UDC 641.1-027.38:[613.263+613.287
DOI: 10.31866/2616-7468.3.1.2020.205562

MODELING OF THE RECEPTURAL COMPOSITION PROTEIN-CARBON SEMI-FABRICATES

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Topicality. The creation of new combined products saves animal raw materials. The use of vegetable purees in the production of food is due to high nutritional and biological value. In view of the above, research aimed at the development of new types of semi-finished protein-based carbohydrates based on milk protein concentrates (MBC) with the addition of vegetable purees are relevant. **The purpose of the article** is to substantiate the technologies development of protein-carbohydrate (NBC) semi-finished products with the addition of vegetable purees and to perform the modeling of the recipe composition of protein-carbohydrate semi-finished products. The following research methods were used in the writing of the article: standard physicochemical, rheological, methods of experiment planning and mathematical processing of experimental data using modern computer programs. **Results.** It is theoretically and experimentally substantiated the feasibility of using in the NBC technologies development on the basis of MBK of cuttings, mashed carrots and mashed pumpkin. The composition of new NBS was simulated, which made it possible to narrow the range of variation of the feedstock concentrations in further studies. It is established that the rational concentrations of recipe components for NBC from carrot puree are: mass fraction of MBK 50… 54 %, carrot puree 26… 30 %, sugar 8… 12 %, stabilizer 8… 12 %; for NBC pumpkin puree – MBC mass fraction 46… 50 %, pumpkin puree 30… 34 %, sugar 8… 12 %, stabilizer 8… 12 %. **Conclusions and discussions**. Developed and modeled NBC technologies using carrot and pumpkin puree to allow more efficient use of the nutritional potential of milk and its processing products in combination with carotene-containing vegetable raw materials**.** The scientific novelty of the obtained results is the theoretical substantiation and experimental

confirmation of the expediency of using MBK made from cuttings, puree from carotene-containing vegetable raw materials in NBC technologies.

Key words: modeling, semi-finished product, milk protein concentrate, mashed potatoes, pumpkin, carrots, stabilizer.

The topicality of the problem

Formulation of the problem. Insufficient consumption of essential protein-containing products such as meat, fish, milk, and products containing vegetable protein has contributed to a serious problem in the nutrition of the population of the whole world, and in particular of Ukraine (Deinychenko et al., 2018).

Expanding the range of food products, enhancing their biological value, as well as creating the next generation of products that meet the requirements of healthy nutrition are urgent problems of modern society (Rudavska et al., 2018). One of the possible ways of realization of these problems is development of technologies of obtaining various combined products of certain physical and biological orientation (Mamtcev et al., 2016).

Creation of new combined products saves animal raw materials, in particular milk, thus providing the population with complete protein nutrition (Trukhachev et al., 2017).

Status of problem study. Many studies of domestic and foreign scientists have been devoted to the study of the chemical composition, nutritional value of dairy raw materials and the development of protein-based food technologies: S. Gulyaev-Zaitsev (2009), G. Deynichenko (2018), V. Kozlov (2016), A. Iashin (2015), G. Polishchuk (2015), G. Rudavska (2018), N. Tkachenko (2016), A. Khramtsov (2017), V. Gnitsevich, T. Yudina (2018), and others. A number of scientists continue to work in this area, since this problem has not lost its relevance today.

Unresolved issues. The increase in the production of biologically complete combined foods is relevant in the light of the balanced nutrition concept, according to which a sufficient amount of protein should be present in a person's daily diet (Borova & Polishchuk, 2015; Hnitsevych et al., 2018). The main advantage of such products lies in the potential for the mutual enrichment of the ingredients included in one or more factors in order to fully match their formula (Tkachenko et al., 2016).

The use of vegetable raw materials, including vegetable purees, in the production of food is due to high nutritional and biological value (Guliaev-Zaitcev et al., 2009; Iashin & Romanova, 2015). In view of the above research aimed at developing new types of semi protein-carbohydrate milk-based protein concentrate with added vegetable puree is relevant.

