



**A RESEARCH ON THE PRODUCTION OF GREEN COFFEE
BEVERAGE FORTIFIED WITH APRICOT PULP**

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ABSTRACT

The purpose of this research was to formulate a novel functional beverage possessing acceptable sensorial properties by using green coffee extract and apricot pulp. Green beans of *C. arabica* and *C. caniphora* were ground and brewed with drip filter coffee machines as 10 and 15% (w/v) concentrations for 10 min. Apricot pulp (38%) and green coffee extracts (62%), sucralose (0.014 g/L) and lemon flavored emulsion (0.15 g/L) were used in the formulation. Bioaccessible phenolics were determined between 3446.62 ± 12.86 and 4042.08 ± 71.26 mg GAE/100mL. Antioxidant activities of bioaccessible phenolics were ranged between 453 ± 0.41 - 514 ± 0.30 μ mol trolox/100 mL and 729 ± 0.03 - 794 ± 0.04 μ mol trolox/100 mL in DPPH and FRAP methods, respectively. Combination of green coffee extracts with apricot pulp allowed designing of functional cold beverage favored by consumers for their organoleptic features.

Keywords: Beverage, green coffee, apricot, antioxidant activity, bioaccessibility

**KAYISI PULPU İLE ZENGİNLEŞTİRİLMİŞ YEŞİL KAHVE
İÇECEĞİ ÜRETİMİ ÜZERİNE BİR ARAŞTIRMA**

ÖZ

Bu çalışmanın amacı yeşil kahve ekstraktı ve kayısı pulpu kullanımı ile yeni, fonksiyonel ve kabul edilebilir duyuşal özelliklere sahip bir içeceğin üretilmesidir. *Coffea arabica* and *Coffea caniphora* (Robusta) yeşil daneleri öğütülüp %10 ve %15 (w/v) konsantrasyonlarında 10 dakika süreyle damlamalı filtre kahve makinesinde suyla demlenmiştir. Formulasyonda, kahve ekstraktları (%62), kayısı pulpu (%38), sukraloz (0.014 g/L) ve limon aromalı emulsiyon (0.15 g/L) kullanılmıştır. İçecek örneklerinin biyoerişilebilir fenolik madde miktarı 3446.62 ± 12.86 ve 4042.08 ± 71.26 mg GAE/100mL arasında belirlenmiştir. Biyoerişilebilir fenoliklerin antioksidan aktiviteleri DPPH metoduna göre 453 ± 0.41 - 514 ± 0.30 μ mol troloks/100 mL, FRAP metoduna göre ise 729 ± 0.03 - 794 ± 0.04 μ mol troloks/100 mL arasında değişmiştir. Yeşil kahve ekstraktlarının kayısı pulpu ile kombinasyonu, duyuşal özellikleri bakımından tüketicilerin beğendiği fonksiyonel bir soğuk içeceğin oluşmasına olanak sağlamıştır.

Anahtar kelimeler: İçecek, yeşil kahve, kayısı, antioksidan aktivite, biyoerişilebilirlik

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INTRODUCTION

Coffee is one of the most commonly consumed beverage in the world. Unroasted mature or immature coffee beans are named green coffee. The total coffee produced in the world is from *Coffea arabica* (75%) and *Coffea caniphora* (Robusta) (25%) (Etienne, 2005; Belitz et al., 2009).

