

Quality Function Deployment Method for Development of Innovative Production

A. V. Aleshkov, A. V. Zhebo

Associate professor of commodity research chair
Khabarovsk State University of Economics and Law
Khabarovsk, Russia
aleshkov@inbox.ru

T. K. Kalenik

Professor of Food Sciences and Technologies Department
Far Eastern Federal University
Vladivostok, Russia
kalenik.tk@dvfu.ru

D. B. Solovev^{*,**}

*Far Eastern Federal University,
**Vladivostok Branch of Russian Customs Academy
Vladivostok, Russia
solovev.db@dvfu.ru

Abstract— This article contains results of research of Russian scientists in the field of innovative food technology based on one of the quality management methods as quality function deployment. The objective of this research is identification of the main technical parameters of chopped meat-contained semi-finished products enriched with hondroprotectors – glycosamine and chondroitin sulfate before sending them to the market. The result of research is the model of food for osteoarthritis prevention, ready to production, which most satisfies to consumer demand. During the research consumer's requirements (the consumer's voice) of the Khabarovsk population (Russian Federation) concerning innovative food products on the basis of meat raw materials came to light, the structure of the range of the chopped meat-contained semi-finished products that realized at retail was analyzed. The type of chopped meat-contained semi-finished product is defined as schnitzel, and the nomenclature of technical characteristics of innovative food was established by creating of House of Quality matrix. By means of Pareto's chart it is shown that the main parameters on which it is necessary to concentrate attention are the content of high-quality beef and pork (24%), content of biologically active agents (a glycosamine and chondroitin sulfate, 20%), the energy value (20%). The developed product was introduced in production under the trademark "Allegro schnitzel".

Keywords— *quality function deployment, House of Quality, Pareto chart, chopped meat-contained products, chondroprotectors.*

1. INTRODUCTION

For achievement of competitive advantage in the market it is necessary to reveal the buyers expectations of new production, having realized them quicker than other participants of the market. For this purpose there are different ways, however the general tendency speaks about prevalence of the methods connected with tests of virtual model samples. Researchers agree in opinion on maximum efficiency of the transfer of consumer's requirements in characteristics of a new product by means of quality function deployment [1-4]. In the offered research this methodology was approved concerning

innovative foodstuff – the chopped meat-contained semi-finished product enriched with biologically active food supplements – chondroprotectors glycosamine and chondroitin sulfate.

2. RELEVANCE

Chondroprotectors (from Greek *chondros* – a cartilage and English *to protect*) a glycosamine and chondroitin sulfate, on a level with hyaluronic acid, are a part of the synovial fluid which is filling cavities of joints of the person and carrying out a lubricant role when bending joints and treat(belong) minor components of food with the proved biological efficiency [5]. Aminosaccharide glycosamine promotes formation and restoration of cartilages. Chondroitin sulfate, polymeric sulphated glycosaminoglycan, is a cartilage component, to the promoting deduction of water and increase in its elasticity [6].

In spite of synthesis of both connections in our organism, with the age and at active physical activities the amount of synovial fluid decreases, cartilages come to contact with each other that causes their further destruction which is followed by painful symptoms (osteoarthritis). In Russia such signs are found in 50-60% of persons elder than 50 years and in 80% of persons elder than 60 years, and various diagnoses of diseases of bone and muscular system and connecting fabric have to 4,3 million Russians.

Biological activity, high bioavailability and safety of glycosamine and chondroitin sulfate, and also their thermal stability are confirmed with numerous researches [7, 8].

The main food sources of chondroprotectors are cartilaginous tissue of birds, animal and marine organisms, and to a lesser degree a nonfood offal of an animal origin – a trachea of the large horned cattle; P. Zhang allocated a glycosamine also from hydrolyzate of mushrooms [9]. The daily need for a glycosamine is 0,7 g, in a chondroitin sulfate – 0,6 g.

At the same time it is impossible to present cartilages in a daily diet of Russians, and the biologically active food supplements are consumed with only an insignificant part of

the population. Therefore, enrichment by a glycosamine and chondroitin sulfate production of daily consumption, such as chopped meat-contained semi-finished products, will promote prevention of diseases of joints of the population that causes social efficiency of the offered technology.

