СУЧАСНІ НАПРЯМКИ ПІДВИЩЕННЯ ЯКОСТІ ХАРЧОВИХ ПРОДУКТІВ

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DETERMINATION OF THE COMPREHENSIVE QUALITY INDICATOR OF COMBINED MINCED

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ВИЗНАЧЕННЯ КОМПЛЕКСНОГО ПОКАЗНИКА ЯКОСТІ КОМБІНОВАНИХ ФАРШІВ

Objective. *The purpose of the article is to determine the comprehensive quality indicator of combined minced taking into account the principles of Qualimetry.*

Methods. *The quality of the combined minced meat was evaluated by a combination of organoleptic, physico-chemical, microbiological, structural-mechanical indicators and nutritional value, taking into account their weight in use. Sampling and preparation for research were carried out according to DSTU ISO 6498: 2006. Research of the chemical composition of minced meat was carried out according to traditional methods: the protein content was determined by the modified Kjeldahl method, fat was determined by the extraction weight method, mineral content of minced meat was determined by atomic absorption spectrophotometer AAS-30, the content of vitamins was determined according to standard methods. Investigation of the structural and mechanical properties of minced meat was carried out on a rotary viscometer Rheotest RN4.1. In studies, we used a measuring system — a cone-plate with a type S1 rotor. Organoleptic evaluation of combined minced was carried out by conducting profile analysis. Determination of pH was carried out using a potentiometric method. Titrated acidity was investigated by titration of a mixture of minced meat and distilled water with a solution of potassium hydroxide in the presence of phenolphthalein to a non-fading over 60 s of weak pink coloring. In the study of microbiological indicators of combined minced was guided by the medical-biological requirements and Sanitary norms of quality of food raw materials and food products, as well as the Instruction on the organization and conduct of microbiological studies of food products and assess their quality. Preparation of samples was carried out according to GOST 26669-85, sampling for microbiological analysis — in accordance with GOST 26668-85. Cultivation of microorganisms was carried out in accordance with GOST 26670-91, definition of yeast and mold fungi — according to GOST 10444.12-75, determination of bacteria of the E. coli group (BGKP) — according to GOST 9225-84.*

Results. *It was defined the comprehensive measure of quality of combined minced. It was established that the complex indicator of quality of developed combined minced is positioned in the interval*

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of «excellent quality», while the control is in the range of «good quality». The expediency use of combined minced in the production of culinary products, contributing to the expansion of product range restaurant industry improve its food and biological value.

***Key words**: comprehensive quality indicator, nutritional value, structural and mechanical properties, microbiological parameters.*

Problem statement. Health of the population depends on nutrition. This fact is proved by numerous researches and practical experience. According to WHO, health depends by 50 % on life style, the most important part of which is nutrition.

Unfortunately, modern level of nutrition is unsatisfactory both qualitative, and quantitative relation. The reason for this is lack of native proteins, polyunsaturated fatty acids, vitamins, macro- and micronutrients, and dietary fibres [1]. Lack of nutrients leads to reduction in immunity towards diseases and unfavourable environmental factors.

One of the ways to provide an optimal balance of nutritives is combining of different types of raw materials with certain functional and technological properties. Thus, combination of milk and vegetable raw materials gives the possibility to get food with high content of animal protein, rich in bioactive compounds. As well, it gives the chance to use raw materials rationally [2].

We developed milk and vegetable mince production technology. The designed technology proposes to use milk and protein concentrate with buttermilk as the main component. Also, mince recipes should include mashed carrot, pumpkin and zucchini, egg mixture, wheat flour, and sugar.

Evaluation of the designed milk and vegetable minced is of current interest as one of the main tasks of modern society is providing quality food raw material and food products, including culinary goods. Evaluation of quality should be made on the basis of different properties of various types which characterise the product, namely — nutrition value, structural-mechanical, organoleptic, physicochemical, and microbiologic properties.

Analysis of recent research and publications. Today, the most popular method of quality determination is combination of properties which influence its ability to satisfy established and forecast requirements [3]. The issues of quality evaluation of food are the topics of research for native and foreign scientists: Dorokhovich, A. M., Korolkova, E. P., Matiukhina, Z. P., Nesterenko, A. A., Ratushnyi, A. S., Topolnik, V. G., J. R. Brunner, H. Mulder, P. Walstra and others.

