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Quality characteristics of Korean traditional rice wine (Takju) prepared by addition of green pepper

Chan Yong Kim[1], Kil Su Jang[1], Su Gyeong Jeon[1], Sanjeev Kumar Dhungana[2], Hyeon Min Do[2], Oh Hun Kwon[1], Oh-Heun Kwon[1], Hye-Ryun Kim[3] and Il-Doo Kim[4]*

[1]Yeongyang Pepper Research Institute, Gyeongbuk Agricultural Research and Extension Service, Yeongyangchangsu-ro, 36531, Korea.
[2]School of Applied Biosciences, Kyungpook National University, Daegu 41566, Korea.
[3]Cheonnyeonmiin Co. Limited., Gyeongju-si 38180, Korea.
[4]International Institute of Agricultural Research and Development, Kyungpook National University, Daegu 41566, Korea.

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Makgeolli, frequently called Takju, a famous Korean traditional rice wine, has long been prepared and consumed in Korea. Takju consumption in Korea has been increased because of its nutritional and functional values. The objective of the present study was to investigate the chemical characteristics, color values, 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activities, total phenolic contents, and sensory characteristics of Takju. Green peppers enhanced the antioxidant potential, and the overall acceptance of pepper Takju. Moreover, unfavorable effects of green peppers were not observed on the basic chemical and organoleptic properties, but imparted favorable properties on pepper Takju. The appropriate amount of green peppers to be added to the second phase of Takju fermentation was about 9% of the total rice for fermentation. The results of the present study revealed that, an addition of optimum amount of green peppers could enhance the antioxidant potentials and also the overall acceptance of Takju.

Key words: Antioxidant potential, green pepper, Korean traditional wine, quality characteristic, Takju.

INTRODUCTION

Makgeolli, frequently called Takju, is a Korean traditional rice wine that has long been prepared and consumed in Korea (Lee et al., 2010). Takju consumption in Korea has been increased because of its nutritional and functional values (Kim and Cho, 2015). Permitted use of rice in the preparation of Takju in late 1980s, which once was replaced by wheat flour in 1963 due to the food policy of Korea, favored to improve its quality and many studies of Takju have been conducted since then (Lee et al., 2010).

A number of studies have been conducted to examine the effect of microbes, enzymes, flavor, taste, and nutritional value on the fermentation to enhance the use

*Corresponding author. E-mail: ildookim@hanmail.net. Tel: +82-53-950-5707.

Table 1. Formulae of ingredients for takju prepared using different proportions of green peppers.

Sample[1)]	Rice (Kg)	Green pepper (Kg)
Control	10 (100.000)[2)]	0.00 (0.000)
PT-500	10 (95.239)	0.50 (4.761)
PT-1000	10 (90.910)	1.00 (9.090)
PT-2000	10 (83.334)	2.00 (16.666)

[1)]Control, ordinary takju containing no green pepper; PT-500, pepper takju containing 0.5 kg of raw green pepper for 10 kg of steamed rice; PT-1000, pepper takju containing 1.0 kg of raw green pepper for 10 kg of steamed rice; PT-2000, pepper takju containing 2.0 kg of raw green pepper for 10 kg of steamed rice. [2)]Values in parentheses represent percentages of ingredients in takju.

of raw materials, and to optimize the manufacturing process, storage and marketing (Kim et al., 2002). Continuous researches have enhanced the quality of alcoholic drinks and thus improved trades; however, room for improvements still persist. Development of distinctive features and a superior preference and physiological functionality are some of the factors which need to be addressed.

Takju has a milky, turbid color because no clarification process is allowed after fermentation. Rice grains, which are the most widely used ingredient of carbohydrate sources for Takju brewing, are processed prior to fermentation so that, fats, proteins, and inorganic components from the grain surface could be removed (Saito et al.,1997). After fermentation, the matured mash is squeezed using cheesecloth and Takju is separated out from the fermentation mixture (Woo et al., 2001).

About 6% alcohol is maintained in Takju, which has a distinctive smell with slight acidic properties and a sweet taste. Some of the active substances like polyphenols, polysaccharides, and polysaccharide-peptide complexes have been isolated from Takju (Lee et al., 1996; Park and Lee, 2002). These ingredients in Takju are responsible for diverse chemical and biological properties, including antioxidant and immunomodulating potentials. Some Takju contained even higher amount of total polyphenol as compared to white wine (Bae et al., 2010). Preparation of different varieties of Korean traditional rice wines using dandelion (Kim et al., 2000), chamomile (Lee et al., 2002a), acasia (Seo et al., 2002), and *Paecilomyces japonica* (Lee et al., 2002b) is already in practice.

