USING THE HOUSE OF QUALITY SCHEME TO BOOST THE PRODUCTION OF BIOLOGICALLY ACTIVE ADDITIVES

Evgenia Olegovna Ermolaeva, Yuliya Igorevna Dymova and Olga Vladimirovna Zhukova

Institute of Engineering Technologies, Department of Quality Management, Kemerovo State University - 650000, Kemerovo, Russia

Anastasia Evgenievna Mikhaylova

Department of Linguodidactics and Crosscultural Communication, Moscow State University of Psychology & Education - 127051, Moscow, Russia

ABSTRACT

The purpose of the research is to determine the most popular customers’ requirements for biologically active additives using the Quality Function Deployment methodology. To evaluate the clients’ demands regarding biologically active additives eight principal categories were identified, they include functional orientation, consistency, smell, shape, price, manufacturer, safety and efficacy. The focus on customers’ needs ensures high product sales. The Quality Function Deployment method is a procedure which outlines customers’ expectations to fit the relevant requirements of the production at each stage of the product development process: from the research stage through design and manufacture to sales. This approach ensures the effective communication between customers with certain product expectations and the product manufacturer. The methodology includes three types of questionnaires advanced as a means of customer attitude tracking. The Quality Function Deployment method allows launching the procedure of dietary supplements quality and safety development at early stages of product design. The article summaries the basic principles of the production and distribution of dietary supplements that ensure their quality and safety. The obtained material made it possible to determine the guidelines for the further quality improvement of the biologically active additives and highlighted the key steps of the Quality Function Deployment procedure. This document gives the results of the in-house research which include all received data considered at the stages of design, development, production and distribution of biologically active additives in Russia.

Key words: Quality Function Deployment, Biologically Active Additives, Dietary Supplements, Product Development, Competitive Recovery.
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1. INTRODUCTION

The conducted studies of present-day human nutrition patterns indicate the lessening of essential food components [1]. According to the official statistics data, 64.1% of the population in Russia do not control their nutritional habits (2). This can be explained by the pattern regularities that influence the food ration and nutritional habits in all economically developed countries.

Due to various climatic, national and social factors, there is a certain deviation of genuine nutrition programs from the recommended norms of consumption. For instance, scientific and technological progress leads to a sharp reduction in power inputs, the environmental pollution increased its negative effect, as well as the technological advances in cultivating, transporting, processing, distributing and cooking which led to the loss of vital diet components. All this explains an increasing demand in the consumption of health-essential food. Today the poor diet modification cannot occur simply by an increase in the norms of natural food consumption. One of the most effective ways to do that is to enrich the nourishment program with specific natural regulators represented by a wide range of biologically active food supplements which will improve different functions and systems of the human body [3].

The use of dietary supplements is considered a fast, affordable and cost-effective way to correct the diet of a modern human and prevent nutritional diseases. Biologically active additives are a good alternative to vitamin-mineral premixes as a means of adjusting inadequate and unbalanced diets.

The market of dietary supplements in Russia began to form at the end of the twentieth century. BAA (biologically active additives) are natural (or identical to natural) substances intended for the use with food or as an integral food component (Federal Act of Russian Federation № 29 "On the quality and safety of food"). The medical and consumer interest to dietary supplements was caused by the results of scientific research on rational nutrition aimed at strengthening of the immune system. It was found that the present-day human diet lacks some biologically active substances necessary for healthy body functioning. This discovery coincided with the growing attention of people to their health. In contrast to drugs, dietary supplements help the body to self-adjust and eliminate disorders that lead to the development of a disease without damaging the body or any kind of side effects inherent in many medications [3-5].

According to the research of the monthly retail audit of the pharmaceutical market in Russia, conducted by the DSM Group, in 2017, 340.7 million items of dietary supplements were sold through the pharmacy network at the cost of 51.2 billion rubles (in retail prices). For the recent twelve months of 2017, the market of dietary supplements has increased by 4.6% in rubles and by 1.7% in product items in comparison to 2016. Though in January 2018, the capacity of the Russian BAA market decreased by 0.7% in value terms as compared with December 2017 and costs to 4.3 billion rubles. In natural units, the market fell by 4.5% to 27.9 million items. The average price for a pack of BAA was 155.2 rubles, which is still 4.0% higher than in December 2017. The growth rate of the pharmacy segment of dietary supplements in early 2018 declined, continuing the negative dynamics of Q4 2017.

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Given this negative trend, manufacturers are trying to attract consumers and focus on their preferences. Thus, for example, in recent years, BAA made from plant raw materials successfully compete with synthetic drugs [6].

Accordingly, a manufacturer must ensure the competitiveness of the designed products. The advance of new products is a strategic step for the successful setup and development of manufacturing enterprises. However, to achieve and maintain the advantage in a competitive and dynamic market, it is not enough to produce a product that meets only the requirements of technical regulations or standards [7]. Any disregard for the real needs of future customers in the course of production, deployment and circulation of innovative products can lead to unpredictable consequences for the manufacturer. In this regard, when designing new and improving existing products, more and more attention is paid to the use of modern scientific methods. Carefully examined consumer behavior, efficient ways of evaluation reviews, improved methods of quality management will benefit the process.

