Chapter 2

TECHNOLOGY OF A SEMI-FINISHED PRODUCT BASED ON PUMPKIN PULP AND EMULSION SAUCES WITH ITS USE

Gnitsevych V. A., Yudina T. I.
DOI https://doi.org/10.30525/978-9934-26-445-0-2

INTRODUCTION

The ideology of a healthy lifestyle, an integral part of which is a nutritious diet, is a priority trend in preserving and strengthening the nation's health. The most common type of dietary disorder is its imbalance, which is marked by a lack of certain amino acids, vitamins, vegetable fats, trace elements, dietary fibre, with excessive consumption of cholesterol from animal fats and refined products. Under these conditions, it becomes important to combine food raw materials with different functional and technological properties, which allows us to produce new products that have a targeted effect on various aspects of the body's functional activity.

On the other hand, due to the increasing stress on the human body and unfavourable environmental conditions, the body's need for a rational and balanced diet is growing sharply. Food components such as polyunsaturated fatty acids (PUFAs), essential amino acids and dietary fibre play an important role in regulating metabolic processes. At the same time, the increasing pace of modern life of the country's population and the emergence of new organisational forms in the restaurant industry system lead to the centralisation of culinary production processes. All of this contributes to the development of semi-finished products, including highly prepared ones, and ready-to-eat culinary products.

Pumpkin and its processed products are a valuable raw material source of carotene. A promising source of functional ingredients involved in vital biochemical processes is pumpkin seeds, a secondary product that is hardly used in food, although it has a unique chemical composition and pharmacological properties.

Thus, the development of a scientifically based technology for a semi-finished product based on pumpkin seeds and its processed products with maximum preservation of the nutritional and biological value of the raw material, certain functional and technological properties that are convenient for consumption and meet the needs of modern consumers, as well as products using it, is an urgent problem.

The aim of the study is to determine the optimal ratio of the main recipe components, namely pumpkin pulp and seeds, whey powder in the composition of the semi-finished product, determine its quality indicators and develop the technology of sauces using it.

1. Analysis of the level of developments in the processing of pumpkin plants

Modern nutritionists consider food not only as a source of plastic material and energy, but also as a complex of biologically active substances that regulate certain body functions.

One of the priority areas of nutrition is food fortification, the general principles of which were formulated in 1987 by the Codex Alimentarius Commission[1].

Food fortification is the addition of any essential nutrients and minor components to food: vitamins, macro- and microelements, dietary fibres, polyunsaturated fatty acids, phospholipids and other biologically active substances of natural origin in order to maintain or improve the nutritional value of certain foods or diets. Violations of the requirements for a balanced diet lead to a decrease in the rate of growth and development of the body, mental and physical performance, and reduce its resistance to adverse external factors, and, as a result, lead to premature aging[2-3].

Of particular interest for use in combined product technologies is plant material, which is a source of nutritionally valuable ingredients, such as polyphenolic compounds, polyunsaturated fatty acids (PUFAs), vitamins, etc. Such raw materials include carotene-containing pumpkin, which is mainly processed into canned products or sold fresh, while the range of semi-finished products is virtually non-existent.

The area under pumpkin cultivation in the industrial vegetable sector of Ukraine has increased more than 3-fold over the past 15 years and amounts to 744.4 thousand tonnes[4]. Pumpkins are grown in Ukraine with the aim of further industrial processing to produce oil and sherried pumpkin seeds. The pulp is used for livestock feed and silage after the seeds are extracted. In

[1] Codex Alimentarius. Режим доступу: https://www.fao.org/3/ca2329en/ca2329en.pdf

[2] Смоляр В. Основні тенденції в харчуванні населення України. Проблеми харчування. 2010. № 2. С. 5–9.

[3] Баланси та споживання основних продуктів харчування населенням України. Державна служба статистики України. 2019. С. 12. URL: http://www.ukrstat.gov.ua/druk/publicat/kat_u/2019/zb/07/zb_bsoph2018_pdf.pdf

[4] Діденко В.П., Шабля О.С. Сучасний стан і перспективи забезпечення населення України продукцією баштанництва. Овочівництво і баштанництво. 2014. № 49. С.80-85.

general, only 28% of the total volume of pumpkin pulp is sent for further processing, mainly for juice production[5].

Thus, in view of the above, and in accordance with the "Declaration on Low Waste and Zero Waste Technologies", it is necessary to study the problem of pumpkin pulp processing in a multilateral manner with the subsequent implementation of appropriate technological solutions[6].

The chemical composition of pumpkin is presented in Table 1.

Table 1

Chemical composition of pumpkin[7]

Indicator	Content, g per 100g of product
Water	88,5
Proteins	1,3
Fats	0,1
Carbohydrates, incl.	7,0
mono-, disaccharides	6,0
starch	0,2
Fibre	1,2
Organic acids	0,1
Pectin substances	0,8

A small amount of fibre (1.2%) and organic acids makes it possible to include pumpkin in the diet for gastrointestinal diseases, and a large amount of pectin has a particularly positive effect on inflammation of the large intestine. Pectin substances are known to be able to remove toxic substances and radioactive metals from the body. In addition, given the high nutritional value of pumpkin fruit, which is rich in carotenoids, vitamins K, C, B_1, B_2, B_6, B_9, and PP, pumpkin processing is of particular relevance.

Pumpkin pulp is a valuable source of macro– and micronutrients such as mono– and polysaccharides, dietary fibres, proteins, organic acids and pectin substances. Pumpkin contains a significant amount of potassium, calcium and phosphorus among the organically bound mineral elements. Pumpkin is most valuable for its β-carotene and other carotenoids. In terms of β-carotene content, it is superior to any other type of vegetable raw material, except carrots[8].

[5] Колтунов В.А.; Пузік Л. М.. Зберігання гарбузових плодів. Наук. вид. Х.: Харк. нац. аграр. ун-т ім. В. В. Докучаєва. 2009. 365 с.

