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Prospects for the Use of Powdered Viburnum Food Additive in the Production of Soft Ice Cream

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ABSTRACT

This study aims to substantiate the feasibility of producing soft ice cream using a powdered food additive from viburnum fruit. The article investigates the effect of a powdered food additive from wild berries Viburnum opulus on the organoleptic and physicochemical quality indicators of ice cream. The nutritional and biological value of the enriched ice cream was analyzed and the compliance of the developed ice cream samples with safety indicators by current standards was investigated.

Keywords: soft ice cream, powdered food additive, amino acid profile, *Viburnum opulus, dietary fibre*

Mathematics Subject Classification: 92B05

Computing Classification System: O13

1. INTRODUCTION

The modern lifestyle leads to significant changes in the human diet. Excessive consumption of carbohydrates and fats, depletion of the diet in terms of protein, pro- and prebiotics, and low physical activity are the causes of the rise in cardiovascular disease, obesity, and diabetes. Among the new generation, there is already a significant percentage of children and adolescents who are overweight and have intestinal disorders. Therefore, in recent years, the production of health food products with reduced calorie content with a high content of ingredients with therapeutic or preventive properties has been growing.

Ice cream is a popular product among all segments of the population, especially children. However, this dessert product is quite high in calories, so nutritionists do not recommend its consumption by overweight children. Typically, ice cream contains 0.2% to 0.3% stabilizer, 0.1% emulsifier, 10% to 15% sugar, 12% flavors and colors, 4.1% protein, 20.7% carbohydrates, and an energy value of 196.7 kcal per 100 g. Also, ice cream contains vitamins A, B, C and E. Ice cream with fruits and berries is characterized by a high content of vitamin C.

Soft ice cream is a refreshing product obtained by whipping and freezing milk mixtures with sugar, stabilizers, and other additives, which is produced by ice cream factories, milk processing plants, and restaurant establishments.

Vegetable raw materials, due to their ability to bind moisture, help prevent the formation of a "coarse crystal structure" defect in ice cream during freezing, especially when the temperature fluctuates. It also contains natural coloring agents that can structure food systems, influence technological processes, and improve the organoleptic and physicochemical properties of ice cream. The process of forming the foam structure of ice cream is complex and closely related to the chemical composition of the product and its physical characteristics.

Given the above, the relevance of the research is to expand the range of soft ice cream with biologically complete plant raw materials.

2. THE PURPOSE AND OBJECTIVES OF THE STUDY

2.1 The purpose and objectives of the research

The study aims to substantiate the feasibility of producing soft ice cream using a powdered food additive made from viburnum fruit. This will increase its biological value and improve the organoleptic characteristics of the product.

To achieve this goal, the following tasks should be performed

- to investigate the effect of powdered food additives from viburnum fruit on the organoleptic and physicochemical quality indicators of ice cream;
- analyze the nutritional and biological value of fortified ice cream;
- to determine the compliance of the developed ice cream samples with safety indicators by current standards.

2.2 Materials and methods of the study

The technological process for the production of powdered food additives involves the following technological processes: fruit preparation (washing and sorting); freezing; defrosting; preparation of sugar solution; osmotic dehydration; separation of sugar solution; drying of viburnum fruit derivatives; grinding; sieving; packaging [16].

Experimental studies and formulation development were conducted in the laboratory of Sumy National Agrarian University.

The amino acid profile of the ice cream samples was identified by ion-exchange column chromatography using a BIOTRONIK amino acid analyzer (Germany).

The appearance and color, consistency were checked visually. Consistency, structure, and taste were determined organoleptically.

The titratable acidity of the ice cream was determined by titration with NaOH solution until a slightly pink color appeared. The end of titration was determined by comparing the color of the mixture with the control sample. The acidity in Turner's degrees was calculated by multiplying the amount of alkali used for neutralization (in ml) by a factor of 20. Two parallel determinations were made, the difference should not exceed 1°T.

The mass fraction of fat in soft ice cream was determined by acid hydrolysis followed by extraction.

The mass fraction of dry matter was determined according to DSTU ISO 3728:2005.

The mass fraction of total sugar was determined by the Bertrand method. The mass fraction of sucrose was determined by the iodometric method.

Ice cream whipping was determined by comparing the weight of ice cream with the weight of the same volume of water.

The mass fraction of additives was determined by the actual recipe according to the calculation method.

The resistance of the ice cream to melting was determined by the time it took for 10 ml of the mixture to melt at 25°C.