Objective of the article. As the quality of the designed minced is characterised by a number of parameters, the purpose of the work was determining a comprehensive quality indicator using theoretical background of qualimetry [4].

Presentation of the main material of the study. The paper [4] offers the algorithm of determining of comprehensive quality indicator of culinary goods which consists of several stages.

First, there was developed a hierarchical structure of comprehensive properties which are required for proper evaluation of milk and vegetable minced quality, and which concern stages of production and storage. During production, quality of the goods is determined by nutrition value, structural-mechanical, organoleptic, physicochemical, and microbiologic properties. During storage, the quality of minced is determined by structural-mechanical, organoleptic, and microbiologic properties.

Nutritional value is characterised by proteins, fats, carbohydrates, vitamins, and minerals. Structural-mechanical properties are represented by border shift stress and viscosity. Organoleptic properties are represented by outer appearance, colour, smell, taste, and texture. Physicochemical properties include titrated and active acidity. Microbiologic properties include quantitative characteristic of yeast, mold, coliform bacteria, and pathogenic microorganisms.

Properties that were included into the above mentioned groups were measured and used as singular indicators of quality. Evaluation of singular quality indicators of the designed minced (studied sample No.1 — milk and carrot mince, No. 2 — milk and pumpkin mince, No. 3 — milk and zucchini mince, No. 4 (reference [5]) — mince of low-fat acid curd cheese mince) were carried using Harrington desirability function:

$$K_i = \exp\left[-\exp(-Y_i)\right], \qquad (1)$$

where Y_i — coded identification of adjustable scale.

Coded and respective absolute values of properties indices are located on X-axis, and relative values are located on Y-axis. Harrington scale implies 5 intervals in, total interval of the scale is from 1 to 0: 1,00...0,80 — very good (perfect); 0,80...0,63 — good; 0,63...0,37 — satisfactory; 0,37...0,20 — bad; 0,20...0,00 — very bad.

Harrington desirability function has the following useful and important properties: monotone, continuity, smoothness, adequacy, effectiveness and statistical sensitivity. On the following stage, we determined possible interval for change of each of simple quality indicators in terms of allowable values of indicators Pijallowable, which are minimum according to the requirements of documentary standards, desired reference value Pijref — the best values among similar objects in the world practice, and faulty indicator value Pijfaulty. Note that if the values are lower than faulty, it is impossible to turn production into condition allowed under documentary standard.

To calculate Pallowable, we considered the values given in the documentary standard — DSTU 4554:2006 "Acid curd cheese" and values of the known sample — "Milk and protein products of buttermilk" TOR U 40-01566330.094-2000, "Milk and protein minced" TOR U 15.5-01566330-161-2004. Specific values of reference, allowable and faulty indicators are shown in Table 1.

Table 1 — Critical limits of mince quality indicators

Indicator	Units of measurement	Reference indicator value	Allowable indicator value	Faulty indicator value
1	2	3	4	5
Nutrition value				
Protein content	%	25	14	10
Fats content	%	0	6	8
Carbohydrates content	%	20	11	8
Vitamins content	%	0,025	0,010	0,005
Minerals content	%	1,5	0,6	0,3
Structural-mechanical properties				
Shift stress	Pa	700	1900	2300
Effective viscosity	Pa*s	21	6	3
Organoleptic properties				
Outer appearance	grade	50	30	20
Colour	grade	50	30	20
Smell	grade	50	30	20
Taste	grade	50	30	20
Texture	grade	50	30	20
Physicochemical properties				
Titrated acidity	°T	60	180	220
Active acidity	%	4,8	4,0	3,7
Microbiologic properties				
Yeast	CFU/G	0,5×10	10^2	5×10^2
Microscopic fungi	CFU/G	0,5×10	5×10	10^2

Values of Table 1 were considered during evaluation of the designed goods. Evaluation of the reference (P_{ijref}), allowable ($P_{ijallowable}$) and faulty $P_{ijfaulty}$ indicator values under adjustable Harrington scale will be equal to 1,00 (Y_{ijref}=+3); 0,37 ($Y_{ijallowable}$ = 0,0); 0,20 ($Y_{ijfaulty}$ = –0,5) respectively. Indicator values between 1,00 and 0,37 were chosen in terms of providing steadiness of the scale as well as practical and logical reasoning.

