Persimmon fruit enhanced quality characteristics and antioxidant potential of beer

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Abstract Various adjuncts, including fruits, are added for flavoring beer, one of the most famous beverages in the world. The influence of persimmon fruit on antioxidant activities and quality characteristics of beer was investigated in this study. The antioxidant activities measured through DPPH and superoxide and hydroxyl anions scavenging potentials as well as total polyphenol contents of the persimmon-treated beer were significantly ($p < 0.05$) high compared to the control. The mineral elements Mg, K, and Ca were also significantly ($p < 0.05$) increased, however toxic heavy metals were not detected in the persimmon beer. Among the persimmon beer samples, the overall acceptance value was significantly ($p < 0.05$) high when the beer was prepared by adding 150 g of the fruit in 10 L of water. The results suggested that an addition of 150 g of persimmon fruit per 10 L of water could better enrich the nutritional, organoleptic, and antioxidant potentials of beer.

Keywords Antioxidant potential · Beer · Persimmon fruit · Quality characteristic

Introduction

Beer is a popular drink and stands as the fifth most consumed beverage in the world [33]. It is prepared by fermenting starch-containing raw materials like barley or other cereals; including wheat, wheat malt, corn, rice, and millet; as a source of maltose and glucose. In addition, various adjuncts like fruits and spices might also be used to contribute to the flavor and aroma profile of some beer styles. There are several traditional beer styles which are brewed with spices, for example, coriander is used in Belgian Witbier [30] and Finnish Sahti [7] is brewed with juniper berries. Similarly, different fruits such as cherry, raspberry, and peach have been used as a beer adjunct or as a flavoring agent for centuries. Fresh fruits such as cherries and raspberries are mixed to the finished beer and allowed a further fermentation to prepare a special fruit beer in Belgium [5]. The fruits used in beer preparation are not essentially fermented; they might be rather added only for imparting the fruit flavor to the finished beer. Among the various starch-containing beer adjuncts, the addition of fruit is common to wheat which also contributes to a good texture. A Belgian fruit beer, Fruli is prepared from 70% wheat beer and 30% strawberry fruit juice [8].

Persimmon (*Diospyros kaki*) is a popular fruit crop in Korea, China, and Japan. The fruits of persimmon contain various nutrients and phytochemicals like organic acids, vitamins, phenols, and carotenoids, which impart for their color, taste, and nutritive and medicinal values [2, 6]. Potential health benefits of the fruit are attributed to its high antioxidant properties. The antioxidants catechins and gallic acid found in persimmon fruits are considered to have anti-infective, anti-inflammatory, and antihemorrhagic properties [17]. Reports show that the fruits also possess antidiabetic [20], antitumor, and multidrug

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resistance-reversal [14] properties. The flavonol glucosides found in persimmon are reported to have a hypotensive action in rats [9].

The production of persimmon fruits is ever increasing in Korea. The fruits are generally consumed as fresh or are used in dried and candied forms. Some of the other processed forms are jelly, jam, dye, and vinegar. High quantity of damaged and/or surplus fruit for fresh consumption necessitates the development of new products from the persimmon fruits. A limited report about the use of the fruits in preparing beer has been published. Martínez et al. [22] used persimmon fruit juice to prepare a special fruit ale beer. Considering the high nutritive and functional values [2, 6, 14, 17, 20] as well as an increasing production of persimmon fruits, the objective of this study was to investigate the use of raw persimmon fruit in the preparation of beer. This study was the first to report on the use of ripe persimmon fruit in beer preparation.

Materials and methods

Chemicals and materials

Folin–Ciocalteu phenol reagent and 1,1-diphenyl-2-picrylhydrazyl (DPPH) were purchased from Sigma-Aldrich (St. Louis, MO, USA). All the chemical and reagents were of analytical grade. A commercial Beer Mix (The Great American Beverage Company, Reno, NV, USA) was used for brewing the beer samples. The ripe fruits of persimmon cv. Sangjudoongsi were obtained from Sangju Persimmon Experiment Station, Gyeongsangbuk-do, Korea in October 2016. The moisture, total soluble solid, and crude ash contents and pH value of the persimmon fruit were 79.31%, 13.90°Bx, 0.27%, and 6.10, respectively. Sangjudoongsi is one of the popular persimmon cultivars grown in Korea. There was not any other special reason to select the particular cultivar of persimmon in this study.