Peppers show many health promoting effects like anti-obesity activities (Jeon et al., 2010), antiproliferative activity against tumor cells (Jeon et al., 2012), antioxidant activity (Kedage et al., 2007; Sun et al., 2007; Domínguez-Martínez et al., 2014; Jang et al., 2015) and no report on the use of green peppers in preparation of Takju has been published. Therefore, the objective of the present study was to investigate the quality characteristics and antioxidant potentials of the Takju prepared by addition of green peppers.

MATERIALS AND METHODS

Chemicals

Folin-Ciocalteu phenol reagent and 1, 1-diphenyl-2-picrylhydrazyl (DPPH) were purchased from Sigma-Aldrich (St. Louis, MO, USA). All other reagents used were of analytical grade. Fresh green pepper (*Capsicum annuum* L.) cv. Longgreenmat was obtained from a local market in Daegu, Korea and washed with tap water.

Preparation of takju samples

Takju was prepared using a 2 step fermentation of steamed rice as described earlier (Kim et al., 2015).

A mixture of rice *koji*, commercial steamed rice (10 kg), yeast (12.5 g), and water (15 L) was fermented at 25°C for 1 day. For the second step, green peppers were cut into small pieces, added to the mixture of first stage fermentation and allowed for further fermentation at 25°C for 5 days. The amount of ingredients used, in the preparation of different varieties of pepper Takju are presented in Table 1.

The varieties of pepper Takju were named based on the amount of green peppers, added in as; Control: ordinary Takju containing no green pepper, PT-500: pepper Takju containing 0.5 kg of raw green pepper for 10 kg of steamed rice, PT-1000: pepper Takju containing 1.0 kg of raw green pepper for 10 kg of steamed rice, PT-2000: pepper Takju containing 2.0 kg of raw green pepper for 10 kg of steamed rice.

Various concentrations of additives were used to optimize the amount of the green pepper in other to prepare better quality Takju. Following the 2 step fermentation, Takju samples were pasteurized at 85°C for 5 min using a sterilizer (CK-25, Hanil Co., Seoul, Korea). The pasteurized samples were stored at 4°C until analyses.

Physicochemical parameters

The pH, titratable acidity (TA), alcohol, and °Brix of Takju samples were evaluated for physicochemical properties. A pH Meter (Model 250, Beckman Coulter, Inc., Fullerton, CA, USA) was used to determine the pH value.

TA (lactic acid in g/L) was measured by mixing 5 mL of Takju and 125 mL of deionized water, then the mixture was titrated using 0.1 N sodium hydroxide to an endpoint pH of 8.2. The alcoholic concentration and brix value was determined as described by Fletcher and van Staden (2003) and NRRDI (2006), respectively.

Determination of the total phenol content

The total phenol content was determined following the Folin-Ciocalteau method (Singleton et al., 1999). A mixture of 250 μL of Folin-Ciocalteau reagent and 50 μL of Takju sample was allowed to react for 1 min at room temperature. After 1 min, 750 μL of aqueous Na_2CO_3 (20%) was added to the mixture, and the volume was made up to 5 mL with distilled water.

The final mixture was kept for 2 h of incubation under dark condition at room temperature and the absorbance value was measured at 760 nm (Multiskan GO Microplate Spectrophotometer, Thermo Fisher Scientific Oy, Vantaa, Finland). A calibration curve

Table 2. Chemical characteristics of takju prepared using different proportions of green peppers.

Sample[1)]	pH	Alcohol (%,v/v)	Titratable acidity[2)] (g/100 mL)	Soluble solid (°Bx)
Control	3.88±0.03[c]	6.0±0.03[a]	0.89±0.02[a]	3.6±0.2[b]
PT-500	4.04±0.07[b]	6.0±0.02[a]	0.24±0.01[b]	4.0±0.3[a]
PT-1000	4.51±0.03[a]	6.0±0.07[a]	0.19±0.02[e]	4.3±0.1[a]
PT-2000	4.50±0.02[a]	6.0±0.04[a]	0.20±0.03[bc]	4.4±0.2[a]

[1)]Control, ordinary takju containing no green pepper; PT-500, pepper takju containing 0.5 kg of raw green pepper for 10 kg of steamed rice; PT-1000, pepper takju containing 1.0 kg of raw green pepper for 10 kg of steamed rice; PT-2000, pepper takju containing 2.0 kg of raw green pepper for 10 kg of steamed rice. [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).

was plotted using gallic acid as standard. The total phenol contents were determined as, gallic acid equivalents (µg GAE/mL of Takju).

