Методом диференціально-термічного аналізу досліджено вміст адсорбційно зв'язаної вологи пасти сиркової з екстрактом сумаху із додаванням крупи гречаної несмаженої, що становив 32,0 %. Для кисломолочної основи – 30,0 %, гречано-сироваткової суміші – 36,6 %, пасти сиркової із використанням модифікованого крохмалю (E 1410) – 32,5 %. Доведено ефективність використання крупи гречаної несмаженої у якості вологозв'язуючого компоненту

Ключові слова: стан вологи, диференціально-термічний аналіз, паста сиркова, крупа гречана несмажена

Методом дифференциально-термического анализа исследовано содержание адсорбционно связанной влаги пасты творожной с экстрактом сумаха и крупой гречневой нежареной, который составил 32,0 %. Для кисломолочной основы – 30,0 %, гречнево-сывороточной смеси – 36,6 %, пасты творожной с использованием модифицированного крахмала (E 1410) – 32,5 %. Доказана эффективность использования крупы гречневой нежареной в качестве влагосвязывающего компонента

Ключевые слова: состояние воды, дифференциально-термический анализ, паста творожная, крупа гречневая нежареная

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STUDY OF THE STATE OF MOISTURE IN THE CURD PASTE WITH SUMACH EXTRACT AND THE ADDITION OF BUCKWHEAT GROATS

O. Kochubei-Lytvynenko
PhD, Associate Professor, Director
Educational and Scientific Institute of Food Technologies**
E-mail: okolit@email.ua

A. Marynin
PhD, Associate Professor, Head of Laboratory
Problem research laboratory**
E-mail: andrii_marynin@ukr.net

N. Yushchenko
PhD, Associate Professor*
E-mail: YuNM_NUFT@ukr.net

U. Kuzmyk
Assistant*
E-mail: ukuzmik@gmail.com

M. Lazarenko
PhD, Associate Professor
Department of Molecular Physics
Taras Shevchenko National University of Kyiv
Volodymyrska str., 60, Kyiv, Ukraine, 01033
E-mail: maxs@univ.kiev.ua

*Department of Milk and Dairy Product Technology**
**National University of Food Technologies
Volodymyrska str., 68, Kyiv, Ukraine, 01601

1. Introduction

Curd pastes are made from cottage cheese with the addition of various flavoring and nutritional supplements, they are characterized by viscous consistency and are prepared for immediate consumption.

Despite a wide range of paste-like dairy products, there is a steady modern tendency to extend it. It is proposed to employ new types of raw materials, specifically soybean and the products of its processing, to improve existing techniques and to introduce new methods for processing raw materials and cheese clot. The dominant direction is to expand product range by introducing the fillers of natural origin as a source of biologically active substances, which provides products with functional properties.

It is proposed to use in the technology of curd dessert pastes with spicy compositions the following spices: ginger, fenugreek, cinnamon, turmeric, cloves, black pepper, fragrant pepper, sumach, star anise, anise, cardamom, nutmeg. A dosage for introducing the compositions of spices is 0.3...1.1 %. Spices, except for sumach, should be introduced in a dry form with particle size not exceeding 2 mm [1].

Sumach is the dried fruit of the eponymous plant that have a hard shell and a core. When this spice was added to the samples, preliminary shredded to particles the size not larger than 1 mm, a hard shell was felt. Uneven coloration of the samples was observed, due to the gradual release of colored extractive substances. That is why it is recommended to introduce sumach in the form of an extract based on milk whey (the content of solid substances is (4.8±0.2) %), dosage of the extract to be introduced is 10 % [2].

Adding the extract naturally improves the content of free moisture that predetermines a decrease in the viscosity of the product and leads to spontaneous release of moisture both in freshly prepared pastes and during storage. In order to prevent this process, the moisture-binding components are used. Structure stabilizers also help prevent this process. Most often, the dairy industry employs the following substances for this purpose use: modified starch, pectin, carboxymethylcellulose, carrageenan (both separately and in the composition of stabilization systems) [3].

Taking into consideration recommendations of the concept of healthy nutrition, it is a promising direction in stabilizing the structure of food systems to use natural moisture-binding components. This will make it possible to additionally enrich food products with a complex of biologically active substances and to save resources.