Today there are many low-cost but effective methods to identify new product consumers' expectations. But the key to success is to become informed about them faster than competitors. For example, a couple years ago manufacturers used to produce a pilot sample release with a limited quantity of new goods to the market to conduct the required research, losing valuable time and bearing significant costs. A virtual product model will help to investigate the consumers' reaction.

Many researchers [2, 7-11] agree that the most effective model for transforming customer requirements into high-quality features of a new product is the method of shaping the product quality, usually applied in combination with sociological (marketing) methods, benchmarking and other techniques.

The quality function structuring (synonym for the deployment management, Quality Function Deployment, QFD-analysis, the House of Quality) is an original Japanese methodology for the systematic and structured conversion of the consumers’ demands into quality requirements of a product [12-14].

Additionally, with the view to enhance the research on QFD the results of BAA product study have been provided. The description of BAA product features is structured in tables and graphs based on the House of Quality method and includes the suggestions of our associate researchers [6]. The paper includes a conclusion concerning the feasibility and projections of some developing tools and equipment for the production of a new generation BAA.

Regardless the fact of the availability of publications on the application of this method in various fields, the studies concerning the use of QFD in the development of biologically active additives, which this article is devoted to, can be seen as insufficient. Thus, this work demonstrates the application of the House of Quality tool in the production of dietary supplements with antacid effect. The following sections present the concept of QFD and its use in the development of food products.

The methods and stages of the research used to carry out this work, as well as suggestions for the application of the House of Quality in the development of dietary supplements will be discussed further.

Analysis of recent research and publications. The purpose of the QFD application [13] is to translate quality requirements from customers into product quality indicators; it can also be used to develop services [15]. The use of QFD improves product reliability, reduces the time of product development [16], and increases customer satisfaction [17, 18].

The QFD method of structuring the quality function or focusing on the consumer’s voice is one of the most effective approaches to organize the planning process. It arose in Japan in
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1972. Yet, nothing was known about this technique until the first publications appeared in 1983 in the US. The most vivid example of the application and further development of QFD methodology is Toyota Automobile Corporation [19].

The success led to a wider use of QFD methodology, which was adopted in other countries, in particular in the US and Europe in the 1980s. After 1987 the first publications on the QFD method appeared in the food industry [20, 21]. After the 1990s, the method was introduced in Brazil and other countries [22]. Since that time many studies suggested this method as applied to food products design and packaging [23].

Customer-centered food products design, based on QFD method, allows to manufacture BAA products with new technical requirements, considering the consumers’ needs with heavy expenses for the design development as well as labor costs reduced significantly [24]. This makes it possible to bring a high-quality innovative product with reasonable and competitive price onto the global market.

QFD has long been considered the most comprehensive and consistent method, which helps to integrate the goals and processes aligning them with customer requirements [25]. Thus, QFD has become widely adopted as a tool for product development and quality improvement in many countries including Russia.

To transform customers’ requirements into the technological parameters and quality parameters of the anticipated products, the method of structuring of quality functions is used. QFD structures consumers’ needs and wishes. The key principle of QFD is a graphic tool in the form of a table, called the House of Quality. It reflects the relationship between actual quality indicators (consumer properties) and auxiliary indicators (technical requirements). This method allows making well-grounded decisions on the quality management of the manufacturing processes. It is also possible to avoid changes in product parameters after its production, and, consequently, provide a relatively low cost by minimizing expenses and high product value [12].

QFD is a method in which wishes (established and perceived needs) of consumers via matrices (Figure 1) are translated into detailed product specifications and design goals [13]. The structure presented in Figure 2 (consisting of several matrix-like tables) is called the House of Quality.

First, the important consumers’ needs are transformed into a detailed technical description of the product model, then it’s followed by three stages: the specification of key product components, the means of the process and quality management systems and the requirements for the equipment and production phase. These elements are presented with the first House through the fourth House graphs, accordingly (Figure 1). Technical requirements must comply with the high-quality product output. As a result, a high level of customer satisfaction is ensured by the production of high-quality products at an affordable price.

QFD has its advantages and disadvantages. There are tangible benefits, such as improved reliability, decreased volatility, effective time use and costs reduction [15]. There are also other benefits like increase in the method flexibility, improvements in communication, decision-making and priority-setting, as well as enhanced proficiency and customer satisfaction [15].
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![House of Quality Diagram]

**Figure 1.** Main steps of the QFD methodology application.

![Quality Function Deployment Diagram]

**Figure 2.** The QFD diagram basic structure (the House of Quality)

The difficulties stem from the lack of knowledge on how to use the method [15] and the necessity to use all four stages of the quality function deployment for the proper translation of customer requirements into technical specifications.

