Developing a healthier chocolate spread: using persimmons to reduce sugar content

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Abstract. This article presents research results about the obtention of an extract from persimmon fruit and its application in a chocolate spread recipe. The physicochemical properties of persimmon fruit were determined, and a technology for obtaining sweet-tasting aqueous extracts was developed. The study established the effectiveness of a three-stage extraction process and determined the optimal conditions for each stage. Chocolate spread recipes were developed using concentrated aqueous extract and spread obtained from persimmon fruit, resulting in a reduction of sugar content from 32.2% to 15.2% (a two-fold decrease). The article presents and explains the physicochemical, organoleptic, and microbiological parameters of the resulting chocolate spread.

1 Introduction

Persimmon (*Diospyros kaki* L.) is a fruit rich in natural carbohydrates which is industrially processed to obtain juice, jam, and other sweet products. It is a widespread fruit throughout Asia, where it is not only consumed as a food product but also widely used for medicinal purpose [1]. Its leaves and fruits have been used for centuries to treat coughs, atherosclerosis, hypertension, and apoplexy [2]. Recently, the pulp, skin, and leaves of persimmon have received attention due to their antioxidant, anti-edema, anti-hyperlipidemic, and anti-diabetic biological activities [2]. Interest in persimmon juice is particularly growing due to its nutritional content. Persimmon is rich in many nutritious and biologically active components, such as proteins, sugars, vitamins A, B6, B12, D, C, E, polyphenols, flavonols, flavonoids, and carotenoids [1,3]. It contains trace elements such as potassium, sodium, iron, calcium, and others. Not only the fruit but also leaves, calyx, and other parts are important for health. In particular, a strong scavenging effect against active oxygen free radicals has been found due to flavonoids [3]. Many researchers have found that the biological activity of persimmons is associated with phytochemicals [1-4]. The healing properties of persimmon depend on the type and amount of biologically active substances in its composition, which varies according to the geographical regions where they are grown [1]. In Uzbekistan, thousands of tons of

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persimmons are discarded every year due to untimely harvest, lack of sales, or improper storage, making them unusable [5]. To increase shelf life, persimmons can be processed into value-added products, such as dried persimmons with their skin removed, ready-to-eat persimmon drinks, ice cream, and vinegar [1, 6]. Studying the physicochemical properties of persimmon is important in the production of various food products from it.

Although persimmons are widely grown in many countries worldwide and significant achievements have been made in the research on dried persimmon production, their industrial processing has not become widespread. In addition to their consumption as raw fruits, persimmons are mainly consumed as dried raisins, and are exported from many countries, including our own [5,7]. There are several methods for processing persimmon fruits into powder (Chinese Patents: CN103960612A, CN109221992A, CN109938142A), which is widely exported to Japan, Korea, China, and other countries. Persimmon powder is primarily used to reduce sugar content in flour confectionery products or to produce gluten-free confectionery products. For instance, there are confectionery products with reduced sugar content through persimmon powder addition (Korean Patent: KR101313040B1).

Even though persimmon cultivation in Uzbekistan began in the last century, its physical and chemical properties have not been fully studied [5,8]. Today, there are insufficient or no studies on the physical and chemical properties of the main and secondary products of persimmon processing and their waste. Usually, juice is first extracted from fresh fruits by squeezing them, and then the residual substances in the squeeze are separated by extraction in water. This method is used for apples, pears, pomegranates, quince, peaches, apricots, and other similar fruits. However, obtaining large amounts of juice from persimmons by squeezing is not feasible because persimmon fruit is hard and relatively dry when freshly ripe [9]. When fully ripe, pressing produces a very thick juice, and separating the sediment through filtration is difficult. Due to its high pectin content, obtaining clear juice is practically impossible [7]. Therefore, it is advisable to obtain an aqueous extract from persimmon rather than juice, thus one of the objectives in this research is to obtain an aqueous extract by processing the local persimmon variety Zenji-maru and then study the physical and chemical properties of the extract.

Chocolate products are among the most widely consumed food products globally. The main ingredients for chocolate are primary and secondary products obtained from cocoa fruits [10,11]. However, since cocoa is not grown worldwide, its price is high. Consequently, manufacturers globally are seeking to utilize cocoa by-products or substitutes extensively. Examples include coffee powder (Korean Patent: KR101985334B1) or flour confectionery products with persimmon additions (Korean Patent: KR102364270B1) to reduce cocoa content.