Absolute quality indicators nodal values scale if designed in terms of data from Table 1 and is shown in Table 2.

Relative values of singular quality indicators K_{ij} were determined using chart method using curves and in terms of absolute quality indicators nodal values (Table 2). The received results of quality evaluation calculation K_i of certain properties of calculations are shown in Table 3.

Average-weighted arithmetic value was used to calculate a comprehensive evaluation of quality indicators of j-group:

$$K_j = \sum_{i=1}^{nj} K_{ij} \cdot m_{ij} \ , \qquad (2)$$

where K_{ij} — is evaluation of a singular indicator; *mij* — ratio of indicator's weight; *n* — quantity of indicators considered in *j*-group.

Table 2 — Nodal values scale of mince quality indicators

Indicator	Units of measurement	Evaluation, K_i					
		1,00	0,80	0,63	0,37	0,20	0,00
		Coded identification У					
		3,00	1,50	0,85	0,00	-0,50	-3,00
1	2	3	4	5	6	7	8
Nutrition value							
Protein content	%	25	21	18	14	10	5
Fats content	%	0	2	4	6	8	10
Carbohydrates content	%	20	17	14	11	8	5
Vitamins content	%	0,025	0,020	0,015	0,010	0,005	0
Minerals content	%	1,5	1,2	0,9	0,6	0,3	0
Structural-mechanical properties							
Shift stress	Pa	700	1100	1500	1900	2300	2700
Effective viscosity	Pa*s	21	16	11	6	3	0
Organoleptic properties							
Outer appearance	grade	50	45	40	30	20	10
Colour	grade	50	45	40	30	20	10
Smell	grade	50	45	40	30	20	10
Taste	grade	50	45	40	30	20	10
Texture	grade	50	45	40	30	20	10
Physicochemical properties							
Titrated acidity	ºT	60	100	140	180	220	260
Active acidity	%	4,8	4,6	4,3	4,0	3,7	3,5
Microbiologic properties							
Yeast	CFU/G	0,5×10	1×10	$0,5×10^2$	10^2	$5×10^2$	10^3
Microscopic fungi	CFU/G	0,5×10	2×10	3×10	5×10	10^2	10^3

Table 3 — Mince quality indicator

Quality indicator	Units of measure-ment	Absolute values, P_i				Relative value, K_i			
		Studied sample			Reference sample № 4	Studied sample			Reference sample № 4
		№1	№2	№3		№1	№2	№3	
1	2	3	4	5	6	7	8	9	10
Manufacturing									
Protein content	%	14,06	13,99	15,79	17,2	0,37	0,37	0,49	0,58
Fats content	%	1,82	1,81	1,80	1,00	0,82	0,82	0,82	0,9
Carbohydrates content	%	17,23	18,49	7,62	11,1	0,82	0,90	0,18	0,38
Vitamins content	%	0,015	0,023	0,015	0,002	0,64	0,93	0,64	0,09

Continuation of table 3

1	2	3	4	5	6	7	8	9	10
Minerals content	%	0,830	0,825	1,400	0,486	0,57	0,57	0,93	0,31
Shift stress	Pa	744,1	947,0	801,05	1153	0,98	0,88	0,95	0,78
Effective viscosity	Pa*s	15,68	11,3	16,98	9,1	0,79	0,64	0,84	0,53
Outer appearance	grade	49	49	49	47	0,96	0,96	0,96	0,88
Colour	grade	49	50	50	44	0,96	1,00	1,00	0,77
Smell	grade	48	49	49	46	0,92	0,96	0,96	0,84
Taste	grade	48	49	50	46	0,92	0,96	1,00	0,84
Texture	grade	49	49	49	45	0,96	0,96	0,96	0,8
Titrated acidity	ºT	65	72	69	67	0,98	0,94	0,95	0,97
Active acidity	%	4,68	4,50	4,61	4,74	0,88	0,75	0,81	0,94
Yeast	CFU/G	6	8	8	8	0,96	0,88	0,88	0,88
Microscopic fungi	CFU/G	7	5	7	7	0,97	1,00	0,97	0,97
Storage									
Outer appearance	grade	47	48	48	45	0,88	0,92	0,92	0,80
Colour	grade	49	49	49	44	0,96	0,96	0,96	0,77
Smell	grade	45	45	43	43	0,80	0,80	0,73	0,74
Taste	grade	45	46	44	44	0,80	0,84	0,77	0,77
Texture	grade	49	47	48	45	0,96	0,88	0,92	0,80
Shift stress	Pa	720	866,0	759,4	1110	0,99	0,92	0,97	0,80
Effective viscosity	Pa*s	12,02	9,7	16,04	19,63	0,67	0,56	0,80	0,95
Yeast	CFU/G	36	32	31	36	0,79	0,81	0,82	0,79
Microscopic fungi	CFU/G	29	28	34	30	0,70	0,71	0,64	0,69

