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The study of functional and technological properties of vegetarian ice cream

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ABSTRACT

The use perspective and expediency of plant-based milk, enriched with fiber when combined with organic products, biobased products, and sugar substitute products, has been substantiated in the manufacturing process of vegetarian ice cream. When combined with pumpkin fiber, stevia, bananas, pistachios, coconut oil, and coffee beans with different functional and technological properties, rice milk has a purposeful influence on organoleptic and Physico-chemical properties of food products. Accordingly, the expediency of added rice milk (62%) has been determined to optimize vegetarian ice cream's vitamin and mineral composition. The optimal component ratio has been determined employing experimental studies and multi-criteria optimization: for ice cream "Banana & Pistachio": rice milk – 62%, pumpkin fiber – 2.5%, – 0.5%, banana – 16%, pistachio – 6.8%, coconut oil – 12.2%; "Coffee and chocolate": rice milk – 62%, pumpkin fiber – 4.8%, stevia – 4%, cocoa powder – 7%, coffee beans – 8%, coconut oil – 14.2%. It has been found that the main physicochemical parameters of the vegetarian ice cream depend on the chemical composition of the ice cream mixture and its freezing conditions. Thus, when the fat content increases, the stability of air bubbles increases, but their sizes decrease. The study results make it clear that the increase in the fat amount is good for the ice cream structure and consistency, while the distance between the fat balls decreases, which, in turn, helps to obtain the product with the smaller ice crystals.

Keywords: vegetarian, functional product, vegetable raw material, ice cream, technology

INTRODUCTION

The primary importance is given to dairy products, considering their biological value, in the organization of a healthy diet. The above is also true of such dairy desserts as the ice cream, the nutritional value of which is due to complete proteins, highly-digestible fats, essential amino acids, calcium, and phosphorus salts, which are vital for the proper functioning of the human body [1], [2]. However, the demand for foods of plant origin, having different enhanced biological values, is one of the main trends in the modern world food market [3]. Today, the trend to use foods of plant origin instead of animal origin is spreading worldwide. Some nutritionists believe that this is because such foods are better digested and do not have harmful hormones and antibiotics found in foods of animal origin [4], [5]. Moreover, the share of people without lactose tolerance and milk allergy, who are forced to use lactose-free products or fully exclude milk proteins from the diet, replacing them with vegetable ones, has increased recently. Such products as rice, soy, almond milk, and others are alternatives to dairy products [6]. Considering the increasing demand for vegetarian products, the prospective line of the industry development is the targeted manufacture of vegetarian ice cream with high functional and technological properties [7]. There the ice cream is based on flora vegetable milk made of germinated soybean and hemp seeds. Such ice cream is better than traditional milk ice cream in terms of fatty acid composition and vitamin content. However, the development

studies of new types of dry ice cream mixtures made of vegetable raw materials without the components of dairy origin are very limited.

However, there are no conceptual developments in the study direction of the consumer properties of vegetarian ice cream using rice milk enriched with fiber when combined with organic, biobased, and sugar substitute products.

Scientific Hypothesis

Rice milk with pumpkin fiber, stevia, bananas, pistachios, coconut oil, and coffee beans will purposefully affect vegetarian ice cream's functional and technological indicators. Accordingly, improving combined ice cream technology will contribute to expanding the range of ice cream for vegetarians.

MATERIAL AND METHODOLOGY

Samples

The samples of the vegetarian ice cream "Banana & Pistachio" (Figure 1) and "Coffee and chocolate" (Figure 2) were developed due to the study objects. The fruit and berry ice cream manufactured by Alpro "Almond&Salted caramel" with the following components was selected as control 1: drinking water, soluble maize fiber, sugar, soluble oils (rape: shea: coconut), almond-fructose syrup, dextrose, emulsifier of mono- and diglycerides of fatty acids, natural flavour, sea salt, stabilizers (carob bean gum, guar gum, carrageenan), starch, caramelized sugar. The chocolate ice cream "Coconut Milk-Chocolate" manufactured by TM Dalana, with the following recipe composition was selected as control 2: coconut milk, water, sugar, glucose syrup, chocolate (sugar, fat-extracted cocoa powder, cocoa butter), guar fiber, citrus fiber, lemon juice concentrate.



