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Article

Physical and Chemical Properties of Fat-Free Yogurt Enriched with Various Fruit Seed Extracts

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Abstract: This study investigated the physicochemical properties of non-fat yogurt produced with 0.5% fruit seed extracts, including those from date, rosehip, black grape, pomegranate, and grapefruit. The analysis focused on the yogurt samples' pH, titration acidity, total phenolic compound, and antioxidant capacity using various methods (DPPH, ABTS, CUPRAC, and FRAP) and sensory analysis. The results revealed that the functional properties of yogurt could be enhanced by adding fruit seed extracts, with black grape seed extract showing a particularly positive effect on the phenolic components. Moreover, adding date palm seed extract and rosehip seed extract resulted in higher DPPH radical scavenging activity than the other samples. Based on the CUPRAC and FRAP methods, yogurt with date seed extract exhibited the highest antioxidant activity. In contrast, the ABTS method indicated that the yogurt samples containing black grape seed extract and rosehip seed extract exhibited the most significant antioxidant activity. Overall, the antioxidant activity of the yogurt samples with added fruit seed extracts was significantly higher than that of the control sample. Additionally, differences in antioxidant activity among the yogurt samples were observed based on the method used for measurement. This study indicates that yogurt can be developed as a functional product featuring bioactive components, such as antioxidants and phenolics, by enhancing its technological properties by incorporating fruit seed extracts.

Keywords: yogurt; fruit seed extract; date; rose hip; black grape; pomegranate; grapefruit; total phenolic; antioxidant capacity; sensory analysis

1. Introduction

Yogurt is a dairy product produced with or without sugar and is obtained as a result of fermentation using bacterial cultures. The bacterial cultures used in fermentation convert lactose into lactic acid and other derivatives. Therefore, fermented products are considered to have a higher nutritional value compared to their raw materials. Although yogurt is similar to milk in terms of its chemical composition, it is known to be more nutritious than milk due to the increased dry matter ratio during production. Although the chemical composition of yogurt varies depending on the type of milk and the technological processes applied, it generally consists of 80-86% water, 14-20% dry matter, 2-8% fat, 4-8% protein, 2-5% milk sugar, 0.8-1.2% mineral substances [1].

With the formation and increase in consumers' awareness of healthy nutrition, different expectations have come to the agenda in addition to meeting basic nutritional needs. In particular, the findings that excessive fat consumption leads to various health problems and the recommendations of nutritionists to reduce animal fat consumption have led manufacturers to produce foods with reduced fat [2]. In recent years, there has been a significant increase in the consumption of functional foods in Turkey. The demand for functional food products has also increased, especially with consumers' awareness of healthy living. For this reason, many companies have started to increase the production of functional foods [3]. Still, it has been observed that some deficiencies in taste, aroma, and textural properties of low-fat and/or fat-free yogurts have been

observed due to the decrease in fat content [4, 5, 6, 7]. A critical method has been used in low-fat and fat-free yogurt production to overcome these deficiencies and increase the amount of dry matter. However, recent studies suggest using substances that increase fat stability to overcome these problems [2]. The literature review on yogurt shows that functional studies have been carried out to improve the nutritional quality and give different properties to yogurt with new techniques [8]. Recently, yogurts flavored with fruit or fruit seeds have started to be produced in Turkey and the world to increase yogurt's consumption and nutritional value. Consumers prefer yogurt not only for its bioavailability of essential nutrients but also for its wide variations in texture, taste, and content profiles [9]. Numerous scientific and clinical studies support the benefits of fermented dairy products for human health. These studies indicate that fermented dairy products have an innovative dimension [10]. Generally, yogurt is enriched with omega-3 fatty acids [11], phytosterols [12], and antioxidant food ingredients such as green and black teas [13], herbal extracts [14, 15], fibers [16], and fruit seeds [17].

Many studies have been conducted from the past to the present to benefit from the positive effects of phenolic compounds on human health and to understand the interactions of these compounds with other molecules. Phenolic compounds show hydrophobic and hydrophilic interactions due to aromatic rings and hydroxyl groups in their structures and can bind to fats, proteins, and cell walls through various interactions. Fruits and vegetables, in particular, contain high amounts of phenolic compounds [18]. Phenolic compounds are of great interest today due to their antioxidant properties. However, they also have antiallergic, anti-inflammatory, antidiabetic, antimicrobial, antipathogenic, antiviral, and antithrombotic properties. In addition, phenolic compounds have protective effects against cardiovascular diseases, cancer, osteoporosis, and diabetes [19]. This study aimed to increase the amount of phenolic compounds naturally present in fruit seeds by adding various fruit seed extracts before yogurt fermentation, increase the amount of phenolic substances in yogurt by various interactions occurring during the yogurt production process, and determine the changes in chemical and physical quality parameters and sensory properties of fermented fat-free yogurt enriched with different fruit seed extracts.

2. Materials and Methods

2.1. Materials

In this study, the thermophilic YoFlex® company supplied the CHR-Hansen culture and contained *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus* bacterial strains were used as starter cultures in yogurt production. In addition, date palm seed extract was purchased from İzmit Can Şifa, rosehip seed extract was purchased from Istanbul Ayhan Ercan, black grape seed extract was purchased from Istanbul Arifoğlu Baharat ve Gıda San. Ltd. Şti, pomegranate seed extract from Germany Natur Foods, grapefruit seed extract from Istanbul BioFenast and skim milk powder from Enka Süt ve Gıda Mam. San. Tic. A.Ş. Yogurt production was conducted at Balıkesir Milk Producer Association Food Control and Analysis Laboratory.