Green coffee contains poly and monosaccharides, proteins, free amino acids, lipids, fatty acids, sterols, polyphenols, phenolic acids, alkaloids, vitamins and minerals (Parras et al., 2007; Daglia et al., 2007; Köseoğlu Yılmaz et al., 2014). Caffeine in green coffee is a mild stimulant of the central nervous system (Bicho et al., 2013; Herman and Herman, 2013). Especially hydroxycinnamic acids (i.e. caffeic and ferulic acids), and their esters with quinic acid, named as chlorogenic acids (CHAs) are found in green coffee beans (Iwai et al., 2004; Sato et al., 2011; Budryn et al., 2013). CHAs prevent chronic disorders, cardiovascular and rheumatologic diseases with their antimutagenic and anti-inflammatory effects (Cheng et al., 2007). The main contributors to the antioxidant capacity of green coffee are CHAs (Farah et al., 2006; Lima et al., 2010; Abrahao et al., 2010; Babova et al., 2016). Health benefits of coffee is mainly related with its phenolic composition, which is drastically reduced with roasting process (Perrone et al., 2002; Schenker et al., 2002; Somporn et al., 2011). During roasting, CHAs are particularly degraded, as well as antioxidant activity. Eventually, green coffee beans are accepted as better source of these components (Brezová et al., 2009; Köseoğlu Yılmaz et al., 2014; Wei and Tanokura, 2015; Şemen et al., 2017). For this reason, the consumption of green coffee products has shown increase in recent years as a healthier alternative to roasted coffee (Baeza et al., 2018).

The extensive scientific researches have been focused on examination of the relationship between coffee intake and chronic diseases and health outcomes (Pourshahidi et al., 2016). Despite the contradictive effects of caffeine and process induced toxicants of roasted coffee, utilization of green coffee in food industry as well as nutraceutical and pharmaceutical industry

draws a great interest since green coffee is known as good resource of components having antioxidant and radical scavenging activities (Brezova et al., 2009; Anissi et al., 2014; Bresciani et al., 2014).

Health benefits and weight-loss properties of green coffee are under discussion. Recent researches allege that CHAs have antihypertensive effects (Zhao et al., 2012), prophylactic effects on Type II diabetes (Stefanello et al., 2014; Bassoli et al., 2008; Budryn et al. 2016) and lean towards to reduce visceral fat and body weight (Shimoda et al., 2006).

Balanced diet, physical activity and consumption of phytochemicals from various foods and beverages could provide a natural preventive approach to improve health status of individual, including potential efficient cancer prevention with minimal toxicity (Rossi et al., 2014). Nowadays, consumers demand ready to consume products related with health (Costa et al., 2012). Depending on its favorable composition and health-improving properties, utilization of green coffee as a supplement for functional foods has created interest. However, coffee's sensory and technological attributes could limit the use of coffee preparations for enrichment of foodstuffs (Budryn and Nebesny, 2013). Green coffee supplementation of food was the subject of several researches (Glei et al. 2006; Budryn and Nebesny, 2013; Dżiki et al., 2015; Budryn et al., 2016; Vasudevaiah et al., 2017; S'wieca et al., 2017; Se,czyk et al., 2017).

Apricot is a delicious and nutritious fruit. It is rich in minerals such as K and it contains considerable amounts of carotenoids (mainly β -carotene), and phenolics like chlorogenic, caffeic, p-coumaric and ferulic acids and (+)-catechin, (-)-epicatechin and rutin. As precursor of vitamin A, β -carotene is necessary for epithelia tissues covering body and organs, eye-health, osteogenesis, odontogenesis and working of endocrine glands. Apricot is considerable source of provitamin A carotenoids, as 250 g of fresh or 30 g of dried fruit supplies 100% of recommended dietary allowance (RDA) of carotenoids. β -carotene comprises 60-

70% of total carotenoids in the fruit (Dragovic-Uzelac et al., 2007; Haciseferoğulları et al., 2007; Drogoudi et al., 2008).

The main reason of coffee consumption has been related to reduction of temporizing and defatigation, and for enhancing cognitive performance and its antioxidant capacity (Bicho et al., 2013; Herman and Herman, 2013). There is a progressing high interest in producing a “healthy and mild” coffee beverage (Clarke, 1987; Siebert et al., 2018). Because green coffee has a mild, green, bean-like aroma, the beverage containing only green coffee extract could not meet the consumers' expectations. For this reason, designing of novel low calorie functional beverage containing both green coffee extract and apricot pulp sweetened with sucralose was aimed in this research. Determination of extractable and bioaccessible phenolics, antioxidant activity and

also evaluation of organoleptic characteristics of these beverages were the main goals of this research.