The advantages and difficulties presented by Benner and others [21], highlight the fact that method was successfully applied in the sphere of food products development, for instance, chocolate bars [26], chocolate sweets [27], pies [28, 29], wheat flour [30], fruits [31], meat [32, 33], mineral water [34], olive oil [9, 35], as well as a number of functional products [29].
The study of literature on the topic shows that there were no publications on the adaptation of the House of Quality technique with respect to BAA production. The study was also conducted within the analysis of the framework of the House of Quality application in Russia.

2. MATERIALS AND METHODS

To apply the QFD methodology, a study scheme consisting of several stages was used. At the first stage, a survey was conducted to identify consumer preferences and satisfaction with dietary biological additives marketed in Kemerovo with the aim of the following segmentation of the consumers according to demographic, socio-economic and behavioral features. The consumer properties of dietary supplements affecting purchases of dietary goods were considered. To carry out sociological research three types of questionnaires were developed. Questionnaire No. 1 was designed to conduct sociological research to identify the target consumers and their motivation when purchasing products. This helped to establish a range of consumer indicators for the quality of dietary supplements.

At the second stage, Questionnaire No. 2 was developed with the pairwise comparison method to determine the effective weighing factor and the levels of consumer quality indicators of biologically active additives. The experts’ assessment questionnaire was developed with the involvement of enterprise specialists to study the consumers’ evaluations of the quality of competitive supplements available for sale. The design scheme and commodity evaluation of the gel form BAA are presented. Sociological research and the survey of BAA consumers’ preferences was conducted in Kemerovo with the help of questionnaires.

At the third stage, the Questionnaire No. 3 was developed to evaluate the quality of competing products and the degree of customer satisfaction with these products.

Choosing the Poll Technique. Sociological research and survey were conducted. At the level of consumers’ preferences analysis, the non-random sampling was used – the quota selection (the parameters of sex and age were quoted), which makes it possible to spread the data obtained from the total number of respondents to the preferences of the whole population of Kemerovo.

There are several reasons for using the sampling method:

- Data accuracy. The reduction in the number of units of the sample observation reduces registration errors. Due to incomplete coverage of the units, there may be an error in the representation of the sample data. Taken together, the sample observation error and the error in the representation still guarantee more valid statistics as compared to the complete coverage method results.

- Sampling significantly saves the material, labor and time expenses.

- Ethical problem – objects cannot be forced to respond if they refuse.

The core principle of the method lies in the fact that the research is focused on one or two features that are important to control the sample results. The number of units in a sample that has certain characteristics should be proportional to the number of such units in the general totality.

Development and preparation of the questionnaire. To study consumer preferences, the survey was conducted with the help of the standardized instrument – a survey.

This is the most common method of quantitative marketing research. With the help of the consumer survey, it is possible to spot the shifts in consumer demand timely, and, therefore, to make the right decision at the forecasting and production stage. The background information about consumers is gathered with the help of personal interviews, by phone, by mail and an interactive survey via the Internet. The parameters to evaluate the effectiveness of the survey
methods from the point of view of the amount of information, the possibility of extending questions, the stimulation, the pace of the survey, the potential distortions of the estimates and costs vary. Table 1 presents the comparative characteristics of each of the survey methods.

**Table 1. The efficiency of methods**

<table>
<thead>
<tr>
<th>Efficiency parameter</th>
<th>Evaluating the effectiveness of survey methods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Personal interview</td>
</tr>
<tr>
<td>1. Scope of information collected</td>
<td>Enough</td>
</tr>
<tr>
<td>2. Possibility of deepening issues</td>
<td>Constantly</td>
</tr>
<tr>
<td>3. Use of visual stimuli</td>
<td>Constantly</td>
</tr>
<tr>
<td>4. Opportunity to promote</td>
<td>High</td>
</tr>
<tr>
<td>5. Survey speed</td>
<td>Medium</td>
</tr>
<tr>
<td>6. The likelihood of distortion of answers</td>
<td>Medium</td>
</tr>
<tr>
<td>7. Cost</td>
<td>High</td>
</tr>
</tbody>
</table>

The research relies on the results of the personal and phone interviews held in accordance with the content of pre-designed questionnaires.

Questionnaire No. 1 is designed to conduct interviews with a group of 530 people to determine the target group of BAA consumers, the purpose scheme and the motivation stimuli, as well as the listing of product properties specified by the consumers of BAA and to range the properties in accordance with their importance rate.

Several options are suggested as possible answers for questions No. 2, 4, in Questionnaire No. 1. Giving their answer to question 4 of Questionnaire No. 1, respondents list the desired properties of BAA.

As a result, after processing the answers from Questionnaire No. 1 with Statistica 6.0 software, a list of all the stated indicators of consumer requirements for the quality of dietary supplements was formed. This list was reviewed for the possibility of duplication and mutual exclusion of indicators. The nomenclature of the most frequently used indicators of consumer requirements for the quality of dietary additives was formed. Based on this nomenclature, Questionnaire No. 2 was formed.

