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APPLICATION OF PROCESSING PRODUCTS OF VEGETABLE RAW MATERIAL IN MARSHMALLOW PRODUCTION

Abstract

The article examines the main trends in obtaining new types of confectionery products with a balanced composition and functional properties, the production of which is based on the use of a product of plant raw materials processing - carob. Studies on increasing the nutritional value and reducing the energy intensity of marshmallow-type whipped products with the use of carob and the sugar substitute isomalt are given. Information on the functional properties of carob, the effect of the roasting process on its quality indicators, and the possibility of using carob in the production of confectionery products to expand the range of raw ingredients and increase their nutritional value were considered. A comparative description of the nutritional and energy value of medium-roasted carob and cocoa powder is given. The article examines the influence of the product of the processing of plant raw materials of carob on the nature of the formation of the structure of marshmallow masses of reduced energy content, and their main structural-mechanical, physico-chemical and organoleptic indicators are determined. Based on the determination of the structural and mechanical properties of marshmallow masses, such as critical shear stress, degree of general deformation and density of the mass, it is proposed to reduce the duration of their whipping by increasing the rate of structure formation of the mass when using carob powder, so the complete replacement of cocoa powder with carob leads to an increase critical shear stress by 51.83 Pa and an increase in mass density by 171 kg/m³ compared to the control sample. As a result of a complex of conducted studies of physico-chemical and organoleptic quality indicators, the expediency of using the product of the processing of plant raw materials of carob in reduced-energy marshmallow products with 75% isomalt has been proven, it is recommended to completely replace cocoa powder with carob at the stage of whipping the mass. The calculated nutritional and energy value of the new marshmallow products showed a decrease in the total content of fats and carbohydrates in the developed products, an increase in the content of vegetable dietary fibers by 28% and a decrease in the energy value by 55.65 kcal. Enrichment of marshmallow products with minerals, in particular calcium, sodium and vitamins B6 and E, was noted.

Key words: marshmallows, whipped confectionery, carob, isomalt, density, nutritional value.

Introduction

Whipped confectionery products are in demand among consumers due to their delicate light consistency and the useful protein and pectin substances contained in them. Marshmallow or "air marshmallow" is an aerated confection consisting mainly of gelatin, sugar solutions, glucose syrup, and foaming agents such as egg albumin. Marshmallow products are most often white and have various shapes (round, square, cylindrical, in the form of colored bundles), glazed with chocolate or caramel glaze, or with nuts [1].

A promising direction in the production of whipped marshmallow products is to increase their nutritional value, reduce energy content, and impart functional properties. Modern consumers care about their health and prefer products with a balanced composition, which contain significant amount of dietary fibers, biologically active substances, vitamins, and minerals [2, 3]. Therefore, the development of new marshmallow-type whipped products with increased nutritional value and reduced energy content using the products of processing plant raw materials (carob and isomalt) is relevant and promising.

Analysis of recent research and publications

Carob is a sweet powder made from the pulp of the fruits (pods) of the carob tree, a plant of the legume family. In its wild form, the carob tree is often found in Palestine, and it is this country that is considered its homeland. Currently, the plant is cultivated in India, Brazil, Argentina, Mediterranean countries, and other subtropical regions. Raw carob pods are collected, laid out in the sun and dried. In the process of drying, the fruits become sweet and suitable for consumption. After drying, the pods are processed into powder: carob. Well-roasted pods taste similar to dark chocolate [4]. Carob can be used as a natural substitute for cocoa powder in confectionery recipes. Carob is classified as a functional food product due to its preventive properties, which are due to its chemical composition: most of the pulp consists of sugars (mainly sucrose, glucose, and fructose), and dietary fibers. Carob fruits contain gum, which has the properties of a stabilizer and thickener. Due to this substance, carob is used as an ingredient that gives the product thickness, shine, and viscosity. There are few proteins in the pods, but they contain an almost complete set of amino acids, including essential ones. A



distinctive feature is the high content of arginine [5, 6]. In addition, carob contains pinitol (5-7%), condensed tannins (18-20%), ash (mineral elements) 2-3%, as well as fats (0.2-0.6%). Carob tannins bind toxins, thus deactivating them [7-9].

