ІННОВАЦІЙНІ ТЕХНОЛОГІЇ ХАРЧОВИХ ВИРОБНИЦТВ

УДК 664.149:664.162.8

TECHNOLOGICAL PARAMETRS OF HALVA WITH ISOMALT AND MALTITOL

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The sunflower halva recipe was optimized by replacing sugar and molasses with isomalt and maltitol. A series of experiments were conducted to determine the structural-mechanical indicators of halva samples, confirming the feasibility of using isomalt and maltitol to create an alternative product to the high-calorie halva made according to the classical recipe. Additionally, the technological parameters of its production were justified.

Keywords: halva, energy value reduction, maltitol, isomalt.

ТЕХНОЛОГІЧНІ ПАРАМЕТРИ ВИРОБНИЦТВА ХАЛВИ З ІЗОМАЛЬТОМ ТА МАЛЬТИТОЛОМ

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Оптимізовано рецептуру соняшникової халви шляхом заміни цукру та патоки на ізомальт та мальтитол. Проведено аналіз технологічного процесу та визначено етап, що є важливим процесом формування структурно-механічних та фізико-хімічних показників якості халви. Грунтуючись на цьому було складено план проведення експериментальних досліджень.

Для оцінки впливу різних параметрів на якість халви використовувався два змінні параметри технологічного процесу, це час уварювання та час збивання карамельної маси. Установлено, що при заміні цукору-пісоку на ізомальт, патоки – сиропом мальтитолу параметри приготування карамельного сиропу змінюються, а саме скорочується час уварювання і складає 18…19 хв до масової частки сухих речовин напівфабрикату 82 %. Час збивання карамельної маси має складати 12…13 хв, даний зразок показав найкращі результати щодо зовнішнього вигляду, кольору та текстури продукту.

Визначено, що ефективна в’язкість карамельного сиропу з ізомальтом та сиропом мальтитолом знижується несуттєво. В'язкість мальтитолу менша за в'язкість патоки. Мальтитол є мальтотріозою, яка має більш низьку молекулярну вагу, ніж глюкоза або фруктоза (патока), тому вона утворює менш в'язкі розчини. В свою чергу ізомальт має в’язкість на 33 % більшу в порівнянні з цукор-піском. Таким чином в’язкість урівноважується відповідно до протопипу.

Досліджено вплив замінників цукру на пінну систему продукту в цукровій масі та встановлено, що заміна цукру-піску на ізомальт та патоки на сироп мальтитолу підвищує піноутворення на 7 %. Визначено, що раціональним є інтервал збивання 13...14 хв, система належним чином насичується бульбашками повітря. Показник піностійкості у досліджуваній модельній системі не відрізнявся від контрольної. Дослідження дисперсності показали, що ізомальт і мальтитол сприяють утворенню більш дрібних і рівномірно розподілених пухирців повітря в карамельній масі.

За результатами дослідження реалізовано можливість використання ізомальту та мальтитолу в рецептурі халви.

Ключові слова: халва, зменшення енергетичної цінності, мальтитол, ізомальт.

General problem formulation. In contemporary society, the pervasive issues of obesity and overweight represent significant public health concerns. Within the European Union, recent data indicate that a majority, constituting 52% of the adult populace, currently grapple with either surplus weight or clinical obesity. Moreover, an average of 17% of adults are afflicted with obesity. The prevalence of obesity, a condition bearing heightened health risks compared to mere overweight, varies across EU member states, ranging from 8% (e.g., Romania and Switzerland) to exceeding 25% (notably observed in Hungary and the United Kingdom).

Consumers are progressively discerning the attributes and utility of low-calorie product categories, aligning with preferences for health-conscious dietary practices, reduced caloric intake, and dental health preservation. Consequently, a surge in demand for low-calorie offerings is witnessed globally. Halva, a traditional confectionery item, distinguished by its firm consistency derived from a blend of boiled sugar syrup, aerated saponin-rich extract sourced from Saponaria officinalis, nougat, and either sesame or sunflower paste (tahini), exemplifies this trend.

The utilization of sunflower seeds as a substitute for sesame in sunflower halva, particularly prevalent in Eastern European nations, attests to ongoing innovation in response to dietary requirements. Recognizing the calorific excess exceeding 500 kcal/100 g in halva formulations, there emerges a compelling need for sugar-free alternatives within this confectionery segment [1].

