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THE EFFECT OF PLANT PROTEINS ON THE FORMATION OF STRUCTURAL AND RHEOLOGICAL PROPERTIES OF NOUGAT

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Introduction. Formulation of the problem

The confectionery market is one of the most developed industry markets. It keeps actively developing, and domestic confectioners cannot satisfy all the needs of the market. Ukrainian buyers have been satiated with traditional flavours and decided to try new ones. The import of macaroons (almond flour biscuits), cakes and pastries with a mirror glaze, Belgian waffles, Turkish delight, and other oriental sweets is growing. According to analytical forecasts, whipped confectionery will be in demand by consumers due to its delicate light consistency and the content of fruit and berry ingredients, eggs, dairy products, and flavourings in its composition [1].

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Abstract. This paper considers the problem of increasing the nutritional value of whipped confectionery such as nougat by using hemp-based and soya-based protein-containing ingredients. The main tendencies of obtaining new types of food based on plant proteins with complete amino acid composition are described. The paper presents information on cultivating and using hemp and soya both in Ukraine and in the world, and suggests how products of their processing can be applied to improve the quality and increase the biological value of confectionery. It has been investigated what effect protein-containing ingredients obtained from hemp and soya have on the structural properties of foam in the technology of whipped confectionery such as nougat. It has been established that increasing the amount of plant protein additives leads to a decrease in the foaming ability, but the stability of protein foams increases. Adding 10% of protein-containing hemp additives increases the foam stability by 6%, while protein-containing soya additives increase it by 5%. The paper presents the results of studying the structural and rheological properties of nougat mass with protein-containing plant additives in the amount 2.5–10% of the weight of sugar. It has been determined that adding protein-containing hemp and soya ingredients increases the viscosity and plastic strength of the products and stabilises their structure. The effect of different amounts of nuts on the kinetics of nougat crystallisation has been studied. It is recommended to add 5% of hemp and 7.5% of soya protein-containing additives instead of sugar during the whipping of nougat mass, because it reduces the whipping time and has a positive effect on structure formation. The recommended amount of roasted pistachio kernels in the samples suggested is 25–35% of the total weight of nougat, with the resting time 30–60 minutes and the moulding temperature 50–55°C. The nutritional value of the new products with protein-containing hemp and soya ingredients and nuts has been calculated. It has been noted that nougat has been enriched with protein, unsaturated fatty acids, and minerals (potassium, calcium, magnesium, phosphorus).

Key words: nougat, confectionery foams, plant proteins, viscosity, strength, nutritional value.

A promising direction in whipped confectionery production is increasing the nutritional and biological value of these products and imparting functional properties to them. Modern consumers prefer products with a balanced composition, improved protein content, enriched with vitamins, minerals, dietary fibre, and other bioactive components. Currently, much attention is paid to the wider use of plant proteins in the production of food. The technological and functional properties of proteins and their foaming ability make using them to manufacture whipped products promising and topical. Introduction of plant proteins will not only enrich the diet, but also expand the range of whipped confectionery for different social groups with different tastes and lifestyles.

Analysis of recent research and publications

Domestic and foreign researchers pay more and more attention to creating new types of products using plant proteins with complete amino acid composition. It was proposed to use sunflower protein isolate (13–15% by the weight of egg white) as a plant additive and partial foaming agent substitute in whipped confectionery masses to improve the product's quality. It is also possible to use wheat protein the Gemtek-2100 to replace some part of egg whites in marshmallows [2].

Nowadays, soya bean proteins, which have a fairly balanced amino acid composition and are highly digestible, are especially widely used. Numerous dishes high in protein are made from soya: soya milk, cheese, sauces, etc. Besides, soya is used to make protein additives, which can be introduced into various foods to increase their nutritional value [3,4].

There is extensive experience of using soya products in various dishes, but little attention is paid to hemp products. Hemp seeds belong to the largest sources of protein, unsaturated fatty acids, vitamins, enzymes, and antioxidants. According to Canadian scientists who studied the chemical composition of Canadian hemp seeds, their lipid content is 24.0–30.6% and their protein content is 23.8–28.0%. Hemp seed oil mainly consists of polyunsaturated fatty acids. Linoleic (Omega-6) and α -linoleic (Omega-3) acids are dominant (59.7 and 17.0% respectively). γ -tocopherol is present in a much higher concentration than δ -tocopherol (2481 vs. 774mg/g); the phenol content is 1.37–5.16 g/100g; the concentration of ash ranges from 5.1 to 5.8%, while the concentration of fibre is 25.9–38.8% [5].