While creating the trial samples, ten different (0.1%, 0.2%, 0.3%, 0.3%, 0.4%, 0.5%, 0.5%, 0.6%, 0.7%, 0.8%, 0.9%, 1.0%) amounts of fruit seed extract were tested separately for each variety. After sensory controls, pH and SH values were evaluated, and 0.5% fruit extract was added. During yogurt production, three replicates were used as control samples (C): yogurt sample with 0.5% date seed extract (DS), yogurt sample with 0.5% pomegranate seed extract (PS), yogurt sample with 0.5% rosehip seed extract (RS). Eighteen yogurt samples were made from reconstituted milk with a dry matter content of approximately 11.5% w/w, including a yogurt sample with 0.5% black grape seed extract (BG) and a yogurt sample with 0.5% grapefruit seed extract (GS). During yogurt production, the milk was heated at 90°C for 10 minutes, then cooled to 42°C, and 0.5% fruit seed extracts were added to 5 samples except the control sample. After adding 2% *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus* yogurt culture to all samples, the samples were incubated at 42°C until pH 4.6 was reached. After the incubation period was completed, the yogurts were brought to room temperature (20°C) and stored in cold storage at 4±1°C. During the storage period, pH and titration acidity were determined on days 1, 7, 14, and 21. In addition, total phenolic matter,

antioxidant capacity analysis (DPPH (2,2-Diphenyl-2-picrylhydrazyl), CUPRAC, FRAP, and ABTS methods), and sensory analysis were performed on each yogurt sample.

Titration acidity (% lactic acid equivalent) was determined by titrating with 0.1 N NaOH and using a Hanna HI11310 pH digital pH meter. The total phenolic compound was determined in yogurt samples using a modified microscale Folin Ciocalteu method. The results were evaluated using a gallic acid (GA) calibration curve and reported as mg GA/100 g. Antioxidant activity assays were performed by DPPH (2,2-Diphenyl-1-picrylhydrazyl), CUPRAC (Cupric Reducing Antioxidant Capacity), ABTS [(2,2-azino-di-(3-) ethylbenzothialosin-sulfonic acid)], FRAP (Ferric Reducing Antioxidant Power) method. After producing yogurts enriched with fruit seed extract at ten different concentrations during preliminary trials, it was concluded that 0.5% extract provided the best sensory properties. Six yogurt samples were created using five different fruit seed extracts and a control sample and were presented to experienced panelists for sensory evaluation. The yogurt samples were randomly coded and presented to the panelists randomly. The samples were served with water and bread in well-lit conditions and evaluated using a 9-point hedonic scale, where the most liked yogurt sample received 9 points, and the least liked one received 1 point. The evaluation focused on various attributes: color, odor, taste, consistency, coagulation, serum separation, coarseness, citrus flavor, acetaldehyde aroma, granular structure, overall acceptability, and homogeneity.

2.2. Statistical Analysis

Statistical analyses were carried out according to the "Factorial Experiment Plan in Coincidence Plots" ($5 \times 4 \times 3$) (Fruit Seed Extract Type x Storage Time x Repetition). The data obtained in the study were analyzed using SPSS Statistics (Statistical Package for Social Sciences) for Windows 25.0. Descriptive statistical methods (median, mean, and standard deviation) were used to evaluate the data. The Shapiro–Wilk test was used to test whether the variables were suitable for normal distribution. According to the results of the Shapiro–Wilk test, it was determined that the variables did not show normal distribution, and accordingly, nonparametric tests were preferred. The Kruskal–Wallis test was applied to compare two or more independent groups, and the Friedman test was applied to compare two or more dependent stages. In cases where differences were detected, significance was tested using Bonferroni, a post hoc pairwise comparison method.

3. Results and Discussion

Lactic acid bacteria have an important place in food technology. They are known to be responsible for forming aroma and texture in the foods they are involved in. On the other hand, they are of particular importance to human health due to their ability to inhibit the development of some pathogens in foods [20]. Most lactic acid bacteria are microbial agents found in natural environments where humans and animals live, as well as in plant environments. They can be isolated from these environments and used in biotechnological studies and many industrial fields. *Streptococcus thermophilus* (S. thermophilus) and *Lactobacillus delbrueckii subsp. bulgaricus* are the main lactic acid bacteria generally used as yogurt starter bacteria and responsible for yogurt production [21]. During yogurt fermentation, metabolic activity is very high; when the incubation period is completed and the yogurt is allowed to cool at storage temperature, the number of lactic acid increases, and the pH value decreases [22]. These changes are essential to incubation temperature, storage temperature, and fermentation time [23, 24]. In addition, lactic acid value has an important place in terms of yogurt's aroma, taste, and flavor characteristics [25].

