Functional confectionery product using whey protein concentrate development

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Abstract. In connection with the spread of the use of sweeteners, as well as whey processing products as fortifying components, the production of functional confectionery products with improved nutritional value, including using biotechnology methods, is an urgent task. The purpose of the study is to develop a formulation based on sweeteners enriched with whey protein concentrate. The subject of the study is the influence of raw materials obtained because of ultrafiltration of whey on the organoleptic, physicochemical and microbiological properties of low-calorie pastille mass. Objects of research: a pastille product made according to a standard recipe, and 3 samples of functional pastille products using whey protein concentrate in a ratio of 5%, 15% and 30% by weight of raw materials. Samples prepared according to the developed recipes contain 63% fewer calories than samples prepared according to the standard recipe. Acceptable levels of the number of mesophilic aerobic and facultative anaerobic microorganisms of functional marshmallow samples are maintained for 72 hours (no more than 1×103 CFU/g). The optimal percentage of adding protein to the pastille mass has been identified. The proposed recipe for a pastille product will allow us to expand the range of enriched confectionery products for functional purposes.

1 Introduction

In Russia, according to the International Dairy Association, up to 80% of the whey obtained during the production of cheese and cottage cheese is discharged into wastewater. Whey processing in the country is hampered due to a number of reasons: lack of investment in the production of dairy products, lack of information about the advantages and benefits of dairy products, underdevelopment of technologies for the production of a multifunctional product based on whey protein, refusal to use modern technologies for the production of high-quality milk products, liberal environmental policy [1].

Disposal of dairy products is also one of the pressing issues for many producers in the Sverdlovsk region. Whey processing can quickly become profitable and profitable. There are known methods for producing protein concentrates using membrane processing of dairy raw materials. The developed technologies guarantee environmental safety through deep processing of raw materials to produce high-quality products [2]. The concentrate obtained

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as a result of ultrafiltration, containing more than 20% of dry dissolved components, can be used as an independent raw material for the production of products [3, 4, 12-14].

Products obtained from whey have medicinal and preventive value. This is due to the fact that whey contains whey proteins, lactose, a complex of micro- and macroelements that help improve metabolism, as well as normalize the function of the pancreas, kidneys, liver and other organs [3, 4, 12-14].

The most promising direction is the use of whey components in functional products to improve nutritional value. There is an increase in the share of fortified products among confectionery products. Confectionery products enriched with beneficial micro- and macroelements, minerals and vitamins contribute to a healing effect. There are numerous studies on the development of pastille products for functional purposes, so the most promising products for enrichment with products obtained from whey are products such as marshmallows. Marshmallows and marshmallows among confectionery products have a number of advantages in production: the possibility of using regional raw materials, the introduction of enriching additives at the final stage of production, long shelf life, and the use of a minimum amount of equipment [5-7].

Today, the use of sugar substitutes in food products is becoming increasingly widespread due to their advantages: zero or low calorie content, safety, high taste, small portion size. These properties of sweeteners make it possible to create sugar-free food products for people suffering from type 2 diabetes or consuming a reduced amount of carbohydrates [8-9].

There are numerous studies on the development of pastille products for functional purposes. Marshmallows were obtained with the addition of lactulose and microencapsulated forms of bacteria, creating a synbiotic complex. A marshmallow recipe has been developed on vegetable protein using berry processing products for people who do not consume egg whites. A method has been proposed for making marshmallows based on a mixture of sweeteners (isomalt and erythritol) with the addition of black currants in order to reduce calorie content and increase antioxidant activity. A technology has been developed for the production of marshmallows with the addition of chia seeds, spirulina microalgae powder and Jerusalem artichoke syrup. A marshmallow recipe has been developed that replaces sugar with fructose and enriches it with inulin [10-12].

Thus, a promising direction in the field of functional confectionery products is the creation of marshmallows based on sweeteners using whey protein concentrate to improve the nutritional value of the product.

The purpose of the research is to determine the quality indicators of a pastille product made according to a standard recipe, and 3 samples of pastille products with a sugar substitute, enriched with whey protein concentrate.

2 Materials and Methods

To carry out the experimental part, the objects of research were the following variants of samples:

– sample No. 1 (control) – a pastille product made according to a standard recipe;

– sample No. 2 – a pastille product made according to a developed recipe with the replacement of sugar in the ratio of 9% Jerusalem artichoke syrup, 91% isomalt and the addition of 5% whey protein concentrate (WPC) of the total mass of raw materials;

– sample No. 3 – a pastille product made according to a developed recipe with the replacement of sugar in the ratio of 9% Jerusalem artichoke syrup, 91% isomalt and the addition of 15% WSC from the total mass of raw materials;

– sample No. 4 – a pastille product made according to a developed recipe with the replacement of sugar in the ratio of 9% Jerusalem artichoke syrup, 91% isomalt and the addition of 30% WPC from the total mass of raw materials.