Carob is a functional product and has a wide range of therapeutic and preventive effects on the human body. There are 10 times less fats in carob than in cocoa. Sucrose and fructose provide sweetness, which gives carob the right to be considered dietary. The fiber contained in the powder improves digestion, and together with antioxidants removes harmful substances from the body, including toxins. Carob is sweeter than cocoa powder, so diabetics should use it with caution (Table 1). Raw and fried carob have certain differences. Non-roasted powder is the sweetest, it has a light pink-beige shade, and the taste is different from chocolate. Lightly roasted powder has a light caramel taste. Medium-roasted carob has dark chocolate color and characteristic smell. The taste gains some bitterness characteristic to dark chocolate. It is necessary to pay attention to the degree of roasting, since the sugar content in the roasted powder is

Table 1 - Comparative characteristics of carob and cocoa powder

Indicators	Cocoa	Carob
Taste	Bitter	Sweet
Color	Dark brown	Light brown (raw); brown (roasted)
Allergy	Causes	Does not cause
Effect on the central nervous system	Invigorates, can cause migraines and insomnia	Does not affect
Vitamins	Beta-carotene, A, B ₉ , PP, B ₆ , E	Cholin, PP, B ₅ , E, C, B ₂ , B ₁ , B ₆
Caffeine	Contains	Does not contain
Mineral substances	Calcium, zinc, sulfur, phosphorus, molybdenum, copper, chlorine, iron, manganese, potassium, magnesium	Copper, selenium, calcium, manganese, zinc, phosphorus, potassium, magnesium, sodium, iron

Table 2 - Nutritional and energy value of carob and cocoa powder, g/100 g

Components	Cocoa powder	Medium-roasted carob
Proteins	27	4.6
Fats	11	0.6
Carbohydrates, including	54	49
Sugars	0.5	40.5
Energy value	1789 kJ (428 kCal)	929 kJ (222 kCal)

lower than in the raw one. The energy value of carob is almost two times lower than that of cocoa powder, while a large number of calories are accounted for by sugar. The nutritional and energy value of medium-roasted carob and cocoa powder is shown in Table 2 [10].

Carob, the product of processing plant ingredients, is used in the manufacture of cookies, flour desserts, craft candies, dark and white glaze, without changing the original color and aroma of the final product. The use of carob improves the sensory qualities of products, particularly taste and aroma, and enriches them with vegetable dietary fibers, vitamins, and minerals [5, 11-12].

Studies were conducted regarding the use of raw and roasted (at +110°C and +130°C for 20 min) carob powder in the production of beverages and the use of carob concentrate in the production of confectionery products. According to the results of sensory evaluation, the use of carob concentrate in the manufacture of toffee, jelly candies, and Turkish delights in the amount of 5%, 20% and 10% of the sugar mass, respectively, led to an increase in the antioxidant activity of these confectionery products. Research results have proven that carob concentrate can be used for the production of functional and healthy food products [13].

The purpose and goals of the research

The purpose of the research is determining the expediency of using carob, the product of processing plant ingredients, in the technology of marshmallow whipped products with low energy value, establishing its effect on the type of the marshmallow mass structure formation, physical, chemical, and sensory properties.

To achieve the goal, the following tasks have been set:

1. To investigate the influence of carob, the product of processing plant ingredients, on the structure formation type of the whipped mass of marshmallows with reduced energy content.
2. To establish the main physical, chemical, and sensory properties of the developed products.
3. To determine the nutritional and energy value of marshmallows with carob and sugar substitute isomalt.

Research materials and methods

Research materials used were white crystalline sugar according to DSTU 4623:2006; starch molasses (DSTU 4498:2005); food gelatin (GOST 11293-89); citric acid (DSTU 908:2006); isomalt (TM "IRCA"); medium-roasted carob powder from the company "Manteca" (Lviv) TU U 10.6-2949619066-001-2019.

