RESEARCH ARTICLE

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Influences of grape seed substitution on the bioactive and sensory properties of brewed coffee

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Abstract
In this research, ground coffee beans were replaced with grape seed powder in different proportions. Thus, it was aimed to benefit from the health benefits of grape seeds and develop a new coffee formulation that is functional, low in caffeine and has a different taste and odor. For this purpose, the moisture, ash and crude fiber contents, antioxidant activity and total phenolic compounds of Besni karası (*Vitis vinifera* L.) grape seeds were examined. Grape seeds were ground and included in the coffee formulation in different proportions (0, 25, 40, 55%) with the same particle size. Physicochemical, bioactive and sensory properties of the produced coffee grounds were examined. As a result of the analyses, as the grape seed powder concentration increased in the coffee composition, the acidity decreased ($p<0.05$) and the antioxidant activity and total phenolic compounds increased ($p<0.05$). The brightness (L*) of the samples increased depending on the grape seed powder composition and usage rate. As a result of the sensory analysis, it was determined that the samples with 25% grape seed powder added received the closest score to the control group, and the samples with 40-55% grape seed powder had the similar scores with the control group in terms of roughness. In our study, the nutritional composition of grape seeds, which are food waste in the industry, has been revealed that it can be used as a substitute product in coffee and will contribute to sustainability.
Keywords: Functional food, Fortification, Antioxidant activity, Quality parameters

INTRODUCTION

Coffee is a type of beverage that is prepared according to the grinding of raw coffee seeds and different brewing methods and made ready for consumption (Arslan, 2019). Coffee, which is in the category of the most consumed beverage group in the world, especially after water and tea, is the second most traded commodity after petroleum (Atabani et al., 2019). Coffee is very rich in components that have healing effects on health, including polyphenols, compounds with antioxidant activity (chlorogenic acids), macro (carbohydrates, nitrogenous compounds, lipids) and micro (vitamins and minerals) nutrients (Nieber, 2017). The type of coffee bean, brewing conditions (temperature-time) and consumption frequency are factors that affect human health. Studies have shown that coffee consumption generally has a protective effect on cardiovascular diseases, hypertension, cancer, type 2 diabetes, Parkinson's disease, Alzheimer's and cognitive functions (Higdon and Frei, 2006; Bae et al., 2014).

Coffee culture, spanning health, social, and commercial realms, enjoys broad appeal across age groups (Hung, 2012). Consumption patterns are influenced by factors like gender, age, diet, occupation, and income, with coffee accessible in diverse settings (Samoggia et al., 2020). Recent shifts in coffee habits have spurred an uptick in producers, prompting a focus on novel coffee varieties to meet evolving demand (Czarniecka-Skubina et al., 2021). In this context, there are various coffee brewing methods (filtration, boiling, pressure) (Stanek et al., 2021), aromatic components (hazelnut, vanilla, chocolate etc.) (Andrzejewski et al., 2004) and different coffee preparing methods to reveal the characteristic aroma and taste of coffee. Different types of coffee such as espresso, americano, latte macchiato or filter coffee are offered to consumers using various coffee beans (Banu et al., 2020; Wu et al., 2022). In order to increase the aromatic and nutritional value of coffee, seeds from different plant species can be used. There are some studies using different seeds such as durian seed (Natania and Wijaya, 2022), baobab seed (Ismail et al., 2022), pedada seed (Wulandari et al., 2021), palm seed (Fikry et al., 2019), salak seed (Suastitu et al., 2019) as substitutes for coffee. In general, one of the common goals of this type of research is to reduce the caffeine content of coffees. However, the plants used in such research are quite local and their availability is very limited.