[6] Тимчак В.С. Ефективність інновацій комплексного використання відходів харчової промисловості: Дис. канд.ек.наук.-Житомир, 2016. С. 41-43.

[7] Дубініна А. Порівняльна оцінка якості господарсько-ботанічних сортів гарбуза / Дубініна А., Летута Т., Томашевська Р.// Товари і ринки, 2011. № 1. С.132-139.

[8] Дубініна А. Порівняльна оцінка якості господарсько-ботанічних сортів гарбуза / Дубініна А., Летута Т., Томашевська Р.// Товари і ринки, 2011. № 1. С. 132-139.

A. M. Baidulova, S. O. Belinska, N. Y. Orlova, E. V. Odarchenko, V. M. Golubev, V. F. Vinnytska, V. Y. Mikhalev, A. V. Matora, O. G. Shkodina, V. E. Korshunova, M. M. Tipsina, G. K. Selezneva and others have studied the problems of pumpkin pulp processing[9,10,11,12].

Among the currently known methods of pumpkin pulp processing are thermal, biochemical (acid and enzymatic) and complex processing. Domestic scientists focus their work on the possibility of using processed pumpkin pulp to produce independent products, while little attention is paid to the issue of processing pumpkin pulp for further use as a source of biologically active substances for the production of combined products and semi-finished products.

Pumpkin seeds are a secondary product that is used in food to a limited extent, although they have a unique chemical composition and pharmacological properties. The most attractive for food production are pumpkin seeds of the Holonasinniy variety[13], which do not have a shell – a woody, dense tissue consisting mainly of water-insoluble carbohydrates – cellulose and hemicellulose (Table 2).

The development of speciality products involves enrichment with dietary fibre, which helps to eliminate cholesterol, lipids, xenobiotics, radionuclides, carcinogens and other contaminants from the body, thus contributing to the natural prevention of civilisation diseases.

Table 2

Chemical composition of pumpkin seeds

Name of the indicator	Component content
Moisture, %	6,8
Protein, %	35,3
Lipids, %	31,8
Carbohydrates, % incl.	21,4
cellulose, %	4,2
Soluble sugars, %	17,2
Minerals g/100g	4,7

[9] Інноваційні технології борошняних кондитерських виробів із використанням продуктів переробки гарбузового насіння : монографія / Т. В. Капліна, В. М. Столярчук, С. О. Овчіннікова-Дудник, Е. М. Бровко. Полтава. ПУЕТ, 2015. 356 с.

[10] Інноваційні технології харчової продукції : колективна монографія / за заг. ред. Г.В. Дейниченка. Харків: Факт, 2019. 248 с.

[11] База патентів України UAPATENTS.COM [Електронний ресурс]. – Режим доступу : http://uapatents.com/

[12] Технологія харчових продуктів із заданими властивостями на основі вторинної молочної та рослинної сировини: монографія Гніцевич В.А., Никифоров Р.П., Федотова Н.А., Кравченко Н.В. Донецьк : Донбасс, 2014. 337 с.

[13] Тимчак В.С. Ефективність інновацій комплексного використання відходів харчової промисловості: Дис. канд.ек.наук, 2016. С.41-43.

The analysis of the amino acid composition of pumpkin seed proteins shows that the protein fractions contain all amino acids, including essential ones, which suggests their high biological value. The content of certain essential amino acids (leucine, lysine) is within the FAO/WHO standard, and the content of phenylalanine and threonine is significantly higher.

The fatty acid composition of pumpkin seed lipids is mainly represented by four acids – palmitic, stearic, oleic and linoleic acids. The significant content of polyunsaturated fatty acids makes it possible to consider naked pumpkin seeds as a promising ingredient for the development of functional foods.

It is known that the ratio of PUFAs is physiologically reasonable: MUFA: PUFA ratio as 3:6:1. For naked-seeded pumpkin lipids, this ratio is 2:4:4, i.e. it does not meet physiological needs, but it is possible to optimise this ratio by adjusting the number of components in the developed food systems.

The characteristics of the mineral composition show that naked pumpkin seeds contain the most phosphorus, potassium, magnesium, calcium, zinc and iron. According to the results of the analysis of the chemical composition of naked pumpkin seeds, this raw material is promising for the development of a product with functional properties, and the quantitative lack or excess of certain functional nutrients can be corrected by optimising the components of the recipe using modern computer modelling methods.

At present, there are developments in the use of pumpkin pomegranate flour in combination with wheat flour, which reduces the elastic properties of gluten and increases its elasticity, which can be used in the technologies of shortbread, biscuit and cupcake products[14].

If we analyse the diet of a modern person, it should be noted that the consumption of animal protein is insufficient, and such a deficit is predicted to continue in the future. Therefore, it is advisable to use dried milk products. Their high nutritional and biological value, shelf life, and more stable physical and chemical characteristics compared to fresh milk allow them to be widely used as an additional component, as evidenced in many studies[15,16,17].

[14] Інноваційні технології борошняних кондитерських виробів із використанням продуктів переробки гарбузового насіння : монографія / Т. В. Капліна, В. М. Столярчук, С. О. Овчіннікова-Дудник, Е. М. Бровко. Полтава. ПУЕТ, 2015. 356 с.

[15] . Інноваційні технології харчової продукції : колективна монографія / за заг. ред. Г.В. Дейниченка. Харків: Факт, 2019. 248 с.

[16] База патентів України UAPATENTS.COM [Електронний ресурс]. – Режим доступу : http://uapatents.com/

[17]Технологія харчових продуктів із заданими властивостями на основі вторинної молочної та рослинної сировини: монографія Гніцевич В.А., Никифоров Р.П., Федотова Н.А., Кравченко Н.В. Донецьк : Донбасс, 2014. 337 с.