The density of the whipped mass was determined by the volumetric method: the relation of the research object mass to the mass of water, which occupies the same volume and has the same temperature. Research on the critical shear stress of marshmallow samples was carried out by the penetration method: immersion of a cone with 60° angle at the top with a constant penetration force into the product using an automated penetrometer AR-4/1 [14]. Physical and chemical properties were determined by generic methods. Sensory properties (taste, smell, color, consistency, structure, shape, and

surface appearance) had to meet the requirements of DSTU 6441-2003.

A chocolate marshmallow recipe, where 50 to 100% of cocoa was replaced with carob and 75% of sugar was replaced with isomalt was chosen as a control sample. The expediency of replacing 75% of sugar with isomalt in the marshmallow recipe was proven in previous studies [15]. To obtain marshmallows, gelatin mass is prepared first. For this, pre-swollen gelatin and molasses are gradually heated in an open pot to a temperature of +80-90°C. The resulting mixture is cooled to a temperature of +60-65°C, then isomalt and citric acid are added and mixed. The resulting mass is filtered through a sieve with a hole diameter of no more than 3 mm.

Preparation of foamy marshmallow mass is carried out in a whipping unit. First, the gelatinous mass is fed to the installation, then powdered sugar with a particle size of no more than 260 µm is loaded. Carob is added to this mixture and whipped for 5-6 minutes at a speed of 340 rpm. The marshmallow mass is formed by depositing it in the form of bundles on a surface covered with a polymer film. The products are proofed indoors at a temperature of +18-20 °C for 55-65 minutes. Then the

formed clusters are cut into separate products of the required length. The technological scheme of making marshmallows with isomalt and carob is presented in Fig.1.

Results and their discussion

During the production of whipped marshmallow products, two processes take place in succession: foam and jelly formation. Foamy whipped masses are dispersed systems consisting of cells filled with air and separated from each other by films of the dispersion medium. The hydrocarbon component of the dispersion medium significantly affects its rheological properties, which in turn depend on the type of structure formation. In order to determine the effect of carob on the formation type of the marshmallow mass structure, structural and mechanical properties were determined by penetration, which is characterized by such indicators as the critical shear stress, the degree of general deformation, and the density of the marshmallow mass. The obtained research results indicate that increasing the amount of carob in marshmallows with isomalt leads to a slight increase in the critical shear stress of all the studied samples (Fig. 2). When increasing the amount of carob from 50 to 100%,