Grape seed, which is called a by-product of grape processing in the food industry, is a rich source of vitamins, minerals and phytochemicals (polyphenols, aromatic acids, phenolic acids, flavonoids) (Makris et al., 2007). Due to its nutritive quality and high antioxidant capacity, its popularity is gradually increasing and it attracts the attention of both the producer and the consumer (Duba et al., 2015). It is a valuable product included in bread, biscuit, yogurt, and various meat product formulations to add functional properties (Antonic et al., 2020; Ayoubi et al., 2022; Elkatry et al., 2022). However, it has been determined that the study using grape seeds in the composition of coffee with a high consumption potential is limited in the literature. Only one study was found where grape seed powder was used as a coffee substitute. Ülger (2022) conducted the study in which grape seeds were used as a coffee substitute and 0-15% grape seed powder (30% Boğazkere and 70% Öküzgözü) were added to Turkish coffee. In the study, it was revealed that the total amount of phenolic compound 41.52-41.84 mg GAE/g DM, antioxidant activity value of 258.98-311.14 mmol trolox/g DM, grape seed addition improved the bioactive properties of Turkish coffee. The low concentration of grape seed powder used in the samples in the research and the limited global effect of Turkish coffee are different from the current study.

Caffeine content may vary depending on the brewing method applied, the type and amount of coffee beans used, the amount of water, brewing process conditions (pressure, temperature, time) and roasting conditions. In this case, the caffeine content of espresso type coffees obtained with the coffee machine was reported as 4.20 g/L (Olechno et al., 2021). The average caffeine content in grape seeds was reported as 0.96 mg/mL (Kim et al., 2006). In the current research, a new product with reduced caffeine content was obtained by reducing the amount of coffee and using grape seed powder as a substitute.

In this study, it was aimed to develop sustainable, functional coffee with high added value in terms of dietary fiber and bioactive properties and with less caffeine content by using Besni Karası grape seeds (in Figure 1), which are food waste in the industry.

Figure 1. Besni Karası Grape Seed

MATERIALS AND METHODS

Raw materials

Medium roasted Arabica whole coffee beans (*Coffea arabica* L.) grown in Latin American countries were procured from the Tchibo (Hamburg, Germany) sales point. The dried seeds of Besni Karası grapes grown in the Adıyaman region of Türkiye were obtained from a local spice shop (Güneş Baharat, Mersin, Türkiye). Tap water was used in the coffee production.

Ground coffee and grape seed powder production

Whole coffee beans and grape seeds were ground in a laboratory mill (Kiwi KSPG-4812, Istanbul, Türkiye) using 150 W power. Then, they were sieved (Model VE 50, Retsch, Germany) with a pore diameter of 50 µm.

Coffee production

Some preliminary experiments were carried out to determine the appropriate coffee production method. For this purpose, three different coffee brewing methods (filtration (French-press), pressure and boiling methods) were tried. In each method, coffee was replaced by grape seed by 55%. As a result of the sensory analyses made by 15 trained panelists (age range 20-36, non-smokers) the production was carried out with the most creditable method. The method used for sensory analyses is explained in detail in the "coffee analysis" section. According to the sensory analysis results, the roughness caused by the insoluble of the ground grape seeds in the coffee obtained by boiling and filtration methods was not appreciated by the panelists. For this reason, it was decided that the appropriate method to be used in production was the pressure method. However, due to the fact that Espresso and many Espresso-based coffees can be produced with the pressure method, two different coffees, Espresso and Americano, were presented to the panelists. As a result, Americano was the more appreciated coffee type.

Americano-type coffee samples were made with a fully automatic espresso machine (Philips 3200 Series, Cluj-Napoca, Romania) working with a pressure of 15 bar and water temperature of 70-82°C as declared by the manufacturer. Americano coffee brew was prepared as described by Liu et al. (2017). Americano can simply be defined as a diluted espresso. When preparing single-shot espresso, 7 g of ground coffee and hot distilled water are used. Americano is made by adding 200 mL of boiling distilled water to single-shot espresso. In the study, the control sample was prepared according to the standard Americano production technique. In the other samples, 25%, 40% and 55% of the ground coffee was replaced with grape seed powder. Coffees prepared with grape seed substitute were coded as C208 (25%), C967 (40%) and C580 (55%), while the control sample was coded as C157. Coffee samples that were produced are presented at Figure 2. While the coffees prepared for use in sensory analyses were served hot, the coffees used in other analyses were stored in the refrigerator (UES 273 D2K 208 LT A++, Uğur, İzmir, Türkiye) at +4 °C for further use. Production, processes and all analysis on raw materials and coffees were carried out in the Toros University Food Technology laboratory.