Hemp seeds are used to produce protein-containing raw material – powder with a high protein content, made after separating oil from the seeds by pressing. Depending on the temperature and the number of stages of pressing, it is possible to obtain hemp flour or a concentrate containing 30 and 50% of protein, respectively. The residual amount of fat is about 10%, and the content of fibre beneficial for digestion is about 20% [6]. It should be noted that psychotropic substances are contained only in the inflorescences of hemp and its leaves, and the seeds are absolutely safe.

The authors [7,8] note the potential benefits of using various hemp seed products, including hemp flour, concentrates, and isolates, in food as non-traditional sources of protein. Hemp protein consists mainly of globulin (edestin) and albumin; it has high digestibility and a balanced amino acid composition.

The main hemp producers in the world are China, Chile, Europe, Korea, Canada, France, and Russia.

In Ukraine, hemp cultivation is undergoing the process of transformation to market conditions and the period of formation, which is associated with an increase in the growth area for industrial hemp [9].

Most industrial hemp is grown for its fibre and seeds. In recent years, the number of hemp enterprises in Ukraine has increased tenfold. This can be considered a raw material base large enough to allow using hemp and products of its processing in food production.

Europe, North America, and Asia have experience in using hemp as a food ingredient with unique fatty acid composition to produce biscuits, sweets, various tonics, beer, ice cream, halva, and many other foods [10].

In North America, hemp seeds are used to make nut butter, breads, biscuits, yoghurts, pancakes, cereals, frozen desserts, burgers, pizza, salt substitutes, mayonnaise, cheese, and a variety of beverages. Crushed seeds of industrial hemp are stored by canning or vacuum preservation. In Germany, pasta, chocolate, and various confections are added to the above list of products [11].

The Hemp Food Industries Association (UK), which specialises in hemp seed production, produces sweet bars *Nine Bar* (made from a mixture of caramel, honey, hemp seeds, and dried apricots) and nut bars *Hem Flapjack* (which include oats, light treacle, plant margarine, hemp seeds, raw cane sugar, and soya flour), bread with sprouted hemp seeds, ice cream topped with shelled hemp seeds, and soups sold in natural product department stores [12].

Recipes for gluten-free energy bars made of extruded rice with 20% of whole hemp powder have been developed, which has allowed increasing the production volume and nutritional value of extruded products [13,14].

In contrast, domestic scientists have not sufficiently studied the technological potential of hemp products in food technology. Thus, it is important to determine the feasibility of using soya and hemp proteins in confectionery production as technological additives that can regulate the composition and structure of finished products, increase their nutritional value, and enrich them with physiologically useful nutrients.

The purpose of this study is to determine whether protein-containing hemp and soya ingredients can be used in the technology of whipped confectionery masses, and to establish how they should be introduced and how they effect on the process of egg white foaming and on the structural and rheological parameters of nougat.

In order to achieve this purpose, the following **tasks** were set:

1. Investigating the effect of protein-containing soya and hemp ingredients on the technological properties of egg white.
2. Establishing the structural and rheological parameters of whipped masses, such as nougat, with protein-containing ingredients added.
3. Studying the effect of different amounts of nuts on the nougat crystallisation kinetics.
4. Determining the nutritional value of nougat with plant protein additives.

Research materials and methods

The materials used in this study were dry egg white (DSTU 5028:2008); protein-containing hemp ingredients (PCHI) – a powder with 52% of protein, 11.8% of fat, and 24.4% of carbohydrates, obtained from hemp seeds after oil separation by pressing according to TU U 10.4-39224310-002:2019 (Desnaland); protein-containing soya ingredients (PCSI) – a soya concentrate with 63% of protein, 1% of fat, and 25% of carbohydrates, obtained from peeled and defatted soya beans by removing most of the water-soluble non-protein components according to TU 10.89.19-034-83387545-2017 (FitActive); white crystalline sugar (DSTU 4623:2006); glucose (DSTU 4464:2005); treacle (DSTU 4498:2005); cocoa butter (DSTU 5004: 2008); and pistachios (DSTU 4822:2007).

The recipe of the soft nougat *Montilemar* was chosen as a control sample. To make it, sugar-glucose-treacle syrup was added to the pre-whipped whites in a thin stream and continued to be stirred intensively until a whipped mass was formed. The cocoa butter was heated to 36°C and added to the whipped mass, then pistachios were added, and the mass was placed onto the cooling surface. After 60 minutes of resting, the nougat mass was shaped into bars with the diameter 25–30 mm and cut into pieces weighing 35–40g.

