DOI: 10.29050/harranziraat.1472726
Harran Tarım ve Gıda Bilimleri Derg. 2024, 28(2): 248-257

Research Article/Araştırma Makalesi

Effect of Some Additional Ingredients on Quality and Sensorial Characteristics of Spreadable Carob Molasses

Bazı İlave Bileşenlerin Sürülebilir Keçiboynuzu Pekmezinin Kalite ve Duyusal Özelliklerine Etkisi

Mehmet Durdu Öner[1], Muhittin Durusoy[2], Manolya Eser Öner[3*]

[1,2] Department of Gastronomy and Culinary Arts, Faculty of Arts and Design, Alanya University, 07400, Alanya, Antalya, Turkey
[3]Department of Food Engineering, Faculty of Engineering, Alanya Alaaddin Keykubat University, 07425 Alanya, Antalya, Turkey

[1]https://orcid.org/0000-0002-1334-983X; [2]https://orcid.org/0000-0002-5736-8602; [3]https://orcid.org/0000-0003-4237-437X

To cite this article:
Öner, M. D., Durusoy, M. & Öner, M. E. (2024). Effect of some additional ingredients on quality and sensorial characteristics of spreadable carob molasses. Harran Tarım ve Gıda Bilimleri Dergisi, 28(2):248-257

DOI: 10.29050/harranziraat.1472726

Address for Correspondence:
Manolya Eser ÖNER
e-mail:
manolya.oner@alanya.edu.tr

Received Date:
25.04.2024
Accepted Date:
12.05.2024

ABSTRACT

Carob (*Ceratonia siliqua* L.) is a nutritious fruit that has been grown in Mediterranean region. Carob holds an important place in various cultures, which has been used in baked goods, confectionery, chocolate milk products, snacks, tea, and coffee. The objective of this study was to produce spreadable carob molasses by using carob molasses (CM) with different proportions of locust bean gum (LBG), crystallized honey (CH), cocoa oil (CO), egg white (EW), additive mixture (AM) and evaluate pH, total soluble solids (TSS), color, viscosity, density, volume increase, and sensorial properties. The darkest color was obtained in sample consisting of LBG and CO while the lightest color was determined in sample with LBG, EW, AM, indicating EW and AM enhanced lightness with bleaching effect. The highest volume increase, about 145%, was observed in sample with LBG and EW. The LBG addition significantly increased the viscosity in all spreadable carob molasses samples ($p<0.05$). Adding CO reduced the volume and increased the density of samples, which is probably due to lubricating effect of CO on the carob molasses. According to the sensory evaluation, the highest value of color, taste, consistency, spreadability and overall acceptability was determined in sample including CM, LBG, EW, CH, and AM. Consumer preference test was confirmed that same sample was the first choice with 20.77% preference score. Sensorial values of color and consistency had significant effect on overall acceptability with a correlation coefficient of 0.93 ($p<0.05$). With its appealing physical and sensorial property, spreadable carob molasses can be a healthy option.

Key Words: Carob molasses; Spreadable; Color; Viscosity; Sensory analysis

ÖZ

Keçiboynuzu *(Ceratonia siliqua* L.) Akdeniz bölgesinde yaygın olarak yetiştirilen oldukça besleyici bir meyvedir. Çeşitli kültürlerde geleneksel tatlar arasında önemli bir yere sahip olan keçiboynuzu, unlu mamullerde, şekerlemelerde, çikolatalı süt ürünlerinde, atıştırmalıklarda, çay ve kahvede kullanılmaktadır. Bu çalışmanın amacı keçiboynuzu pekmezini (CM) keçiboynuzu sakızı (LBG), kristalize bal (CH), kakao yağı (CO), yumurta akı (EW), katkı karışımı (AM) gibi çeşitli bileşenlerle farklı oranlarda kullanarak sürülebilir keçiboynuzu pekmezi üretmek ve pH, toplam çözünür katı madde (TSS), renk, viskozite, yoğunluk, hacim artışı ve duyusal özelliklerdeki değişiklikleri değerlendirmektir. Renk değerleri karşılaştırıldığında, en koyu renk LBG ve CO içeren numunede elde edilirken, en açık renk LBG, EW ve AM içeren numunede belirlenmiştir; bu da EW ve AM'nin ağartma etkisine sahip olduğunu ve sürülebilir pekmez ürününde renk açıklığını arttırdığını göstermektedir. Numuneler arasında, %145'e varan en yüksek hacim artışı LBG ve EW içeren numunede gözlenmiştir. LBG ilavesi tüm sürülebilir keçiboynuzu pekmezi örneklerinde viskoziteyi önemli ölçüde artırmıştır (p<0.05). CO'nun bir bileşen olarak eklenmesi hacmi azaltmış ve böylece örneklerin yoğunluğunu arttırmıştır, bu da muhtemelen CO'nun keçiboynuzu pekmezi üzerindeki kayganlaştırıcı etkisinden kaynaklanmaktadır. Duyusal değerlendirme analizine göre, en yüksek renk, tat, kıvam, sürülebilirlik ve genel kabul edilebilirlik değerleri CM, LBG, EW, CH ve AM formülasyonundan yapılan numunede tespit edilmiştir. Tüketici tercih testi de aynı numunenin %20.77 tercih puanı ile ilk tercih olduğunu doğrulamıştır. Renk ve kıvamın duyusal değerleri, 0.93 korelasyon katsayısı ile genel kabul edilebilirlik üzerinde önemli bir etkiye sahiptir (p<0.05). Sürülebilir keçiboynuzu pekmezi ürünleri, fiziksel ve duyusal özelliklerinin albenisi ile tüketiciler için sağlıklı bir seçenek olabilir.