Purpose and research methods

The purpose of the article is to substantiate the technologies development of protein-carbohydrate semi-finished products with the addition of vegetable purees and to conduct the modeling of the recipe composition of semi-finished protein-carbohydrates.

The methodological basis of the study is the process of modeling the formulation of protein-carbohydrate semi-finished products.

Research Methods are standard physicochemical, rheological, methods of experiment planning and mathematical processing of experimental data using modern computer programs.

Information base of the research is scientific articles, materials of international congresses and symposia, scientific and practical conferences, regulatory and technical documentation, patents.

Research results

It is well known that dairy products play an important role in the human diet. Today, much attention is paid to multicomponent products based on protein-carbohydrate milk raw materials. Such products are characterized by high nutritional value, optimal amino acid composition and high digestibility.

During the formulations development of combined dairy products, namely semi-finished products based on protein-carbohydrate milk raw materials, the competent selection of plant components on qualitative and quantitative characteristics is important. Therefore, it was considered relevant to study the composition and properties of herbal supplements. The results of the research are given in Table 1.

Table 1. Composition and properties of puree from vegetable raw materials

Indexes	Puree			
	carrot		pumpkin	
	unconsolidated	compacted	unconsolidated	compacted
Mass fraction, %: of solids	24,6±0,6	42,3±1,1	14,0±0,4	28,5±0,6
mono- and disaccharides	21,5±0,5	36,5±0,8	11,8±0,3	23,3±0,5
pectin substances	0,4±0,01	0,7±0,01	0,5±0,01	1,1±0,01
fiber	0,9±0,01	1,3±0,01	0,4±0,01	0,9±0,01
cell walls	2,8±0,06	4,7±0,11	1,7±0,04	3,1±0,05
Mass fraction of ascorbic acid, mg / 100 g	5,1±0,12	7,6±0,18	12,2±0,2	15,0±0,2
pH	5,5±0,14	5,4±0,14	5,4±0,14	5,2±0,14
Boundary shear stress, Pa	345,0±9,0	429,0±11,0	254,0±6,0	270,0±7,0

Source: own development

Analysis of the data in Table 1, allowed drawing conclusions about the peculiarities of the composition and properties of vegetable raw materials, which in the future it is planned to use in milk-protein semi-finished products.

Carrot puree has a high content of solids, pH, shear stress, cell walls, and the least amount of pectin substances and ascorbic acid. Condensed carrot puree contains the largest amount of mono- and disaccharides, fiber. Pumpkin puree differs in several ways: it contains the least amount of solids, mono- and disaccharides, fiber and cell walls, and has the lowest value of the shear stress. Therefore, the aforementioned types of mashed potatoes are a promising raw material for use in the technology of milk-protein semi-finished products based on co precipitate.

Not only the chemical composition but also the functional properties of the raw materials, their influence on the physical and chemical factors, which are the purpose of further research in this field, are essential in the development of any new technologies.

Combined dairy based products in combination with plant components have high biological value. Creation of new combined products saves animal raw materials, in particular milk, thus providing the population with complete protein nutrition. The use of vegetable raw materials, including vegetable purees, in the production of food is due to high nutritional and biological value.

An important stage in the preparation of combined dairy products, which affects the organoleptic and physio-chemical parameters, is the preparation of vegetable purees. Puree is a pure homogeneous mass. When applying mashed potatoes to dairy products, the quality of the food is improved by increasing the organoleptic characteristics and nutritional value as well as the consistency of the product.

Fresh ripe vegetables: carrots and pumpkins were used to make the puree. Vegetables were pre-prepared and blanched. To determine the diameter of the sieve cells, in which the puree has high organoleptic and physicochemical characteristics, rubbing the prepared vegetables was carried out on sieves with a diameter of cells from 0.7 to 1.4 mm. The content of pectin substances, solids, as well as the rheological characteristics of the puree, namely the shear stress, that is, the value characterizing the system's ability to resist shear deformation, has been investigated. The results of the studies are given in Table 2, 3.