Preparation of beer samples

Beer samples were prepared adopting a 4-step fermentation process of a mixture of commercial beer mix and different proportions of ripe persimmon using a beer machine (Model 2000, The Beer Machine, Reno, NV, USA). The mixture of beer mix (0.9 kg), yeast (2.5 g), water (10 L), and different proportions of ripe persimmon (50, 100, 150 or 200 g) was kept into the beer machine and allowed for fermentation at 25 °C for 6 days. The fermented mixture was stored at 4 °C for 3 days and then subjected for second step fermentation at 25 °C for 7 days after adding 5 g sugar per liter of fermenting product, followed by the last

step of storage at 4 °C for 3 days. The beer samples were named as RP-0 (control): beer containing no added ripe persimmon, RP-50: beer prepared with 50 g of ripe persimmon in 10 L of water, RP-100: beer prepared with 100 g of ripe persimmon in 10 L of water, RP-150: beer prepared with 150 g of ripe persimmon in 10 L of water, and RP-200: beer prepared with 200 g of ripe persimmon in 10 L of water. The addition of different proportions of ripe persimmon was expected to impart differential effects on the physicochemical properties of beer samples. A range of amounts of persimmon fruit was tested in order to determine an optimum proportion of the fruit to be added so that a superior quality persimmon beer could be brewed.

Measurement of chemical characteristics

The pH of beer samples was measured using a pH Meter (Model 250, Beckman Coulter, Inc., Fullerton, CA, USA). Titratable acidity (TA) was measured following the method described by Lee et al. [19] with some modifications. The beer sample (5 mL) was mixed with deionized water (125 mL) and titrated using a 0.1 N sodium hydroxide solution to an endpoint pH 8.2. The alcohol concentration of beer samples was determined as described by Ough and Amerine [25].

Color measurement

L^* (lightness), a^* (redness, + or greenness, −), b^* (yellowness, + or blueness, −) values of the beer samples were measured using a Chroma Meter (CR-300, Minolta Corp., Tokyo, Japan). A calibration plate (Minolta Corp.; YCIE = 94.5, XCIE = 0.3160, YCIE = 0.330) and a standard plate (Hunter Associates Laboratory Inc., Reston, VA, USA; L^* = 97.51, a^* = −0.18, b^* = + 1.67) were used to standardize the instrument with D65 illuminant [15].

Determination of mineral composition

An aliquot of beer sample (15 mL) was put into a beaker and mixed with 1% (v/v) nitric acid (0.5 mL). The mixture was diluted with distilled water (2 mL) and mixed thoroughly. Mineral composition was determined using an inductively coupled plasma-atomic emission spectrophotometer (ICP-AES; Varian Vista Inc., Victoria, Australia) following the manufacturer's recommended procedures [32]. A peristaltic pump was used to inject the solutions to the nebulizer. All the solutions were aspirated for 30 s in order to allow equilibrium to be reached in the plasma.

DPPH radical scavenging activity

The DPPH radical scavenging activity was measured according to the method described by Cheung et al. [3]. A freshly prepared 0.1 mL of 0.1% (w/v) DPPH-methanol solution was mixed with 0.1 mL of sample in 96-well microplate reader. The reaction mixture was incubated for 30 min at room temperature in dark condition and then the absorbance value of the mixtures was measured at 517 nm using a spectrophotometer (Multiskan GO, ThermoFisher Scientific, Vantaa, Finland). The radical-scavenging activity (RSA) was calculated as a percentage inhibition using the following equation.

$$\%RSA = (1 - S_{ab}/C_{ab}) \times 100$$

where S_{ab} is the absorbance of the mixture of sample and DPPH solution and C_{ab} is absorbance of DPPH solution without sample.

Superoxide anion scavenging activity

Measurement of the superoxide anion scavenging activity was carried out following the method described by Marklund and Marklund [21]. A freshly prepared 90 μ L of 3 mM pyrogallol (dissolved in 10 mM HCl) was added to a mixture of 0.3 mL of beer sample and 2.61 mL of 50 mM phosphate buffer (pH 8.24). The inhibition rate of auto-oxidation of pyrogallol was measured at 325 nm using a microplate spectrophotometer (Multiskan GO, ThermoFisher Scientific). The absorbance of each reaction mixture was recorded at 1 min interval for 10 min and the increment of absorbance was calculated as the difference.