Almost all raw materials for chocolate spreads produced in our country are imported from abroad, as the main ingredients - cocoa, sugar, and fats - are not available locally [12]. Therefore, the main goal of this research is to reduce cocoa and sugar consumption by obtaining powder or extract from locally grown persimmon fruits and incorporating it into chocolate spread composition. Additionally, plans include replacing part of the fat used in the chocolate spread recipe with modified local fats. Since the spread is a fat emulsion product, it is crucial to determine which phase will incorporate the persimmon extract, its effect on emulsion stability, and the required technological parameters. As a summary, this research work is about developing a technology for producing chocolate spread with reduced sugar and cocoa content, enriched with biologically active substances from persimmon fruits.

2 Methodology

2.1 Raw Materials

The study used persimmon fruits grown in the Tashkent and Kashkadarya regions. The Zenji-maru variety was selected for conducting this work, based on a previous study where persimmon varieties grown in Uzbekistan were evaluated for their suitability for drying [5]. In that study. the best indicators were observed in Hyakume (30.5%), Zenji-maru (31.3%), Tomapon (27.7%), and Fuyu (24.8%).
Before taking aditional steps, the physical characteristics of the persimmon fruit were evaluated. The examination included fruit color, length, width, weight, edible part, density, number of seeds, volume, and firmness. The color of the persimmon fruit ranges from flame to deep red. The average fruit weight is 145.41-153.25 g for large fruits, 107.08-112.45 g for medium fruits, and 69.69-74.24 g for small fruits; the length is 65.8-72.6 mm for large fruits, 51.5-54.9 mm for medium fruits, and 44.0-47.8 mm for small fruits; and the width is 63.5-78.3 mm, 58.5-63.2 mm, and 50.0-54.6 mm, respectively, with an average number of seeds of 3-8. The fruit hardness was found to be 4.98-6.01 (kg/m²), depending on size.

2.2 Obtention of an aqueous extract of persimmon fruit

Persimmon fruits were washed in cold water and dried. To obtain persimmon extract, the fruits were cut into pieces, and the pulp and seeds were separated. The fruit pieces were placed in a blender with water added at a ratio of 3:1 and pureed. The puree was then transferred to a container, water was added at a ratio of 3:2, and the mixture was boiled at 80°C for 30 minutes. The resulting product was separated into phases in a centrifuge at 3000 rpm. The separated aqueous phase was transferred to a separate container, and the remaining solid phase underwent re-extraction twice following the same procedure. All obtained extracts were concentrated separately in a rotary evaporator until the extract volume decreased by 50%. The physicochemical parameters of the resulting finished products were analysed (Table 2).

2.3 Methods for analysing the physical and chemical properties of raw materials and extracts

Equipment

The necessary equipment for physicochemical analysis - digital pH meter, analytical balance, drying oven, refractometer, and other instruments - was provided by the Food Technology Training Laboratory of the Technical University of Technology. To achieve accurate and reliable results, physicochemical properties were evaluated using the methodologies described in subsequent sections.

The moisture content and volatile matter content in raw materials and products were determined using a KERN DBS60-3 moisture meter. The amount of carbohydrates was determined using a DMA4500M optical alcoholometer. Dietary fibre was determined using a method based on enzymatic hydrolysis of starch and non-starch compounds to mono-, di-, oligosaccharides and peptides using α-amylase, protease, and amyloglucosidase. Dietary fibre was precipitated with ethyl alcohol, dried, and determined gravimetrically. The total mass fraction of dietary fibre was expressed as a percentage (g/100 g). The protein content was determined by the Kjeldahl method using a Steam distillation unit SDU 100. The fat content was determined by extraction with a 50:50 mixture of diethyl ether and ethyl alcohol in a Soxhlet extraction FAT6 extractor. The pectin content was determined photometrically

using a Fast Track UV/VIS spectrophotometer. The ash content was determined by weighing the mineral residue formed after complete combustion of the organic portion of the product sample. Techniques will be described in detail in the following sections.