The main sphere of the use of chondroprotector is the pharmaceuticals. In the meat industry a glycosamine and chondroitin sulfate were not applied earlier that causes scientific novelty and relevance of a research.

3. TARGET AND RESEARCH PROBLEMS

Identification of the major technical characteristics of the chopped meat-contained semi-finished products enriched with a glycosamine and chondroitin sulfate at their conclusion to the market, by creation of the house of quality became the purpose of work. For achievement of a goal the following problems were solved:

1. To reveal consumer's requirements ("the consumer's voice") of the population of Khabarovsk (Russian Federation) concerning innovative food production on the basis of meat raw materials.
2. To analyze the structure of the range of the chopped meat-contained semi-finished products realized in retail stores of Khabarovsk (Russian Federation).
3. To establish the nomenclature(range) of technical characteristics of the developing product.
4. To establish a rank of technical characteristics of production with the help of quality function deployment of chopped meat-contained semi-finished products.

4. LITERATURE REVIEW

Quality function deployment (QFD analysis, "House of quality") represents methodology of systematic transformation of consumer's requirements at early stages of a quality loop in requirements to quality of production. Originally this method was offered by the Japanese professors Sh. Mizuno and A. Akao in 1972 [10] was also based on the cause and effect chart of Ishikawa. However, during design of the oil tanker on shipyards of Mitsubishi concern in Kobe (Japan), the engineer K. Tashimi could not manage to apply it owing to congestion, having developed a matrix of consumer's requirements in which lines requirements of consumers were postponed, and in columns – the controlled and measured reasons. The method was improved by the Toyota company that promoted 60-to percentage depreciation of development of each new model of trucks from January, 1977 till April, 1984. In 1978 professors Sh. Mizuno and A. Akao published the first monograph on structuring function of quality, and in 1987 under A. Akao's edition in Japan there was published a collection with 12 articles about experience of application of this method in various branches. This concept gained development in the manuscripts of G. Vahouni [11], L. Sullivan [12] and H. Ross [2, 4] which today are its base. In the relation of foodstuff the methodology was applied including in the works Jambrak A.R. et al. [13], Kowalska M. et al. [14], Eshel G. et al. [15], Djekic I. et al. [16]. Gained further development of QFD due to application of neural networks when calculating technical

characteristics of a product. Similar practices are described in the works of H.I. Amy Lee & Chun-Yu Lin [17], I. Kutschenreiter-Praszkiewicz [18], Zhihui Yang & Yizeng Chen [19, 21].

5. METHODOLOGIES

Consumer's requirements ("the consumer's voice") were studied by means of questioning what the questionnaire that included 13 closed questions. Selection included 448 respondent of various sex, age, education(formation) and income level. Processing of results of a research was carried out with the use of means of GoogleForms.

Creation of qualimetric model and matrix of consumer's requirements was carried out on the basis of techniques of G.V. Vahouni [613], H. Ross [596]. Creation of the chart of Pareto was carried out according to a technique of L.M. Surhone et al [20].

5. EMPIRICAL ANALYSIS

The methodology of quality function deployment optimized by us for foodstuff from animal raw materials included 6 main stages:

1. Examination and specification of requirements of consumers by a sociological research. From results of a market and sociological research the following requirements were marked out: a type of a semi-finished product – schnitzel; high taste characteristics; gentle consistence; pleasant color; traditional appearance and form; existence in structure of high-quality beef and pork; absence of poultry meat of mechanical separation, soy ingredients, water-retaining agents, flavor enhancers; availability of natural spices; high content of protein; the lowered content of fat and power value; presence of functional food ingredients (chondroprotector of a glycosamine and chondroitin sulfate) in composition. These requirements were grouped in several blocks (functional characteristics, organoleptic characteristics; ingredient composition; nutritive and power value; economic characteristics) were also presented in table 1.
2. Ranging of consumer's requirements. Each consumer's requirement was estimated on importance degree. Coefficients of weight were appropriated in the expert way, considering results of market researches and the existing mark scales of organoleptic assessment of chopped semi-finished products (table 1).
3. Formation of the nomenclature (rank) of technical characteristics of chopped meat-contained semi-finished products taking into account requirements of standard documentation and expert estimates. As a result technical characteristics of chopped meat-contained semi-finished products, enriched with chondroprotector, are weight, the maintenance of qualitative meat, content of functional food ingredients – chondroprotector of a glycosamine and a chondroitin sulfate, the content of spices, protein content, content of fat, power value, pH level, temperature at release from the enterprises (cooled or frozen).

