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ENRICHMENT OF ŞEKERPARE DESSERT WITH SPENT COFFEE GROUND: PHYSICOCHEMICAL, NUTRITIONAL, SENSORY AND TEXTURE CHARACTERISTICS

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ABSTRACT

Spent coffee grounds (SCG) were used as a flour substitute at different ratios (5, 10, 15, 20 and 25%) in the production of the şekerpare. Baking and textural properties, nutritional content (moisture, fat, ash, protein, dietary fiber amount, total phenolic content, and antioxidant activity), color and sensory properties were investigated. SCG-added şekerpare samples had higher moisture, protein, and ash than the control samples. The highest dietary fiber content (6.96 g/100 g) was observed in samples with a 25% SCG addition. With increasing SCG addition, hardness decreased and, fracturability increased. The microbial count did not increase during the storage period in samples containing 5 to 20% SCG. As the amount of SCG increased, the total phenolic content and the DPPH radical scavenging activity increased. The sensory analysis results indicated that şekerpare with 5% SCG addition was found to be the most appealing product in terms of flavor, softness, chewiness, and swallowing.

Keywords: Dietary fiber, phenolics, bakery products, natural antioxidants

ŞEKERPARE TATLISININ KULLANILMIŞ KAHVE TELVESİ İLE ZENGİNLEŞTİRİLMESİ: FİZİKOKİMYASAL, BESİNSEL, DUYUSAL VE DOKUSAL ÖZELLİKLERİ

ÖZ

Kullanılmış kahve telvesi (KKT) şekerpare üretiminde farklı oranlarda (%5, 10, 15, 20 ve 25) un ikamesi olarak kullanılmıştır. Pişirme ve dokusal özellikler, besin içeriği (nem, yağ, kül, protein, diyet lifi miktarı, toplam fenolik madde içeriği ve antioksidan aktivite), renk ve duyusal özellikler araştırılmıştır. KKT ilaveli şekerpare örnekleri kontrol örneklerine göre daha yüksek nem, protein ve

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kül içeriğine sahiptir. En yüksek diyet lifi içeriği (6.96 g/100 g), %25 KKT ilaveli örneklerde gözlenmiştir. KKT ilavesi arttıkça, sertlik azalmış ve kırılganlık artmıştır. %5-20 KKT içeren örneklerde depolama süresi boyunca belirgin mikrobiyal yük artışı gözlenmemiştir. KKT miktarı arttıkça, toplam fenolik madde içeriği ve DPPH radikali temizleme aktivitesi artmıştır. Duyusal analiz sonuçları, %5 SCG ilaveli şekerparenin lezzet, yumuşaklık, çiğnenebilirlik ve yutma açısından en beğenilen ürün olduğunu göstermiştir.
Anahtar kelimeler: Diyet lif, fenolik, fırıncılık ürünleri, doğal antioksidanlar

INTRODUCTION

The taste/aroma and health benefits of coffee make it one of the world's most popular beverages (FAOSTAT, 2016; Torga and Spers, 2020). It is mainly sourced from Brazil (Arabica and Robusta), Vietnam (Robusta), Colombia (Arabica) and Indonesia (Robusta). Brazil is the largest coffee producing country, accounting for 40% of the world's coffee supply. Vietnam is the second largest coffee producing country accounting for around 20% of world production. Colombia and Indonesia are also significant contributors to the coffee market (ICO, 2017; Statista, 2024). Global daily coffee consumption has been reported to be three billion cups (ICO, 2022).

The bioactivities of coffee such as antioxidant, antibacterial, anti-inflammatory, anti-obesity, and neuroprotective properties due to various components have been reported in the literature (Carneiro et al., 2021; Castaldo et al., 2021; Bramantoro et al., 2022; Díaz-Hernández et al., 2022; Liczbiński and Bukowska, 2022; Rawangkan et al., 2022; Wang et al., 2024). In addition, coffee has been shown to be high in fibre, which has a significant effect on cardiovascular health, reducing the risk of heart attack and preventing diseases such as diabetes, obesity and hypertension (Salazar-López et al., 2020). The daily intake of dietary antioxidants from coffee consumption has been indicated to be greater than that from tea, fruit and vegetables (Elhussein et al., 2018). In a study conducted by Agudelo-Ochoa et al. (2016), it was reported that the plasma antioxidant capacity exhibited a significant increase in the groups one hour after coffee consumption compared to the control group. Tunnicliffe and Shearer (2008) demonstrated that the ability of coffee to reduce blood glucose possibly due to chlorogenic acid. Agudelo-Ochoa Gloria et al. (2016) showed an increase in the caffeic and ferulic acid concentrations after coffee consumption.