Hydroxyl radical scavenging activity

The hydroxyl radical scavenging potential of beer samples was measured as described by Chung et al. [4]. A reaction mixture containing 0.2 mL of 10 mM $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, 0.2 mL of 10 mM EDTA, and 0.2 mL of 10 mM 2-deoxyribose was mixed with 0.2 mL of the beer samples, followed by an addition of 0.2 mL of 10 mM H_2O_2 and incubation at 37 °C for 4 h. After the incubation, 1 mL mixture of 2.8% (w/v) TCA (trichloroacetic acid) and 1.0% (w/v) TBA (thiobarbituric acid) was added to the reaction mixture and then allowed to equilibrate in boiling water bath for 10 min. The mixture was cooled in ice and absorbance value was measured at 520 nm using a microplate spectrophotometer (Multiskan GO, ThermoFisher Scientific).

Total polyphenol content

The total polyphenol content of beer samples was determined according to the Folin–Ciocalteu method [31]. Fifty microliters of beer sample and 1000 μ L of 2% (w/v) aqueous Na_2CO_3 were mixed using a vortexer and kept for 3 min at room temperature and then 50 μ L of 1 N Folin–Ciocalteu reagent was added to the mixture, followed by an incubation for 30 min at room temperature in dark condition. The absorbance value was measured at 750 nm using a microplate spectrophotometer (Multiskan GO, ThermoFisher Scientific). Gallic acid was used as a standard to plot the calibration curve. Total polyphenols were determined as gallic acid equivalents (μ g GAE/mL persimmon beer).

Sensory properties evaluation

Analysis of the sensory properties was performed with the freshly prepared beer samples. The samples were rated for color, flavor, and overall acceptance, respectively, on the following scale: 1 = very bad, 2 = bad, 3 = fair, 4 = good, 5 = very good [16]. The sensory properties were evaluated by 20 volunteer panelists (10 women and 10 men) selected from the graduate students of College of Agriculture and Life Sciences of Kyungpook National University, Daegu, Korea.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using SAS 9.3 [28] and significant differences among the treatment means were separated using Tukey test at 5% probability. The mean values of triplicate measurements were considered for statistical analysis.

Results and discussion

pH, titratable acidity, and alcohol

The pH value of beer samples was significantly ($p < 0.05$) increased with the addition of persimmon fruits (Table 1). A significantly ($p < 0.05$) low pH value was found in RP-0 (pH 4.20) and high in RP-150 (pH 4.71) and RP-200 (pH 4.78). However, the alcohol concentration of beer samples was not significantly ($p > 0.05$) influenced with the addition of persimmon fruits (Table 1). The addition of a small amount (0.5–2.0%, w/v) of persimmon fruit did not cause significant difference in the alcohol concentration of the beer samples. The alcohol concentration is one of the important qualities of beer, and which was not altered even after the addition of persimmon fruits. The TA values of

Table 1 Chemical characteristics of beer samples prepared with different amounts of persimmon fruit

Sample ¹	pH	Alcohol (% v/v)	Titrateable acidity ² (g/100 mL lactic acid)
RP-0	4.20 ± 0.03 ³ d	4.0 ± 0.02a	0.12 ± 0.01b
RP-50	4.44 ± 0.03c	4.0 ± 0.04a	0.17 ± 0.02a
RP-100	4.50 ± 0.02b	4.0 ± 0.06a	0.16 ± 0.02a
RP-150	4.71 ± 0.04a	4.0 ± 0.08a	0.18 ± 0.02a
RP-200	4.78 ± 0.07a	4.0 ± 0.07a	0.17 ± 0.02a

¹RP-0 (Control): beer containing no added persimmon fruit, RP-50: beer prepared with 50 g of ripe persimmon in 10 L of water, RP-100: beer prepared with 100 g of ripe persimmon in 10 L of water, RP-150: beer containing 150 g of ripe persimmon in 10 L of water, RP-200: beer containing 200 g of ripe persimmon in 10 L of water

²As lactic acid

³Values are expressed as mean ± standard deviation of three replicates. Values followed by different letters (a–d) in the same column indicate significant difference ($p < 0.05$, ANOVA, Tukey test)

persimmon beer samples (0.16–0.18 g/100 mL) were significantly ($p < 0.05$) high as compared to that of the control (0.12 g/100 mL of lactic acid) (Table 1).

