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Influence of Ripe Persimmon on Quality Characteristics and Antioxidant Potential of Sparkling Wine

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Sparkling wine has widely been consumed because of its high added value. Sparkling wine is mainly produced using grape, however different fruits have been studied to ferment the wine. The objective of this study was to determine the quality characteristics and antioxidant potential of sparkling wine produced by using ripe persimmon with three strains of *Saccharomyces*, that is, *S. bayanus, S. carlsbergensis,* and *S. cerevisiae*. Persimmon sparkling wine samples were prepared by fermenting different amounts of persimmon fruit and water. Alcohol content was significantly varied in base wine with different proportion of persimmon fruit and water. Antioxidant potential in term of DPPH radical scavenging potential of the base wine prepared with 4:1 ratio of persimmon and water was significantly high. However, the tannin content of the wine samples was not significantly affected. Sensory characteristics in term of full-body was also significantly high for the wine prepared with 4:1 ratio of persimmon and water. Inoculation method also affected the ethanol content of persimmon sparkling wine. Results of this experiment showed that good quality persimmon sparkling wine could be prepared by fermenting 4:1 ratio of ripe persimmon and water during first fermentation.

Keywords: Antioxidant potential, Persimmon, Quality characteristics, Sparkling wine.

Production of sparkling wine has been increased because of its high added value. Report shows that production of sparkling wine increased in recent years[1].

Sparkling wine are produced after second fermentation of a base wine. The base wine produced in first fermentation is subjected to second fermentation, which is conducted in closed bottles, after adding sugar and yeast. During the second fermentation, the sparkling wines remain in contact with lees for at least nine months at low temperatures (12-16°C). The considerable variations among sparkling wines are fundamentally attributed to the grape varieties and the aging time on lees[2-5]. During the aging of sparkling wine, the yeast autolysis causes significant variations in the wine composition[6], especially for the volatile compounds that could impart significant effect on the final quality of the wines[7-9]. Various enzymatic as well as chemical reactions, during the second fermentation, may cause modification in the aroma of the wines due to the formation or degradation of some volatile compounds[3,5]. Similarly, the yeast lees may adsorb some volatile compounds, reducing the latter's concentration in the aged wines[10, 11].

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During the second fermentation, yeasts are exposed to various stress factors, like elevated ethanol, nitrogen deficiency, low pH, low temperatures and overpressure of CO_2[12], which influence their metabolism and consequently may cause a significant modification in organoleptic properties of sparkling wine. Two forms of impact are recognized during the second fermentation, also called 'prise de mousse'. Firstly, an increased ethanol content and CO_2 overpressure, while yeasts live. Later, the yeasts release mannoproteins that affect some aroma precursors[4, 6, 13] when they die and also during the aging time on lees. Because of these reasons, several experiments have been conducted to select appropriate yeast strains for their potentiality to autolysis and flocculation, production of enzymes and tolerance to ethanol and low temperature[13].

Although few fruits such as pineapple[14], mulberry[15], and guava[16] have been used in production of sparkling wine, majority of the wines are fermented using grape[9, 12, 17, 18]. To the best of our knowledge, to date, no studies have been conducted on preparation of sparkling wine using persimmon fruits although the fruits are rich in different nutrients and phytochemicals[19 22]. Therefore, the objective of this study was to determine the quality characteristics and antioxidant potential of sparkling wine produced by using ripe persimmon with three strains of *Saccharomyces; S. bayanus, S. carlsbergensis,* and *S. cerevisiae*.

MATERIALS AND METHODS

Chemicals and materials

Folin-ciocalteu phenol reagent and DPPH were purchased from Sigma-Aldrich (St. Louis, MO, USA). All other reagents used were of analytical grade. Fruits of persimmon cultivar Sangju Doongsi, grown at Sangju Persimmon Research Institute (Gyeonsangbuk-do, Korea), were harvested at commercial maturity stage. Yeasts (*Saccharomyces bayanus, S. carlsbergensis,* and *S. cerevisiae*) were purchased from local stores in Daegu (Korea).