The most attractive for the enrichment of semi-finished products is whey milk powder (WMP)[18]. WMP consists of a dry residue that includes proteins, nitrogenous substances, fat, milk sugar, mineral salts, as well as trace elements and vitamins (Table 4).

Table 4

Chemical composition of WMP

Indicator	Content, g/100 g
Proteins	10,2
Fats	1,5
including unsaturated fatty acids	10,1
Carbohydrates	39,3
Organic acids	1,2
Water	4
Mono- and disaccharides	39,3
Ash	6,3

The most valuable component of milk is protein, which accounts for about 10%. Milk proteins contain all essential amino acids and are complete. Thus, the combination of vegetable products with a high content of pectins, minerals and vitamins, PUFAs, on the one hand, and dairy products with a high content of complete protein, on the other, will allow to obtain a product with improved nutritional and biological value, certain functional and technological properties.

An analysis of the literature has shown that the creation of food products with a polycomponent composition with specified functional and technological properties is a broad and promising area of food technology development.

Thus, it is of practical interest to use pumpkin seeds and pulp, which, in terms of the content of essential nutrients, technological properties, and especially biological value, are promising raw materials for the production of multifunctional semi-finished products that can be used both as part of minced meat products and as fillings.

2. Objects, methods and techniques of the study

The technology for the production of a semi-finished product based on pumpkin pulp and seeds was chosen as the main object of research. Within this object, the following main materials were used in the experimental work:

– pumpkin pulp of Cucurbita moschata Duch. pomological variety Butternut (DSTU 3190-95);

[18] ДСТУ 4552:2006. Сироватка молочна суха. Технічні умови. К.: Держспоживстандарт України, 2006. 13 с.

– pumpkin seeds (TU U 15.3-32941822-001:2009);

– whey milk powder (DSTU 4556:2006).

All materials meet the requirements of current standards and specifications.

The organoleptic quality of the semi-finished product was assessed by analytical methods. The mass fraction of moisture was determined by drying to a constant weight at a temperature of 105±2°C[19]. The chemical composition was determined by the calculation method.

The degree of balance of essential amino acids was determined by comparing their proportions with the standard protein proposed by FAO/WHO[20].

The fatty acid composition of the products was modelled using the formula:

$$L_i = \frac{\sum_{k=1}^{n} l_{ik} q_k x_k}{\sum_{k=1}^{n} q_k x_k}, \quad (1)$$

Where L_i is the mass fraction of the i-th fatty acid in the fat of the modelled formulation, %;

l_{ik} – mass fraction of the i-th fatty acid in the fat of the k-th ingredient, %;

q_k – mass fraction of fat in the k-th ingredient, %;

x_k – mass fraction of the k-th ingredient, %.

The mathematical model of Professor Lipatov M. M. was used to model the amino acid composition of the semi-finished product:

$$A_i = \frac{\sum_{k=1}^{n} a_{ik} p_k x_k}{\sum_{k=1}^{n} p_k x_k}, \quad (2)$$

where A_i is the mass fraction of the i-th amino acid in the protein of the modelled formulation, %;

a_{ik} – mass fraction of the i-th amino acid in the protein in the k-th ingredient, %;

p_k – mass fraction of protein in the k-th ingredient, %;

x_k – mass fraction of the k-th ingredient, %.

[19] ДСТУ ISO 7804:2015. Продукти переробляння фруктів та овочів. Методи визначання сухих речовин або вологи. К.: Держспоживстандарт України, 2015. 20 с.

[20] Крисанов Д.Ф. Детермінанти якості й безпечності харчової продукції та мінімізація впливу факторів ризику // Продуктивні сили і регіональна економіка : зб. наук. праць : у 2 ч. / РВПС України НАН України. К., 2008. Ч. 1. С. 249–261.

The study of organoleptic, physicochemical, microbiological parameters of model systems and semi-finished products was carried out according to standard methods using appropriate equipment.

Sampling for research, determination of chemical, physicochemical, biochemical and organoleptic parameters was carried out using generally accepted and modified methods of analysis in accordance with current standards[21,22,23,24]. The study of microbiological parameters of the semi-finished product was guided by the Medical and Biological Requirements and Sanitary Standards for the Quality of Food Raw Materials and Food Products.

3. Technology of the semi-finished product based on pumpkin pulp

The working hypothesis of the study is that it is possible to combine raw materials of animal origin (WMP) with vegetable raw materials (pumpkin pulp and seeds), which will allow to obtain a semi-finished product balanced in terms of nutritional and biological value, with high functional and technological properties.

Fig. 1 shows a model of the technological process of producing a semi-finished product based on pumpkin pulp and seeds.

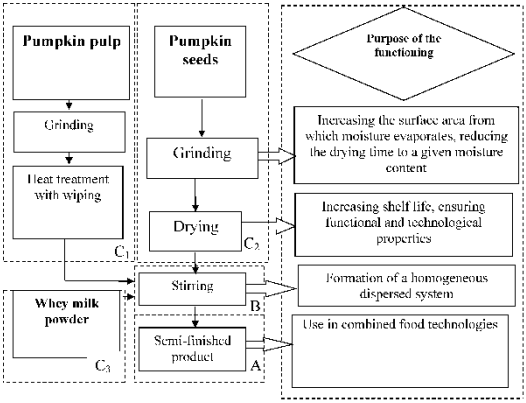

Fig. 1. Model of the technological process of obtaining a semi-finished product based on pumpkin pulp and seeds

[21] ДСТУ ISO 5983:2003 Корми для тварин. Визначення вмісту азоту і обчислення вмісту сирого білка методом К'єльдаля. К.: Держспоживстандарт України, 2007. 12 с.

[22] Методи контролю якості харчової продукції : метод. рекомендації до лабораторних робіт / уклад. : М.М. Воробець, І.М. Кобаса, І.В. Кондрачук Чернівці : Чернівец. нац. ун-т ім. Ю. Федьковича, 2022. 32 с.

