International Journal of Sciences

Research Article Volume 7 – July 2018 (07)

Eastern Prickly Pear (*Opuntia humifusa* Raf.) Power Enhanced the Quality of Korean Traditional Wine, *Takju*

Young-Joon Choi[1], Sanjeev Kumar Dhungana[2], Il-Doo Kim[3]

[1]Food Beverage and Culinary Arts, Daegu Technical University, Daegu 42734, Korea
[2]School of Applied Biosciences, Kyungpook National University, Daegu 41566, Korea
[3]International Institute of Research & Development, Kyungpook National University, Daegu 41566, Korea

Abstract: *Takju*, also known as *makgeolli*, is a famous traditional alcoholic beverage in Korea. Various studies on the effect of raw materials on the quality of *takju* have been carried out. This study aimed to investigate the influence of *Opuntia humifusa* powder on the quality of *takju*. Chemical characteristics, color value, antioxidant potential as well as sensory characteristics were considered for the quality evaluation. Addition of the powder improved the functional as well as organoleptic properties of *takju*. The optimum proportion of *O. humifusa* powder to be added for having better impact was 0.5% (w/v). Results of this study suggested that *O. humifusa* could enhance the antioxidant potential as well as overall acceptance of Korean traditional rice wine, *takju*.

Keywords: antioxidant potential, Korean traditional wine, *Opuntia humifusa*, overall acceptance

Introduction

Takju, also known as *Makgeolli*, is a traditional alcoholic beverage with an alcohol concentration of 6–8%, a characteristic fragrance with a slightly acidic character, and a sweet taste. It is a turbid wine prepared from cereals, mostly glutinous rice, and Nuruk, a fermentation starter, containing yeast and several types of fungi. It is a famous Korean traditional rice wine. Majority of native Koreans as well as foreign visitors to Korea enjoy drinking *Takju*. It is rich in protein and carbohydrates and also possesses a small amount of organic compounds. Beneficial health effect of this wine has received attention among consumers and researchers. However, due to a lack of unique characteristics and inferior acceptability, *Takju* has received an attention by food scientists to improve the quality so that its popularity could be increased. Various kinds of cocktail *Takju* have been developed and studies on the microbial activities, functional characteristics, utilization of raw materials, manufacture processes, extension of shelf life, and more have been carried out (Lee et al., 2002a; Han et al., 1997; Song and Park, 2003; Kim et al., 2004; Cho et al., 2010).

In order to improve the overall quality of *takju*, various raw materials and additives, including dandelion (Kim et al., 2000), chamomile (Lee et al., 2002b), acasia (Seo et al., 2002), and *Paecilomyces japonica* (Lee et al., 2002c) blueberry (Kim et al., 2015), banana (Kim et al., 2013a), mulberry (Kim et al., 2013b), *Laminaria japonica* (Choi et al., 2014), have been added. The quality of traditional wine and liquor has gradually improved, resulting in increased sales in recent years; however, problems still exist.

Different active substances such as polyphenols, polysaccharides, and polysaccharide-peptide complexes have been isolated from *takju* (Lee et al., 1996; Park and Lee, 2002). These active substances found in *takju* show various chemical characteristics and biological effects, including antioxidant and immunomodulating activities. Bae et al. (2010) mentioned that some *takju* samples possessed significantly high total polyphenol contents compared to white wine.

Opuntia humifusa (Raf.), commonly known as eastern prickly pear (EPP) is a kind of cactus, contains good radical scavenging and anti-inflammatory activity (Han et al., 2007). EPP also lowered the blood glucose and cholesterol levels in streptozotocin-induced diabetic rats (Hahm et al., 2011). In addition, EPP showed anti-cancer effect by inhibiting the growth of MCF-7 Human Breast Cancer Cells (Yoon et al., 2009) and U87MG Human Glioblastoma Cells (Hahm et al., 2010). EPP has also been used in cookies (Han et al., 2007). Considering

Published at: http://www.ijsciences.com/pub/issue/2018-07/
DOI: 10.18483/ijSci.1750; Online ISSN: 2305-3925; Print ISSN: 2410-4477

Il-Doo Kim (Correspondence)
ildookim @ hanmail.net
+82-53-950-5707, Fax: +82-53-958-6880

the functional and medicinal values of EPP and effect of raw material on wine quality the objective of this study was to investigate the quality characteristics of traditional Korean rice wine, *takju*, prepared with EPP.