Physical properties

Ripe persimmon fruits were analysed for various physical parameters such as fruit colour, weight, overall dimensions, chewable portion, number of seeds, size, density, and firmness. Colour determination: Visual observation was used to record the colour of persimmon fruit. Determination of gauge dimensions: The overall dimensions of persimmon fruits were determined using a calliper, with the average value shown in millimetres (mm). Determination of weight: Persimmon fruits were weighed using an electronic scale. The average weight of 10 fruits was determined and expressed in grams (g). Determination of the number of seeds: Ten persimmon fruits were deseeded and counted by hand.

Chemical properties

The chemical characterization of ripe persimmon fruits was evaluated by determining total soluble solids, moisture, pH, soluble sugar, ascorbic acid concentration, non-soluble sugar, fat, total phenolics, dietary fibre, total sugar, total flavonoids, and antioxidants.

Moisture

A 2 g sample of persimmon fruit was weighed and dried in an oven at 105°C for 4–5 h. After cooling, it was reweighed until a constant weight was obtained. The resulting weight loss was calculated as the moisture content.

Moisture (%) = a × 100 / b

Where: a – Weight loss of the sample after drying

b – Weight of the obtained sample

pH

A digital pH meter (FiveGo™ pH F2) was used to determine the pH value of the persimmon fruit. After calibrating the pH meter with buffers of pH 4, 7, and 9, the sample was tested.

Total soluble solids (TSS)

A drop of crushed fruit was placed on the prism of a digital refractometer, and the amount of total soluble solids was determined. The TSS was estimated by Brix.

Titratable acidity

Titratable acidity was estimated by titrating a known volume of the sample with 0.1 N NaOH standard solution using phenolphthalein as an indicator.

The percentage of titratable acidity in terms of anhydrous citric acid was calculated using the following formula:

Acidity (%) = [Titration value (X) × H base × Acid equivalent weight × volume × 100] / [sample weight × aliquot taken for evaluation × 100]

Dietary fibre

3-5 grams of the sample, free from moisture and fat, were weighed and placed in a beaker. Then 200 ml of boiling 0.25 N (1.25 Wt/V) H_2SO_4 (sulfuric acid) was added. The mixture was boiled for 30 minutes, with water added periodically to maintain constant volume. After filtering through filter paper, the mixture was washed thoroughly with hot water to remove acid residues. After material recovery, 200 ml of boiling 0.313 N NaOH (sodium hydroxide) solution was added to the same beaker. After boiling for another 30 minutes, it was washed with hot water until alkali residues were removed. The washing process was then repeated with alcohol. Finally, the mixture was placed in a crucible and dried overnight at 80-100°C. After cooling, the contents were weighed again. The difference between initial and final weights indicated the amount of crude fibre.

Total sugar

50 ml of clear filtrate was placed in a 100 ml beaker and 5 ml of strong hydrochloric acid was added. The mixture was placed in a water bath for 30 minutes for hydrolysis. After hydrolysis, excess HCl in the sample was neutralized by adding sodium carbonate. The mixture was then transferred to a volumetric flask and diluted with distilled water to the specified volume. The solution was titrated with 5 ml each of Fehling's A and Fehling's B solutions. The endpoint of the titration, characterized by a brick-red precipitate with methyl blue indicator, was determined and the total sugar percentage was calculated.

Fehling's A is an aqueous solution of copper sulphate, prepared by dissolving pentahydrated copper sulphate in distilled water and adding a few drops of dilute sulfuric acid. Fehling's A is blue in colour due to the presence of copper in the solution. Fehling's B is a Rochelle salt, prepared by dissolving potassium tartrate in an aqueous solution of sodium hydroxide. Also known as potassium sodium tartrate solution, it is colourless and acts as a gelling agent.

Sensory properties

Evaluation of sensory properties of persimmon extracts was conducted by ten volunteers according to Chinese Standard NY 82.2-1988 with modifications. Samples of persimmon extracts were placed in small plastic cups (50 ml of extract per cup) and labelled with random three-digit codes. All samples were evaluated at approximately 18°C. Participants evaluated the samples for colour, taste, mouthfeel, appearance, and overall acceptability. Each parameter was rated from 1 to 10. Results were accepted as a total score of 5 indicators for each persimmon extract. To ensure accurate assessment of colour and appearance, organoleptic evaluation was conducted under low-intensity light conditions. Participants first assessed the appearance, then tasted the samples to evaluate mouthfeel. Participants were required to rinse their mouths with plain distilled water after evaluating each sample.

