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INVESTIGATION OF THE EFFECT DRIED FOOD PRODUCTS ON THE PROPERTIES OF THE BUTTER MIXTURE DURING STORAGE

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Abstract

In recent years, there has been a general trend in the world to increase the consumption of low-fat dairy products. Butter mixtures are quite popular food products for daily consumption, as evidenced by the significant volume of their industrial production. The aim of work was to investigation the effect of dried food products on the properties of the butter mixture during storage.

To meet the needs of consumers, technology has been developed for the production of an butter mixture using dried food products - tomato and carrot powder and pre-dispersed sesame seeds. The butter mixture was stored at temperatures t = 0 - 8 ^{0}C during 8 days. Changes occurring in the fat phase of butter mixtures were studied by differential scanning calorimetry. The resulting melting endotherms, which are generalized crystal phase melting curves, were decomposed by the least-squares method into Gaussians using the program Peak.Fit, using the regularities of the normal distribution of Gaussian curves. X-ray diffraction analysis of the butter mixture was determined by a diffractometer type DRON-3M in CuKα radiation. The protein content was determined by the Kjeldahl method, the organic acids by the gas-liquid chromatography method, the iron and beta-carotene - by the colorimetric method. The content of minerals - potassium and sodium - by ionometry method, calcium and magnesium - by complexometric method, phosphorus - by photometric method. Microbiological studies were performed by methods of determination: quantity of mesophilic aerobic and facultative anaerobic microorganisms, CFU/g; *Escherichia coli* in 0.001 g; *Staphylococcus aureus* in 1 g, *Listeria monocytogenes* and *Salmonella* in 25 g, as well as yeasts, and molds, CFU/g.

X-ray diffraction analysis revealed the intensification of recrystallization and differentiation of groups of low-melting and medium-melting glycerides in the crystalline fat phase of the enriched butter mixture as early as 3 days of its storage due to the components of plant additives. The optimized combination of ingredients allows to ensure the quality of the butter mixture for 8 days of storage in the following conditions: t = 0 - 8 ^{0}C and 75% relative humidity. In terms of nutritional value, there is an increase in protein by 3.5 times, organic acids by 4.5 times, beta-carotene by 2.6 times, the daily human need for sodium, potassium, and iron by 40 %, magnesium, calcium, and phosphorus from 15 to 30% is provided. Microbiological studies have proven that the butter mixture enriched with dried food products and sesame seeds is characterized by purity during the specified storage.

According to the intensity of accumulation of free acids and peroxides, resistance to oxidation of the butter mixture during storage is proved. Incubation of the oxidative transformation of lipids of butter and sesame seeds due to the antioxidants of plant additives is shown.

Key words: *Butter mixture, Dried food products, Storage, Fat phase, Melting endoderm, Nutritional value, Microbiological stability, Functional numbers.*

1. Introduction

In the daily diet of the population, dairy products are perceived as traditional products with a pleasant taste. However, in recent years there has been a general trend to increase the consumption of low-fat dairy products. This is often due to the idea of the harmful effects of one milk component, or more precisely milk fat that can cause high levels of cholesterol in the human body.

Also, it should be noted that the results of long-term research conducted in research centers of developed countries indicate that cholesterol is involved in the synthesis of bile acids and some sex hormones, used in the construction of myelin sheaths of nerve cells and cell membranes [1]. Leading scientific journals also report that the presence of milk fat and fat globules are valuable medically components that can act as inhibitors in carcinogenesis, some cardiovascular and gastrointestinal diseases, even in small concentrations [1, 2].

Given the above, it is relevant and promising today to create new types of products based on butter with a high content of natural micronutrients. These kind of products include butter mixture, which is culinary products made from butter, used to make and decorate sandwiches, meat and fish dishes, and can be found also in the restaurants [3].

Butter mixtures are in great demand among consumers because they have a clean, creamy taste, and also, due to the harmonious combination with the components of the main dishes, which give them pleasant and refined organoleptic properties. In many European countries, butter pastes are quite popular food products for daily consumption, as evidenced by the availability of current documentation for these products and significant volumes of their industrial production.

Currently known works about the creation of butter mixtures analogs - butter pastes, according to the developed technology are proposing to use plant additives in the butter composition, which is enabling enrichment of the product with natural micronutrients [4, 5]. The results obtained by the researchers indicate a significant improvement in the consumption characteristics of finished products and increase their nutritional value.

