Стаття присвячена питанню використання методології розгортання функції якості при розробці нового зернового продукту оздоровчого призначення. На основі одержаних вимог споживачів до цього продукту виявлено серед них найбільш важливі і перспективні та проведено перетворення цих вимог у кількісні технічні характеристики продукту. Отримані результати дозволили виділити ті споживчі переваги, які необхідно обов'язково враховувати при розробці нових зернових хлібців для того, щоб забезпечити попит на такі продукти з боку потенційних споживачів

Ключові слова: якість, методологія розгортання функції якості, споживчі вимоги, зернові хлібці, "будинок якості"

Статья посвящена вопросу использования методологии развертывания функции качества при разработке нового зернового продукта оздоровительного назначения. На основе полученных требований потребителей к данному продукту выявлены из них наиболее важные и перспективные, проведено преобразование данных требований в количественные технические характеристики продукта. Полученные результаты позволили определить те потребительские предпочтения, которые необходимо обязательно учитывать при разработке новых зерновых хлебцев для того, чтобы обеспечить востребованность данных продуктов со стороны потенциальных потребителей

Ключевые слова: качество, методология развертывания функции качества, потребительские свойства, зерновые хлебцы, "дом качества"

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QFD METHODOLOGY TO DEVELOP A NEW HEALTH-CONDUCIVE GRAIN PRODUCT

M. Mardar
Doctor of Technical Sciences, Professor, Head of Department*
E-mail: mardar.marina@yandex.ua
D. Zhygunov
Doctor of Technical Sciences, Associate Professor, Head of Department**
E-mail: ZhygunovD@gmail.com
R. Znachek
Postgraduate student*
E-mail: rafaehlab@yandex.ru
*Department of Marketing, Business and Trade***
Department of Technology of Grain Processing*
***Odesa National Academy of Food Technologies
Kanatna str., 112, Odesa, Ukraine, 65039

1. Introduction

Development of new products is a strategic stage in successful functioning and expansion of food enterprises. However, competitive advantage in a dynamic market cannot be achieved and maintained only by manufacturing a product that would comply with requirements of normative documents. Lack of knowledge about real demands of consumers when offering new products for sale may lead to adverse consequences for the manufacturer [1]. For example, according to research findings of General Motors (USA), development and manufacture of products entails a rule of tenfold expense: if a mistake was made at one stage of the product life cycle and was revealed at the next stage, it would cost ten times more to correct it than if it had been revealed in due time. If it was detected past one stage, it will cost 100 times as much, and if two stages have already passed, its correction will cost 1,000 times more, and so on. If all the stages proceed correctly, the result will meet the established requirements. A Japanese proverb says: "The tree grows depending on the branch bending". In the context of this study, it means that a decision at the initial stage of the product development has to be the most responsible [2].

Thus, during the stage of developing food products, more attention should be paid to using modern scientific methods. Nowadays, there are low-cost but effective methods that help reveal consumer expectations of any new product and implement them faster than it can be done by competitors. Moreover, if the manufacturer used to produce a limited batch of new goods during the time of studying the demand and, thus, wasted precious time and costs, nowadays consumer response can be researched even by applying a virtual model.

The most effective model of transferring consumer demands into quantitative characteristics of a new product is the methodology of quality function deployment, which is usually used alongside sociological marketing methods, bench-marking and other instruments of quality management [1].

This methodology is used to determine consumer requirements for a new product, to reveal the most important and persistent ones among them, and to transfer these requirements into quantitative technical characteristics of the product. The peculiarity and advantage of using this methodology is to elicit not only overtly surveyed requirements for the product but also those subconscious requirements meeting which can enable an enterprise to win the market competition by offering the consumer a product with unique characteristics [3, 4].

2. Analysis of the reference literature and statement of the problem

Quality function deployment (QFD) is a methodology that represents an unconventional Japanese tactic of a sys-

tematic and structural transformation of consumer wishes into technical requirements for product quality [4].