MATERIAL and METHODS

Green beans of *Coffea arabica* and *Coffea caniphora* (Robusta) were used after grinding by coffee grinder (Moulinex). Apricot pulp is obtained from Aroma Bursa Fruit Juices and Food Ind. Inc. Lemon flavored emulsion is supplied from AROMSA and sucralose (SPLENDAR®) is purchased from local market. Depending on the result of the preliminary sensory evaluation, the most preferred ratios (%) of green coffee extract and apricot pulp were 62% and 38% respectively. Sucralose (0.014 g/L) was benefitted as zero-calorie sweetener and lemon flavored emulsion (0.15 g/L) was added for flavor balance. Flow diagram of the beverage production is given in Figure 1.

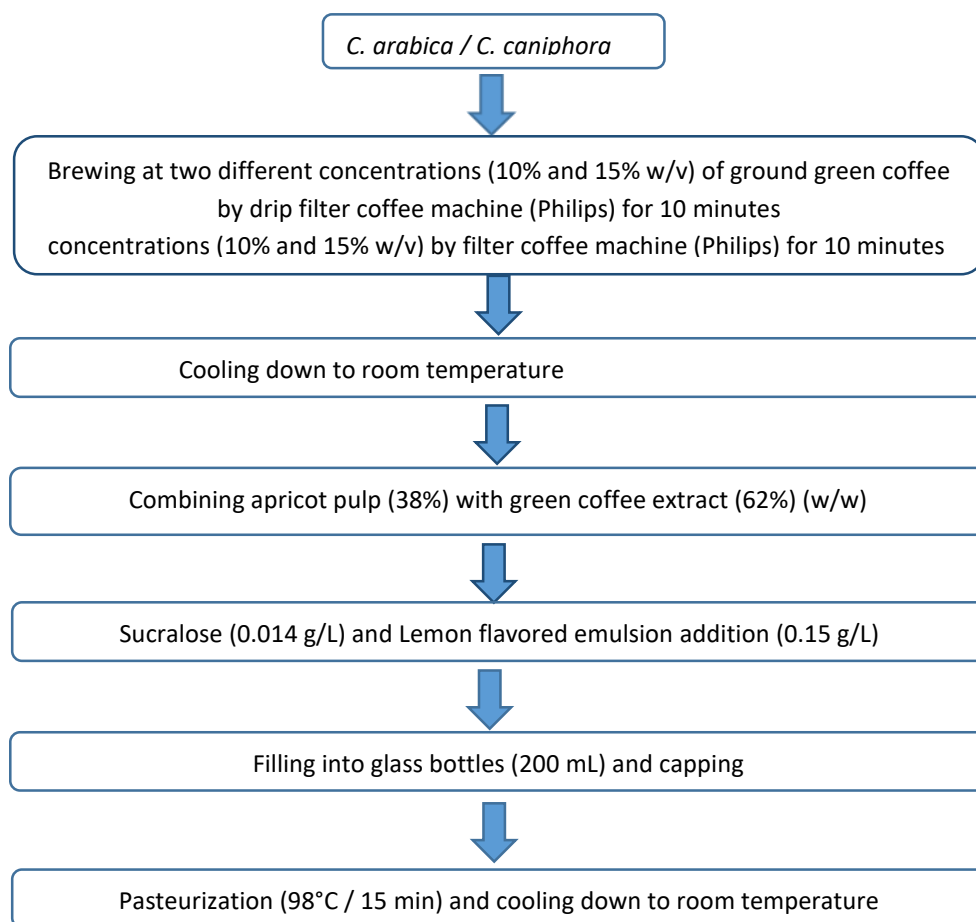


Figure 1. Flow diagram of the beverage production

ANALYSIS

Determination of some physicochemical properties of beverages

The water soluble dry matter (brix^o) is measured by using RA-500 model KEM refractometer, total acidity is determined by potentiometric method, pH analysis were conducted by Mettler Toledo Sevencompact pH/Ion pH meter. Shimadzu (UV 1208) spectrophotometer was used for total phenolics and antioxidant activity analyses. Color analysis was done by Konica Minolta Chroma Meter, CR-5, Japan. All analyses were performed in three replicates.