Anahtar Kelimeler: Keçiboynuzu pekmezi; Sürülebilir; Renk; Viskozite; Duyusal analiz

Introduction

In recent years, the high demand on natural healthy foods makes food processors to consider plant-based alternative products. Carob (*Ceratonia siliqua* L.) is a highly nutritious crop which is rich in phenolics (gallic, cinnamic, o and p-coumaric, ferulic, and ellagic) and flavonoids (rutin, catechin, apigenin, and naringenin) (Batu, 2005; Chait et al., 2020). It has positive effect on health issues such as diabetes, cholesterol, obesity, and digestion (Valero-Muñoz et al., 2014). In the world, the Mediterranean region is the main carob production area with 135,000 tons per year and Turkey is the fifth major carob producer after Spain, Portugal, Italy, and Morocco (FAO, 2021). Its chemical composition may vary based on species, harvesting season, soil, and climate (Brassesco et al., 2021). The carob pod has over 50% of sugar which mainly consists of sucrose, fructose, and glucose ranges between 34 and 42%, 10 and 12%, and 7 and 10%, respectively (Nasar-Abbas et al., 2016). Traditionally, carob pod has been consumed as fruit and in the form of food and beverage products. Meanwhile, there has been an extensive carob powder and molasses production in the food industry (Tounsi et al, 2017). The carob seeds consists of protein, ash, fat, sucrose, fructose, glucose, and significant amounts of potassium and calcium, which are primarily used for locust bean gum production (Papaefstathiou et al., 2018). The locust bean gum has been widely used as a constituent in food industry including yogurt, pudding, cheese, fish products, and ketchup.

With the functional properties and proven health benefits, scientific research towards the discovery of carob processing into different food products is one of the most interesting and innovative area for food industry. Carob products fulfill the criteria's of allergic consumers by providing gluten-free, caffeine-free and bromine-free food products with natural chocolate like sweetness (Rodríguez-Solana et al., 2021). Several researchers have been carried out the product development including gluten free pastry products (Ceylan and Muştu, 2017), low-fat ice-cream (Badem and Alpkent, 2018), kefir (Sarıca et al., 2021), confectionery (Ibrahim et al., 2020), halva (Tounsi et al., 2022), and snack bar (Donmez et al., 2022).

Spreadable food products look bright for the future by offering convenient, tasty, and nutritional properties. Sensorial properties, mainly color, flavor and taste, are the major factors affecting quality perception and consumer acceptance. Spreadable carob cream has been studied by several researchers in order to investigate healthier alternatives to hazelnut spreads with cocoa. Different formulations have been tested and Memiş and Tontul (2021) found that 25% carob flour, 39.3% sugar syrup, and 24% fat was convenient to produce spreadable carob cream with higher phenolic content and sensorial properties. In other research study, Shiehzadeh (2019) replaced sugar powder and cocoa with carob flour, which affected the sensorial property of the carob cream negatively. In this current study, the objective was to produce spreadable carob molasses by using various ingredients including locust bean gum (LBG), crystallized honey (CH), cocoa oil (CO), egg white (EW), and additive mixture (AM) in different proportions and evaluate changes in pH, TSS, color, viscosity, density, volume increase, and sensorial properties.

Materials and Methods

Materials

Carob molasses (CM) (Aksuvital, Istanbul, TR), Locust bean gum (LBG) (E410, Benosen, Istanbul, TR), Egg white (EW) (Dr. Gusto Pastry Inc. Istanbul, TR), Cocoa oil (CO) (Aksuvital, Istanbul, TR), Crystal honey (CH) (Gazipaşa, Antalya, TR) and additive mixture (AM) (Ovalette Bakery Mixture, Katsan, Istanbul, TR) were used in spreadable carob molasses (SCM) formulations.

Sample Preparation

Spreadable carob molasses sample formulations were listed in Table 1. Each sample was prepared by using mixer (5L, 1400W, Schafer Prochef XL, Istanbul) for 30 min. Depending on the formulation (Table 1), CM has been mixed with LBG, EW, CO, and CH. In some formulations, commercially available AM was used, which consists of emulsifier, stabilizer, humectant, and carrier. Prepared samples were stored at 4°C until analysis.

Table 1. Formulations of carob molasses samples.