This investigation is directed towards pioneering novel formulations of dietary halva. A primary objective is the development of innovative treacle-free and sugar-free halva mirroring the sensory and textural attributes of conventional counterparts.

Analysis of recent research and publications. Research efforts are aimed at developing methods to diversify the assortment of halva, particularly through various additives and production technologies. Scientists such as Chuyko V.G. have proposed a new method of halva production involving mixing durations (2.5–3 min, at temperatures of 40–50°C for ground sunflower mass and 135–145°C for beaten caramel mass), utilizing an extract of licorice root as a plant raw material extract. Additionally, researcher suggested adding grains of millet, corn, or rice in quantities of 15–30% to the mixed mass. This method allows for reducing the amount of fats and the caloric content of halva [2].

Boloban L.G. discusses the use of various components to create halva with health-promoting properties. The halva contains caramel mass, protein mass from flax seeds or flaxseed meal, and special additives in specific proportions. This halva is dietary and has high biological value [3].

Chuyko V.G. and Shulaev V.M. propose halva using sunflower mass and a foaming agent of licorice root extract. This method improves the taste by eliminating bitterness and negative effects on blood formation [4].

Researchers [5] propose nut-sunflower halva, using heat-treated peanut kernels at temperatures of 180–220°C, and sodium bicarbonate as a foaming agent (0.009÷0.010). As a result, there is an improvement in organoleptic indicators, reduction of defects, and energy consumption.

In the work [6], the author proposes a method of halva production using licorice root extract or tea seed decoction and plant grains (rice and/or millet, and/or corn), enhancing the biological value and extending the shelf life of halva.

Kholodnyak L.V., Kholodnyak O.G., and Lyimar A.O. have developed a method of obtaining halva from pumpkin seeds, which enhances the therapeutic and prophylactic properties of halva [7].

However, the assortment of halva with reduced sugar content remains rather limited. This can be explained by various factors such as high cost, market demand, production complexity, and raw material availability. Demand for halva production with reduced sugar content is increasing and will continue to grow, with maltitol playing a significant role in meeting this demand. Among permitted sugar alcohols, maltitol is closest in properties to sugar and related syrups, thus maltitol syrups can substitute glucose syrups.

The aim of this study was to find the technological parameters for replacing sugar with isomalt and molasses with maltitol syrup in halva technology. The object of this study was technology of halva with isomalt and maltitol.

For halva with isomalt and maltitol was used: sunflower seeds of industrial mixture of 2023 harvest (in accordance with DSTU 4843:2007) [8]; granulated sugar (in accordance with DSTU 2316–93)[9]: drinking water (in accordance with DSTU 7525:2014) [10]; isomalt (KUK, Germany); maltitol syrup (Cargill, Maltidex™16311, 76%)

It was used a traditional method to make caramel mass: whipping concentrated caramel syrup with soap root extract.

Determination of moisture and dry matter content according to DSTU 4910:2008 "Confectionery products. Methods of determining the mass fractions of moisture and dry substances" [11].

Determination of effective viscosity using rotary viscometer "Rheotest-2" in accordance with the instructions for using the device and the research methodology [12].

Study of foaming ability and foam stability according to Luré method [13].

Evaluation of organoleptic characteristics: GOST 5897-90 "Confectionery products. Methods of determining organoleptic indicators of quality, size, net weight and components".

To calculate the reliability of the obtained results, it was used the Student coefficient (tST) for the accepted level of dependence P > 0.05 and the corresponding (n – 1) number of degrees of freedom.

Presentation of the main research material:

A review of the sources indicated the feasibility of using isomalt and maltitol in a technology for halva with reduced calorie content and glycemic index. An innovative product concept presented in Table 1 has been developed.

Table 1

Innovative concept of the product

Indicator name	Characteristics	Implementation sources
Product concept	The new product is a confectionery based on sunflower seeds and the use of sugar substitutes, which has reduced calorie content and glycemic load, acting as a product with an average GI. The production process is simple to execute with low cost compared to the prototype. Ready for consumption	Achieved through the use of sugar substitutes with lower calorie content and glycemic index, which have similar structural-mechanical properties to sugar and syrup.
Assortment	The assortment formation is achieved by varying the recipe composition, namely using raw	Assortment formation is carried out considering the