The methodology of quality function deployment was developed in 1966 by Dr Yoji Akao and was first practically used by Matsushita Electric as its "quality assurance plan". In 1978, the Japanese scientists Dr Yoji Akao and Dr Shigeru Misuno published their first monograph on quality function deployment, and in 1987 a collection of works was edited by Dr Yoji Akao and published in Japan on the experience of using this methodology in various industries [1, 5–7].

Since 1977, this methodology has been persistently used by Toyota Motor Corporation [5–7]. In 1983, the methodology of QFD was introduced in the USA, and slightly little it started being applied in Europe. Today the QFD methodology is successfully used in Japan, the USA and Europe, which has facilitated significant achievements of world-known companies such as Rank Xerox, Ford, Motorola, and Digital [2]. The future of the QFD methodology means its application as an integral part of total quality management (TQM), which is a more advanced level of quality management in comparison with the ISO 9000 series of quality standards.

The problems of quality management are especially crucial for sophisticated multi-stage technological processes of manufacturing products in which the resultant components are combined in particular proportions and the obtained mixture is affected by various technological operations to achieve the necessary properties, shape, and size. Such technologies are used in the food industry [7–11].

The key factor of success achievable by a food enterprise through introduction of a new product onto the market is a conformity between the main characteristics of the product and consumer needs. Client-oriented food products development puts consumers at the centre of the process of deploying products and production technologies that serve as instruments of achieving consumers' favour [12].

Application of the quality function deployment methodology at a food enterprise can help [13]:

– formalize the procedure of determining the main characteristics of the product that is developed with regard to consumers' wants;

– make well-grounded decisions on managing the quality of the new product development processes;

– minimise correction of the product parameters after its appearance on the market;

– provide high value and simultaneously relatively low price of the product at the expense of minimising non-production costs.

Thus, the QFD methodology is one of the main ways of achieving and sustaining business competitiveness because in order to survive on the products-flooded market an enterprise has to offer new products and maintain their high quality.

However, so far Ukrainian manufacturers of food products still lack the systematic experience of using this methodology. At the same time, many contemporary representatives of the food industry are strategically oriented towards production of healthy foods. Despite the intentions, the range of Ukrainian-made food products is limited and open to broadening and optimization. That is why the prospect of this research is to structure the quality function of a new food product by the example of grain crackers for health improvement and care for consumer demands.

3. The purpose and tasks of the research

The aim of the present study was to develop a new grain product for a healthy diet on the basis of the quality function deployment methodology.

The stated purpose was achieved by solving the following two tasks:

– to reveal conscious and subconscious requirements of consumers in order to transform consumer wants into quantitative technical characteristics of the grain product;

– to determine priorities in optimising a new product, namely to reveal those consumer preferences that must be necessarily taken into account while developing grain crackers so that this product could comply with the demand for it among potential customers.

4. Materials and methods of research

QFD-based development of the new product comprised the following stages [3, 4]:

(1) determining consumer requirements for new competitive products;

(2) processing and ranking consumer requirements;

(3) composing a list of the most important technical characteristics of the product to be developed;

(4) assessing the degree of closeness in the paired interactions between consumer requirements and the product's technical characteristics;

(5) determining an interrelation between the product's technical characteristics;

(6) developing the new product concept;

(7) devising the technical task for the product.

The given methodology includes application of quality management instruments such as an affinity diagram, a tree diagram, and benchmarking. Consumers' requirements for the product quality are shown stage by stage, beginning with the estimated necessity to offer the product on the market and finishing with the ways of quality control [3, 14, 15].

5. The results of implementing the QFD methodology

According to the algorithm of implementing the QFD methodology, the first stage includes conducting marketing research on consumers' preferences for the developed product with the purpose to collect information. The survey, however, is mostly aimed at studying consumers' opinions about already known characteristics of goods, which is not enough for creating a new competitive product. According to William Deming, the consumer expects to obtain only the thing that producers or their competitors "have allowed" to expect [16], which entails a necessity to understand consumers' real needs if consumers themselves do not know them.