The processing of coffee cherries and the brewing of coffee using various techniques generate large quantities of by-products (Scully et al., 2016). Spent coffee grounds (SCG) are a by-product of coffee production (45%) which is the insoluble residue formed during the preparation of coffee beverages (Cruz et al., 2012; Murthy and Naidu, 2012; Ballesteros et al., 2014). Approximately 6 million tonnes kg of SCGs are generated annually from 1 tonnes of green coffee (Mussatto et al., 2011). The adverse environmental impact of SCG has been emphasized due to their high organic load (Balzano et al., 2020). Most researchers have focused on the composition of SCG for their potential utilization to contribute to the circular economy of countries. One of these alternative ways could be the use of SCG in the food industry. Following the European Commission policy on food waste management (Directive 2008/98/EC, 2008; EU Publication (2012), it was reported that they could be used in new functional foods (Balzano et al., 2020). It has been reported that SCG contain 54% insoluble dietary fibre, about 6% resistant starch, high antioxidant activity and DPPH radical scavenging capacity (Salazar-López et. al., 2020; Franca and Oliveira, 2022).

SCG have been formulated in various bakery products and beverages (Bevilacqua et al., 2023). Hussein et al. (2019) evaluated sponge cakes with wheat flour replaced by SCG (2%, 4, and 6) and found higher dietary fiber content and the rheological properties. Severini et al. (2020) utilized SCG as a flour substitute at 15% and 30% in muffin cakes and they found higher total phenolic content and dietary fibre content. Martinez-Saez et al. (2017) reported that the addition of SCG to biscuit formulations was

effective in providing microbiological safety in addition to antioxidant insoluble fiber, essential amino acids. According to Vázquez-Sánchez et al. (2018), the use of SCG-derived antioxidant compounds in bakery foods increased the antioxidant potential of the food sample, total dietary fiber and phenolic bioaccessibility of the samples, as these criteria are expected from fortified/formulated functional foods. Castaldo et al. (2021) found high levels of polyphenols, melanoidins, and caffeine, and observed high antioxidant activity and the total phenolic compounds in SCG used in baked foods.

In this study, we aimed to use SCG which are generated by the production of instant and granulated coffee, for the functionalization of şekerpare. Şekerpare is a traditional Turkish dessert made by kneading flour, eggs, oil and various flavours or yoghurt into a smooth dough, which is then baked and served with sherbet. Due to the high availability and quantity of SCG and its beneficial effects on human health, its evaluation in a functional food can be an alternative approach to both waste management and sustainability issues. The composition, color, and textural properties, microbial load and antioxidant capacity of şekerpare dessert containing varying amounts of SCG were investigated and sensory analyses of samples were performed.

MATERIALS AND METHODS

Materials

Except for the spent coffee grounds specified in the recipe, all other ingredients were sourced from local markets in Istanbul. SCG samples were obtained from a third-wave coffee shop in Istanbul, using espresso-based beverages prepared exclusively from Arabica coffee beans. Plate count agar and potato dextrose agar used in microbiological analysis were purchased from Neogen (Neogen Corporation, Lansing, MI, USA). Gallic acid, Trolox, Folin-Ciocalteu reagent, 2,2-Diphenyl-1-picrylhydrazyl (DPPH) and all chemicals used in the determination of chemical composition were analytical grade and supplied from Sigma-Aldrich (St. Louis, MO, USA).

Preparation of SCG

The SCG samples were dried in a laboratory oven (at 50±5°C) until their moisture content ranged between 12% and 14.5%. After drying, the samples were sieved through a 60-mesh sieve. Subsequently, they were stored in glass jars at a temperature of -18°C (Vázquez-Sánchez et al., 2018).

Preparation of Şekerpare Samples

In this study, the şekerpare samples were prepared by modifying the method of Ertürk (2015). Wheat flour was the primary ingredient for producing şekerpare, a traditional Turkish dessert. The wheat flour was partially replaced with SCG at substitution rates of 5%, 10%, 15%, 20%, and 25%. The added SCG ratios were determined based on the study of Aguilar-Raymundo et al. (2019). The dough was prepared using butter, powdered sugar, eggs, wheat flour, SCG, semolina, and baking powder. The syrup was prepared by 1200 ml boiling water and 700 g sugar, followed by adding 5 ml lemon juice after achieving the desired consistency. The syrup was cooled before use. The ingredients and their proportions used in the recipes are detailed in the accompanying Table 1. Using a stand mixer (KitchenAid) with a paddle attachment, butter and powdered sugar were mixed for three minutes. Eggs were then added, and mixing continued for another three minutes. Flour was added in three increments while mixing, followed by the addition of semolina, resulting in the şekerpare dough. The dough was portioned into 35 g pieces, shaped into round forms by hand, and placed on baking trays. The şekerpare dough was baked in an industrial convection oven (Inoksan) at 180±2°C for 20 minutes. The images of control and SCG added samples shown in Figure 1. After baking, they were allowed to rest on the trays for five minutes. Baked samples were soaked in room-temperature syrup for three hours before removal, while others were unsweetened. Sensory analysis was conducted exclusively on şekerpare samples soaked in syrup, while all other analyses were performed on unsweetened şekerpare samples. Color analysis was conducted on unsweetened samples the same day after cooling, while texture analysis was performed on

unsweetened samples after 24 hours. The remaining samples were portioned, packed in plastic bags, and stored at -18°C for further analyses. Sensory analysis was conducted on the same day for syrup-soaked samples.

Table 1. Ingredients used for the dough of şekerpare dessert samples.