Table 1 – Ranging of consumer’s requirements

The group of consumer’s requirements	Single consumer’s requirements	Coefficient of weight	Bases for establishment Coefficient of weight
Functional	Classification (kind of semi-finished product) - schnitzel	1,3	13% of respondents prefer to get schnitzel, demand for which it is not satisfied, coefficient of weight is received by division this value on 10
	Possibility of the choice of lot of packing (weighing of cooled semi-finished product at presence of a consumer)	0,2	Only 1,8% of respondents make purchase because of packing; coefficient of weight is received by division on 10
	Small period of storage for maximum freshness (thermal state – cooled)	1,0	Expert assessment
Organoleptic	high flavoring characteristics (including a smell)	4,0	According to a scale of organoleptic assessment are appropriated to indicators following coefficients of weight: flavor and aroma – 4; color – 3; consistence – 2; appearance and form – 1.
	gentle consistence	2,0	
	pleasant color	3,0	
	traditional appearance and form	1,0	
Composition	existence of qualitative beef and pork in composition	2,3	23% consider structure most important factor of motivations to purchase; we receive coefficient of weight by division on 10
	availability of natural spices	0,5	Expert assessment
	existence of functional food ingredients (chondroprotector glycosamine and chondroitin sulfata) in composition	7,5	75% of respondents conditions are ready to get similar chopped semi-finished products for those or other; coefficient of weight is received by division on 10
Food and energy values	high content of protein	2	Expert assessment
	the lowered content of fat	1,8	
	the lowered energy value	2,3	
Economical	the price does not matter (in	7,7	23% of respondents put price on the first place buying goods; the rest 77% - do not consider the price an important factor; we receive coefficient of weight by division on 10

4. Calculation of dependences of consumer’s requirements and technical characteristics. As a result of performance of the previous stages the ranged list of consumer’s requirements made in the consumer's language is received well as technical characteristics formulated in language of developers. For successful development of food products on the basis of meat raw materials consumer’s requirements were transferred to technical characteristics.

At the same time such heuristic concepts as "strong correlation", "average correlation " and "weak correlation ", expressed respectively by coefficients 3, 2 and 1 were operated (Figure 1).

Technical characteristics with the greatest contribution in formation of consumer’s requirements should be paid the main attention during production. While ranging of importance of technical characteristics it was established that the main contribution to formation of quality of chopped meat-contained semi-finished products is made by the maintenance of qualitative meat (24%), chondroprotector of a glycosamine and chondroitin sulfata (20%), the energy value (20%), a weight of packing (10%), and also protein and fat content, in the sum of 90% providing quality of finished goods.

It is expedient to specify the possible directions of improvements of the chopped meat-contained semi-finished products enriched with chondroprotector. In the house of quality they are designated by arrows in the low line. For achievement of optimum quality it is necessary to increase the content of spices, including due to decorative sprinkling, to increase protein content, having insignificantly reduced the power value of a product (for example, due to partial replacement of pork by beef).

6. Construction of a correlation matrix. The correlation matrix is the "roof" of the house of quality reflecting the correlation between technical characteristics considered at design of a product. Figures design us correlation level (1 – weak, 2 – noticeable/moderate, 3 – strong).

As a result strong dependences between the maintenance of qualitative meat and protein content, fat, the power value and level pH were established; and weak – between a lot of packing and temperature at release, maintenance of chondroprotector and pH level. Also strong influence of additives of chondroprotector on temperature at release is shown – so it necessary to make such products cooled, but not frozen.