Therefore, our questionnaire was developed by the method once suggested by Noriaki Kano, a professor at the Tokyo University of Science. In 1984, the Japanese scholar developed a concept of attractive quality creation and a questionnaire thereupon aimed at revealing product characteristics that appeal to the consumer. The questionnaire allows dividing all requirements for a product into three types: must-be, one-dimensional, and attractive. These three characteristics should satisfy three corresponding types of demands, which, according to the Kano model of customer satisfaction, are divided into ba-

sic needs, linear satisfiers, and delighters [16]. The first group of product characteristics (must-be requirements) is understood by consumers as implied, self-evident, or taken for granted. Complying with the must-be requirements hardly increases the product value, but non-compliance with them sharply reduces it (Fig. 1). The second group of characteristics is "quantitative", which entails that the consumer satisfaction (i.e. the conscious consumer valuation) increases to the extent of quantitative improvement of the corresponding parameter. The third group of characteristics has been called "attractive", or "surprising" [17].

The characteristics of desirable quality are highly valued by consumers and greatly capable of creating substantial long-term competitive advantages for a manufacturer. Consumer satisfaction increases when the parameters of quality value of the offered product surpass expectations. Discontentment appears when the parameters of quality value of the offered product are below consumer expectations. Thus, it is necessary to reveal all conscious and subconscious needs of the consumer concerning the product at the first stage of developing it so that the product could become competitive on the consumer market.

Answers to the open question "Please list your preferences on the quality of grain crackers" revealed a list of consumer requirements for the expected products. Since consumers stated their preferences in an abstract form, the responses were further processed by the method of compiling a "consumer voice" table in which the consumers' requirements were identified, simplified, and specified. Generalisation and classification of consumer requirements resulting from the questionnaire survey were derived with the help of two instruments of quality management – an affinity diagram and a tree diagram [3, 4].

First, the affinity (similarity) diagram was used to systematise and process all the requirements expressed in the "consumer language", which allowed to determine dubbing and complementarity preferences as well as to reveal contradictory requirements. As a result, the number of requirements was reduced by omitting identical preferences and generalising similar ones.

The next stage of the quality function deployment was to rank the consumer requirements. The tree diagram was used to classify the surveyed requirements into expected, expressed, and unexpected (Fig. 2).