[23] Фізіолого-біохімічні методи досліджень у біології, тваринництві та ветеринарній медицині: довідник. Львів, 2004. С.309-311.

[24] Хімічний та мікробіологічний аналіз харчової продукції : навч. посібник / І.М. Кобаса, Л.М. Чебан, М.М. Воробець, Юкало В.Г., Кухтин М.Д. Чернівці : Чернівецький нац. ун-т, 2014. 196 с.

The model was developed on the basis of a working hypothesis that allows us to predict the strategy for further research.

To obtain pumpkin pulp puree, the raw materials were subjected to inspection, washing and cleaning, dicing, followed by steam heat treatment at 110±2°C for (20–25)×60s, followed by wiping at 80±2°C and further steam heat treatment at 75±5°C for (6–7)×60s. Pumpkin seeds were ground to a size of (350...450)-10-3m[25].

The biological value of the compositions was assessed by the amino acid balance of the total protein of the semi-finished product in comparison with the set standards of amino acid composition and criteria for amino acid balance. Methodological approaches to solving the problem of designing the composition of balanced food products were laid down in the works of I. A. Rogov and M. M. Lipatov.

Organoleptic studies have established the limit values of the content of the main components. By mathematical calculations using formula (1), it was found that for the semi-finished product to acquire functional properties in terms of PUFA content, the minimum amount of pumpkin seeds should be 20%. Taking into account the specified minimum amount of pumpkin seeds, mathematical modelling of the amino acid composition of the semi-finished product was carried out using formula (2). The results confirmed the need to use WMP in its composition, the content of which should be at least 25%.

For the semi-finished product, the priority is given to functional properties due to the content of such functional and physiological ingredients as dietary fibre and PUFAs. In order to determine the optimal ratio of components, the Box-Benkin orthogonal symmetric plan experiment planning method was used. The content of WMP was chosen at 25% as a constant, the content of pumpkin puree was varied in the range of 25...55%, pumpkin seeds – 20...50%.

Using the method of conjugate gradients, the ingredient composition of the semi-finished product was optimised by the content of polyunsaturated fatty acids (PUFA) and dietary fibre (DF).

Regression equations were obtained that adequately describe the dependence of PUFA content Y_1 (3) and dietary fibre content Y_2 (4) on the ingredient composition of the semi-finished product:

$$Y_1 = 18{,}13 - 0{,}12\, x_1 + 3{,}28\, x_2 + 0{,}27 x_1 x_2 + 0{,}14\, x_1^2 - 0{,}42\, x_2^2 \quad (3)$$

$$Y_2 = 10{,}24 + 0{,}55\, x_1 + 1{,}84\, x_2 + 0{,}15\, x_1 x_2 + 0{,}03\, x_1^2 + 0{,}03\, x_2^2 \quad (4)$$

Fig. 2 shows a graphical representation of the response surfaces of PUFA and dietary fibre dependence on the ratio of formulation components.

[25] Гніцевич В., Кущенко В. Технологія та якість напівфабрикату на основі м'якоті гарбуза для оздоровчого харчування. Обладнання та технології харчових виробництв. Кривий Ріг : ДонНУЕТ, 2021. Вип. 2 (43). С. 5-11. DOI : 10.33274/2079-4827-2021-43-2-5-11

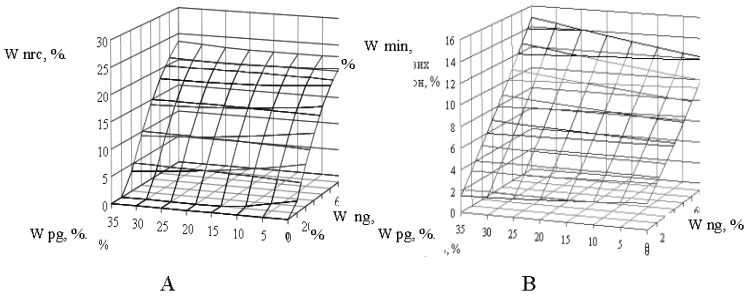

Fig. 2. Response surface for the dependence of PUFA content (A) and dietary fibre content (B) on the content of pumpkin puree (PP) and pumpkin seeds (PS)

As a result of mathematical modelling, a semi-finished product recipe was developed that is optimal in terms of PUFA balance, with the following ratio of components, wt.%: W_{PG}: W_{NG}: W_{WMP} = 40:35:25.

Based on the experience of previous developments, a fundamental technological scheme for the production of a semi-finished product based on pumpkin pulp and seeds was developed, which is presented as an integral system within which subsystems A, B, C_1, C_2, C_3 are distinguished. The functioning of the existing subsystems is aimed at obtaining the output result of the system functioning – the formation of a semi-finished product based on pumpkin pulp (Fig. 3).

Within subsystem C_1, the preparation of WMP is carried out by sieving it. Subsystem C_2 involves the preparation of the main ingredient – pumpkin puree – for introduction into the recipe mixture. Subsystem B is formed by performing technological operations in a certain sequence – mixing all the above-mentioned components of the recipe until a mass with evenly distributed particles throughout the volume is formed and cooled (frozen) at a temperature of -18°C for 180...190 minutes.

As a result of the functioning of subsystems C_1, C_2, C_3, B, the final product is formed – a semi-finished product based on pumpkin pulp and seeds (subsystem A), which is characterised by certain organoleptic properties, has stable physical and chemical properties and is safe during the established shelf life.

The developed semi-finished product is a puree-like mass with a dry matter content of 35%. The composition of the dry residue includes proteins, carbohydrates, fats, and minerals (Table 5).