Questionnaire No. 2 is designed to rank the indicators of consumer requirements for dietary supplements. Questionnaire No. 2 is based on the quantitative consumer testing approach, which involves a survey of a large number of respondents, that is, from 50 to several hundred people. Conducting this survey involves the use of the pairwise comparison method, which requires the respondent to be attentive and make an extra effort while giving their response. It is recommended, therefore, that the respondent should be provided with a short explanation on the procedure of filling the corresponding table and that questionnaire should be completed in a written form [36].

As a result of the sociological survey, 100 respondents answered the questionnaire about their experience of the BAA use. A nomenclature of consumer quality indicators has been worked out and the consumer requirements weighting factors were specified with absolute and relative importance weights.

**Survey.** From November 2017 to December 2017, the “Study of Kemerovo consumers attitude to dietary supplements” was carried out. The field research phase was held from November 10 to November 17, 2017. The information was gathered in the form of an interview taken from people on the streets of the city. The survey involved residents of all the five districts of the city.
Filling out the Questionnaire No2. To determine the weight coefficient, the pairwise matching method was used. Each customer had to fill an incomplete matrix with two axes which helped to locate the estimated indicators.

Each cell of the matrix should be filled with a numerical indicator, which, from the point of view of the consumer marks the most important parameter. Later, the matrix is processed for further analysis.

This procedure presupposes the evaluation of the rate of the indicator according to its frequency of prevalence in the matrix row with parameters of the \( e^1 \) column and the frequency of prevalence in the matrix row with parameters of the \( e^2 \) column.

Later the total predominant frequency of each of the indicators was determined. The results are presented in the form of a table.

Based on the total sum of the frequencies \( (e,q) \) showed by the participants an average prevalence frequency of \( i^{th} \) additive property \( (e_i) \) was determined for all the BAA consumers.

\[
e_i = \frac{\sum_{q=1}^{N} e_{iq}}{N}, \tag{1}
\]

where \( N \) is the number of consumers.

The total number of comparisons made by each consumer is

\[
Y = n(n-1)/2, \tag{2}
\]

where \( n \) is the number of indicators to be evaluated.

The weight of the \( i^{th} \) property is determined by the formula

\[
M_i = \frac{e_i}{Y}, \tag{3}
\]

There are situations when the quantities \( e_i, e_{ii}, e \) are equal to 0. In this case, the weight coefficients are not assigned.

At the next step, the subjects filled the Questionnaire No. 3. Fifty people took part in the process of evaluation. Based on the results, the right part of the consumer preferences matrix has been completed, the consumer quality indicators were converted into guidelines for the required improvements in the property of BAA product.

Processing of profiles. The data was processed using mathematical statistics on a PC with Microsoft Excel and Statistica 6.0 software.

3. RESULTS AND DISCUSSION

The purpose of the study was to evaluate the consumers’ behavior and their preferences regarding BAA products. The first stage of sociological research was aimed at the collection of statistical data. The interview of 530 people who met the requirements of the representative sample was held in compliance with the content of the Questionnaire No. 1.

The consumer profile is built on the following behavior analysis of data-blocks: the reasons they refuse to buy BAA; the places they purchase BAA; the factors affecting the purchase of BAA; the most significant consumer properties of BAA; the preferences of BAA by functional orientation; the type of BAA used.

The survey results from Questionnaire No. 1 show that the target group of BAA consumers has different reasons for rejecting dietary supplements. Their answers, as they put it: "I don’t want to use any kind of BAA", "I have no problems with health, so I don’t buy any food additives", "I have a fear of some allergic reaction", "The produced BAA are all of the low quality", etc.
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To determine the preferences in the functional orientation of the purchased BAA products, the experts from the Scientific Research Institute of Nutrition proposed a classification of BAA based on their functional (primary) effect. The unit is founded in 1930 and is formerly known as the Scientific Research Institute of Nutrition of the Russian Academy of Medical Sciences. It is a Federal Russian state-owned budgetary organization, located in Moscow.

In terms of functional orientation, consumers explained their choice of dietary supplements in the following way. They value BAA because these additives are the sources of vitamins, mineral elements and other nutrients – 77.1%; they help to normalize the digestion, bowel function, bile secretion – 68.9%; they might have restorative and tonic effect – 67.7%; the additives have anti-stress, hypnotic and sedative effect – 47.8%; they can stimulate the functional activity of the cardiovascular system – 29.8%; they are antioxidants – 12.3%; they can be used as a means for control of body weight – 11.7%; the supplements can normalize the intestinal microflora – 9.1%; they might stimulate the healing of bone injuries – 5.7%. The other variants of the respondents were distributed in the relatively equal number and referred to the sanative effect (taken periodically by women and men or elderly people to support the immune system, etc.).

Consumers prefer to use dietary supplements in the form of capsules (mostly gelatinous) – 34.2%. Older people prefer either a liquid or powdered form of dietary supplements (16.1% and 9.9%, respectively). The second place is taken by tablets (pills), as the most traditional form of medication – 27.8%. However, there was a positive trend towards growing demand for such a form of dietary supplements as gels. Consumers prefer gel-like BAA substance because they believe that this form allows for more effective treatment of the target organism. The younger generation chose the gel form because of its usability: gel BAA need no water as compared with the tablets (pills), capsules or powder.