DPPH radical scavenging activity

The DPPH radical scavenging activity was determined as described by Cheung et al. (2003) with some modifications. Eight hundred microliters of 0.2 mM DPPH ethanol solution and 0.2 mL of a Takju sample were thoroughly mixed using vortexer (KMC-1300V, Vision Scientific Co. Ltd., Korea). The mixture was allowed to react for 30 min at room temperature under dark condition and the optical density was read at 520 nm (Multiskan GO Microplate, Thermo Fisher Scientific).

Evaluation of sensory properties

Freshly prepared Takju was considered for evaluating the sensory properties. Different varieties of Takju were assessed for sweetness, sourness, bitterness, and overall acceptance using the scale values 1= very bad, 2= bad, 3= moderate, 4= good, 5= very good.

Twenty volunteer panelists (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 were assigned to evaluate the sensory properties (Kim et al., 2015). Mean values of 10 evaluations for each sensory property were reported as scores.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using SAS 9.4 (statistical analysis software). Differences between means at P<0.05 were identified using Tukey test. All the experiments were carried out in triplicates and the average values with standard deviations (SD) were reported.

RESULTS AND DISCUSSION

Chemical characteristics of Takju

The pH value of pepper Takju (4.04±0.07 to 4.51±0.03) was significantly (P<0.05) high as compared to the control (3.88±0.03). The higher pH values of different Takju might be due to, addition of green peppers as the average pH value of pepper (4.87) is slightly higher (Derossi et al., 2010) than that of the control Takju (3.88±0.03) (Table 2).

Addition of pepper did not significantly (P>0.05) change the alcohol concentration of pepper Takju as compared to untreated control. An unchanged alcohol concentration (6.0±0.02 to 6.0±0.07%) of pepper Takju when compared to control (6.0±0.03%), confirmed the maintenance of one of the major qualities of Takju, even after the addition of peppers as an additive. The titratable acidity (TA) values of pepper Takju samples were significantly (P<0.05) lower (0.19±0.02 to 0.24±0.01 g/100 mL of lactic acid) than that of control Takju (0.89±0.02 g/100 mL of lactic acid). The reduction in TA values of pepper Takju might be due to the addition of green pepper.

Green pepper has increased the pH value of Takju and the increase in pH was paralleled by a decrease in TA (Bruhn et al., 1992). Addition of green pepper to Takju significantly (P<0.05) increased the soluble solids (SS) values of pepper Takju (4.0±0.3 to 4.4±0.2 °Bx) as compared to control (3.6±0.2 °Bx) (Table 2). Increase in the SS content in pepper Takju might be due to addition of green peppers.

DPPH radical scavenging activities and total phenol contents of Takju

The DPPH radical scavenging activities and total phenolic contents of pepper Takju samples were significantly (P<0.05) high, as compared to control (Table 3). The DPPH radical scavenging activities of green pepper takju (79.33±2.00 to 90.51±1.31%) samples were significantly (P<0.05) higher than that of control (16.03±2.22%).

Takju sample PT-1000 and PT-2000 showed higher DPPH radical scavenging potential as compared to PT-500. Disparities in DPPH radical scavenging activities of various pepper Takju varieties might be caused by, addition of different amounts of green peppers. About 5

Table 3. DPPH radical scavenging activities and total phenol contents of takju prepared using different proportions of green peppers.

Sample[1)]	DPPH (% Inhibition)	Total phenol content (GAE[2)] μg/ml of sample)
Control	16.03±2.22[d3)]	89.21±3.00[d]
PT-500	79.33±2.00[c]	398.12±5.21[c]
PT-1000	90.51±1.31[a]	418.43±3.19[a]
PT-2000	89.32±1.91[a]	412.61±2.00[b]

[1)]Control, ordinary takju containing no green pepper; PT-500, pepper takju containing 0.5 kg of raw green pepper for 10 kg of steamed rice; PT-1000, pepper takju containing 1.0 kg of raw green pepper for 10 kg of steamed rice; PT-2000, pepper takju containing 2.0 kg of raw green pepper for 10 kg of steamed rice. [2)] Gallic acid equivalents. [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 4. Sensory characteristics of takju prepared using different proportions of green peppers.

