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DESIGN AND DEVELOPMENT OF CONSUMER-ORIENTED PRODUCTS THROUGH THE METHOD OF QUALITY FUNCTION DEPLOYMENT

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Abstract

One of the promising areas for new product development is the use of modern quality management tools and methods, such as the QFD (Quality Function Deployment) methodology. QFD methodology includes application of such instruments and methods of quality management as the: Diagram of Affinity, Tree Diagram, Method of Benchmarking, Method of "Kano model" and so on. The aim of this study was to apply the methodology of QFD to develop a new product of improved quality (granola), taking into account the wishes of the consumers.

In accordance with the set task, the object of the research is the development of a new type of granola. Based on the marketing research and the Kano method, the consumer preferences were identified and the relationship between the consumer satisfaction and the product characteristics was established. The obtained results were used in the construction of the "House of Quality". Benchmarking method was used to compare the quality indicators of the new products with the indicators of competing products.

As a result, it has been determined how much the product we are developing will compete with the best analogues in the market. Based on the analysis of the study of regulatory documents, the list of the most important technical characteristics of granola, which are included in the ceiling of the "House of Quality". For determining strength of the connections between the consumers' demands and technical characteristics, the matrix of the connections was made. Based on the calculations, the total assessment and the priority of the quantifiable indicators were determined, taking into account their rating of importance and the strength of the relationship between the consumer requirements and the quantifiable indicators.

As a result of the research, the following characteristics have been highlighted as the priority - oriented in the development of the new granola: the type of the main raw materials and additives, the content of the biologically active substances, the natural composition, and the preventive properties. These technical characteristics should be paid attention to first of all as it will allow to create a product with improved consumer properties and good organoleptic indicators.

***Key words**: QFD methodology, Grain product, Quality, Marketing researches.*

1. Introduction

Food needs are of great importance in the system of social needs in any country of the world, and failure to meet them leads to catastrophic consequences (disease and population decline, decline in the level of working capacity, etc.). The United Nations (UN), represented by its most important unit - the World Health Organization (WHO) has put nutrition at the top of the list of indicators of living standards of modern person. According to the UN report "State of Food Security and Nutrition in the World 2021", due to the shortcomings of global food systems, health care costs due to an unhealthy diet are growing rapidly. The need to rationalize human nutrition is supported by WHO data on medical problems in Europe related to nutrition problems [1]. Therefore, there is a need to develop new types of foods of increased nutritional value with regulated nutrient composition. But the food product

cannot be considered as a mixture of components of the recipe and the result of technological processes of its production. Food products are designed for consumers who expect product characteristics that meet their requirements.

In this regard, in the development of new foods more and more attention is paid to the use of modern scientific methods. Currently, there are low-cost but effective methods to identify consumer expectations of new products, implementing them faster than competitors. At the same time, if earlier the manufacturer had to launch a limited batch of new goods while studying demand, losing precious time and incurring significant material costs, today only modern methods are enough to study consumer reaction [2].
The most effective method of transforming consumer requirements into quality characteristics of a new product is the methodology of the quality function deployment (QFD-methodology) [3]. The application of this methodology is based on obtaining consumer requirements for the product, identifying the most important and promising of them, and converting these requirements into quantitative technical characteristics of the product. The peculiarity and advantage of using this methodology is to obtain not only the requirements for the product expressed during the survey, but also unconscious requirements. Fulfillment of these requirements will allow the enterprise to offer the consumer the goods with the unique characteristic and to win in competition [2 - 4].

The structure of consumer demand has recently been transformed by social and economic factors. People try to minimize cooking time, while consuming more products with a high content of biologically active substances (BAS), a balanced chemical composition and pleasant organoleptic properties. Modern technologies allow to produce products based on various types of raw materials and additives. As a result, to obtain products with such properties as high concentration of nutrients and their absorption, the possibility of use without additional heat treatment, long storage period [5]. In this regard, the ready-to-use products - granola in the form of bars - are of particular interest to consumers. We are conducting research on the development of new types of granola for preventive purposes based on grain raw materials with the inclusion of various types of natural additives. This is also due to the fact that the range of these products in the consumer market is quite limited. Granola on the market does not always meet consumer requirements. As can be seen from the above, it is important to develop new grain products of high nutritional value, taking into account consumer preferences based on modern methods of quality management.