In our study, the pH values of the yogurt samples ranged between 4.17 and 4.68. The lowest value was 4.18 on the 21st day of the storage period in the yogurt sample with grapefruit seed extract, and the highest value was 4.68 on the 7th day of the storage period in the yogurt sample with date seed extract (Table 1). In previous studies, the pH value of yogurt generally varies between 4 and 4.46, while the titration acidity is known to be in the range of 0.6-1.5% as an acceptable value [22,24,26]. The titration acidity values of the yogurt samples varied between 0.95%-1.45 (%) and the highest value was 1.45 (%) in the yogurt sample with grapefruit seed extract at the end of the 21st day of storage, while the lowest value was 0.95 (%) in the yogurt sample with date seed extract at the

end of the 1st day of storage. As a result, the yogurt samples' pH and titration acidity values differed between the control and fruit-extracted yogurts during the storage period. It is seen that there is a statistically significant difference between the pH and titration acidity values on the 1st, 7th, 14th, and 21st day of storage of 6 different samples: pomegranate seed extracted, black grape seed extracted, date seed extracted, grapefruit seed extracted, rosehip seed extracted and control ($p<0.05$).

Ibrahim et al. [27] showed that the pH values of yogurt samples with pomegranate seeds addition decreased, and titration acidity values increased during 21 days of storage. Similarly, Bchir et al. [28] found that the pH of yogurt samples with pomegranate seeds decreased, and titration acidity values increased during 28 days of storage. Felix da Silva et al. [29] found that the pH value increased from 4.63 to 4.65, and titration acidity decreased from 92.70 to 92.10 during the fermentation period of yogurt samples with grape seed addition. Abdollahzadeh et al. [30] observed that the pH value decreased and titration acidity increased during the 14-day storage period in yogurt samples with palm seeds addition. Qin et al. [31] reported that grapefruit-added yogurt samples had lower pH and higher titration acidity than control samples. Şahingil and Hayaloğlu [32] found that the pH values of yogurt samples with rosehip pulp addition decreased, and titration acidity values increased during the 15-day storage period.

Guggisberg et al. [33] examined the effects of inulin addition to yogurt samples with different fat contents on the chemical composition, pH, textural and microstructural properties of yogurt, and it was found that the addition of inulin to yogurt samples during the 6-day storage period had a significant effect on sensory analysis and rheological properties. In addition, while no significant difference was detected in pH values in yogurt samples, it was reported that the effect of inulin on microstructure may result from protein-protein interaction consisting of milk proteins Guggisberg et al. [34] examined sugar changes in yogurt set with stevia and stevia or palatinose in combination with twilight. They found that adding sweeteners did not negatively affect the yogurt-making process or pH development. The study determined no difference in the sensory analysis of sweetener-added samples.

In contrast to our study, Hassan et al. [34] investigated the physicochemical properties of yogurt by incorporating guar gum and cress seed mucilage. There was no significant difference in pH values on the 1st, 5th, 10th, and 15th days; however, the concentration of acetaldehyde, one of the taste components, increased during storage. As a result, similar to the studies in the literature, it was concluded that the pH values of yogurt samples with pomegranate, grape, date, grapefruit, and rosehip seed extracts decreased, and titration acidity values increased during the storage period (Table 1).

Table 1. The analysis of the yogurt samples obtained pH and titration acidity values.

Variable	Yogurt Type	1			7			14			21			Test Value	P	Bonferroni
		Med	$\bar{X}$	SD	Med	$\bar{X}$	SD	Med	$\bar{X}$	SD	Med	$\bar{X}$	SD			
pH	C	4.60	4.60 ^{ab}	0.03	4.53	4.53 ^{ab}	0.02	4.51	4.51 ^{ab}	0.02	4.44	4.43 ^{ab}	0.02	8.200***	0.042*	1>21
	PS	4.47	4.48 ^{bc}	0.03	4.47	4.47 ^{bc}	0.02	4.31	4.31 ^{bc}	0.02	4.33	4.33 ^{bc}	0.02	8.200***	0.042*	7>14
	BGS	4.28	4.28 ^c	0.06	4.31	4.31 ^c	0.01	4.35	4.35 ^{bc}	0.02	4.26	4.27 ^{bc}	0.02	7.000***	0.072	
	DS	4.59	4.59 ^{ab}	0.03	4.68	4.68 ^a	0.02	4.64	4.64 ^a	0.04	4.69	4.69 ^a	0.04	6.600***	0.086	
	GS	4.43	4.43 ^{ba}	0.02	4.35	4.35 ^{bc}	0.02	4.22	4.21 ^c	0.05	4.17	4.18 ^c	0.02	8.200***	0.042*	1>21
	RS	4.64	4.64 ^a	0.03	4.56	4.56 ^{ab}	0.02	4.46	4.47 ^{ab}	0.03	4.45	4.45 ^{ab}	0.04	8.200***	0.042*	1>21
	Test value	15.596**			16.392**			16.309**			16.249**					
	p	0.008*			0.006*			0.006*			0.006*					
	Bonferroni	6>3			4>3			4>5			4>5					
Titration Acidity (%)	C	1.02	1.03 ^{bc}	0.03	1.08	1.08 ^{bc}	0.01	1.10	1.09 ^{bc}	0.03	1.16	1.17 ^{bc}	0.02	8.200***	0.042*	21>1
	PS	1.17	1.17 ^{ab}	0.02	1.16	1.16 ^{ab}	0.02	1.19	1.19 ^{bc}	0.02	1.23	1.23 ^{ab}	0.02	5.444***	0.142	
	BGS	1.27	1.27 ^a	0.02	1.27	1.27 ^a	0.03	1.36	1.36 ^a	0.01	1.39	1.39 ^{ab}	0.02	8.143***	0.043*	21>1, 21>7
	DS	1.03	1.03 ^{bc}	0.03	0.97	0.97 ^c	0.02	0.98	0.98 ^c	0.01	0.95	0.95 ^c	0.02	7.000***	0.072	