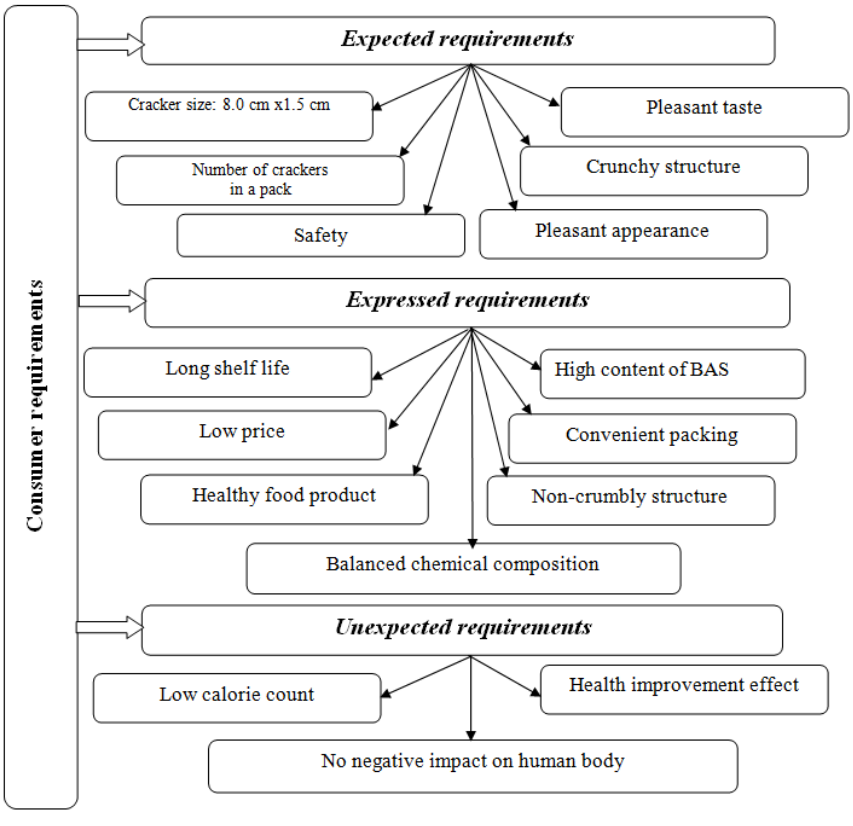


Fig. 2. The tree diagram of consumer requirements

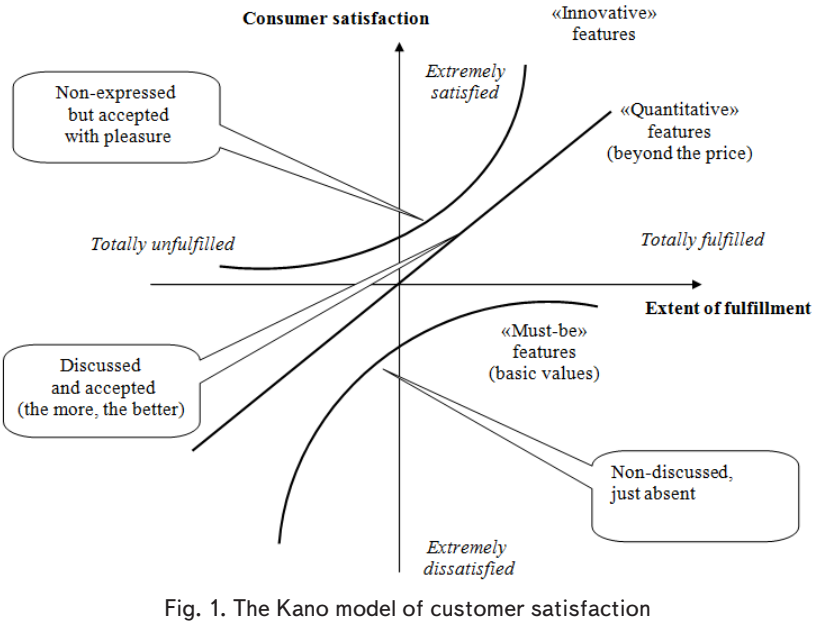
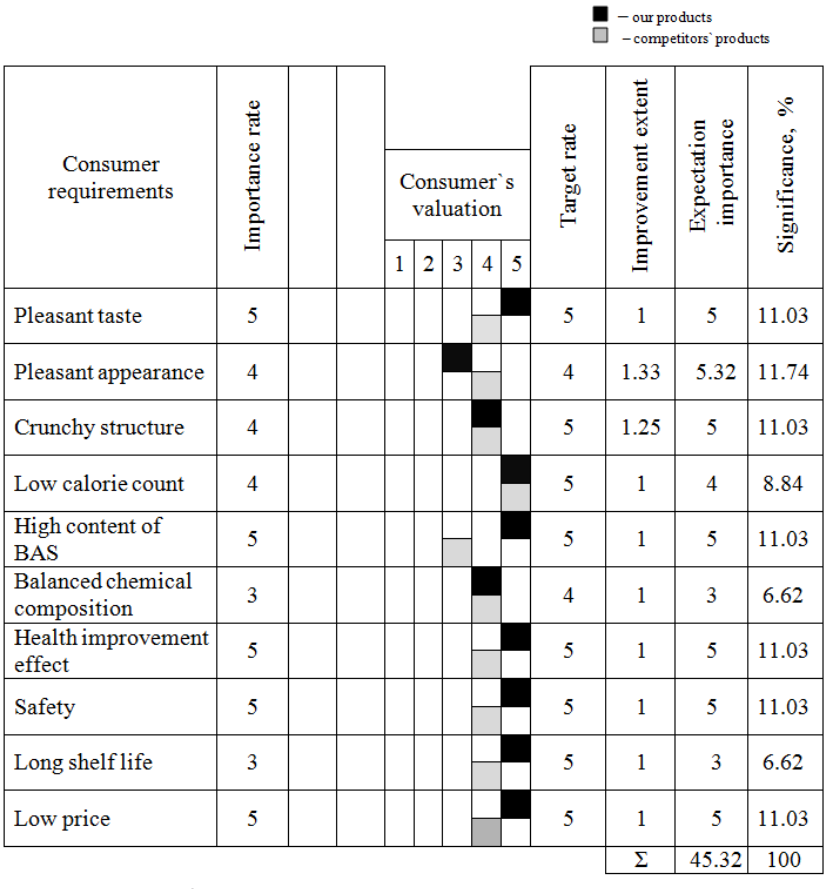