	DOUGH						
Ingredients[1]	Butter (25 °C)	Powdered sugar	Semolina	Egg	Wheat Flour[2]	Sodium bicarbonate	SCG[2]
Control	250 g	90 g	40 g	120 g	350 g	5 g	-
SGC5	250 g	90 g	40 g	120 g	332.5 g	5 g	17.5 g
SCG10	250 g	90 g	40 g	120 g	315 g	5 g	35 g
SCG15	250 g	90 g	40 g	120 g	297.5 g	5 g	52.5 g
SCG20	250 g	90 g	40 g	120 g	280 g	5 g	70 g
SCG25	250 g	90 g	40 g	120 g	262.5 g	5 g	87.5

[1] Ingredients at 21±1 °C,

[2] Based on 14% moisture content.

(SCG5: Şekerpare sample with 5% SCG addition, SCG10: Şekerpare sample with 10% SCG addition, SCG15: Şekerpare sample with 15% SCG addition, SCG20: Şekerpare sample with 20% SCG addition, SCG25: Şekerpare sample with 25% SCG addition)

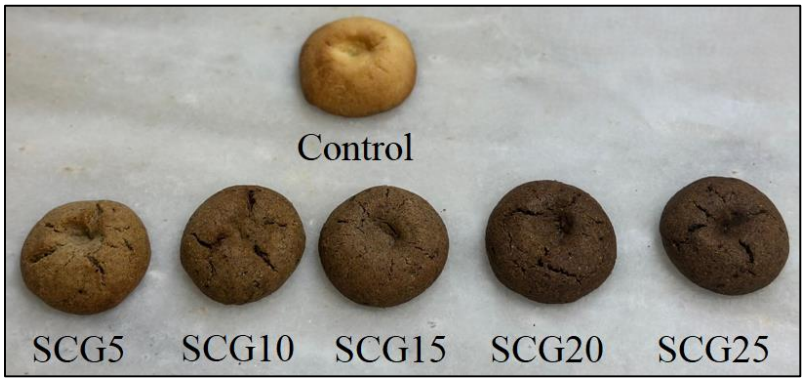

Figure 1. Şekerpare dessert produced from wheat flour (control) and its supplement with different SCG ratios. (SCG5: Şekerpare sample with 5% SCG addition, SCG10: Şekerpare sample with 10% SCG addition, SCG15: Şekerpare sample with 15% SCG addition, SCG20: Şekerpare sample with 20% SCG addition, SCG25: Şekerpare sample with 25% SCG addition)

Chemical Analyses

Moisture content was determined according to AOAC Official Methods 990.19 (AOAC, 2016). The ground samples were spread as thinly as possible in pre-weighed aluminium drying trays and dried at 105±5°C to constant weight. Moisture content was calculated based on the difference between the pre-and post-drying weights. The samples were incinerated at 550 °C in a muffle furnace to determine ash content (Nabertherm LV 9/11, Germany) according to NMKL No. 173 (2005). Protein content was analyzed using the Dumas method (Velp Dumas Nitrogen Analyzer – NDA 701, Italy) according to AOAC (2016). Total dietary fiber was measured enzymatically and gravimetrically following AOAC (2016). Total fat content was determined using the acid hydrolysis method with petroleum ether extraction and solvent evaporation, based on NMKL No. 160 (1998). An automated fat extraction device (Velp SER 148/6, Italy) was used. The energy and carbohydrate values of the şekerpare samples were calculated

using equations (1) and (2) (FAO, 2003). Every analysis was carried out in triplicate.

% Total Carbonhydrate = 100 - (% Moisture + % Ash + % Protein + % Fat) (1)

Energy (kcal) = 9 x Fat (g) + 4 x Protein (g)+4 x [Carbonhydrate (g) – Dietary fiber (g)] (2)

Spread Factor of Şekerpare Samples

Standard calipers were used to measure the şekerpare samples' diameter and thickness by AACCI Approved Method No. 10.54. The spread ratio was calculated as the diameter-to-thickness ratio for each sample (AACCI, 1995).

Color Analysis

The CIE LAB* scale was used to measure color properties using the Minolta Chroma Meter CR-400 (Minolta Camera, Osaka, Japan). L* represents lightness, a* red-green values, and b* yellow-blue values.

Texture Profile Analysis

A TA-XT Plus texture analyzer (Stable Micro Systems, UK) with a heavy-duty platform (HDP/90) and a three-point bending probe (HDP/3BP) was used to conduct the texture profile analysis (TPA). The settings included a trigger force of 25 g and a load cell capacity of 50 kg. The analysis was carried out at 1.0 mm/s for the pre-test, 3.0 mm/s for the test, and 10 mm/s for the post-test. The test parameters included a travel distance of 10 mm, with the gap between the two bottom supports set to 5 mm. The maximum force (g) recorded at the point where the cookies fractured into two primary pieces was noted as the hardness (g). The deformation of a sample until it breaks during compression was recorded as fracturabillity (mm) of sample. Measurements were taken after the cookies had been baked and allowed to cool to room temperature for 24 hours (Büyük and Dulger Altiner, 2024).

