounting for the individual characteristics of children (including their intolerance to certain foods and dishes).

8. Ensuring sanitary and epidemiological safety of all processes of the product life cycle.

However, analysis of the state of nutrition of children in school organizations, which has been carried out on an ongoing basis in the past few years, as well as an analysis of a sociological study on the satisfaction of students and their parents with the organization and quality of nutrition in educational organizations, indicates significant deviations from these principles [1-4].

The state authorities and Rospotrebnadzor of the Russian Federation have done a lot of work in terms of ensuring the safety and balance of school meals. However, some food organizers, due to objective reasons, most often practically exclude fish dishes from the diet. The specific contingent of those who eat dictates special requirements for the taste, aroma and appearance of products. All these indicators form an organoleptic characteristic. Methods for organoleptic evaluation are selected depending on the objectives of the study [5-10].

A critical factor in all sensory methods is the accuracy and objectivity of measurements, as well as the appropriate interpretation of the results of these measurements, so that they can be analyzed objectively and arbitrary interpretation of the data obtained can be avoided. Through the process of data digitization, sensory evaluation becomes a quantitative science using statistical analysis, numerical modeling and forecasting.

The relevance of using objective methods for assessing the desirability of certain healthy foods in the diet of schoolchildren is beyond doubt.

Thus, the purpose of this study is to form a “house of quality” that allows to establish the relationship between consumer requirements for fish products, its quality characteristics and the requirements of regulatory and technical documents.

Objects and methods of research

The objects of the study are minced fish products with the addition of products of plant and animal origin, questionnaires of potential consumers and their legal representatives.

Research methods of determining organoleptic indicators are applied, according to GOST 7631-2008 “Fish, non-fish objects and products from them. Methods for determining organoleptic and physical indicators”, determination of the mass fraction of moisture, protein, fat according to GOST 7636 “Fish, marine mammals, marine invertebrates and products of their processing. Methods of Analysis”. Design methods “House of Quality” [11].

Results and discussion

The results of the organoleptic evaluation of products can be quantified by means of dimensionless numbers, commonly known as “scores”. A set of numerical values that combines the assessment of product properties in a given quality range forms a scoring scale. The method of scales is widely used due to its information capabilities and a large number of scales due to their various modifications. At the same time, the application of this method gave a large number of doubtful and even erroneous results due to unjustifiably free circulation in the choice of scales, in the process of changing their range and content, in the statistical analysis of the results [12].

For sensory analysis, interval scales are most often used. Interval scoring scales differ in the number of points used to evaluate the product, the quality range of the object under study, the method of assigning points, the verbal description of each quality level corresponding to a certain number of points, the method of overall evaluation of the product, the presence or absence of coefficients of significance of individual organoleptic features. The significance coefficient reflects the value assigned to individual indicators in assessing the overall quality.

Significance coefficients differ in value depending on the type of product, the country where they are installed, and other factors. The choice of significance

factors is at the discretion of those responsible for quality control.

A five-point scale has become the most widely used scale in the practice of organoleptic evaluation. In particular, it is widely used in the assessment of fresh, frozen and canned fish and fish semi-finished products and culinary products. The use of a five-point scale allows a taster with average sensory sensitivity and experience to obtain fairly accurate results. A variant of a simple five-point scale is shown in Table 1.

Table 1

A variant of the five-point scale for assessing food quality

Verbal characteristic of quality	Quality percentage	Score
Excellent	80-100	5
Good	60-80	4
Average	40-60	3
Unsatisfactory	20-40	2
Very bad	0-20	1

When using a five-point system for a comparative evaluation of several samples, tasters may need to obtain a more differentiated assessment of them, for example, a half-point value, or express their attitude to the product in addition to the assessment of points with plus or minus signs. The five-point assessment system can be recognized as the main or reference.

Using extensive research experience in the field of sensory assessment [12] of product quality, a five-point scale was developed to assess the quality of semi-finished fish and culinary products. This scale is double, i. e. contains positive and negative deviations from some average product quality and a verbal description of each quality level. At the same time, gradually increasing positive quality indicators (from a product of average quality to ideal) are located at the top of the table, and negative ones (from medium to very poor) – at the bottom. When developing the scale for organoleptic evaluation the following indicators were taken as the main ones: appearance, aroma, taste, texture, color. Each indicator has 5 levels of quality: optimal quality 5 points, very good – 4, acceptable (but undesirable) – 3, unacceptable – points 2 or 1 (Table 2).

Table 2

General characteristics of evaluation steps (for all product features)

Number of points	Characteristics of the assessment steps
5	According to the corresponding feature, the product is characterized positively; no noticeable flaws or defects found
4	The product has minor flaws or defects that have little or no negative effect on the taste of the product
3	The product has flaws or defects, but the product meets the minimum requirements of the standard
2	Deficiencies or defects are found in the product, as a result of which, although the product does not meet the minimum requirements of the standard, it does not lose its suitability for consumption and, although it is no longer marketable, after appropriate processing it can still be used under certain conditions
1	The product is found to be so severely defective that it must be considered spoiled and, in any case not suitable for human consumption

The scoring system for determining product quality ensures clarity and uniformity of judgments, comparability of data, smoothes out the subjectivity of organoleptic evaluation.