The foaming ability of egg white foams was determined by the Lurie method. Water (300cm³) was poured into a 500cm³ measuring cylinder, and 6g of the mixture was added. The water temperature was 18°C. The cylinder was closed with a glass or rubber stopper and vigorously shaken for 1 min. Then the cylinder was placed on the table, and after a few seconds, the height of the foam formed was measured.

Foaming ability (FA, %) is calculated according to the formula

$$FA = V_f/V_m \cdot 100 \quad (1)$$

where V_f is the foam volume, cm³;

V_m is the volume of the mixture before shaking, cm³.

Foam stability was determined by the height of the foam column after 60 min.

Foam stability (FS, %) is calculated according to the formula

$$FS = (H_f^{60})/H_f \cdot 100 \quad (2)$$

where H_f^{60} is the height of the foam after 1 hour, cm;

H_f is the initial height of foam, cm.

The microstructure of protein foams was studied using an electron microscope XS-5510, with Samsung SCC-B1311 optics (magnification x100).

The rheological characteristics of the nougat mass were determined on a rotary viscometer Reotest-2 using a measuring system of cylinders N/N. The density of the whipped masses was determined by the volumetric method: the proportion of the mass of the sample to the mass of water occupying the same volume and having the same temperature. The strength of the nougat masses and their crystallisation kinetics were studied by penetration: immersing a cone with a

60° angle at the apex into the product with a constant force using an automated penetrometer AR-4/1 [15].

The experimental data were mathematically processed using the MATSTAT programme (number of repetitions of the experiments n=3, reliability P≤0.05).

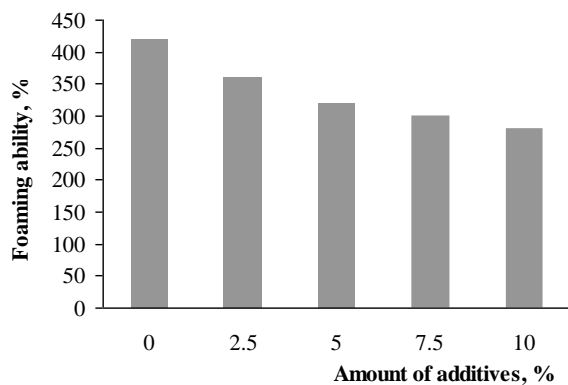
Results of the research and their discussion

The effect of protein-containing soya and hemp ingredients on the foaming process of nougat masses has been studied. In order to prevent any changes to the physical, chemical, and technological properties of the egg white, it has been suggested to add protein-containing ingredients at the stage of whipping the nougat mass, immediately after the introduction of the syrup.

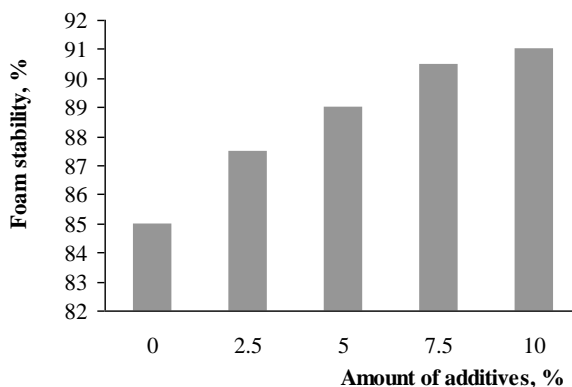
The resulting nougat mass is a dispersed system in the form of foam, where the air bubbles are evenly distributed in the dispersed phase. They are separated by thin layers of the dispersion medium. This medium is a sugar-glucose-treacle mass with other components. The size of the bubbles in the dispersed phase depends on the quality of the dispersion medium and can range from a fraction of a millimetre to several centimetres [16]. Foam is formed by a foaming agent, namely egg white. As part of the film that envelops the air bubbles, it forms the whipped nougat mass and provides its stability.

An important characteristic for whipped confectionery production is the foaming ability of egg whites (FA). The composition of the dispersion medium, namely the amount and optimum concentrations of surfactants, structure stabilisers, etc., has a significant effect on the foaming process and the quality of the resulting foam. Therefore, using new types of ingredients can change the FA of the white. Thus, it is necessary to determine their effect on the foaming process when whipping egg white with PCHI and PCSI. The previous studies [17] have shown that it is practical to introduce no more than 10% of protein-containing additives (by the weight of sugar) into the nougat. The nougat structure remains in an amorphous, plastic state, which allows it to be formed using traditional equipment.