The authors note that the formation of the structure of finished products depends not only on the nature of additives, but also on the method of their manufacture and dispersion. According to the latest development, the production of butter pastes can be provided in industrial conditions with the use of complex technological equipment. This makes it impossible to obtain products in small batches and immediately before consumption, which would have an potentialy positive effect on the human body. Also, simplified technologies are attractive to restaurants.

Given this, the aim of work was to investigation the effect of dried food products on the properties of the butter mixture during storage. More precisely,

developed
Tables 1-3 show that the butter mixture according to the proposed recipe is a product of high nutritional value due to the enrichment of essential nutrients of plant raw materials. There was an increase in protein 3.5 times, organic acids 4.5 times. With the introduction of a biogenic complex of plant raw materials increases the content of β-carotene 2.6 times, B_1 - 14.0 times, B_2 - 23.8 times, PP - 37.0 times.

Compared with the traditional recipe of butter mixtures, the amount of ash increases, which indicates a significant enrichment of the mineral composition of new products: sodium content increases 24.0 times (40 % of daily requirement), potassium - 5.6 times (40 %), calcium - in 2.8 times (10 %), magnesium - 3.8 times (20 %), phosphorus - 4.2 times (15 %), iron - 7.6 times (30 %).

In view of the above, the aim of work was to investigation the effect of dried food products on the properties of the butter mixture during storage.

2. Materials and Methods

Material for this research was butter mixture with use of dried food products (DFP) - tomato and carrot powder and specially prepared sesame seeds [6].

In Tables 1 - 3 is presented chemical composition, the content of vitamins and minerals in the enriched butter mixture.

Table 1. Chemical composition of the butter mixture with vegetable DFP and sesame seeds

Composition	Content in the butter mixture, %	
	"Green Butter" - control	With vegetable dried food products and white sesame seeds
Water	17.2 ± 1.5	30.1 ± 2.5
Protein	1 ± 0.1	3.5 ± 0.3
Fat	67.1 ± 6.5	51.4 ± 5
Carbohydrates	10.9 ± 1.1	10.1 ± 1
Cellulose	1.3 ± 0.1	0.9 ± 0.07
Organic acids	0.2 ± 0.02	0.9 ± 0.07
Ash	2.3 ± 0.2	3.1 ± 0.3

Table 2. Vitamin composition of the butter mixture with vegetable DFP and sesame seeds

Vitamin	Content in the butter mixture, mg/100 g	
	"Green Butter" - control	With vegetable dried food products and white sesame seeds
A	0.48 ± 0.04	0.35 ± 0.03
β - carotene	1.17 ± 0.1	3.03 ± 0.3
B_1	0.01 ± 0.001	0.14 ± 0.01
B_2	0.008 ± 0.0007	0.19 ± 0.01
PP	0.02 ± 0.002	0.74 ± 0.06

Table 3. Mineral composition of the butter mixture with vegetable DFP and sesame seeds

Mineral element	Content in the butter mixture, mg/100 g	
	"Green Butter" - control	With vegetable dried food products and white sesame seeds
Sodium	19 ± 1.5	455 ± 40
Potassium	70 ± 6.5	391 ± 32
Calcium	50 ± 4.5	138 ± 12
Magnesium	14 ± 1.4	53 ± 5
Phosphorus	27 ± 2.5	113 ± 11
Iron	0.48 ± 0.04	3.7 ± 0.3

The mass fraction of water was determined by the accelerated method of drying [7], while the mass fraction of fat was determined by the extraction-weight method [8]. Total protein content was determined by the Kjeldahl method, which is based on the mineralization of a sample of the test sample with concentrated sulfuric acid formed ammonia and its subsequent determination by back titration [8].

Organic acids were converted into volatile esters with their subsequent determination by gas-liquid chromatography [9], while the mass fraction of ash was determined by the conventional method of burning a sample of the sample in a muffle furnace [9].

Determination of carotenoid content was determined by the absorption spectrum in the range (400 - 500) x 10^{-9} m. Vitamins A, and vitamins from group B were determined by high-performance liquid chromatography, and PP by spectrophotometric method. Minerals as potassium and sodium were determined by ionometry, iron - by colorimetric method [9], calcium and magnesium - by complexometric method by Dudenkov [10], and phosphorus - by photometric method [9, 11].