For the customers’ voice to be heard, the information about the most significant attributes of the purchased BAA products was analysed, which allows establishing a nomenclature of consumer indicators of the quality of dietary supplements, expressed in the "language of consumers." The outcome then was processed using the affinity chart by examining the inconsistency of consumers' demands, duplication of indicators in the identified list of quality indicators, their complementarity and mutual exclusion. Based on this, the final formation of the list of consumer quality indicators of dietary supplements was carried out.

The quality and safety indicators for specialized nutrition (food items) is the main (or necessary) product property, which according to the model of Noriaki Kano is "obvious and ordinary" food attribute for a consumer. However, the results of the conducted studies demonstrate the consumers' uncertainty about the quality and safety of the products in the Russian market, which challenges the manufacturer to minimize the risks and guarantee the sustained product quality to avoid any negative health consequences.

The research shows that most of the respondents interested in buying BAA is made up of women (19.2%), who are mostly driven by the functional orientation of the product (79.3%), which is most likely due to their care for the family, appearance, health, etc. The efficiency of the product is seen by the respondents in the received effect of used supplements (78.6%), which subsequently reflects on their further purchases, recommendations to relatives, friends and acquaintances. The balance criterion is chosen by 4.1%. Next comes safety (77.4%), justified by the absence of side effects (like an allergy), and also the opinion that BAA are "safer than drugs", etc. The respondents note the natural organic composition of dietary supplements is an important indicator when choosing a product (49.1%). It is visible in the choice of women (9.8%) who see the BAA production from natural raw materials as more useful than synthetic substances. Men prefer foreign BAA manufacturers, justifying this by an
insufficient quality level of domestic production. The organic nature of the composition is of interest only to 4.2% of male respondents. The cost of dietary supplements (68.7%) is noted, as BAA purchase is much cheaper for the family budget than buying medicines. The form of dietary supplements (tablets, capsules, etc.) is significant for 39.2% of the respondents. Mostly it concerns women – 2.7% and is explained by the fact that they are informed about the dietary supplements (tablets, capsules, etc.) is significant for 39.2% of the respondents. Mostly it concerns women – 2.7% and is explained by the fact that they are informed about the conditions for better assimilation process of certain BAA forms. The respondents also noted the packaging: colorful design, informative labelling, ease of use, etc.

The identified consumer quality indicators of dietary supplements are systematized and processed with the help of the affinity diagram (Figure 3), as a result, the nomenclature of wishes of dietary supplements consumers was formed (Table 2).

**Figure 3. Diagram of the affinity consumer properties BAA**

Safety indicators detailed by consumers are necessary and mandatory. The task of manufacturers and sellers is to minimize the risks of any possible harm and ensure food safety. Products that do not meet safety requirements cannot be distributed.
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Table 2. Consumers’ wishes when buying dietary supplements.

<table>
<thead>
<tr>
<th>Utility</th>
<th>Taste</th>
<th>Composition</th>
<th>Consistency and appearance</th>
<th>Smell</th>
<th>Price</th>
<th>Trademark</th>
<th>Shelf life</th>
<th>Safety</th>
<th>Directon</th>
<th>Ergonomics of packaging</th>
</tr>
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<tbody>
<tr>
<td>1</td>
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</tbody>
</table>

- The balance effect
- Taste of fruit, berries
- Pleasant flavour
- No added colouring or flavouring agents
- Natural composition
- Homogeneous consistency
- Form
- Pleasant smell
- Reasonable price
- Manufacturer
- Long shelf life
- Functional orientation
- Practical and convenient packaging
- Beautiful package

A broad scope of assortment will satisfy all possible taste preferences of the consumer, who buys the products of a brand from a trustworthy manufacturer. Widening the range and assortment of the BAA products is a safe and sure way to attract patrons among consumers. The development of the assortment of BAA has a well-established and tested procedure, which consists of the ingredients’ composition arrangement, adjustments of the technology of production and the choice of new package design.

A product package is the first thing that the buyer sees and evaluates. It is necessary to pay special attention to the selection of packaging materials when developing the design, shape, color, and content of a product package, as well as the content of the label and properties of the noticeable product visualization. Based on the conducted sociological research, it is possible to formulate recommendations for the package design of the BAA products:

- the package materials should be organic and look solid and durable;
- the container should be stable, ergonomic and with user-friendly design; it should have a practical cap, that can be conveniently opened and closed several times and a spoon for dense BAA products;
- the label should be informative, attractive and bright.

The control of these indicators might be irrational and is driven, for the most part, by aesthetic, psychological or ethical considerations and shaping factors. Consumers’ focus on quality testifies their uncertainty in the quality and safety of BAA products. This is especially important for the production of gel-based additives, since this substance can become a favorable environment for the growth of detrimental microorganisms, which makes such products easily perishable and dangerous, especially due to the fact that, for example, functional nutritional additives (group of specialized food items) are used by people whose health is already weakened. Finally, according to the survey results among the consumers of BAA, there are many women, who exhaust their body by the weight reduction diets and children whose immune system is not strong enough to overcome detrimental pathogens.