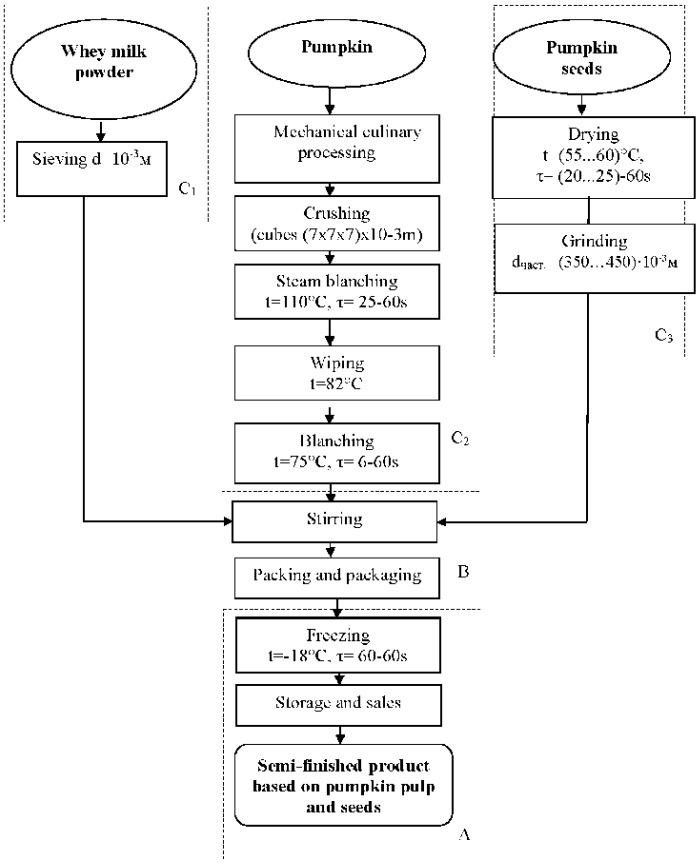

Fig. 3. Process flow diagram for the production of a semi-finished product based on pumpkin processing products

Table 5

Chemical composition of the semi-finished product

Indicator	Content, % (on a dry matter basis)
Proteins	8,5
Fats	9,6
Carbohydrates, incl.	32,0
Fibre	8,4
Unsaturated fatty acids	3,9
Mono- and disaccharides	6,5
Ash	5,1
Vitamins	3,6
Minerals	5,1

Not only does the quantitative content of protein matter play an important role, but also its qualitative composition. We calculated the ratio of essential amino acids in proteins and compared it with the FAO/WHO standard. The results are shown in Table 6.

Table 6

Content of essential amino acids in the semi-finished product

Name of the amino acid	FAO/WHO reference, g/100 g	Content, % (on a dry weight basis)	Amino acid profile, %.
Valine	5,0	3,8	76,0
Isoleucine	4,0	3,1	77,5
Leucine	7,0	4,9	70,0
Lysine	5,5	4,9	89,1
Methionine	3,5	3,1	88,6
Threonine	4,0	4,1	102,5
Phenylalanine	6,0	5,9	98,3
Tryptophan	1,0	0,8	80,0
Total amount	36,0	34,2	

The data analysis shows that the limiting amino acids in the semi-finished product proteins are valine, isoleucine, leucine, and the level of all other essential amino acids is close to the FAO/WHO standard, which indicates the high biological value of the product.

The fatty acid composition of lipids is presented in Table 7.

Table 7

Fatty acid composition of lipids of the semi-finished product

Name of fatty acid (FA)	Acid index	Content, mg/100mg	Content, % of the total amount
Lauric acid	$C_{12:0}$	0,70	3,34
Myristic acid	$C_{14:0}$	0,55	2,64
Pentadecanoic	$C_{15:0}$	0,17	0,81
Palmitic	$C_{16:0}$	1,80	8,59
Stearic acid	$C_{18:0}$	0,80	3,82
Arachinic	$C_{20:0}$	0,30	1,43
Total saturated fatty acids			**20,63**
Palmitoleic	$C_{16:1}$	0,27	1,29
Oleic	$C_{18:1}$	6,60	31,50
Linoleic	$C_{18:2}$	7,65	36,51
Linolenic	$C_{18:3}$	2,11	10,07
Total unsaturated fatty acids			**79,37**
Total		**20,95**	**100**

It was found that among unsaturated fatty acids, polyunsaturated linoleic acid (36.51%) and monounsaturated oleic acid (31.50%) are dominant. Due to its high content of linoleic acid, it can be considered a functional food.

The nutritional value of products is also determined by their mineral and vitamin composition. The mineral composition of the semi-finished product is shown in Table 8.

According to the data presented, the main macronutrients in the semi-finished product are potassium, magnesium, calcium, phosphorus; the semi-finished product is also enriched with trace elements: zinc, copper, and iron.

Table 8

Characteristics of the mineral composition of the semi-finished product

Indicator	Content
Macronutrients, mg/100 g	
Calcium	520,4
Magnesium	123,8
Potassium	318,6
Phosphorus	629,1
Sodium	48,8
Trace elements, μg/100 g	
Copper	1695
Ferrous	3828
Manganese	1248
Zinc	1890

Analysis of the vitamin composition (Table 9) shows that the semi-finished product is a source of fat– and water-soluble vitamins.

Table 9

Vitamin composition of the semi-finished product (P≤0.05, n=3)

Vitamins	Content, mg/100g of product
β-carotene	6,2
Thiamine B_1	5,7
Riboflavin B_2	6,8
Niacin PP	44,6
Ascorbic acid C	4,8

The storage process is a stage that significantly affects the quality of the finished product, so it is important to study the behaviour of the semi-finished product during storage.

The semi-finished products were stored at a temperature of -18...-20°C, which was chosen in accordance with the requirements of regulatory

documents for frozen vegetable products. The samples were stored in polyethylene sealed containers.

Semi-finished product samples were selected as a control, the parameters of which were determined immediately after production. The results are summarised in Table 10.