Weight ratios were determined using expert method:

$$\sum_{i=1}^{n} m_{ij} = 1, \quad (3)$$

where m_{ij} — weight ratio of *i*-value of *j*-group ($m_i > 0$); *n* — number of production quality indicators.

Table 4 — Weight indicators (as of the data from the expert group)

Expert	Weight ratio											
	Manufacturing											
	Nutrition value					Structural-mechanical properties		Organoleptic properties				
	Protein content	Fats content	Carbohydrates content	Vitamins content	Minerals content	Shift stress	Effective viscosity	Outer appearance	Colour	Smell	Taste	Texture
1	2	3	4	5	6	7	8	9	10	11	12	13
1	5	3	4	5	5	5	5	4	3	4	4	5
2	5	4	3	4	4	5	4	4	4	5	4	5
3	5	3	3	5	4	5	3	3	4	5	3	4
1	2	3	4	5	6	7	8	9	10	11	12	13
4	5	3	4	4	4	5	4	4	3	4	4	5
5	5	3	3	4	5	5	4	4	5	5	3	5
6	5	4	4	5	4	5	3	3	4	5	3	5
7	5	4	4	4	4	4	4	4	4	5	4	4
m_{ijcp}	5,00	3,43	3,57	4,43	4,29	4,86	3,86	3,71	3,86	4,71	3,57	4,71
m_{ij}	0,241	0,166	0,172	0,214	0,207	0,557	0,443	0,181	0,188	0,229	0,174	0,228

Continued Table 4

Expert	Weight ratio												
	Manufacturing				Storage								
	Structural-mechanical properties		Microbiologic properties		Organoleptic properties					Structural-mechanical properties		Microbiologic properties	
	Titrated acidity	Active acidity	Yeast	Microscopic fungi	Outer appearance	Colour	Smell	Taste	Texture	Shift stress	Effective viscosity	Yeast	Microscopic fungi
1	14	15	16	17	18	19	20	21	22	23	24	25	26
1	4	4	4	5	4	3	4	4	5	5	5	4	5
2	5	4	5	4	4	4	5	4	5	5	4	5	4
3	4	3	5	5	3	4	5	3	4	5	5	5	4
4	5	4	5	4	4	3	4	4	5	5	4	5	4
5	5	4	5	4	5	4	5	3	5	5	5	5	4
6	4	5	4	5	3	4	5	3	5	5	4	4	5
7	5	4	5	5	4	4	5	4	4	5	4	5	5
m_{ijcp}	4,57	4,00	4,71	4,57	3,86	3,71	4,71	3,57	4,71	5,00	4,43	4,71	4,43
m_{ij}	0,533	0,467	0,508	0,492	0,188	0,181	0,229	0,174	0,228	0,530	0,470	0,516	0,484

Weight ratio m_{ij} was calculated as follows:

$$m_{ij} = \frac{m_{ijcp}}{\sum_{i=1}^{n} m_{ijcp}}, \quad (4)$$

where m_{ijcp} — is arithmetic average of expert evaluations of quality *i*-value of *j*-group.

Average value m_{ijcp} was calculated as follows:

$$m_{ijcp} = \frac{1}{N}\sum_{z=1}^{N} m_{ijz}, \ (z = 1, 2, 3, \dots N), \quad (5)$$

where *N* — is quantity of experts; m_{ijz} — is evaluation of quality *i*-value of *j*-group given by *z*-expert (z = 1, 2, 3, ... *N*).

The results of weight ratio calculations are shown in Table 4.