The high pH value of beer prepared with higher amount of persimmon fruits might be due to higher pH value of the persimmon fruit (pH 6.10) than that of the ordinary beer (pH 4.20) in the present study. The pH value of beer samples ranged from 4.20 to 4.78, which was in agreement with that of a previous report [1]; however was higher than that found in another study [22]. The elevated TA value of persimmon beer might be due to the formation of high amount of organic acids during the alcoholic fermentation [24]. The TA value of persimmon-added beer was also higher than that of the control in a previous report [22], although the TA values were higher than those found in the present study. The difference in chemical properties like pH and TA values might be due to variation in the form, amount, and cultivar of the persimmon fruit added.

Hunter's color value

Hunter's color values of beer samples were significantly ($p < 0.05$) affected with the addition of persimmon fruit (Table 2). Lightness value of beer samples was significantly ($p < 0.05$) reduced with the addition of the fruit. The lightness value ranged from 89.11–72.31 with the highest for the control and the lowest for RP-200. In contrary, the redness value were significantly ($p < 0.05$) increased with the amount of fruit added. The yellowness value followed a similar trend of the redness values with the lowest value for RP-0 (26.17 yellowness) and the highest for RP-200 (46.30 yellowness).

The relatively high redness and yellowness values in the persimmon beer samples might be due to the carotenoid present in the persimmon fruit [35]. Since carotenoids are fat-soluble, the carotenoid-rich fruits like persimmon may transfer relatively little color to the beer. Therefore,

Table 2 Hunter's color values of beer samples prepared with different amounts of persimmon fruit

Sample ¹	Color value ²		
	L* (lightness)	a* (redness)	b* (yellowness)
RP-0	89.11 ± 0.05 ³ a	0.59 ± 0.08e	26.17 ± 0.12d
RP-50	80.17 ± 0.07b	2.10 ± 0.04d	35.17 ± 0.06c
RP-100	78.22 ± 0.09c	3.25 ± 0.03c	39.41 ± 0.17b
RP-150	75.33 ± 0.06d	3.70 ± 0.07b	40.21 ± 0.11b
RP-200	72.31 ± 0.03e	3.98 ± 0.02a	46.30 ± 0.07a

¹Samples are defined in Table 1

²L*, lightness (100, white; 0, black); a*, redness (–, green; +, red); b*, yellowness (–, blue; +, yellow)

³Values are expressed as means ± standard deviations of three replicates. Values followed by different letters (a–e) in the same column are significantly different ($p < 0.05$, ANOVA, Tukey test)

different proportions of persimmon fruits could be added as a natural coloring agent to enhance the redness and yellowness of the light-colored beers. Color values of the persimmon beer found in the present study were slightly out of the range of commercial lager beer [10], although the redness value was within the range of previous report [22].

Mineral content

Addition of persimmon fruit significantly ($p < 0.05$) increased the content of some of the minerals such as Na, Mg, K, and Ca; whereas the amount of Mn, Fe, Cu, and Zn was not substantially affected in the beer samples (Table 3). Persimmon fruit increased the amount of Na almost 4–7 times in persimmon beer samples (4.11–6.52 mg/kg) compared to the control (0.88 mg/kg). The elements like Mg, K, and Ca; which were significantly ($p < 0.05$) increased in the persimmon beer samples; are

Table 3 Mineral contents (mg/kg) of beer samples prepared with different amounts of persimmon fruit

Element ²	Sample ¹				
	RP-0	RP-50	RP-100	RP-150	RP-200
Na	0.88 ± 0.01 ³ e	4.11 ± 0.02d	5.31 ± 0.03c	6.00 ± 0.03b	6.52 ± 0.12a
Mg	5.31 ± 0.02e	8.12 ± 0.04d	9.31 ± 0.05c	10.11 ± 0.02b	12.00 ± 0.02a
K	3.11 ± 0.05d	3.11 ± 0.02d	3.21 ± 0.03c	3.53 ± 0.04b	4.00 ± 0.04a
Ca	3.55 ± 0.04e	4.88 ± 0.03d	6.00 ± 0.01c	6.50 ± 0.02b	7.11 ± 0.03a
Mn	0.01 ± 0.01a	0.02 ± 0.01a	0.03 ± 0.02a	0.03 ± 0.02a	0.04 ± 0.01a
Fe	0.01 ± 0.01a	0.01 ± 0.01a	0.02 ± 0.01a	0.02 ± 0.01a	0.03 ± 0.02a
Cu	0.15 ± 0.03b	0.18 ± 0.03ab	0.19 ± 0.02ab	0.20 ± 0.01a	0.20 ± 0.03ab
Zn	0.06 ± 0.02a	0.08 ± 0.01a	0.07 ± 0.02a	0.08 ± 0.02a	0.09 ± 0.02a
As	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND
Hg	ND	ND	ND	ND	ND
Pb	ND	ND	ND	ND	ND