The form stability of ice cream was determined by the ability of the product to retain its shape under certain storage and use conditions.

Safety indicators were determined by determining the content of toxic elements (cadmium, lead, copper, zinc) by DSTU 7670:2014, and microbiological indicators by DSTU 7357 and DSTU IDF 122C.

The studies were conducted with a threefold repeatability.

2. RESULTS

It is proposed to replace a part of the milk mixture in the production of soft ice cream with a powdered food additive made from viburnum fruit. Viburnum powder will give the product a characteristic color and unique taste, and increase its antioxidant properties. It will also improve the nutritional value of the ice cream, making it more attractive to consumers looking for healthy alternatives to desserts.

The technological process of production of viburnum powder food additive involves fruit preparation (washing and sorting); freezing; defrosting; preparation and pasteurization of sugar solution; osmotic dehydration; separation of sugar solution; drying of dehydrated berries; grinding; sieving; packaging. The technological scheme for the integrated processing of wild fruits developed by us is waste-free and universal.

The ice cream mixes were prepared by mixing the ingredients in the proportions shown in Table 1. Four samples of soft ice cream were developed: control (from the mix), sample 1 (5% additive) and sample 2 (7% additive), sample 3 (10% additive).

Table 1. Recipe of the test samples (per 1 kg of dry mix)

Raw materials	Monitoring	Sample 1	Sample 2	Sample 3
Milk powder "Milk Premium"	1000	950	930	900
Water	2500	2500	2500	2500
Viburnum powder food additive	-	50	70	100
Total	3500			

The finished dry mixture was poured into the container of the freezer and mixed with 2.5 liters of clean drinking water, the temperature of which should not exceed 25°C. After that, the contents were thoroughly mixed (15-20 minutes) until smooth with a pastry spatula with a silicone tip. After insisting for some time, the mixture was sent to the freezer cylinder after swelling. Three processes took place simultaneously in this cylinder: mixing, whipping, and freezing to a finished product temperature of -8°C. The ice cream preparation time was 10-15 minutes. The finished ice cream was poured into paper cups through a shaped nozzle.

In the first stage of the research, the expert group determined the effect of viburnum powder food additive on the organoleptic characteristics of soft ice cream. It was noted that the prepared samples meet the requirements of this type of product according to DSTU 8686.1:2016 (Fig. 1).

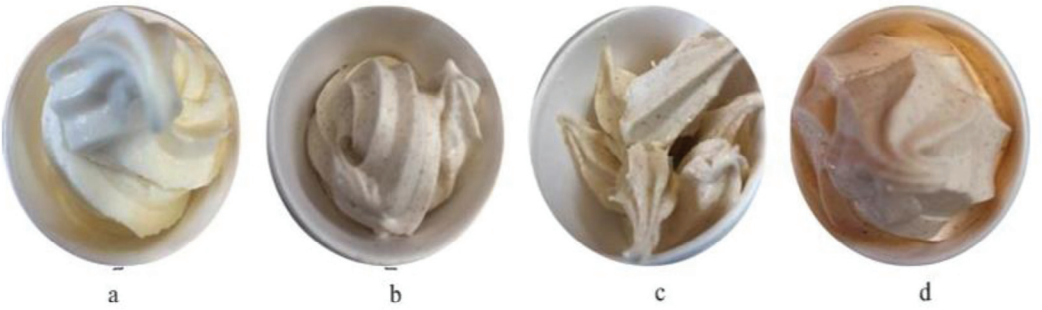

Figure 1. Appearance of the test samples of soft ice cream

The control sample (a) had a clean, milky taste, no off-flavors or odors, soft and creamy texture, homogeneous structure, and white color. According to the organoleptic evaluation, there was no significant difference between samples b and c. The highest score was given to sample 4 (d), but it had the lowest whipping index. We assume that this is due to the dietary fiber contained in the powder additive. They can affect the texture of the ice cream, making it thicker and less whipped.

All samples were well received by the tasters. The only difference was in the ice cream color and taste. Samples b, c, d had a pleasant sweetish sourness and a light flavor due to the addition of the filler. The color intensity differed from the amount of filler from light cream to light pink. In sample d, there was an inclusion of the additive.

The results of the study of sensory indicators of ice cream samples showed that all samples with viburnum powder have high taste advantages, which are achieved due to a well-chosen quantitative combination of the components of the mixture.

The results of the analysis are presented in the form of a profilogram (Fig. 2).