GS	1.04	1.04 ^{bc}	0.02	1.29	1.29 ^a	0.03	1.34	1.33 ^{ab}	0.02	1.45	1.45 ^a	0.02	8.200***	0.042*	21>1
RS	0.99	0.99 ^c	0.01	1.06	1.06 ^{bc}	0.01	1.12	1.12 ^{bc}	0.02	1.16	1.16 ^{bc}	0.02	9.000***	0.029*	21>1
Test value	14.693**			16.075**			16.350**			16.145**					
p	0.012*			0.007*			0.006*			0.006*					
Bonferro ni	3>6			3>4, 5>4			3>4			5>4					

*p < 0.05, **Bonferroni test, C: Control, PS: fat-free yogurt with 0.5% Pomegranate Seed, BGS: fat-free yogurt with 0.5% Black Grape Seed, DS: fat-free yogurt with 0.5% Date Seed, GS: fat-free yogurt with 0.5% Grapefruit Seed, RS: fat-free yogurt with 0.5% Rosehip Seed.

In our study, when the total phenolic compound values of the control and 0.5% fruit seed-extracted yogurt samples were examined, the highest total phenolic compound value was 215,22 mg GAE/kg in yogurt with black grape seed extract, and the lowest value was 52,11 mg GAE/kg in the control sample. The total phenolic compound of the yogurt with rosehip seed extract, yogurt with date seed extract, yogurt with grapefruit seed extract, yogurt with pomegranate seed extract, yogurt with grapefruit seed extract, yogurt with pomegranate seed extract, and yogurt with grape seed extract, respectively, from the lowest to the highest total phenolic compound, and there was a statistically significant difference between the total phenolic compound values (p<0.05). As a result, it is seen in Table 2 that the addition of fruit seed extract from yogurt varieties increased the total phenolic compound 3-4 times compared to the control yogurt variety.

Similar to our study, Mercan et al. (2018) examined the effects of different concentrations of grape seed addition on the development of starter bacteria in yogurt samples and their physicochemical, texture, and sensory properties during 21 days of storage. They found that yogurt samples with grape seed addition had significantly higher total phenolic compounds than control samples [35]. Yadav et al. (2017) also examined the physicochemical properties, total phenol compound, and antioxidant activity of yogurt samples with encapsulated and non-encapsulated grape seed extract. They found that yogurt samples with encapsulated and non-encapsulated grape seed extract had higher total phenol compounds and antioxidants than control yogurt samples. In addition, the total phenolic compound of encapsulated yogurt samples increased three-fold, and antioxidant activity increased four-fold [36].

Table 2. Total phenolic compound values obtained as a result of the analysis applied to yogurt sample.

Variable	Yogurt Type	Med	<u>X</u>	SD	Test Value	p	Bonferroni
TPC	C	52.11	52.11 ^c	2.93	16.579**	0.005*	3 > 1
	PS	201.19	201.19 ^{ab}	0.32			
	BGS	215.22	215.22 ^a	1.46			
	DS	156.56	156.56 ^{bc}	3.22			
	GS	186.43	186.43 ^{ab}	6.96			
	RS	114.21	114.21 ^{bc}	3.83			

*p < 0.05, **Bonferroni test, TPC: Total phenolic compounds, C: Control, PS: fat-free yogurt with 0.5% Pomegranate Seed, BGS: fat-free yogurt with 0.5% Black Grape Seed, DS: fat-free yogurt with 0.5% Date Seed, GS: fat-free yogurt with 0.5% Grapefruit Seed, RS: fat-free yogurt with 0.5% Rosehip Seed.

In our study, when examined using the DPPH radical scavenging activity method, the highest value was determined in 41/.21 mg/100 mL yogurt with date seed extract addition. The lowest value was determined in the 14.37 mg/100 mL control sample. When the antioxidant activity value was analyzed by the CUPRAC method, the highest value was determined in 42.73 mg/100 mL yogurt with date seed extract addition, and the lowest value was determined in the 18.44 mg/100 mL control sample. When the antioxidant activity value was evaluated using the FRAP method, the highest value

was determined in 60.05 mg/100 mL yogurt with date seed extract addition, and the lowest value was measured in a control sample of 6.29 mg/100 mL. When the antioxidant activity values were calculated using the ABTS method, the highest value was 31.56 mg/100 mL in the yogurt sample with rosehip seed extract. The lowest value was 13.13 mg/100 mL in the control sample. When the antioxidant activity value was analyzed statistically, it was seen that there was a statistically significant difference between the yogurt varieties, DPPH, CUPRAC, FRAP, and ABTS methods ($p<0.05$). According to the DPPH method, the antioxidant activity value was statistically higher in yogurt with date seed extract and rosehip seed added yogurt compared to other samples. According to CUPRAC and FRAP methods, the amount of antioxidant activity was statistically higher in the yogurt sample with date seed extract addition. According to the ABTS method, the amount of antioxidant activity was statistically higher in the yogurt sample with black grape seed extract addition and in the yogurt sample with rosehip seed extract addition. As a result, it is seen in Table 3 that the addition of fruit seed extract from yogurt varieties increased the amount of antioxidant activity 2-3 times compared to the control yogurt variety.