Extract preparation for antioxidant activity and total phenolic content analysis

Extracts were prepared according to the literature procedure with a few modifications (Wojdylo et al., 2007). Three grams of baked şekerpare samples were weighed and the methanol extract was prepared by adding 15 ml of methanol solution (75%). The test tubes were kept in an ultrasonic water bath at 25°C for 15 minutes. The supernatants were used for analysis of antioxidant activity and total phenolic content after centrifugation at 8000 rpm for 10 minutes.

Determination of Total Phenolic Content

The Folin–Ciocalteu colorimetric method was carried out for the determination of total phenolic content according to Wojdylo et al. (2007). Briefly, 0.1 ml of extract was treated with 2 ml of Folin-Ciocalteu reagent and 1 ml of sodium carbonate solution was added after 3 minutes. Then, the samples were kept in the dark at room temperature for 1 hour. The absorbance values were recorded at 765 nm with a spectrophotometer (Shimadzu UV-1240, USA). Gallic acid standard curve ($y=0.003x+ 0.0796$ and $R^2=0.9985$) was used to express the data as mg gallic acid equivalent (GAE) /kg sample.

Determination of DPPH Radical Scavenging Activity

The evaluation of the DPPH activity of the samples was in accordance with the colourimetric method of Brand-Williams et al. (1995) with minor modifications. 50 µL of extract and 150 µL of methanol solution (75%) were put into the test tube and, 3 ml of DPPH solution (0.051 mmol/L) was added to the mixture and incubated in the dark place at room temperature for 30 minutes. The absorbance was measured at 517 nm with a spectrophotometer (Shimadzu UV-1240, USA). The results were expressed as mg Trolox equivalent (TE) /kg sample, using a trolox standard curve ($y=-0.0053x+0.4766$ and $R^2=0.9983$).

Microbiological Analysis

The samples were stored at room temperature conditions in double-layer plastic bags for 30 days. The assessment of the microbial load was performed on days 0, 15, and 30. A microbiologic load analysis was conducted, which included counting the total aerobic mesophilic bacteria, yeast, and mold. Each sample of şekerpare (10 g) was taken aseptically and placed in a sterile 90 ml peptone saline solution. A series of three fold

dilutions was performed using the sample homogenates for the inoculation of the experimental setup. The total number of mesophilic aerobic bacterial colonies was enumerated on PCA following incubation at 30±2°C for 48 hours, while the fungal colonies were counted on PDA at 25±2°C for five days.

Sensory Analysis

Şekerpare samples were analyzed by sensory evaluation via a semi-trained panel of 38 participants, including students and faculty lecturers from the Department of Gastronomy and Culinary Arts. The evaluation criteria included color, aroma, taste, appearance, softness, mouthfeel, chewability, and overall acceptability. A 9-point hedonic scale was used, with scores ranging from 1 ("disliked extremely") to 9 ("liked extremely"). This sensory analysis in this study was reviewed and approved by the Ethics Committee of Maltepe University (Approval Number: 2024/22-14).

Statistical Analysis

SPSS software (version 16; SPSS Inc., Chicago, IL, USA) was used for data analysis. The mean values were presented with standard deviations. One-way ANOVA and Tukey's multiple comparison test were used to determine statistical differences at the 0.05 level.

RESULTS AND DISCUSSION

Nutritional Composition of Şekerpare Dessert Samples

The nutritional composition of the şekerpare samples is presented in Table 2. The moisture content ranged from 7.9% to 9.4%, ash content from 0.6% to 1.1%, protein content from 8.8% to 9.3%, and fat content from 29.3% to 31.0%. As the SCG substitution level increased, carbohydrate content (from 53.4% to 49.1%) decreased, and dietary fiber content (from 0.8% to 7.0%) increased. Adding SCG significantly increased moisture, protein, ash, fat, and fiber content compared to the control group ($P<0.05$). The increase in moisture content was attributed to the water holding capacity of SCG during kneading, a property linked to its soluble dietary fiber content, as reported in the literature (Song et al., 2021). This moisture enhancement may contribute to a softer and more acceptable texture in syrup-soaked şekerpare.

SCG is rich in unsaturated fatty acids, phytosterols, and tocopherols (Sakouhi et al., 2024), which explains the increase in fat content (29.3% to 31.0%) with SCG addition. The rise in ash content (0.6% to 1.1%) is due to the mineral composition of SCG, which includes essential minerals such as potassium, calcium, magnesium, sulfur, phosphorus, iron, manganese, boron, and copper (Ballesteros et al., 2014). According to Ali et al. (2018), nutraceutical biscuits with higher SCG additions (2, 4, and 6%) showed a good increase in ash content compared to the control. In a different study, Aguilar-Raymundo et al. (2019) reported that the ash content of cookies prepared with 25% SCG addition was 1.4 g per 100 g of sample. The results from our research showed that the 25% SCG added şekerpare sample had a similar ash content (1.10±0.05 g/100 g sample).