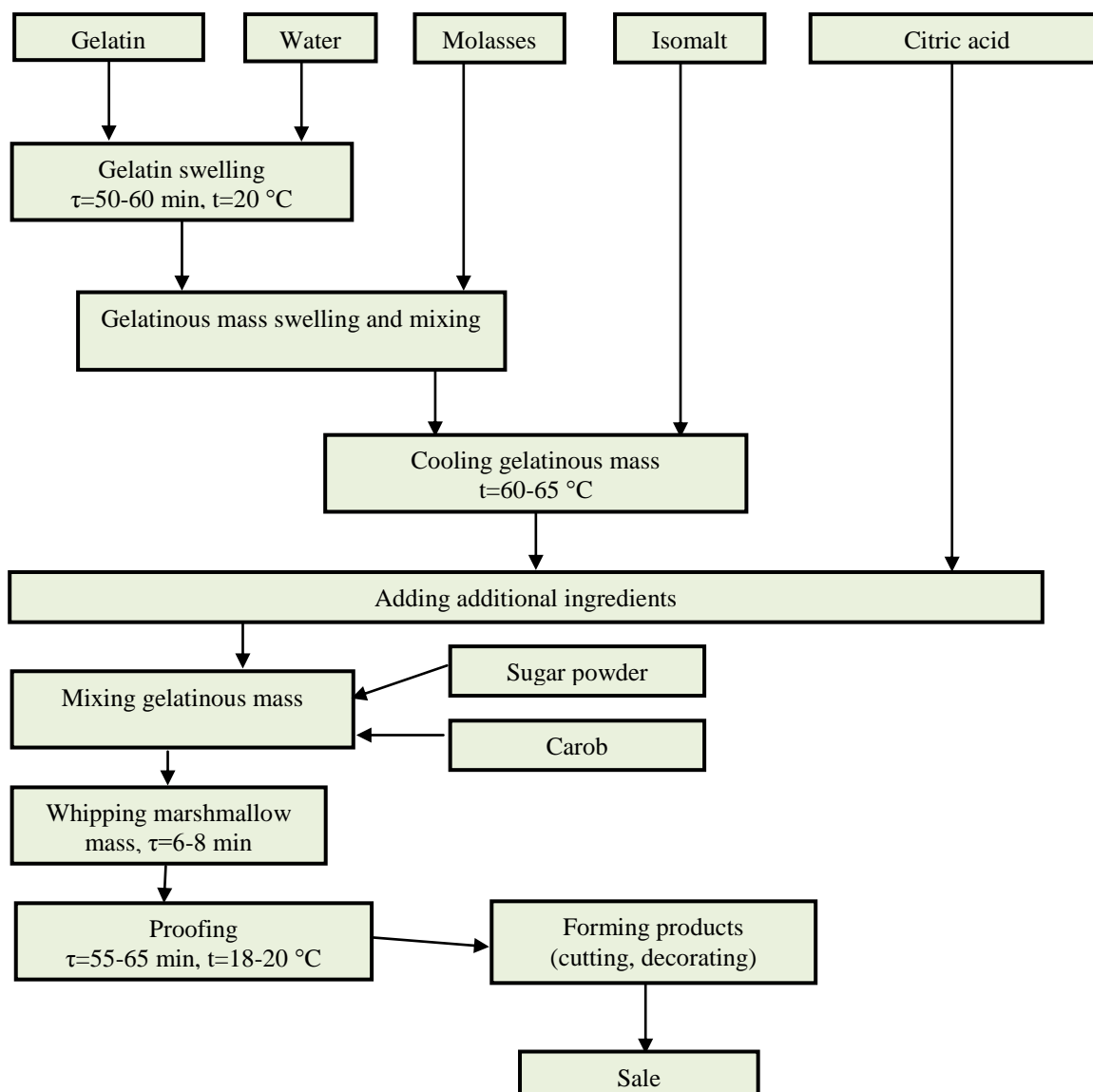


Fig. 1. Technological flowchart of making marshmallows with carob

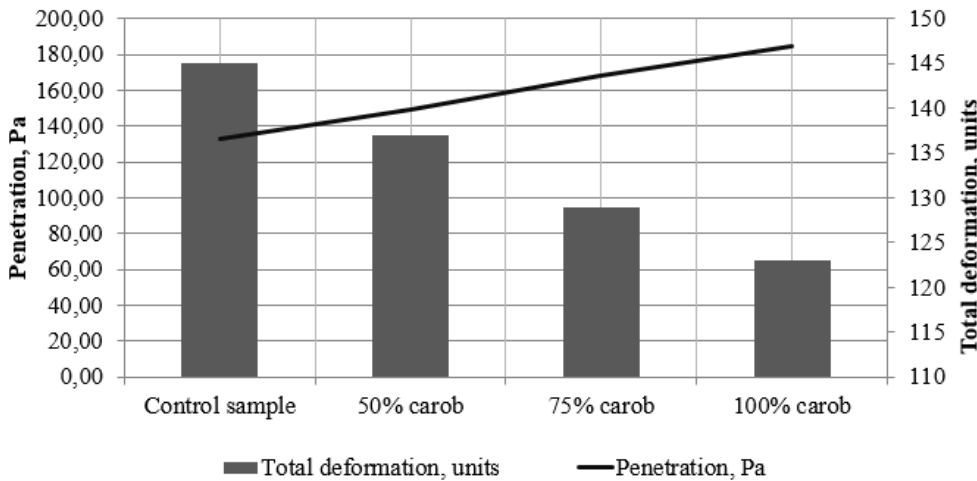


Fig. 2. Dependence of the penetration of marshmallow masses on the amount of carob