Van Nieuwenhove et al. [17] examined the pH value and antioxidant capacity values of pomegranate and jacaranda seed-added yogurt samples using the DPPH method; no significant difference was found in pH analysis in control, pomegranate, and jacaranda seed-added yogurt samples. As a result of antioxidant analysis by the DPPH method, statistically significant differences were reported between all samples, but no change was found in antioxidant levels according to storage time. The antioxidant values of the samples were listed as pomegranate seed, jacaranda seed, and control sample.

Akan [37] investigated the antioxidant activity capacity of blackberry and oat bran in addition to probiotic yogurt by different methods. DPPH, ABTS, and CUPRAC methods were used to examine the antioxidant activity during the 21st day of storage, and it was found that storage time had no significant effect on the amount of antioxidants. In addition, antioxidant activity capacity was evaluated between the methods, and it was observed that there was a difference between the methods that were similar to our study. Similar to our study, Lejko et al. [38] examined the acidity, antioxidant value, and sensory properties of yogurts enriched with various vegetables (carrot, pumpkin, broccoli, red pepper) and in the light of their study when the samples were compared during the storage period, a decrease in pH value and an increase in titration acidity were observed during the storage period. Compared to the control sample, the antioxidant capacity value was lower in carrot and pumpkin-enriched yogurts and higher in broccoli and red-pepper-enriched yogurts.

Table 3. Antioxidant capacity values obtained as a result of the analysis applied to yogurt sample.

Variable	Yogurt Type	Med.	$\bar{X}$	SD	Test Value	p	Bonferro ni
Antioxidant capacity DPPH (% Inhibition rate)	C	14.37	14.44 ^c	0.51	15.409**	0.009*	4 > 1, 6 > 1
	PS	21.32	22.17 ^{bc}	3.04			
	BGS	31.22	31.58 ^{ab}	1.94			
	DS	41.21	40.81 ^a	1.56			
	GS	22.32	22.92 ^{bc}	1.54			
	RS	39.63	38.23 ^a	5.61			
Antioxidant capacity CUPRAC (mg/100 mL)	C	18.44	18.42 ^c	0.06	13.304**	0.021*	4 > 1
	PS	37.24	37.50 ^{bc}	5.68			
	BGS	32.46	31.93 ^{bc}	1.63			
	DS	42.73	41.67 ^a	2.90			
	GS	32.63	31.75 ^{bc}	2.27			
	RS	42.56	42.26 ^{ab}	1.78			
Antioxidant capacity FRAP (mg/100 mL)	C	6.29	6.27 ^c	0.05	15.690**	0.008*	4 > 1
	PS	21.17	21.68 ^{bc}	2.75			
	BGS	29.83	29.90 ^{bc}	2.28			

Antioxidant capacity ABTS (mg/100 mL)	DS	60.05	60.38 ^a	0.74	15.784**	0.007*	3 > 1.6 > 1
	GS	57.23	55.55 ^{ab}	3.90			
	RS	59.36	59.33 ^{ab}	8.15			
	C	13.13	13.12 ^c	0.07			
	PS	25.35	26.19 ^{ab}	3.36			
	BGS	31.14	31.52 ^a	1.09			
	DS	21.17	20.85 ^{ab}	1.50			
	GS	19.78	19.33 ^{ab}	2.07			
	RS	31.56	31.85 ^a	1.80			

*p<0.05, **Bonferroni test, C: Control, PS: fat-free yogurt with 0.5% Pomegranate Seed, BGS: fat-free yogurt with 0.5% Black Grape Seed, DS: fat-free yogurt with 0.5% Date Seed, GS: fat-free yogurt with 0.5% Grapefruit Seed, RS: fat-free yogurt with 0.5% Rosehip Seed.

This study examined the sensory properties of yogurt samples. A total of thirteen experienced panelists participated in the sensory evaluations. Panelists conducted the sensory test by tasting yogurt samples on the 1st, 7th, 14th, and 21st day. Panelists evaluated yogurt samples based on twelve criteria: color, odor, taste, consistency, coagulation, serum separation, coarseness, citrus taste, acetaldehyde aroma, granular structure, homogeneity, and general acceptability. The panelists evaluated the yogurt samples on a scale from 1 to 9, where 1 indicated poor quality, and 9 indicated excellent quality. The data were tabulated by averaging the evaluations. The sensory test of the control sample on the 7th day received the highest overall acceptability rating. The evaluation of yogurt samples, as presented in Tables 4 and 5, reveals a statistically significant difference (p <0,05) in several attributes, including color, odor, taste, consistency, coagulation, serum separation, lumpiness, citrus flavor, acetaldehyde aroma, granular structure, overall acceptability, and homogeneity.

Table 4. Sensory analysis values (color, odor, taste, consistency, coagulation, serum separation) were obtained as a result of the analysis applied to yogurt samples.