The purpose of the work is development of new types of granola of increased nutritional value taking into account consumer preferences with the help of QFD-methodology. To achieve this goal, the following objectives should be pursued:
- To identify the needs of potential consumers for a new product;
- To build a "House of Quality" by transforming the wishes of consumers into quantitative technical characteristics of the product
- To determine the priority of optimization of a new product that will ensure its demand by potential consumers.

2. Materials and Methods

Development of a new type of granola using QFD-methodology involves performing the following steps [2, 6]:
1. Determination of consumer requirements for the products being developed;
2. Ranking and grouping of consumer requirements;
3. Comparison of quality indicators of new products with indicators of product quality of a competitor;
4. Compiling a list of the most important technical characteristics of the products being developed;
5. Transformation of expectations (requirements) of consumers in technical requirements of production;
6. Determining the relationship between consumer expectations and the parameters of technical requirements for new products;
7. Identification of the closeness of the interaction between the technical parameters and the reflection of the strength of such interaction in the triangular correlation matrix
8. Development of a new product concept; and
9. Determination of target (planned) quality indicators of new products.

QFD methodology includes application of such instruments and methods of quality management as the: Diagram of Affinity, Tree Diagram, Method of Benchmarking, Method of "Kano model", matrix diagram and so on [6, 7]. "Voice of the Customer" was used to determine consumer requirements. This is a hierarchical structured set of needs for a new product, set out in the language of the consumer [7].

According to the Kano method, a map of the potential of consumer satisfaction and dissatisfaction was compiled. In this matrix, all product characteristics are divided into four main categories, which are displayed on the graph, where the X axis reflects the potential for consumer dissatisfaction, the presence of the function (implemented, not implemented), and the Y axis - the potential for customer satisfaction (Satisfied, unsatisfied) [8 - 10].

Consumer satisfaction potential was calculated by the formula [10]:

$$P_{s.c.} = \frac{(k_c + k_o) \times 100}{(k_c + k_o + k_n + k_r + k_{n.m.})} \quad (1)$$

Where: $P_{s.c.}$- consumer satisfaction potential,%; k_c- answers of respondents characterizing questionable properties,%; k_o- answers of respondents characterizing one-dimensional properties,%; k_n- answers of respondents characterizing the required properties,%; k_r - answers of respondents characterizing the properties of the reverse action,%; $k_{n.m.}$- respondents' answers that characterize properties that do not matter,%.

The potential for consumer dissatisfaction was calculated by the formula:

$$P_{s.c.} = \frac{(k_o + k_H + k_r) \times (-100)}{(k_c + k_o + k_n + k_r + k.n.m.)} \quad (2)$$

On the basis of certain target values can be calculated "degree of improvement" of quality (for each of the characteristics of the product) by the formula [7]:

$$\text{Degree of improvement} = \text{Target value} / \text{Quality assessment} \quad (3)$$

After determining the degree of improvement, the importance of each consumer expectation or product characteristics is determined. The weight is calculated by the formula [7]:

$$\text{Weight} = \text{importance rating} \times \text{degree of improvement} \quad (4)$$

Numerical estimates of the significance of the strength of the relationships, each technical characteristics of the new product, which are given in the squares of the matrix of relationships, are calculated by the formula [7]:

$$\text{Significance of relationships} = \text{strength of relationships} \times \text{weight} \quad (5)$$

3. Results and Discussion

The first step in a new product development on the basis of the QFD-methodology is to determine consumer expectations using the "Voice of the Customer". We interviewed 50 potential consumers who were asked an open-ended question "Please make a list of your wishes regarding the quality of a new type of granola with increased nutritional value." The answers to this question allowed us to establish a list of consumer requirements for expected products. Due to the fact that the consumer formulates his wishes in an abstract form, we at the stage of information processing all the requirements of consumers were clarified, simplified and specified. Generalization and structuring of consumer requirements was carried out using two quality management tools, namely, the affinity diagram, and the tree diagram.