Among them, especially interesting are whole grain types of plant raw materials.

Buckwheat groats have enhanced protein content among cereals – 13.0–15.0 %. A signature of buckwheat proteins, compared with proteins of other cereals, is practically complete absence of prolamins, a low content of glutelin and a high content of albumens (18.2 % of the mass of the protein) and globulins (43.3 % of the mass of the protein) [4]. Buckwheat protein contains 18 amino acids, the grains are rich in arginine and lysine, biological value of the protein is 93.1 % [5]. This is one of the most valuable plant proteins, which is characterized by high solubility and digestibility. The proteins of buckwheat groats have high moisture-binding capacity, emulgating and foam-forming properties. These characteristics can be used to change the structure and improve nutritional value of food products [6].

Results of research [7, 8] revealed that the granules of buckwheat starch are mostly polygonal, rarely spherical and oval, and the surface of the particles is rough. These characteristics indicate that buckwheat starch can be eaten with food, as well as use it as a food thickener and stabilizer. Buckwheat starch is white; it does not change color when added to food; temperature of gelatinization is about 65 °C.

Total content of the dietary fiber of buckwheat groats is 5–11 %, including cellulose, non-starch polysaccharides, lignan. It should be noted that soluble fiber is dominant in buckwheat groats.

Dietary fiber and buckwheat mucus have high moisture-binding capacity. They can form chelated compounds with heavy metals and cholesterol, repress the formation of tumor cells, promote normalization of metabolism [9].

Groats contain 3 % of fat (the content of unsaturated fatty acids in the lipids of groats is approximately 83.2 %, including oleic acid – 47.1 % linoleic acid – 36.1 % [10], they are a source of vitamin E and compounds with P-vitamin activity, namely rutin.

2. Literature review and problem statement

Such products of cereal crops processing as groats, (wheat) flour, flakes and extrudates of wheat, rice, oats, corn, etc., are widely used in the technology of dairy products as moisture-binding and structure-forming components [10]. These technological properties are due to the high content of starch, which is in the endosperm of grain in the form of starch grains of different size and shape, as well as fiber and protein. In addition, cereal crops contain a complex of vitamins (especially, group B) and mineral substances. In addition to the technological functions, cereal crops serve as enriching components.

It was established that adding a mixture of rice and buckwheat to dough improves the structure of bread. That is, the volume of bread rises while its friability reduces [11].

Scientists suggested substituting 15 % of wheat flour with buckwheat flour in the production of bread. This would enrich bread with biologically active substances and ensure stable quality indicators during storage, due to the antioxidant properties of buckwheat [12].

In Germany, a number of fermented acid milk beverages are produced of the yoghurt type using whole-ground grains of wheat, rye, corn, barley, oats, buckwheat, rice, as well as fruit fillers, honey, chocolate, dried fruits and other fillers [13].

The use of buckwheat flour is proposed to create gluten-free products. The products without gluten that contain buckwheat flour have, accordingly, higher values of water absorption [14].

Consumer demand for the production of biscuits with the addition of buckwheat flour grows annually. Adding buckwheat to the composition of biscuits improves biological value of the product [15].

The possibility of using a plant complex of non-toasted buckwheat groats in the technology of cheesecake production was investigated. The unique chemical composition of green buckwheat, rich in minerals and vitamins, ensures not only its consumption as food, but also using it for the preparation of products with preventive and functional effect [16].

Based on the studies, we can conclude that bakery products made from buckwheat flour are considered to be functional foods [17].

When cooking, mostly used are the buckwheat groats, treated thermally, by moistening with subsequent steaming and drying. As a result, the fruit shells of buckwheat become more elastic, the kernel gets stronger. However, such a treatment leads to the gelatinization of starch. Its amount, depending on the treatment parameters, reduces by 1.3...2.8 % at the expense of complex-formation with proteins, lipids and other components of the grain [5]. This contributes to the formation of dextrin, with protein partially denaturated and transformed into insoluble state (the content of albumens reduces by 2.9 times, globulins by 1.7 times). The groats acquire brown coloration and pronounced characteristic aroma; the moisture-binding properties decrease dramatically.