Table 2. Physical and chemical indicators of pumpkin puree

The diameter of the sieve cells, mm	Content of pectin substances, g / 100 g	The solids content, g / 100 g	Shear stress, Pa
0,7…0,8	0,46±0,01	13,4±0,3	238±5,0
0,9…1,0	0,50±0,01	14,0±0,4	254,0±6,0
1,1…1,2	0,57±0,01	14,8±0,4	269±6,0
1,3…1,4	0,62±0,01	15,2±0,4	276±6,0

Source: own development

The results of the analysis of table 2, 3 showed that with increasing the size of the puree particles when wiping, there is an increase in the values of the shear stress. This is due to the fact that as the diameter of the cells increases, more pectin and dry substances form the structure of the final product.

Table 3. Physical and chemical indicators of carrot puree

The diameter of the sieve cells, mm	Content of pectin substances, g / 100 g	The solids content, g / 100 g	Shear stress, Pa
0,7…0,8	0,37±0,01	23,9±0,6	329,0±8,0
0,9…1,0	0,40±0,01	24,6±0,6	345,0±9,0
1,1…1,2	0,42±0,01	25,2±0,6	353,0±10,0
1,3…1,4	0,48±0,01	26,0±0,6	364,0±10,0

Source: own development

However, during visual analysis of the fractions present, it was found that the puree obtained by rubbing through a sieve with a mesh diameter of 1.1 mm or more is a heterogeneous, grossly dispersed system. High purity is low purée obtained by wiping through a sieve with a mesh diameter of 1.0 mm and less.

According to the basic needs of the consumer, food systems have to have a certain set of consumer properties, and one of the key factors that shape their parameters is modeling the formulations of these food systems.

We were tasked with designing the compounding composition of protein-carbohydrate semi-finished products with predetermined organoleptic and structural-mechanical properties. We chose MBK, carrot and pumpkin puree and powdered sugar as the main components.

The shear stress index (GNS) is recommended by us as a given marker in the study of semi-finished products with plastic consistency, since it is the most sensitive to changes in technological and mechanical factors, even during obtaining plastic food systems.

First of all, we studied the dependence of GNS on the ratio of the main components of the model system "MBK + vegetable puree". The results of the studies are shown in Fig. 1.