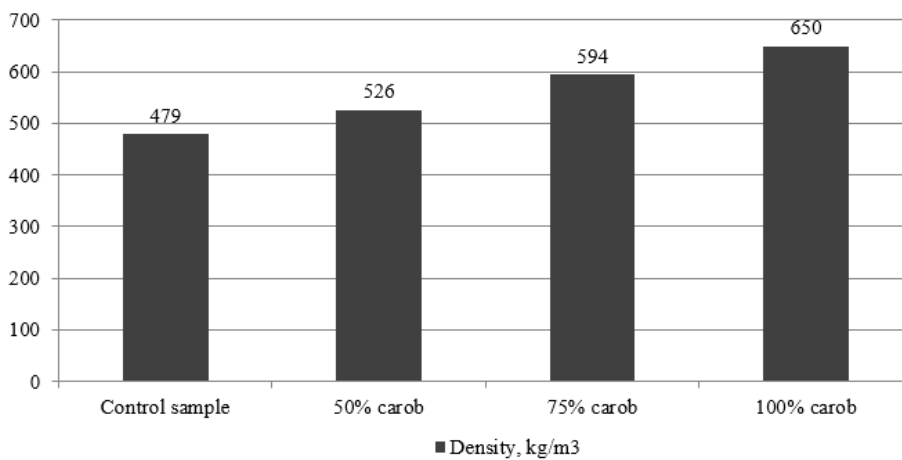


Fig. 3. Dependence of the density of marshmallow masses on the amount of carob

the mass of marshmallows becomes denser, so the penetration indicators increase by 51.83 Pa for the sample with 100% carob compared to the control. At the same time, there is a decrease in the total deformation, so for the control sample, the value of the total deformation is 144 units, and for a sample with 100% carob it is 123 units.

Density is one of the main factors that determine the quality of whipped confectionery products. As a result of whipping, a mass is formed, with that part of volume occupied by the gas phase. The degree of saturation of the whipped mass with air can be characterized by its density. Conducted studies on determining the mass density of marshmallows with isomalt and carob powder showed that the density of the investigated samples increases with an increase in the carob amount due to the additional filling of the spatial frame around the bubble with powder particles. Thus, when adding 50% carob, the density of marshmallow masses increases slightly by 47 kg/m³, and when cocoa powder is completely replaced by carob, the density increases by 171 kg/m³ (Fig. 3). This is due to the fact that carob powder has moisture-retaining properties, i.e. the ability to bind and retain moisture in the studied samples.

The quality of finished marshmallow products with carob and reduced energy content was studied by their physical, chemical, and sensory properties. As can

be seen from the data in Table 3, when the amount of carob increases from 50 to 100%, the amount of marshmallow dry matter increases, which may be related to the moisture-retaining properties of the additive. Thus, for the sample with complete replacement of cocoa powder with carob, the amount of dry substance increases by 3.82% compared to the control. The introduction of carob helps to slightly reduce the acidity of the products. As the amount of carob increases, the number of reducing sugars in the samples increases as well, which may be related to the chemical composition of carob powder. The duration of whipping the products is reduced by 2 min compared to the control for a sample with 100% carob due to an increase in the density and speed of structure formation of the mass when using carob

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powder.

Sensory properties include quality parameters that determine consumer properties of products, such as appearance, shape, taste, consistency, and color. The sensory properties of low-energy chocolate marshmallow with carob were converted using the Harington scale into relative units and presented in the form of a profile diagram (Fig. 4).