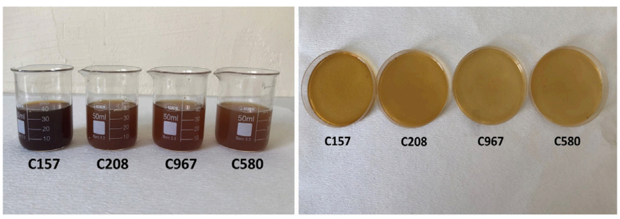

Figure 2. Americano coffee samples without and with grape seed powder
C157: Control, C208: Coffee with 25% grape seed powder, C967: Coffee with 40% grape seed powder, C580: Coffee with 55% grape seed powder

Raw material analysis

The moisture content of the samples was found by using the gravimetric method, by drying the coffee and grape seeds in a laboratory oven (Nuve EN400, Türkiye) at 105°C until they reach a constant weight, and then calculating the percent moisture content (AACC, 2010).

While calculating the amount of ash, the samples were weighed into porcelain crucibles and burned in a furnace (Thermnevo, Nevola, Türkiye) at 550±5 °C until they turned white. The residue was reweighed and the results expressed as a percentage (AOAC, 1990).

The crude fiber ratios in the raw material were determined using the gravimetric method (Özdemir et al., 2022), and for this purpose, 10 g of ground and sieved sample was kept in 300 mL of distilled water for 20 minutes. The mixture was filtered through coarse filter paper. Washing with distilled water was continued until the residue remaining on the paper reached a constant weight, and then dried in a laboratory oven (Nuve EN400, Türkiye) at 105°C. The dried residue was weighed and the amount of insoluble fiber and, accordingly, the % crude fiber content were calculated.

The total amount of phenolic substances was determined according to the Folin–Ciocalteau method (Singleton and Rossi, 1965). Solutions consisting of a mixture of samples and 80% methanol (1:25 w/v) were centrifuged (Nuve NF800 R, Türkiye) at 4500 rpm for 15 minutes. After 0.2 mL of the supernatant was taken, it was mixed with 1.5 mL of Folin-Ciocalteu reagent (reagent:water mixture, 1:10 v/v) and left in the dark for 5 minutes. Then, 1.5 mL of 7.5% sodium carbonate solution was added and after 90 minutes of resting in the dark, their absorbance at 765 nm was recorded with a UV–Vis spectrophotometer (UV-1601, Rayleigh, BFRL, China). The results were evaluated by calculating the phenolic content over the gallic acid equivalent.

Antioxidant activities of raw materials and coffee samples were measured according to the method specified by Brand-Williams et al. (1995). For this purpose, 5 g of sample and 50 mL of 80% methanol aqueous solution were mixed for 30 minutes. The mixture was filtered through coarse filter paper and the filtrate was centrifuged (Nuve NF800 R, Türkiye) at 4500 rpm for 15 minutes. Then, 100 µL of the extracts were taken into a cuvette and 3900 µL of DPPH (1,1-diphenyl-2-picrylhydrazil radical) solution (3.94 mg/100 mL methanol) was added and kept in the dark for 30 min. The absorbances of the samples were measured at 515 nm with a UV–Vis spectrophotometer (UV-1601, Rayleigh, BFRL, China). Trolox calibration was used to determine the antioxidant activity.