Extraction method of the samples

The extracts of beverages were prepared according to modified method of Glahn et al. (1998). 2 g of sample was mixed with 20 mL of HCl/methanol/water solution (1:80:10, v/v) and put in a shaking water bath for 2 h at 20°C and then centrifuged (Sigma 3K 30, Germany) at 3500 rpm for 10 min at 20°C. The supernatants were kept at -20°C until analyzed.

In Vitro Digestion Procedure

For the determination of bioaccessibility of phenolics and antioxidants, in vitro digestion enzymatic extraction method that mimics the conditions of gastrointestinal tract (GIT) was applied with slight modifications (Glahn et al., 1998). 10 mL of distilled water and 0.5 mL of pepsin solution (20 g/L pepsin in 0.1 mol/L HCl) were added to 1 mL of sample. By using HCl (5 mol/L), pH was adjusted to 2 and then sample was incubated at 37°C in a shaking water bath for 1 h. Simulation of gastric digestion was stopped by addition of 1 M NaHCO₃ (pH is adjusted to 7.2). 2.5 mL of bile/pancreatin solution (2 g/L of pancreatin and 12 g/L of bile salt in 0.1 M NaHCO₃) and 2.5 mL of NaCl/KCl solution (120 mmol/L NaCl and 5 mmol/L KCl) were added to the sample and simulation of intestinal digestion was conducted for the following 2 h. Samples were centrifuged at 3500 rpm for 10 min and the supernatant was used for determination of the bioaccessibility of total phenolics and their antioxidant activities.

Determination of total phenolic content

Folin-Ciocalteu method was applied to determine total phenolics (Spanos and Wrolstad, 1990). 0.25 mL of sample/extract, 2.3 mL of distilled water and 0.15 mL of Folin-Ciocalteu reagent (FC/Water, 1:5, v/v) were mixed within 10 mL volumetric flasks and vortexed (Velp Scientifica, Italia) for 15 s at room temperature. After 5 min, 0.3 mL of Na₂CO₃ (35%) was added and mixed thoroughly. After incubation for 2 h at room temperature, absorbance of the mixture was measured at 725 nm. Distilled water was used as the blank and gallic acid (GA) solution was used for the calibration of the standard curve ($R^2=0.9835$). Total phenolic content was given as gallic acid equivalents (mg of GAE/100 mL sample).

Determination of antioxidant activity

Antioxidant activity of the samples were measured with DPPH and FRAP assays and the results were given as $\mu\text{mol trolox} / 100 \text{ mL}$.

DPPH method of total antioxidant activity

Antioxidant activity was determined by using modified method of the Katalinic et al. (2006). The assay involves the use of the free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH), proceed where antioxidants are allowed to react with the stable radical in methanol solution. 0.1 mL sample was added to 3.9 mL of $6 \times 10^{-5} \text{ M}$ methanol solution of DPPH radical and vortexed (Velp Scientifica, Italia) for 15-30 s. The reaction was proceeded in the dark condition at room temperature for 30 min, and then the absorbance was determined at 515 nm. A trolox calibration curve ($R^2=0.9929$) was obtained by measuring the reduction in absorbance of the DPPH solution in the presence of different concentrations of trolox (10-200 $\mu\text{mol/L}$).