Studies of phase changes of milk fat glycerides in samples of butter mixtures were performed by the hermodynamic method on a differential scanning calorimeter in the temperatures t= (-100 ^{0}C, and -70 ^{0}C). On the obtained melting endotherms, heat release peaks were observed, which are characteristic of one or another group of glycerides or the aqueous phase of the product. The identification of peaks was performed by melting points of characteristic groups of glycerides [12]. Melting endotherms obtained during the study, which are generalized melting curves of the crystalline phase, were decomposed by the least-squares method into Gaussians using the Peak.Fit program, using the regularities of the normal distribution of Gaussian curves.

X-ray diffraction analysis of the butter mixture was determined by a diffractometer type DRON-3M in CuKα radiation (nickel filter), U = 30 кW, I = мA, $\Delta 2^{\theta}$ = 0,04°, τ = 3 s [13].

The acid value was determined by neutralizing the free fatty acids in a sample of the test sample with an alcoholic solution of potassium hydroxide, peroxide value - by dissolving the sample in hexane, followed by filtration from insoluble components and distillation of hexane in a vacuum. Released iodine was titrated from a microburette with 0.01 mol/dm^3 sodium thiosulfate solution to decolorize the solution [14].

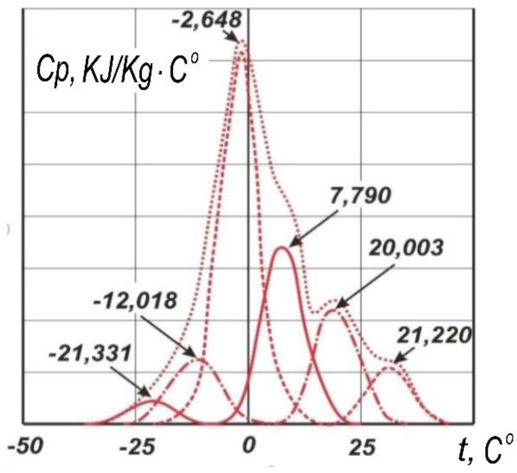
Microbiological studies were performed by following methods of determination: quantity of mesophilic aerobic and facultative anaerobic microorganisms, CFU/g [15]; *Escherichia coli* in 0.001 g [16]; *Staphylococcus aureus* in 1 g [17], *Listeria monocytogenes* and *Salmonella* in 25 g [18, 19]; and yeast and moulds, CFU/g [20].

Studies of these characteristics were performed in a butter mixture with DFP after receipt and storage at a temperature t = 0 - 8 ^{0}C during 8 days, which is common for this type of culinary products. The butter mixture "Green Butter", which was made according to the traditional recipe, was chosen for control [3].

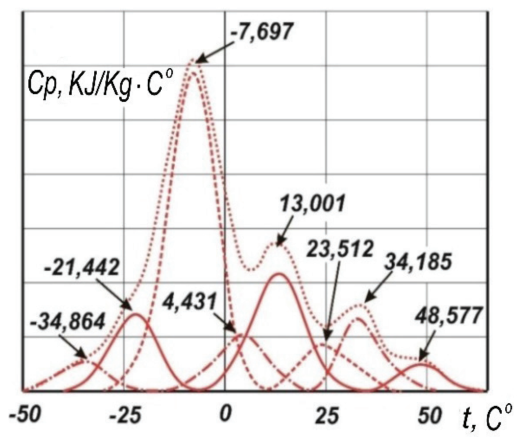
3. Results and Discussion

The outlined peaks are characterized by changes in the crystallization processes in the butter mixture with DFP.

In Figure 1 are presented mathematically processed endotherms of melting of experimental samples of butter mixtures.



a)



b)

Figure 1. Endotherms of melting of crystalline phases of the butter mixtures: a - control; b - butter mixture with DFP

The nature of the heat capacity curve of the control (Figure 1, a) indicates the gradual melting of the crystalline phase of the butter mixture. During the mathematical processing of the melting curve in the range of low temperatures, appeared Gaussians with maxima at t = -21.3 ^{0}C and -12.1 ^{0}C.

The most intense peak (t = -2.6 ^{0}C) is the result of melting processes of water and partially melting of low-melting glycerides (LMG) of the fat phase of products. Presence of a diffuse peak on the total heat capacity and Gaussian curve at t = 7.8 ^{0}C indicates the completion of LMG melting processes in the crystalline fat phase of the product.