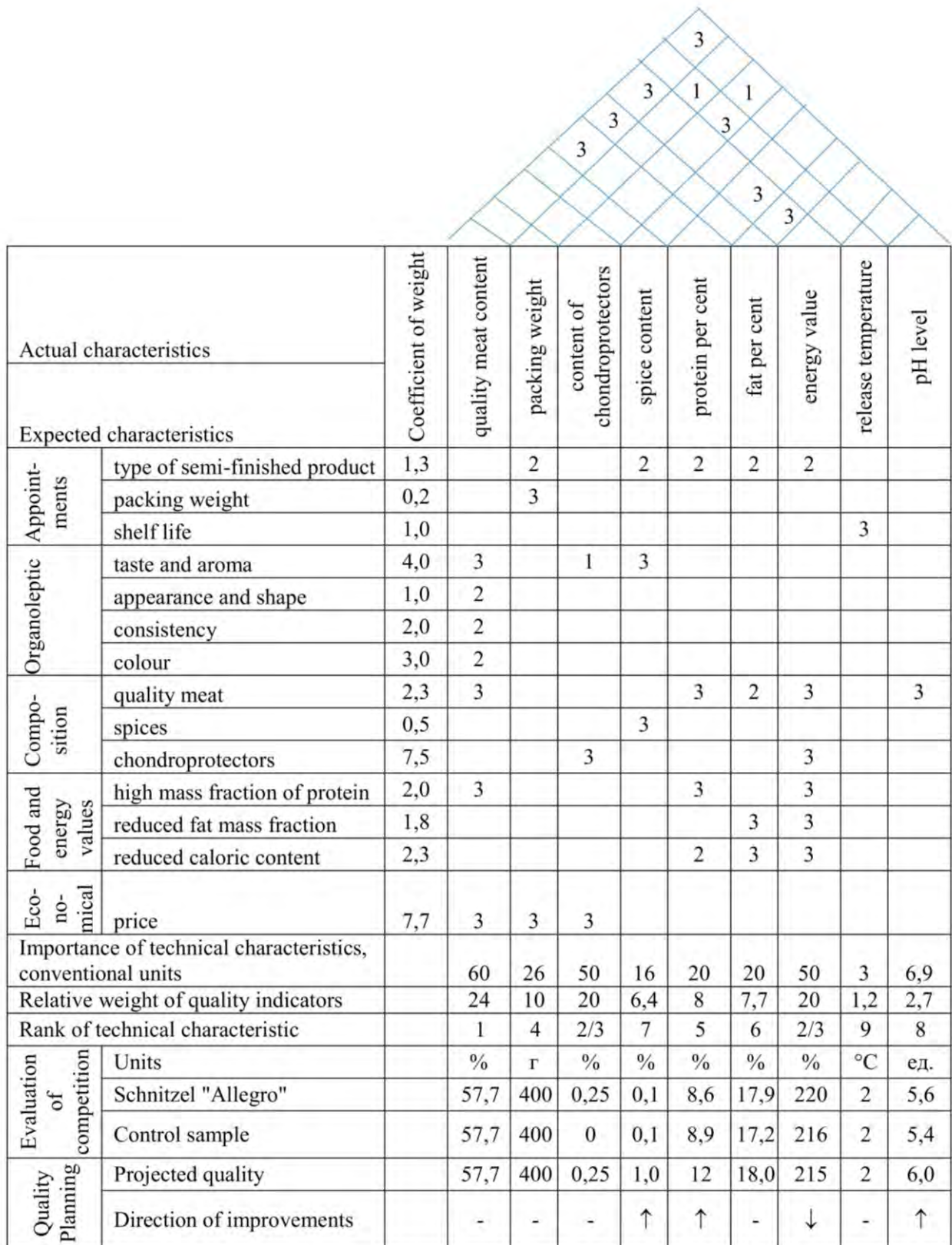


Figure 1 – The house of quality of the chopped semi-finished products enriched with chondroprotectors

5. Definition of weight values of technical characteristics. In line "Specific weight of technical characteristics" was counted a share of each characteristic in percentage. Further

technical characteristics were ranged and presented in the form of the chart of Pareto (Figure 2).