In the production of the functional pastille product, sugar was replaced by Jerusalem artichoke syrup with an energy value of 1117 kJ and a calorie content of 267 kcal per 100 g and BENEO isomalt (Germany) with an energy value of 987 kJ and a calorie content of 236 kcal per 100 g. When consuming isomalt, only 10% is absorbed sweetener, which causes a slight increase in blood glucose (from 2 to 12%). This food additive is stable and does not decompose chemically; at 100 °C its solubility is comparable to that of sucrose. At 60–90°C, the viscosity of aqueous solutions of isomalt does not differ from sucrose solutions.

In order to enrich the pastille product with protein, dry whey protein concentrate with an energy value of 1500 kJ and a calorie content of 360 kcal per 100 g (55 g of protein per 100 g) was used in its production.

Applesauce for making pastille samples was prepared at home by baking at 180°C and further processing Granny Smith apples.

When developing the recipe for the pastille product, the amount of sugar used to prepare the apple-pectin mass was replaced with a reduced amount of Jerusalem artichoke syrup in order to preserve the physicochemical properties. Sugar for making syrup was replaced with an equivalent amount of isomalt. As a result of using sweeteners in this ratio, a marshmallow sample was obtained that was characterized by low humidity, which led to complete drying within 5 hours. In order to increase the moisture content of the product, it was decided to increase the amount of Jerusalem artichoke syrup in the apple-pectin mass. The percentage of Jerusalem artichoke syrup relative to the replaced amount of sugar in the recipe was 8.6%, isomalt – 91.4%.

After stabilization of marshmallow samples, studies were carried out on organoleptic, physico-chemical and microbiological indicators using standard methods, including GOST 5900-2014 “Confectionery products. Methods for determining moisture", GOST 5898-87 "Confectionery products. Methods for determining acidity and alkalinity", GOST 34551-2019 "Confectionery products. Method for determining the mass fraction of protein", GOST 6441-2014 "Pastille confectionery products. General technical conditions".

The storage duration of the marshmallow samples under study was determined by determining microbiological indicators for 72 hours on an automatic colony counter “Scan 300” in a training laboratory according to OFS.1.7.2.0008.15 “Determination of the concentration of microbial cells”.

3 Results and discussion

Recipes for 4 marshmallow samples are presented in Table 1. Recipe No. 1 is standard. In recipes No. 2, No. 3 and No. 4, sugar is replaced with Jerusalem artichoke syrup and isomalt. In addition, whey protein concentrate was added to these recipes in the amount of 5%, 15% and 30%, respectively, of the total mass of raw materials.

Table 1. Recipes for analyzed marshmallow samples

Name of raw materials	Consumption of raw materials per 100 kg of finished products, kg			
	Recipe No. 1	Recipe No. 2	Recipe No. 3	Recipe No. 4
Sugar	57,895	–	–	–
Jerusalem artichoke syrup	–	5,053	5,053	5,053
Isomalt	–	51,842	51,842	51,842
Applesauce	21,053	21,053	21,053	21,053
Pectin	1,053	1,053	1,053	1,053
WPC	–	2,000	6,000	12,000
Egg white	3,788	6,000	12,000	12,000

Table 1. Continued

Lemon acid	0,211	0,210	0,210	0,210
Water	16,000	16,000	16,000	16,000
Total	100,000	103,211	113,211	119,211

As a result of a physico-chemical assessment of 4 marshmallow samples, it was revealed that the mass fraction of moisture complies with GOST 6441-2014 “Pastille confectionery products. General technical conditions" (Table 2). The lowest moisture content was found in marshmallow product No. 2, which is explained by the insufficient amount of binder (BCB) and, consequently, the low stability of the marshmallow mass during depositing and intensive drying of the sample. The overall acidity of samples with whey protein concentrate is higher than that of the control sample due to the alkaline reaction obtained as a result of an increase in the proportion of protein. In addition, compared to the standard sample, samples No. 2, No. 3 and No. 4 contained 1.4%, 4.33% and 6.36% more protein, respectively.