Materials and Methods

Chemicals and materials

Folin-Ciocalteu phenol reagent and DPPH were purchased from Sigma-Aldrich (St. Louis, MO, USA). All other chemicals and reagents used were of analytical grade. EPP [*Opuntia humifusa* (Raf.)] powder was obtained from a local market in Daegu, Korea.

Preaparation of takju samples

Typically, Korean traditional rice wine, *takju* is made of steamed rice with yeast and water fermented for about 6 d. *Takju* is prepared by 2-step fermentation of steamed rice without distillation. A mixture of rice *koji*, a commercially available steamed rice (2 kg), yeast (2.5 g) and water (3 L) fermented at 25°C for 1 d. In the second step, mixture of steamed rice (8 kg), *nuruk* (200 g), water (12 L), and different proportions of EPP powder was fermented at 25°C for 5 d. Addition of various proportions of additives (blueberry powder and black rice powder) does influence the physicochemical properties of *takju* differently. Different varieties of *takju* prepared with various proportion of EPP were named as Control: Ordinary *takju* containing no added EPP, OH-A: *takju* containing 0.75 g of EPP in 750 mL of raw *takju*, OH-B: *takju* containing 3.75 g of EPP in 750 mL of raw *takju*, and OH-C: *takju* containing 7.5 g of EPP in 750 mL of raw *takju*. A range of additive concentrations was used for formulation of optimum proportions of Eastern prickly pear powders so that a superior quality *takju* could be prepared. After preparation, *takju* varieties were pasteurized at 85°C for 5 min using a sterilizer (CK-25; Hanil Co.) and were stored at 4°C for subsequent analyses.

Physicochemical parameters

The pH value of *takju* was measured using a pH Meter (Model 250; Beckman Coulter, Inc., Fullerton, CA, USA). Titratable acidity (lactic acid in g/L) was measured using addition of 5 mL of *takju* to 125 mL of deionized water, followed by titration using 0.1N sodium hydroxide to an endpoint pH of 8.2. Alcohol concentration was determined following the method of Ough and Amerine (1988). The brix (^{o}Bx) value was measured following the Official Methods of the National Tax Service (2006). All the chemical measurements were replicated 3 times and mean values were reported.

Color measurement

L* (lightness), a* (redness, + or greenness, −), and b* (yellowness, + or blueness, −) values of *takju* samples 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 (Kim et al., 2013). Color values were measured directly from 3 zones of *takju* and mean values were calculated.

Determination of the total phenol content

The total phenol contents of *takju* samples were estimated according to the Folin-Ciocalteau method (Singleton et al., 1999). The undiluted Folin-Ciocalteau reagent (250-µL) was added to *takju* sample (50 µL). After 1 min, 750 µL of 20% (w/v) aqueous Na_2CO_3 was added to the mixture, and the volume was made up to 5.0 mL using distilled water. A control sample contained all the reaction reagents except the *takju* sample. After incubation at room temperature under dark condition for 2 h, the absorbance value was measured at 760 nm using microplate spectrophotometer (Multiskan GO, Thermo Fisher Scientic, Vantaa, Finland). Gallic acid was used to prepare a calibration curve and the total phenol contents were determined as gallic acid equivalents (µg/mL of *takju*).

DPPH radical scavenging activity

The DPPH free radical scavenging potential was determined following the methods described by Cheung et al. (2003) with some modifications. A 0.8-mL of 0.2 mM DPPH ethanol solution was mixed with 0.2 mL of a *takju* sample. The mixture was thoroughly mixed and left to stand for 30 min at room temperature under dark condition. The absorbance value was measured at 520 nm using microplate spectrophotometer (Multiskan GO, Thermo Fisher Scientic).

Evaluation of sensory properties

The sensory properties of *takju* samples was evaluated with the freshly prepared samples. The samples were rated for color, flavor, and overall acceptance using a scale: 1= very poor, 2= poor, 3= fair, 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 employed for the sensory evaluation.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using SAS9.4 (SAS Institute Inc., Cary, NC, USA). Differences between means were separated using Tukey test at $p<0.05$.