Coffee analysis

pH measurements were determined directly using the WTW 3110 brand pH meter (WTW, Germany) (Hannon et al., 2003). Titratable acidity was determined by titration of 1g aliquot of coffee brew with 0.1N NaOH at 22°C to a pH of 6.0 and a pH of 8.0 (Rao and Fuller, 2018). The results were expressed in mL of (0.1 N) NaOH. Total phenolic compounds and antioxidant activity were determined as specified in the raw material analysis section. Color analysis was performed using Chroma Meter (Minolta, CR300, Japan). Results were expressed in parameters

L*, a* and b*. Before measurements, calibration was performed with white and black calibration plates as references. The results were the average of at least three measurements from different quadrants of each sample (Martley and Michel, 2001). Sensory evaluation of coffee samples obtained in preliminary trials and final productions were performed according to the method specified by Stone and Sidel (2004). A trained panelist group of 15 consisting of Toros University faculty members and graduate students participated in the analyses. Necessary training was given to the panelists before the analysis and random codes were given to the samples. Sensory evaluation was performed immediately after the coffees were produced, while the samples were still warm (70±5 °C). Coffee samples were evaluated using a 5-point linear hedonic scale (1:extremely dislike to 5:extremely like); rated for color, odor, taste and flavor, fluidity, roughness, mouthfeel and overall acceptability.

Statistical analysis

Coffee production was carried out as four different samples at three replications. The experimental data were evaluated by variance analysis (ANOVA) to detect the significant differences ($p<0.05$). SPSS (Version 20, IBM, USA) was used to determine the Duncan correlation coefficients with 95% confidence level (Efe et al., 2000).

RESULTS AND DISCUSSION

Compositional properties of coffee bean and grape seed

The compositional properties of ground coffee bean and grape seed powder are given in Table 1. The moisture and ash contents of the coffee bean and grape seed powder were 7.65-6.98% and 5.39-2.39%, respectively. The coffee bean moisture content should be below 12.5% (Kyaw and Budiastra, 2020). Moisture content above this value causes microbial deterioration in the coffee bean and causes off-flavors (Adnan et al., 2017). When previous studies were examined, it was determined that the moisture content of granule coffee beans varied in the range of 5.52-13% and was consistent with the results of our study (Mazzafera, 1999; Murthy and Manonmani, 2009). Elkatry et al (2020) determined the moisture and ash content of grape seed powder as 7.16%-3.54%, respectively. The difference in results with our study is related to the type of grape seed, cultivation area and soil composition. Total fiber content of grape seed powder was found higher than that of ground coffee beans (1.5 times higher). Therefore, coffee enriched with grape seed powder has been of superior quality in terms of fiber. When the previous studies were examined, it was determined that the crude fiber content of the coffee bean and the grape seed varied between 2.30-24.70% and 32.21-83.01%, respectively and this situation was due to the raw material composition (Maman and Yu, 2019; Grzelczyk et al., 2022; Oprea et al., 2022). Vazquez-Sanchez et al (2018) reported that the change in the chemical composition of polysaccharides in coffee, depending on the roasting process, affects the fiber content. When the total phenolic content of ground coffee beans and grape seed powder used in making Americano coffee are examined (Table 1), it was observed that the total phenolic content of the coffee bean was 435.84 mgGAE/100g and the grape seed powder was 989.52 mgGAE/100g. Similarly, the antioxidant activity of grape seed powder was higher than that of coffee beans (145.32 and 139.11 µmolTE/100g, respectively). As a result, it was determined that grape seed powder had 2.26 times more phenolic substances and 1.04 times more antioxidant activity than coffee beans. In the current study, the higher phenolic component content of grape seed powder (catechin, epicatechin, epicatechin gallate, dimeric, trimeric) compared to granulated coffee might be associated with the diversity of phenolic species. Grape seeds and coffee beans contain different phenolic compounds. Grape seeds are rich in proanthocyanidins (OPCs), a type of phenolic compound known for its potent antioxidant properties. They also contain flavonoids such as quercetin and kaempferol, as well as phenolic acids like gallic acid and caffeic acid. On the other hand, coffee beans are abundant in chlorogenic acids, which contribute to the taste and antioxidant properties of coffee. They also contain caffeine, providing a stimulating effect, and trigonelline, another important alkaloid. Both seeds provide significant antioxidants, but their phenolic profiles are distinct, suggesting different potential health benefits (Rababah et al. 2004; Bucić-Kojić et al., 2009).