FRAP method of total antioxidant activity

3 mL of FRAP reagent (incubated at 37°C) was mixed with 300 μL of distilled water and 100 μL of the sample (or extraction solvent for the reagent blank) (Benzie and Strain, 1996). The samples and blank were incubated at 37°C for 30 min. Absorbance was measured immediately at 595 nm at the end of the incubation period. The

FRAP reagent was prepared by mixing 25 mL of 0.3 mol/L acetate buffer (pH 3.6), 2.5 mL of 20 mmol/L $\text{FeCl}_3 \cdot x \cdot 6\text{H}_2\text{O}$ and 2.5 mL 10 mmol/L TPTZ solution in 40 mmol/L HCl. The concentration of sample in reaction mixture was 1.10^{-3} M trolox ($R^2=0.9993$). The results were expressed as $\mu\text{mol trolox}/100 \text{ mL sample}$.

Sensory Analysis

Sensory analysis was done by a selected panel comprising 9 judges from academicians and graduate students. The beverages (15°C) were coded by three-digit random numbers and served to the panelists randomly. Samples were evaluated for color, appearance, odor and taste by using a hedonic scale. For this aim, a 9-point hedonic scale with 9-like extremely, 8-like very much, 7-like moderately, 6-like slightly, 5- neither like or dislike, 4-dislike slightly, 3-dislike moderately, 2-

dislike very much, and 1-dislike extremely was applied. Water was used to clear the palate before the each test sample (Altuğ and Elmacı, 2011).

Statistical Analysis

The experiment was conducted in a completely randomized design with three replications. The results were statistically evaluated by ANOVA using the JMP 6.0 (SAS Institute Inc. NC, 27513). When significant differences were determined ($p < 0.05$), the Least Significant Difference (LSD) test was used to define the differences among means.

RESULTS and DISCUSSION

The results of the physicochemical analysis of the beverages were shown in Table 1.

Table 1. Physicochemical analysis results of the of beverages (mean \pm standard deviation)

Beverage Samples	Water soluble dry matter (brix $^\circ$) (g/100 g)	Total acidity* (g/100 mL)	pH	Total phenolics		Total phenolics bioaccessibility** (%)
				Extractable phenolics (mg GAE/100 mL)	Bioaccessible phenolics (mg GAE/100 mL)	
A	4.70 \pm 0.10 ^c	0.64 \pm 0.00 ⁿ	3.79 \pm 0.04 ^{bc}	2419.13 \pm 183.04 ⁿ	3446.62 \pm 12.86 ^c	142.47 \pm 9.96 ^b
B	4.60 \pm 0.00 ^c	0.65 \pm 0.02 ⁿ	3.77 \pm 0.04 ^c	2498.15 \pm 135.76 ⁿ	3698.86 \pm 49.58 ^b	148.06 \pm 8.43 ^b
C	5.17 \pm 0.06 ^a	0.66 \pm 0.02 ⁿ	3.86 \pm 0.04 ^a	2476.90 \pm 25.56 ⁿ	3700.05 \pm 80.86 ^b	149.38 \pm 4.39 ^b
D	5.03 \pm 0.06 ^b	0.65 \pm 0.01 ⁿ	3.84 \pm 0.04 ^{ab}	2405.97 \pm 11.93 ⁿ	4042.08 \pm 71.26 ^a	168.00 \pm 2.41 ^a

A: beverage containing *C. robusta* extract (10% w/v)

B: beverage containing *C. arabica* extract (10% w/v)

C: beverage containing *C. robusta* extract (15% w/v)

D: beverage containing *C. arabica* extract (15% w/v)

^{a, b, c, d} Letters indicate significant differences among beverages, $P < 0.05$.

ⁿ indicates statistically insignificant results among beverages, $P > 0.05$.

* as citric acid

** Total phenolics bioaccessibility was calculated as (Bioaccessible phenolics / Extractable phenolics) x 100

The water soluble dry matter (brix $^\circ$) of the beverages were found to vary between 4.60 \pm 0.00-5.17 \pm 0.06 g/100 g. As it was expected, when coffee extract ratio was increased, brix $^\circ$ was also increased. While the differences between brix $^\circ$ and pH value of the samples were statistically significant ($P < 0.05$), the differences between total acidity of the samples were found insignificant ($P > 0.05$). "The sample C" containing *C. robusta* (15%, w/v) had the highest

brix $^\circ$ (5.17 \pm 0.06 g/100g), total acidity (0.66 \pm 0.02 g/100 mL) and pH value (3.86 \pm 0.04).