	materials for preparing "Protein Mass."	forms of implementation and achieved through the possibility of using various plant raw materials.
Target audience	B2C (HoReCa sector, wholesale and retail trade counterparts) B2B (consumers leading a healthy lifestyle, vegetarians, overweight individuals, consumers with insulin resistance)	Achieved through the opportunity to market the confectionery product in any food industry establishment.
Competitive advantages	Biological value with reduced calorie content, a product in the medium GI group, corresponding to modern trends in food technology.	Achieved through the use of sugar substitutes – isomalt and maltitol.
Organoleptic properties	A confectionery product with a tender homogeneous structure, porous and vaguely expressed fibrous-layered consistency without crumbling when cut, non-sticky dry mass, creamy color. Sunflower taste and aroma, without signs of bitterness and moderately sweet.	Achieved through the developed technology of sugar extraction, syrup, and their replacement with isomalt and maltitol.
Product weight	50 g	Recommended daily consumption
Storage period and conditions	From 45 to 90 days	Storage duration depends on packaging, temperature at 18±3°C, and relative humidity ≥ 75.0%.

Excluding granulated sugar and syrup as key components of the recipe affects the structure and flavor characteristics of the confectionery product, as demonstrated in the concept of the developed product. Analysis of the technological process of halva production showed that the main changes are necessary only in certain elements of the process. It was found that the key stage is a technological operation involving the simultaneous use of granulated sugar and syrup to prepare caramel syrup. This operation determines the structural-mechanical and physicochemical characteristics of halva. At this stage, it is necessary to replace granulated sugar with isomalt and syrup with maltitol. Based on this task formulation, ways to implement the innovative concept were formulated, as outlined in Table 2. Research on the impact of using isomalt and maltitol on the technological process of halva production at various stages allows for the realization of the innovative idea - creating a recipe, production technological scheme, and obtaining a high-quality product with reduced calorie content and glycemic index.

To improve, the basic recipe for sunflower seed halva was used [14]. The presented recipe was implemented by preparing a sugar syrup, where isomalt was used instead of granulated sugar, and maltitol instead of syrup. This allowed for obtaining caramel mass with less sugar.

Table 2

Implementation strategies of innovative concept

№	Potential parameter changes	Measures and objectives
1	Taste	Determine organoleptic indicators of experimental model systems
2	Caramel syrup boiling temperature	Study the parameters of preparing caramel syrup with isomalt and maltitol until the dry matter content w = 80 – 85 %
3	Effective viscosity of caramel syrup	Investigate the effective viscosity of caramel syrup made with isomalt and maltitol, and compare the results obtained with the reference formulation
4	Influence of sugar substitutes on caramel mass formation: - foaming ability; - foam stability; -whipping time; - dispersion composition	Study changes in foaming and foam stability in the caramel mass system with sugar substitutes and determine the whipping interval until a dispersed system with density ρ = 1.1…1.15 g/sm³ is obtained
5	Recipe and production	Calculate and develop the recipe for the new product, analyze the recipe

		composition of halva with isomalt and maltitol, develop a production technological scheme highlighting the main production stages, compile equipment and technological scheme
6	Quality indicators	Study the influence of isomalt and maltitol on organoleptic, physicochemical, microbiological quality indicators and compare the obtained data with the requirements of regulatory documentation
7	Nutritional value	Study the biological, energy, and caloric value of halva with isomalt and maltitol
8	Glycemic load	Calculate the glycemic load of classic sunflower halva recipe and new product and compare the results, determine the product group according to glycemic load

We started the experiment by replacing granulated sugar with isomalt and molasses with maltitol according to the classic halva preparation technology parameters: syrup boiling time $\tau = 20 \cdot 60$ s and whipping time of the caramel mass with soapwort extract $\tau = 15 \cdot 60$ s; and the ratio of recipe components [14]. To create the new halva recipe, it was decided to choose the optimized technological parameters.

It was used four samples with different combinations of boiling time and whipping time of the caramel mass. Working variants with experimental samples and their studied graduations presented in Table 3.