When the studies are examined, it has been determined that the antioxidant activity of the Arabica coffee bean is in the range of 511.66-1150.50 µM TE/g (de Souza et al., 2020) and the grape seed powder is in the range of 88.60-3068.00 µM TE/g dry matter (Li et al., 2008). The higher antioxidant capacity of some species of grape seed powder is associated with the presence of polymeric and monomeric compounds (catechin and epicatechin) (Peng et al., 2010). It was reported that the total phenolic substance amount of Arabica coffee was in the range of 14.92-16.55 mg GAE/g (Alnsour et al., 2022), and the phenolic substance amount of grape seeds was in the range of 79.06–111.22 mg GAE/g (Krasteva et al., 2023). As a result, other studies have also shown that the phenolic substance content of grape seeds is higher than roasted coffee.

pH and titratable acidity of coffee

The pH value and titratable acidity of the coffee samples are presented in Figure 3. When the graph is examined, it is seen that the pH value of the control sample is lower than the pH values of all coffees using grape seed ($p<0.05$). As the addition of grape seed powder increased, the pH values of the coffees decreased and statistically significant differences were detected between pH values of all coffee samples ($p<0.05$). Supporting these results, the titratable acidity of the grape seed powder added

Table 1. Compositional properties of coffee bean and grape seed (n=3)

Composition	Ground coffee beans (*Coffea arabica* L.)	Grape seed powder (Besni Karası, *Vitis vinifera* L.)
Moisture (%)	7.65±0.24	6.98±0.31
Ash (%)	5.39±0.08	2.39±0.03
Crude fiber (%)	27.22±1.56	48.65±2.67
Antioxidant activity (mmol trolox/100g)	139.11±9.73	145.32±8.22
Total phenolic compound (mg GAE/100g	435.84±6.45	989.52±8.71

samples was also found lower than the control sample ($p<0.05$). The lowest acidity level was determined in coffees with 25% grape seed powder substitute. While there was no statistical difference between the acidity of 40% and 55% grape seed powder substituted coffees ($p>0.05$), the acidity of these samples was found significantly higher than that of 25% grape seed powder substituted coffee ($p<0.05$).

The acid content of coffee is an important factor that determines the aroma, flavor and content of bioactive components of coffee. Chlorogenic acid is responsible for the bitterness of coffee and is the main component that creates the acidity of coffee, and it provides the decomposition of phenolic components during the roasting process of coffee. Many low molecular weight compounds with water-soluble properties such as citric, malic, quinic, succinic and gluconic acids are responsible for the acidity of coffee (Yıldız, 2022). Maier et al. (1983) stated that pH values in the perception of bitterness of coffee provide a better correlation with bitter taste than titratable acidity value. In this study, it was observed that the high acidity of coffee decreased with the addition of grape seeds. It is known that grape seed releases potassium and potassium causes precipitation in acid fractions (Pascual et al., 2016). It is thought that the decrease in the acidity and the increase in the pH may be related to the potassium released from the grape seed.