Figure 1 Banana & Pistachio.



Figure 2 Coffee and chocolate.

Chemicals

Sulfuric acid (brand A, chemically pure, Khimlaborreaktiv LLC, Ukraine).

Phenolphthalein solution (NaOH, (Novokhim), Kharkiv, Ukraine).

Sodium hydroxide (NaOH, (Novokhim), Kharkiv, Ukraine).

Animals, Plants and Biological Materials

Rice milk, pumpkin fiber, stevia, bananas, pistachios, coconut oil, cocoa powder, and coffee beans, which satisfy the standard technical documents, were used for the studies.

Instruments

Centrifugal for ice cream test bottles (Nova Safety, Germany).

Water bath Funke-Gerber WB-436 A, Germany).

Ice cream test bottles (butyrometers) Funke-Gerber, Germany).

Ice cream freezer (Spaceman 6225 Berg, Germany).

Laboratory microscope (Daffodil MCX-100 MICROS, Germany).

Laboratory Methods

Organoleptic quality evaluation was carried out according to the five-grade scale. The ice cream overrun was determined with the use of the freezer. A glass with a capacity of 150 cm³ or more was used. The same glass was alternately weighed empty with the mixture and the ice cream. The glass was filled with the ice cream to the brim [8].

The ice cream overrun (B), % was calculated using the formula (1):

$$B = \frac{M2 - M3}{M3 - M1} \times 100 \quad (1)$$

Where:

M1 is the weight of the empty glass, g; M2 is the weight of the glass filled up with the mixture, g; M3 is the weight of the glass filled with ice cream, g.

The weight fraction of fat in the ice cream was determined by the Gerber method. It was determined with the use of the butyrometer. The summary of the method lies in the dissolution of the ice cream proteins with sulfuric acid, resulting in the fat balls losing their shell and combining into a single fatty layer [8].

Description of the Experiment

Sample preparation: 4 types of the ice cream were used for the studies: developed – “Banana & Pistachio” and “Coffee and chocolate”; control ones – fruit and berry as well as chocolate. The following raw materials were used when manufacturing the vegetarian ice cream: rice milk manufactured by The Bridge (organic); pumpkin fiber manufactured by Golden Kings of Ukraine according to TU U 15.3-24239651-010:2009 [9]; stevia according to TU U 15.8-30729147-003-2004 [10]; coconut oil (bio) according to DSTU 4562:2006 [11]; banana according to DSTU ISO 931:2019 [12]; pistachio according to DSTU EEK OOH DDP-10:200 [13]; cocoa powder (organic) according to DSTU 5006:2017 [14]; coffee beans according to GOST 6805-97 [15].

Number of samples analyzed: During the experimental studies 4 samples of vegetarian ice cream were used, namely: two experimental and 2 control ones. The ice cream “Banana & Pistachio” experimental sample was compared with control 1; “Coffee and chocolate” – with control 2.

Number of repeated analyses: The study was repeated 5 times, while the mathematical statistics methods processed the experimental data.

Number of experiment replication: Each experiment was carried out five times, and the number of samples was three, resulting in fifteen repeated analyses.

Design of the experiment: Production of vegetarian ice cream “Banana & Pistachio” and “Coffee-chocolate” according to the general technological scheme, which consists of the following operations: reception and preparation of raw materials, dosing and mixing of components, filtering (impurity removal), pasteurization, homogenization, cooling, ageing, freezing, hardening and post-hardening of the mixture, packaging, and storage of the finished product.