Jeszka-Skowron et al. (2016) reported that pH was changed in pH of green coffee extracts of Robusta type as 4.29-5.03 and in Arabica type as 4.60-4.92. Because of the use of apricot pulp in the formulation, our pH results was lower than the abovementioned pH values of green coffee extract. Addition of apricot pulp contributed flavor improvement of the beverages as well as

reduced the pH. By this means, beverages could be preserved easily with pasteurization.

Extractable phenolic content of the beverages was not statistically significant ($P > 0.05$), while the highest value of the bioaccessible phenolics (4042.08 ± 71.26 mg GAE/100 mL) was determined in “the sample D”. These results were similar to findings reported by Jeszka-Skowron et al. (2017). Total phenolics of green coffee beans was measured as 46.49 ± 0.78 – 68.01 ± 0.27 and 14.17 ± 0.52 – 17.37 ± 1.96 mg GAE/g for Robusta and Arabica respectively in their study.

Polyphenols must first survive the passage through the gastrointestinal tract (GIT), before exerting any physiological effect (Bouayed et al., 2012). Absorption and metabolism of them are determined principally by their physico-chemical properties. Their structure, molecular size, polymerization or glycosylation degree, solubility, and conjugation with other phenolics are critical factors. In addition to this, food composition, release of phenolics from the food matrix, interactions with other components and the presence of suppressors or cofactors affect bioaccessibility of polyphenols (Parada and Aguilera, 2007). Small-molecular weight phenolic acids like gallic acid, flavones, catechins, quercetin glucosides and isoflavones are easily absorbed through the GIT (Martin and Apple, 2010). Contrarily, higher molecular weight polyphenols like proanthocyanidins are poorly absorbed. Before being absorbed, most proanthocyanidins have to be degraded into monomer or dimer units (Hackman et al., 2008). In vitro digestion procedures have been commonly used and offer an alternative tool to estimate the bioaccessibility of polyphenols depending on their simplicity and speed (Spínola et al., 2018; Carbonell-Capella et al., 2014).

Total phenolics bioaccessibility of the beverage samples changed between 142.47 ± 9.96 % - 168.00 ± 2.41 %. Previous researches reported in vitro

increase of total phenolic and flavonoid contents upon simulated digestion which is in agreement with our results (Chen et al., 2015; Podsędek et al., 2014; Tagliazucchi et al., 2010). It was reported that, when non-extractable phenolics are released from the food matrix by the help of digestive enzymes in the small intestine and bacterial degradation in the large intestine, they may become bioactive in gut (Jenner et al., 2005). Besides, while dietary fiber, divalent elements, and high in protein and viscous meals are likely to induce impairing effects on polyphenol bioaccessibility; digestible carbohydrates, dietary lipids (especially for hydrophobic polyphenols), and additional antioxidants may improve polyphenol bioavailability (Bohn, 2014). It has been found that antioxidants and phenolics in certain fruit and vegetable juices became more bioaccessible post digestion (Ryan and Prescott, 2010; Wootton-Beard et al., 2011). Phenolic compounds from fruit juices are expected to be more bioaccessible and bioavailable than those from fruit flesh because of their differences in proximate fiber content. Kris-Etherton et al. (2002) determined that the bioavailability and antioxidant capacity of the phenolic compounds are preserved, or may increase, when the mango is processed into juice. Fawole et al. (2015) investigated the effect of digestion on total phenolic concentration and antioxidant capacity of pomegranate juice and by-products. Total phenolic compounds and total antioxidant capacity after the duodenal phase of in vitro digestion were higher than the initial values (before digestion), suggesting the effect the environments of in vitro digestion on total phenolics in pomegranate fruit fractions. In contrast, after the duodenal phase, total phenolic compounds decreased significantly compared to gastric phase. Tomas et al. (2018) reported that with an increase in dietary fiber content, there is a concomitant decrease in the in vitro bioaccessibility of antioxidants.