Table 10

Organoleptic quality indicators of semi-finished products

Quality indicator	Characteristics of the semi-finished product	
	Freshly cooked	**After freezing**
Appearance	Homogeneous viscous mass with pumpkin seed particles	Solid homogeneous mass
Consistency	Plastic	Firm
Smell	Pleasant, pumpkin-like flavour with a slight milk aroma	Pleasant, characteristic of pumpkin
Colour	Yellow-orange	Yellow-orange
Taste	Peculiar to pumpkin and pumpkin seeds, without off-flavours and flavours	Peculiar to pumpkin and pumpkin seeds, without off-flavours and flavours

The dynamics of changes in the organoleptic and physicochemical parameters of the semi-finished product during storage is presented in Table 11.

Thus, based on the studies, the shelf life of the semi-finished product was determined to be 6 months at a temperature of -18...-20°C.

By adjusting the ratio of the recipe components, the optimal ratio of amino acid composition and polyunsaturated fatty acid content was achieved, which allows the developed semi-finished product to be classified as a functional product. In addition, the multifunctionality of the semi-finished product is achieved by its use in the technologies of minced meat, pastes, puree soups, sauces, as a filler, etc.

Table 11

Characteristics of semi-finished product quality indicators during storage

Name of indicators	Shelf life, months			
	0	3	6	12
Organoleptic				
Appearance	Solid homogeneous mass	No changes	No changes	No changes
Consistency	Firm	No changes	No changes	No changes
Smell	Pleasant, characteristic of pumpkin	No changes	No changes	The smell is slightly pronounced
Taste	Peculiar to pumpkin and seeds, without foreign flavours and aftertaste	No changes	No changes	There is a bitter aftertaste
Physical and chemical				
Mass fraction of dry substances, %.	14,92±0,25	No changes	No changes	No changes
Microbiological				
total amount of MAFANM in 1 g of product, CFU.	$3*10^4$	$3,2*10^4$	$4*10^4$	$5*10^4$
pathogenic microorganisms, including salmonella	Not found	Not found	Not found	Not found
bacteria of the E. coli group	Not found	Not found	Not found	Not found

4. Technology of emulsion-type sauces using semi-finished products

The semi-finished product is delivered to the restaurant business in packages made of shrink film with a light-tight coating or other materials approved by the Ministry of Health of Ukraine for contact with food, and packed in transport containers – plastic boxes.

Store the semi-finished product at a temperature of -18...-20°C. Before use, the semi-finished product is released from the casing and thawed for 120*60 seconds at a temperature of 25°C.

The main directions of use of the developed semi-finished product in the technologies of culinary products are proposed (Fig. 4).

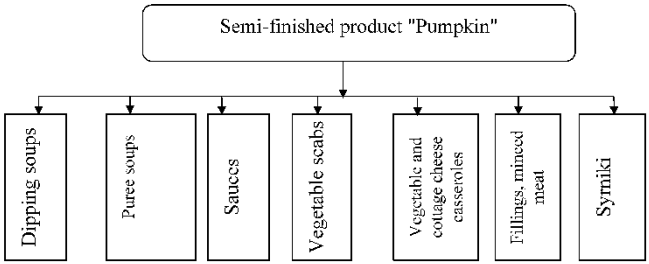

Fig. 4. Main areas of use of semi-finished products in culinary technologies

The developed semi-finished product can be used to prepare a wide range of first courses (filling, puree soups), sauces, culinary products from vegetables (zrazy, rolls, casseroles, stuffed vegetables), as a mincemeat or filling for flour products (pies, pancakes), as a filler for cottage cheese dishes (casseroles, babka, syrniki) in restaurant business enterprises.

Taking into account the beneficial properties of the pumpkin-based semi-finished product, its use in the technology of emulsion-type sauces is proposed.

The most common emulsion-type sauce is mayonnaise. According to DSTU, "Mayonnaise" is a food product that is a multicomponent, stable in a wide temperature range (from 0°C to 18°C), finely dispersed emulsion made from refined, deodorised oils with the addition of emulsifiers, stabilisers, flavourings and spices". Due to its composition, Mayonnaise sauce is characterised by low nutritional and biological value, it is high in calories, and is not used in the therapeutic and preventive nutrition of people with certain diseases. The disadvantage of modern Ukrainian emulsion sauces is that they contain mono– and diglycerides of fatty acids, potassium sorbitol, sodium benzoate, organic acid salts and other technological additives, which makes it impossible to use them in special and dietary nutrition.

Thus, the promotion of emulsion-type sauces based on protein-carbohydrate and vegetable raw materials to the market is constrained by the insufficient level of applied research in this area. Therefore, there is a need to conduct research aimed at substantiating the modes of production of emulsion sauces, taking into account the functional and technological properties of the developed semi-finished product.

The main requirement for emulsion-type sauces is the ability not to change the structure over time. One of the ways to solve this problem is to use food compositions in the ratio of components that ensures both emulsification and structure formation of the system.

Model systems of emulsion sauce consisting of refined deodorised sunflower oil and a semi-finished product based on pumpkin puree are proposed. Preliminary studies have shown that the emulsifying ability of the semi-finished product varies in the range of 40-80%. This means that it is possible to produce mayonnaise-like sauces of different fat content. To study the influence of technological parameters on the emulsification process, the oil content in the model composition of the emulsion sauce was 50%, as it corresponds to the more classical technology of light mayonnaise and expert opinions on taste properties.

To obtain an emulsion structure with specified structural and mechanical properties, it is important to determine the influence of technological factors on the emulsification process. In the production of emulsion sauces, changes in the viscosity (η, Pa-s) and inversion stability (V, %) of the systems were studied at the emulsification stage. The main factors affecting them are the pH of the medium and the emulsification temperature (t, ˚C).

The effect of the pH of the medium on the effective viscosity of the model system containing 50% of the semi-finished product and 50% of the oil was studied (Fig. 5). The dependence of the viscosity of the model system on the emulsification temperature is shown in Fig. 6. The emulsification was carried out in the temperature range from 14 °C to 26 °C.