The overall organoleptic evaluation of product quality is expressed as a total score, if the individual properties of the product are evaluated by points without a significance factor:

$$X = X_1 + X_2 + X_3 + ... + X_n,$$

where X – overall product quality in points; X_1, X_2, X_3, …, X_n – scores given for each indicator.

When using a score with significance coefficients, the total score is calculated by dividing the sum of the product of scores by the significance coefficient of each indicator by the sum of these coefficients:

$$X = (K_1 \cdot X_1 + K_2 \cdot X_2 + K_3 \cdot X_3 + ... + K_n \cdot X_n) / K,$$

where K_1, K_2, K_3, …, K_n – significance coefficients; X_1, X_2, X_3, X_n – scores given for each indicator; K – sum of significance coefficients.

An important element of the sensory study of food is the unambiguous description of perceived properties. The concepts used to characterize perceived properties should preclude or at least limit the possibility of their different interpretations. This implies the requirement to use standard concepts in the sensory study of food products. Practice has shown that it is impossible to obtain a generally recognized clear and unambiguous description of organoleptic features in the absence of unification of the terms expressing them [5-10].

It is important to develop a questionnaire to assess the organoleptic characteristics of products and identify consumer preferences (Table 3).

Table 3

Formation of a questionnaire to analyze the requests of potential consumers

Poll parameter	Versions of answers
Age (if a student answers)	7-11 11-14 14-18
Relationships (if not a student answers)	Mother/Father Grandmother/Grandfather Brother/Sister Guardian
What foods students eat most often at school	Brings home cooked food
	Brings what his parents bought
	Brings what he bought
	Buys food cooked at the school canteen
	Buys food at the school cafeteria
How often a student east fish products (dishes)	More than 3 times a week 2 times per week 1 time per week 1 time per month Doesn't eat fish
What qualities of fish products (dishes) are negative for you	A specific fishy smell Small bones Allergic reaction
What characteristics need to be changed in order for fish products (dish) to cause a desire to eat	Attractive color (not grey) In appearance, it resembles a product (dish) from meat or poultry Product (dish) made from minced meat or fillet (easily eaten)
What characteristics should an “ideal” fish product (dish) have?	Useful products (the natural beneficial characteristics of fish are preserved as much as possible) No preservatives No artificial colors and flavor enhancers; The products (dishes) include only natural ingredients In the production of products heat treatment is used, with the exception of frying or deep-frying and smoking

Justification of the product parameters for school meals should consist of two parts of equal importance. First, the requirements of sanitary and regulatory documentation for food products for schoolchildren, taking into account the requirements for a balanced healthy diet. Second, it is the taste preference of schoolchildren, their organoleptic expectations from the products offered.

An important factor is that, in fact, a potential consumer is deprived of the opportunity to choose food products. Quality management plays a major role in assessing the level of attractiveness of products for children and adolescents. It can both maintain quality at the required level and improve it. Increasing expectations of potential consumers leads to the fact that the concept of continuous improvement is increasingly used, which is directly dependent on the tools and methodologies used to manage and improve quality.

One of the goals of quality management methods is sufficient simplicity and visualization of solutions. A fairly simple and well-known quality improvement technique - Quality Function Deployment (QFD) methodology - is a project of Japanese scientists that allows to translate the expected ever-increasing needs of food consumers into the detailed basic and additional characteristics of the products under study; the goal of this design is using the matrix “House of quality” (quality house) [11]. Quality Function Deployment (QFD) is a methodology for the systematic and structured transformation of the wishes of schoolchildren into quality requirements for fish dishes made in an industrial setting or in a school cafeteria. In accordance with the proposed QFD methodology, the wishes of schoolchildren and their parents are established, namely: color, taste, smell and texture. However, on the part of the state responsible for the health of the younger generation, important factors are: safety, absence of preservatives, flavors, dyes and production cost.

To identify the reliability of the applied categories of indicators, special questionnaires were developed and interviews were conducted with both potential consumers and their legal representatives, state control bodies and representatives of companies providing food services in schools.

The starting point is the official requirements for ensuring the normalized nutrient sufficiency established in the norms of physiological need [13].

In the course of the research, an assessment was made of the quality of fish dishes. In a comparative analysis, as a control sample, fish cakes were made according to traditional technology using wheat bread. All samples received satisfactory results, but two samples differed significantly in organoleptic characteristics, which received the highest score and the lowest score.

The results of studying the requests of potential consumers made it possible to divide the requirements into three groups.

The first group – implied:

– absence of a distinct fishy smell;

– absence of gray tones in the color range of finished products;

– absence of fish bones in the finished product.