2.4 Elaboration of the fat phase for chocolate spread

A combination of several oils is suggested for the fat-based formulation of chocolate spread. Fatty acid content, melting temperature, SFC (solid fat content) index, and hardness of oils were selected as the main factors. Since the organoleptic and physical properties of chocolate spread directly depend on its fatty base, the physicochemical parameters of selected fats were analysed. The results are presented in Table 1.

Table 1. Physico-chemical parameters of selected oils for forming the fat base of chocolate spread

№	Name of oil and fat	Melting point, °C	Hardness, g/cm	Iodine value, J_2 %
1	Cocoa butter	35,9	78,6	38,2
2	Interesterified	35,7	220,1	62,9
3	Cottonseed palmitin	24,3	50,2	78,6

Table 1 shows that the selected fats differ in their physicochemical parameters. Although the melting points of cocoa butter and transesterification are similar, their hardness and iodine values differ significantly. Cottonseed palmitin oil is distinguished from other fats and oils by its melting point, hardness, and low iodine value. Since cocoa butter determines the physical and organoleptic properties of chocolate spread, a decrease in its mass fraction in the recipe significantly affects the product parameters. Considering this, the composition of the proposed fat base for chocolate spread was set at 30% cottonseed palmitin oil, 30% transesterification, and 40% cocoa butter.

2.5 Preparation of the chocolate spread emulsion

Experiments on spread emulsion preparation were conducted in the "Food Technology" training laboratory of the Tashkent Institute of Chemical Technology. A SHM1 homogenizer was used as a mixer and an electric oven as a heater.

In a 0.5 L beaker, water, aqueous phase components, and extract from persimmon or apple juice were placed according to the recipe and mixed thoroughly. Oil and fat-soluble components were then placed in the main mixer and mixed thoroughly. The mixture was heated to 40-45°C. The aqueous phase was added to the mixture while stirring at 150-200 rpm. Mixing of the aqueous and oily phases continued for 20-30 minutes until the mixture became homogeneous. To control the emulsion, a sample was taken from the mixer with a glass rod and a few drops were placed onto a glass or porcelain plate. After the emulsion is ready, colouring and odorant substances were added and mixing continued. The final mixing with slow rotation took 5-10 minutes, ending when a homogeneous mixture was achieved.

Analysis of chocolate spread

The organoleptic and physicochemical parameters of the produced chocolate spread products are routinely checked by state control bodies according to standard requirements. The chocolate spread obtained in this study was packed in plastic or glass jars and stored at 25 ± 5°C. Storage studies were conducted at intervals of 0, 10, 15, and 30 days to evaluate oxidation stability, quality, and organoleptic parameters.

Lipids

Lipids were separated from all chocolate spread samples according to the following procedure: Before sampling, the spread is carefully mixed. 30 g of chocolate spread is poured into 50 ml polypropylene centrifuge tubes. Samples are frozen at -20°C for 24 hours and thawed at 4°C for 2 hours to break the emulsion. Two millilitres of water are added, and the mixtures are centrifuged at 5000 rpm for 20 minutes. The separated lipid phase is stored in closed glass containers at -40°C until analysis.

Physicochemical analyses

Peroxide value (PV), anisidine value (AV), free fatty acids, iodine value, pH, and viscosity were determined according to standard methods (GOST 27107–2016 and GOST 31933–2012).

Organoleptic properties

The evaluation of organoleptic parameters is conducted after one day of storage at room temperature. Ten specially trained evaluators, selected based on their interests and abilities, assess the organoleptic parameters (appearance, colour, odour, texture, and overall acceptability) of the chocolate spread. The parameters are evaluated using a ten-point hedonic scale: 1 = lowest or very high dislike and 10 = highest or very high liking. All samples were randomly coded and presented to evaluators on white plates at room temperature.

3 Results and discussion

Physico-chemical parameters of the AEPF (aqueous extract of persimmon fruit) obtained by the method described in section 2.2 in laboratory conditions are presented in table 2.