Fig. 1. The Kano model of customer satisfaction

As it has been stated before, the expected requirements for a food product must include obligatory safety and compliance with normative documents. Consumer requirements, however, are always contradictory and impossible to meet entirely while creating a product; thus, it is important to know what requirements must be satisfied while partially disregarding the other ones [3, 4, 14, 15, 18]. Therefore, the requirements listed in the tree diagram were prioritized. For this purpose, the surveyed consumers were addressed again to determine the significance factors of the consumers' preference indices at a five-point scale, namely: 5 – very valuable; 4 – valuable; 3 – less valuable but nice to have; 2 – not very valuable; 1 – not valuable at all [4].

By rating the consumers' requirements, we have determined the following most important preferred characteristics of grain crackers: taste, content of BAS

(biologically active substances), health improvement effect, safety, and low price. The results of the consumers' requirements, i.e. their priorities, were listed in special graphs of a "quality house" (Fig. 3).



Consumer requirements	Importance rate			Consumer`s valuation 1	2	3	4	5	Target rate	Improvement extent	Expectation importance	Significance, %
Pleasant taste	5							■	5	1	5	11.03
Pleasant appearance	4					■			4	1.33	5.32	11.74
Crunchy structure	4						■		5	1.25	5	11.03
Low calorie count	4							■	5	1	4	8.84
High content of BAS	5							■	5	1	5	11.03
Balanced chemical composition	3						■		4	1	3	6.62
Health improvement effect	5							■	5	1	5	11.03
Safety	5							■	5	1	5	11.03
Long shelf life	3							■	5	1	3	6.62
Low price	5							■	5	1	5	11.03
										Σ	45.32	100

Fig. 3. Importance ranking of customer requirements

The method of benchmarking was used to determine the comparative value of a competitive type of products developed by a well-known trade brand of grain crackers. However, unlike in traditional benchmarking of products, this stage included comparison of competitive systems beyond the technical characteristics: it dealt with the rate of consumer satisfaction with a range of product characteristics. The consumers' survey findings were transferred into a five-point scale and displayed in the "veranda" of the "quality house" (Fig. 3).

The results of the "Improvement extent" column were obtained according to the equation [4]:

Improvement extent=
=target rate : consumers' valuation. (1)

Significance of each expectation expressed by the consumers was determined by the following equation [4]:

Expectation significance=
=importance rate x *improvement extent.* (2)

Studying normative and technical documents resulted in determining the technical characteristics of the grain crackers with regard to the consumers' wants and expectations. The results were registered in the "ceiling" of the "quality house"; they were: protein content, starch content, cellulose content, BAS content, moisture content, energy value, acidity, strength, safety indices, number and type of additives, type of grain, proactive properties, shelf life, and price.

The strength of connections between the consumers' requirements and the technical characteristics was registered in a matrix that is shown in the central "room" of the "quality house" (Fig. 4). Empty cells in the matrix refer to absence of any connection between the consumers' expectations and the technical characteristics of the product. If there was an interrelation, a symbol was entered into a cell to specify the strength of connection. Besides, each feature was calculated as a criterion that took into account the importance of strength in the interrelation between a particular feature of the product and the requirements' priority suggested by the consumers.