With SCG substitution levels of 15%, 20%, and 25%, the dietary fiber content reached 3.7%, 5.5%, and 7.0%, respectively. This classifies the şekerpare samples as "fiber source" and "fiber-rich" products, according to thresholds of 3.0 g/100 g and 6.0 g/100 g, respectively (Giuberti et al., 2018). Coffee has high cellulose, lignin, and hemicellulose content (Campos-Vega et al., 2020; Arya et al., 2022). The addition of coffee grounds increases the fiber content of şekerpare, which may contribute to enhanced satiety and a reduced risk of diabetes and obesity (Vázquez-Sánchez et al., 2018; Hosseini and Pazhouhandeh, 2023). The energy content of şekerpare samples, ranging from 485.3 to 509.1 kcal/100 g (dry basis), decreased with increasing SCG levels due to the high dietary fiber content of SCG. This trend aligns with findings in the literature. A study found that the control sample without SCG had the highest calorie content, while the shortbread containing 10% SCG had a reduced calorie content, approximately 10% lower. The study suggested that as the SCG percentage increased, the energy content decreased, likely due to the high dietary fiber content of SCG, which is

associated with a low glycemic index and lower calorie content in foods (Koay et al., 2023). Another study reported that SCG was incorporated into biscuit formulations along with low-calorie sweeteners and oligofructose. The results indicated that SCG could be used as a direct food ingredient in biscuits (up to 4% w/w) without negatively affecting the final nutritional or sensory quality of the product (Franca and Oliveira, 2022).

Table 2. Nutritional composition of şekerpare dessert samples, (g/100g şekerpare).

Samples	Moisture	Ash	Protein	Fat	Total Carbohydrate	Total Dietary Fiber	Energy (kcal/100g)
Control	7.9.±0.04^{f}	0.61±0.04^{d}	8.82±0.02^{e}	29.30±0.12^{e}	53.35±0.06^{a}	0.83±0.05^{f}	509.10±0.98^{a}
SGC5	8.15±0.06^{e}	0.75±0.06^{c}	8.95±0.02^{d}	30.33±0.11^{d}	51.82±0.09^{b}	2.06±0.04^{e}	507.78±0.61^{ab}
SCG10	8.37±0.07^{d}	0.87±0.04^{b}	9.00±0.04^{cd}	30.61±0.04^{c}	51.15±0.16^{c}	2.42±0.13^{d}	506.41±0.71^{b}
SCG15	8.61±0.04^{c}	0.92±0.02^{b}	9.07±0.04^{c}	30.77±0.02^{bc}	50.63±0.03^{d}	3.73±0.10^{c}	500.83±0.38^{c}
SCG20	8.82±0.07^{b}	0.98±0.04^{b}	9.19±0.05^{b}	30.90±0.06^{ab}	50.11±0.13^{e}	5.49±0.11^{b}	493.34±0.68^{d}
SCG25	9.41±0.07^{a}	1.10±0.05^{a}	9.33±0.03^{a}	31.03±0.06^{a}	49.13±0.13^{f}	6.96±0.06^{a}	485.30±0.79^{e}

Data are presented as mean ± standard deviation.
Letters that are different in the same column are considered to be significantly different (P<0.05).
(SCG5: Şekerpare sample with 5% SCG addition, SCG10: Şekerpare sample with 10% SCG addition, SCG15: Şekerpare sample with 15% SCG addition, SCG20: Şekerpare sample with 20% SCG addition, SCG25: Şekerpare sample with 25% SCG addition)

Physical Properties of Şekerpare

The baking and textural properties of the şekerpare samples are given in Table 3. Sample diameters ranged from 5.85 to 6.2 cm, with increasing SCG addition levels leading to larger diameters. Replacing wheat flour with SCG enhanced the spread ratio compared to the control group. This may result from a lowering in dough viscosity, influenced by SCG, and increased fat content in the samples (Oliveira Batista et al., 2023). Regarding hardness and fracturability, SCG addition reduced hardness and increased fracturability. Factors such as moisture content, baking conditions, partial substitution of wheat proteins, and high fiber content likely contributed to the softer texture of SCG-enriched şekerpare. The high fiber content of SCG may have enhanced water retention capacity, improving the softness of the cookies (Papageorgiou et al., 2024). The fracturability has a strong effect on the crispiness of the bakery products. Singh et al. (2015) observed that fracturability increased in biscuits enriched with dietary fiber. They reported that fracturability may have increased due to reduced resistance for snapping during texture analysis. Similarly, in this study, the high fiber content of SCG also enhanced the fracturability of SCG-added samples.

Table 3. Baking and textural properties.

Samples	Diameter (mm)	Thickness (mm)	Spread Ratio	Hardness (g)	Fracturability (mm)
Control	58.54±0.72^{c}	33.87±1.46^{a}	1.73±0.09^{d}	6719.51±690.64^{a}	2.66±0.34^{b}
SGC5	58.89±0.70^{c}	33.28±0.68^{a}	1.77±0.04^{d}	5514.20±567.99^{ab}	4.45±0.84^{ab}
SCG10	59.03±0.65^{c}	30.98±0.66^{b}	1.91±0.04^{c}	5547.88±601.43^{ab}	5.29±0.77^{b}
SCG15	60.13±0.36^{bc}	30.30±0.60^{b}	1.99±0.04^{bc}	5436.18±503.60^{ab}	5.23±0.34^{b}
SCG20	61.34±1.13^{ab}	29.28±1.08^{b}	2.10±0.07^{b}	5306.69±238.76^{ab}	6.54±0.86^{b}
SCG25	61.95±1.44^{a}	24.85±0.39^{c}	2.49±0.08^{a}	4091.06±1979.81^{b}	6.36±1.71^{b}