Variable	ST	Color	Odor	Taste	Consistency	Coagulation	Serum Separation
C	1st	8.46±0.09 ^b	8.84±0.19 ^a	8.84±0.19 ^a	8.76±0.25 ^a	8.41±0.02 ^a	8,49±0,10 ^b
	7th	8.65±0.56 ^a	8.61±0.40 ^a	8.90±0.67 ^a	8.61±0.51 ^b	8.33±0.31 ^a	8,41±0,26 ^b
	14th	8.73±0.64 ^a	8.53±0.32 ^a	8.76±0.51 ^b	8.69±0.59 ^a	8.46±0.44 ^a	8,76±0,61 ^a
	21st	8.62±0.53 ^a	8.76±0.55 ^a	8.61±0.36 ^{ab}	8.53±0.43 ^b	8.30±0.28 ^a	8,61±0,46 ^a
PS	1st	8.08±0.01 ^c	8.25±0.04 ^c	7.69±0.56 ^c	8.33±0.23 ^b	8.41±0.39 ^a	8,46±0,31 ^b
	7th	8.25±0.16 ^b	8.07±0.14 ^c	7.61±0.64 ^d	8.38±0.28 ^b	8.25±0.23 ^a	8,92±0,77 ^a
	14th	8.53±0.44 ^a	8.15±0.06 ^c	7.84±0.41 ^d	8.15±0.05 ^b	8.25±0.23 ^a	8,76±0,61 ^a
	21st	8.15±0.06 ^b	8.07±0.14 ^c	7.53±0.72 ^d	8.23±0.13 ^b	8.07±0.05 ^b	8,69±0,54 ^a
BGS	1st	7.61±0.48 ^c	8.46±0.25 ^b	8.38±0.13 ^{bc}	7.84±0.26 ^c	7.92±0.10 ^b	7,69±0,46 ^d
	7th	7.46±0.63 ^c	8.61±0.40 ^a	8.53±0.28 ^b	7.53±0.57 ^c	7.84±0.18 ^b	7,76±0,39 ^d
	14th	7.38±0.71 ^c	8.25±0.04 ^c	8.61±0.36 ^b	7.61±0.49 ^c	7.61±0.41 ^c	7,61±0,54 ^d
	21st	7.46±0.63 ^c	8.33±0.12 ^c	8.33±0.08 ^{bc}	7.15±0.95 ^c	7.53±0.49 ^b	7,53±0,62 ^d
DS	1st	7.46±0.63 ^c	7.53±0.68 ^e	8.25±0.00 ^{bc}	7.61±0.49 ^c	7.53±0.49 ^b	7,84±0,31 ^d
	7th	7.61±0.48 ^c	7.61±0.60 ^e	8.31±0.06 ^{bc}	7.84±0.26 ^c	7.30±0.72 ^c	7,91±0,24 ^d
	14th	7.69±0.40 ^c	7.46±0.75 ^d	8.38±0.13 ^{bc}	7.69±0.41 ^c	7.07±0.95 ^c	8.08±0.07 ^c
	21st	7.53±0.56 ^c	7.38±0.83 ^e	8.46±0.21 ^b	7.74±0.36 ^c	7.23±0.79 ^c	8.25±0.10 ^c
GS	1st	8.15±0.06 ^b	7.92±0.29 ^e	7.84±0.41 ^d	8.33±0.23 ^b	8.07±0.05 ^b	7.76±0.39 ^d
	7th	8.23±0.14 ^b	8.07±0.14 ^d	8.38±0.13 ^{bc}	8.46±0.36 ^b	8.46±0.44 ^a	7.84±0.31 ^d
	14th	8.07±0.02 ^c	7.84±0.37 ^d	8.25±0.00 ^{bc}	8.15±0.05 ^b	8.15±0.13 ^b	7.46±0.69 ^d
	21st	8.08±0.01 ^c	7.76±0.45 ^e	8.46±0.21 ^b	8.25±0.15 ^b	8.25±0.23 ^a	7,61±0,54 ^d
RS	1st	8.53±0.44 ^c	8.84±0.63 ^a	8.07±0.18 ^d	8.15±0.05 ^b	8.46±0.44 ^a	8,38±0,23 ^d
	7th	8.61±0.52 ^a	8.61±0.40 ^a	8.46±0.21 ^b	8.38±0.28 ^b	8.15±0.13 ^b	8,53±0,38 ^b
	14th	8.46±0.37 ^a	8.53±0.32 ^b	7.92±0.33 ^d	8.07±0.03 ^b	8.25±0.23 ^a	8,15±0,00 ^c
	21st	8.41±0.32 ^a	8.46±0.25 ^b	7.61±0.64 ^d	7.84±0.26 ^c	8.07±0.05 ^b	8,07±0,08 ^c

Test Value	20.425**	20.791**	17.230**	19.704**	17.485**	20.041**
P	0.001*	0.001*	0.004*	0.001*	0.004*	0.001*
Bonferronni	1>3. 1>4. 6>3	1>4. 6>4	1>2	1>3. 1>4	1>4	2>3. 2>5
Med	8.09	8.20	8.25	8.09	8.01	8.14
$\bar{X}$	8.15	8.25	8.35	8.15	8.15	8.11

*p<0,05, ** Kruskal Wallis test, C: Control, ST: Storage Time, PS: fat-free yogurt with 0.5% Pomegranate Seed, BGS: fat-free yogurt with 0.5% Black Grape Seed, DS: fat-free yogurt with 0.5% Date Seed, GS: fat-free yogurt with 0.5% Grapefruit Seed, RS: fat-free yogurt with 0.5% Rosehip Seed.