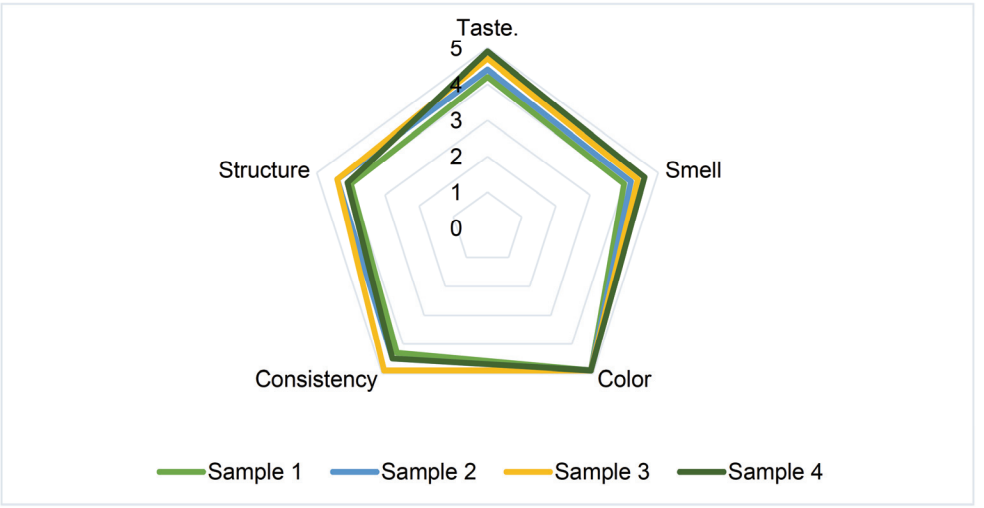

Figure 2 . Organoleptic characteristics of experimental samples of soft ice cream

The ice cream was characterized by its whiteness, homogeneity of structure, and melting speed. The homogeneity of the ice cream structure ensured a uniform distribution of ingredients, which contributed to a uniform taste and texture. The addition of viburnum powder improved the homogeneity of the structure, making the ice cream more stable and uniform.

In terms of physicochemical parameters, the prepared samples met the requirements specified in Table 3.

Table 3 . Physical and chemical parameters of ice cream quality indicators

Indicator	Control	sample 1	sample 2	sample 3
Mixture density, kg/m3	1.095	1.1	1.11	1.12
Mass fraction of fat, %.	3.3	4.79	5.56	6.7
Mass fraction of dry substances, %.	29.3	31.5	32.3	33.2
Mass fraction of sucrose, %.	17.7	16.9	16.5	16.0
Acidity, 0T	14.5	18	20	22

The results showed that the density of the mixture gradually increased from the control sample to sample 3 by 0.025, which is due to the addition of harder components such as dry viburnum powder, which increases the total weight of the mixture. The mass fraction of fat increases from 3.3% in the control sample to 6.7% in sample 3, but the texture of the ice cream improves due to the fat in the ice

cream. The mass fraction of solids gradually increases from 29.3% in the control sample to 33.2% in sample 3. The increase in solids improves the stability of the ice cream, reducing the likelihood of ice crystal formation. The mass fraction of sucrose, on the contrary, decreases from 17.7% in the control sample to 16.0% in sample 3. The acidity increases from 14.5°T in the control sample to 22°T in sample 3, but is within the normal range, due to the acid content of the viburnum powder.

Ice cream whipping means the volume of air contained in the product (Fig. 3). The higher the air content, the lighter and fluffier the ice cream becomes. It also affects the texture and melting rate of the product.

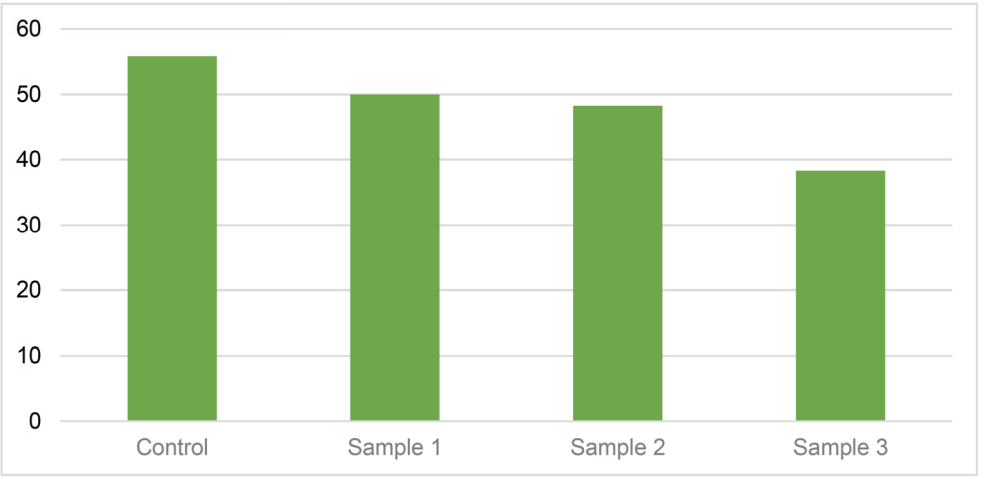

Figure 3. Ice cream whipping indicators, %.