ND non-detected

¹Samples are defined in Table 1²Detection limit: Pb; < 5 mg/kg, As; < 10 mg/kg, Cd; < 5 mg/kg, Hg; < 10 mg/kg³Values are expressed as means ± standard deviations of three replicates. Values followed by different letters (a–e) in the same row are significantly different ($p < 0.05$, ANOVA, Tukey test)

reported to have beneficial health effects in the prevention and treatment of essential hypertension [12]. The elements like As, Pb, Cd, and Hg; which are also health hazardous; were not detected in the beer samples. Difference in the mineral contents in different varieties of beer might be due to the presence of different phytochemicals in persimmon fruits [2, 6].

Sensory characteristics

The sensory characteristics of beer samples were significantly ($p < 0.05$) influenced with persimmon fruit (Table 4). Sensory characteristic is one of the decisive

Table 4 Sensory characteristics of beer samples prepared with different amounts of persimmon fruit

Sample ¹	Sensory characteristics		
	Color	Flavor	Overall acceptance
RP-0	4.28 ± 0.24 ² a	3.65 ± 0.18b	3.61 ± 0.08d
RP-50	4.00 ± 0.20b	3.81 ± 0.14b	3.80 ± 0.11c
RP-100	3.52 ± 0.11c	3.70 ± 0.15b	4.00 ± 0.06b
RP-150	3.11 ± 0.21d	4.02 ± 0.11a	4.21 ± 0.10a
RP-200	3.01 ± 0.11d	3.40 ± 0.06c	3.20 ± 0.21e

¹Samples are defined in Table 1²Quoted values are mean ± standard deviations (n = 20) based on 5-point score (very bad, 1; bad, 2; fair, 3; good, 4; very good, 5). Values followed by different letters (a–e) in the same column are significantly different ($p < 0.05$, ANOVA, Tukey test)

factors in beer qualities [18]. Color value of the control was significantly ($p < 0.05$) high compared to the persimmon-added beer samples. The color value of beer samples was reduced with the amount of persimmon added. The flavor value of RP-150 (4.02 flavor) was significantly ($p < 0.05$) high and that of RP-200 (3.40 flavor) was low. The other three samples including the control were not significantly ($p > 0.05$) different for flavor value. The results of flavor value suggested that addition of high or low amount of persimmon fruit may reduce the flavor of beer. The flavor differences of alcoholic beverages may play a crucial role in the product development and marketing although the variation in perception of oral sensations is complex, and may be influenced by different factors such as ethnicity [26], gender [23], age [23], overall health/medication [29], and other psychological and physiological factors. Assessment of sensory characteristics revealed that the overall acceptance of beer could be improved by addition of 150 g of persimmon fruit in 10 L of water during fermentation. The improved overall acceptance of persimmon-added beer might be due to the different phytochemicals present in the persimmon fruit [2, 6].

Antioxidant potential and total polyphenol content

The antioxidant activity and total polyphenol content among the beer samples were significantly ($p < 0.05$) different (Table 5). The DPPH radical-scavenging activity of beer samples increased with the amount of persimmon added; the highest value was found in RP-200 (91.0%) and

Table 5 Scavenging activities of reactive oxygen species and total polyphenolic content of beer sample prepared with different amount of persimmon fruit