Table 2. Physico-chemical indicators of AEPF

Index name	Value
Extract yield, %	72,4
pH	6,05
Brix, %	15,74
Total phenols (mg GAE/100 g)	3,71
Ascorbic acid (mg/100 g)	11,5
Pectin, (g/100 g)	1,48

Table 2 shows that the Brix value of the obtained extract is lower than that of the sugar solution. For example, when 2 kg of sugar is dissolved in 1 liter of water at 20°C, its Brix value is 66.74%, and when 3.7 kg of sugar is dissolved in 1 liter of water, a saturated solution forms with a Brix value of 78.74%. The Brix value of the extract obtained in the study was 15.74%, pointedly lower than that of the sugar solution. Therefore, we increased the Brix value by evaporating water from the extract to increase its concentration.
To increase the concentration of dry matter in the extract, including sucrose, and to sterilize the solution, the residual medium (sample 1) obtained in the experiment with a hydromodulus of 1:1 was evaporated under a vacuum of 150-200 mm·cm at 90-95°C. When the extract volume was reduced by half, sample 2 was obtained; when evaporated to 1/3 of the total volume, sample 3 was obtained; and when evaporated to a foam state, sample 4 was obtained. The composition of the obtained extracts was analysed (Table 3).

Table 3. Composition of persimmon aqueous extract

№	Name of components	Amount of components in AEPF, %			
		Initial extract	Concentrated extract		Syrup
		1 sample	2 sample	3 sample	4 sample
1	Mass percentage of moisture and volatile substances (%)	80,34	60,68	41,05	16,02
2	Dietary fiber (%)	2,5	5,2	7,46	10,68
	Ash content (%)	0,05	0,11	0,15	0,21
3	Protein mass percentage (%)	0,6	1,17	1,78	2,56
4	Fat mass percentage (%)	0,1	0,19	0,31	0,42
5	Mass percentage of carbohydrates (%)	16,41	32,65	49,25	70,11
6	Including total sugar mass percentage (%)	16,08	32,14	48,26	67,98
7	º Brix	15,81	31,45	47,51	67,54
8	Total phenols (mg/100 g)	3,71	7,43	11,12	15,84

Table 3 presents the composition of extracts in 4 different concentrations. Sample 1 contained 19.66% dry matter, 16.41% carbohydrates (of which 16.08% was sugar), and 80.34% water. Sample 2 contained 39.32% dry matter, 32.65% carbohydrates (of which 32.14% was sugar), and 60.68% water. Sample 3 contained 58.95% dry matter, 49.25% carbohydrates (of which 48.26% was sugar), and 41.05% water. Sample 4, in syrup form, contained 83.98% dry matter, 70.11% carbohydrates (of which 67.98% was sugar), and 16.02% water.
Persimmon fruit is distinguished from other fruits by its high carbohydrate content. Therefore, in subsequent experiments, the carbohydrate content of persimmon fruit and its extract was determined. The results are presented in Table 4.

Table 4. Carbohydrate content of persimmon fruit and its extract (in %)

Product Name	Sucrose	Glucose	Fructose	Disaccharide
Persimmon fruit	1,6	55,5	41,3	1,6
Concentrated extract from persimmon fruit	1,4	57,1	40,1	1,4

Table 4 shows that carbohydrates in persimmon fruit consist of more than 55.5% glucose, 41.3% fructose, and 1.6% sucrose and disaccharides. The concentrated extract contains 57.1% glucose, 40.1% fructose, and 1.4% sucrose and disaccharides. The increase in glucose and decrease in fructose in the extract is attributed to the decomposition of sucrose and disaccharides into monosaccharides.

The composition of chocolate spread emulsion typically includes sugar, fat, emulsifier, cocoa, and milk powder, with taste and type varying according to their relative proportions. For example, chocolate spread with a sharp taste contains higher amounts of cocoa and lower amounts of milk powder and sugar, while sweeter spreads contain reduced cocoa and increased sugar and milk powder. When modifying the mass fractions of recipe components, organoleptic properties must be considered, including taste, smell, color, structure, consistency, and emulsion stability.

Since the main research objective was to replace some or all of the sugar with AEPF (aqueous extract of persimmon fruit), modifications were made to the water and sugar content in the recipe. Additionally, as AEPF's color resembles cocoa, a partial reduction in cocoa content was attempted. The control chocolate spread recipe contained sugar, cocoa powder, butter, vegetable oil, dry milk, lecithin, and emulsifier. The proposed chocolate spread recipes used identical ingredients, except that varying amounts of sugar and water were replaced with different concentrations of persimmon fruit extract. The recipes are presented in Table 5.