Sample	Formulation[1]	Amount (g)					
		CM	LBG	EW	CO	CH	AM
1	CM	300	-	-	-	-	-
2	CM + LBG + EW	300	6	3	-	-	-
3	CM + LBG + CO	300	6	-	1.5	-	-
4	CM + LBG + CH	300	6	-	-	6	-
5	CM + LBG + EW + AM	300	6	3	-	-	3
6	CM + LBG + CO + AM	300	6	-	1.5	-	3
7	CM + LBG + CH + AM	300	6	-	-	6	3
8	CM + LBG + EW + CO	300	6	3	1.5	-	-
9	CM + LBG + EW + CH	300	6	3	-	6	-
10	CM + LBG + CO + CH	300	6	-	1.5	6	-
11	CM + LBG + EW + CO + AM	300	6	3	1.5	-	3
12	CM + LBG + EW + CH + AM	300	6	3	-	6	3
13	CM + LBG + CO + CH + AM	300	6	-	1.5	6	3
14	CM + LBG + EW + CO + CH	300	6	3	1.5	6	-
15	CM + LBG + EW+ CO + CH + AM	300	6	3	1.5	6	3

[1]CM: Carob Molasses; LBG: Locust Bean Gum; CO: Cocoa Oil; CH: Crystal Honey; AM: Additive Mixture, EW: Egg White

pH, TSS, and Color Analysis

Measurement of sample pH was carried out using a digital pH meter (Orio MI 151, Milwaukee Instruments Inc. Rocky Mount, NC USA) and the samples were diluted with distilled water 1/10 (v/v) before measurement (Ozbey et al., 2013).

The total soluble solids (TSS) content of carob molasses (CM) was determined using a refractometer (ATAGO PAL-1 Digital, Japan), which was diluted with distilled water 1/1 (v/v) and measured at room temperature (Ozbey et al., 2013).

A Chroma Meter CR-400 (Konica Minolta, Tokyo, Japan) was used to measure the color of samples using the L*a*b*C*h°ΔE* system, where L* is lightness, ranging from 0 (absolute black) to 100 (absolute white); a* is ranging from -60 (green) to 60 (red); b* is ranging from -60 (blue) to 60 (yellow); C* is chroma, ranging from 0 (least saturation) to 60 (full saturation); and h° is hue angle, ranging from 0° to 360°, where 0° or 360° is red, 90° is yellow, 180° is green, and 270° is blue. ΔE* indicates color difference between reference and sample. A white ceramic plate was used for calibration of the instrument. During the measurement, 20 grams of samples were placed into the petri plate and color values were recorded by measuring three different locations (Ozmen et al., 2023).

Viscosity

The viscosity of spreadable carob molasses was measured by using designed apparatus (Alanya/Antalya, TR), which consists of probe (5.48 g) with a base area of 1.12 cm^2. At the certain time period (15 s), the distance (in cm) probe traveled through the samples were measured. The spreadable carob molasses samples were kept in the refrigerator (570463 MB, Eskisehir, TR) for 24 hours before measurement.

Density and Volume Increase Analysis

The volume of 100 g of untreated and treated carob molasses samples were measured. Volume increase percentages were calculated using Eq. 1 (Badilli, 2020). The density (g ml^{-1}) was calculated dividing 100 g of samples by their corresponding volume.

Volume Increase (%) = [(Volume of 100 g sample-Volume of 100 g untreated carob molasses)/Volume of 100 g untreated carob molasses]x100 (1)

Sensory Evaluation

Sensory attributes including color, taste, consistency, spreadability, and overall acceptability were evaluated by a semi-trained panel of twenty-six people from students, academic and administrative staff of Alanya University (Alanya/Antalya, TR) by using a nine-point hedonic rating scale (1 = dislike extremely to 9 = like extremely) (Meilgaard et al., 2006). Samples were randomly coded and served to sensory panelists inside the transparent packaging materials with water and crackers.

Statistical Analysis

The results were presented as mean ± standard deviation. One-way analysis of variance (ANOVA) was performed using JMP package program (JMP 13.0; Cary, NC, USA) at 95% (α=0.05) confidence interval and the difference between carob molasses samples was determined by Tukey's multiple range test. All experiments were replicated two times. Also, correlation coefficients between some sensory and physical attributes were calculated using Excel (2016).

Results and Discussion

Effect of ingredients on pH and color

The TSS value of carob molasses used was determined as 78.4±0.1 °brix. The pH values of spreadable carob molasses varied from 5.70 to 5.91, but there was no significant difference between pH values of samples ($p>0.05$). pH values of samples indicated that there was no significant acid production by microbial fermentation or enzymatic digestion during the preparation of the samples.