Data are presented as mean ± standard deviation.
Letters that are different in the same column are considered to be significantly different (P<0.05).
(SCG5: Şekerpare sample with 5% SCG addition, SCG10: Şekerpare sample with 10% SCG addition, SCG15: Şekerpare sample with 15% SCG addition, SCG20: Şekerpare sample with 20% SCG addition, SCG25: Şekerpare sample with 25% SCG addition)

In Table 4, the color analysis results are presented. Measurements were conducted for the outer and inner sections, reporting L*, a*, and b* values. The control sample exhibited a lighter color (L^*_{inner}: 68.5, L^*_{outer}: 72.2). With increasing SCG levels, the samples darkened (L^*_{inner}: 36.8–68.5, a^*_{inner}: -1.3–4.3, b^*_{inner}: 9.1–25.3; L^*_{outer}: 39.2–72.2, a^*_{outer}: 4.9–6.4, b^*_{outer}: 11.5–31.8). These changes are attributed to the dark color of SCG and the caramelization of sugars during baking (Desai et al., 2020; Oliveira Batista et al., 2023). The a* value of şekerpare samples increased with an increased amount of SCG. In contrast with a* value, b* value of the şekerpare samples with SCG addition decreased significantly. Color characteristics are mainly affected by the degree of browning during baking. At the beginning of non-enzymatic browning, which occurs as a result of the interaction of proteins or amino acids and sugars, an increase in a* value can be observed due to increased browning (Azuan et al., 2020). It is also known that the Maillard reaction during baking creates brown pigments (Petroviç et al., 2016).

Table 4. Color properties of şekerpare samples.

Samples	L^*_{outer}	a^*_{outer}	b^*_{outer}	L^*_{inner}	a^*_{inner}	b^*_{inner}
Control	72.19±1.30^{a}	4.89±0.93^{b}	31.78±0.36^{a}	68.46±1.94^{a}	-1.25±0.37^{e}	25.31±1.27^{a}
SGC5	54.27±2.27^{b}	6.38±1.23^{a}	22.67±0.85^{b}	52.37±1.26^{b}	2.97±0.23^{d}	15.00±0.40^{b}
SCG10	48.76±1.89^{c}	6.05±0.79^{ab}	18.35±0.62^{c}	44.41±1.89^{c}	3.57±0.24^{c}	12.63±0.65^{c}
SCG15	45.49±1.04^{d}	6.06±0.67^{ab}	16.40±1.25^{d}	41.26±0.81^{d}	3.82±0.19^{bc}	10.86±0.67^{d}
SCG20	40.79±1.28^{e}	6.65±0.45^{a}	13.45±0.90^{e}	40.27±1.99^{d}	4.07±0.19^{ab}	9.10±1.06^{e}
SCG25	39.21±0.44^{e}	6.19±0.18^{ab}	11.54±0.72^{f}	36.78±1.79^{e}	4.30±0.27^{a}	10.36±0.88^{d}

Data are presented as mean ± standard deviation.
Letters that are different in the same column are considered to be significantly different (P<0.05).
(SCG5: Şekerpare sample with 5% SCG addition, SCG10: Şekerpare sample with 10% SCG addition, SCG15: Şekerpare sample with 15% SCG addition, SCG20: Şekerpare sample with 20% SCG addition, SCG25: Şekerpare sample with 25% SCG addition)

Phenolic Content and Antioxidant Activity

The variations in antioxidant activity and total phenolic content of şekerpare samples at different ratios of SCG are shown in Table 5. When increasing the SCG ratio in the şekerpare samples, the total phenolic content and DPPH scavenging activity statistically increased (P< 0.05). Similar results were found in the study by Aguilar-Raymundo et al. (2019), who added SCG to cookies at three different ratios. Flavonoids, chlorogenic acid, and protocatechuic acid is the most important phenolic compounds of SCG (Mussatto et al., 2011; Han and Lee, 2021). As phenolic compounds such as flavonoids and phenolic acids are known as the main antioxidants in plant-based foods, adding SCG is expected to increase the phenolic content and antioxidant activity and consequently improve the functionality of the şekerpare samples.

Table 5. Antioxidant activity and total phenolic content of şekerpare samples.

Samples	Total Phenolic Content (mg GAE/kg sample)	DPPH Scavenging Activity (mg Trolox/kg sample)
Control	191.65±5.09^{a}	118.10±7.56^{a}
SGC5	516.86±12.60^{b}	520.22±13.36^{b}
SCG10	965.11±20.97^{c}	912.96±22.11^{c}
SCG15	1248.03±32.45^{d}	1149.78±19.94^{d}
SCG20	1446.92±12.28^{e}	1545.64±44.19^{e}
SCG25	1641.26±28.31^{f}	1828.51±34.54^{f}

Data are presented as mean ± standard deviation.
Letters that are different in the same column are considered to be significantly different (P<0.05).
(SCG5: Şekerpare sample with 5% SCG addition, SCG10: Şekerpare sample with 10% SCG addition, SCG15: Şekerpare sample with 15% SCG addition, SCG20: Şekerpare sample with 20% SCG addition, SCG25: Şekerpare sample with 25% SCG addition)