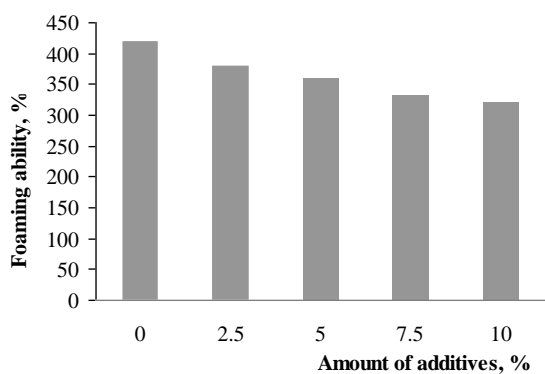
Studying the foaming process has shown that the FA of egg white is 420%. Adding 2.5–10% of PCHI and PCSI slightly decreases the FA (Fig. 1). This might be due to the chemical composition of the protein-containing ingredients, namely their content of fat, which exhibits the properties of a defoamer. At the same time, its higher content in the PCHI leads to a more intensive decline in the FA of egg white. Thus, it decreased by 33% in the sample with 10% of PCHI, while in the sample with PCSI, it decreased by 24%. It is known that mono- and diglycerides of unsaturated fatty acids, which are part of plant fats, form a liquid-insoluble impermeable film on the border of the liquid and gaseous phases, thereby increasing the surface tension and preventing the process of air saturation. E.A. Foegeding and P.J. Luck [18] have also shown that egg white foaming agent, traditional for the confectionery industry, has high FA compared to the studied types of proteins (hydrolysates and whey protein isolates).



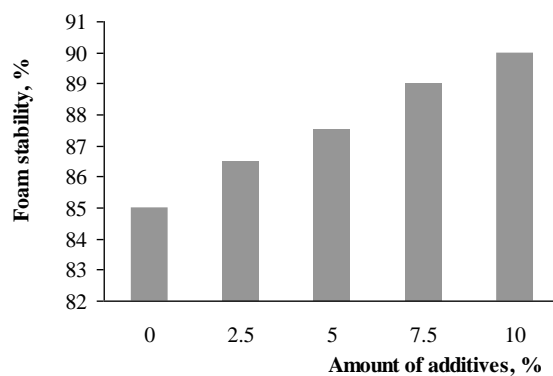
a)



a)



b)



b)

Fig. 1. Foaming ability of egg white with PCHI (a) and PCSI (b)

Fig. 2. Foam stability of egg white with PCHI (a) and PCSI (b)

The foams formed as a result of whipping are thermodynamically unstable systems which have a developed interface between the gaseous and the liquid phases. The pressure difference in the bubbles leads to diffusion transfer of gas, interface reduction, and coalescence of the system. Therefore, besides the foaming ability, the main parameters that characterise the foam system include its stability.

Studying the effect of the suggested ingredients on the intensity of destruction of the system obtained has shown that the foam stability of egg white increases if protein-containing ingredients are added. Thus, the foam with 10% of PCHI has stability higher by 6% (Fig. 2a), while the stability of the sample with PCSI is higher by 5% (Fig. 2b). This could be due to the fact that high molecular weight compounds that are part of the protein-containing ingredients, namely proteins and polysaccharides, have high moisture-binding capacity and their swelling increases the viscosity of the dispersion medium. As a result, the flow of liquid in the layers between the bubbles is slowed down, and the rate of their thinning is reduced, thus preventing the coalescence of the foam. Besides, these substances give the foam film high mechanical strength, creating a kind of elastic framework, thus increasing the stability of the system.

Based on the data obtained regarding the effect of protein-containing ingredients on the technological properties of egg white, it is suggested to keep its amount the same and use 2.5–10% of PCHI and PCSI by the weight of sugar.