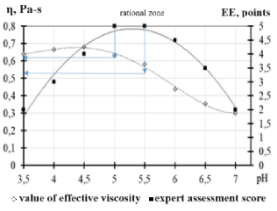

Fig. 5. Dependence of the effective viscosity of emulsion systems (η, Pa-s) and expert evaluation of consistency (EE, points) on the pH of the medium

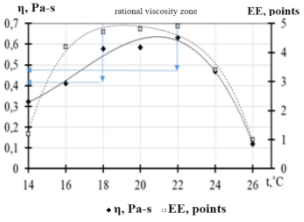

Fig. 6. Dependence of the effective viscosity of emulsion systems (η, Pa-s) and expert evaluation of consistency (EE, points) at different temperatures (t, ˚C)

From the results of the study shown in the diagrams, it can be stated that in terms of effective viscosity, the rational pH range of the medium is 4...4.5 (Fig. 5). However, experts preferred systems with a pH range of 5...5.5 in terms of taste. No significant decrease in viscosity with a decrease in acidity of the systems was observed. Since the pH of the medium is also decisive for

the taste characteristics of the product, all model systems were further tested at pH 5.5.

The emulsification temperature of 18...220Cwas determined to be rational (Fig. 6). The model systems of sauces obtained in such ranges of production modes were evaluated by experts with maximum quality scores.

The dependence of the phase inversion of emulsion systems on the emulsification temperature was studied, the data are presented in Fig. 7.

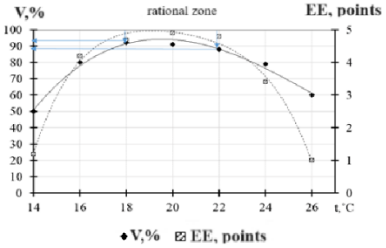

Fig. 7. Dependence of inversion (V, %) and expert evaluation of consistency (EE, points) at different temperatures (t, ˚C)

The analysis of the dependence of the inversion on the emulsification temperature (Fig. 7) showed that the temperature range from 18 °C to 22 °C was also determined to be rational, at which the emulsifying ability of the system is maximum and amounts to 58...90%, respectively, while maintaining the homogeneity of the system without signs of coalescence of fat globules for a sufficiently long time. This fact is marked by correspondingly high scores of expert evaluation.

Based on the results obtained, the technology of a mayonnaise-type base sauce was proposed. The classic recipe of the emulsion sauce "Provence 67% fat" was taken as a control. The fat content in the control sample is 67%, in the tested sauces – 50%, according to the results of organoleptic studies.

The innovative sauce technology involves the use of a semi-finished product as the main component, which will act as an emulsifier due to the content of whey proteins and a structure-forming agent due to the high content of pectin substances. Powdered pumpkin seeds, as a component of the semi-finished product, will act as a stabiliser, sealing the strength of the interfacial adhesive layers.

The basic technological scheme of sauce production provides for the introduction of vegetable oil and flavour components into the semi-finished product and the emulsification process at a standard rate of 0.1 ml/s at 20...22˚C for (1.1...1.2)×60s to maintain a glossy surface and prevent delamination (Fig. 8).

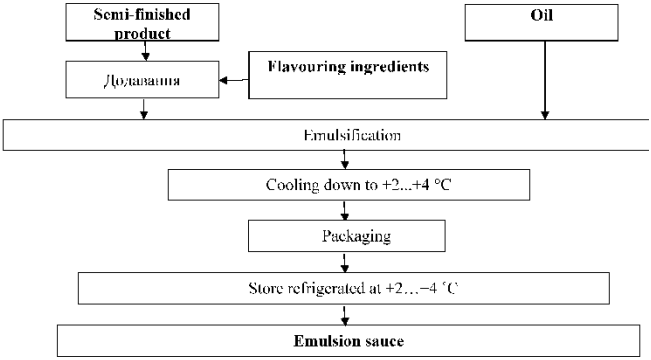

Fig. 8. Schematic diagram of the production of emulsion-type sauces

The resulting emulsion-type sauce is characterised by a set of quality indicators, among which the most important are nutritional and biological value.

The content of the main nutrients and energy value of emulsion-type sauces in comparison with the control are shown in Table 12.

The resulting sauce is characterised by lower moisture content, higher ash content due to the content of pumpkin seeds, and lower fat content due to a reduction in the content of oil as a recipe component. The carbohydrate content has increased significantly due to the use of a vegetable base for the sauce. The protein content doubled due to the addition of whey powder to the semi-finished product.

Table 12

Chemical composition and energy value of sauces, n=5, P≤0.05

Indicator.	Unit of measurement	Unit of measurement	Unit of measurement
Mass fraction: moisture	g/100g	21	18,5
ash		1,5	2,18
proteins		2,8	5,7
fats		67	53
carbohydrates		3,7	21,2
Energy value, kcal	Kcal	629	584

In order to expand the range of emulsion sauces, it is possible to add various flavouring components to their composition. In particular, apple or plum puree can be added to the main emulsion sauce to match the taste of pumpkin.

CONCLUSIONS

The analysis and systematisation of literature sources on the problem of creating semi-finished products with a high content of biologically active substances have revealed that the use of plant materials, in particular pumpkin pulp (as a source of β-carotene) and pumpkin seeds (due to the high content of PUFAs), as well as whey powder, is promising in this direction.

The mathematical modelling performed allowed us to determine the semi-finished product that is as balanced as possible in terms of amino acid and fatty acid composition. Studies of nutritional and biological value lead to the conclusion that the developed semi-finished product is characterised by high protein content, well balanced in terms of essential amino acids (47.05% essential and 52.95% nonessential amino acids), and has a fairly high content of polyunsaturated fatty acids (20.63% of the total fatty acids). The technology of cold sauce based on semi-finished product and minced meat is proposed.