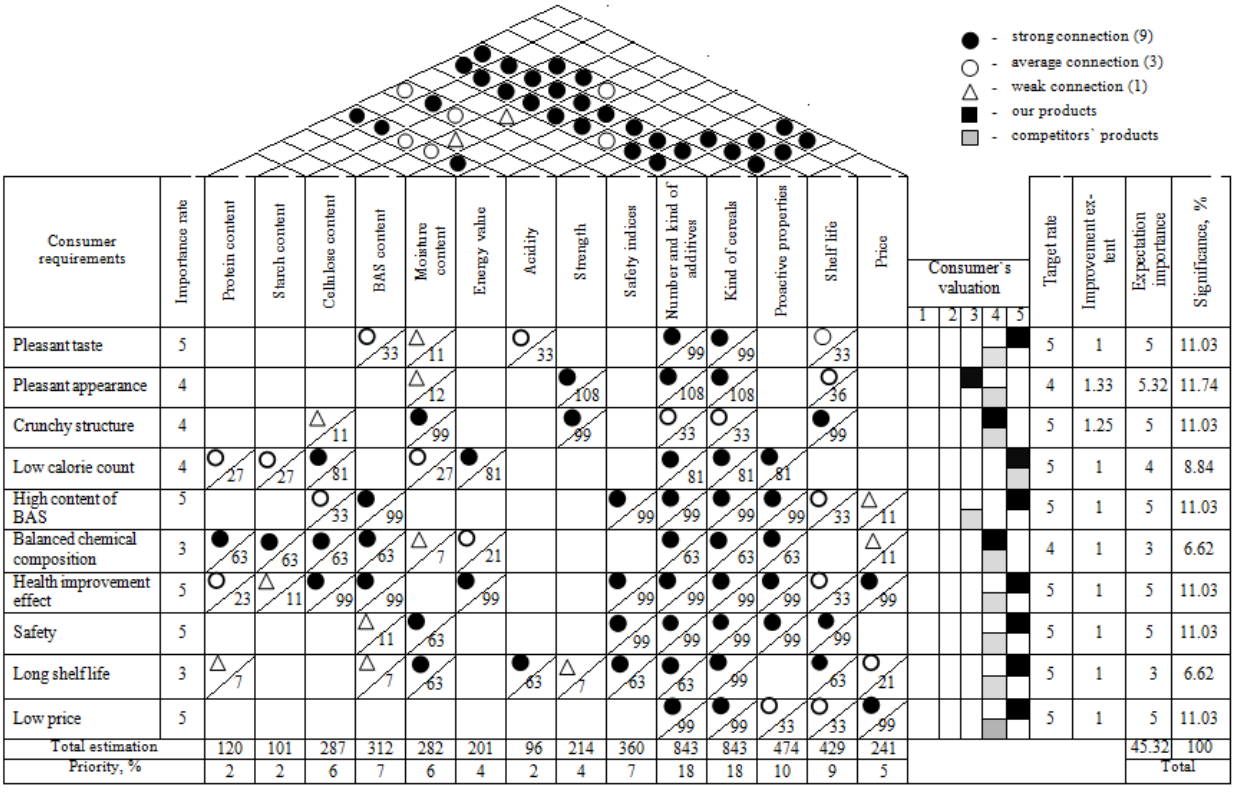
The numerical data on the importance of strength in the feature-priority interrelation for each technical characteristic of the product were determined by the following formula [4]:

Interrelation importance=interrelation strength x *significance, %* (3)

The transfer of the consumers' requirements into the technical characteristics shows that the balanced chemical composition of the product depends on the following factors: the chemical composition of the product (protein, starch, cellulose, and BAS content), the type and amount of the additives, the main grain as raw material, and presence of prophylactic properties of the finished product. The health improvement effect of a new product depends on the type of the main raw material and enriching additives as well as BAS and cellulose contents in them. The indices of safety and energy value of the finished product directly influence the health effect of the product.

The strength of interrelation between the technical parameters is represented by the elements of a triangular matrix in the "roof" of the "quality house". The cells of the roof are filled with data on the way the technical characteristics are interrelated with one another. Due to the fact that some technical characteristics are interrelated, it was technically impossible to shift the interrelated variables to sides. That is why each cell of the roof was filled with one of the following signs (empty or ● or ○ or Δ) to develop an exhaustive picture of the dependencies.