Color values of spreadable carob molasses samples were listed in Table 2. The lightness (L*) value of the carob molasses (CM) was determined as 25.87±0.09. Throughout the samples, L* values were varied from 23.83±0.26 to 69.49±1.16, in which the darkest color was obtained in sample 3 while the lightest color determined in sample 5; indicating egg white (EW) and additive mixture (AM) enhanced lightness in the spreadable molasses product. In consistent with our results, other researcher has reported that EW had bleaching effect on liquid and solid molasses production (Batu, 2005). However, in the current study, there was no significant difference observed in L* values of sample 5, 7, and 12, which illustrated replacing EW with crystal honey (CH) and/or addition of both EW and CH did not affect the lightness when there is an AM in the formulation ($p>0.05$). Furthermore, lighter color was found in samples of 6, 11, 13, and 15 indicating AM was an important ingredient in the formation of light color. Whereas replacement of cocoa oil (CO) with CH significantly reduced the lightness of the samples ($p<0.05$). When a* and b* values were compared, the lowest values of a* (0.59±0.03) and b* (0.50±0.05) was observed in sample 1 consisting of CM, only. With the highest a* value, reddish color was evaluated in samples of 2 and 9; which includes EW and/or EW and CH in the formulation; however, with the higher b* values, contribution of AM increased yellowness in the samples significantly ($p<0.05$). The usage of EW formed air bubbles and refracted more light in the product which might resulted in yellow color in the product. In terms of chroma value (C*), the higher saturation was obtained in samples with AM ingredient. With the EW, CO, CH, and AM ingredients, the brightest color was determined in samples of 11, 13, and 15. The results confirmed that color values were parallel to the other described color parameters. In hue angle (h°) values, yellowish color was obtained in samples of 5, 6, 7, 11, 12, 13, and 15. There was no significant difference determined in samples of 1, 4, and 10 ($p>0.05$); indicating addition of CO and/or CO and CH did not affect h° value. Total color change (ΔE) in spreadable carob molasses samples varied from 34.63±0.56 to 69.87±0.26. There was no statistical difference observed between sample 1, 8, 10, and 14 ($p>0.05$). When compared to sample 1, lower color change value was observed in samples of 5, 7 and 8 ($p<0.05$).

Table 2. Color values of spreadable carob molasses samples[1].

Sample	L*	a*	b*	C*	h°	ΔE
1	25.87±0.09 ^{g}	0.59±0.03 ^{l}	0.50±0.05 ^{f}	0.77±0.01 ^{h}	40.49±3.79 ^{ef}	67.88±0.08 ^{bc}
2	34.49±0.06 ^{f}	11.83±0.24 ^{a}	14.57±0.58 ^{d}	18.76±0.60 ^{d}	50.92±0.56 ^{bcd}	61.39±0.31 ^{d}
3	23.83±0.26 ^{h}	1.90±0.27 ^{i}	2.32±0.12 ^{f}	3.00±0.08 ^{g}	50.86±5.33 ^{cd}	69.87±0.26 ^{a}
4	32.78±0.23 ^{f}	9.65±0.02 ^{b}	10.03±0.01 ^{e}	13.92±0.02 ^{e}	46.08±0.02 ^{de}	61.93±0.22 ^{d}
5	69.49±1.16 ^{a}	3.59±0.10 ^{h}	28.93±0.35 ^{c}	29.15±0.36 ^{c}	82.92±0.11 ^{a}	34.63±0.56 ^{k}
6	59.66±1.24 ^{d}	8.05±0.14 ^{c}	33.13±1.25 ^{ab}	30.82±2.03 ^{bc}	79.55±3.48 ^{a}	45.30±0.11 ^{f}
7	68.06±1.46 ^{ab}	3.95±0.09 ^{gh}	29.93±0.02 ^{bc}	30.15±0.05 ^{bc}	82.49±0.17 ^{a}	36.38±1.03 ^{j}
8	26.46±0.24 ^{g}	1.50±0.09 ^{j}	2.41±0.47 ^{f}	2.85±0.45 ^{g}	57.62±3.55 ^{b}	67.23±0.23 ^{bc}
9	37.12±0.23 ^{e}	11.89±0.01 ^{a}	16.40±0.03 ^{d}	20.26±0.02 ^{d}	54.06±0.08 ^{bc}	59.05±0.23 ^{e}
10	25.47±0.11 ^{gh}	1.10±0.07 ^{k}	1.16±0.02 ^{f}	1.60±0.03 ^{gh}	46.57±2.31 ^{de}	68.26±0.12 ^{b}
11	63.15±0.28 ^{c}	6.25±0.08 ^{e}	32.79±0.15 ^{ab}	33.37±0.17 ^{a}	79.21±0.07 ^{a}	42.15±0.08 ^{h}
12	68.66±0.68 ^{a}	4.44±0.05 ^{f}	35.18±4.23 ^{a}	31.00±0.27 ^{b}	81.76±0.02 ^{a}	36.55±0.27 ^{j}
13	62.39±0.31 ^{c}	6.78±0.10 ^{d}	33.73±0.18 ^{a}	34.40±0.19 ^{a}	78.64±0.09 ^{a}	43.44±0.09 ^{g}
14	26.98±0.28 ^{g}	4.15±0.08 ^{fg}	2.86±0.07 ^{f}	5.05±0.03 ^{f}	34.59±1.19 ^{f}	66.82±0.27 ^{c}
15	66.30±0.81 ^{b}	5.99±0.12 ^{e}	33.70±0.40 ^{a}	34.23±0.41 ^{a}	79.93±0.08 ^{a}	40.55±0.24 ^{i}

[1]The values in the same column shown with different letters are statistically different from each other ($p<0.05$).