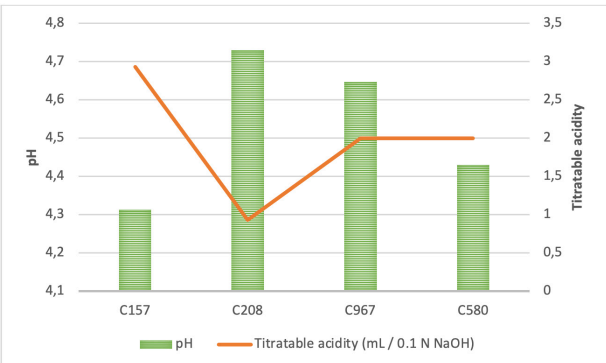

Figure 3. pH and titratable acidity of Americano coffee with grape seed powder (n=3)

C157: Control, C208: Coffee with 25% grape seed powder, C967: Coffee with 40% grape seed powder, C580: Coffee with 55% grape seed powder

Antioxidant activity and total phenolic compound of coffee

Antioxidant activity and total phenolic compounds of coffee samples are given in Table 2. The antioxidant activity depending on the grape seed powder in coffee formulations varies in the range of 140.43 (control)-179.03 (55%) mmol trolox/100g and this data shows a gradual increase as the use of grape seed powder ($p<0.05$). The increase is associated with the rich phenolic compounds of grape seeds. Additionally, it has been shown that high temperature application in the coffee roasting process affects the chemical composition of the coffee bean. Polyphenol levels of coffee decrease due to polymerization, auto-oxidation and degradation that occur during the roasting process (Cheong et al., 2013). The grape seeds used in our study were not subjected to the roasting process, but were directly ground and included in the product formulation. Thus, the effectiveness of compounds with antioxidative properties (chlorogenic acid) was preserved (Priftis et al., 2015).

Coffee is an important source of bioactive compounds, in particularly phenolic compounds (chlorogenic, coumaric, caffeic acid) (Ismail et al., 2022). In our study, it was determined that the total phenolic compound of coffee samples varies between 203.26 (control)-304.75 (55% grape seed powder) mg GAE/100 g. As with antioxidant activity, the total amount of phenolic substances in coffees increased proportionally with the increase in the use of grape seed powder. It is thought that the type-origin and usage amount of grape seeds may be effective in this increase. Ülger (2022) found that the total phenolic substance increased significantly due to the use of grape seed in Turkish coffee. It was stated that this situation is related to grape seed type, brewing temperature and particle size. It has been reported that the total phenolic substance and antioxidant capacity increases with the use of grape seed powder, especially in bakery products such as dough (Aghamirzaei et al., 2015), bread (Hoye and Ross, 2011), muffins (Yalçın et al., 2022) and cookies (Acun and Gül, 2014).

Color properties of coffee

The L*, a*, b* color values of Americano coffee with grape seed powder describing brightness (L*), redness (a*) and yellowness (b*) (Seçilmiş et al., 2015), and the color characteristics of the coffee samples are given in Table 3. It was observed that the L* values of the coffees increased

Table 2. Antioxidant activity and total phenolic compound of Americano coffee with grape seed powder (n=3)

Coffee samples	Grape seed powder (%)	Antioxidant activity (mmol trolox/100g)	Total phenolic compound (mg GAE/100g)
C157	-	140.43±0.79d	203.26±2.77d
C208	25	152.22±1.00c	225.27±2.80c
C967	40	165.79±0.52b	246.38±3.13b
C580	55	179.03±0.45a	304.75±2.25a

a, b, c, d Values shown with different exponential letters in the same column differ from each other at the $p < 0.05$ level

significantly as the grape seed powder concentration in the coffees increased (p<0.05). In other words, the addition of grape seeds resulted in lighter and brighter coffees. While the L* values of the 25% and 40% grape seed powder added coffees were statistically equivalent to each other (p>0.05), they were significantly different from the other samples (p<0.05). The a* values of the coffees decreased due to the increase in the grape seed concentration, that was, a higher amount of redness was detected in the control sample (p<0.05). Coffees made with grape seed substitutes were less intense in terms of redness (p<0.05). When the b* value of the coffees was examined, it was seen that the coffees made with 25% grape seed powder substitute had a similar level of yellowness with the control sample (p>0.05). However, when the grape seed powder was substituted at 40% and 55%, the b* value increased significantly (p<0.05). There was no statistically difference between C967 and C580 samples (p>0.05).