Table 3

Working variants with experimental factors

Variant	Boiling time [min]	Whipping time [min]
Variant 1 – a_1 b_1	15	12
Variant 2 – a_1 b_2	15	18
Variant 3 – a_2 b_1	25	12
Variant 4 – a_2 b_2	25	18

Additionally, variant 5 was used as a control sample with the same parameters as in the classic technology. The ratio of protein mass remained unchanged, in accordance with the classic technology. Organoleptic evaluation of all produced samples of halva was performed, and the results are presented in Table 4. The sample produced according to variant 4 stands out for its pleasant appearance, color, and texture. According to the experimental results, boiling time has the greatest influence on the quality of the caramel mass. The optimal amount of dry matter (DM) in the caramel mass after boiling for halva is 80-85%. If the DM content is below 80%, the mass will be soft and sticky, while a content above 85% will result in hard and brittle halva.

Table 4

Organoleptic characteristics of halva samples with sugar substitution

Halva Samples	Appearance	Color	Texture
Variant 1	Fat homogeneous mass with glossy surface with slight stickiness	Slightly dark - due to lack of shine, white caramel colors	Soft chewy
Variant 2	Fat homogeneous mass with glossy surface with slight stickiness	Pleasant color - well-beaten caramel mass with bright white color	Soft chewy
Variant 3	Homogeneous dry mass of proper shape, not sticky, easy to cut	Slightly dark - due to lack of shine	without shedding when cut, not chewy, slightly soft
Variant 4	Homogeneous dry mass of proper shape, not sticky, easy to cut	Pleasant color - well-beaten nougat with bright creamy color	without shedding when cut, not chewy, slightly soft
Control	at homogeneous mass with slight stickiness	Acceptable color, not chewy	slightly soft

Caramel syrup consists of a mixture of granulated sugar and molasses, which prevents the crystallization of the finished product. According to the traditional recipe, warm water and granulated sugar are poured into a container, heated to a temperature of $t = 138–140$ °C, and molasses is added in a ratio of 1:2 to sugar. All components are mixed and boiled at the same temperature until the moisture content $w = 14\ldots19\%$. In our case, isomalt was dissolved in water, boiled at the same temperatures, then maltitol was added and boiling continued until the dry substance content w = 80…85%. The drying method was used to determine the dry substance content for each sample (see table 5). Experimental studies have shown that the optimal parameters for preparing caramel syrup with isomalt and maltitol are boiling for τ = 18…19 · 60 s to a mass fraction of dry substance w = 82% and whipping time 12...13 · 60 s. This indicates the influence of using sugar substitutes on this parameter, which is τ = 20 · 60 s according to the classic recipe. This is explained by the fact that the viscosity of isomalt exceeds the viscosity of granulated sugar by 33%. According to organoleptic indicators, the caramel mass had a transparent light-yellow color, without cloudiness, which corresponds to the regulatory documentation.

Table 5

Parameters for preparing caramel syrup depending on the boiling time
P ≥ 0.95, n = 5

Indicator name	Boiling time (τ), 1·60 s			
	15…16	18…19	20…21	23…24
Content Dry Substance, (w) %	78	82	87	92
Boiling temperature (tк), ˚C	140	138	139	140

The obtained results became the basis for studying the effective viscosity (EV) of caramel syrup made with isomalt and maltitol, and the results are presented in Figure 1.

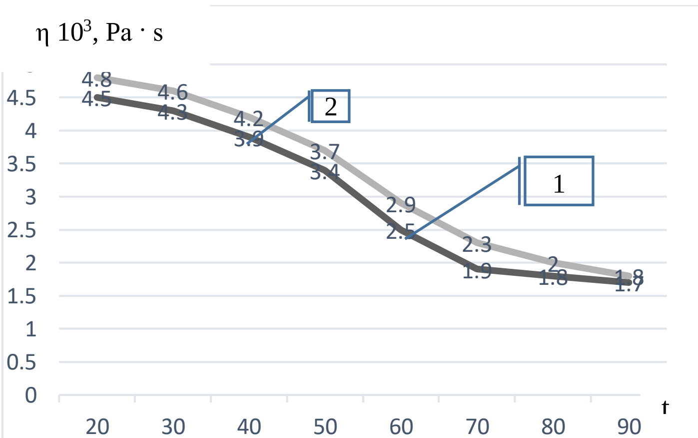


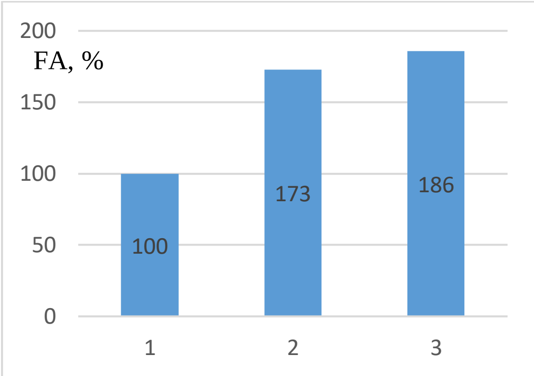
Fig. 1. The effective viscosity (EV) of caramel syrup: 1) MS "sugar-syrup 1:2" (control); 2) MS "isomalt-maltitol 1:2"