Effect of ingredients on viscosity, volume increase and density

The viscosity (plunge depth, cm), volume increase (%), and density (g ml^{-1}) values of the samples produced from carob molasses in accordance with the experimental design were given in Table 3. The lowest viscosity with a highest plunge depth of 9.95±0.05 cm and the highest density with 1.43±0.00 g ml^{-1} was determined in sample 1 (CM only) ($p<0.05$). Since no treatment was applied to sample 1 (as control sample) volume increase was 0%. Addition of LBG and EW to CM significantly increased the volume to 144.74±2.80 % ($p<0.05$), which was the highest volume increase throughout the other spreadable carob molasses samples. In addition, significant volume increases were observed mostly in EW added samples, indicating that EW had significant effect on air incorporation and thus volume increase of the product ($p<0.05$). Whereas, it is important to highlight that CH and AM had also significant contribution in volume increase of the samples ($p<0.05$).

Table 3. Viscosity, volume increase and density values of spreadable carob molasses[1].

Sample	Viscosity plunge depth, cm	Volume Increase (%)	Density (g mL^{-1})
1	9.95±0.05 ^{a}	0.00±0.00 ^{h}	1.43 ^{a}
2	2.00±0.20 ^{d}	144.74±2.80 ^{a}	0.59 ^{j}
3	2.90±0.10 ^{c}	22.86±0.09 ^{g}	1.17 ^{bc}
4	2.60±0.10 ^{c}	113.49±2.22 ^{c}	0.67 ^{h}
5	0.55±0.25 ^{e}	110.50±2.17 ^{c}	0.68 ^{h}
6	1.00±0.20 ^{e}	84.67±0.52 ^{e}	0.78 ^{f}
7	0.60±0.20 ^{e}	102.02±0.68 ^{d}	0.71 ^{g}
8	3.55±0.05 ^{b}	23.87±0.92 ^{g}	1.16 ^{c}
9	1.80±0.30 ^{d}	129.79±2.52 ^{b}	0.62 ^{i}
10	2.95±0.05 ^{c}	23.87±0.92 ^{g}	1.16 ^{c}
11	0.60±0.20 ^{e}	80.24±0.48 ^{e}	0.80 ^{e}
12	0.95±0.35 ^{e}	74.00±1.58 ^{f}	0.82 ^{d}
13	0.65±0.25 ^{e}	84.67±1.75 ^{e}	0.78 ^{f}
14	2.75±0.05 ^{c}	21.87±0.90 ^{g}	1.18 ^{b}
15	0.55±0.25 ^{e}	110.50±2.17 ^{c}	0.68 ^{h}

[1]The values in the same column shown with different letters are statistically different from each other ($p<0.05$).

Locust bean gum affects viscosity due to its molecular weight, concentration, and solubility. Even though, it is generally considered less viscous than guar gum and taro gum, it forms a highly viscous gel structure over a wide pH range (4-9); thereby it is used as a stabilizer and thickener in many foods (Barak and Mudgil, 2014). Based on viscosity analysis results, LBG addition significantly increased the viscosity in all spreadable carob molasses samples compared to sample 1 ($p<0.05$). Similar results were obtained when LBG used in different products. Researchers have reported that LBG had been used to improve dough rheology and product texture in the absence of gluten by forming emulsions and stabilizing dispersion with its enhancement ability of viscosity (Topaloglu, 2019). Other researchers have found similar effect of LBG on yogurt, this carbohydrate-based hydrocolloid increased the clot tightness, viscosity, dry matter and also reduced serum separation of the product (Peker, 2012). Furthermore, it was determined that the addition of 0.7% LBG increased the consistency, enhanced the structure and thereby prevented water separation of pudding (Derazshamshir, 2017). In the present study, findings confirm that addition of AM as an ingredient increased the viscosity of samples of 5, 6, 7, 11, 12, 13, 15 and there was no significant difference observed between these samples ($p>0.05$).

Sample 1 (CM) had the highest density of 1.43 g ml^{-1} ($p<0.05$). Addition of CO as an ingredient reduced the volume increase and thereby increased the density of samples 3, 8, 10,14, which is probably due to lubricating effect of CO on the carob molasses. However, addition of AM reduced the density of the spreadable carob molasses samples of 5, 6, 7, 11, 12, 13, and 15. It is important to highlight that addition of CH had effect on density reduction of samples 4 and 9. These findings confirmed that increase in volume reduced density of spreadable carob molasses samples as expected.

Effect of ingredients on sensorial quality

Product development has been carried out in order to improve the physical structure, appearance, and function of the product in turn to increase its overall quality. Sensory analysis is an essential method to measure the perception of reactions to different characteristics of foods through the senses of taste, smell, touch, hearing and sight (Stone and Sidel, 2004). In the present study, sensory analysis was used to determine reaction of consumers on the color, taste, consistency, spreadability, and overall acceptability of spreadable carob molasses samples obtained by adding different ingredients. The scores of the sensory evaluation analysis of 15 products were listed in Table 4. According to the 9-point hedonic scale, overall acceptability scores varied between 5.38±2.06 and 7.58±1.45, indicating panelists had a positive approach to all the features of the products. The findings confirmed that the highest overall acceptability was found in sample 12 with 7.58±1.45 and there was no significant difference observed between sample 12 and samples of 5, 6, 7, 11, 13 (p>0.05).