Table 2. Results of the antioxidant activity analysis of beverages (mean \pm standard deviation)

Beverage samples	Antioxidant activity					
	DPPH Chemical extract (μmol trolox/100 mL)	DPPH Physiological extract (μmol trolox/100 mL)	DPPH Bioaccessibility* (%)	FRAP Chemical extract (μmol trolox/100 mL)	FRAP Physiological extract (μmol trolox/100 mL)	FRAP Bioaccessibility* (%)
A	848 \pm 0.02 ⁿ	473 \pm 0.25 ^{ab}	55.77 \pm 2.95 ^{ab}	938 \pm 0.03 ^d	745 \pm 0.04 ^b	79.42 \pm 0.54 ^a
B	845 \pm 0.04 ⁿ	514 \pm 0.30 ^a	60.83 \pm 3.86 ^a	1066 \pm 0.03 ^c	729 \pm 0.03 ^c	68.38 \pm 0.34 ^b
C	846 \pm 0.04 ⁿ	453 \pm 0.41 ^b	53.55 \pm 5.10 ^b	1190 \pm 0.04 ^a	752 \pm 0.10 ^b	63.19 \pm 0.85 ^c
D	843 \pm 0.08 ⁿ	513 \pm 0.11 ^a	60.85 \pm 1.31 ^a	1151 \pm 0.03 ^b	794 \pm 0.04 ^a	68.98 \pm 0.46 ^b

A: beverage containing *C. robusta* extract (10% w/v)

B: beverage containing *C. arabica* extract (10% w/v)

C: beverage containing *C. robusta* extract (15% w/v)

D: beverage containing *C. arabica* extract (15% w/v)

^{a, b, c, d} Letters indicate significant differences among beverages, $P < 0.05$.

ⁿ indicate statistically insignificant results among beverages, $P > 0.05$.

*Bioaccessibility of antioxidant activity was calculated as (antioxidant activity of physiological extract/ antioxidant activity of chemical extract) x 100

Since each individual assay demonstrates antioxidant capacity in a different way, more than one assay should be used to measure the antioxidant activity of foods. For this reason, application of at least two assays based on different reaction mechanisms leads to better projection of the antioxidant activity of a sample (Pekal et al., 2012). Consequently, antioxidant activities of these phenolics were determined spectrophotometrically with DPPH and FRAP methods. As given in Table 2, although DPPH antioxidant activity of extractable phenolics was determined statistically insignificant ($P > 0.05$), antioxidant activities of bioaccessible phenolics were changed significantly ($P < 0.05$). The free radical scavenging capacity of the beverages measured by the DPPH method and the reducing power determined by the FRAP method showed that the antioxidant activity of physiological extract of the beverages was related to their bioaccessible phenolic content. The highest antioxidant activity of bioaccessible phenolics determined with DDPH assay was found in “the sample D” (513 \pm 0.11 μmol trolox/100mL) and “the sample B” (514 \pm 0.30 μmol trolox/100mL) which were prepared from *C. arabica* extract. Also, “the sample D” demonstrated the highest antioxidant activity of bioaccessible phenolics

(794 \pm 0.04 μmol trolox/100mL) determined with FRAP assay.

Jeszka-Skowron et al. (2017) measured antioxidant capacity of Robusta and Arabica type green coffee extract as 32.14 \pm 2.62 – 46.23 \pm 0.54 (mmol trolox/100 g) and 16.13 \pm 2.57- 23.41 \pm 1.81 (mmol trolox/100 g) in DPPH assay respectively.

Bioaccessibility of antioxidant activity of the beverages was changed between 53.55 \pm 5.10% - 60.85 \pm 1.31% for DPPH assay and 63.19 \pm 0.85 % -79.42 \pm 0.54 % for FRAP assay.