Preparation of persimmon sparkling wine samples

Persimmon sparkling wine was prepared using 2-step fermentation. Briefly, a mixture of sugar, ascorbic acid, and SO_2 was kept at 25°C for 5 h. The mixture of ripe persimmon and dry yeast activated at 60°C for 30 min was fermented for 14 days at 22°C, followed by removal of ripe persimmon pulp and re-fermentation for 14 days at 22°C. Different persimmon sparkling wines prepared by different amounts of water and inoculation methods were named as SW-1: persimmon sparkling wine was fermented with ripe persimmon and water at a ratio of 1:0 (w/w), SW-2: persimmon sparkling wine was fermented with ripe persimmon and water at a ratio of 4:1 (w/w), SW-3: persimmon sparkling wine was fermented with ripe persimmon and water at a ratio of 1:4 (w/w), SW-4: persimmon sparkling wine was fermented with ripe persimmon and water at a ratio of 1:1 (w/w), and I : The diluents were mixed with base wine and distilled water at a ratio of 1:1 (w/w), and the diluted samples, added with 0.05% of yeast and 1% of sucrose, were cultured at 25°C for 48-72 h. After preparation, the stains *Saccharomyces bayanus, Saccharomyces carlsbergensis* and *Saccharomyces cerevisiae* were inoculated into the culture broth in base wine, II: The 0.05% of the stains *Saccharomyces bayanus, Saccharomyces carlsbergensis* and *Saccharomyces cerevisiae* and 1% of sugar in water (25°C) were mixed and activated at 50°C for 30 min. In the second step, the mixture of first ferment, sugar and yeasts was fermented in a 750 mL glass bottle at 22°C.

Physicochemical parameters

Alcohol concentration analysis was conducted following the method of Ough and Amerine[23]. The reducing sugar obtained was measured by using a phenol-H_2SO_4 method[24]. Titratable acidity (lactic acid in %) was measured by addition of 5 mL of persimmon sparkling wine to 125 mL of deionized water, followed by titration using 0.1 N sodium hydroxide to an endpoint pH 8.2.

Color measurement

L*(lightness), a*(redness, + or greenness,-) and b*(yellowness, + or blueness, -) values of persimmon sparkling wine were measured using a Chroma Meter (CR-300; Minolta Corp., Osaka, Japan). A Minolta calibration plate (YCIE=94.5, XCIE=0.3160, YCIE=0.330) and a Hunter Lab standard plate (L*= 97.51, a*= -0.18, b*= +1.67) were used to standardize the instrument using a D65 illuminant[25]. Color values were measured directly from 3 zones of persimmon sparkling wine and mean values were calculated.

DPPH radical scavenging activity

DPPH radical scavenging activity of persimmon sparkling wine was measured following the methods described by Blois[26] with some modifications. Eight hundred microliters of a 0.2 mM DPPH ethanol solution was mixed with 0.2 mL of a persimmon sparkling wine. The mixture was thoroughly mixed using a vortexer and left to stand for 10 min at room temperature under dark condition. After incubation the absorbance value was measured using a spectrophotometer at 520 nm (Multiskan GO Microplate; Thermo Fisher Scientific, Vantaa, Finland).

Evaluation of sensory properties

Sensory properties was evaluated for the freshly prepared sparkling wine. The wine samples were scored for color, sweet, sour, astringent, bitter, and full-body using scale of 1= very bad, 2= bad, 3= fair, 4= good, 5= very good. The sensory property evaluation was carried out with a panel of 20 volunteers (10 women and 10 men) selected from the list of graduate students of College of Agriculture and Life Sciences of Kyungpook National University, Daegu, Korea. Mean values of 20 evaluations for each sensory property were reported as scores.

Statistical analysis

Data were subjected to analysis of variance using SAS 9.4 (Cary Institute, NC, USA). Differences between sample means were determined using Tukey test at $p<0.05$ probability.

Table 1. Chemical characteristics of persimmon base wines prepared with different amounts of persimmon and water

Sample[1)]	Alcohol (%, v/v)	Reducing sugar (%)	Titratable acidity[2)] (%)
SW-1	7.81±0.05$^{c3)}$	3.39±0.20^{b}	3.50±0.02^{b}
SW-2	10.20±0.10^{a}	3.34±0.16^{b}	4.27±0.05^{a}
SW-3	9.86±0.08^{b}	3.27±0.17^{b}	4.32±0.06^{a}
SW-4	7.91±0.07^{c}	4.66±0.08^{a}	3.20±0.03^{c}

1)Samples are defined in 'Preparation of persimmon sparkling wine samples' under Materials and Methods section.
2)As lactic acid.
3)Quoted values are means±SD of triplicate measurements. Values followed by different superscripts in the same column are significantly different ($p<0.05$).