The samples are prepared by adding the protein-containing ingredients to the mass of nougat at the stage of whipping it after introduction of syrup. The whipping continues until the required minimum density is reached. Using PCSI and PCHI reduces the duration of whipping. Thus, in the samples with 5% of the additives, the time to obtain the required density is reduced by 5 minutes, and in samples with 10%, it is reduced by 8 minutes (the control sample is whipped in 15 minutes). As a result of whipping, a mass is formed with its volume partially occupied by the gas phase. The degree to which the whipped mass is saturated with air can be characterised by its density. Studies have been held to determine the mass density of nougat with the suggested ingredients. The density of the control sample is 918kg/m^3 . Increasing the amount of additives leads to an increase in the mass density. Thus introducing 5% of PCHI and PCSI increases the density by 90 and 84kg/m^3 , and 10% of PCHI and PCSI increases it by 242 and 235kg/m^3 respectively.

An important structural and rheological property of the whipped mass which determines its behaviour at different stages and affects the course of the

technological process is viscosity. This parameter, which depends on the adhesion forces between molecules, characterises the resistance of the mass to flowing under the effect of external forces and depends on many factors, such as the dry matter content, composition and ratio of ingredients, temperature, etc. [19]. Thus, the effect of PCHI and PCSI on the viscosity of the nougat samples has been studied (Fig. 3). The rheological properties have been determined with the temperature of the sample 60°C, which corresponds to the temperature of mass formation.

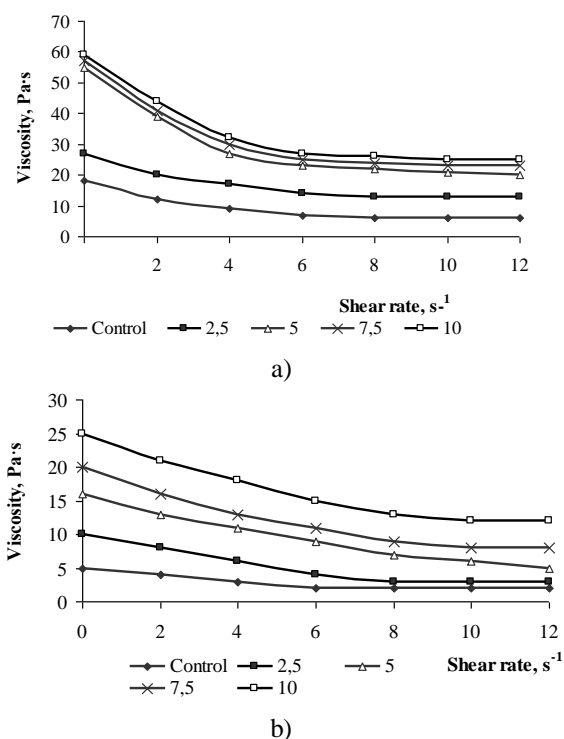


Fig. 3. Viscosity of the nougat mass with PCHI (a) and PCSI (b)

The rheological properties presented in Fig. 3 show the pseudoplasticity of all test samples, where viscosity is a property of the equilibrium state between the processes of destruction and recovery. Small mechanical influences ($0.6\text{--}1.0\text{ s}^{-1}$ shear rate) with other conditions being equal decrease the viscosity, and the structure starts to collapse. Shear rates of $2\text{--}4\text{ s}^{-1}$ and higher increase the rate of destruction and decrease the structural strength. The structural bonds do not have time to recover due to the speed of the process, and the effective viscosity decreases to the limit corresponding to the full destruction of the structure which no longer depends on the shear stress and velocity gradient under steady flow conditions.

Nougat mass can be considered a supersaturated solution with evenly distributed molecules of water, sucrose, glucose, maltose, proteins, and other nougat components which have compactly packed particles bound by molecular interaction forces. These forces

are rather strong, as evidenced by the high viscosity of the mass of nougat. Adding 2.5 to 10% of PCHI and PCSI to the whipped mass increases the effective viscosity 1.5-3.5 times. This could be due to the content of polymer molecules of carbohydrates and proteins in the protein-containing ingredients that bind moisture and increase the dispersion medium viscosity and thus that of the whole mass.

The moulded mass of nougat undergoes further maturation and cutting. According to the traditional technology, the structure formation of nougat takes 60 minutes in order to achieve the specified structural characteristics. Studying the structural and mechanical properties of the test samples (Fig. 4) has shown that the strength of the control sample at this stage is 32 kPa. Adding 2.5–10% of PCHI and PCSI increases the plastic strength 1.8-2 times compared to the control sample. Such a significant increase in the strength of the nougat mass reduces the duration of structure formation in the mass to ensure its subsequent high-quality cutting.

