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QUALITY FUNCTION DEPLOYMENT METHOD FOR THE REGIONAL CONSUMER MARKET

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Abstract

Market competitive advantages can be provided by the earliest possible detection of consumer expectations towards new products. To reach the purpose, one can use various scientific methods; however, the trend exists to apply mainly the methods involving virtual testing of engineering prototypes - models allowing one to efficiently use time and funding. The analysis shows the expediency of translating consumer requirements to the new product characteristics with the help of the quality function deployment. The suggested research evaluates this method for the innovative food products – minced meat-containing semi-products (chops) rich in functional food ingredients – prebiotic lactulose and biologically active components of the Manchu nut *Juglans mandshurica* M. The suggested method included 7 stages: identification and specification of the consumer requirements by sociological research, requirements ranging, development of product model concept, development of the technical characteristics list, calculating the dependences between consumer requirements and technical characteristics, defining weight values of technical characteristics with the account of the consumer requirements rating, correlation matrix building. The main impact into the formation of the quality of minced meat-containing semi-products is made by 7 technical characteristics: lean meat content (17.3%), Manchu nut (16.4%), lactulose (11.2%), energy value (10.8%), fat and protein content as well as package mass. The Pareto diagram shows the impact of technical characteristics on the ready products quality. The authors outline the areas of improving minced meat-containing semi-products and suggest several formulations with various content of the Manchu nut *Juglans mandshurica* M. kernel.

Keywords: Quality function deployment, house of quality, innovative food products, lactulose, Manchu nut, Pareto diagram

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1. Introduction

Competitive advantages on the market can be provided and retained by the earliest possible detection of consumer expectations concerning new products. To reach the purpose, one can use the methods from various scientific areas; however, modern trends exist to apply mainly the methods involving virtual testing of engineering prototypes - models allowing for the maximum efficient distribution of limited resources, first and foremost, time and finance. The scientists share the opinion on the expediency of translating consumer requirements into the new product characteristics with the help of the quality function deployment (Eshel et al., 2018). The suggested research evaluates this method in relation to the innovative food products – minced meat-containing semi-products (chops) rich in functional food ingredients – prebiotic lactulose and biologically active components of the Manchu nut Juglans *mandshurica* M.

2. Problem Statement

Despite the fact that the method of quality function deployment is widespread and used in most industries, it is quite rarely applied in the food industry, and it further leads to the difficulties in the promotion of innovative food products on the market. In this connection, the method evaluation by the example of innovative food products made from meat raw materials seems relevant.

3. Research Questions

Quality Function Deployment (QFD analysis, “House of Quality”) is a methodology of system transformation of consumer expectations into the product quality requirements at the early stages of the quality loop. As a scientific concept, the method was suggested by Japanese professors Sh. Mizuno and A. Akao in 1972 (as cited in Akao, 1990) and developed in the manuscripts of Vahouni (1982), L. Sullivan and H. Ross (as cited in Ross & Kioumars, 1995) making it basis today. In terms of food products the methodology was applied also in the research of Jambrak et al. (2018), Kowalska et al. (2018), Aleshkov et al. (2020).

3.1. Lactulose as a functional food ingredient in the technologies of innovative food products made of meat raw materials

The use of functional nutrition products rich in prebiotic components is the most optimal method of recovering and maintaining a normal gut microflora (Delgado-Fernández et al., 2019). Being the lactose isomer lactulose has a slightly sweet taste. It was not applied for the enrichment of meat and meat-containing products in any research conducted before. A characteristic feature of lactulose is the arrest of pathogenic microflora and the decrease in the formation of toxic metabolites in the large gut against a significant growth of the population of bifidobacteria, which preconditions good intestinal motility and provides an eccoprotic effect.