Therefore, to stabilize the structure of curd dessert pastes, it is proposed to use non-toasted buckwheat groats. Although in such groats the enzymes remain active, the presence of phenolic compounds (that predetermine high antioxidant properties of buckwheat groats) would ensure stability of curd dessert pastes during storage. Technological parameters for the preparation of non-toasted buckwheat groats as a structure-forming component were determined: particle size to 2 mm, hydro-module is 1:4, extragent is milk whey, thermal treatment is (90±2) °C, process duration is 15 min.; rational dosage is substantiated (5.0–6.0 %) for structural-mechanical properties compared with samples of curd pastes with traditional stabilizers [18].

3. The aim and objectives of the study

The aim of present study was to examine patterns of moisture state in curd pastes with added non-toasted buckwheat groats as a moisture-binding and a structure-forming component.

To achieve the set aim, the following tasks have been solved:

– to perform a comparative analysis of thermogravimetric indicators of acid-milk base and a buckwheat-whey mixture;

– to determine the content of the adsorption- and capillary-bound moisture in curd paste with non-toasted buckwheat groats, and in the paste, produced with the use of a modified starch (E 1410);

– to substantiate the expediency of using non-toasted buckwheat groats in the technology of curd pastes.

4. Materials and methods for the study into thermogravimetric indicators and differential-thermal analysis of the experimental samples

4. 1. The examined materials and equipment used in the experiment

The study was carried out within the framework of scientific-experimental work (SEW) "Scientific principles for designing resource-saving technologies of protein-containing polyfunctional concentrates for food products with a targeted purpose" (State Registration Number 0117U001243), Ukraine.

We fabricated 4 model samples to study the state of moisture. Sample 1: thermally treated and chilled buckwheat-whey mixture. Sample 2: – curd paste with sumach extract, stabilized by a buckwheat-whey mixture. Sample 3: – curd paste with sumach extract, stabilized by acetylated modified starch (introduction dosage is 1.3 %). We used low-fat dietary soft curd as control (Sample 4).

In order to prepare a buckwheat-whey mixture, we first ground the groats (particle size not larger than 2 mm) using a hammer crusher. Then we mixed it with whey (pH 4.2, the mass fraction of dry substances is 5.1 %) at a temperature of (40±2) °C in ratio 1:4. Next, it was exposed to thermal treatment at a temperature of 95±2 °C for 15 minutes. Then the mixture was cooled to a temperature of (20±2) °C.

To conduct the study, we prepared a sample of curd paste with sumach extract. The extract was prepared on the base of whey, obtained in the production of cottage cheese (pH – 4.1, the mass fraction of dry substances is 10.1 %, including extractive substances of the spice, 5.0 %).

The model sample of curd paste was prepared in the following way. We used, as a acid-milk base, soft dietary curd (the mass fraction of moisture is 79.8 %, acidity is 150 °T). The paste was made according to the formulation. Sumach extract based on milk whey was added in the amount of 10 %. The prepared buckwheat-whey mixture was added in the amount of 25 % by weight of the mixture, it was thoroughly agitated, then left for 2 hours at a temperature of (6±2) °C for the final formation of structure.

In order to determine efficiency of using non-toasted buckwheat groats, we prepared a model sample, to which modified starch was introduced as the moisture-binding component. The preparation of the moisture-binding component was carried out in the following way. We added modified starch in the amount of 5 % to the dairy whey, warmed to a temperature of (40±2) °C, at constant stirring. Preparation of a starch-whey gel with higher concentration is not appropriate because such solutions are characterized by high viscosity and lose their fluidity. The mixture was heated to a temperature of (82±2) °C and held for 30 s, followed by cooling to (20±2) °C, and then we added it to the acid-milk base in the amount of 25 % by weight of the mixture. The content of the modified starch in the finished product was 1.3 %.

The most informative method to study the state of moisture in food systems is dynamic thermogravimetry. Thermogravimetry (TG) is a method of thermal analysis during which a change in mass is registered, depending on temperature. A TG-curve provides information about thermal stability and components of a sample [19]. By using a given method, it is possible to simultaneously measure temperature of the examined sample (T), its mass (TG), rate of change in mass (DTG), and a change in enthalpy (DTA).