Results and Discussion

General chemical characteristics of takju

The chemical composition of *takju* samples in terms of pH, alcohol, titrable acidity (TA), and soluble solid (SS) are shown in Table 1. The pH of ordinary *takju* (3.90) was significantly low compared to OH-A (4.00) and OH-C (4.02) but not different from OH-B (3.89). Although the pH of *takju* samples was significantly different, the values differed by only a small fraction. However, the alcohol and SS contents of *takju* samples were not significantly altered by the addition of EPP powder. The unaltered alcohol concentration of EPP-added *takju* (6%) showed restoration of one of the fundamental attributes of Korean traditional rice wine. The TA of all the EPP-added *takju* samples were significantly higher (0.21−0.24) than the ordinary *takju* (0.18 g/100 mL of lactic acid). The variation in pH and TA of different *takju* might be due to the addition of EPP powder.

Table 1. pH, alcohol, titratable acidity (TA), and soluble solid (SS) content of *takju* samples

Properties	Sample[1)]			
	Control	OH-A	OH-B	OH-C
pH	3.90±0.05[b]	4.00±0.04[a]	3.89±0.17[b]	4.02±0.01[a]
Alcohol (%)	6.01±0.08[a]	6.00±0.07[a]	6.00±0.05[a]	6.00±0.03[a]
TA[2)] (g/100mL)	0.18±0.02[b]	0.24±0.03[a]	0.22±0.02[a]	0.21±0.03[a]
SS (°Bx)	3.40±0.20[a]	3.70±0.20[a]	3.50±0.10[a]	3.50±0.10[a]

[1)]Samples are defined in preparation of *takju* samples (Materials and Methods).
[2)]As lactic acid.
[3)]Quoted values are means±SD of triplicate measurements. Values followed by different superscripts in the same column are signigicantly different ($p<0.05$).

Color value of takju

The Hunter's color value of *takju* samples was significantly altered with the addition of EPP (Table 2). The lightness value of EPP-added *takju* (9.51−16.51) was significantly lower than the ordinary *takju* (45.91). The redness value of *takju* was significantly increased (27.20−35.12) by the addition of EPP compared to the ordinary *takju* (2.61). The yellowness value of ordinary *takju* (19.81) and EPP-added *takju* (13.91−28.12) was significantly different except for OH-B (19.88). The variations in lightness, redness, and yellowness values among blueberry *takjus* might be due to addition of different proportions of EPP powder.

Table 2. Hunter's color value of *takju* samples

Sample[1)]	Color value[2)]		
	L*	a*	b*
Control	45.91±0.05[a]	2.61±0.02[d]	19.81±0.02[b]
OH-A	16.51±0.04[b]	35.12±0.07[a]	28.12±0.03[a]
OH-B	11.21±0.08[c]	31.21±0.03[b]	19.88±0.03[b]
OH-C	9.51±0.05[d]	27.20±0.03[c]	13.91±0.02[c]

[1)]Samples are defined in preparation of *takju* samples (Materials and Methods).
[2)]L*, lightness (100, white; 0, black); a*, redness (–, green; +, red); b*, yellowness (–, blue; +, yellow).
[3)]Quoted values are means±SD of triplicate measurements. The values followed by different superscripts in the same column are significantly different ($p<0.05$).

DPPH radical scavenging activities and total phenol contents of takju

The addition of EPP powder significantly increased the DPPH radical scavenging activities and total phenolic contents of *takju* compared to the ordinary *takju* (Table 3). The DPPH radical scavenging activities of EPP-added *takju* (50.31−61.30%) were significantly higher than that of ordinary *takju* (16.31%). More than three times higher DPPH radical scavenging activities in EPP-added *takju* might be due to higher antioxidant potential of EPP (Han et al., 2007). Similarly, total phenol content of EPP-added *takju* (292.30−445.98 μg/mL) was significantly high compared to that of ordinary *takju* (77.71 μg/mL). Almost six times higher total phenol content was detected in OH-C than that in ordinary *takju*. Such higher values of total phenols might be due to addition of EPP powder which is rich in phenolic compounds (Yoon et al., 2009). Park and Lee (2002) report that the polyphenols, flavonoids, and flavonols in *takju* account for its antioxidant activities. Report shows that there are multiple mechanisms involved in wine preparation, therefore, no single assay could reveal all the antioxidants precisely within a mixed or complex system (Muntana and Prasong, 2010).