The control sample had the highest loss rate of 55.71%, and sample 3 had the lowest loss rate of 38.29%. In sample 1, the deflated was 5.71% lower, in sample 2 by 7.41%, and in sample 3 by 17.42% compared to the control sample. This is due to the presence of dietary fiber in the powder additive.

Since the viburnum powder contains fat-soluble vitamins, the effect of fats on the moldability of ice cream was investigated by subjecting the samples to a hardening process. The moldability of ice cream is a qualitative characteristic of its structure, which is influenced by the product's components and the forces of interaction between them.

The melting rate of the tested samples was in the range of 10-25 minutes. It was found that in the case of using a powdered food additive, the moldability of ice cream was better than that of the control sample. After 25 minutes, the samples with the viburnum powder additive melted completely but kept their shape. Ice cream with a lower whipping index melts more slowly, which can be an advantage during the summer season or when consumed outdoors. Products with a high air content melt slowly because air bubbles act as an insulator and fat stabilizes the foam structure.

During the storage of soft ice cream in the freezer, crystal growth is observed: small ice crystals melt, and water migrates to neighboring crystals, on which it freezes. In this regard, it was advisable to study

the distribution of ice crystals in the samples under study. In the samples of soft ice cream with viburnum powder food additive, the ice crystals have a narrower size interval from 20 to 35 microns, which makes the structure of the ice cream more homogeneous (Fig. 4).

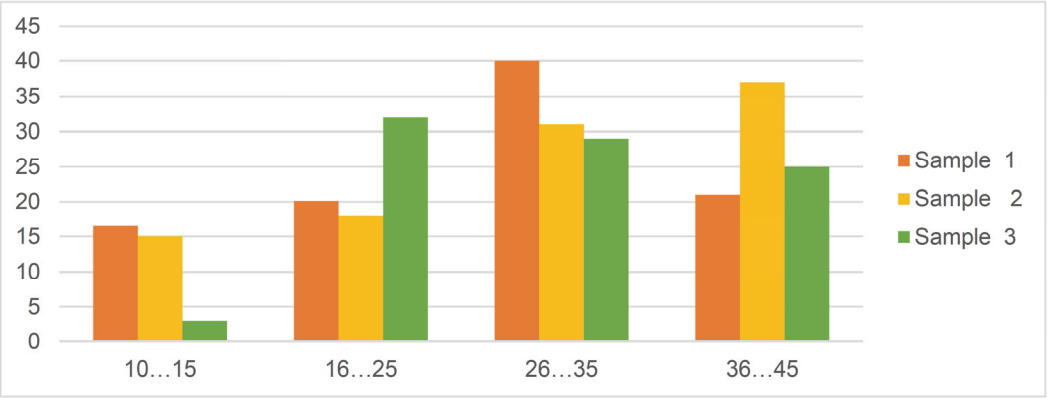

Figure 4. Distribution of ice crystals in ice cream

The largest number of ice crystals is observed in the size range of 26...35 microns for all three samples, with the highest content in sample 1. The highest content of ice crystals with a size of 26...35 microns (approximately 35%) is in sample 1, the content of crystals of other sizes ranges from 10% to 25%.

The content of the main nutrients (proteins, fats, carbohydrates) in the developed samples was studied. The results are presented in Table 4.

Table 4. Nutritional value of soft ice cream, per 100 g

Indicators, g	Control	Sample 1	Sample 2	Sample 3
Proteins	1.97	3.16	3.74	4.02
Fats	3.3	4.79	5.56	6.7
Carbohydrates	27.4	24.14	24.4	24.79
Energy value, kilocalories	147.18	152.31	162.6	175.54

The addition of viburnum powder significantly affects the nutritional value of soft ice cream - the content of proteins and fats in the samples increases significantly. Sample 1 contains 1.19 g more proteins, sample 2 by 1.77 g, and sample 3 by 2.05 g more compared to the control sample. This is because viburnum powder itself contains proteins.