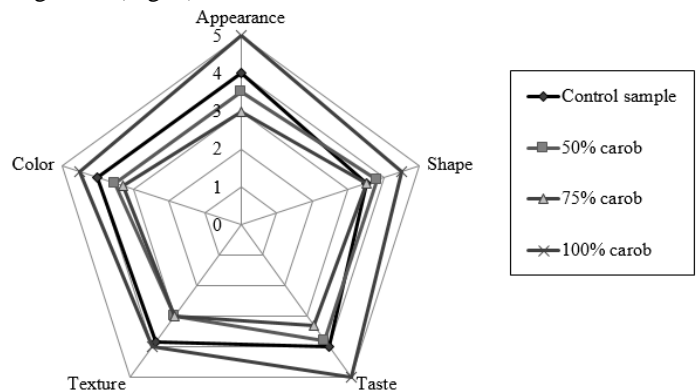


Fig. 4. Quality profile diagram of low-energy marshmallows with carob

When increasing the amount of carob from 50 to 100%, samples of marshmallows with isomalt acquire rich chocolate color, and the taste becomes more pronounced,

Table 3 – Physical, chemical, and sensory properties of marshmallows with carob

Properties	Control sample	Carob amount, %		
		50%	75%	100%
Mass fraction of dry substances, %	81.88	83.05	84.25	85.7
Acidity, degrees	0.68	0.65	0.66	0.66
Mass fraction of reducing substances, %	25.84	28.26	29.97	32.0
Duration of whipping, min	8	8	7	6
Sensory properties				
Taste and aroma	Typical for marshmallows, with a hint of chocolate		The taste and aroma of bitter chocolate intensifies	
Color	Brown			Rich brown
Texture	Foamy, homogeneous, porous			

Table 4 - Marshmallow recipes

Ingredients	Amount of ingredients per 1 ton of semi-finished product, kg	
	Control sample	Marshmallow "Chocolate Bear"
Sugar	671.0	167.1
Isomalt	-	510.8
Molasses	94.6	94.6
Cocoa powder	38.7	-
Carob	-	40.5
Gelatin	29.5	29.5
Water (for soaking gelatin)	177.0	177.0
Citric acid	7.7	7.7
In total	1018.5	1027.2
Yield	1000.0	1000.0

with bitterness characteristic of chocolate. The texture of the products is uniform, the sample where cocoa powder is completely replaced with carob is denser than the control sample. Products have a smooth surface and uniform porosity. According to the sensory evaluation of the studied samples, 100% of carob additive to the mass of cocoa powder was recognized as optimal.

As a result of evaluating physical, chemical, and sensory properties of chocolate marshmallows with reduced energy content, the possibility of completely replacing the cocoa powder with carob in the studied products has been proven, while all quality indicators were within normal parameters. Based on the conducted research, the "Chocolate Bear" marshmallow recipe with 75% isomalt and 100% carob has been developed and recommended for implementation in production (Table 4).

Data on the nutritional and energy value of the developed marshmallows showed that adding 75% isomalt and carob, the product of processing plant ingredients, allows to reduce the total content of fats by 89%, carbohydrates by 16%, increase the amount of dietary fiber by 28%, which will have a positive effect on the human body. The enrichment of marshmallows with mineral substances, particularly calcium, sodium, and vitamins B6 and E, was also determined. The energy value of marshmallows "Chocolate Bear" decreased by 55.65 kcal compared to the control sample.

Conclusions

Structure formation type of the marshmallow masses with reduced energy content with added carob, the product of processing plant ingredients, has been studied. Based on the determined structural and mechanical properties of marshmallow masses, it is proposed to reduce the duration of their whipping by increasing the rate of mass structure formation when using carob powder, so the complete replacement of cocoa powder with carob leads to an increase in the critical shear stress by 51.83 Pa and an increase in the density of the mass by 171 kg/m³ compared to the control sample.

As a result of conducted studies on physical, chemical, and sensory properties, the expediency of using carob, the product of processing plant ingredients, in the technology of marshmallows with reduced energy content with 75% isomalt has been proven. It is recommended to carry out a complete replacement of cocoa powder with carob at the stage of whipping the mass. The use of products of processing plant materials in marshmallow technology allows to expand the range of ingredients for the production of whipped confectionery products, increase their nutritional value, and enrich them with plant dietary fibers, vitamins, and minerals.