Table 5. Sensory analysis values (roughness, citrus taste, acetaldehyde aroma, granular structure, general acceptability, homogeneity) were obtained as a result of the analysis applied to yogurt samples.

Variable	ST	Roughness Citrus		Acetaldehyde	Granular	Homogeneity General	
e	s	Taste		Aroma	Structure	Acceptability	
C	1st	8.53±0.26 ^a	7.92±0.85 ^b	8.69±0.02 ^{ab}	7.23±0.70 ^d	8.76±0.30 ^a	8.84±0.08 ^a
	7th	8.76±0.13 ^a	7.53±0.63 ^a	8.71±0.29 ^a	7.69±0.10 ^{bc}	8.84±1.12 ^a	8.92±0.53 ^a
	14th	8.69±0.06 ^{ab}	6.92±1.24 ^c	8.84±0.42 ^a	7.07±0.52 ^d	8.69±0.97 ^a	8.76±0.37 ^{ab}
	21st	8.30±0.37 ^c	7.23±0.93 ^b	8.76±0.34 ^a	7.23±0.36 ^d	8.61±0.89 ^a	8.69±0.30 ^{ab}
PS	1st	8.46±0.26 ^c	8.53±0.37 ^a	8.38±0.04 ^{bc}	7.92±0.33 ^{ab}	7.61±0.11 ^d	8.46±0.07 ^b
	7th	8.53±0.42 ^{bc}	8.46±0.60 ^a	8.46±0.04 ^{bc}	8.07±0.48 ^a	7.76±0.04 ^c	8.69±0.30 ^a
	14th	8.61±0.34 ^{bc}	8.76±0.53 ^a	8.53±0.96 ^{ab}	8.00±0.41 ^a	7.92±0.20 ^c	8.38±0.01 ^{ac}
	21st	8.46±0.49 ^c	8.69±0.30 ^a	8.61±1.05 ^{ab}	7.61±0.02 ^{cd}	7.23±0.49 ^d	8.31±0.08 ^c
BGS	1st	8.76±0.34 ^{ab}	8.46±0.37 ^a	8.00±1.35 ^c	7.30±0.29 ^d	6.84±0.88 ^d	7.92±0.47 ^d
	7th	8.92±0.29 ^a	8.53±0.45 ^a	8.07±1.13 ^c	7.23±0.36 ^d	6.92±0.80 ^d	8.00±0.39 ^c
	14th	8.84±0.11 ^a	8.61±0.22 ^a	8.46±0.02 ^{bc}	7.69±0.10 ^{bc}	6.76±0.96 ^d	7.61±0.78 ^d
	21st	8.76±0.19 ^a	8.38±0.69 ^a	8.38±0.04 ^{bc}	7.15±0.44 ^d	6.46±1.26 ^d	7.69±0.70 ^d
DS	1st	8.84±0.42 ^a	7.69±1.01 ^b	8.31±0.15 ^c	7.53±0.06 ^{cd}	7.07±0.65 ^d	8.15±0.24 ^c
	7th	8.76±0.57 ^{ab}	7.30±1.54 ^b	8.46±0.20 ^{bc}	7.15±0.44 ^d	7.15±0.57 ^d	8.07±0.32 ^c
	14th	8.69±0.03 ^{bc}	7.23±1.0 ^b	8.53±0.67 ^{ab}	7.23±0.36 ^d	6.92±0.80 ^d	7.96±0.43 ^d
	21st	8.61±0.50 ^{bc}	7.15±1.50 ^b	8.07±0.99 ^c	7.53±0.06 ^{cd}	6.84±0.88 ^d	8.15±0.24 ^c
GS	1st	8.53±0.04 ^{bc}	8.46±0.23 ^a	8.53±1.81 ^{ab}	8.07±0.48 ^a	7.76±0.04 ^c	8.46±0.07 ^b
	7th	8.46±0.34 ^c	8.53±0.26 ^a	8.46±1.55 ^{bc}	8.00±0.41 ^a	8.07±0.35 ^c	8.53±0.14 ^b
	14th	8.69±0.19 ^{bc}	8.38±0.31 ^a	8.69±0.15 ^{ab}	8.15±0.56 ^a	7.53±0.19 ^c	8.61±0.22 ^b
	21st	8.76±0.12 ^{ab}	8.31±0.08 ^a	8.46±0.28 ^b	7.92±0.33 ^{ab}	7.92±0.20 ^c	8.69±0.30 ^{ab}
RS	1st	8.53±0.34 ^{bc}	8.76±0.59 ^a	8.07±0.99 ^c	7.61±0.02 ^{cd}	8.31±0.59 ^c	8.76±0.37 ^{ab}
	7th	8.30±0.50 ^c	8.84±0.65 ^a	8.38±0.81 ^{bc}	7.53±0.06 ^{cd}	8.53±0.81 ^c	8.69±0.30 ^{ab}
	14th	8.61±0.88 ^{bc}	8.69±0.48 ^a	7.92±0.50 ^c	7.69±0.10 ^{bc}	8.46±0.74 ^b	8.61±0.22 ^{ab}
	21st	8.69±0.34 ^{bc}	8.53±0.28 ^a	8.31±0.23 ^c	7.76±0.17 ^{bc}	8.38±0.66 ^c	8.46±0.07 ^b
Test Value		12.026**	18.943**	16.499**	19.948**	21.608**	19.754**
P		0.034*	0.002*	0.006*	0.001*	0.001*	0.001*
Bonferronni		3>2	6>1. 6>4	1>3. 1>6	1>3. 1>4	1>3. 1>4. 6>3	1>3. 1>4
Med		8.62	8.16	8.42	7.59	7.72	8.39
$\bar{X}$		8.65	8.46	8.46	7.61	7.76	8.46

*p<0,05, ** Kruskal Wallis test, C: Control, ST: Storage Time, PS: fat-free yogurt with 0.5% Pomegranate Seed, BGS: fat-free yogurt with 0.5% Black Grape Seed, DS: fat-free yogurt with 0.5% Date Seed, GS: fat-free yogurt with 0.5% Grapefruit Seed, RS: fat-free yogurt with 0.5% Rosehip Seed.