Table 3. DPPH radical scavenging activities and total phenol content (TPC) of *takju* samples

Sample[1)]	DPPH (% Inhibition)	TPC (GAE[2)] μg/mL of sample)
Control	16.31±2.22[c]	77.71±2.20[d]
OH-A	50.31±1.81[b]	292.30±3.00[c]
OH-B	60.20±1.90[a]	415.31±3.75[b]
OH-C	61.30±2.02[a]	445.98±5.21[a]

[1)]Samples are defined in preparation of *takju* samples (Materials and Methods).
[2)]Gallic acid equivalents.
[3)]Quoted values are means±SD of triplicate measurements. The values followed by different superscripts in the same column are significantly different ($p<0.05$).

Sensory characteristics of takju

Sensory characteristics of *takju* samples, except bitterness value, were significantly affected by the addition of EPP powder (Table 4). Based on the overall acceptance, OH-B (4.32) was the most acceptable *takju*. The sweetness value of EPP-added *takju* was increased with the increased amount of EPP powder. However, the addition of EPP powder reduced the sourness value.

Table 4. Sensory characteristics of *takju* samples

Sample[1)]	Sensory characteristics			
	Sweetness	Sourness	Bitterness	Overall acceptance
Control	2.11±0.11[c]	1.81±0.02[a]	1.12±0.20[a]	2.31±0.21[c]
OH-A	3.00±0.25[b]	1.21±0.03[b]	1.05±0.31[a]	3.40±0.37[b]
OH-B	3.51±0.15[a]	1.14±0.30[b]	1.10±0.25[a]	4.32±0.05[a]
OH-C	3.61±0.21[a]	1.11±0.21[b]	1.00±0.21[a]	3.41±0.21[b]

[1)]Samples are defined in preparation of *takju* samples (Materials and Methods).
[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 ($p<0.05$).

In conclusion, addition of *Opuntia humifusa* (Raf.) powder enhanced the functional value as well as overall acceptance of Korean traditional rice wine, *takju*. Addition of the powder did not cause any adverse effect on the basic chemical and organoleptic properties, instead contributed to have positive impacts in *takju*. Based on the overall acceptance and antioxidant potentials, the optimum proportions of *O. humifusa* (Raf.) powder to be added during *takju* fermentation was 0.5% (w/v). Results of this study showed that addition of optimum amount of *O. humifusa* (Raf.) could enhance the antioxidant potentiality as well as overall acceptance of Korean traditional rice wine, *takju*.

References

1. Bae SH, Jung EY, Kim SY, Shin KS, Suh HJ. 2003. Antioxidant and immuno-modulating activities of Korean traditional rice wine, *takju*. J. Food Biochem. 34: 233–248.
2. Cheung LM, Cheung PCK, Ooi VEC. 2003. Antioxidant activity and total polyphenolics of edible mushroom extracts. Food Chem. 81: 249–255.
3. Cho EK, Kim HY, Byeon HJ, Kim SW, Choi YJ. 2010. Nitrite scavenging and alcohol metabolizing activities of hot water extract from *Makgeoly* and its angiotensin converting enzyme inhibitory effect. J. Life Sci. 20: 768–774.
4. Choi JS, Seo HJ, Lee YR, Kwon SJ, Moon SH, Park SM, Sohn JH. 2014. Characteristics and in vitro anti-diabetic properties of the Korean rice wine, *makgeolli* fermented with *Laminaria japonica*. Prev. Nutr. Food Sci. 19: 98–107.
5. Hahm SW, Park J, Son YS. 2010. *Opuntia humifusa* partitioned extracts inhibit the growth of U87MG human glioblastoma cells. Plant Foods Hum. Nutr. 65: 247–252.
6. Hahm SW, Park J, Son YS. 2011. *Opuntia humifusa* stems lower blood glucose and cholesterol levels in streptozotocin-induced diabetic rats. Nutr. Res. 31: 479–487.
7. Han EH, Lee TS, Noh BS, Lee DS. 1997. Quality characteristics of mash of *Takju* prepared by using different *Nuruk* during fermentation. Korean J. Food Sci. Technol. 29: 555–562.
8. Han IH, Lee K, Byoun KE. 2007. The antioxidant activity of Korean cactus (*Opuntia humifusa*) and the quality characteristics of cookies with cactus powder added. Korean J. Food Cook. Sci. 23: 443–451.
9. Kim E, Chang YH, Ko JY, Jeong Y. 2013a. Physicochemical and microbial properties of the Korean traditional rice wine, *Makgeolli*, supplemented with Banana during fermentation. Prev. Nutr. Food Sci. 18: 203-209.
10. Kim E, Chang YH, Ko JY, Jeong Y. 2013b. Physicochemical and microbial properties of Korean traditional rice wine, *Makgeolli*, supplemented with mulberry during fermentation. J. Korean Soc. Food Sci. Nutr. 42: 1682–1689.
11. Kim ID, Lee JW, Kim SJ, Cho JW, Dhungana SK, Lim YS, Shin DH. 2013. Exogenous application of natural extracts of persimmon (*Diospyros kaki* Thunb.) can help in maintaining