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3.2. Bioactive agents of the Manchu nut kernel (*Juglans mandshurica* M.) for the technologies of innovative food products made of meat raw materials

The Manchu nut (*Juglans mandshurica* Maxim.) grows at the Russian Far East, in Northwest China and North Korea. Its first botanic description was made as early as in 1856. However, the research reached its climax only in the XXIth century. Despite the fact that the approximate biological yield of the Manchu nut in the Khabarovsk Territory is 1.7 thousand ton/year while in the Primorsk Territory - 1.2 thousand ton/year, a large part of these resources remains uncultivated.

The Manchu nut kernel contains 53 – 63% of lipides, 24 – 32% of proteins and up to 3.3% of mineral substances (Zemliak & Okara, 2015). All parts of the Manchu nut are rich in phenol and mineral compounds, vitamins, glycosides, ether oils and other functional nutrition ingredients which allows recommending it for meat products enrichment (Zhang et al., 2018).

4. Purpose of the Study

The purpose of the paper was the practical evaluation of the method for structuring the quality function as applicable to the identification of technical characteristics of minced meat-containing semi-products rich in the prebiotic lactulose and biologically active components of the Manchu nut *Juglans mandshurica* M. at the product launch.

5. Research Methods

Consumer preferences (“consumer voice”) were studied in 2018-2019 yy. with the help of the questionnaire survey and a specially developed questionnaire including 13 yes-no questions. The sampling included 663 respondents living in Khabarovsk, Russian Federation (0.11% of the city population, which provides it representativeness). The structure of the people surveyed showed an insignificant prevalence of female respondents (54.2%) with higher education (54.8%). Virtually all the surveyed are of the working age, the income of most respondents do not exceed 50 thousand rubles per month. The research results were processed with the use of GoogleForms.

The qualimetric model and the matrix of consumer requirements were built on the basis of the methods developed by Vahouni (1982), Ross and Kioumars (1995). The Pareto diagram was built in compliance with the method of Surhone et al. (2010).

6. Findings

The method of quality function deployment optimized by the authors for food products includes 7 main stages:

1.The identification and specification of consumer requirements by means of sociological survey.

In the course of the questionnaire survey the following preferences of respondents were specified: product type - chops; high flavor characteristics (including odor); soft consistency; pleasant color; conventional appearance and form; the composition must include high-quality beef and pork (such requirement is transformed into the technical characteristics “lean meat content”); absence of questionable

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ingredients like mechanically deboned poultry, soy protein ingredients, water-retaining agents, flavor intensifiers; presence of natural spices; high protein content; presence of functional food ingredients (against high loyalty to the addition of the prebiotic lactulose and components of Manchu nut kernel Juglans mandshurica M.);

These requirements were divided into several blocks (functional intended use, organoleptic characteristics, ingredients; nutrition and energy value; economic characteristics) and transferred into the table lines - a so-called coupling matrix of the house of quality.

2. Consumer requirements ranging. Each consumer requirement was assessed by its importance. Weight coefficients were assigned in the expert way taking into account the results of marketing research and the existing rating scales for organoleptic evaluation of the minced meat-containing semi-products. The results of consumer requirements ranging are provided in Table 01.

Table 1. Consumer requirements ranging

Consumer requirements group	Individual consumer requirements ("consumer voice")	Weighing coefficient	Grounds for weighing coefficient establishing
Functional intended use	Classification (product type) - chops	2.9	29% of respondents prefer to buy chops, $К_{вес}$ is obtained by means of dividing this value into 10
	The opportunity of selecting the package mass (weighing a cooled minced meat-containing semi-product in presence of the consumer)	0.2	Only 1.8% of respondents buy products because of the pleasant package;$К_{вес}$ is obtained by means of dividing this value into 10
	A small shelf life for maximum freshness (cooled products)	1.0	Expert evaluation
Organoleptic	high flavor characteristics (including odor)	4.0	GOST 9959-2015, cl. 8.13, 9.4, annex Д.
	soft consistency	2.0	
	pleasant color	3.0	
	conventional appearance and form	1.0	
ingredient content	presence of high quality beef and pork in the composition	2.3	23% of respondents think that the composition is the most important motivation for purchase; $К_{вес}$ is obtained by means of dividing this value into 10
	presence of natural spices	0.5	Expert evaluation
	presence of functional food ingredients (lactulose)	0.4	Only 3.8% of the population specified dietary fibers and prebiotics as the most known biologically active substances;$К_{вес}$ is obtained by means of dividing this value into 10