The second group – unconscious:

– resembles meat or poultry products in appearance;
– no negative effects on the body (allergic reactions);
– ease of use (it is possible to eat without a knife, as knives are not always available in the school cafeteria).

The third group – expressed:

– useful (preservation of the native properties of the components included in the composition);
– no preservatives;
– no dyes or flavor enhancers;
– natural ingredients;
– mild heat treatment;
– aesthetically attractive look.

Consumers' requirements were prioritized. To do this, we used the expert method of full pairwise matching. As a result of the comparison, the most important requirement of the consumer turned out to be (the requirement that he did not express during the survey) the absence of fish bones in the finished product and the stated requirement – the presence of natural ingredients in the composition (Table 4).

Table 4

Prioritized customers' requirements

Consumers' requirements	Natural Ingredients	Lack of fish bones	No preservatives or flavor enhancers	Ease of use of products	Utility	Gentle heat treatment	Lack of a distinct fishy odor	Aesthetic appearance	Product color range
Significance coefficients	0.3	0.1	0.03	0.09	0.15	0.13	0.08	0.07	0.03

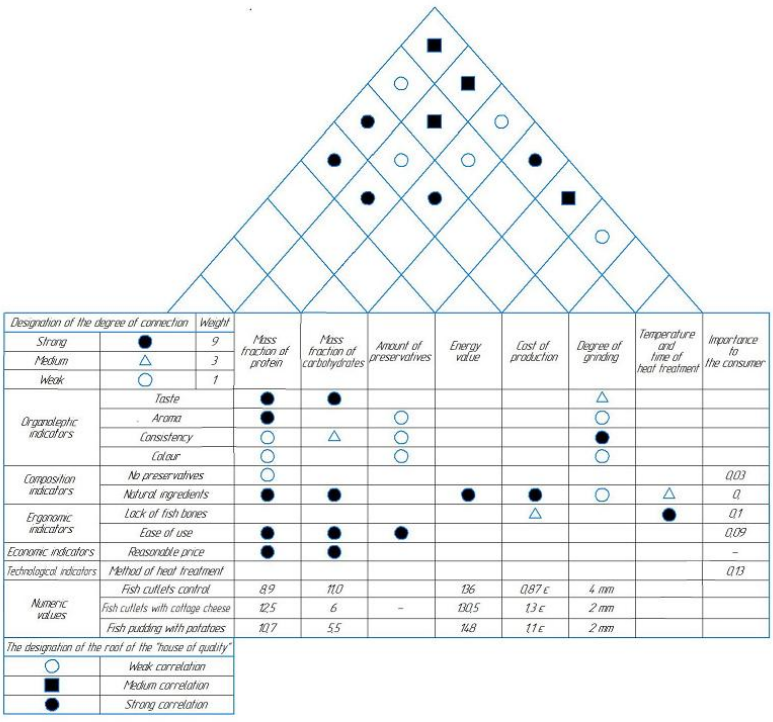
As a result of the analysis of personal data and the established coefficients of significance, a "house of quality" was built, shown in the figure. The presented relationships allow us to correlate consumer requirements for fish products, which should be implemented in the menu of school canteens, with the requirements of regulatory documents and technical parameters of products, as well as to establish the relationship between product characteristics.

Quantitative values of indicators have been established, which fish dishes should have for schoolchildren in order to meet the predicted consumer preferences (Table 5).

Table 5

Quality indicators of fish products for schoolchildren for one meal (lunch)

Chemical composition	Cutlets from minced white fish	Cutlets from a combination of minced white/red fish
Mass fraction of protein %, not less than	8.0	8.0
Mass fraction of fat %, not less than	1.0	5.5
Mass fraction of carbohydrates %, not less than	5.0	5.0
Energy value, kcal, not more than	180	180



Picture Preference Matrix "House of Quality"

Analysis of the relationship between quality indicators and the importance of the parameters of perception of the product by the consumer made it possible to choose the appropriate optimum in quantitative terms of indicators that most accurately characterize the quality of the final product. The choice of indicators was also influenced by the possibility of achieving important characteristics for the consumer, while the costs had to be minimized. As a result, areas for improvement were identified. Creating a product range for schoolchildren has a number of limitations, primarily related to the inability to use various technological aids (preservatives, flavor enhancers, flavors and dyes).

Conclusion

Thus, the direction of improving the parameters of products has been chosen, which ensures using the affordable and healthy natural ingredients. Particular attention is required to the development of technological regimes to ensure the absence of bones in the finished product.

After a systematic analysis of the resource provision of qualitative and quantitative indicators of the composition of fish raw materials, taking into account the requirements for food products for schoolchildren and the identified consumer preferences, it was decided to make minced products from frozen cod, hake and pollock as objects of study.

Based on the conducted qualimetric forecasting, recipes and technology for manufacturing a line of fish products were developed for inclusion in the diet of schoolchildren both in school canteens and through a retail network for cooking at home for this category of the population.

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