The peak with a maximum at t = 20 ^{0}C is the result of the combined melting of LMG and medium-melting glycerides (MMG). Diffuse peak at 31.2 ^{0}C characterizes the melting of high-melting glycerides (HSV) of the crystalline phase of milk fat.

Comparing the endotherms of the control and the butter mixture with DFP, it can be seen that the melting of crystalline phase of the latter occurs in a wider range and is described by more Gaussians, and the melting peaks of individual groups of glycerides are more pronounced. This nature of the curve indicates the discrete crystallization of glycerides in the crystalline fat phase of the enriched butter mixture during storage.

It should be noted that in the butter mixture with DFP, the temperatures of the splitting peaks are 14 ^{0}C and 9 ^{0}C shifted towards lower temperatures. The peak temperature of the combined melting of the aqueous and LMG fatty phases of the product is significantly reduced (by ≈ 5 ^{0}C).

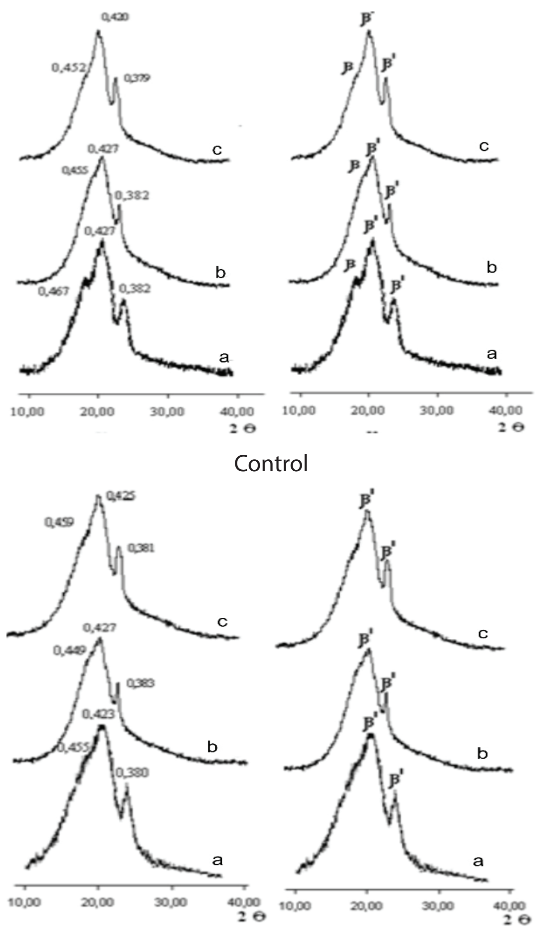
Obviously, such processes are due to the content in sesame oil of linoleic acid with a low melting point. As a result of phase transformations and the appearance of a significant amount of vegetable fats carried by sesame seeds, the number of Gaussians describing the melting processes of the crystalline fat phase of the product and the temperatures of their maxima changes. Thus, there is a peak of LMG melting in the butter mixture with DFP at t = 4.4 ^{0}C. The nature of the melting endotherm and the decrease in the temperature of the combined melting of LPG and MMG to t = 13 ^{o}C indicates the course of recrystallization processes.

Melting of the MMG group occurs at higher temperatures than in the control sample, with a maximum at t = 23.5 ^{0}C. The melting processes of the HMG fraction are described by two Gaussians with peaks at t = 34.2 ^{0}C and 48.8 ^{0}C.

It should be noted that the temperature of the first melting peak is t = 3 ^{o}C higher than the control. The appearance of an additional peak of HMG melting with a small area is due to the presence of stearic and palmitic acids in sesame oil, which have high melting points.

Results of the research indicate a significant effect of the introduced plant ingredients on the structure and consistency of the enriched butter mixture. It should be noted that the decision processes in the formation of quality indicators of the finished product are the changes that occur in the crystalline fat phase of the product. Therefore, the further task of the research was to study by X-ray diffraction analysis the effect of plant ingredients on polymorphic transformations of glycerides of the fat phase of the enriched butter mixture when stored at different temperatures: 0, 5, and -25 ^{0}C for 8 days.

According to the results of the research, diffractograms were obtained (Figure 2) on which maximum corresponding to different crystalline polymorphic forms were revealed.