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	presence of functional food ingredients (Manchu nut kernel)	3.9	38.5% of respondents pointed out that would buy chops with Manchu nut; $K_{вес}$ is obtained by means of dividing this value into 10
Nutrition and energy value	high protein content	2.0	Expert evaluation
	lowered fat content	1.8	
	lowered energy value	2.3	
Aesthetic	package appearance (expensive colorful package)	1.0	Expert evaluation
Economic	the price does not matter (to a reasonable extent)	7.7	23% of respondents think the price is the most important factor when purchasing products; the rest 77% think the price is not important;$K_{вес}$ is obtained by means of dividing this value into 10

3. Development of product model concept. The sociological research showed that it is reasonable to launch innovative food products on the market with a high consumer price but meeting the needs of most people. To reach the purpose, meat raw materials with a high lean meat content are used (trimming obtained from beef of the 1st category, semifat pork) and functional food ingredients – lactulose and the Manchu nut kernel *Juglans mandshurica* M. The package of the minced meat-containing semi-product of 400-500 g (405 chops) can be made of premium polymer materials; however, in case of the cooled product, which would be possibly weighed for a polymer support in presence of the consumer, it is not significant.

4.Development of the technical characteristics list. To resolve this problem, a team of expert product engineers was formed. Technical characteristics are put in the headings of the columns of the house of quality. The technical characteristics of the minced meat-containing semi-products rich in lactulose and the Manchu nut kernel *Juglans mandshurica* M. included the package weight; content of lean meat, lactulose; the Manchu nut kernel *Juglans mandshurica* M., spices; protein; fat; energy value; level pH; water-binding power of minced meat; losses at thermal processing.

5.Calculating the dependence of consumer requirements and technical characteristics. In the course of the previous stages the authors made a ranged list of consumer requirements in the consumer language as well as technical characteristics formulated in the language of developers. For a successful development of food products on the basis of meat raw materials consumer requirements were transmitted into technical characteristics. The authors use such heuristic concepts as “strong connection”, “mean connection” and “feeble connection” expressed, correspondingly by the coefficients 3, 2, 1 (Figure 01).

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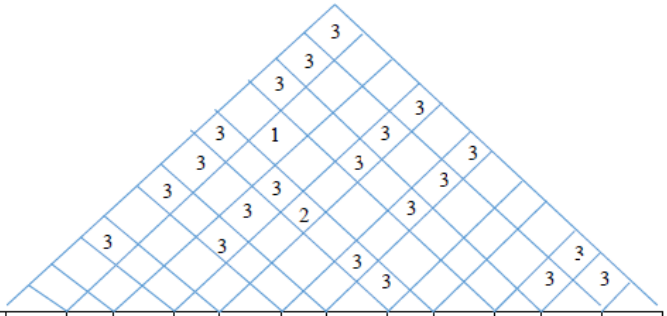