It was found that the lowest values of effective viscosity (EV) are observed in the system at a temperature of t = 90 °C. Gradual increase in temperature in the range from t = 20 to 50°C led to a noticeable decrease in EV of model systems. This can be explained by the characteristics of sugar and sugar substitutes. In the temperature range of t = 50…90°C, the value for the control model system is η = 3.77…1.89 × 10 · 3 Pa·s, and for the "isomalt-maltitol" model system it is η = 3.43…1.72 × 10 · 3 Pa·s. This is because isomalt has a higher viscosity (η = 1.5…2.5 × 10 · 3 Pa·s) compared to sugar (η = 1.0…1.2 × 10 · 3 Pa), while the EV of maltitol is 35% less than that of syrup. However, when used in combination in a ratio of 1:2, the EV of the system is balanced, so the decrease is not significant – the viscosity of maltitol is η = 2.5 × 10 · Pa·s, and of syrup – η = 3.5 × 10 · 3 Pa·s. Maltitol is maltotriose, and syrup is a mixture of glucose, fructose, and maltose. Maltotriose, having a lower molecular weight, forms less viscous solutions. To confirm the obtained data, additional studies were conducted on model systems: MS6 – 10% sugar solution and 10% syrup solution; MS7 – 0% isomalt and maltitol solution, at a temperature of t = 20 °C. The results showed that in MS6, the average EV value is η = 25.5 × 10 · 3 Pa·s, while in MS7 it is η = 23.5 × 10 · 3 Pa·s. As the temperature decreases, the Brownian motion of water molecules in the system becomes ordered, resulting in the formation of a syrup framework.

Another important factor in halva production is the whipping time of caramel mass. The influence of whipping time is also significant; increasing or decreasing the whipping time of the caramel mass directly affects the quality of the final product. This process occurs at a temperature of t = 105…110°C for a duration of τ = 15…20 × 60 s according to the classical recipe. To obtain halva with a fibrous stable structure, it is necessary to saturate the dense and viscous caramel mass with air.

At this stage, a foaming agent (2% of the total mass of caramel mass) is used. During whipping, the caramel mass becomes a white porous mass that can be easily mixed with protein semi-finished products. The quality of the caramel mass lies in its ability to be drawn into a long, thin, uniform thread with moisture content within w = 3.5…5% and density ρ = 1.1… 1.15 g/cm³.

Considering the substitution of sugar with isomalt and syrup with maltitol, changes in the foaming process of the system (FA) were investigated. For this purpose, the following MS were used: 1) MS "sugar-syrup" (control) before whipping; 2) MS "sugar-syrup" (control) after whipping; 3) MS "isomalt-maltitol".



P ≥ 0.95, n = 5

Fig. 2 Foam-forming ability of caramel mass: 1) MS "sugar-syrup" (control) before whipping; 2) MS "sugar-syrup" (control) after whipping; 3) MS "isomalt-maltitol"

Foam-forming ability increase in case of using MS "isomalt-maltitol" comparing to control.

Thus, experimental studies have confirmed the feasibility of using isomalt and maltitol to create an alternative product to high-calorie halva according to the classical recipe, as well as justified the technological parameters for the production of halva using isomalt and maltitol were corrected, in particular, the caramel mass ищшдштп time $\tau = 18...19 \cdot 60$ s and $\tau = 12...13 \cdot 60$ s (whipping time).

Conclusions. The possibility of using maltitol and isomalt in the technology of low-calorie halva with reduced glycemic load has been determined. An innovative concept has been developed, and indicators informing about the change in structural-mechanical and organoleptic parameters during recipe modification have been studied. It has been established that the caramel syrup cooking time is reduced to 18..19 minutes. The effective viscosity of caramel syrup with isomalt and maltitol syrup is insignificantly reduced. The foaming ability of the foam system for halva is increased. Further research prospects include the development of a recipe and technological scheme for halva production using isomalt and maltitol.

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