Statistical Analysis

Statistical processing was performed in Microsoft Excel 2016 in combination with XLSTAT. The accuracy of the obtained experimental data was determined by the Student’s test with a confidence probability of ≤ 0.05 for the number of parallel determinations of 5 minimum. The linear programming problems were solved with the use of setting the MS Excel spreadsheet “Solution search” (Excel Solver).

RESULTS AND DISCUSSION

Milk is the main raw material for manufacturing ice cream [16], [17]. The absence of milk from the alimentation may cause many nutritional disadvantages, such as calcium, phosphorus and vitamin deficiencies, which could be supplemented by consuming fruits and vegetables [45]. Due to the nutrition specifics of vegans, there is a need to use vegetable milk for the ice cream to be manufactured. The analysis of scientific and patent information revealed that there are about 35 types of “vegetable milk” today [19], [20]. Such types of milk as rice, soybean, almond, sesame and hempseed milk could be used for vegetarian ice cream [45]. In the study of [46] are presented as raw material hemp milk, and sesame milk are in the formulation of the vegetable ice cream. Sesame milk contains sesamol which causes resistance against oxidation, and lignin, which has antioxidant properties and a considerable quantity of vitamin E. Scientists have proven that soy milk seems to be a good choice for cow milk substitution because is a rich protein source with balance essential amino acids [47]. Many benefits of soy milk consumption are related to lowering the risk of cancers, diseases associated with heart and vascular systems, hypercholesterolemia, diabetes, and bone and kidney-related diseases [45]. In the study of [47], being easy to be digested, coconut milk is a very rich source of minerals and antioxidants. The prevention of arteriosclerosis and other heart-related illness is given by coconut milk's high oleic and lauric acids [48]. However, these types of milk have certain disadvantages during the production of vegetarian ice cream – also a disadvantage, which needs to be controlled, is the stability of the colloidal system.

Accordingly, rice milk was added to the developed vegetarian ice cream to obtain the necessary consistency and texture of the product.

Rice milk reduces the cholesterol level, controls the blood sugar level, provides energy for the body, enhances the performance of the digestive system, supporting healthy intestinal flora [18]. Rice milk also has a good influence on skin health due to para-aminobenzoic acid, which is one of the components helping to protect the skin from the sun's negative rays. Rice milk is also an antioxidant and a powerful anti-inflammatory drug for the skin [41], [42]. And also improves the consistency and structure of finished products. Inositol alcohol contributes to powerful cell growth, delays the aging process, and normalizes blood circulation [43], [44]. The energy content of rice milk is not-too-high compared to other types of vegetables – 47 kcal per 100 g [19], [22].

During the production of vegetarian ice cream, the choice of additional components is no less important. According to research results, [49] fruits and vegetables represent the main ingredient for the sorbet, being an important source of tanning substances, ascorbic acid, β -carotene, anthocyanins, chlorophylls, pectin, organic acids, proteins and many other bioactive compounds.

So, pumpkin fiber was added to the recipes to remove toxic substances and excess cholesterol, stevia to enhance the performance of the gastrointestinal system, and coconut oil to stabilize the product's shape better [24], [25].

Table 1 Recipe composition of vegetarian ice cream "Banana & Pistachio".

| Component name | g/100 g of products |
|----------------|---------------------|
| Rice milk | 62 |
| Pumpkin fiber | 2.5 |
| Stevia | 0.5 |
| Banana | 16 |
| Pistachio | 6.8 |
| Coconut oil | 12.2 |

Table 2 Recipe composition of vegetarian ice cream "Cocoa and chocolate".

| Parameter name | g/100 g of products |
|----------------|---------------------|
| Rice milk | 62 |
| Pumpkin fiber | 4.8 |
| Stevia | 4 |
| Cocoa powder | 7 |
| Coffee beans | 8 |
| Coconut oil | 14.2 |

The organoleptic parameters of the food product are one of the first evaluation criteria of the consumer's perception of the finished product [20-26], [40]. They depend on the type of raw materials used and the food technology. Accordingly, the organoleptic quality evaluation of the finished product was carried out according to the five-grade scale to choose the best functional food composition in the recipes of the vegetarian ice cream. The results are listed in Table 3.