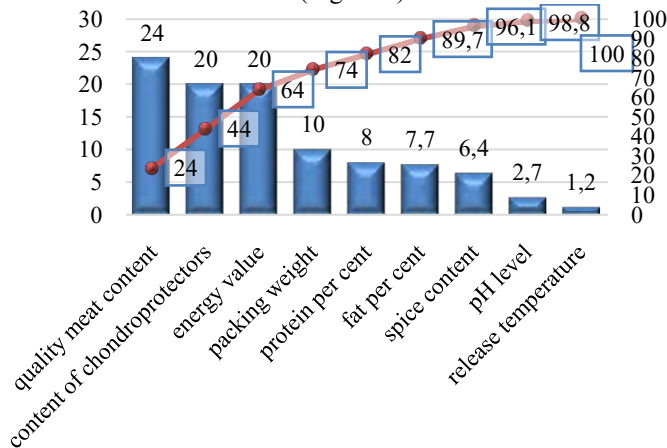


Figure 2 – Pareto's chart of the importance of technical characteristics of the chopped semi-finished products enriched with chondroprotector

Technical characteristics with the greatest contribution in formation of consumer's requirements should be paid the main attention during production. While ranging of importance of technical characteristics it was established that the main contribution to formation of quality of chopped meat-contained semi-finished products is made by the maintenance of qualitative meat (24%), chondroprotector of a glycosamine and chondroitin sulfate (20%), the energy value (20%), a weight of packing (10%), and also protein and fat content, in the sum of 90% providing quality of finished goods.

It is expedient to specify the possible directions of improvements of the chopped meat-contained semi-finished products enriched with chondroprotector. In the house of quality they are designated by arrows in the low line. For achievement of optimum quality it is necessary to increase the content of spices, including due to decorative sprinkling, to increase protein content, having insignificantly reduced the power value of a product (for example, due to partial replacement of pork by beef).

6. Construction of a correlation matrix. The correlation matrix is the "roof" of the house of quality reflecting the communications (connections) between technical characteristics considered at design of a product. Figures design us communication (connection) force (1 – weak, 2 – noticeable/moderate, 3 – strong).

As a result strong dependences between the maintenance of qualitative meat and protein content, fat, the power value and level pH were established; and weak – between a lot of packing and temperature at release, maintenance of chondroprotector and pH level. Also strong influence of additives of chondroprotector on temperature at release is shown – so it necessary to make such products cooled, but not frozen.

6. CONCLUSIONS

Results of structuring function allow to offer the consumer ready model of a chopped meat-contained semi-finished product, enriched with chondroprotector a glycosamine and chondroitin sulfate. This product of daily consumption for prevention of osteoarthritis, is schnitzel with high content of meat (about 60%), the lowered content of fat and power value, high content of protein and the increased physiological value because of enrichment by chondroprotector in number of 0,25-0,5% that makes about 25-50% of daily need for one portion weighing 100 g. For achievement of these parameters qualitative meat raw materials and functional food ingredients such as chondroprotector glycosamine are used and chondroitin sulfate in the form of biologically active food supplement «Doppel herz Aktiv». Packing of a chopped semi-finished product weighing 400-500 g (4-5 items) can be made of prestigious materials, however the cooled product, perhaps, will be weighed on a polymeric substrate in the presence of the consumer, but it is not so essential.

This product was introduced by us in production under the trade name "Allegro schnitzel".