On the basis of affinity diagrams (interrelationship), all of them were structured, and the very, systematized and refined, they were duplicated and superbly versed [6 - 7]. As a result, the number of requirements was significantly reduced, because the same requirements were removed and similar ones were generalized. But consumer demands are always contradictory. It is impossible to create new products that meet all consumer requirements, so you need to know which requirements must be met, and which can be somewhat neglected. In this regard, the ranking of consumer requirements for the Kano model was performed. To do this, an additional focus group was involved, namely 50 respondents who are experts in new product development (manufacturers, developers, scientists). Respondents were asked to rate the importance of consumer requirements on a ten-point scale [9]. This allowed to form a relationship between different characteristics of granola and customer satisfaction and to create a satisfaction map based on the quality model of Kano (Figure 1).

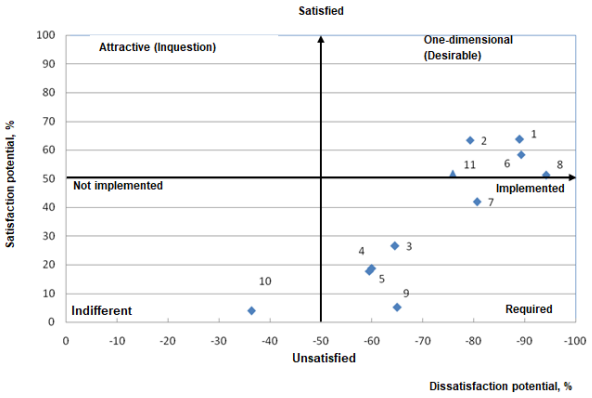


Figure 1. Map of satisfaction and dissatisfaction of consumers of a new type of granola according to the Kano model: 1 - taste and aromatic characteristics; 2 - color and appearance; 3 - balanced chemical composition; 4 - content of BAS; 5 - energy value; 6 - natural composition; 7 - health effect on the body; 8 - safety; 9 - affordable price; 10 - long storage life; 11 - convenient and informative packaging

The results of the calculation of the potential of satisfaction and dissatisfaction, which we performed earlier [10], indicate that the analyzed characteristics of the product can be divided into the following categories:

1. Required product specifications are in the lower right square

The presence of these properties determines that the product will be in demand among consumers. Lack of them will lead to dissatisfaction. The presence of these requirements is taken for granted, but if they are not taken into account, no other (hidden or established) can affect the benefits of the product. Respondents included in this category "balanced chemical composition", "content of BAS", "energy

value", "wealth effect on the body", "affordable price". The potential for satisfaction and dissatisfaction with these characteristics, which was calculated according to formulas 1 and 2, was: 26.58; 18.67; 17.72; 41.93; 5.10%, and - 64.56; - 60.00; - 59.49; - 80.65; -65.00%, respectively. From the developer's point of view, these features need to be maintained and improved.

2. Characteristics in the upper right square are desirable

They are not directly related to basic needs, but their presence makes the consumer satisfied. Based on these characteristics, the competitive advantages of the product are based. Respondents included the following characteristics in this category: "taste and aromatic characteristics", "color and appearance", "natural composition", "safety" and "convenient and informative packaging". Satisfaction potential is quite high (respectively 63.70; 63.40; 58.33; 51.16 and 51.72%), with a significant potential for dissatisfaction - respectively - 89.00; -79.26; -89.29; - 94.19 and -75.86%). The developer needs to maintain and improve these features.

3. The properties in the upper left square are called "In question".

These are the characteristics of the product that make the consumer more satisfied. They can be considered for product positioning in the premium segment. In the course of research, the consumer did not identify the characteristics that should be included in the "hidden opportunities"

4. No value is given to the properties of the product falling into the left bottom square - "Indifferent".

Respondents attributed such properties to "long storage period". The potential for satisfaction is 3.89%, dissatisfaction - 36.36%. This indicates that this characteristic has little effect on customer satisfaction or dissatisfaction.