Table 3. Color properties of Americano coffee with grape seed powder (n=3)

Coffee samples	Grape seed powder (%)	L*	a*	b*
C157	-	10.11±1.76c	11.51±0.20a	8.86±0.41b
C208	25	19.23±0.57b	8.72±0.33b	9.05±0.51b
C967	40	20.62±0.43b	6.92±0.24c	20.75±1.76a
C580	55	23.92±1.14a	4.07±0.14d	20.10±2.07a

a, b, c, d Values shown with different exponential letters in the same column differ from each other at the $p < 0.05$ level

The caramelization and Maillard reactions that produce the melanoidins responsible for browning the coffee take place during the roasting of the coffee. Therefore, the color of roasted coffee darkens (Ismail et al., 2022). Since the grape seeds were not roasted, no browning reaction took place. This was due to the fact that the L* and b* values of the control sample were lower than the coffees with the addition of grape seed powder. In a study where durian seeds were used as a coffee substitute, it was reported that the L* values of coffees produced with durian seeds were higher than coffees produced from Arabica and Robusta coffee beans (Natania and Wijaya, 2022). According to Hutami et al. (2018), the red color increases when tannins interact with enzymes or acids such as gallic acid, sinapic acid, which give the red color pigment under conditions of high roasting temperatures. Therefore, tannin, gallic acid, sinapic acid amounts, pH and acidity levels and heat treatment conditions have critical importance on red color. When the levels of total phenolic compounds were examined, it was seen that grape seeds contain higher levels of gallic acid than coffee. In addition, it was reported that the tannin content (3.12 mg/g to 8.82 mg/g) (Ju et al., 2021) and sinapic acid content (0.169-0.291 mg/g) (Salem et al., 2022) of grape seeds are higher than coffee (0.7-0.9 mg/g and 0.07-0.16 µmol/g, respectively) (Monente et al., 2015; Choi and Koh, 2017). Under these conditions, it can be expected that the a* values of the coffees made with grape seed substitute are higher than the control sample, but on the contrary, it is seen that the a* value of the control sample was higher. The reason for this was that the roasting process was not applied in the grape seeds. As mentioned before, high roasting temperature is an important criterion in obtaining red color. In addition, when the acidity and pH values of the samples were examined, it was seen that the control sample had higher acidity than the grape seed substituted samples. This was another factor explaining the highest a* value of the control sample.

Sensory properties of coffee

The sensory properties of Americano type coffees produced with the addition of grape seed powder at different rates were evaluated in terms of color, odor, taste and flavor, fluidity, roughness, mouthfeel and overall acceptability, and the results are presented in Figure 4. As a result of the evaluation, significant differences between the samples were observed in all sensory parameters except roughness (p<0.05). It was determined that the color, odor, taste and flavor, fluidity, mouthfeel and overall acceptability of the control sample and the coffees with 25% grape seed powder (C208) added were statistically equivalent to each other (p>0.05). However, the addition of grape seed powder at the rates of 40% and 55% significantly reduced the scores given to these characteristics of the coffees (p<0.05). As the concentration of grape seed powder increased, the sour taste and odor perceived in the coffee samples were not liked. For the same reason, the C967 and C580 samples also scored low in terms of mouthfeel. The high level of polyphenols contained in grape seeds can cause sourness (Axten et al., 2008). It has been reported that the addition of grape seed powder causes sour taste and odor in bread samples (Pecivova et al., 2014). Considering the pH and titratable acidity results, the unique bitterness of the coffee decreased due to the fact that the addition of grape seed reduced the acidity, and accordingly, the taste, odor and mouthfeel scores decreased. In addition, the color of the coffees with high grape seed powder concentration was lighter, so samples C967 and C580 were not liked in terms of color when compared to the control. The water solubility of grape seed powder is not as high as that of coffee. Therefore, the viscosity of the coffee samples differed, and the C967 and C580 samples with less coffee got low scores in terms of fluidity. However, the panelists did not observe any difference in the roughness characteristics of the samples. In terms of overall acceptability, it was detected that the coffee with 25% grape seed powder got similar scores with the control sample ($p>0.05$), but the 40% and 55% grape seed powder addition was not acceptable ($p<0.05$).