Table 4. Sensory evaluation of spreadable carob molasses samples[1].

Sample	Color	Taste	Consistency	Spreadability	Overall Acceptability
1	6.50±2.16 ^{abcd}	6.31±1.89 ^{ab}	6.12±2.08 ^{bc}	5.38±2.21 ^{d}	6.31±1.74^{bcde}
2	5.31±2.07 ^{f}	5.69±2.20 ^{bc}	5.50±2.02 ^{c}	5.96±2.05 ^{cd}	5.38±2.06 ^{e}
3	6.31±1.09 ^{abcde}	6.04±1.75 ^{abc}	6.35±1.55 ^{bc}	6.27±1.66 ^{bcd}	6.04±1.25 ^{bcde}
4	6.23±1.73 ^{bcdef}	5.69±1.93 ^{bc}	6.15±1.69 ^{bc}	6.35±1.92 ^{bcd}	5.88±1.70 ^{cde}
5	6.62±1.79 ^{abcd}	6.35±1.60 ^{ab}	6.35±2.06 ^{bc}	7.15±1.67 ^{ab}	6.81±1.50 ^{abc}
6	6.73±1.73 ^{abc}	6.35±1.87 ^{ab}	6.77±2.14 ^{b}	7.12±2.08 ^{ab}	6.88±1.68 ^{ab}
7	6.81±1.65 ^{ab}	6.42±2.28 ^{ab}	6.54±2.18 ^{bc}	6.85±1.99 ^{abc}	6.62±2.19 ^{abcd}
8	5.35±1.98 ^{ef}	5.42±2.23 ^{bc}	5.88±2.08 ^{bc}	5.88±1.93 ^{cd}	5.65±1.94 ^{de}
9	5.73±1.82 ^{def}	5.50±2.20 ^{bc}	5.62±1.92 ^{c}	5.85±1.59 ^{cd}	5.50±1.82 ^{e}
10	5.81±1.98 ^{cdef}	5.50±2.35 ^{bc}	5.69±1.74 ^{c}	5.92±1.85 ^{cd}	5.65±1.87 ^{de}
11	6.85±1.32 ^{ab}	6.00±2.02 ^{abc}	6.46±1.63 ^{bc}	7.08±1.92 ^{ab}	6.73±1.54 ^{abc}
12	7.27±1.64 ^{a}	6.96±1.71 ^{a}	7.73±1.66 ^{a}	7.85±1.49 ^{a}	7.58±1.45 ^{a}
13	6.38±2.00 ^{abcd}	6.42±1.96 ^{ab}	6.50±2.23 ^{bc}	6.77±1.90 ^{bc}	6.73±1.80 ^{abc}
14	5.35±2.10 ^{ef}	5.15±2.09 ^{c}	5.65±1.72 ^{c}	5.85±1.83 ^{cd}	5.58±2.12 ^{e}
15	6.65±1.96 ^{abcd}	6.35±2.04 ^{ab}	6.15±2.31 ^{bc}	6.46±2.25 ^{bc}	6.58±1.88 ^{bcd}

[1]The values in the same column shown with different letters are statistically different from each other (p<0.05).

Color is essential attribute in food products to give a positive impression on the consumer acceptance. Without appealing color, the product will receive negative score even if the other sensorial properties are good. Even though having dark color of samples were appreciated, lighter colors were preferred in spreadable molasses samples of 1, 3, 5, 6, 7, 11, 12, 13, and 15. The highest score with 7.27±1.64 was obtained in sample 12 which consist of CM, LBG, EW, CH, and AM in its formulation. Results indicated that lighter color samples (5, 6, 7, 11, 12, 13, and 15) with high color score were contained AM in their formulation. Even though traditionally carob molasses is not commonly consumed in lighter and yellowish color, these findings indicated that there is a potential in these new formulations. As reported in previous studies, addition of LBG (2%) in new generation snack design from carob fruits was acceptable in terms of taste, aroma, flavor, texture and general preference (Donmez et al., 2022). In this study samples with AM had higher taste scores. However, scores of samples of 1 and 3 with no AM were acceptable. Similar results were obtained in consistency values of sensory analysis. The highest taste and consistency score was determined in sample 12 as 6.96±1.71 and 7.73±1.66, respectively. In terms of spreadability values, the samples with AM ingredient received higher values ranging from 6.46±2.25 to 7.85±1.49 and sample 12 received the highest value with 7.85±1.49 within all the samples. According to the consumer preference test, sample 12 (20.77%), sample 15(11.92%), and sample 7(10.77%) were preferred as first, second and third choice, respectively. The least favorite sample was sample 2 with ingredients of LGB and EW. Results indicated that sample 12 (with all ingredients except CO) was the most preferred sample.