With the help of a tree diagram, all requirements were structured and divided into groups. As a result, a three-level structure (Figure 2) was built, which was later used to form the concept of a new product.

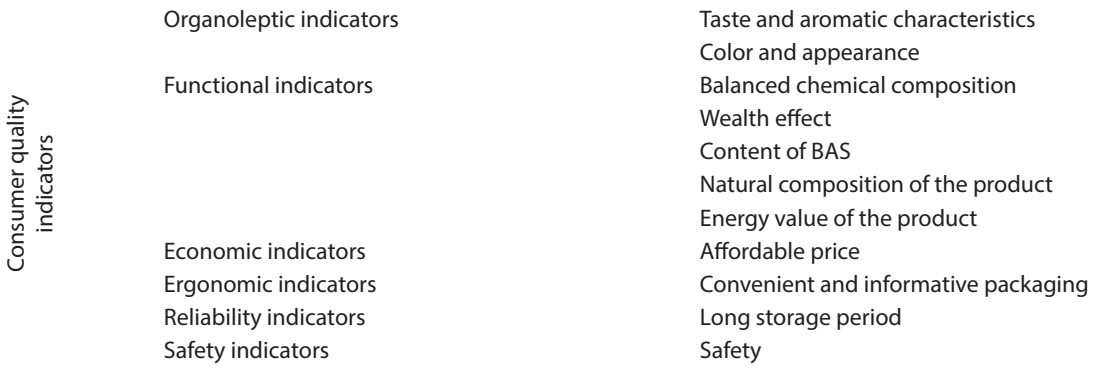


Figure 2.Tree diagram of quality indicators of a new type of granola

Table 1.Quality indicators of a new type of granola

Quality indicators	Desirable characteristics of the quality of the new product
Taste and aromatic characteristics	The taste and smell of the product should be harmonious, pleasant, characteristic of the component composition of the product with a pleasant aftertaste, without extraneous flavors
Color and appearance	Color is uniform, corresponding to the color of the components used. Rectangular product, the shape of the products is correct, rough surface with minor splashes of additives used
Balanced chemical composition	Product must be characterized by a balanced chemical composition (in terms of protein, carbohydrates and fats).
Wealth effect	When consuming the product, the consumer must receive a wealth effect
Presence of biologically active substances	Product must contain a high and balanced content of BAS
Natural composition of the product	The product must be made of natural ingredients, do not contain preservatives, artificial flavors and colors
Energy value of the product	The product must meet the consumer's energy needs
Affordable price	Affordable price of the product
Convenient and informative packaging	Convenience of opening and informative packaging
Long storage period	Storage period is more than 6 months.
Safety	The product must be completely safe in terms of microbiological parameters, content of toxic elements, mycotoxins, radionuclides, pesticide residues

The first level of the diagram shows the generalized characteristics (consumer quality indicators) of the new product. At the second level, quality indicators are defined. At the third level, consumer requirements for each quality indicator of a new type of granola of high nutritional value are determined, which are given in Table 1.

In the course of the following focus group questionnaires, the weighting coefficients of certain quality indicators [6 - 7] were established on a five-point scale, namely: 5 - very valuable, 4 - valuable, 3 - less valuable, but it would be good to have; 2 - not very valuable; and 1 - is not a value. According to the rating of consumer requirements, it is established that the most important for consumers of granola are improved taste and aroma characteristics of the product; color and appearance, natural composition of the product, safety; convenient and informative packaging. The results of consumer requirements, their priorities are included in special columns of the "House of Quality" (Figure 3).