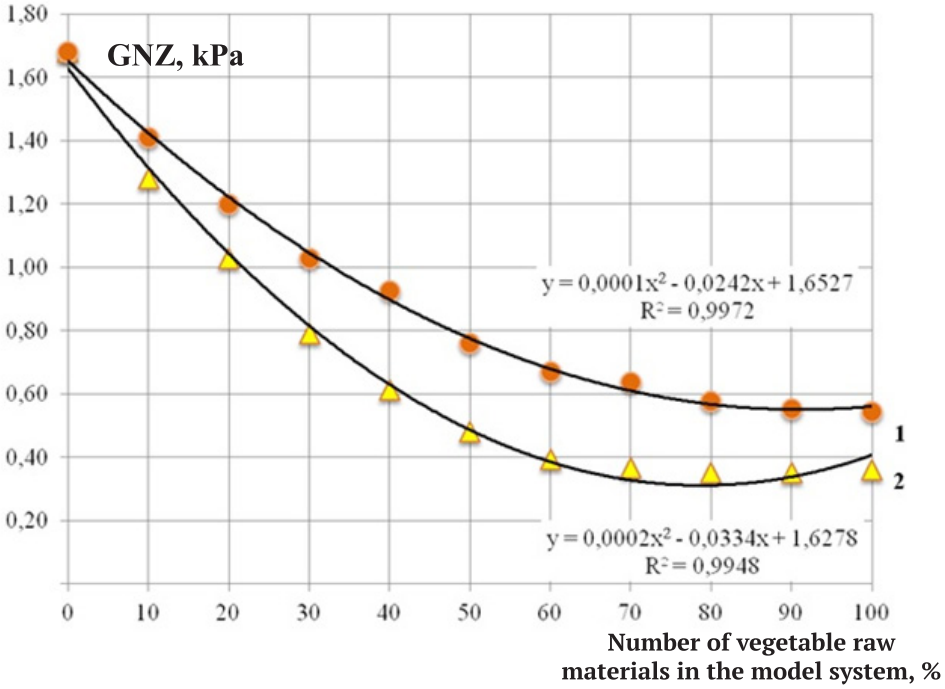


Fig. 1. Change of GNZ two-compon ent system "MBK + vegetable puree" depending on the amount of vegetable puree: 1 – carrot puree (PM); 2 – pumpkin puree (PG)
Source: own development

In figure 1 the decrease in the GNS clearly shows which caused by the increase in the proportion of vegetable purees in the system. The high moisture content and poor interconnection of the particles of the rubbed vegetables are most likely the reason for such low rates of puree. Thus, increasing the proportion of vegetable puree

in the system by 20 percent reduces the GNP model system by 28.8... 38.8 %, and increasing the concentration of vegetable puree to 50 percent – by 54.7... 71.4 %. We also noticed a less intense decline in GNS when adding carrot puree (PM), as opposed to pumpkin (PG). It is known that mashed carrots contain dietary fiber, which has greater compared to pumpkin, mechanical strength. This fact, in turn, may be the root cause, which explains the fluctuation of the GHI indicator for MBC with vegetable purees. In this case, the modeling of the formulation requires consideration of the identified circumstances by structural and mechanical parameters.

White sugar was used to improve the taste of NBC. This recipe component not only acts as a sweetener of the food system, but also has a direct impact on the whole group of organoleptic indicators of the quality of semi-finished products. Therefore, we further investigated the changes of the GNS in model systems by conducting a full-scale experiment of type 23, where 3 is the number of prescription components for each NBS. As lower and upper levels of factor variation, constraints were used to characterize the desired organoleptic characteristics.

In the table figures 4 and 5 show the experiment planning matrices. Using the Mathcad software, we approximated the experimental data on the change of the second-degree polynomial polynomials.

Table 4. Experimental planning matrix for the study "MPC + PP + Sugar" system

Experiment number	**The factor meaning**					
	Natural			**Coded**		
	МВС g	**ПГ, г**	**Sugar, g**	X_1	X_2	X_4
1	50	50	20	+	+	+
2	30	50	20	-	+	+
3	50	30	20	+	-	+
4	30	30	20	-	-	+
5	50	50	5	+	+	-
6	30	50	5	-	+	-
7	50	30	5	+	-	-
8	30	30	5	-	-	-

Source: own development

Table 5. Experimental planning matrix for the study "MPC + CP + Sugar" system

Experiment number	The factor meaning					
	Natural			Coded		
	МВС, g	**РМ g**	**Sugar,g**	X_1	X_3	X_4
1	50	50	20	+	+	+
2	30	50	20	-	+	+
3	50	30	20	+	-	+
4	30	30	20	-	-	+
5	50	50	5	+	+	-
6	30	50	5	-	+	-
7	50	30	5	+	-	-
8	30	30	5	-	-	-

Source: own development

Using the Fisher criterion at 5 % significance level, the adequacy of the mathematical models developed was checked, and the significance of the coefficients was checked by determining the confidence interval.