In the control sample, the fat content was found to be 1.49 g less than in sample 1, 2.26 g less than in sample 2, and 3.4 g less than in sample 3.

At the same time, the carbohydrate content decreases due to the replacement of the carbohydrate portion of the milk mixture with viburnum powder. The carbohydrate content in sample 1 is 3.26 g less, in sample 2 - 3 g, in sample 3 - 2.61 g compared to the control sample. This may be due to the replacement of a part of the carbohydrate component of the milk mixture with viburnum powder, which has.

The energy value increases with the amount of added viburnum powder by 5.13 kcal, 15.42, and 28.36 kcal, respectively, compared to the control sample. This is due to an increase in the content of proteins and fats, which have a higher energy value.

The biological value of the proteins of the powdered food additive [16, 17] led to the study of the amino acid profile of ice cream samples.

In the experimental samples of soft ice cream, 17 amino acid residues were identified, shown in Fig. 5.

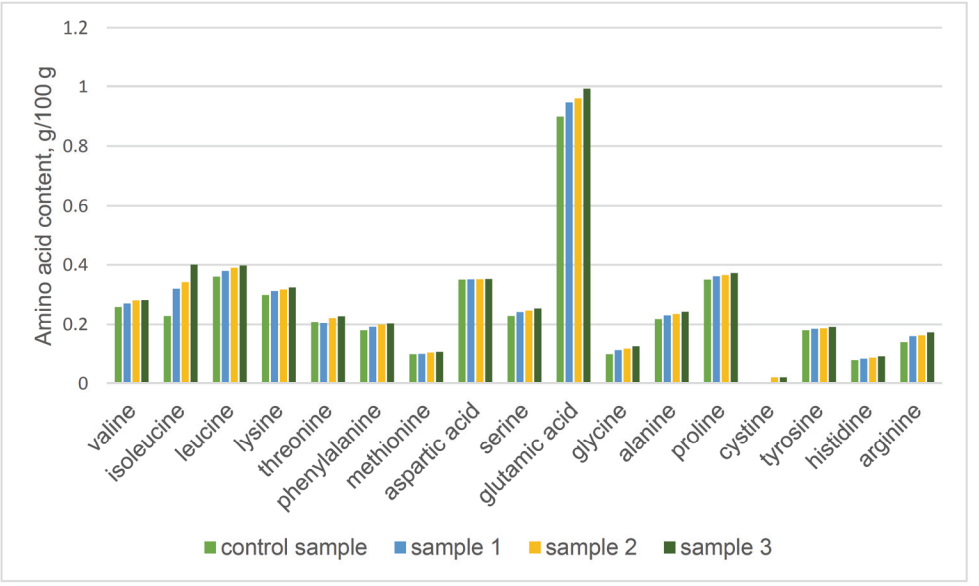

Figure 5. Amino acid profile of the experimental soft ice cream samples

The introduction of plant powders from the derivatives of Viburnum opulus berry processing in the amount of 10% (sample 3) and 7% (sample 2) increases the content of amino acids (Fig. 5), in particular, essential ones, such as isoleucine (Ile), leucine (Leu), lysine (Lys) - by 6.67 %, phenylalanine (Phe) and threonine (Thr) - by 5.6...11.11 %, valine (Val) - by 3.3 % compared to the control sample. As well as substitutable ones, such as alanine (Ala) and glycine (Gly) - by 10...20%, arginine (Arg) - by 11.11-16.11%, tyrosine (Tyr) - by 7.14...14.29%, histidine (His) - by 8.33...16.3%, serine (Ser) - by 4.5...9%. Aspartic acid (Asp) remained unchanged, as it is contained in small amounts in the powder.

Under the above results, the expediency of using viburnum powder food additive in the formulation of soft ice cream to improve the amino acid profile of the finished product was confirmed.

It was also found that the developed ice cream samples contain more fiber than the control sample since there is almost no dietary fiber in the milk mixture for ice cream (Fig. 6).