Table 2. Hunter's color values of persimmon base wines prepared with different amounts of persimmon fruit and water

Sample[1)]	Color value[2)]		
	L*	a*	b*
SW-1	95.11±0.02$^{3)a}$	-1.00±0.03^{c}	9.32±0.04^{a}
SW-2	94.77±0.12^{b}	-0.92±0.02^{b}	7.21±0.01^{b}
SW-3	92.00±0.05^{d}	-0.82±0.05^{a}	6.92±0.03^{c}
SW-4	93.31±0.04^{c}	-1.11±0.03^{d}	6.00±0.02^{d}

1)Samples are defined in 'Preparation of persimmon sparkling wine samples' under Materials and Methods section.
2)L*, lightness (100, white; 0, black); a*, redness (-, green; +, red); b*, yellowness(-, blue; +, yellow).
3)Quoted values are means±SD of triplicate measurements. Values followed by different superscripts in the same column are significantly different ($p<0.05$).

Table 3. DPPH radical scavenging activities and tannin content of persimmon base wines manufactured with prepared by adding different amounts of water

Sample[1)]	DPPH (%, Inhibition)	Tannin content (%)
SW-1	81.20±1.82$^{2)a}$	0.03±0.01^{a}
SW-2	80.31±1.20^{a}	0.02±0.01^{a}
SW-3	76.21±1.63^{b}	0.02±0.01^{a}
SW-4	45.23±1.88^{c}	0.01±0.01^{a}

1)Samples are defined in 'Preparation of persimmon sparkling wine samples' under Materials and Methods section.
2)Quoted values are means±SD of triplicate measurements. Values followed by different superscripts in the same column are significantly different ($p<0.05$).

RESULTS

Chemical characteristics of persimmon base wine

Chemical characteristics of persimmon base wine prepared with different amounts of water are given in Table 1. The chemical characteristics of persimmon base wine were affected by the amounts of water added. SW-2 base wine had higher value for alcohol concentration (10.20%). On the other hand, the SW-4 base wine had the highest reducing sugar content (4.66%) but lowest titratable acidity value (3.20%) among the four base wine samples.

Color values of persimmon base wine

Color values of persimmon base wine samples fermented with different amounts of water were signigicantly different (Table 2). L* (lighteness) and b* (yellowness) values of SW-1 were higher than those of the other samples, however SW-3 had the highest value (-0.82) for a* (redness).

DPPH radical scavenging potential and tannin content

DPPH radical scavenging potential was significantly ($p<0.05$) different, however tanning content was not (Table 3). DPPH radical scavenging activities of persimmon base wines were in the order SW-1=SW-2>SW-3>SW-4.

Sensory characteristics of persimmon sparkling wine

Sensory characteristics (color, sweetness, sourness, astringency, bitterness, and full-body) of persimmon base wine prepared with different amounts of persimmon and water were significantly

Table 4. Sensory characteristics of persimmon base wines manufactured with prepared by adding different amounts of water

Attributes	Sample[1)]			
	SW-1	SW-2	SW-3	SW-4
Color	4.21±0.26[a2)]	4.00±0.31[ab]	3.67±0.25[b]	3.66±0.21[b]
Sweetness	2.10±0.21[a]	2.00±0.20[a]	2.20±0.05[a]	2.11±0.31[a]
Sourness	2.00±0.33[b]	2.53±0.27[a]	2.65±0.19[a]	2.70±0.05[a]
Astringency	1.10±0.02[a]	1.11±0.04[a]	1.01±0.03[b]	1.03±0.02[b]
Bitterness	1.85±0.06[b]	2.50±0.17[a]	2.39±0.20[a]	2.50±0.11[a]
Full-body	3.09±0.13[b]	3.51±0.21[a]	3.00±0.11[b]	2.21±0.32[c]

[1)]Samples are defined in 'Preparation of persimmon sparkling wine samples' under Materials and Methods section.
[2)]Quoted values are means±SD of triplicate measurements (*n*=20) based on 5 point scores (1, very poor; 2, poor; 3, fair; 4, good; 5, very good). Values followed by different superscripts in the same row are significantly different ($p<0.05$).