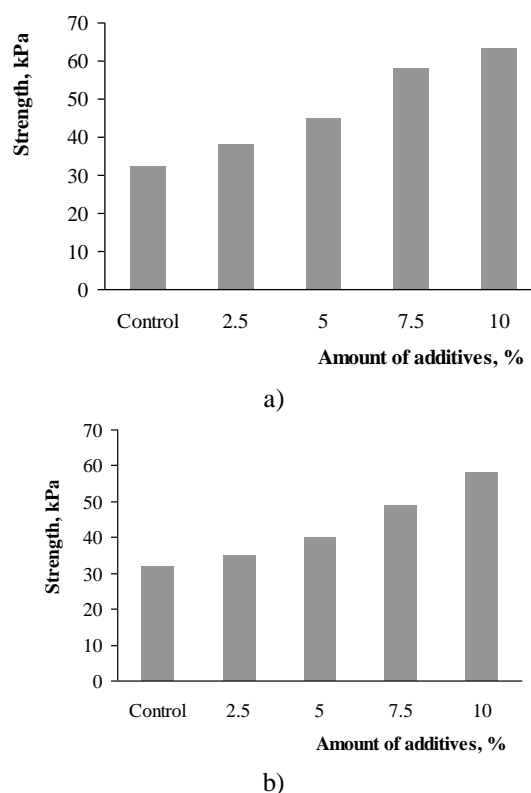


Fig. 4. Strength of the nougat mass with PCHI (a) and PCSI (b) (resting time 60 min)

The strength of the mass increases due to the combined crystallisation effect of cocoa butter, sugar-treacle-glucose syrup, and protein powders. When using protein powders, the strength of the whipped mass increases due to additionally filling the spatial framework around the bubble with powder particles.

Based on structural and rheological studies of nougat masses, it has been concluded that adding

protein-containing plant ingredients increases their viscosity and plastic strength and stabilises the structure. Adding 5% of PCHI and 7.5% of PCSI allows obtaining products with sensory, structural, and mechanical parameters that are the closest to the control sample and meet the demands of regulatory documents.

The foam structure of nougat samples with 5% of PCHI and 7.5% of PCSI has been studied using an electron microscope. The photos are presented in Fig. 5.

It should be noted that the nature of the pores in the foam masses with protein is almost the same as in the control sample. They have a spherical shape, but the sample with PCSI is characterised by a more uniform distribution of air bubbles compared to the sample with PCHI. The compaction of bubble walls in the samples with protein-containing ingredients is also noticeable (Fig. 5 b, c), which indicates an increase in the stability of these foam samples. Introduction of the suggested ingredients increases the structural strength of the films in the dispersion medium. This happens because the liquid present in the whipped mass makes the high molecular weight ingredients swell.

In order to establish the rational amount of roasted pistachio kernels, it has been investigated how they effect

on the kinetics of nougat crystallisation determined by the value of the shear stress limit (Fig. 6). Pistachios, in the amount 25–45%, were added to the nougat samples with 5% of PCHI and 7.5% of PCSI. The kinetics of structure formation in the sample with 25% of roasted pistachio kernels is similar to that of the control sample. Increasing the amount of nuts accelerates the structure formation process and increases the final value of the shear stress limit. This could be due to the ability of roasted pistachios to adsorb free moisture, which increases the viscosity and strengthens the mass.

The recommended amount of roasted pistachio kernels in the samples with PCHI and PCSI is 25–35% of the total weight of nougat. With the moulding temperature 50–55°C and resting time 50–60 min, the strength of the control sample and of the sample with 25% of pistachios is 48–50 kPa. Increasing the amount of nuts to 35% shows a similar value after 25 min and 30 min for the samples with PCHI and PCSI respectively. At 50–55°C, the nougat structure remains amorphous, plastic, which allows using traditional equipment to mould it. Samples with a higher amount of nuts have too high viscosity and strength, which complicates further formation and cutting of products.