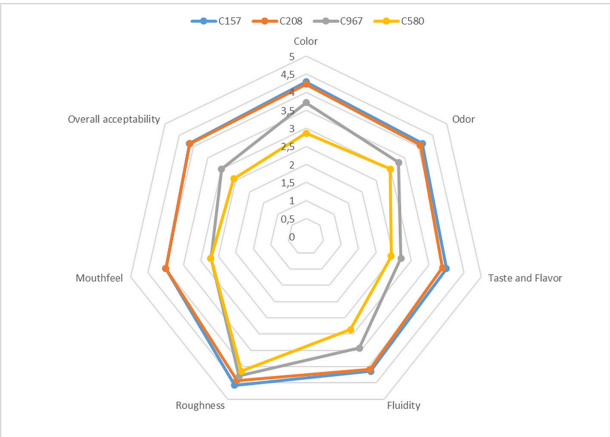

Figure 4. Sensory properties of Americano coffee with grape seed powder

C157: Control, C208: Coffee with 25% grape seed powder, C967: Coffee with 40% grape seed powder, C580: Coffee with 55% grape seed powder

In the research conducted by Ülger (2022), different proportions of grape seeds (Öküzgözü and Boğazkere) and pine hull were used in the production of Turkish coffee, and the sensory properties of the coffees were examined. The researcher stated that the grape seed substitute creates fruity and fermented odors in coffees, and oily and sour taste was perceived. The author reported that the coffees using grape seed were high-grained and high in roughness. The author also stated that in terms of taste, the coffee with 10% grape seed addition was the most demanded coffee. In studies where fruit seeds such as date (Fikry et al., 2019), baobab (Ismail et al., 2022), and durian (Natania and Wijaya, 2022) were used as coffee substitutes, it was stated that the fruity taste and odors that were generally perceived in coffees were liked.

CONCLUSION

As a result of this research, which aims to provide functional properties to coffee, one of the most consumed beverages in the world, a coffee variety with different taste, texture and flavor, low in caffeine and high in bioactive properties has been obtained. The raw materials used in the research were examined and it was determined that grape seeds were richer than coffee in terms of crude fiber, antioxidant activity and total phenolic substance amount. For this reason, using grape seeds, which mostly appear as food waste, in food products not only gives functional properties to the products, but also provides gains in sustainability, environmental health and financial terms. In coffees obtained by substituting grape seed powder in different amounts, as the amount of grape seeds increased, the amounts of antioxidants and phenolic substances also increased. Since grape seeds release potassium into the media, they reduced the total acidity of the coffees and increased the pH. As the amount of grape seed powder increased, a lighter color was observed in the coffees. Additionally, brightness and yellowness increased, while redness decreased. It was determined that 25% grape seed addition was equivalent to the control sample in terms of all sensory properties, while 40 and 55% were not acceptable. The use of grape seeds increased the sourness in coffees and reduced the desired bitterness. As a result, 25% grape seed substitution can be applied in coffee production. Due to the high water content of Americano type coffee, the use of high amounts of grape seeds may have caused a further decrease in sensory properties. Therefore, in coffees with more intense coffee content, such as espresso, the evaluation of substances with rich composition, which are considered waste, can be tried in different studies.

COMPLIANCE WITH ETHICAL STANDARDS

Peer-review

Externally peer-reviewed.

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

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