Weight ratios of values properties' groups were chosen according to practical and logical reasoning on importance of this or that values for the studied products. At the production stage,

they constitute: nutrition value — 0,25, structural-mechanical properties — 0,35, organoleptic properties — 0,15, physicochemical properties — 0,1, microbiological properties 0,15. At the storage stage, they constitute: organoleptic properties — 0,25, structural-mechanical properties — 0,35, microbiological properties — 0,40. Weight ratio for the production stage constitutes 0,6, for storage stage — 0,4.

In order to receive a comprehensive quality evaluation at the stage of production and storage, the following model was applied:

$$K_{em} = (x_1 \wedge x_2)\sum_{j=1}^{n} M_j \cdot K_j, \quad (6)$$

where K_{em} — is a comprehensive production quality evaluation at the stage of shelf life; $(x_1 \wedge x_2)$ — is veto function made by quality indicators having alternative nature — coliforms and pathogenic microorganisms (when meeting the requirements x_1 and x_2 are equal 1, alternatively it equals 0); M_j — is weight ration of indicators' j-group; K_j — is group evaluation of indicators.

The received data of the comprehensive quality evaluation of milk and vegetable minced and control are given in Table 5.

Table 5 — Mince quality evaluation

Samples	Groups										General evaluation K_0
	Production stage						Storage stage				
	Nutrition value	Structural-mechanical properties	Organoleptic properties	Physicochemical properties	Microbiologic properties	Comprehensive quality	Organoleptic properties	Structural-mechanical properties	Microbiologic properties	Comprehensive quality	
Reference	0,438	0,669	0,825	0,956	0,924	0,702	0,776	0,870	0,742	0,795	0,739
Milk and carrot mince	0,621	0,896	0,944	0,933	0,965	0,849	0,881	0,840	0,746	0,813	0,834
Milk and pumpkin mince	0,697	0,774	0,968	0,851	0,939	0,816	0,877	0,751	0,762	0,787	0,804
Milk and zucchini mince	0,614	0,901	0,974	0,885	0,924	0,842	0,858	0,890	0,733	0,819	0,833

The analysis of the received data shows that the comprehensive quality indicator of milk and vegetable minced is higher than the results of the reference sample: milk and carrot mince — by 12,86 %, milk and pumpkin mince — by 8,83 %, milk and zucchini mince — by 12,71 %. High comprehensive qualitative indicator of milk and vegetable mince in comparison with the reference sample is determined by the evaluation of its quality both at the stage of production and storage. For example, at the stage of production, the comprehensive evaluation of milk and carrot mince constitutes 0,849; milk and pumpkin mince — 0,816; milk and zucchini mince — 0,842. All these values are higher than those of the reference samples by 10,94 %, 16,24 % and 19,94 % respectively. High evaluation of milk and vegetable mince at the stage of production can be explained by the fact that minced have higher absolute values of indicators of the following groups: "nutrition value", "structural and mechanical properties", "organoleptic properties", and "microbiologic properties". For example, milk and vegetable mince contain more nutritives which characterise "nutritional value" group than the reference sample; that is why the evaluation of this milk and vegetable mince properties is higher than the evaluation of reference sample.

It should be noted that the values of "structural and mechanical properties" group has better indicators for milk and vegetable minced, that is why their evaluation is higher than the evaluation of the reference sample.

According to Table 5, high quality evaluation at the stage of storage is characteristic for "organoleptic properties" and "microbiologic properties" groups, which also influences the comprehensive evaluation of mince quality.

Conclusions. Thus, comprehensive quality indicator of the designed milk and vegetable mince lies within the interval of "perfect quality". At the same time, the reference sample lies in the interval of "good quality". The determined comprehensive indicator verifies high quality of milk and vegetable minced and practicability of their use for manufacturing culinary products.

The perspective of the following researches in this direction is determining of economic effectiveness of using milk and vegetable minced in culinary production.