After simplifying the equations due to the weightless coefficients, the following equations were obtained characterizing the GNZ of the model systems depending on the content of the ingredients in kPa:

– model system «MBC + GHG + sugar»

$$Q = 1{,}375 \cdot 10^{-4} \cdot X_1 \cdot X_4 + 1{,}708 \cdot 10^{-4} \cdot X_2 \cdot X_4 + 2{,}943 \cdot 10^{-4} \cdot X_4^2 - 0{,}023 \cdot 10^{-4} \cdot X_4 - $$
$$- 3{,}720 \cdot 10^{-4} \cdot X_4 \cdot X_2 - 2{,}451 \cdot 10^{-4} \cdot X_2^2 + 0{,}028 \cdot 10^{-4} \cdot X_1 + 0{,}016 + 3{,}430 \cdot 10^{-3} \cdot X_1 +$$
$$+ 1{,}316 \cdot 10^{-4} \cdot X_1^2;$$

– model system «MBC + GHG + sugar»

$$Q = -1{,}077 \cdot 10^{-4} \cdot X_1 \cdot X_4 + 7{,}662 \cdot 10^{-6} \cdot X_3 \cdot X_4 + 3{,}815 \cdot 10^{-5} \cdot X_4^2 + 2{,}728 \cdot X_4 -$$
$$- 2{,}381 \cdot 10^{-4} \cdot X_4 \cdot X_3 - 1{,}184 \cdot 10^{-4} \cdot X_3^2 + 0{,}017 \cdot X_3 + 5{,}639 \cdot 10^{-3} + 1{,}562 \cdot 10^{-3} \cdot X_1 +$$
$$+ 1{,}561 \cdot 10^{-4} \cdot X_1^2.$$

In Figures 2 and 3 show graphs of the dependence of the model gas systems on the quantities of mashed potatoes and sugar in the three-component NBV system, taking into account that the fractions of the two components were given from the beginning of the experiment, and the fraction of the third was set automatically.

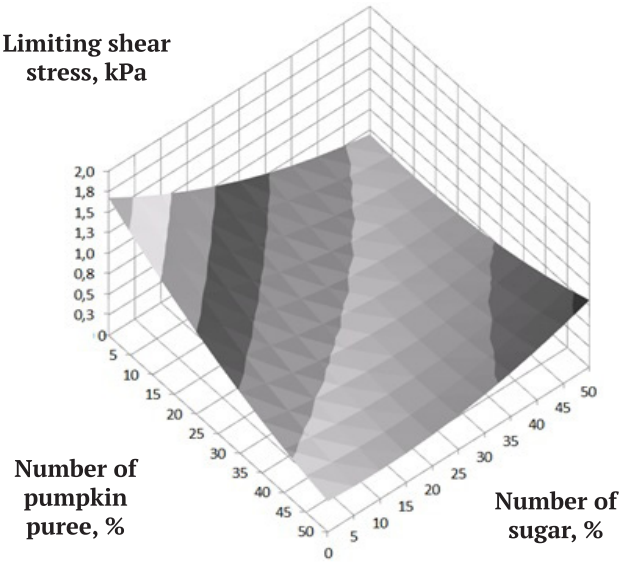
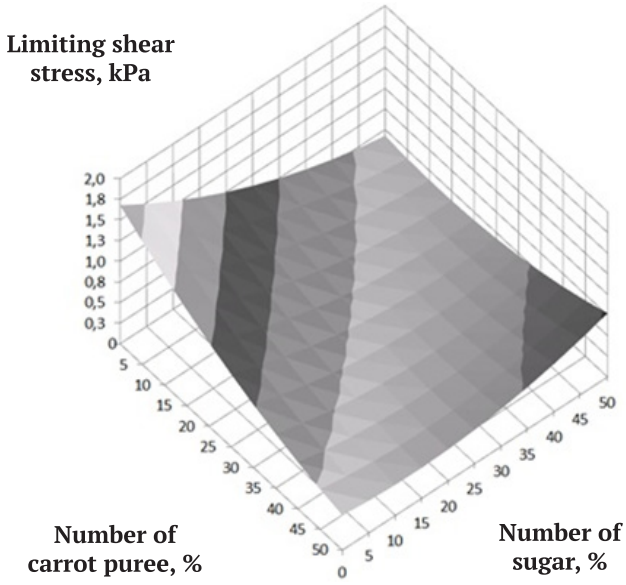