In evaluating color, the control sample achieved the highest score on the 14th day, with 8.73 points, while the yogurt sample with grape seed addition received the lowest score of 7.38 points.

Upon analyzing the odor values, it was found that the highest reading was from the control sample on the first day, measuring 8.84. In contrast, the lowest reading was recorded for the yogurt sample with date seed addition, which occurred on the twenty-first day, scoring 7.38 points. When the tasting was evaluated, the control sample received the highest score of 8.92 on the 7th day, while the yogurt sample with pomegranate seeds received the lowest score on the 21st. When considering consistency, the control sample on day 1 had the highest value of 8.76, while the yogurt with grape seed addition recorded the lowest value of 7.15. The highest coagulation value was recorded at 8.46 in three different yogurt samples: the control sample on the 14th day, the yogurt sample with grapefruit seed added on the 7th day, and the yogurt sample with rosehip seed added on the 1st day. The yogurt sample with date seed addition showed the lowest value of 7.07 on the 14th day. The highest serum separation value recorded was 8.92 in the pomegranate seed yogurt sample on the 7th day, while the lowest value was 7.53 in the grape seed yogurt sample on the 21st day. When assessing roughness, the yogurt with grape seed addition on the 14th day had the highest value of 8.84, which was also matched by yogurt with date seed addition on the 1st day. Regarding citrus flavor, the highest score was 8.84 for yogurt with rosehip seed addition on the 7th day, whereas the lowest value was 7.30 for yogurt with date seed addition. Regarding acetaldehyde flavor, the control sample achieved the highest score of 8.84 on the 14th day, while the lowest score of 7.92 was recorded in yogurt with rosehip seed addition. For granular structure, the yogurt with grapefruit seed addition on the 14th day had the highest value of 8.07, compared to the control sample, which recorded the lowest value of 7.07 on the 14th day. Regarding general acceptability, the control sample received the highest score of 8.92 on the 7th day, whereas the yogurt with grape seed addition recorded the lowest score on the 14th day. Finally, when evaluating homogeneity, the control sample again had the highest score of 8.84 on the 7th day, while the yogurt with grape seed addition received the lowest score of 6.46.

Mercan et al. [40] investigated the effects of different concentrations of grape seed (0.5%, 1%, and 1.5%) on the growth of starter bacteria in yogurt samples, as well as their physicochemical, textural, and sensory properties over a 21-day storage period. The study found that yogurt samples with added grape seed had significantly higher total phenolic compound content than the control samples. Additionally, no significant differences were observed in sensory properties between the grape seed yogurt and the control. These findings suggest that yogurt incorporating grape seed could be a functional food beneficial to human health.

Domagala et al. [41] investigated the texture, viscosity, and sensory properties of yogurts with varying levels of milk fat (1, 2, and 3 kg per 100 kg of milk) and maltodextrin (1, 2, and 3 kg per 100 kg). The study found that replacing milk fat with maltodextrin in yogurt samples did not lead to significant differences in sensory analysis, rheological properties, or texture parameters; however, it did increase viscosity.

Hassan et al. [42] investigated the physicochemical properties of yogurt made from 3.2% fat milk with the addition of 0.025% and 0.05% guar gum, as well as 0.10% cress seed mucilage. The study analyzed various physicochemical properties, including pH values, taste components, and viscosity, at temperatures of $5\pm 2^{\circ}\text{C}$ on the 1st, 5th, 10th, and 15th days. The results showed no statistically significant difference in pH values between the samples ($p > 0.05$). The taste components, acetaldehyde, and diacetyl, were also assessed, with findings indicating that acetaldehyde levels increased during storage. Furthermore, the study reported a positive and statistically significant improvement in the quality and sensory properties of yogurt samples containing guar gum and cress seed mucilage ($p < 0.05$).

4. Conclusions

Using fruit seed extracts in food products offers positive health benefits for consumers. These extracts enhance the nutritional value of functional foods and contribute to product diversity. Moreover, a significant amount of fruit seeds are discarded globally. We can reduce food waste by conducting such studies and effectively utilize fruit seed extracts. This study investigated the effect of adding fruit seed extract on the physicochemical properties of yogurt samples. Using fruit seed extracts in food products has positive health effects on consumers. Adding fruit seed extract

positively impacted pH and total acidity values and increased total phenolic matter and antioxidant capacity. With the findings obtained, experimental analyses will be carried out to increase the product diversity of the world's yogurt industry by adding fruit seeds to yogurt production. The aim is to improve the texture and technological properties of yogurt produced with reduced fat content and fruit seeds and increase its antioxidant and functional properties.

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