Correlation coefficients between some physical and sensory analysis results of spreadable carob molasses samples were given in Table 5. A correlation of 0.69 was found between sensorial quality of spreadability and physical quality of viscosity values. Even though this correlation value was at acceptable level, it was not high due to the efficacy of other factors on spreadability. The stronger positive correlation at ρ= 0.86 was observed between spreadability and consistency. Additionally, sensorial values of spreadability and consistency had a significant effect on overall acceptability with a correlation coefficient of 0.86 and 0.93, respectively. Similar result was obtained between taste on overall acceptability scores. The correlation coefficient between physical color values of L*, a*, b*, C*, h°, ΔE and sensorial overall acceptability was 0.83, 0.78, 0.70, 0.81, -0.82 respectively; however, correlation coefficient of sensorial color value and overall acceptability was 0.93. These results indicated that sensorial quality parameters of spreadability, consistency, taste and color are correlated with sensorial quality parameter of overall acceptability.

Table 5. Correlation coefficients (ρ) between some physical and sensory values of spreadable carob molasses samples.

Values	Values	Correlation (ρ)
Spreadability	Viscosity	0.69
Spreadability	Consistency	0.86
Spreadability	Overall acceptability	0.86
Consistency	Overall acceptability	0.93
Taste	Overall acceptability	0.92
Color	Overall acceptability	0.93
L^*	Overall acceptability	0.83
b^*	Overall acceptability	0.78
C^*	Overall acceptability	0.70
h°	Overall acceptability	0.81
ΔE	Overall acceptability	-0.82

Conclusions

There was no significant difference between pH values of spreadable carob molasses samples ($p>0.05$). Throughout the samples, L* values were varied from 23.83±0.26 to 69.49±1.16, in which the darkest color was obtained in sample 3 (with CM, LBG, and CO) while the lightest color determined in sample 5 (with CM, LGB, EW, and AM), which indicated EW and AM enhanced lightness in the spreadable molasses products. The addition of CO increased a* value which indicates redness, while addition of EW and AM increased b* value which is yellowness. Based on C* values, the brightest color was determined in samples 11, 13, and 15 with EW, CO, CH, and AM ingredients. Based on the viscosity analysis, usage of LBG as an ingredient significantly increased the viscosity of all spreadable carob molasses compared to sample 1 (carob molasses only). Addition of CO as an ingredient reduced the volume and thereby increased the density of samples of 3, 8, 10, and 14. However, addition of AM reduced the density of the spreadable carob molasses samples of 5, 6, 7, 11, 12, 13, and 15. In all parameters, the highest sensory evaluation score was obtained in sample 12 (with CM, LBG, EW, CH, and AM). Based on the consumer preference test, sample 12 (20.77%), sample 15 (11.92%) and sample 7 (10.77%) were preferred as first, second and third choice, respectively. Results indicated that sample 12 (with all ingredients except CO) was the most preferred sample. Sensorial quality parameters of spreadability, consistency, taste and color were highly correlated with sensorial quality parameter of overall acceptability. The highest positive and significant correlations were observed between the overall sensory ratings and consistency, color and taste, with ρ values of 0.93, 0.93, and 0.92, respectively ($p>0.05$).

Acknowledgements: This article has been produced from Muhittin Durusoy's MSc. Thesis, named as "A research on production of spreadable carob molasses". (YOK Thesis No: 829446)

Conflict of interest: The authors declare that they have no conflict of interest.

Author contributions: M.D. methodology, data collection, writing; M.E.Ö. conceptualization, methodology, analysis and writing; M.D.Ö. conceptualization, methodology, analysis, writing, review and editing.

References

Badem, D. A., & Alpkent, D. Z. (2018). Production of Ice Cream with Carob Bean Pekmez (Molasses). *International Journal of Environment, Agriculture and Biotechnology*, *3*(1), 28–32. https://doi.org/10.22161/ijeab/3.1.5

Badilli, A.G. 2020. *Investigation of Possibilitires of Chickpea Flour Usage Opportunities instead of Milk Powder in Reduced Fat Functional Ice Cream Production.* Harran University, Sanliurfa, TR.

Barak, S., & Mudgil, D. (2014). Locust bean gum: Processing, properties and food applications—A review. *International Journal of Biological Macromolecules*, *66*, 74–80. https://doi.org/10.1016/j.ijbiomac.2014.02.017

Batu, A. (2005). Production of Liquid and White Solid Pekmez in Turkey. *Journal of Food Quality*, *28*(5–6), 417–427. https://doi.org/10.1111/j.1745-4557.2005.00045.x

Brassesco, M. E., Brandão, T. R. S., Silva, C. L. M., & Pintado, M. (2021). Carob bean (Ceratonia siliqua L.): A new perspective for functional food. *Trends in Food Science & Technology*, *114*, 310–322. https://doi.org/10.1016/j.tifs.2021.05.037

Ceylan, V., & Muştu, Ç. (2017). Development of Carob Flour Based Gluten Free Cookie Formulation. *Aydın Gastronomy*, *5*(1), 1–12. https://doi.org/10.17932/IAU.GASTRONOMY.2017.016/gastronomy_v05i1001

Chait, Y. A., Gunenc, A., Bendali, F., & Hosseinian, F. (2020). Simulated gastrointestinal digestion and in vitro colonic fermentation of carob polyphenols: Bioaccessibility and bioactivity. *LWT*, *117*, 108623. https://doi.org/10.1016/j.lwt.2019.108623

Derazshamshir, M. (2017). *Development of Formulation of Pudding Containing Caseinomacropeptide*. Istanbul Technical University, Istanbul, TR.