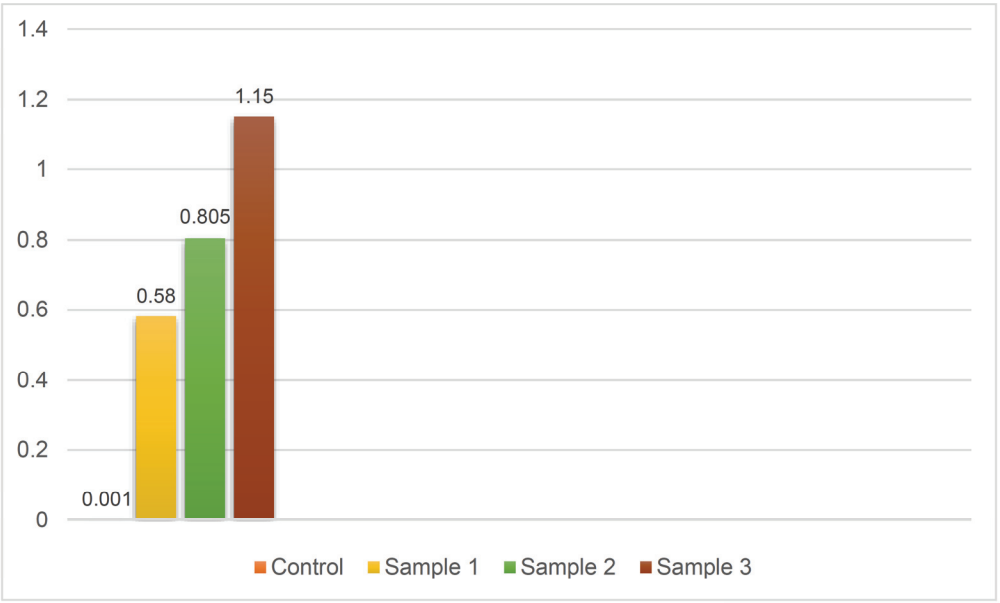

Figure 6. Dietary fiber content in soft ice cream

The results showed that the addition of powdered food additives to ice cream can increase their amount by 1.15 g/100 g.

Based on the results of the analysis of the state of modern theory and practice in ice cream production, it can be concluded that it is expedient and necessary to develop a technology for enriched soft ice cream based on a dry mix with powdered food additives, which makes it possible to obtain a product with high consumer properties.

To produce safe products, the ice cream prototypes were tested for the content of harmful microflora and toxic elements (Table 5).

Table 5. Safety indicators of soft ice cream prototypes

Indicator name	Control	Sample 1	Sample 2	Sample 3
The number of mesophilic aerobic and facultative anaerobic	$<1*10^4$	$<1*10^4$	$<1*10^4$	$<1*10^4$

microorganisms (QMAFAnM), CFU per 1.0 g of product				
Bacteria of the Escherichia coli group (coliform) in 0.1 g of product	Not detected			
Pathogenic microorganisms, including bacteria of the Salmonella genus, in 25 g of product	Not detected			
St. aureus, in 0.01 g of product	Not detected			
Listeria monocytogenes in 25 g of product	Not detected			
Mold fungi, CFU per 1 g of ice cream	Not detected			
Yeast, CFU per 1 g of ice cream	Not detected			
Lead	0,001	0,001	0,001	0,001
Cadmium	0,01	0,01	0,01	0,01
Arsenic	0,01	0,01	0,01	0,01
Mercury	0,001	0,001	0,001	0,001
Aflatoxin B1	Not detected			
Aflatoxin M1	Not detected			

The research showed that the microbiological indicators and toxic elements in all ice cream samples did not exceed the established requirements. The research results indicate that the developed samples meet modern food safety standards.

4. DISCUSSION AND CONCLUSION

The results of the analysis have proved the feasibility and necessity of creating a technology for enriched soft ice cream based on a dry mixture with the addition of viburnum powder, which makes it possible to obtain a product with high consumer properties.

Based on the results of comprehensive experimental studies of the effect and proportions of Viburnum opulus powder food additives, it is recommended to use 7% of viburnum powder in the recipe.

The developed samples comply with the requirements of DSTU 8686.2:2016 in terms of all physicochemical and safety parameters. The results of studies of the content of harmful microflora and toxic elements confirm the compliance of the developed samples of soft ice cream from viburnum

processing derivatives with safety indicators in accordance with current standards. It was found that the use of a powdered food additive improves the form stability of ice cream.

The developed formulation significantly improves the nutritional value of ice cream, its taste and appearance, and makes the product more attractive to consumers. It was also found that the addition of powdered food additives from viburnum fruit in the amount of 7% increases the content of amino acids, such as lysine, threonine, valine, isoleucine, leucine, phenylalanine, aspartic acid, arginine, histidine, tyrosine, alanine, glycine, and serine.

In particular, samples of soft ice cream with viburnum powder contain 0.8 g/100 g of fibre.

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