Development of formulation and technology of marshmallows with dried persimmon

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Abstract. The paper shows a short review of main useful properties of persimmon fruits, methods of their processing and practical use in formulations of different food production types. Based on the review, the advisability of using persimmon in marshmallows formulations is shown. Comparative characteristics of two drying methods of persimmon are carried out practically, and optimal parameters of drying process, where losses of biologically active substances are minimal, are established. The comparison of sensory characteristics of two marshmallow samples is shown, and their nutritional value is calculated. First (control) marshmallow sample was obtained using classical formulation. The formulation of second (experimental) marshmallow sample also included dried persimmon powder. It is determined that persimmon powder does not have negative effect on sensory properties of marshmallows and improves its nutritional value. Therefore, powder can be implemented practically. The developed marshmallows are a healthy food product, so it can work towards sustainable development of modern society reducing the number of nutritional diseases.

1 Introduction

One of the main problems of modern post-industrial society is a problem of over- and undernutrition. Most of currently produced food products are highly refined and high calorie, while their useful nutrients content is minimal. Thereby, the improvement of existing formulations and technologies of different food products including sugar confectionery is an actual problem.

Development of new sugar confectionery formulations, where refined lipids and carbohydrates are replaced with their safer counterparts, will help to improve population diets in developed countries. In turn, these actions are the components of sustainable development of modern society, because they can solve the problems of new healthy food production, which prevents several widespread nutritional diseases.

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Marshmallow is a peculiar sugar confectionery product. Classical marshmallow formulation based on apple puree and sugar has high amount of carbohydrates, especially in sucrose, and a small number of vitamins and minerals. In this regard, urgent task is partial or full substitution of sugar contained in the product with suitable natural additives. These additives can contain less sugar and must not affect on the appearance and consistency of the food product. Due to it, persimmon fruits (*Diospyros kaki*) can be of interest as a source of natural sugar, vitamins and minerals.

Persimmon is a typical subtropical food crop. It is not widespread like other fruits, but at the same time persimmon fruits contain many biologically active components. Most persimmon varieties contain high amounts of carbohydrates, dietary fibers, potassium, phosphorus, provitamin A and other substances [1], which allows to use persimmon fruits both in natural and processed state. They can also be used in therapeutic and prophylactic nutrition because of their anti-inflammatory [2] and antioxidant [3] properties.

China is the birthplace of persimmons. Now this country is the leader in its world cultivation. Subsequently, persimmon cultivation spread to Japan, Korea and the Mediterranean coast of France, Italy and Algeria [1]. Persimmon is also widespread in Brazil [4], which is also one of its largest exporters. The other leaders in persimmons export are Israel, Italy, Spain, Columbia, Georgia and Azerbaijan [3].

For Russian consumer market, fresh persimmon fruits are seasonal product. Thereby, the actual problem is to find its optimal processing method, which will preserve its native properties as much as possible. It can be achieved by different methods, including drying [5].

Persimmon in its natural or processed form can be used in fortification of various food products: spaghetti [6], yoghurts [7, 8], milkshakes [9], liver pâté [10], etc. In all cases, it was noted that sensory and rheological properties of enriched production were improved. In particular, the use of freeze-dried apple and persimmon powder mixture in formulations of yogurts with probiotics not only increased its sensory characteristics, but also intensified the growth of probiotics [8].

Thus, the use of persimmon in marshmallows formulation is advisable. In turn, it determines the course of further experimental research.

2 Materials and methods

The main ingredients for obtaining of marshmallow samples were fresh apples, white crystalline and powdered sugar, agar-agar, chicken eggs, salt, and dried persimmon. Dried persimmon samples were grown and processed in Azerbaijan. All other products were produced in Russia and sold in retail enterprises in Novosibirsk.

Drying of persimmon fruits samples of different varieties with their further composition research were carried out in the Laboratory of Technology of Processing and Storage of Research Institute of Fruit and Tea Growing of the Ministry of Agriculture of the Republic of Azerbaijan. For this research stage, persimmon fruits of Hiakume, Guiboshi and XX century varieties grown in different parts of Azerbaijan were selected. The drying process was carried out by two methods.

The first method included manual piece-by-piece removal of peel and cups from the fruits, then their cutting into 4 or 8 approximately equal pieces depending on the mass (XX Century: fruit mass – 118 g, peel mass – 105 g; Guiboshi: fruit mass – 176 g, peel mass – 150 g; Khiakume: fruit mass – 184 g, peel mass – 154 g) and drying fruit pieces on wire trays in layers of 7–8 cm during 13...14 h at 70...72 °C to a residual water content of 20%.