Table 3 Organoleptic evaluation of vegetarian ice cream according to the five-grade scale.

| Parameter | Control 1 | "Banana & Pistachio" | Control 2 | "Coffee and chocolate" |
|--------------------|-----------|----------------------|-----------|------------------------|
| Appearance | 4.5 | 4.6 | 4.3 | 4.7 |
| Taste | 4.5 | 4.7 | 4.6 | 5 |
| Smell | 4.4 | 4.7 | 4.5 | 4.8 |
| Structure | 4.1 | 4.3 | 4.5 | 4.5 |
| Consistency | 4.4 | 4.4 | 4.4 | 4.4 |
| Colour | 4.7 | 4.8 | 4.5 | 4.9 |
| Overall evaluation | 4.4 | 4.5 | 4.4 | 4.7 |

According to the organoleptic evaluation, the developed samples of the vegetarian ice cream "Banana & Pistachio" and "Coffee and chocolate" got a higher overall score than the control ones due to the improved appearance, color, and taste-aromatic parameters. The vegetarian ice cream has a uniform color which was determined by the addition of banana, pistachio, and coffee beans ("Banana & Pistachio" – slightly green color with brown inclusions, "Coffee and chocolate" – saturated brown color with dark brown inclusions). In the study [50], cocoa and coffee were added as well in these types of frozen desserts, and the result was the acceptance of

the samples by the panellists, the most preferred one is that with a coffee addiction. The substitution of cow milk affected the melting and aeration properties, but this is an expected result.

The appearance, taste, and smell of the ice cream "Banana & Pistachio" are improved due to the addition of banana, which gives the product a sweetish taste and a good smell compared to control one 1, which is too sweet because of high content of sugar and additional sweetening syrups [27], [28]. These parameters of the ice cream "Coffee and chocolate" are improved due to the addition of coffee beans, which give the product a saturated brown color and a good coffee taste [29]. Similar results were achieved in the research effect of coconut milk, tender coconut and coconut sugar on ice cream's physicochemical and sensory attributes [51].

The profilograms, which allowed us to visualise sensory evaluation results, were built to determine the qualitative differences in the organoleptic evaluation of the developed product (Figure 3 and Figure 4).