To classify the data obtained we apply the following principles. Consumers have different demands, sometimes very contradictory. When designing and developing dietary additives it is necessary to consider the following requirements, giving preference to the needs and desires of the respondents.

The main impact on the determination to purchase any dietary supplements is made by a doctor. An important role is also played by advertising in the form of vivacious video clips, scientific materials in printed publications and notes in the form of the recommendatory or problematic articles, instructions, annotations and discussions on the Internet. Some advice and guidance from relatives or acquaintances might also have a certain influence on the desire to purchase BAA products – 11.1%. Impulsive consumption, sellers and distributors marketing strategy – 16.1%.

The next stage of the research locates the main places for the purchase of dietary additives.

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The typical modern consumers prefer to buy BAA in pharmacies, given the credibility of the pharmacy as a distributor that provides additional product quality control, the opportunity to get professional consulting and a trustworthy outlet that distributes a wide range of products – 40.7%. 21.1% of respondents buy BAA products on the Internet, which, most likely, issues from the Russian mentality (typical traits like laziness, indifference and lack of time to visit a doctor or pharmacy). 12.4 % of consumers are committed to medical institutions, hospitals, doctors, etc. 6.4% of respondents buy BAA in specialized departments of supermarkets, as a companion product, in some cases, impulsively, for example, dietary supplements to reduce excessive body weight. As an "option answer" some consumers said that they did not purchase BAA independently on their own and get it from their spouse, parents, friends or distributors.

Based on the results of sociological research, the model of the target consumer was set forth: a woman aged 25-59 years who pays attention to the dietary issues.

Based on the results of the studies we can conclude that most of the population uses dietary supplements, the main consumer category is the women who care about their health. The prevalent places of BAA distribution are pharmacies, the Internet stores and specialized medical institutions.

**Questionnaire No. 2.** The second stage of sociological research (Questionnaire No. 2) shows that the most important factors that shape the requirements and product quality expectations are: the functional orientation and safety, as well as the price. The presence of dyes, flavors and preservatives or consistency, are the features of the least interest, which indicates a certain confidence in product quality and trust to the manufacturer. The main condition that guarantees the production and maximized turnover of a competitive product is the respectful attitude to customers’ requests and proper customization of the product.

The data gathered from the participants of the conducted surveys shape the consumer decision tree – a scheme that shows the parameters of customer preferences. The marketing research materials were structured and grouped to build the tree diagram of the BAA preferences.

The modal weighting factors of consumer demands were specified using pair-wise comparison method.

A sociological survey of 100 respondents (focus group) was carried out using the developed questionnaire to establish the weight indicators of the identified BAA consumer quality demands.

Thus, by operating the consumer demands with high-rate indicators, it is possible to improve consumer quality standards for dietary supplements with low labor and financial costs.

The evidence obtained by means of the sociological studies was systematized. It became the basis for the nomenclature of consumer preferences that form one of the branches of the tree diagram with indicators of the BAA quality and safety requirements.

The identified quality criteria are structured and presented in the form of a tree of quality and safety indicators in Figure 4.
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Figure 4. The quality and safety index tree by the example of the designed BAA product

The use of the proposed nomenclature of indicators characterizing the quality and safety of dietary supplements including three groups: the target consumer, the brand and safety indicators, allows the BAA manufacturer to place the proper focus on the product quality control and identify the ways to purposefully rise specific quality indicators.

The House of Quality. The collected data was used to complete the subsection “Customer Expectations” (sub-table 1) of the “House of Quality” matrix, these are functional orientation, consistency, smell, form, price, producer, safety, efficiency. The weight factors, consumers indicate as important are specified by a five-point scale, where 5 is "very valuable", 4 is "valuable", 3 is "less valuable", 2 is "not very valuable", 1 is "not valuable".

The results are presented in the section named “The Importance of Expectations” of the House of Quality matrix (Figure 5).
Evgenia Olegovna Ermolaeva, Yuliya Igorevna Dymova, Olga Vladimirovna Zhukova and
Anastasia Evgenievna Mikhaylova

Figure 5. The House of Quality (diagram, matrix) for the designed products

The model was compared with the benchmarks (sample products, the best analogues in the market). The analysis results contributed to improved awareness and understanding of the targeted quality of the product. A 5-point scale was used for the assessment. The comparison results are presented in the sub-table 2 (Figure 5).

The survey involved 50 respondents who independently filled the Questionnaire No. 3.

The experts’ assessment of the comparison of competing products added to the results collected on the previous stages of the research allowed to build a framework matrix to shape required BAA quality and determine the degree of the correlation between organoleptic indicators of consumer preferences and quantitatively measured indicators of the finished product.