The color of green coffee beans can be affected by a number of factors during cultivation, picking, drying, and milling. Color specifications of beverages were noticed in Table 3. All color parameters were measured significantly different ($p < 0.05$). Except a^* (redness) value, “the sample C” had the highest L^* (brightness), and b^* (yellowness), chroma and hue values. Beverages (sample A and sample C) prepared with *C. robusta* extract had higher L^* , b^* , chroma and hue values than others produced with *C. arabica*. Akdemir Evrendilek et al. (2013) determined color parameters of the apricot nectar samples as 34.98, 11.76, and 36.12 for L^* , a^* , and b^* values, respectively. While L^* value of the apricot nectar

was similar to green coffee beverages fortified with apricot pulp; a and b values were lower. This

was related to the difference in beverage formulation containing green coffee extract.

Table 3. Color values of beverages (mean \pm standard deviation)

Beverage samples	L*	a*	b*	Chroma (C*)	Hue
A	34.10 \pm 0.04 ^b	22.14 \pm 0.01 ^b	54.71 \pm 0.07 ^b	58.99 \pm 0.02 ^b	67.97 \pm 0.03 ^b
B	31.88 \pm 0.02 ^d	22.77 \pm 0.02 ^a	52.25 \pm 0.11 ^d	56.99 \pm 0.10 ^d	66.45 \pm 0.03 ^d
C	35.61 \pm 0.05 ^a	21.45 \pm 0.01 ^c	55.78 \pm 0.06 ^a	59.76 \pm 0.06 ^a	68.97 \pm 0.02 ^a
D	32.70 \pm 0.01 ^c	22.78 \pm 0.01 ^a	53.64 \pm 0.06 ^c	58.28 \pm 0.06 ^c	66.98 \pm 0.02 ^c

A: beverage containing *C. robusta* extract (10% w/v)

B: beverage containing *C. arabica* extract (10% w/v)

C: beverage containing *C. robusta* extract (15% w/v)

D: beverage containing *C. arabica* extract (15% w/v)

^{a, b, c, d} Letters indicate significant differences among beverages, $P < 0.05$.

Sensory analysis results were given in Table 4.

Table 4. Sensory analysis results of the of beverages* (mean \pm standard deviation)

Beverage samples	Color	Odor	Appearance	Taste
A	7.78 \pm 0.97	7.44 \pm 0.73	6.56 \pm 1.33	5.89 \pm 2.42
B	7.78 \pm 0.97	7.44 \pm 0.73	6.56 \pm 1.33	6.89 \pm 1.62
C	7.56 \pm 1.13	7.44 \pm 0.73	6.44 \pm 1.59	5.44 \pm 2.46
D	7.44 \pm 1.33	7.44 \pm 0.73	5.78 \pm 1.99	4.78 \pm 2.39

A: beverage containing *C. robusta* extract (10% w/v)

B: beverage containing *C. arabica* extract (10% w/v)

C: beverage containing *C. robusta* extract (15% w/v)

D: beverage containing *C. arabica* extract (15% w/v)

*Results were statistically insignificant among beverages, ($P > 0.05$).

All of the panelists reported their positive opinions about beverage samples. There was no statistically significant difference between tested criteria among beverages ($P > 0.05$). However, when the green coffee concentration increased, color, appearance and taste scores were reduced.

CONCLUSION

Finding possibility of green coffee extract utilization may help to design novel functional apricot beverage. The sensory evaluation results indicated that beverage formulations was given satisfactory overall acceptability. However, increment of the green coffee extract concentration resulted in reduction of appearance and taste scores especially. While “the sample B” containing *C. arabica* extract (10% w/v) was the most preferred beverage for sensory criteria, “the sample D” containing *C. arabica* extract (15% w/v) was the least preferred one. The highest total phenolics bioaccessibility and DPPH bioaccessibility were determined in “the beverage D” containing *C. arabica* extract (15% w/v).

However, “the beverage A” containing *C. robusta* extract (10% w/v) demonstrated the highest FRAP bioaccessibility.

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