The second method included drying of whole peeled persimmon fruits during 35...40 h at 70...72 °C to a residual water content of 20%.

Both in fresh and dried fruits, there were determined according to standard methods the amounts of dry soluble substances, water, monosaccharides and vitamin C, and acidity (malic acid content). The obtained values are the average of 5 replicates.

Based on the obtained result, the persimmon sample of XX Century variety dried by first method was selected for further use in marshmallow formulations.

Preparing and quality evaluation of marshmallow samples were carried out at the Technology and Organization of Food Industries Department of Novosibirsk State Technical University NETI. There were prepared control sample according to classical formulation (sample № 1) and experimental sample with using of dried persimmon in ratio with fresh apples of 1:4 accordingly (sample № 2). This ratio was based on preliminary experiments on preparing of marshmallow samples.

For preparing sample № 1, the apples were washed, and the peduncles were removed. Then the apples were cut into 4 pieces and baked in combi steamer at 180 °C during 20...30 min. Further, the baked apples were ground on a blender and wiped through a sieve. The obtained apple mass was mixed with the part of sugar, brought to a boil while active stirring. Then it was placed into a bowl of whipping machine and cooled to 20...25 °C. Cooled apple mass was mixed with egg whites and salt and whipped with a gradual increase in whipping speed until dense peaks and white color appeared in the mass.

The syrup was being prepared simultaneously with apple and egg whites mass whipping. For its obtaining, the other part of sugar and agar-agar were mixed with water and heated to 112...114 °C while active stirring. Then the syrup was cooled to 95...97 °C and introduced into whipped apple and egg whites mass on maximal whipping speed.

The marshmallow mass was placed into a pastry bag with a figured nozzle and deposited on a parchment in portions of 15–17 g. Then the marshmallows were dried at 20...25 °C for 12...14 h. After drying, they were covered with a thin layer of powdered sugar.

The technology for sample № 2 preparing differed in grinding of dried persimmons of XX Century variety pieces by a blender and introducing then into the apple and egg whites mass after the syrup had been completely introduced into the mass.

Sensory evaluation of obtained marshmallow samples was held according to Russian national standard GOST 31986-2012 “Public catering service. Method of sensory evaluation of catering products” for the following characteristics: appearance, scent, taste, color, consistency.

Every sensory characteristic was evaluated on the 5-point scale (5 indicates the best and 1 implies the worst) by 7 semi-trained panelists (3 lecturers and 4 students). As a result of evaluation, average points for each characteristic were obtained.

Regarding the indicators of taste and scent as the main criteria of choosing marshmallows by the consumers, the descriptor-profile method was applied. This method allows to obtain an objective evaluation of individual properties for food production samples, which will allow to regulate them while changing and improving their formulations and production technology [11].

Every indicator value varied from 0 to 5 points, where 5 points was the highest grade of taste and scent, and 0 points meant the lack of appropriate characteristics for taste and scent.

The nutritional and energy values of marshmallow samples were calculated and evaluated according to reference data from “Chemical Compositions of Russian Food Products Manual” (2002).

3 Results and discussion

The results of physico-chemical properties evaluations of fresh and dried persimmon fruits are shown in Table 1.

Table 1. Physico-chemical properties of fresh and dried persimmons of different varieties

Variety of persimmon fruit	Analysis objects	Indicators				
		Dry soluble substances, °Brix	Water, g/100 g	Mono-saccharides, g/100 g	Acidity (malic acid), g/100 g	Vitamin C, mg/100 g
Khiakume	Fresh fruits	15.0	81.5	13.68	0.12	10.0
	Dried fruits: First method	–	20.0	57.0	0.47	22.14
	Second method	–	20.0	58.21	0.48	10.38
Guiboshi	Fresh fruits	15.0	81.3	13.01	0.12	10.56
	Dried fruits: First method	–	20.0	53.6	0.46	22.4
	Second method	–	20.0	54.7	0.47	15.0
XX Century	Fresh fruits	22.0	73.0	19.51	0.17	17.52
	Dried fruits: First method	–	20.0	56.0	0.48	35.6
	Second method	–	20.0	57.0	0.49	8.8

According to obtained data, the persimmon fruits drying time prolongation from 13...14 h (first method) to 35...40 h (second method) lead to significant losses of vitamin C, and thereby to a decrease in the nutritional value of dried fruits. At the same time, persimmon drying with its preliminary processing according to second method slightly reduced the loss of monosaccharides in the dried product.

The persimmon fruits of XX Century variety dried by first method were chosen as the optimal sample for its further using in marshmallows formulation.