Fig. 2. Modification of BSS model system "MPC + PP + sugar" depending on the amount of mashed pumpkin and sugar



Source: own development

Fig. 3. Modification of BSS model system "MPC + CP + sugar" depending on the amount of mashed pumpkin and sugar

Source: own development

The graphs (Figs. 2 and 3) show a decrease in GNS after the addition of sugar to the MBK + GHG + sugar system by 74.3 %, and the MBK + PM + sugar system - by 75.6 % with a parallel increase in the content vegetable puree and sugar in the system from 0 % to 30 %. This is explained by the dehydration of milk proteins, as well as the constant influence of pumpkin and carrot puree on both two-component and three-component systems. In our opinion, the persistence of the influence of mashed potatoes on vegetables on the indicators of the NBU food system (and most importantly, the difference in their influence) can be justified by the more intense formation of jelly-like structures by pumpkin mashed pectin when interacted with sugar than by those contained in mashed potatoes.

Obtained data on NHV NBS serve as an additional limitation of the lower and upper levels of variation of factors in the modeling of their recipe composition in accordance with nutritional value, organoleptic characteristics and structural and mechanical properties. The introduction of a stabilizer in the amount of 8… 12 % in the NBS system can be improved.

Possible ways of using protein-carbohydrate semi-finished products in the food industry are technologies of such foods as cheeses, dumplings, toppings, etc. NBCs can be stored in cellophane-coated molds in the food industry and in the restaurant industry, as well as other minced semi-finished products, depending on their use and packaging methods.

Conclusions and discussion of results

Thus, we can draw the following conclusions:

It is theoretically and experimentally substantiated the feasibility of using in the development of technologies of milk-protein semi-finished products on the basis of co precipitate from carrot and mashed pumpkin puree.

1. It is established that the puree obtained by rubbing through a sieve with a mesh diameter of 1.1 mm or more is a non-uniform, coarse dispersed system. The pure organoleptic characteristics are puree obtained by wiping through a sieve with a mesh diameter of 1.0 mm or less.

2. A drop of GNZ after the addition of sugar in the MBK + PG + sugar + sugar system was found by 74.3 %, and the MBK + PM + sugar system - by 75.6 % with a parallel increase of the vegetable puree and sugar content in the system from 0 % to 30 %.

3. The composition of new semi-finished products was simulated, which made it possible to narrow the range of variation of the concentrations of feedstock in further studies. It is established that the rational concentrations of the recipe components for NBVM are: mass fraction of milk protein concentrate 50… 54 %, carrot puree 26… 30 %, sugar 8… 12 %, stabilizer 8… 12 %; for NBVG - mass fraction of milk protein concentrate 46… 50 %, pumpkin puree 30… 34 %, sugar 8… 12 %, stabilizer 8… 12 %.

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The article was received on February 24, 2020.