Sample ¹	% Inhibition			Total phenol content ($\mu\text{g GAE}^5/\text{g}$ of sample)
	DPPH ²	O ₂ ⁻³	OH ⁴	
RP-0	80.12 $\pm$ 1.11 ⁶ c	21.07 $\pm$ 0.23d	24.00 $\pm$ 0.61d	507.09 $\pm$ 2.98e
RP-50	85.31 $\pm$ 1.09b	30.11 $\pm$ 0.32c	28.88 $\pm$ 0.72c	595.66 $\pm$ 5.62d
RP-100	86.13 $\pm$ 0.88b	35.13 $\pm$ 1.01b	32.12 $\pm$ 0.24b	672.31 $\pm$ 3.11c
RP-150	90.20 $\pm$ 1.36a	39.31 $\pm$ 0.46a	33.06 $\pm$ 1.01b	701.09 $\pm$ 2.00b
RP-200	91.00 $\pm$ 1.00a	40.00 $\pm$ 0.88a	40.11 $\pm$ 0.49a	714.11 $\pm$ 1.88a

¹Samples are defined in Table 1²DPPH: DPPH free radical scavenging activity³O₂⁻: Superoxide anion scavenging activity⁴OH: Hydroxyl radical scavenging activity⁵GAE: Gallic acid equivalent⁶Quoted values are expressed as means $\pm$ SD of three replicates. Values followed by different letters (a–d) in the same column are significantly different ($p < 0.05$, ANOVA, Tukey test)

the lowest in RP-50 (85.31%). Similarly, the superoxide anion scavenging potential of beer samples significantly ($p < 0.05$) increased with the addition of persimmon fruit. The highest superoxide anion scavenging value was obtained for RP-200 (40.0%) and the lowest for RP-50 (30.11%) among the beer samples prepared with persimmon fruit (Table 5). Reactive oxygen species (ROS), including hydrogen peroxide, hydroxyl radical, and singlet oxygen; primarily generated from superoxide anions; induce oxidative damage in fats, proteins, and nucleic acids. The effect of persimmon fruit was also reflected in the hydroxyl radical scavenging potential of the beer samples as in the DPPH and superoxide anion (Table 5). The hydroxyl radicals are considered as one of the highly reactive free radicals inevitably biosynthesized and are highly injurious in biological systems, and capable of destroying almost every molecule found in living cells [11]. There has been found no specific enzyme available in the human body to nullify the harmful effect of hydroxyl radical and protect against them. Therefore, the persimmon-added beer with good scavenging capacity could be one of the potential protective sources against those harmful free radicals. Total polyphenol contents of the beer samples significantly ($p < 0.05$) increased with the amount of the fruit added; the highest value was found in RP-200 and the lowest in RP-0 (Table 5).

The high total polyphenol value for the persimmon-added beer samples was due to the large amount of phenolic compounds present in the persimmon fruits [13]. The phenolic compounds polyphenols, flavonoids, and flavonols account for the antioxidant potentials of beer [34]. The significantly high DPPH, superoxide anion, and hydroxyl

radical scavenging potentials of persimmon-added beer found in the present study were possibly due to the high phenolic compounds [13], which possess remarkable antioxidant potential [34]. The relationship of antioxidant potentials and phenolic content found in this study was in agreement with that of a previous report [22]. The destructive effects of ROS are counteracted by the enzymatic as well as nonenzymatic antioxidative systems including ascorbic acid, tocopherol, glutathione, and phenolic compounds. The antioxidative properties of polyphenols are attributed to their high reactivity as hydrogen or electron donors, and to the ability of the polyphenol-derived radical to stabilize and delocalize the unpaired electron as well as to chelate transition metal ions [27]. In addition, the phenolic compounds alter peroxidation kinetics by modifying the lipid packing order and decreasing the fluidity of the membranes. The results of the present study showed that addition of persimmon fruit could significantly enhance the antioxidant potential, one of the key health benefits, of beer.

In conclusion, this study investigated the influence of addition of ripe persimmon fruit on quality characteristics and antioxidant potentials of beer. The pH and TA were significantly increased but alcohol concentration remained unaffected. The beer samples prepared with persimmon fruit showed significantly high antioxidant potentials measured through DPPH and superoxide and hydroxyl anions scavenging potentials as well as total polyphenol contents compared to the control. The amount of mineral elements like Mg, K, and Ca was also significantly increased in the persimmon beer. Overall acceptance value of the persimmon beer prepared with the addition of 150 g

of persimmon fruit in 10 L of water was the highest among the beer samples. The results of the present study showed that addition of 150 g of persimmon fruit per 10 L of water could better enhance the nutritional, organoleptic, and antioxidant potential of beer.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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