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ЗАСТОСУВАННЯ ПРОДУКТІВ ПЕРЕРОБКИ РОСЛИННОЇ СИРОВИНИ ПРИ ВИРОБНИЦТВІ МАРШМЕЛЛОУ

Анотація

У статті розглянуто основні тенденції отримання нових видів кондитерських виробів зі збалансованим складом та функціональними властивостями, виробництво яких засновано на використанні продукту переробки рослинної сировини - керобу. Наведені дослідження по підвищенню харчової цінності та зниженню енергоємності збивних виробів типу маршмеллоу з використанням керобу та цукрозамінника ізомальту. Розглянуто інформацію щодо функціональних властивостей керобу, впливу процесу обсмажування на його якісні показники та можливості використання керобу при виробництві кондитерських виробів для розширення асортименту сировинних інгредієнтів і підвищення їх харчової цінності. Наведено порівняльну характеристику харчової та енергетичної цінності керобу середнього ступеню обсмажування і какао-порошку. У статті досліджено вплив продукту переробки рослинної сировини керобу на характер формування структури мас маршмеллоу зниженої енергоємності, визначено їх основні структурно-механічні, фізико-хімічні та органолептичні показники. На підставі визначення структурно-механічних властивостей мас маршмеллоу, таких як гранична напруга зсуву, ступінь загальної деформації та густина маси, запропоновано скорочення тривалості їх збивання за рахунок підвищення швидкості структуроутворення маси при використанні порошку керобу, так повна заміна какао-порошку на кероб приводить до підвищення граничної напруги зсуву на 51,83 Па та збільшення густини маси на 171 кг/м³ у порівнянні з контрольним зразком. У результаті комплексу проведених досліджень фізико-хімічних і органолептичних показників якості доведено доцільність використання продукту переробки рослинної сировини керобу у виробі маршмеллоу зниженої енергоємності з 75% ізомальту, рекомендовано проводити повну заміну какао-порошку на кероб на стадії збивання маси. Розрахована харчова та енергетична цінність нових виробів маршмеллоу, встановлено зниження загального вмісту жирів та вуглеводів у розроблених виробі, підвищення вмісту рослинних харчових волокон на 28% та зменшення енергетичної цінності на 55,65 ккал. Відзначено збагачення виробів маршмеллоу мінеральними речовинами, зокрема кальцієм, натрієм та вітамінами B6 та E.

Ключові слова: маршмеллоу, збивні кондитерські вироби, кероб, ізомальт, густина, харчова цінність.

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STUDIES OF THE NUTRITIONAL VALUE OF COMPOUND FEED FOR STURGEONS

Abstract

Aquaculture is one of the fastest growing food industries in the world today. The share of aquaculture in world fish production is growing every year. Over the past 50 years, the volume of fish farming in the world has increased by more than 50 million tons, while the growth in the volume of world fish catch stopped in the 80s of the last century. Aquaculture is one of the most promising and at the same time underestimated areas of economic activity in the agro-industrial complex of Ukraine, which, with the rational use of water resources, is able to provide consumers with a wide range of fish and fish products in a short time. A certain increase in the production of aquaculture products, especially the cultivation of sturgeon and salmon in Ukraine, is due to the use of imported feed, which has a high cost. However, its further development cannot rely on imported feed products, at the same time, the development of industrial fish farming methods is impossible without full-fledged balanced feeding of cultivated objects. Due to the aquatic environment, the need of fish for energy, nutrients and biologically active substances has its own specificity, in comparison, for example, with warm-blooded agricultural animals: it is the need for a high level of protein, another, a special ratio of protein and total energy, fat and polyunsaturated fatty acids, sensitivity to an excess of carbohydrates. Thus, in natural feed for fish, more than 60% of the gross energy falls on protein, about 36% - on fat and only 4% - on carbohydrates. The development of domestic feed for sturgeon is an important task of the feed industry in Ukraine. The paper investigates the current state of fish farming in the country, the relevance and volume of production of compound feed for sturgeon fish, provides the advantages of growing sturgeon fish in Ukraine, analyzes the needs of sturgeon fish in nutrients, micro- and microelements and vitamins, analyzes the physical properties of compound feed for sturgeon fish recipes, an analysis of existing ones was carried out and a proprietary program for feeding