The next stage concerned determining demand priorities. Priorities in optimising the new product were determined by generalising the data on the strength of interrelations between the technical characteristics of grain crackers and the consumers' requirements; the findings filled the "cellar" of the "quality house". The results show that the primary concern in developing new grain crackers should be consumer requirements for the resulting material, namely the whole grain and natural enriching additives to develop a safe product with a longer shelf life and, primarily, a prophylactic purpose on the basis of high content of BAS.



Consumer requirements	Importance rate	Protein content	Starch content	Cellulose content	BAS content	Moisture content	Energy value	Acidity	Strength	Safety indices	Number and kind of additives	Kind of cereals	Proactive properties	Shelf life	Price	Consumer`s valuation 1	2	3	4	5	Target rate	Improvement extent	Expectation importance	Significance, %
Pleasant taste	5				○ 33	△ 11		○ 33			● 99	● 99		○ 33						■	5	1	5	11.03
Pleasant appearance	4					△ 12			● 108		● 108	● 108		○ 36				■			4	1.33	5.32	11.74
Crunchy structure	4			△ 11		● 99			● 99		○ 33	○ 33		● 99					■		5	1.25	5	11.03
Low calorie count	4	○ 27	○ 27	● 81		○ 27	● 81				● 81	● 81	81							■	5	1	4	8.84
High content of BAS	5			○ 33	● 99					● 99	● 99	● 99	● 99	○ 33	△ 11				■		5	1	5	11.03
Balanced chemical composition	3	● 63	● 63	● 63	● 63	△ 7	○ 21				● 63	● 63	● 63		△ 11				■		4	1	3	6.62
Health improvement effect	5	○ 23	△ 11	● 99	● 99		● 99			● 99	● 99	● 99	● 99	○ 33	● 99				■		5	1	5	11.03
Safety	5				△ 11	● 63				● 99	● 99	● 99	● 99	● 99					■		5	1	5	11.03
Long shelf life	3	△ 7			△ 7	● 63		● 63	△ 7	● 63	● 63	● 99		● 63	○ 21				■		5	1	3	6.62
Low price	5										● 99	● 99	○ 33	○ 33	● 99				■		5	1	5	11.03
Total estimation		120	101	287	312	282	201	96	214	360	843	843	474	429	241								45.32	100
Priority, %		2	2	6	7	6	4	2	4	7	18	18	10	9	5								Total	

Fig. 4. A “quality house” for developing a grain product

6. Analysis of the research findings on a new grain product as healthy food developed on the basis of the methodology of quality function deployment

The obtained results show that the methodology of quality function deployment has helped determine consumer requirements for developing a new grain product, prioritise them, and transfer consumer preferences into detailed technical characteristics. Production of grain crackers on the basis of the obtained results will facilitate obtaining such a product that will be competitive on the market because its economic features and consumption properties will satisfy particular needs of consumers.

Besides, the QFD methodology can further help avoid or minimise correction of the grain product quality after the product’s appearance on the market; it can also help provide high value at a relatively low price of the product due to minimising the cost of correcting product faults.

Research prospects are as follows: scientific and practical consumer-evaluated rationalisation of recipes of new grain crackers as healthy food, experimental development of products and their complex commodity research assessment, development of normative documents for new products, and devising of a set of measures for an effective entry of health-conducive grain crackers to the consumer market.

The suggested algorithm of using the methodology of quality function deployment by the example of new grain products as healthy food will be useful to representatives of the food industry as it can be applied to developing enriched food products of different groups of consumer goods. Development and production of health-conducive food products that take into account consumer requirements comply with modern trends in the food industry and constitute a priority course of the state policy in the field of healthy nutrition in developed countries, including Ukraine.

7. Conclusion

1. Our marketing research has determined consumer requirements for new products. An affinity diagram and a tree diagram were used to generalise and structure consumer demands with their further priority ranking. The study has revealed that consumers of grain crackers prefer taste characteristics, presence of BAS, health improvement effect, safety, and low price.

2. It has been determined that development of a grain product as healthy food should guarantee prophylactic effectiveness of the new product on the basis of natural enriching additives, increased BAS content, and, certainly, longer shelf life and safety parameters of grain crackers.

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