Table 5. Chocolate spread recipes with AEPF (in %)

№	The name of the components	Content,%				
		control	Spread-1	Spread -2	Spread -3	Spread -4
1	Oil base	29,3	29,3	29,3	29,3	29,3
2	Sugar	32,2	32,2	32,2	32,2	0
3	Cocoa powder	8,5	8,5	8,5	8,5	8,5
4	Dry milk	11,5	11,5	11,5	11,5	11,5
5	Lecithin	0,3	0,3	0,3	0,3	0,3
6	Emulsifier	0,2	0,2	0,2	0,2	0,2
7	Water	18	0	0	0	18
8	AEPF	0	18	0	0	0
9	Conc. AEPF (DMC-39.32%)	0	0	18	0	0
10	Conc. AEPF (DMC-58.95%)				18	
11	Persimmon fruit syrup	0	0	0	0	32,2

Table 5 shows that the control recipe consists of 32.2% sugar, 29.3% fat, 18% water, 11.5% dry milk, 8.5% cocoa powder, and 0.5% emulsifiers. In AEPF Spread-1, AEPF replaces water. In Spread-2 and Spread-3, concentrated AEPF substitutes for water. In Spread-4, persimmon fruit pulp replaces sugar. Overall, two recipes used extract instead of water, and one used pulp instead of sugar.

Chocolate spreads were prepared under laboratory conditions following the proposed and control recipes. Components of the aqueous and oily phases were mixed separately, then combined, homogenized, and cooled. The organoleptic indicators were evaluated using a 10-point tasting system. Results are presented in Figure 1.

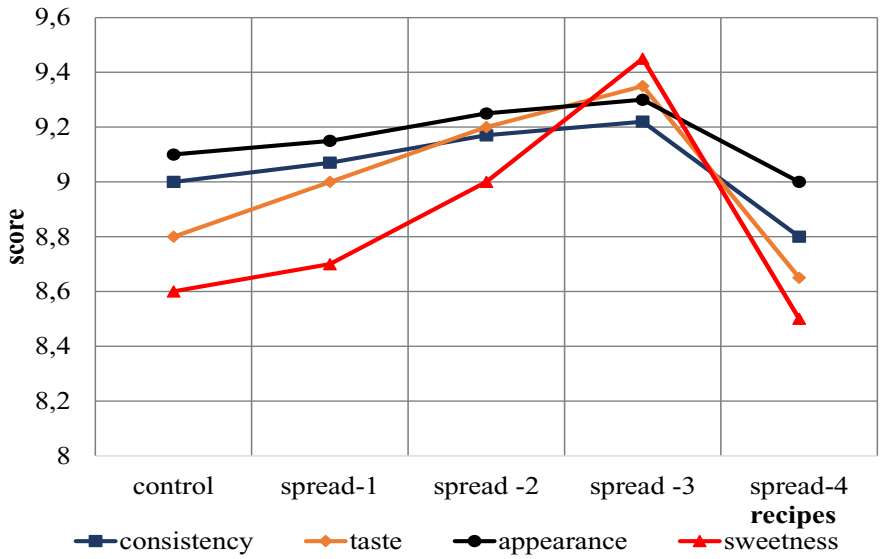

Fig. 1. Changes in organoleptic parameters of chocolate spreads prepared with different AEPF concentrations

Figure 1 shows varying evaluations of organoleptic parameters for spreads prepared according to Table 5 recipes. The consistency, appearance, taste, and sweetness of AEPF-containing spreads were superior to the control spread, with parameters increasing in the order: Spread-1 < Spread-2 < Spread-3. However, Spread-4 showed the lowest values across all parameters, rating below the control spread. Its sweetness and taste decreased significantly compared to other spreads, attributed to the use of persimmon fruit juice instead of sugar. These differences are also reflected in the water and total sugar content changes shown in Figure 2.