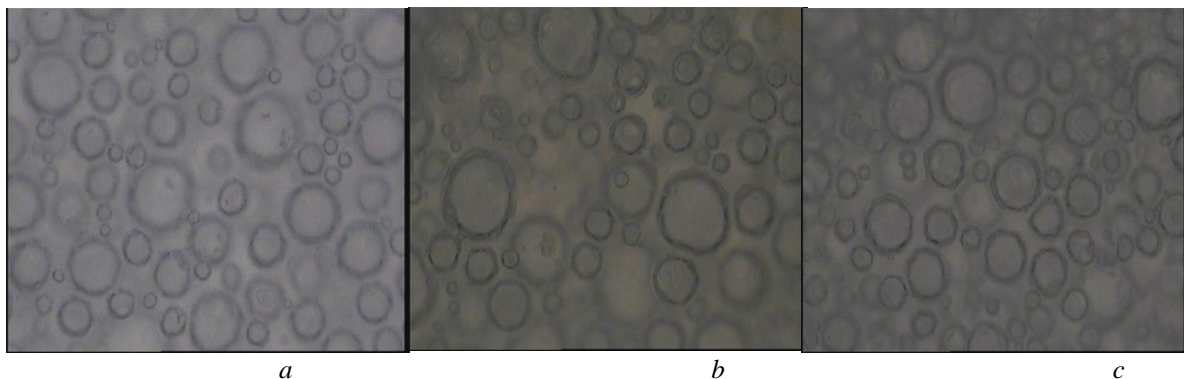


Fig. 5. Photos of the nougat mass foam microstructure (x100): a – control sample; b – sample with PCHI; c – sample with PCSI

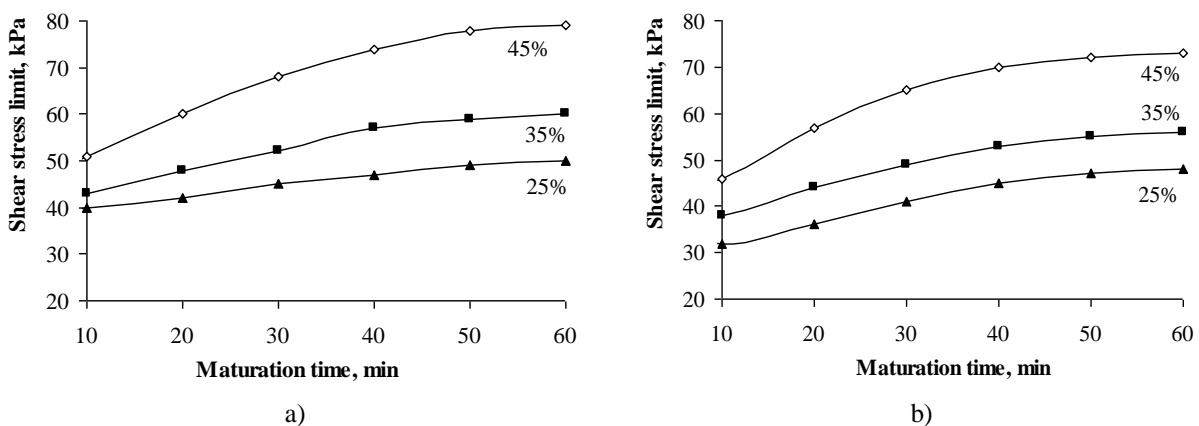


Fig. 6. Crystallisation kinetics of nougat containing PCHI (a) and PCSI (b), with different amounts of roasted pistachio kernels

As a result of this study, recipes of nougat *Fistashkova* and *Soyeva* containing 5% of PCHI and 7.5% of PCSI, respectively, have been developed (Table 1).

Table 1 – Nougat recipes

Ingredients	Control sample	Nougat (kg, to 1000 kg of the product)	
		<i>Fistashkova</i>	<i>Soyeva</i>
Sugar	500.0	478.5	452.4
Glucose	200.0	200.0	200.0
Treacle	50.0	50.0	50.0
Cocoa butter	150.0	150.0	150.0
Egg white	150.0	150.0	150.0
Pistachios	230.0	230.0	230.0
PCHI	–	25.0	–
PCSI	–	–	37.5
Total	1280.0	1283.5	1269.9
Yield	1000.0	1000.0	1000.0

Nutritional value is an important indicator of food quality. It shows how healthy the product is, and, above all, how sufficiently its nutrients satisfy human

physiological needs. Considering that food contains substances that regulate complex life processes and provide human body with materials to build new cellular structures, it was necessary to determine the nutritional value of the products developed. The chemical composition of these products has been calculated according to the relevant recipes and daily nutrient requirements [20], based on the determined chemical composition of protein-containing ingredients and reference tables of the chemical composition of food products [21].

The calculations have shown that using protein-containing plant ingredients in the nougat technology increases the protein content by 19% for *Fistashkova* and 34% for *Soyeva* nougat, and the content of unsaturated fatty acids increases by 1.1 and 1.15 times respectively, while the amount of carbohydrates in the products decreases (Table 2). The nougat samples have also been enriched with minerals, particularly potassium, calcium, magnesium, and phosphorus.