УДК 641.1-027.38:[613.263+613.287

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МОДЕЛЮВАННЯ РЕЦЕПТУРНОГО СКЛАДУ НАПІВФАБРИКАТІВ БІЛКОВО-ВУГЛЕВОДНИХ

Актуальність. Створення нових комбінованих продуктів дозволяє економити сировину тваринного походження. Застосування овочевих пюре при виробництві харчових продуктів обумовлено високою харчовою та біологічною цінністю. У зв'язку з вищевикладеним дослідження, спрямовані на розробку нових видів напівфабрикатів білково-вуглеводних на основі молочно-білкових концентратів (МБК) із додаванням овочевих пюре, є актуальними. **Метою роботи є** обґрунтування розробки технологій напівфабрикатів білково-вуглеводних (НБВ) із додаванням овочевих пюре та проведення моделювання рецептурного складу напівфабрикатів білково-вуглеводних. При написанні статті використовувались наступні **методи дослідження:** стандартні фізико-хімічні, реологічні, методи планування експерименту та математичної обробки експериментальних даних із використанням сучасних комп'ютерних програм. **Результати.** Теоретично та експериментально обґрунтовано доцільність використання під час розробки технологій НБВ на основі МБК зі сколотин, пюре з моркви та пюре з гарбуза. Проведено моделювання складу нових НБВ, що дозволило звузити діапазон варіювання концентрацій вихідної сировини при подальших дослідженнях. Встановлено, що раціональними концентраціями рецептурних компонентів для НБВ із пюре моркви є: масова частка МБК 50…54 %, пюре моркви 26…30 %, цукру 8…12 %, стабілізатора 8…12 %; для НБВ з пюре гарбуза – масова частка МБК 46…50 %, пюре гарбуза 30…34 %, цукру 8…12 %, стабілізатора 8…12 %. **Висновки та обговорення**. Розроблені та змодельовані технології НБВ із використанням пюре моркви та гарбуза, що дозволяють більш раціонально використовувати харчовий потенціал молока та продуктів його переробки в комплексі з каротинвмісною рослинною сировиною. Наукова новизна одержаних результатів полягає в теоретичному обґрунтуванні та експериментальному підтвердженні доцільності використання МБК зі сколотин, пюре з каротинвмісної рослинної сировини у технологіях НБВ.

Ключові слова: моделювання, напівфабрикат, молочно-білковий концентрат, пюре, гарбуз, морква, стабілізатор.

УДК 641.1-027.38:[613.263+613.287

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МОДЕЛИРОВАНИЕ РЕЦЕПТУРНОГО СОСТАВА ПОЛУФАБРИКАТОВ БЕЛКОВО-УГЛЕВОДНЫХ

Актуальность. Создание новых комбинированных продуктов позволяет экономить сырье животного происхождения. Применение овощных пюре при производстве пищевых продуктов обусловлено высокой пищевой и биологической ценностью. В связи с вышеизложенным исследования, направленные на разработку новых видов полуфабрикатов белково-углеводных на основе молочно-белковых концентратов (МБК) с добавлением овощных пюре, актуальны. **Целью работы** является обоснование разработки технологий полуфабрикатов белково-углеводных (ПБУ) с добавлением овощных пюре и проведения моделирования рецептурного состава полуфабрикатов белково-углеводных. При написании статьи использовались следующие методы исследования: стандартные физико-химические, реологические, методы планирования эксперимента и математической обработки экспериментальных данных с использованием современных компьютерных программ. **Результаты.** Теоретически и экспериментально обоснована целесообразность использования при разработке технологий ПБУ на основе МБК из пахты, пюре из моркови и пюре из тыквы. Проведено моделирование состав новых ПБУ, что позволило сузить диапазон варьирования концентраций исходного сырья при дальнейших исследованиях. Установлено, что оптимальными концентрациями рецептурных компонентов для ПБУ с пюре моркови являются: массовая доля МБК 50…54 %, пюре моркови 26…30 %, сахара 8…12 %, стабилизатора 8…12 %; для ПБУ с пюре тыквы – массовая доля МБК 46…50 %, пюре тыквы 30…34 %, сахара 8…12 %, стабилизатора 8…12 %. **Выводы и обсуждение.** Разработаны и смоделированы технологии ПБУ с использованием пюре моркови и тыквы, позволяющие более рационально использовать пищевой потенциал молока и продуктов его переработки в комплексе с каротинсодержащим растительным сырьем. Научная новизна исследования заключается в теоретическом обосновании и экспериментальном подтверждении целесообразности использования МБК из пахты, пюре из каротинсодержащего растительного сырья в технологиях ПБУ.

Ключевые слова: моделирование, полуфабрикат, молочно-белковый концентрат, пюре, тыква, морковь, стабилизатор.