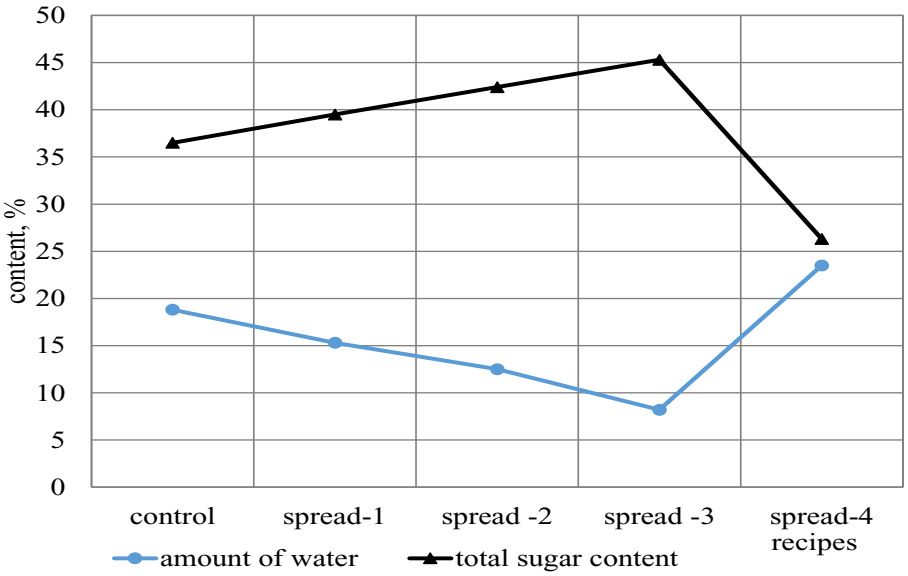

Fig. 2. Changes in water and total sugar content of AEPF-added spreads

Figure 2 indicates that the control spread contains 18.8% water and 36.5% total sugar. Spread-1 (AEPF replacing water) contains 15.3% water and 39.5% total sugar. Spread-2 and Spread-3 (concentrated AEPF) contain 12.5% and 8.2% water, and 42.4% and 45.3% total sugar, respectively. As AEPF concentration increased, water content decreased while sugar content increased. Spread-4, containing neither added sugar nor water, showed 23.5% water and 26.3% sugar content, thus higher water and lower sugar content than the control spread, resulting in decreased organoleptic properties.

To achieve chocolate spreads with organoleptic characteristics closer to the control spread, particularly in sweetness, new formulations were developed by varying AEPF and sugar mass fractions. Based on Spread-1 recipe, by reducing AEPF and increasing sugar, the optimal composition recipe Spread-5 was obtained. Based on Spread-2 and Spread-3 recipes, by reducing concentrated AEPF and increasing sugar, the optimal composition recipes Spread-6 and Spread-7 were obtained. Based on Spread-4 recipe, by reducing persimmon juice and water and increasing sugar, the optimal composition recipe Spread-8 was obtained. The new recipes are presented in Table 6.

Table 6. Optimal recipes of chocolate spreads with AEPF

№	The name of the components	Content (%)				
		control	Spread -5	Spread -6	Spread -7	Spread -8
1	Oil base	29,3	29,3	29,3	29,3	29,3
2	Sugar	32,2	30,2	25,2	18,2	15,2
3	Cocoa powder	8,5	8,5	8,5	8,5	8,5
4	Dry milk	11,5	11,5	11,5	11,5	11,5
5	Lecithin	0,3	0,3	0,3	0,3	0,3
6	Emulsifier	0,2	0,2	0,2	0,2	0,2
7	Water	18	0	0	0	10
8	AEPF	0	20	0	0	0
9	Conc. AEPF (DMC-39.32%)	0	0	25	0	0
10	Conc. AEPF (DMC -58.95%)	0	0	0	32	0
11	Syrup made from persimmon fruit	0	0	0	0	25

Table 6 shows that Spread-5, containing 30.2% sugar and 20% extract, achieved organoleptic parameters similar to the control spread. Comparable results were obtained with Spread-6, containing 25.2% sugar and 25% concentrated AEPF (DMC-39.32%), and Spread-7, containing 18.2% sugar and 32% concentrated AEPF (DMC-58.95%). Spread-8, made with persimmon fruit syrup, contained 15.2% sugar, 25% syrup, and 10% water.

AEPFs, like fruit juices, may be microbiologically unstable, which negatively affects the microbiological indicators of spreads containing them. Therefore, microbiological parameters of AEPF-containing chocolate spreads were analysed. The spreads were stored at 4°C for 3 months before checking their microbiological indicators. The results are presented in Table 7.