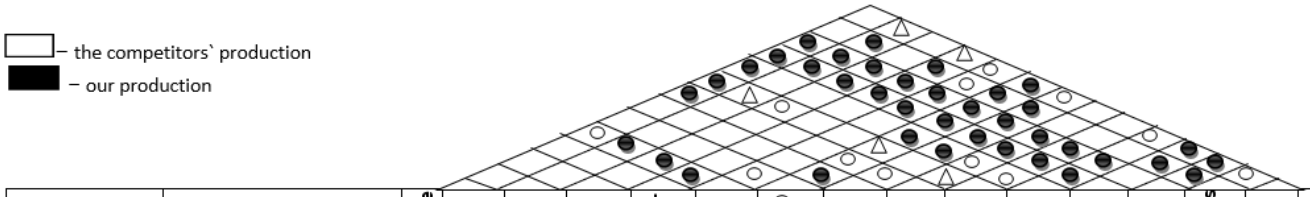
According to the QFD methodology, the next step was to conduct benchmarking to compare the quality of new products with those of competing products. As a result, we gain an understanding of how much our product will compete with the best analogues on the market. When conducting benchmarking, the focus group used a five-point scale from "excellent" to "poor", namely: 5 - excellent, 4 - good; 3 - satisfactory (mostly corresponds); 2 - not very satisfactory (answers in part); 1 - bad (does not meet expectations) [6-7]. The results of this comparison are presented in the veranda of the "House of Quality" (Figure 3).

The competing product was selected on the basis of market analysis and consumer surveys. As a result, TM "Oats and Honey" biscuits were selected, which are sold in retail chains of Ukraine and are in demand among consumers. Information on the technical characteristics of the competitor's products was analyzed using product labeling and regulatory documentation. The results of the "degree of improvement" of the new product and the "weight" calculated according to formulas 3 and 4 are given in the top of the "House of Quality" (Figure 3).

The focus group, then, transformed consumer expectations into the "language" of quantitative technical parameters and product characteristics. The challenge was to determine what consumer expectations could be used to gain a competitive advantage. To establish the strength (durability) of the relationship between the requirements of the consumers and the technical characteristics, a linkage matrix is made, which is shown in the central room of the Quality House (Figure 3). In this case, a black circle indicates a strong dependence (9), an unpainted circle - a medium (3) and a triangle - a weak (1). An empty cell means that there is no relationship between consumer preferences and technical characteristics. Also, for each characteristic according to formula 5, a criterion is calculated that taking into account the value of the relationships strength of a particular characteristic and the weight of the quality indicator. By all appearances, the transformation of consumer requirements into technical characteristics showed that the "wealth effect" of the product depends primarily on the chemical composition of the product (weight fraction of protein, starch, fiber, content of biologically active substances), energy value, type and amount of additives, the type of grain raw materials and the presence of preventive properties of the finished product (Figure 3). The taste and aromatic characteristics are most influenced by the type of additives and grain raw materials, the presence of biologically active substances, the storage period of the product.

The next step is to determine the closeness of the interaction between the technical parameters of the product. Relationships of quantitatively measurable indicators are marked with symbols that characterize the degree of dependence (strong, medium, weak). Reflections of the strength of such interaction are included in the triangular correlation matrix (the so-called roof of the "House of Quality"). For example, the indicator "energy value" is in strong interaction with the chemical composition of the product (mass fraction of protein, starch, fiber), as well as the type of additives and the type of basic raw materials (Figure 3).

At the next stage, the total assessment and priority of quantifiable indicators was determined, taking into account their rating of importance and strength of the relationship between consumer requirements and quantifiable indicators. The sum of the cell scores of one column indicates the priority of the technical parameters of the product being developed. The priority of each technical parameter in percent was found as the ratio of its total score to the sum of all total scores of technical parameters. The obtained data were then used to fill the basement of the "House of Quality" (figure 3), namely in the calculations of product priority. According to the results of the calculation, it is established that when developing a new type of granola, first of all it is necessary to pay attention to the technical characteristics with the highest priority, as they fulfill the wishes of consumers that are most important to them. The most priority in the development of a new type of granola are the following characteristics: type of additive (14.1%), type of grain (14.1%), content of biologically active substances (10.67%), preventive properties (9.37%),