Table 2 – Meeting the body's nutrient requirements when consuming 100 g of nougat

Nutrients	Daily requirement	Control sample	<i>Fistashkova</i>	<i>Soyeva</i>
Proteins, g	78	6.3	7.5	8.5
Carbohydrates, g	324	17.1	16.7	16.5
Fats, g	88	9.4	9.3	9.3
unsaturated fatty acids, g	35	5.2	5.5	5.4
Minerals:				
Na, mg	500	52.6	53.0	53.0
K, mg	2000	255	275	265
Ca, mg	800	30.8	40.9	35.9
Mg, mg	280	7.9	12.7	21.4
P, mg	800	82.9	111.5	241.5

Approbation of results

The newly-developed nougat *Fistashkova* and *Soyeva* with protein-containing hemp and soya ingredients have been implemented into production at the company *Vlasta KP* in Odessa.

Conclusion

Studying the foaming process has shown that increasing the amount of plant protein-containing ingredients in the system decreases the foaming ability of egg white, but the stability of protein foams during resting increases.

Based on the determined structural and rheological properties of nougat masses, it has been suggested that their resting time can be reduced by accelerating their

structure formation and increasing their strength (compared with the control sample) due to using protein-containing ingredients. It is recommended to add 25–35% of roasted pistachio kernels of the total weight of nougat at the moulding temperature 50–55°C. Increasing the amount of nuts to 35% reduces the duration of mass formation by half.

Thus, the results of this research have proved that protein-containing hemp and soya ingredients can be used in the nougat technology. It is recommended to add 5% of PCHI and 7.5% of PCSI by the weight of sugar during the whipping stage. Using plant protein and nut ingredients in the nougat technology allows expanding the range of raw materials used in the production of whipped confectionery, increasing its nutritional value, and enriching it with physiologically useful nutrients.

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ВПЛИВ ПРОТЕЇНІВ РОСЛИННОГО ПОХОДЖЕННЯ НА ФОРМУВАННЯ СТРУКТУРНО-РЕОЛОГІЧНИХ ВЛАСТИВОСТЕЙ НУГИ

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Анотація. У статті вирішується питання підвищення харчової цінності збивних кондитерських виробів типу нуги шляхом використання конопляної та соєвої протеїнвмісної сировини. Розглянуто основні тенденції отримання нових видів харчових продуктів, виробництво яких засновано на використанні повноцінних за амінокислотним складом рослинних білків. Наведено інформацію щодо вирощування та використання конопляної та соєвої сировини як в Україні так і світі, розкрито питання застосування продуктів їхньої переробки при виробництві кондитерських виробів для покращення їхньої якості та підвищення біологічної цінності. У статті досліджено вплив рослинної протеїнвмісної сировини з коноплі та сої на структурні властивості піни в технології збивних кондитерських виробів типу нуги. Встановлено, що збільшення кількості рослинних протеїнових добавок в системі призводить до зниження показника піноутворювальної здатності, але при цьому стійкість білкових піл під час вистоювання зростає. У масі з конопляною протеїнвмісною сировиною зі збільшенням вмісту добавки до 10% стійкість піни підвищується на 6%, а у зразка з соєвою протеїнвмісною сировиною – на 5%. Наведені результати досліджень структурно-реологічних властивостей мас нуги з використанням рослинних протеїнвмісних добавок у кількості 2,5–10% від маси цукру. Встановлено, що додавання конопляної та соєвої протеїнвмісної сировини підвищує в'язкість, пластичну міцність та стабілізує структуру виробів. Досліджено вплив різної масової частки горіхів на кінетику кристалізації нуги. Рекомендовано внесення конопляної протеїнвмісної сировини замість цукру у кількості 5% та соєвої – у кількості 7,5% на стадії збивання маси нуги, що дозволяє скоротити процес збивання та позитивно впливає на структуроутворення. Рекомендована масова частка зм'ячених ядер фісташок у запропонованих зразках 25–35% до загальної маси нуги при тривалості вистоювання 30-60 хв та температурі формування 50–55°C. Розрахована харчова цінність нових виробів з конопляною та соєвою протеїнвмісною сировиною і горіхами. Відзначено збагачення нуги білком, ненасиченими жирними кислотами, мінеральними речовинами (калієм, кальцієм, магнієм, фосфором).

Ключові слова: нуга, кондитерські піни, рослинні протеїни, в'язкість, міцність, харчова цінність

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