Based on the research, it was found that the semi-finished product has sufficiently high stabilising and emulsifying properties in a wide range of concentrations. The possibility of its use as an effective emulsifying base for the production of emulsion sauces has been determined. It was determined that in the temperature ranges of 20...22^{0}C and pH = 5.0...5.5, the emulsion model systems have the maximum effective viscosity and resistance to delamination. The basic technology of emulsion-type sauces has been developed. It has been determined that the sauce is characterised by high nutritional and biological value and a high content of protein substances. The use of the semi-finished product in emulsion sauces will expand the range of products with a high protein content.

SUMMARY

The processes of globalization and Ukraine's integration into the world community, the struggle for resources and access to new markets have become the driving force behind the introduction of innovative food technologies aimed at improving the nation's health, which is driven by the growing interest in the concept of a healthy lifestyle among the country's population. Numerous studies have identified the need to enrich the human diet with polyunsaturated fatty acids, essential amino acids and dietary fiber. The source of such essential nutrients can be such raw materials as pumpkin, a traditional product for Ukraine. The work determines the feasibility of using pumpkin pulp and seeds in combination with whey powder for the production of a semi-finished product for functional purposes. The recipe and technology of the semi-finished product were developed using mathematical modeling methods, and the chemical composition, biological value, and microbiological parameters of the semi-finished product were studied. The physicochemical and

organoleptic changes of the semi-finished product during storage were determined. The use of the semi-finished product for the production of a wide range of culinary products is recommended. The parameters for the production of emulsion-type sauces using the semi-finished product for health food are substantiated.

Bibliography

1. Codex Alimentarius. URL: https://www.fao.org/3/ca2329en/ca2329en.pdf

2. Смоляр В. Основні тенденції в харчуванні населення України. Проблеми харчування. 2010. № 2. С. 5–9.

3. Баланси та споживання основних продуктів харчування населенням України. Державна служба статистики України. 2019. С. 12. URL: http://ww w.ukrstat.gov.ua/druk/publicat/kat_u/2019/zb/07/zb_bsoph2018_pdf.pdf

4. Діденко В.П., Шабля О.С. Сучасний стан і перспективи забезпечення населення України продукцією баштанництва. Овочівництво і баштанництво. 2014. № 49. С. 80-85.

5. Колтунов В.А.; Пузік Л. М.. Зберігання гарбузових плодів. Наук. вид. Х.: Харк. нац. аграр. ун-т ім. В. В. Докучаєва. 2009. 365 с.

6. Тимчак В.С. Ефективність інновацій комплексного використання відходів харчової промисловості: Дис. канд.ек.наук, 2016. С. 41-43.

7. Дубініна А. Порівняльна оцінка якості господарсько-ботанічних сортів гарбуза / Дубініна А., Летута Т., Томашевська Р.// Товари і ринки, 2011. № 1. С. 132-139.

8. Інноваційні технології борошняних кондитерських виробів із використанням продуктів переробки гарбузового насіння : монографія / Т. В. Капліна, В. М. Столярчук, С. О. Овчіннікова-Дудник, Е. М. Бровко. Полтава. ПУЕТ, 2015. 356 с.

9. Інноваційні технології харчової продукції : колективна монографія/ за заг. ред. Г.В. Дейниченка. Харків: Факт, 2019. 248 с.

10. База патентів України UAPATENTS.COM. URL: http://uapatents.com/

11. Технологія харчових продуктів із заданими властивостями на основі вторинної молочної та рослинної сировини: монографія Гніцевич В.А., Никифоров Р.П., Федотова Н.А., Кравченко Н.В. Донецьк: Донбасс, 2014. 337 с.

12. ДСТУ 4552:2006. Сироватка молочна суха. Технічні умови. К.: Держспоживстандарт України, 2006. 13 с.

13. ДСТУ ISO 7804:2015. Продукти перероблювання фруктів та овочів. Методи визначання сухих речовин або вологи. К.: Держспоживстандарт України, 2015. 20 с.

14. Крисанов Д.Ф. Детермінанти якості й безпечності харчової продукції та мінімізація впливу факторів ризику // Продуктивні сили і регіональна економіка : зб. наук. праць : у 2 ч. / РВПС України НАН України. К., 2008. Ч. 1. С. 249–261.

15. ДСТУ ISO 5983:2003 Корми для тварин. Визначення вмісту азоту і обчислення вмісту сирого білка методом К'єльдаля. К.: Держспоживстандарт України, 2007. 12 с.

16. Методи контролю якості харчової продукції : метод. Рекомендації до лабораторних робіт / уклад. : М.М. Воробець, І.М. Кобаса, І.В. Кондрачук Чернівці : Чернівец. нац. ун-т ім. Ю. Федьковича, 2022. 32 с.

17. Фізіолого-біохімічні методи досліджень у біології, тваринництві та ветеринарній медицині: довідник. Львів, 2004. С. 309-311.

18. Хімічний та мікробіологічний аналіз харчової продукції : навч. посібник / І.М. Кобаса, Л.М. Чебан, М.М. Воробець, Юкало В.Г., Кухтин М.Д. Чернівці : Чернівецький нац. ун-т, 2014. 196 с.

19. Гніцевич В., Кущенко В. Технологія та якість напівфабрикату на основі м'якоті гарбуза для оздоровчого харчування. Обладнання та технології харчових виробництв. Кривий Ріг : ДонНУЕТ, 2021. Вип. 2 (43). С. 5-11. DOI : 10.33274/2079-4827-2021-43-2-5-11

Information about the authors:
Gnitsevych Victoriya Albertivna,
Doctor of Technical Sciences, Professor,
Professor at the Department of restaurant and craft technologies
State University of Trade and Economics
19, Kyoto str., Kyiv, 02156, Ukraine

Yudina Tetiana Illivna,
Doctor of Technical Sciences, Professor,
Professor at the Department of restaurant and craft technologies
State University of Trade and Economics
19, Kyoto str., Kyiv, 02156, Ukraine