In the scheme, it becomes obvious that in order to improve the competitiveness of the test model, it is necessary to improve such indicators as “functional orientation”, “consistency”, “smell”. On the other hand, the benchmark sample was evaluated as inferior in terms of “price” and “efficiency”.

The obtained data indicate the potential capacity for BAA product improvement.

Subsequently, the objective for the quality improvement project was set. In the sub-table 3 (section "Target value"), the target values were found for all the opinions of consumers’ product expectations (Figure 5). The workgroup that constructed the House of Quality for BAA decided that consumer expectations like "price" and "efficiency" do not require any improvement. Based on certain target values, the relative values of the “degree of quality improvement” were calculated using the formula: Degree of improvement = Target value / its rate. The results are listed in the section “Degree of improvement” (Figure 5).

Following, the weight of the consumers’ expectations is established, the values are listed in column 3 of the sub-table 3.

Then the weight in percentage was calculated and all the values gathered in the House of Quality matrix. The greatest index weight was attributed to the “functional focus”.

At the fourth stage, we have to choose the technical requirements of the analyzed product, adjusting them will help to achieve the best product quality and satisfy the consumers. At
this stage, we assembled the data in a catalogue of the product technical requirements. The results are listed in the sub-table 4 of the House of Quality.

Next, it is necessary to determine the relationship between the technical requirements and expectations of consumers, while filling the matrix of associations, which is the central part of the quality matrix of the House of Quality (Figure 5). The relationship matrix shows the correlation between customer expectations and technical requirements. To determine the strength of the rapport, a scale of values was used, where “9” is strong, “3” is medium, “1” is weak. Empty cells in the matrix indicate that there is no connection between the technical requirement of the product and the corresponding expectations of consumers.

In the House of Quality scheme, it can be seen that the consumers’ demands for “efficiency” are strongly related to such technical requirements as “the chemical analysis of the product mineral content” and “the duration of BAA use”. At the same time, there is a loose relation between the BAA efficiency and the attributes like “the ingredients of BAA product”, “the water solubility”, and it is slightly related to “the presence of tannins”.

Numerical data representing the relevance of the relationship between the product technical requirements and the customer quality expectations were presented in the corresponding cells of the relationship matrix, identifying their correlation. The numbers were calculated according to the formula: \[ \text{Relevance of the relationship} = \text{Strength of the relationship} \times \text{Weight, \%}. \]

Thus, in Fig. 5 it is clear that the requirements for “the BAA ingredients” receive the highest overall quality score of 498, “the shelf life of dietary supplements” scores 495 points and “mineral content” totals 381 points. At this stage of the BAA product development process, the quality of the above-mentioned technical requirements was in focus.

Stage six established the relations between the technical requirements of the product. The strength of the correlations between technical requirements is presented in the “roof” part of the House of Quality. For example, it can be seen that “the type of packaging” has a weak relationship with “the shelf life”.

The next step marked the units of measurement for particular product requirements in the top graph of the sub-table 8.

With these units of measurement, the corresponding values of the technical requirements of the examined and competing products are given in the second and third lines of the sub-table.

At the final stage, the target values of the product technical requirements were assigned with respect to their priority rates and were directly associated with the account of the future product quality improvement. As can be seen from Figure 5, the sample shows that the manufacturer is to put a special emphasis on the increasing the quality indices of “the content of biologically active additives” (18%) and “the shelf life of dietary additives” (17.9%).

4. CONCLUSIONS

With the help of the House of Quality the following procedures of BAA product development can be proposed:

1) to increase the BAA shelf life, an innovative, environmentally friendly and reasonably priced packaging should be chosen, with the best possible capacity to maintain the product properties and safety indicators for a significantly longer period;

2) to achieve the efficiency criteria of the BAA concept, it is important to guarantee the quality and quantity of raw organic constituents. This is achieved by monitoring and evaluating the wanted suppliers and commodities;
3) to improve the functional orientation indicator, it is necessary to conduct clinical beta testing procedures with various groups of patients with varied disease etiology.

Data structuring is the foundation for the quality function deployment. The main goal of this process is to ensure the production of the safe high-quality BAA products at a relatively low cost. The process of the BAA function quality structuring is based on the following operations:

- allocate the zone of responsibility, mainly for the production units responsible for the continuous BAA product quality improvement in accordance with the requirements of the external and internal consumers;
- implement the transition to the stable characteristics of the manufacturing process and the product quality features;
- track the consistency of the BAA characteristics over the entire period of their production, supporting the subsystem implementing this process;
- Ensure the robustness of the BAA property to resist the changes in external factors, both during the production, and the periods of storage, transportation, sale and consumption.

Structuring of the quality function is carried out by the mechanism of the system-parametric design of BAA production, which provides:

- the application of scientific and engineering solutions in the process of development of the model of dietary additives, the devising of recipes, as well as scientific and technical documentation, considering all customer requirements, standards and production conditions;
- the assessment of levels with controlled factors and minimization of interference factors;
- the application of scientifically grounded limits of changes in parameters at critical control points and rationing of tolerances at process points;
- the identification of conditions with insignificant impact factor.