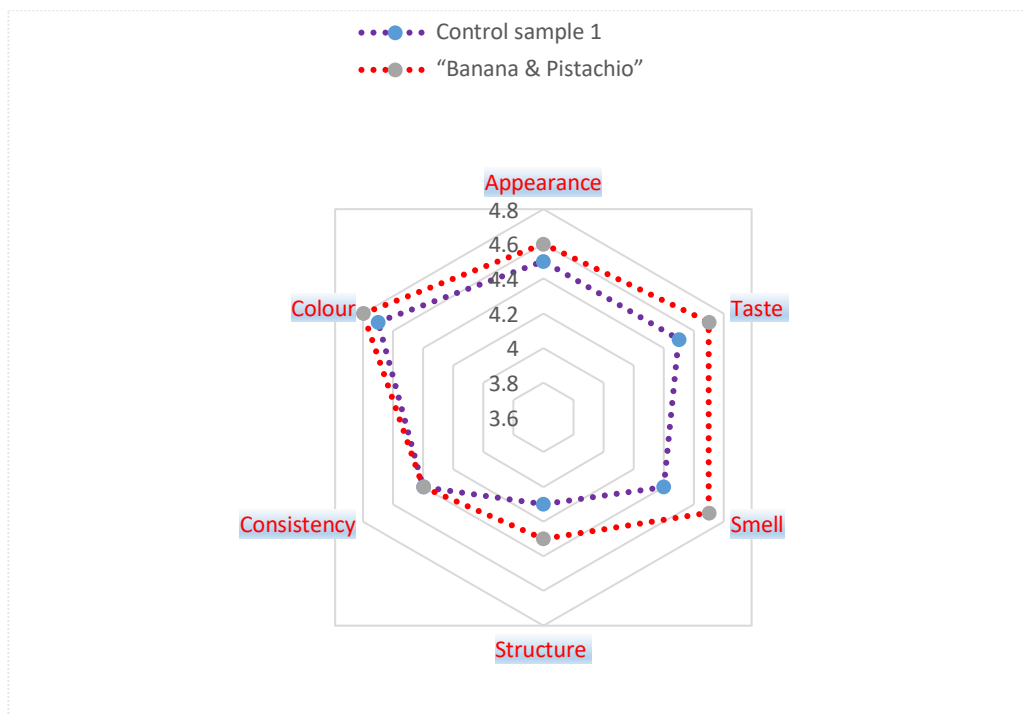


Figure 3 Comparative analysis of control sample 1 ice cream Banana & Pistachio.

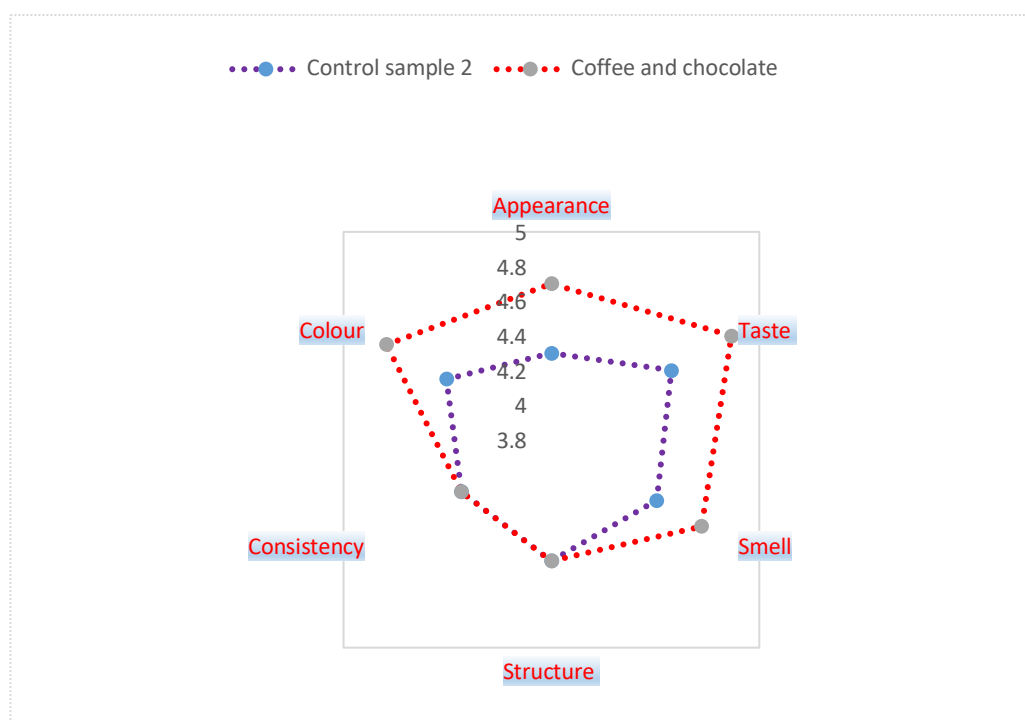


Figure 4 Comparative analysis of control sample 2 with ice cream Coffee and chocolate.

Summing up the results of the comparative evaluation of the organoleptic parameters, one may state that bananas and coffee beans increase the organoleptic parameters [30], [39]. All developed recipes had high overall scores compared to the control samples. The most characteristic quality parameter of the ice cream is overrun, that is, its air saturation in the form of small air bubbles.