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***Мета**. Визначити комплексний показник якості комбінованих фаршів з урахуванням принципів кваліметрії.*

***Методи**. Якість комбінованих фаршів оцінювали за сукупністю органолептичних, фізико-хімічних, мікробіологічних, структурно-механічних показників та харчової цінності з урахуванням їх важливості при використанні. Відбір проб і підготовку їх до дослідження здійснювали за ДСТУ ISO 6498:2006. Дослідження хімічного складу фаршів проводили за традиційними методами: вміст білка визначали модифікованим методом К'єльдаля, жиру — екстракційно-ваговим методом, мінеральний склад фаршів визначали на атомно-абсорбційному спектрофотометрі AAS-30, вміст вітамінів — за стандартними методами. Дослідження структурно-механічних властивостей фаршів проводили на ротаційному віскозиметрі Rheotest RN4.1. При дослідженнях використовували вимірну систему — конус-плита з ротором типу S1. Органолептичну оцінку фаршів здійснювали шляхом проведення профільного аналізу. Визначення pH здійснювали потенціометричним методом. Титровану кислотність досліджували шляхом титрування суміші фаршу і дистильованої води розчином гідроксиду калію в присутності фенолфталеїну до появи не зникаючого протягом 60 с слабко-рожевого фарбування. При дослідженні мікробіологічних показників фаршів керувалися Медико-біологічними вимогами і Санітарними нормами якості продовольчої сировини і харчових продуктів, а також Інструкцією з організації і проведення мікробіологічних досліджень харчових продуктів і оцінки їх якості. Підготовка проб проводилась за ГОСТ 26669-85, відбір проб для мікробіологічного аналізу — відповідно до ГОСТ 26668-85. Культування мікроорганізмів проводили за ГОСТ 26670-91, визначення дріжджів та плісневих грибів — за ГОСТ 10444.12-75, визначення бактерій групи кишкової палички (БГКП) — за ГОСТ 9225-84.*

***Результати**. Визначено комплексний показник якості комбінованих фаршів. Встановлено, що комплексний показник якості розроблених фаршів позиціюється в інтервалі «відмінної якості», тоді як контроль — в інтервалі «доброї якості». Доведено доцільність використання комбінованих фаршів у виробництві кулінарної продукції, що сприяє розширенню асортименту продукції ресторанного господарства, підвищенню її харчової і біологічної цінності.*

***Ключові слова**: комплексний показник якості, харчова цінність, структурно-механічні властивості, мікробіологічні показники.*

***Цель**. Определить комплексный показатель качества комбинированных фаршей с учетом принципов квалиметрии.*

***Методы**. Качество комбинированных фаршей оценивали по совокупности органолептических, физико-химических, микробиологических, структурно-механических показателей и пищевой ценности с учетом их весомости при использовании. Отбор проб и подготовку их к исследованию осуществляли по ДСТУ ISO 6498: 2006. Исследование химического состава фаршей проводили традиционными методами: содержание белка определяли модифицированным методом Кьельдаля, жира экстракционно-весовым методом, минеральный состав фаршей определяли на атомно-абсорбционном спектрофотометре AAS-30, содержание витаминов — стандартными методами. Исследование структурно-механических свойств фаршей проводили на ротационном вискозиметре Rheotest RN4.1. При исследованиях использовали мерную систему — конус-плита с ротором типа S1. Органолептическую оценку фаршей осуществляли путем проведения профильного анализа. Определение pH осуществляли потенциометрическим методом. Титруемую кислотность исследовали путем титрования смеси фарша и дистиллированной воды раствором гидроксида калия в присутствии фенолфталеина до появления не исчезающей в течение 60 с слабо-розовой окраски. При исследовании микробиологических показателей молочно-растительных фаршей руководствовались Медико-биологическими требованиями и Санитарными нормами качества продовольственного сырья и пищевых продуктов, а также Инструкцией по организации и проведению микробиологических исследований пищевых продуктов и оценки их качества. Подготовка проб проводилась по ГОСТ 26669-85, отбор проб для микробиологического анализа — в соответствии с ГОСТ 26668-85. Культивирование микроорганизмов проводили по ГОСТ 26670-91, определение дрожжей и плесневых грибов — по ГОСТ 10444.12-75, определение бактерий группы кишечной палочки (БГКП) — по ГОСТ 9225-84.*

***Результаты**. Определен комплексный показатель качества комбинированных фаршей. Установлено, что комплексный показатель качества разработанных комбинированных фаршей позиционируется в интервале «отличного качества», тогда как контроль — в интервале «хорошего качества». Доказана целесообразность использования комбинированных фаршей в производстве кулинарной продукции, что способствует расширению ассортимента продукции ресторанного хозяйства, повышению ее пищевой и биологической ценности.*

***Ключевые слова**: комплексный показатель качества, пищевая ценность, структурно-механические свойства, микробиологические показатели.*