Table 2. Physico-chemical parameters of marshmallow samples

Indicator name	Sample characteristics				Value according to GOST 6441-2014
	1	2	3	4	
Moisture content, %	14,17	10,23	16,11	15,08	No more than 25%
Total acidity, degrees.	4,50	6,53	6,60	6,71	Not standardized
Mass fraction of protein, %	1,75	3,15	6,08	8,11	Not standardized

Microbiological contamination within 72 hours of 4 marshmallow samples is presented in Table 3. The number of mesophilic aerobic and facultative anaerobic microorganisms in a marshmallow sample made according to a standard recipe complies with the requirements of TR CU 021/2011 “On the safety of food products” (no more than 1 ×103 CFU/g). Microbiological parameters of marshmallow samples with the addition of whey protein concentrate after 72 hours also do not exceed the permissible values (1×103 CFU/g).

Table 3. Microbiological parameters of marshmallow samples during storage

Microbiological indicators	Acceptable level according to TR CU 021/2011 “On food safety”, no more	Shelf life, h	Sample			
			1	2	3	4
Mesophilic aerobic and facultative anaerobic microorganisms, CFU/g	1×10^3	36	240	450	210	630
		72	260	570	295	650

Figures 1, 2, 3 and 4 show a control sample of marshmallows and samples of functional marshmallows with whey protein concentrate. As a result of a visual assessment of samples of pastille products, it was revealed that marshmallows containing sugar have a more pronounced pattern and shine. Sample No. 2 does not have a clear pattern or structure. Samples No. 3 and No. 4 are similar to the control sample in structure, but do not have a pronounced shine.

Fig.1. Control sample of marshmallow No. 1

Fig. 2. Marshmallow sample with WPC No. 2

Fig. 3. Marshmallow sample with WPC No. 3

Fig. 4. Marshmallow sample with WPC No. 4

Table 4 presents the average values of the results of the organoleptic evaluation of two samples of pastille products, carried out by a group of 11 testers aged 20-25 years.

Table 4. Organoleptic evaluation of marshmallow samples on a 5-point scale, point

Index	Weight factor	Sample							
		1, point	1, point with coefficient, weight.	2, point	2, point with coefficient, weight.	3, point	3, point with coefficient, weight.	4, point	4, point with coefficient, weight.
Taste and smell	0,40	4,90	1,96	3,50	1,40	4,60	1,84	3,90	1,56
Colour	0,10	4,90	0,49	4,90	0,49	4,90	0,49	4,90	0,49
Consistency	0,15	4,60	0,69	3,60	0,54	4,60	0,69	4,00	0,60
Structure	0,20	4,50	0,90	3,30	0,66	4,50	0,90	4,50	0,90
Surface	0,10	4,90	0,49	2,90	0,29	4,90	0,49	4,90	0,49
Form	0,05	4,90	0,25	3,00	0,15	4,90	0,25	4,90	0,25
Total	1,00	4,78	4,78	3,53	3,53	4,73	4,73	4,52	4,52

Compared to the first sample of marshmallows made using traditional technology with sugar, the second sample had significantly lower scores for indicators such as taste and smell, consistency, structure, shape and surface. Since this sample with the addition of 5% whey protein concentrate was characterized by a lower value of the mass fraction of moisture, this probably had some negative impact on the consistency of this marshmallow sample, which was noted to be lingering, dry, and dense. Sample No. 4 with the addition of 30% WPC had a pronounced protein odor and a specific repulsive taste. Marshmallow made according to recipe No. 3 (15% WPC) had a pleasant smell, similar taste and external characteristics to the control sample.

As a result of the organoleptic assessment of the quality of pastille products, it was revealed that the developed samples No. 2 and No. 4 do not meet the requirements of GOST 6441-2014 “Pastille confectionery products. General technical conditions". The indicators of sample No. 3 with a mass fraction of whey protein concentrate of 15% correspond to the indicators of the regulatory documentation.

4 Conclusion

There is a tendency to increase the use of whey products in the production of food products with increased nutritional value. In addition, the need for functional foods is increasing every year. A promising industry for the introduction of fortifying additives and the use of sweeteners is the confectionery industry, in particular, marshmallows and marshmallows.

A sample of a pastille product with the addition of 15% whey protein concentrate is not inferior in quality indicators corresponding to GOST 6441-2014 “Pastille confectionery products. General technical conditions", with organoleptic and physico-chemical assessment of a standard sample. Functional marshmallows contain 4.33% more protein than control marshmallows. In addition, a pastille product based on sugar substitutes, made according to recipe No. 3, contains 63% fewer calories than a pastille product containing sugar.

Such an enriching additive obtained because of membrane methods for processing whey, such as a whey protein concentrate in combination with, makes it possible to develop a recipe for functional pastille products with increased nutritional value for dietary and diabetic nutrition.

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