Therefore, we have shown that the quality function deployment in the food additives industry involves the key elements that allow shifting the accents associated with the quality and safety of dietary supplements at the stage of product design. When this goal is achieved, the production loss caused by the construction of inadequate products is reduced, the incidental and operating expenses are reduced, as well as the charges for the defective and low-quality products; the image of the enterprise and its competitiveness are enhanced. So, the application of the quality function deployment is not the end in itself, since this methodology is, in fact, a part of a universal conceptual approach based on the invention, implementation and improvement of a quality management system in the sphere of the BAA production. Incorporating many subsystems and elements, this scheme of product management allows for the realization of the basic principles of production and implementation of dietary supplements that ensure their quality and safety.

The data gathered in the course of the research determine the possible directions of the BAA quality improvement.

The first constituent of the QFD includes the following components:

- the study of the range of domestic and foreign products presented in the market, as well as the sales in the area of interest;
- the study of BAA product development process is based on the examination of focus group users and other segments: doctors, pharmacies, dietary supplements, considering the information on the frequency of common sickness rate of different populations groups;

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- the analysis of the components that make up the BAA to be developed, in agreement with the given direction of product development and the evaluation of their delivery risks;
- the preliminary analysis of the model adequacy for consumers’ preferences regarding flavor, consistency, shape, size, packaging used, etc.;
- the devising of recipes and introduction of experimental batches of laboratory samples;
- the early clinical tests in medical institutions that are accredited to conduct such tests; obtaining a report on clinical assessments.

The second constituent of the QFD consists of the following stages:

- the development of a pilot batch of dietary supplements in accordance with the developed methods and technology, considering the results of clinical tests and in line with consumer’s requests concerning various versions of flavoring additives, consistency, shape, size, packaging used;
- the segmentation of the market by identifying the most numerous groups of consumers by the critical index of preferences by category: age, sex, occupation, physical health of the respondents;
- the selection of respondents for focus groups;
- conducting the research in focus groups with preliminary orientation, processing and evaluating the results;
- obtaining additional information through the distribution of questionnaires and surveys, examination of relevant publications, reports, etc.
- determining the location of the marketing niche for the developed dietary supplements and defining product characteristics for the most numerous groups of consumers;
- the analysis of the initial data for the development of a serial sample of dietary supplements;
- the development of technical documentation of the project with information on technical conditions, technological instruction, recipe, label;
- the compilation of the draft documentation in the relevant departments of the BAA production, approval of the final version of the documents;
- the submission of documents and prototypes of dietary additives to the Federal service responsible for the supervision of consumer rights protection and human well-being in Russia (the Federal Center of Rospotrebnadzor);
- the examination of the package of documents and samples of dietary supplements at the Scientific Research Institute of Nutrition of the Russian Academy of Medical Sciences and the transfer of the results to the Federal Service for Consumer Rights Protection;
- the certified approval of the project based on the credentials of the responsible institutions of Russian Federation. Release and distribution of the registration certificates and an agreed package of documents for the development of new BAA products.

The third constituent of the QFD involves the following main components:

- the examination of the dietary supplements production processes, their identification and structuring;
- the modelling of strategic and key processes based on customer satisfaction. Goals and objectives should be measurable and comprehensible. It is necessary to guarantee the consistent and coherent production process, with clear boundaries of relating procedures, inputs and outputs of characteristics, control parameters;
• the detailed elaboration of the processes supported by the construction of structural and functional schemes;
• the identification of the process indicators, methods and tools for measuring, processing and analyzing results;
• the development of the structure and procedures for the process management based on the creation of an adequate mechanism for achieving the best results, identifying the necessary resources and ensuring competency, professionalism and qualifications of personnel;
• defining the criteria and methods for the assessment of productivity, efficiency and robustness of the procedures, considering the existing risks;
• the launch of a system for monitoring and auditing the process based on the principle of continuous improvement.

The fourth constituent of the QFD includes the following main components:
• selecting the main directions that determine the ability to meet the requirements of both external and internal consumers and leads to the improvement of BAA production;
• tracking the consumers’ demands at every stage of production through the implementation of documented Quality Management System and the procedure execution operational monitoring;
• the implementation of a forecasting system that excludes the overdue stocks of supplies and BAA products in the depository by enforcing the operations constancy and the proper execution of the terms of delivery in relation to both external and internal consumers;
• the commissioning of a security subsystem based on the principles of Hazard Analysis and Critical Control Points approach (HACCP), which provides regular monitoring at critical control points, analysis of biological, chemical and physical risks, as well as monitoring and regular supervision of the process of corrective and preventive measures of BAA production;
• the introduction of the Good Manufacturing Practice (GMP) standard, which ensures strict compliance with the requirements of sanitation and hygiene in relation to the premises, equipment and personnel working in the industry of dietary supplements production.

The data received was taken into consideration when designing, elaborating, and manufacturing new forms of dietary supplements and brought to the attention of prospective BAA producers.

REFERENCES

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