Actual characteristics / Expected characteristics		Weighting	Content of lean meat	Package mass	Lactulose content	Manchu nut content	Protein content	Fat content	Energy value	Content of spices	Temperature at product launch	pH	Water-binding power	Losses at thermal processing
Intended uses	semi-product type	2,9		2			2	2	2	2				
	package mass	0,2		3										
	shelf life	1,0									3			
Organoleptic	flavor and odor	4,0	3		3	2	3							
	appearance and form	1,0	2		2									
	consistency	2,0	2		2	2						2	2	2
	color	3,0	2		2	2								
Formulations	high quality raw materials	2,3	3					3	2	3		3	3	3
	spices	0,5	1				3							
	lactulose	0,4				3		2	2			3	3	3
	Manchu nut kernel	3,9	2		3			2	3	3				
Nutrition value	high protein mass fraction	2,0	3		3			3		3		3	3	3
	decreased fat mass fraction	1,8				1			3	3				1
	decreased calorific value	2,3						2	3	3				
Economic	price	7,7	3	3	3	3								
Importance of technical characteristics, c.u.			68	30	65	44	19	32	35	43	3	18	18	20
Relative weight of quality indicators			17,3	7,5	16,4	11,2	4,9	8,0	8,9	10,8	0,8	4,6	4,6	5,0
Technical characteristics ranging			1	7	2	3	9	6	5	4	12	10-11		8
Estimation of competition	Measurement units		%	г	%	%	%	%	%	%	°C	ед.	%	%
	Elite chops		47,7	400	10	2,5	0,1	10,7	20,2	262	2	7,1	99	15,0
	Control		57,7	400	0	0	0,1	11,2	15,9	215	2	6,8	75	15,0
Quality planning	Designed quality		47,7	400	10	2,5	0,6	12,0	18,0	220	2-4	6,8	99	15,0
	Improvement area		-	-	-	-	↑	↑	↓	↓	-	↓	-	-

Figure 1. The house of quality of minced meat-containing semi-products rich in lactulose and Manchu nut *Juglans mandshurica* M.

6. Defining weighing values of technical characteristics. In the line "Specific weight of technical characteristics" the authors calculated a share of each characteristics in percentage; further, technical characteristics were ranged and presented in the form of the Pareto diagram (Figure 02). The article shows that the main impact into the formation of the quality of meat-containing minced semi-products is made by 7 technical characteristics: content of lean meat, Manchu nut *Juglans mandshurica* M., lactulose, energy

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value, content of protein and fat as well as the package mass totally giving 80% of the ready products quality.