If the ice cream overrun is low, then the dense consistency of the ice cream is formed, and large ice crystals appear. If the ice cream overrun is too high, then the fragile snow-like structure, as well as the empty taste, is formed, and it can cause the sedimentation of the ice cream volume while storing [31], [32].

The vegetarian ice cream overrun study results are listed in (Figure 5).

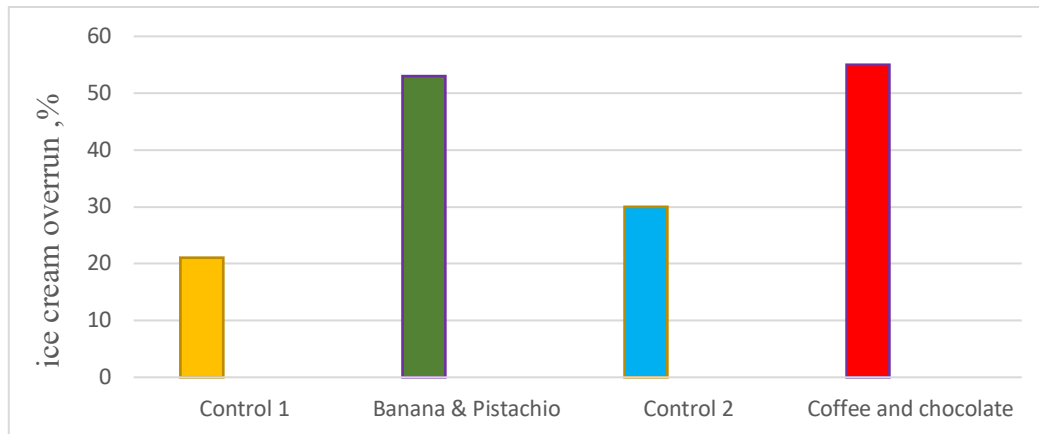


Figure 5 Ice-cream overrun, %.

The air bubbles' stability and sizes depend significantly on the chemical composition of the ice cream mixture and its freezing conditions [33]. Thus, when the fat content increases, the stability of air bubbles increases, but their sizes decrease. At the end of freezing, the bubble sizes remain constant upon reaching a certain minimum. The obtained results are listed in (Figures 6-9).

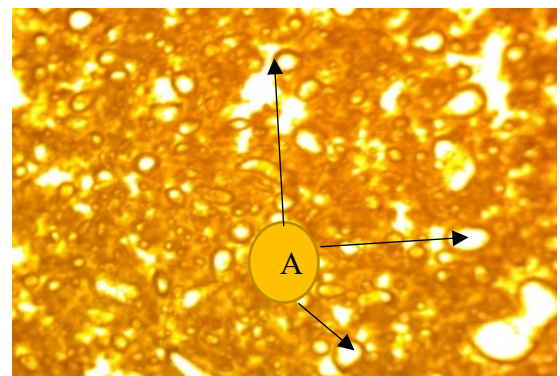
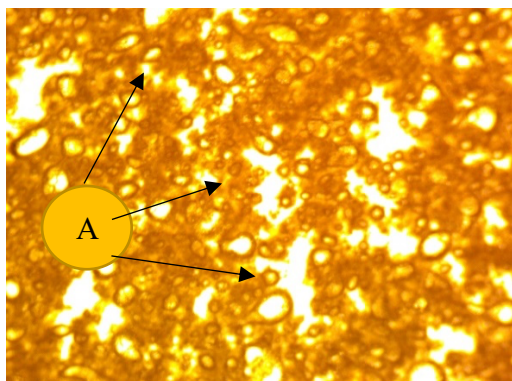


Figure 6 Photomicrographs of the control sample 1 (a.b – air bubbles).