Microbiological Properties of Şekerpare Dessert Samples

The total number of mesophilic aerobic bacteria in the control group was 0.84 log CFU/g and 0.98 log CFU/g on days 0 and 15, respectively. On day 30, the total number of bacteria was highest in the control group (1.39 log CFU/g) compared to the SCG groups with substitution ratios of 5%, 10%, 15%, 20% and 25%. The total number of bacteria in the other SCG groups ranged from 0.20 to 0.75 log CFU/g. Total molds/yeasts were also evaluated in all samples. On day 0, no mold or yeast was detected in any of the samples. The total mould/yeasts in the control group were found to be 0.93 and 0.77 log CFU/g at the end of day 15 and 30. The highest number of mold/yeast between the SCG groups was found in the 25% SCG group (0.93 log CFU/g) at the end of day 30. Although there were fewer molds in the other groups (5%, 10%, 15% and 20% substitution), there was no notable difference and the number of mold/yeast ranged from 0.15 log CFU/g to 0.85 log CFU/g (Table 6). Similar results were also found in a study conducted by Ahmet et al. (2023) with cakes enriched with spent coffee and tea powder. Researchers reported that after 7 and 14 days of storage, cakes fortified with spent coffee and tea powders had considerably higher levels of total bacterial account, total mold, and yeast than cakes stored for 0 days.

Table 6. Microbiological shelf life analysis

	Total plate count (log CFU/g)			Mold and yeast count (log CFU/g)		
	Day 0	Day 15	Day 30	Day 0	Day 15	Day 30
Control	0.85^{aC}	0.98^{aB}	1.39^{aA}	n.d.	0.93^{aA}	0.77^{cB}
SGC5	0.63^{bB}	n.d.	0.75^{bA}	n.d.	0.49^{bB}	0.85^{bA}
SCG10	n.d.	n.d.	0.20^{cA}	n.d.	n.d.	0.15^{eA}
SCG15	0.63^{bA}	0.30^{cB}	n.d.	n.d.	0.43^{bA}	0.49^{dA}
SCG20	0.53^{bA}	n.d.	0.30^{cB}	n.d.	n.d.	0.56^{dA}
SCG25	0.30^{cB}	0.65^{bA}	0.33^{cB}	n.d.	0.50^{bB}	0.93^{aA}

n.d.: not determined

Different lower case letters (a, b, c) in the same column indicate the difference between samples.

Different capital letters (A, B, C) on the same row indicate the difference between days (P<0.05).

(SCG5: Şekerpare sample with 5% SCG addition, SCG10: Şekerpare sample with 10% SCG addition, SCG15: Şekerpare sample with 15% SCG addition, SCG20: Şekerpare sample with 20% SCG addition, SCG25: Şekerpare sample with 25% SCG addition)

Given the high concentration of organic compounds, including fatty acids, amino acids, polyphenols, minerals, polysaccharides and dietary fiber present SCG, there is increased potential for mold/yeast growth. The higher proportion of spent ground coffee in a sample may provide favorable conditions for the growth of mold/yeast. Some researchers have also reported that SCG did not show antifungal activity against some species (Vítězová et al., 2019; Calheiros et al, 2023). Belokurova et al. (2021) indicated that some osmophilic yeasts and xerophilic mycelial molds in food samples may multiply slowly through water activity.

The increase in microbial load of SCG groups with substitution ratios of 25% as compared to control may be due to increase in moisture content with increasing SCG supplementation level. Overall the value of microbial load has been found to be within acceptable limit in accordance with microbiological standards of fortified blended products which were found that total plate count less than 10^5 CFU/g (Wani et al., 2015).

The antibacterial activity of coffee extracts has been reported in the literature. In one of these studies, Monente et al. (2015) showed antibacterial effect of coffee extracts against *Staphylococcus aureus, Listeria monocytogenes* and *Candida albicans*. Almeida et al. (2006) evaluated that three different brands of roasted coffee extracts and chemical compound (caffeic acid, chlorogenic acid, and protocatechuic acid) against nine Enterobacteria and reported the

antimicrobial activity. Moreover, melanoidins were reported that antibacterial activity against Gram-negative and Gram-positive bacteria (Rufián-Henares and de la Cueva, 2009). Furthermore, it has been reported in the literature that SCG has antibacterial activity. From this respect, we suggest that the number of bacteria is lower in SCG groups because of potential antibacterial activity of SCG.

The compounds of coffee such as chlorogenic acid, caffeine, quinic acid, malic acid, phenolic acids, tannin and other hydroxycinnamic acids suggested to contribute to its antimicrobial activity (Duangjai et al., 2016). It has been reported that phenolic compounds may cause alterations the cell membrane causing disruption in the permeability or in the intracellular functions. They also affect cell wall rigidity, disrupting membrane interactions and causing irreversible cytoplasmic membrane damage and coagulation of contents, resulting in the cessation of enzyme activities and cell death (Cushnie and Lamb, 2011; Khochapong et al., 2021). These compounds are likely to be involved in the underlying mechanism of antibacterial activity of SCG supplementation. As a result, adding 5% to 20% SCG in the şekerpare formulation is acceptable for the microbiological quality of the food product because the şekerpare formulation did not increase the microbial count.