References

- [1] Aleshkov A. V., Aleshkova M. A. On prospects of QFD analysis in developing innovative products// Baikal Research Journal. 2015. Vol. 6. no. 1. Available at: <http://eizvestia.isea.ru/reader/article.aspx?id=19930>. DOI: 10.17150/2072-0904.2015.6(1).10. (In Russian).
- [2] Ross H. Proceeding of the International Symposium on Quality Function Deployment'95 // QFD Status in the U.S. Automotive industry. — Tokio, 1995. — C. 19-28.
- [3] Mizuno S. QFD: Customer-Driven Approach to Quality Planning and Deployment / Shigeru Mizuno, Yoji Akao. – Asian Productivity Organization. 1994. – 365 p.
- [4] Ross H. QFD Status in the U.S. Automotive industry / Harold Ross, Kiousmars Paryani // Proceeding of the International Symposium on Quality Function Deployment'95 – Tokio. - 1995. - P. 19-28.
- [5] Barrett St. Glucosamine and Chondroitin for Arthritis: Benefit is Unlikely // November, 21. 2014. Электронный ресурс. Режим доступа <http://www.quackwatch.com/01/QuackeryRelatedTopics/DSH/glucosamine.html>.
- [6] Wilkens P. Scheel I.B., Grundnes O., Helium C, Storheim K. Effect of glucosamine on pain-related disability in patients with chronic low back pain and degenerative lumbar osteoarthritis // JAMA. - 2010. - № 304. - P. 45-52.
- [7] Mazieres B., Hucher M., Zaim M., Garnero P. Effect of chondroitin sulphate in symptomatic knee osteoarthritis: a multicentre, randomised, double-blind, placebo-controlled study // Ann Rheum Dis. - 2007. - № 66 (5). - P. 639-645.
- [8] Sandya S., Sudhakaran P.R. Effect of glycosaminogly cans on matrix metalloproteinases in type II collagen-induced experimental arthritis // Experimental Biology and Medicine. - 2007. - Vol. 232. - P. 629-637.
- [9] Zhang P., Roytrakul S., Sutteerawattananonda M. Production and purification of glucosamine and angiotensin-I converting enzyme (ACE) inhibitory peptides from mushroom hydrolysates // Journal of Functional Foods Volume 36, September 2017, Pages 72-83.
- [10] Akao Yoji. History Of Quality Function Deployment In Japan // The Best Of Quality, I'AO Book Series, 1990. – Vol. 3. – P. 193-196. International Academy For Quality.
- [11] Vahouni G. V. Quality Function Deployment / G. V. Vahouni // Fed. Pros., 1982. Vol. 41. №11. – P. 2801-2806.
- [12] Sullivan Larry P. Quality Function Deployment – a system to assure that customer needs drive the product design and production process // Quality progress. – 1986. - №6. P. 39-50.

- [13] Jambrak A.R., Simunek M., Grbes F., Mandura A., Djekic I. Analysis of apple beverages treated with high-power ultrasound: a quality function deployment approach // *Journal Of The Science Of Food And Agriculture*. 2018. April. Vol. 98. Issue 6. Pp. 2258-2266. DOI: 10.1002/jsfa.8714.
- [14] Kowalska M., Pazdzior M., Krzton-Maziopa A. Implementation of QFD method in quality analysis of confectionery products // *Journal Of Intelligent Manufacturing*. 2018. February. Vol. 29. Issue 2. Pp. 439-447. DOI: 10.1007/s10845-015-1120-y.
- [15] Eshel G., Shepon A., Shaket T., Cotler B.D., Gilutz S., Giddings D., Raymo, M.E., Milo R. A model for sustainable US beef production // *Nature Ecology & Evolution*. 2018. January. Vol. 2. Issue 1. Pp. 81-85. DOI: 10.1038/s41559-017-0390-5.
- [16] Djekic I., Vunduk J., Tomasevic I., Kozarski M., Petrovic P., Niksic M., Pudja P., Klaus A. Application of quality function deployment on shelf-life analysis of *Agaricus bisporus* Portobello // *LWT-Food Science And Technology*. 2017. May. Vol. 78. Pp. 82-89. DOI: 10.1016/j.lwt.2016.12.036.
- [17] Amy H. I. Lee, Chun-Yu Lin An integrated fuzzy QFD framework for new product development // *Flex Serv Manuf J* (2011) 23. Pp. 26–47 DOI 10.1007/s10696-011-9076-5
- [18] Kutschenreiter-Praszkiewicz I. Application of neural network in QFD matrix // *J Intell Manuf* (2013). Pp. 24:397–404 DOI 10.1007/s10845-011-0604-7
- [19] Zhihui Yang, Yizeng Chen Fuzzy Optimization Modeling Approach for QFD-Based New Product Design // *Journal of Industrial Engineering* Volume 2014, Article ID 548271, 8 p.
- [20] Surhone L.M., Timpledon M.T., Marseken S.F. *Pareto Analysis. – VDM Publishing*. 2010: 76 p.
- [21] Solovev D. B., Merkusheva A. E. Study of transients in measuring circuits for negative sequence currents based on using rogowski coils // *Industrial Engineering, Applications and Manufacturing (ICIEAM), International Conference on*. pp. 1-5, 2016. [Online]. Available: <http://dx.doi.org/10.1109/ICIEAM.2016.7911505>