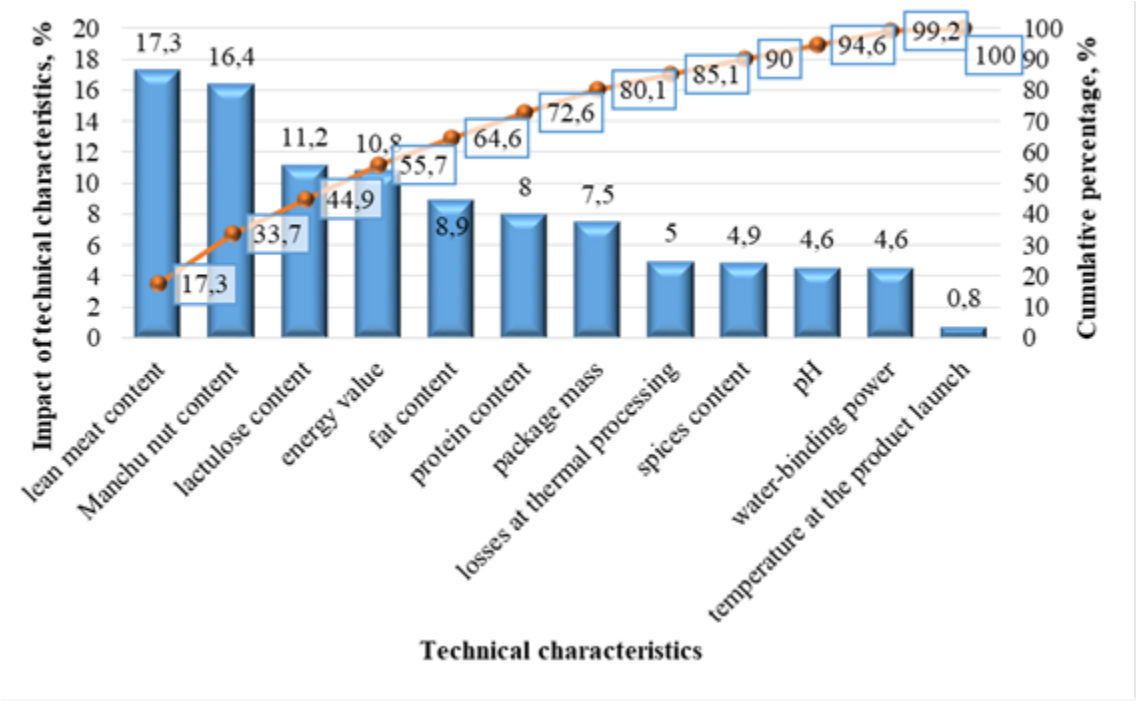

Figure 2. Pareto diagram of minced meat-containing semi-products rich in lactulose and Manchu nut Juglans mandshurica M.

The addition of functional food ingredients (lactulose and Manchu nut kernel Juglans mandshurica M.) makes an important impact into the formation of product quality. The possible directions of improvements of minced meat-containing semi-products in the house of quality are marked with arrows in a lower line. To get the optimal quality, it is necessary:

- to increase the spice content, including by means of decorative sprinkles;
- increase protein content;
- decrease fat content and product energy value;

To get these improvements, the authors suggest the following options of the formulations for the minced meat-containing semi-products with various content of the Manchu nut kernel *Juglans mandshurica* M. (table 02).

Table 2. Formulations of meat-containing minced semi-products, kg/100 kg

Name of ingredients	Control sample	Model 1	Model 2	Model 3
Mild pork	28.0	28.0	28.0	28.0
1st category beef	29.7	24.7	19.7	14.7
Wheat flour bread	13.0	8.7	8.7	8.7
Breadcrumbs	4.0	4.0	4.0	4.0
Lactulose	-	3.8 (2.5) *	3.8 (2.5) *	3.8 (2.5) *
Peeled onion	2.0	2.0	2.0	2.0

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Manchu nut kernel**	-	5	10	15
Mix of sweet peppers	-	0.5	0.5	0.5
Black pepper	0.1	0.1	0.1	0.1
Egg mix (egg)	2.0	2.0	2.0	2.0
Salt	1.2	1.2	1.2	1.2
Water	20.0	20.0	20.0	20.0
Total	100.0	100.0	100.0	100.0

*in terms of net lactulose. The authors used the preparation of lactulose "Lactusan" containing 67% of lactulose (produced by LLC "Felizata Holding, TS 9229-010-53757476-03, Certificate of registration No. RU 77.99.11.3.У.1974.3.09 of 10.03.2009 г.)
**gathered in the Khabarovsk Territory, Russian Federation

7. Correlation matrix building. The objective peculiarity of any product is that a number of technical characteristics are interconnected, and some contradict each other. It is reasonable to take into account similar interdependences during the technology optimization thus obtaining the products meeting the consumer expectations as much as possible. To do this, the house of quality is complemented with a "roof" (correlation matrix) in a triangular form which is filled with the coefficients 3, 2 and 1 pointing to the strong connection between corresponding product technical characteristics. Such matrix building should envisage the strive to change any characteristics at the manufacture, and this can cause a significant change of other characteristics due to the correlation between them.

7. Conclusion

Therefore, applying the method of quality function deployment allows offering the consumer a ready model for the innovative food products - meat-containing minced semi-product rich in prebiotic lactulose and biologically active components of Manchurian walnut Juglans mandshurica M. The article shows that the main impact into the formation of the quality of meat-containing minced semi-products is made by 7 technical characteristics: content of lean meat, Manchu nut Juglans mandshurica M., lactulose, energy value, content of protein and fat as well as the package mass totally giving 80% of the ready products quality. On the basis of the built House of quality the authors suggested the formulations of meat-containing minced semi-products which would be the most high-demanded by the consumers; these formulations include meat raw materials with a high lean meat (42.7-52.7%), lactulose (2.5%), Manchu nut kernel (5-15%) and auxiliary ingredients. Further, on the basis of additional simulation of the organoleptic characteristics and amino-acid composition of samples, one of the formulations suggested was introduced into production (model 2). It was put on the market under the brand "Elite"chops".

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