Symbol	Power of interconnection	Coefficient of weight
●	Strong	9
○	Medium	3
△	Weak	1

Consumers' demands	Quality indicators	Rating of importance	Weight fraction of moisture	Weight fraction of protein	Weight fraction of carbohydrates	Weight fraction of fiber	Energy value	Presence of BAS	Safety indicators	Acidity	Strength	Expiration date	Type of additives	Type of grain crop	Preventive properties	Cost	The consumer`s estimation					Target value	Degree of improvement	Weight	Weight,%
																	1	2	3	4	5				
Organoleptic indicators	Taste and aromatic characteristics	5	△ 10	△ 10	△ 10	△ 40		● 86		○ 29		● 86	● 86	● 86						▭	■	5	1.00	5	9.61
	Color and appearance	5	● 104	△ 12	△ 12			● 104		○ 35	● 104	● 104	● 104	● 104						■	▭	5	1.25	6	11.55
Functional indicators	Balanced chemical composition	4	△ 8	● 69	● 69	● 69	● 69	○ 23	○ 23			○ 23	● 69	● 69	● 69				▭		■	5	1.00	4	7.69
	Wellness effect	4	△ 8	● 69	○ 23	● 69	● 69	● 69				△ 8	● 69	● 69	● 69					▭	■	5	1.00	4	7.69
	Presence of BAS	4		△ 8	△ 8	○ 8	△ 8	● 69				● 69	● 69	● 69	● 69	△ 8				▭	■	5	1.00	4	7.69
	Natural composition of the product	5		○ 29	○ 29	○ 29		● 86	● 86			● 86	● 86	● 86	● 86					▭	■	5	1.00	5	9.61
	Energy value of the product	4	○ 23	● 69	● 69	● 69	● 69	△ 8	● 69				● 69	● 69	● 69						▭ ■	5	1.00	4	7.69
Economic indicators	Affordable price	4											● 86	● 86	△ 10	● 86				■	▭	5	1.25	5	9.61
Ergonomic indicators	Convenient and informative packaging	5	○ 35							△ 12	△ 12	● 104				● 104				▭ ■		5	1.25	6	11.55
Reliability indicators	Long storage period	3	● 69	△ 8	△ 8	△ 8	△ 8	● 69	● 69	● 69	○ 23	● 69	● 69	● 69	● 69	○ 23				■	▭	5	1.25	4	7.69
Safety indicators	Safety	5	● 86					● 86	● 86	● 86	△ 10	● 86	● 86	● 86	● 86	△ 10				▭	■	5	1.00	5	9.61
Total estimation			343	274	228	262	223	600	333	231	149	635	793	793	527	231								52	100
Priority, %			6.1	4.87	4.06	4.66	3.98	10.67	5.92	4.11	2.65	11.3	14.1	14.1	9.37	4.11								Total	

Figure 3. "Quality house" for the design of granola of increased nutritional value

storage period (11.3%). When developing a product, these technical characteristics should be considered in the first place, because they have strong relationships with most consumer requirements.

Thus, the development of new types of granola of increased nutritional value, taking into account the results obtained will help to obtain a product that will be competitive in the market, i.e. in its consumer properties and economic indicators will satisfy the target group of consumers.

4. Conclusions

- Based on marketing research, the main requirements of potential consumers for granola, high nutritional value, have been identified. It has been established that the most important for consumers are the improved taste and aroma characteristics of the product; color and appearance, natural composition of the product safety; convenient and informative packaging.
- By using quality management tools (affinity diagrams, tree diagrams, "Kano" models, benchmarking), consumers' wishes were transformed into quantitative technical characteristics of the product and a "Quality House" was built.
- It has been established that in the development of granola with high nutritional value, it is necessary to ensure the preventive focus of the new product through the use of natural grain raw materials and additives with high content of biologically active substances, and of course, special attention should be paid to storage period and safety indicators, and most of all it allowed to create a product with good consumer properties.

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