nutritional and mineral composition of dried persimmon. Afr. J. Biotechnol. 13:2231–2239.

12. Kim JH, Lee DH, Chio SY, Lee JS. 2002. Characterization of physiological functionalities in Korean traditional liquors. Korean J. Food Sci. Technol. 34: 118–122.
13. Kim JH, Lee DH, Lee SH, Choi SY, Lee JS. 2004. Effect of *Ganoderma lucidum* on the quality and functionality of Korean traditional rice wine, *yakju*. J. Biosci. Bioeng. 97: 24–28.
14. Kim JH, Lee SH, Kim NM, Choi SY, Yoo JY, Lee JS. 2000. Manufacture and physiological functionality of Korean traditional liquors by using dandelion (*Taraxacum platycarpum*). Korean J. Biotechnol. Bioeng. 28: 367–371.
15. Kim MO, Kim ID, Dhungana SK, Lee JW, Shin DH. 2015. Influence of blueberry and black rice powders on quality characteristics of the Korean traditional rice wine, *Takju*. Food Sci. Biotechnol. 24: 439–444.
16. Lee DH, Kim JH, Kim NM, Lee JS. 2002b. Manufacture and physiological functionality of Korean traditional liquors by using chamomile (*Matricaria chamomile*). Korean J. Food Sci. Technol. 34: 109–113.
17. Lee DH, Kim JH, Kim NM, Pack JS, Lee JS. 2002c. Manufacture and physiological functionality of Korean traditional liquor by using *Paecilomyces japonica*. Korean J. Mycol. 30: 141–146.
18. Lee JS, Lee TS, Noh BS, Park SO. 1996. Quality characteristics of mash of *takju* prepared by different raw materials. Korean J. Food Sci. Technol. 28: 330–336.
19. Lee SS, Kim KS, Eom AH, Sung CK, Hong IP. 2002a. Production of Korean traditional rice-wines made from cultures of the single fungal isolates under laboratory conditions. Korean J. Mycol. 30: 61–65.
20. Muntana N, Prasong S. 2010. Study on total phenolic contents and their antioxidant activities of Thai white, red and black rice bran extracts. Pakistan J. Biol. Sci. 13: 170–174.
21. Official Methods of the National Tax Service. 2006. National Rural Resources Development Institute. Food composition table. Rural Development Administration, Seoul, Korea. pp. 353–370.
22. Ough CS, Amerine MA. 1988. Methods for Analysis of Musts and Wines. 2nd ed. John Wiley and Sons, New York, NY, USA. pp. 80–107.
23. Park CS, Lee TS. 2002. Quality characteristics of *takju* prepared by wheat flour nuruks. Korean J. Food Sci. Technol. 34: 296–302.
24. Seo SB, Kim JH, Kim NM, Choi SY, Lee JS. 2002. Effect of Acasia flower on the physiological functionality of Korean traditional rice wine. Korean J. Microbiol. Biotechnol. 30: 410–414.
25. Singleton V, Orthofer R, Lamuela-Raventos R. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. Vol. 299, pp 152–178. In: Oxidants and Antioxidants. Packer L (ed). Academic Press, New York, NY, USA.
26. Song JC, Park HJ. 2003. *Takju* brewing using the uncooked germed brown rice at second stage mash. J. Korean Soc. Food Sci. Nutr. 32: 847–854.
27. Yoon JA, Hahm SW, Park JE, Son YS. 2009. Total polyphenol and flavonoid of fruit extract of *Opuntia humifusa* and its inhibitory effect on the growth of MCF-7 human breast cancer cells. J. Korean Soc. Food Sci. Nutr. 38: 1679–1684.