Control

Butter mixture with vegetable DFP and sesame seeds

Figure 2. Diffractograms of butter mixtures after storage for 8 days at temperatures: a - 5 ^{0}C; b - 0 ^{0}C; c - (-25) ^{0}C

Analyzing the obtained diffractograms of the crystalline fat phase of the studied samples, it was found that the enriched butter mixture, in contrast to the control, is characterized by the presence of a wide diffuse maximum in the range (0.415 - 0.420) $\times$ 10^{-9} m. This indicates the presence in the product of a thermodynamically unstable crystal structure of glycerides in α-polymorphic form. Also, the diffractogram of the butter mixture with plant ingredients contains an intense diffuse peak at 0.420 $\times$ 10^{-9} m, which is due to the presence in the structure of the production of orthorhombic crystals of glycerides of β'-polymorphic form.

In the control sample, the maximum intensity of glycerides of the β'-form is smaller and shifted to 0.427 $\times$ 10^{-9} m. Appearance of super-α- and sub-β'-forms is dictated by the peculiarities of the processes of crystallization of glycerides of animal fat in the presence of fat-soluble components of vegetable raw materials and the presence of a significant amount of vegetable fat sesame seeds, which are not able to crystallize at low positive temperatures.

In general, data obtained on the studied processes of crystallization of the fat phase in enriched butter mixture allows to predict high-quality indicators of consistency not only of a freshly prepared mixture but also after storage for 8 days at low temperatures.

The resistance to oxidation of butter mixture with DFP and sesame seeds, which is a system at the boundary of the distribution of "fat-water" during storage for 8 days at t = 0 - 8 ^{0}C and relative humidity of 75% by the intensity of accumulation of free acids and peroxides (Table 4).

Table 4 shows that the acid value is 1.3 times, and peroxide value is 1.7 times smaller for the enriched butter mixture after storage compared to the control.

Therefore, the rate of accumulation of products of hydrolysis and peroxidation of lipids is reduced. The obtained results are explained by the antioxidant action of carotenoids DFP, which helps to inhibit the oxidative transformation of lipid molecules of butter and sesame seeds.

Table 4. Change in the functional numbers of the butter mixture with vegetable DFP during storage

Functional numbers	Storage, day	Values in the butter mixture	
		Control	With dried food products and sesame seeds
Acid value, мg KOH/g	0	2.33 ± 0.02	2.34 ± 0.2
	4	2.39 ± 0.02	2.39 ± 0.2
	8	2.52 ± 0.02	2.42 ± 0.02
Peroxide value, % J_2	0	0.20 ± 0	0.2 ± 0.01
	4	0.26 ± 0.02	0.23 ± 0.02
	8	0.44 ± 0.04	0.26 ± 0.02

Table 5. Microbiological safety indicators of butter mixture with DFP during storage

Indicator	Normative indicator	Storage, day	Actual content in the butter mixture with vegetable dried food products and white sesame seeds
Quantity of mesophilic aerobic and facultative anaerobic microorganisms, CFU/g	1×10^5	0	1×10^1
		4	20×10^1
		8	2.8×10^2
***Escherichia coli* in 0.001 g**	not allowed	0	not found
		4	not found
		8	not found
Pathogenic microorganisms, including bacteria of the genus *Staphylococcus aureus*, in 1 g	not allowed	0	not found
		4	not found
		8	not found
Pathogenic microorganisms, including bacteria of the genus *Listeria monocytogenes*, in 25 g	not allowed	0	not found
		4	not found
		8	not found
Pathogenic microorganisms, including bacteria of the genus *Salmonella*, in 25 g	not allowed	0	not found
		4	not found
		8	not found
Yeast, CFU/g, not more	1×10^2	0	1
		4	5
		8	12
Moulds, CFU/g, not more	1×10^2	0	2
		4	18
		8	29

The microbiological safety indicators of the butter mixture with DFP and sesame seeds during storage for 8 days under these conditions were determined (Table 5).

The results of researches given in Table 4 testify that the butter mix with DFP on microbiological indicators meets the requirements of the operating regulatory documents. Also, during the regulated storage of *Escherichia coli* and pathogenic microorganisms were not found.

4. Conclusions

- The optimized combination of the selected ingredients in the butter mixture allows us to ensure the quality of the butter mixture for 8 days of storage in conditions - temperature 0 - 8 ^{0}C and relative humidity of 75 %.
- Methods of differential scanning calorimetry and X-ray diffraction analysis showed that the presence of plant additive components leads to the intensification of recrystallization and differentiation of low-melting glycerides and medium-melting glycerides groups in the crystalline fat phase of the enriched butter mixture for 3 days of storage.

5. References

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