Study into the state of moisture was determined by a thermogravimetric method using the derivatograph Q-1500D (Paulik-Erdey), made in Hungary.

A procedure for determining the indicators of sample properties is described in paper [20].

5. Results of study of the state of moisture in curd pastes

In the process of study, we obtained dependences of relative loss of mass TG, % (Fig. 1), and the derivative of change in mass DTG (Fig. 2) on temperature for the examined samples.

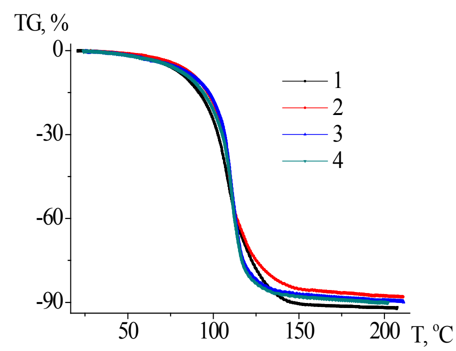

Fig. 1. Temperature dependences of relative loss of mass of curd pastes: 1 – thermally treated and cooled buckwheat-whey mixture; 2 – curd paste with sumach extract, stabilized by buckwheat-whey mixture; 3 – curd paste with sumach extract, stabilized by acetylated modified starch; 4 – control

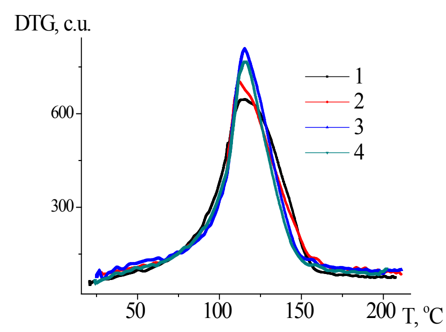

Fig. 2. Temperature dependences of the derivative of change in mass for curd pastes: 1 – thermally treated and cooled buckwheat-whey mixture; 2 – curd paste with sumach extract, stabilized by buckwheat-whey mixture; 3 – curd paste with sumach extract, stabilized by acetylated modified starch; 4 – control

The dependences of relative mass loss for the examined samples show that heating them results in the loss of mass in the temperature range 30–175 °C; this is accompanied by peaks on temperature dependences DTG in the same temperature range. It can be assumed that the loss of mass in the samples is related to the evaporation of moisture, which is in different states in a sample. That is why we divided the DTG dependence into peaks using the Gaussian distribution

(Fig. 3), where f_1 characterizes capillary-bound moisture, f_2 – adsorption-bound moisture, and f_3 are the mass losses due to thermally oxidative destruction.

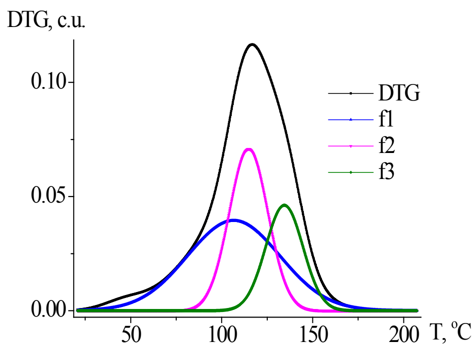

Fig. 3. Approximation of the DTG dependence for sample 1 using the Gaussian distribution with three peaks

The DTG dependence can be optimally described by three peaks with maxima at temperatures $T1$=111 °C, $T2$=116 °C, and $T3$=130 °C. Peak (f_1) is related to the evaporation of moisture of the physical-mechanical bond – the capillary and the junction, which is in rough macro-pores, the second peak (f_2) is related to the destruction of monomolecular hydrated layers of the adsorption-bound moisture, the third peak (f_3) is related to the destruction of the sample. Water in the hydrated shell is linked to bio-molecules through hydrogen bonds that break when heated.

Applying the data of thermographic analysis, of a change in the mass of the sample and the approximation of the DTG dependence, it is possible, with sufficient accuracy, to determine the amount of bound and free moisture in accordance with the Rehbinder's classification, which would characterize hydrophilicity of the examined samples. Summarized data on the analysis of model samples are given in Table 1.