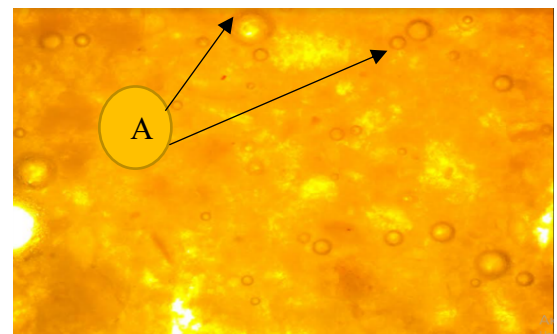
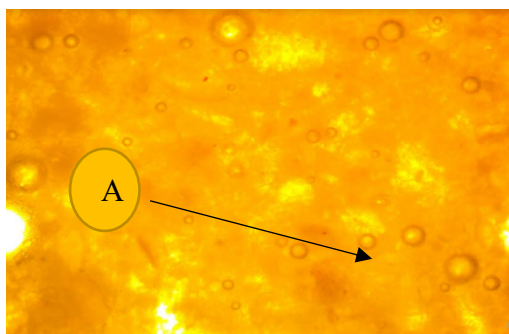


Figure 7 Photomicrographs of vegan ice cream "Banana & Pistachio" (a.b – air bubbles).

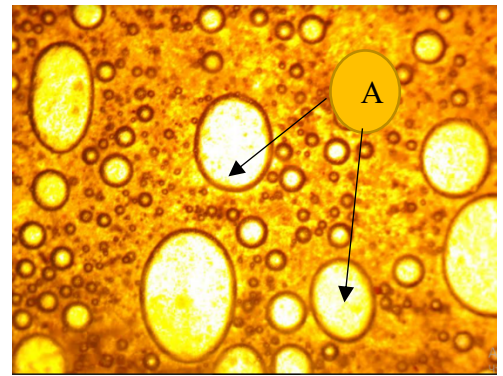
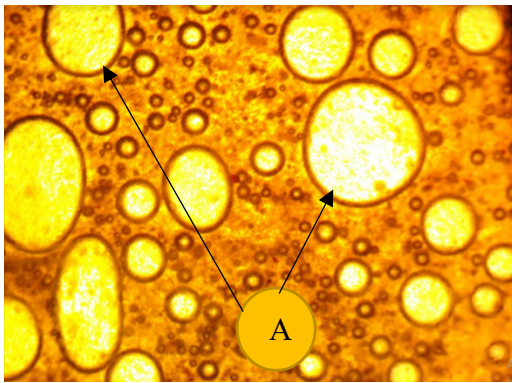


Figure 8 Photomicrographs of the control sample 2 (a,b – air bubbles).

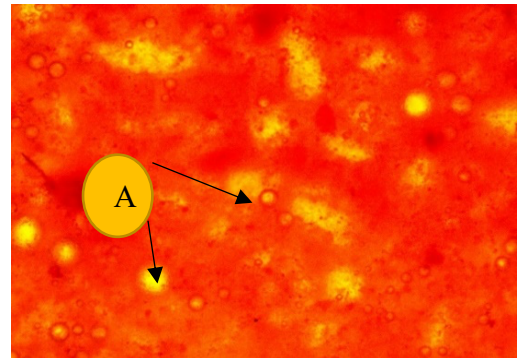
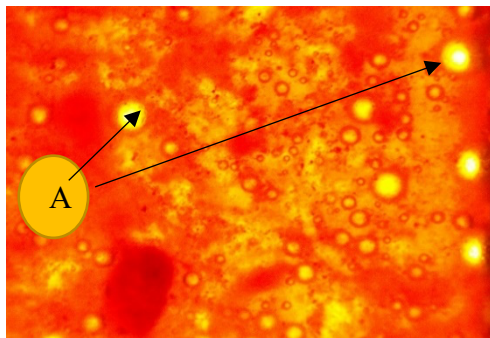


Figure 9 Photomicrographs of vegan ice cream "Coffee-chocolate" (a,b – air bubbles).