Sensory Analysis

A hedonic test was conducted to evaluate the sensory properties of şekerpare samples with varying SCG concentrations, and the results are summarized in Table 7. The scores for evaluated attributes ranged from 4.71 to 7.42, indicating that some formulations were neither liked nor disliked, while others received mild to moderate levels of preference. There was a significant difference between control samples and SCG added samples in terms of color acceptance amongst the panelists. Koay et al. (2023) observed that the SCG ratio added to shortbreads reduced color acceptance in sensory analysis. According to softness results in Table 7, the addition of SCG in şekerpare is acceptable without adverse effect on the softness which is one of the significant characteristic for bakery products. Higher SCG concentrations reduced flavor and overall acceptability, likely due to the intense coffee taste, which was not well-received by the panelists (Aguilar-Raymundo et al., 2019). Bitter xanthines, such as caffeine found in SCG may have contributed to the formation of bitter taste and, consequently, SCG-added şekerpare samples may have received lower scores in terms of taste, flavor and overall acceptability.

Table 7. Sensory analysis results.

Sensory properties	Control	SCG5	SCG10	SCG15	SCG20	SCG25
Color	6.82±1.87^{a}	4.92±2.29^{b}	4.71±2.14^{b}	4.79±2.38^{b}	4.87±2.40^{b}	5.16±2.68^{b}
Odor	6.82±1.78^{a}	6.00±1.90^{ab}	5.55±2.02^{ab}	5.16±2.05^{b}	5.21±2.20^{b}	5.08±2.24^{b}
Flavor/Taste	6.74±1.67^{a}	6.03±2.16^{ab}	5.50±2.12^{ab}	5.53±2.31^{ab}	4.92±2.44^{b}	4.95±2.58^{b}
Appearance	7.26±1.64^{a}	5.24±1.97^{b}	5.26±2.26^{b}	5.21±2.21^{b}	5.00±2.27^{b}	5.50±2.46^{b}
Softness	6.76±1.94^{a}	6.47±1.83^{a}	6.05±2.22^{a}	6.11±2.13^{a}	6.21±1.76^{a}	6.00±2.05^{a}
Mouthfeel	7.05±1.75^{a}	6.58±1.95^{a}	6.66±2.02^{a}	6.68±1.96^{a}	6.47±1.62^{a}	6.08±2.02^{a}
Crumbling	6.55±2.24^{a}	6.24±2.09^{a}	6.21±2.15^{a}	6.61±1.91^{a}	6.16±2.01^{a}	5.71±2.18^{a}
Chewing and swallowing	7.42±1.43^{a}	6.95±1.83^{ab}	6.66±1.96^{ab}	6.42±1.86^{ab}	6.40±1.76^{ab}	5.71±2.47^{b}
General acceptability	7.13±1.51^{a}	6.18±1.83^{ab}	5.87±2.15^{ab}	5.82±2.24^{ab}	5.55±2.17^{ab}	5.24±2.40^{b}

Data are presented as mean ± standard deviation.

Letters that are different in the same row are considered to be significantly different (P<0.05).

(SCG5: Şekerpare sample with 5% SCG addition, SCG10: Şekerpare sample with 10% SCG addition, SCG15: Şekerpare sample with 15% SCG addition, SCG20: Şekerpare sample with 20% SCG addition, SCG25: Şekerpare sample with 25% SCG addition)

CONCLUSION

In this study, SCG powder was a valuable source of fiber and phenolic ingredients and demonstrated high antioxidant activity. The addition of SCG to the şekerpare dessert formulation improved the textural property, hardness decreased and, fracturability increased. The protein, ash, and fiber content of şekerpare samples increased with the increase of SCG addition, compared to the control group. The highest dietary fiber content (6.96 g/100 g) and the lowest energy value (485.30 kcal) were observed in samples with a 25% SCG addition. Sensory acceptance revealed that the most acceptable product in terms of taste, softness, chewiness, and swallowing was şekerpare with 5% SCG addition. The microbial count did not increase when 5% to 20% SCG was added to the şekerpare formulation, suggesting that the food product has acceptable microbiological quality. Considering these findings, SCG is a potentially valuable and functional ingredient that can be utilized to develop different bakery products with enhanced nutritional value. It can also be recommended as a beneficial flour substitute for energy-reduced food formulations. However, the incorporation of SCG in large quantities can negatively impact sensory characteristics, leading to a reduction in overall acceptability, which restricts its potential applications. Therefore, future research could focus on exploring various extraction methods for the preparation of SCG extract or investigating the use of different solvents to effectively remove bitter compounds.

AUTHOR CONTRIBUTIONS

Kübra Topaloğlu Günan: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review and editing. Tuğçe Boğa: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review and editing. Didem Berber: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review and editing. Özlem Aktürk Gümüşay: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review and editing, Supervision.

DECLARATION OF CONFLICTING INTERESTS

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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ETHICAL CONSIDERATIONS

Sensory analysis in this study was reviewed and approved by the Ethics Committee of Maltepe University (Approval Number: 2024/22-14).

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