Table 1

Summarized data on the state of moisture in curd pastes

Sample name	Distribution of the magnitudes of components, %		
	f_1	f_2	f_3
Buckwheat-whey mixture	44.4	36.6	19.0
Curd paste with added non-toasted buckwheat groats	52.0	32.0	16.0
Curd paste with added stabilizer, modified starch (E 1410)	51.0	32.5	16.5
Soft dietary curd (control 1)	56.0	30.0	14.0

It was established that the content of adsorption-bound moisture for the examines samples is at the same level. For the following examined sample, curd paste with buckwheat groats, the content of free (capillary-bound) moisture is 8.2 % less compared to curd without the addition of a structure-stabilizer, and is 2 % larger compared with curd paste, structured by traditional stabilizer (modified starch).

Based on the results of a differential-thermal analysis, we calculated activation energy (E) and pre-exponential factor (k_0) for the temperatures of maximum removal of the adsorption-bound moisture, which are given in Table 2.

Table 2

Characteristic of activation energy and pre-exponential factor of curd pastes

Sample name	Pre-exponential factor (k_0)	Activation energy (E) kJ/mol
Buckwheat-whey mixture	110	370
Curd paste with added non-toasted buckwheat groats	95	240
Curd paste with added stabilizer, modified starch (E 1410)	100	340
Soft dietary curd	70	238

The activation energy, as well as the pre-exponential factor, for curd paste with added ground non-toasted buckwheat groats, are higher compared to curd paste without added structure-stabilizer. In other words, curd paste with the addition of buckwheat-whey mixture will better retain moisture at change in the environmental conditions, which would ensure stability of the product structure during storing.

6. Discussion of results of studying the state of moisture in curd pastes

It was substantiated in earlier studies that the use of shredded non-toasted buckwheat groats provides curd pastes with the necessary rheological parameters. That is why the purpose of the work that followed was to study the patterns of the state of moisture curd pastes with added non-toasted buckwheat groats [18].

The data analysis shows that the content of capillary-bound moisture in the buckwheat-whey mixture is 8.2 % less compared with the soft dietary curd. This proves the feasibility of using non-toasted buckwheat groats as a moisture-binding component in the technology of curd pastes.

Modified starch is traditionally used as the moisture-binding component in the technology of paste-like products. Specifically, acetylated starch acquires the capability to form more viscous gels, resistant to pH of the environment and mechanical action due to additional bonding of separate molecules in the course of treatment of native starch.

In contrast, the moisture-binding properties of non-toasted buckwheat groats are due mainly to the formation, when heating, of hydrated complexes of native starch. That is why, to ensure the desired technological effect, a higher dosage of the specified groats would be required.

It was experimentally established that the introduction of 5.0 % of non-toasted buckwheat groats yields the same effect for binding the moisture as the use of 1.3 % of modified starch.

Thus, non-toasted buckwheat groats could be used as an alternative natural moisture-binding component. In addition, the specified groats might be an additional source of valuable protein, vitamins, macro- and microelements. Therefore, studying the appropriateness and effectiveness of its use is a promising direction for further scientific research.

7. Conclusions

1. The content of the adsorption moisture in a buckwheat-whey mixture is 22 % larger compared with an acid-milk base; the indicators of pre-exponential factor and energy are higher by 57 % and 55.5 %, respectively. This predetermines the capability of a buckwheat-whey mixture to retain free moisture and serve as a moisture-binding component.

2. We performed a comparative analysis of the state of moisture in the curd paste with buckwheat groats, and the curd paste with a moisture-retaining component, modified starch. The content of the adsorption moisture in the curd paste with buckwheat groats was 32 %. For the paste, stabilized by modified starch, it is 32.5 %, which proves efficiency of using buckwheat groats as a moisture-binding component.

3. Based on the results of a differential-thermal analysis, we have proven efficiency of using non-toasted buckwheat groats in the form of a buckwheat-whey mixture (hydro-module is 1:4, dosage is 25 % by weight of the product) as a moisture-binding component of curd pastes.

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