Donmez, A., Cikrikci Erunsal, S., & Sahin, S. N. (2022). Impact of locust bean gum / xanthan gum addition on new generation snack design from carob fruit byproducts. *Gıda*, *47*(4), 690–704. https://doi.org/10.15237/gida.GD22034

FAO (2021). Food and Agriculture Organization of the United Nations. Average Carob Production 2013-2019. https://www.fao.org/faostat/en/#data/QCL/ Accessed on 01.06.2023.

Ibrahim, R. M., Abdel-Salam, F. F., & Farahat, E. (2020). Utilization of Carob (Ceratonia siliqua L.) Extract as Functional Ingredient in Some Confectionery Products. *Food and Nutrition Sciences*, *11*(08), 757–772. https://doi.org/10.4236/fns.2020.118054

Meilgaard, M. C., Civille, G. V., & Carr, B. T. (2006). Sensory Evaluation Techniques. Boca Raton, FL: CRC Press. https://doi.org/10.1201/b1645

Memiş, E., & Tontul, İ. (2021). Optimization of spreadable carob cream formulation with mixture design. *Food and Health*, *7*(2), 75–83. https://doi.org/10.3153/fh21009

Nasar-Abbas, S. M., E-Huma, Z.-, Vu, T.-H., Khan, M. K., Esbenshade, H., & Jayasena, V. (2016). Carob Kibble: A Bioactive-Rich Food Ingredient. *Comprehensive Reviews in Food Science and Food Safety*, *15*(1), 63–72. https://doi.org/10.1111/1541-4337.12177

Ozbey, A. Oncul, N., Erdogan, K, Yildirim, Z. & Yildirim, M. (2013). Some Physical, Chemical and Microbiological Properties of Çalma Pekmez Produced in Tokat Region, Turkey. *Academic Food Journal, 11*(1), 46-52.

Ozmen, D., Yıldırım, R.M., Bursa, K., Kian-pour, N., Toker, O.S., Palabiyik, I., Konar, N., & Yurt, B. (2023). Improvement of spreadability of grape molasses with induced crystallization for production of creamed molasses as a novel product. *International Journal of Gastronomy and Food Science, 31,* 100628. https://doi.org/10.1016/j.ijgfs.2022.100628

Papaefstathiou, E., Agapiou, A., Giannopoulos, S., & Kokkinofta, R. (2018). Nutritional characterization of carobs and traditional carob products. *Food Science & Nutrition*, *6*(8), 2151–2161. https://doi.org/10.1002/fsn3.776

Peker, H. (2012). *Investigation of Production of Low Fat Yoghurt by Using Locust Bean Gum and Functional Fruit Yoghurt by Using Olive Leaf Extract*. Pamukkale University, Denizli, TR.

Rodríguez-Solana, R., Romano, A., & Moreno-Rojas, J. M. (2021). Carob Pulp: A Nutritional and Functional By-Product Worldwide Spread in the Formulation of Different Food Products and Beverages. A Review. *Processes*, *9*(7), 1146. https://doi.org/10.3390/pr9071146

Sarıca, E., Filizkıran, G., Canbek, D., Ertürk, B., Coşkun, M., & Mustuloğlu, Ş. (2021). Effect of Locust Bean Gum Addition on Physicochemical and Sensory

Characteristics of Kefir made from Goat Milk. *Akademik Gida*, *19*(1), 28–37. https://doi.org/10.24323/akademik-gida.927653

Shiehzadeh, R. (2019). *The Effect of the Use of Carob Powder Butter and Olive Oil on the Physical Chemical and Rheological Properties of Spreadable Chocolate*. Ataturk University, Erzurum, TR.

Stone, H., & Sidel, J. L. (Eds.). (2004). *Sensory Evaluation Practices. A Volume in Food Science and Technology* (3rd ed.). Redwood City, CA: Academic Press Inc. https://doi.org/10.1016/B978-0-12-672690-9.X5000-8

Topaloglu, K. (2019). *Production of Gluten Free Cookie*. Bursa Uludag University, Bursa, TR.

Tounsi, L., Karra, S., Kechaou, H., & Kechaou, N. (2017). Processing, physico-chemical and functional properties of carob molasses and powders. *Journal of Food Measurement and Characterization*, *11*(3), 1440–1448. https://doi.org/10.1007/s11694-017-9523-4

Tounsi, L., Mkaouar, S., Bredai, S., & Kechaou, N. (2022). Valorization of carob by-product for producing an added value powder: characterization and incorporation into Halva formulation. *Journal of Food Measurement and Characterization*, *16*(5), 3957–3966. https://doi.org/10.1007/s11694-022-01494-z

Valero-Muñoz, M., Martín-Fernández, B., Ballesteros, S., Lahera, V., & de las Heras, N. (2014). Carob Pod Insoluble Fiber Exerts Anti-Atherosclerotic Effects in Rabbits through Sirtuin-1 and Peroxisome Proliferator-Activated Receptor-γ Coactivator-1α. *The Journal of Nutrition*, *144*(9), 1378–1384. https://doi.org/10.3945/jn.114.196113