Considering the obtained data, one may state that the overrun of the studied samples is higher than that of the control samples [34], [35]. The high overrun indicator points at the snow-like consistency, which is caused by the content of solids and fat, the properties of fat, and the freezing efficiency.

The number of fat influences the structure and consistency of the ice cream. The higher the fat content, the smaller the distance between the fat bubbles, which contributes to obtaining the finished product with smaller ice crystals [36]. The obtained results are listed in (Figure 10).

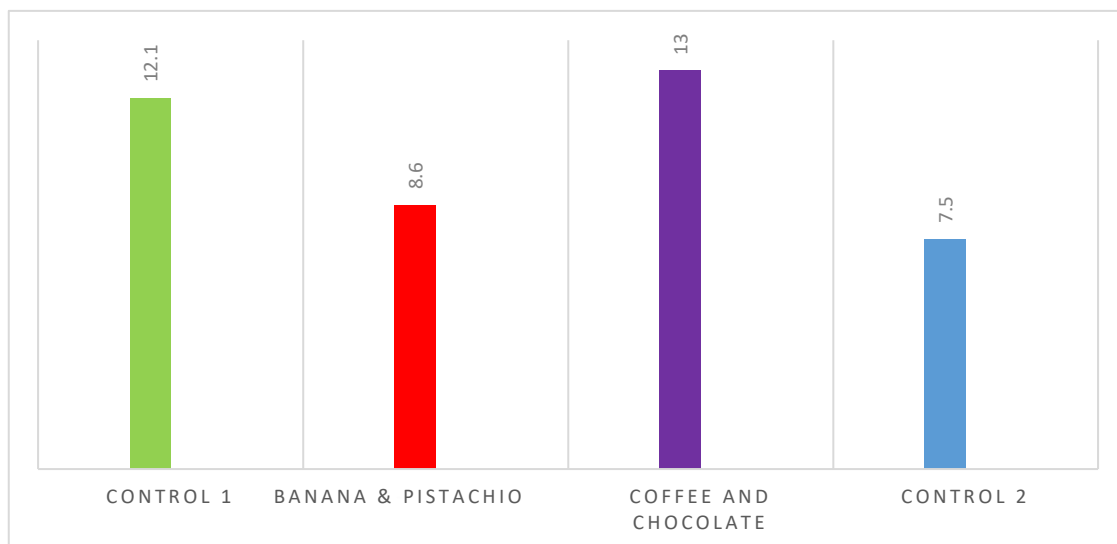


Figure 10 Mass fraction of total fat, %.

Having analyzed the obtained data, one may state that the mass fraction of total fat in the studied samples is lower than in the control samples [37], [38]. This is due to the low-fat content in the raw materials used.

CONCLUSION

The expediency and effectiveness of combining rice milk as the main component with pumpkin fiber, stevia, bananas, pistachios, coconut oil and coffee beans in the technology of vegetarian ice cream have been proven, which is confirmed by the positive results of organoleptic and physicochemical tests. Indicators of experimental samples. Through experimental research and multi-criteria optimization, the optimal ratio of components was determined - for "Banana & Pistachio" ice cream: rice milk - 62 %, pumpkin fibre – 2.5 %, stevia – 0.5%, banana – 16%, pistachio – 6.8%, coconut oil – 12.2%; "Coffee and chocolate": rice milk – 62%, pumpkin fibre – 4.8%, stevia – 4%, cocoa powder – 7%, coffee beans – 8%, coconut oil – 14.2%. As a result of the conducted research, it was established that the shrinkage of the studied samples is higher than the control samples and ranges between 50-55%. A high whipping index indicates a snow-like consistency, which is determined by the content of solids and fat, the properties of the fat and the efficiency of milling. The mass fraction of total fat in the studied samples is lower than the control ones and amounts to 7.5% and 8.6%, respectively. This is due to the low-fat content in the raw materials used.

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