Sample[1)]	Sensory characteristics			
	Sweetness	Sourness	Bitterness	Overall acceptance
Control	2.12±0.13[b]	1.89±0.03[a]	1.10±0.21[a]	3.00±0.12[c]
PT-500	2.50±0.25[a]	1.22±0.02[b]	1.11±0.30[a]	4.00±0.33[ab]
PT-1000	2.78±0.21[a]	1.11±0.31[b]	1.13±0.25[a]	4.45±0.21[a]
PT-2000	2.81±0.37[a]	1.17±0.35[b]	1.00±0.21[a]	3.50±0.30[b]

[1)]Control, ordinary takju containing no green pepper; PT-500, pepper takju containing 0.5 kg of raw green pepper for 10 kg of steamed rice; PT-1000, pepper takju containing 1.0 kg of raw green pepper for 10 kg of steamed rice; PT-2000, pepper takju containing 2.0 kg of raw green pepper for 10 kg of steamed rice. [2)] Quoted values are means±SD of triplicate experiments (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 column are significantly different (P<0.05).

times higher, DPPH radical scavenging activities of pepper takju varieties might have been as a result of higher antioxidant potential of green peppers (Kedage et al., 2007; Sun et al., 2007; Domínguez-Martínez et al., 2014; Jang et al., 2015).

The total phenolic contents of pepper takju (398.12±5.21 to 418.43±3.19 µg GAE/ml Takju) were also significantly (P<0.05) higher than that of control (89.21±3.00 µg GAE/ml Takju), with the highest value of PT-1000 variety followed by PT-2000 and PT-500. More than 4 times high value of total phenol contents were detected in the pepper Takju samples as compared to control. High total phenol contents of green pepper Takju were probably caused by, the addition of green peppers (Kedage et al., 2007; Sun et al., 2007; Domínguez-Martínez et al., 2014; Jang et al., 2015). Park and Lee (2002) stated that polyphenols, flavonoids, and flavonols in Takju account for antioxidant activities. It is difficult to precisely identify the antioxidant potential of Takju, using any single assay as a several mechanisms, which are involved in wine preparation (Hong et al., 2009).

Results of the DPPH radical scavenging potential and polyphenol contents showed improved antioxidant values of pepper Takju.

The improved antioxidant potential of pepper Takju might be due to the presence of ascorbic acid, phenolic compounds, and other antioxidants in pepper (Kedage et al., 2007; Sun et al., 2007; Domínguez-Martínez et al., 2014; Jang et al., 2015).

Sensory characteristics of Takju

Sweetness values of Takju increased with the addition of green peppers. However, no significant differences in sweetness value, was observed among peppers Takju samples (Table 4).

The sourness values (1.11±0.31 to 1.22±0.02 sourness) of pepper Takju varieties were significantly ($P<0.05$) reduced, due to the addition of green peppers as compared with the value of 1.89±0.03 for control Takju. However, addition of green peppers did not cause significant ($P>0.05$) changes in the bitterness values of pepper Takju varieties, as compared to control.

Evaluation of sensory characteristics showed that, the overall acceptance of pepper Takju was significantly ($P>0.05$) high as compared to control Takju sample (Table 4). The highest value for overall acceptance was found to be PT-1000 followed by PT-500 and PT-2000. Overall acceptability of a sample determines the general acceptance of the product. Although, consumers are strictly concerned of the nutrient content (Bae et al., 2010), safety (Wilcock et al., 2004) and even the trademark (Guerrero et al., 2000) or price (Caporale and Monteleone, 2001) of the product, their contributions will not overshadow the sensory properties of foods (Siró et al., 2008).

Conclusion

Addition of green peppers improved the antioxidant activities and the overall acceptance of pepper Takju. Addition of green peppers did not bring any unfavorable effect on the basic chemical and organoleptic properties but enhanced the Takju quality. The optimum proportions of green peppers when added to the second phase of Takju fermentation, was about 9% of the total rice for fermentation. The results of the present study revealed that, an addition of optimum amount of green peppers could enhance the antioxidant potentials as well as overall acceptance of Takju.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interest.

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