Profilogram of sensory evaluation of control and experimental marshmallow samples is shown in Fig. 1.

Fig. 1. Sensory evaluation of marshmallow samples

Sample № 1 got the highest points (5.0) for all indicators. The taste and consistency indicators of sample № 2 lowered to 4.7 points, the others remained at the same level. The reasons for lowering of these indicators were excessive sweetness and sugariness of the

sample, adhesion of dried persimmon particles to the teeth and, as a result, slight difficulties in their chewing. These disadvantages can be eliminated with finer grinding of dried persimmon and reducing of sugar content in marshmallow formulation. Further, marshmallow samples with different content of persimmon powder will be prepared and its optimal concentration will be determined, up to complete replacement of sugar with persimmon powder.

According to descriptive-profile evaluation, the taste of sample № 2 in comparison with sample № 1 ceased being slightly sour (0 points). At the time, it became slightly sweeter (4.5 points), and a spicy aftertaste also appeared (0.2 points). The scent of sample № 2 became more specific (2.2 points), and its intensity remained at the same level (0.2 points). The scent also became less pleasant (4.3 points), but more specific to incoming products (4.7 points).

In the future, undesirable changes in taste and scent of marshmallow samples can be corrected by changing the ratio of ingredients in formulations, what can be achieved by further experimental research.

In Table 2, calculation of the nutritional value of marshmallow samples is presented.

Table 2. Calculation of the nutritional value of marshmallow samples

Nutrients	Daily norm	Content in 100 g		Daily norm percentage, %	
		sample № 1	sample № 2	sample № 1	sample № 2
Proteins, g	75	0.9	1.3	1,2	1.8
Lipids, g	83	0.3	0.3	0,4	0.3
Carbohydrates, g	211	62.7	65.0	29.7	30.8
Energy value, kcal	2500	263	277	10.5	11.1
<i>Minerals</i>					
Na, mg	2400	122.5	116.8	5.1	4.9
K, mg	3500	87.2	83.0	2.5	2.4
Ca, mg	1000	13.8	15.4	1.4	1.5
Mg, mg	400	8.6	10.4	2.1	2.6
P, mg	1000	9.2	16.9	0.9	1.7
Fe, mg	14	1.9	1.9	13.5	13.6
<i>Vitamins</i>					
B1, mg	1.5	0.02	0.02	1.6	1.5
B2, mg	1.8	0.04	0.18	2.2	10.0
PP, mg	20	0.3	0.3	1.7	1.7
C, mg	90	7.8	16.1	8.7	17.9

According to the table, the partial replacement of fresh apples with persimmon powder in sample № 2 increased its content of proteins by 0.4 g, carbohydrates – by 2.4 g, calcium – by 1.6 g, magnesium – by 1.8 g, phosphorus – by 7.7 g, vitamin C – by 8.3 g. Hence, their daily norm percentage and enrichment value increased, and energy value also slightly increased by 14 kcal. At the same time, in sample № 2, the sodium content lowered by 5.7 g and potassium content – by 4.2 g. The lipids, other vitamins and elements content remained the same, or changed slightly. In the future, the optimization of nutritional and energy value of marshmallows with persimmon can be achieved my mathematical modelling of their formulation.

4 Conclusions

1. The research has shown that persimmon fruits can be a source of various useful food substances, while due to their seasonality the use of dried persimmons is advisable. The preservation of nutrients in dried persimmon fruits depends on their

processing method. Thus, drying of persimmons cut into slices during 13...14 h is preferable, because drying time is reduced, and vitamin C content in dried samples is higher.

2. The sensory evaluation of control and experimental marshmallow samples showed a slight decrease in points of taste and scent in experimental sample because of its significant sugariness and sticky consistency. Further, it is advisable to use finer persimmon powder and study the possibility of full replacement of sugar with persimmon powder experimentally.
3. The nutritional value of marshmallows enriched with persimmon increased in comparison with marshmallows obtained by using classical formulation and technology. At the same time, in the experimental sample, its energy value slightly increased, and sodium and potassium content decreased. For optimizing the nutritional value of the product, it is recommended to use mathematical modeling, and subsequently confirm the model adequacy.
4. Using marshmallow as an example, it is shown that introducing of dried persimmon into sugar confectionery formulations is a promising direction in their enrichment with biologically active substances during the whole year, increase of their sensory characteristics and expanding their range. In turn, it corresponds to the goals of sustainable development of modern society, because eating such foods allows to make the nutrition of the population healthier and reduce the number of nutritional diseases.

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