Table 7. Microbiological performance of chocolate spreads with added AEPF

№	Spread sample	Microbiological Indicators			
		BGKP (coliforms), at 0.01 g	Pathogenic microorganisms, including salmonella, at 25 g	Yeasts, COE/g	Mold fungi, COE/g
1	Control	not detected	not detected	less than 10	less than 10
2	spread-5	not detected	not detected	720	128

3	spread-6	not detected	not detected	580	101
4	spread-7	not detected	not detected	210	30
5	spread-8	not detected	not detected	100	less than 10

Table 7 data shows no microbiological changes in the control spread after 3 months of storage. However, the amounts of yeast and mold fungi in Spread-5 and Spread-6 with concentrated AEPF (DMS -39.32%) exceeded the limits specified in the "General Technical Regulation on the Safety of Oil Products." Microbiological changes were also detected in Spread-7 (with concentrated AEPF, DMS-58.95%) and Spread-8 (with persimmon fruit syrup), but the microorganism levels remained within regulatory standards. Microbiological analysis results indicate that Spread-5 and Spread-6 became unsuitable for consumption after 3 months of storage. The control spread, Spread-7, and Spread-8 remained microbiologically stable and are recommended for consumption. The microbiological instability of Spread-5 and Spread-6 during storage is attributed to AEPFs in their composition, providing a favourable nutrient medium for microorganisms.

The organoleptic characteristics, emulsion stability, oxidation stability, and physicochemical characteristics of chocolate spreads were also analysed during storage. Studies were conducted to examine the effect of AEPFs on chocolate spread emulsion stability. The spread emulsions were centrifuged, and stability was assessed based on phase separation degree. Results are presented in Figure 3.

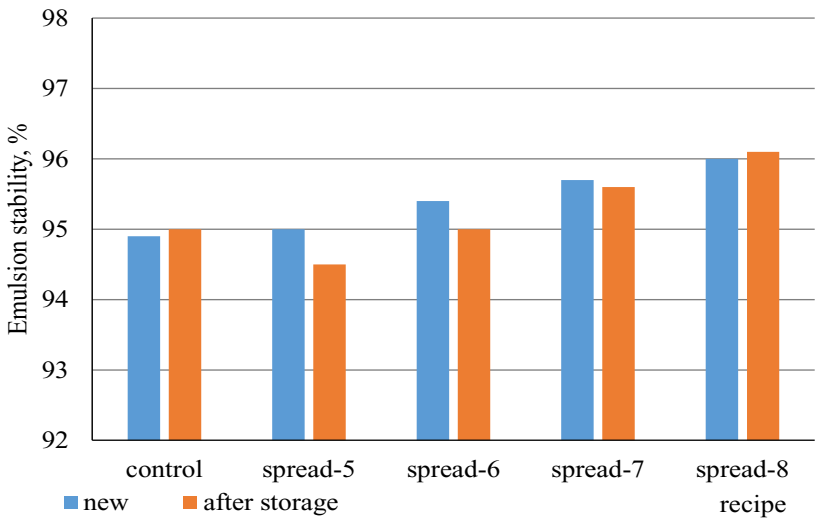

Fig. 3. Changes in emulsion stability of AEPF-containing chocolate spreads after storage.

Figure 3 demonstrates that adding AEPFs to chocolate spread recipes increased emulsion stability, attributed to the stabilizing properties of pectin, sugar, protein, and other substances in the extract. Stability increased with higher extract concentration. However, after 3 months of storage, this pattern changed. While emulsion stability increased in the control and chocolate spreads with added yeast, Spread-5 and Spread-6 showed decreased stability, while Spread-7 maintained relative stability. The decreased emulsion stability after storage is attributed to aqueous phase separation resulting from microbiological changes.

4 Conclusion

The results demonstrate that incorporating persimmon fruit extracts in chocolate spread recipes can reduce sugar content while maintaining taste and sweetness control. Key findings include:

- Chocolate spread can be successfully produced using various concentrations of aqueous persimmon fruit extracts
- Sugar content was reduced from 32.2% to 15.2% by replacing water with AEPFs, depending on extract concentration
- Chocolate spreads prepared with aqueous persimmon fruit extracts showed microbiological instability during storage, with only high-concentration extract or spread proving effective
- Enhanced emulsion stability was achieved when using concentrated extract or spread instead of water

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