Table 5. Ethanol content (%) of persimmon sparkling wine prepared adopting different inoculation methods at second fermentation

Strain	Inoculation method[1)]	
	I	II
Saccharomyces bayanus	9.72±0.06[a2)]	10.43±0.06[a]
S. carlsbergenis	9.69±0.07[a]	10.21±0.02[b]
S. cerevisiae	9.11±0.09[b]	9.87±0.03[c]

[1)]Inoculation methods are defined in 'Preparation of persimmon sparkling wine samples' under Materials and Methods section.
[2)]Quoted values are means±SD of triplicate measurements. Values followed by different superscripts in the same column are significantly different ($p<0.05$).

Table 6. Reducing sugar content (%) of persimmon sparkling wine prepared adopting different inoculation methods at second fermentation

Strain	Inoculation method[1)]	
	I	II
Saccharomyces bayanus	1.31±0.06[a2)]	1.35±0.02[a]
S. carlsbergenis	1.12±0.02[a]	1.38±0.04[a]
S. cerevisiae	1.25±0.08[a]	1.37±0.03[a]

[1)]Inoculation methods are defined in 'Preparation of persimmon sparkling wine samples' under Materials and Methods section.
[2)]Quoted values are means±SD of triplicate measurements. Values followed by different superscripts in the same column are significantly different ($p<0.05$).

(p<0.05) different (Table 4). Other than the sweetness, all the other sensory parameters of base wine samples were significantly (p<0.05) different. Full-body value of SW-2 was significantly highest for SW-2 (3.51) and lowest for SW-4 (2.21). Results of this experiment showed that the sensory properties of base wine could be significantly altered by varying the amount of persimmon and water.

Alcohol content of persimmon sparkling wine

Ethanol content of persimmon sparkling wines prepared by different inoculation methods at second fermentation are given in Table 5. Inoculation methods were found to be a determining factor for ethanol content in persimmon sparkling wine fermented with strains of *S. bayanus*, *S. carlsbergenis,* and *S. cerevisiae*. For the inoculation method I, the ethanol content was in the order *S. bayanus*>*S. carlsbergensis*>*S. cerevisiae*.

Reducing sugar of persimmon sparkling wine

Reducing sugar contents of persimmon sparkling wine samples prepared by adopting different inoculation methods at second fermentation were not significantly (p>0.05) different (Table 6). The reducing sugar contents in the methods I and II were in the range of 1.12 1.31 and 1.35 1.38%, respectively.

DISCUSSION

Chemical characteristics of persimmon base wine

Chemical parameters such as alcohol and sugar contents are important for the analytical panel to aid fraud tracking of sparkling wine[27]. Results of this experiment showed that the chemical characteristics of persimmon base wine could be manipulated by varying the amount of the amounts of ripe persimmon and water. The amount of persimmon in base wines during the aging of the wine may explain the differences in color values[28]. Color of wine is important factor for consumer preference[29, 30]. DPPH is widely used for assessing the free radical scavenging ability[31]. It was found that persimmon base wine fermented with different amounts of persimmon and water had different hydrogen-donating capacity to scavenge DPPH radicals. Results of this experiment showed that the sensory properties of base wine could be significantly altered by varying the amount of persimmon and water. Variations in these sensory characteristics of wine were also observed in previous studies[32]. Hence, it could be speculated that base wine fermented with persimmon and water in the ratio of 4:1 (w/w) might be an optimum amount to produce a high full-body sensory attributes. The ethanol contents the persimmon sparkling wines are probably the factor affected by the second fermentation conditions[33]. There were no significant differences for reducing content of persimmon sparkling wine fermented with different strains of *Saccharomyces*, that is, *S. bayanus*, *S. carlsbergensis*, and *S. cerevisiae*. Similar results were reported in a previous report[34].

CONCLUSION

Persimmon sparkling wine samples were prepared by fermenting different amounts of persimmon fruit and water using different strains of *Saccharomyces*, that is, *S. bayanus*, *S. carlsbergensis*, and *S. cerevisiae*. Alcohol content was significantly varied in base wine samples prepared with different proportion of persimmon fruit and water with the highest value in SW-2. DPPH radical scavenging potential of SW-1 and SW-2 was significantly higher than other two base wine samples. However, the tannin content of the samples was not significantly affected. Sensory characteristics in term of full-body was also significantly high for SW-2. Inoculation method also affected the ethanol content of persimmon sparkling wine. Results of this experiment showed that good quality persimmon sparkling wine could be prepared by fermenting 4:1 ratio of ripe persimmon and water during first fermentation.

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