Agric. Chem. Biotechnol. **49**(4), 125-130 (2006)

Article

Properties of Oriental Melon Wine Developed by Utilizing Rice Wine Fermentation Method

Tae-Young Kim, Sang-Bum Kim, Jin-Sook Kim and Sang-Ho Lee*

Rural Resource Development Institute, National Institute of Agricultural Science and Technology, RDA, Suwon 441-853, Korea

Received June 7, 2006; Accepted September 19, 2006

In order to utilize non-commercial melon as alcoholic beverage material, in this study the optimum fermentation method and manufacture conditions were investigated and thereafter the properties of final product were determined. As for melon wine made with only melon juice, sensorial properties, particularly flavor, were not acceptable as alcoholic beverage. To improve the lack of melon wine, we made mash with cooked rice and *Nuruk*, and then added melon juice during fermentation. Acceptable sensorial properties were obtained in melon wine when 30% extract juice of oriental melon was added after 4 day of fermentation. The alcoholic beverage added melon juice showed much higher yellowness value than that without melon juice indicating that a clear yellow color similar to melon was actually observed in final product. Adding melon juice led little changes in amount and composition of free sugars, organic acids and amino acids and could improve sensorial properties.

Key words: *oriental melon, alcoholic fermentation, rice wine, fermentation condition, quality improvement*

Oriental melon (*Cucumis melon* L.) is considered to be the representative largely consumed fruit during the summer season in Korea. Total production amount has increased in recent years and thus oriental melon has become an important part of agricultural income. However several problems have been causing income reduction for melon producer. First, unsuitable changes in growing conditions lead to the production of abnormally fermented and over-maturated melon.[1,2] Second, oriental melon is largely consumed as fresh fruit because storable period is considerably shorter than other fruits, so that the overproduction of oriental melon in a high-demand season leads to a price decrease. Therefore, problems such as non-commercial melon and overproduction could cause large economical damage to melon producer. In addition, since non-consumed oriental melon could lead to environmental pollution, additional cost must be spent to dispose of waste material.

In such situations, the effective food processing technique using non-commercial oriental melon could be one of the methods that could solve the above described problems in melon production. Because of such demand, many studies have suggested the application of food-processing technique to oriental melon. Shin *et al.*[3] tried to produce natural juice and determine the changes in properties. Lee *et al.*[4] recently reported changes of organoleptic properties of oriental melon juice prepared with various heating temperature and time. Moreover, melon could be applied to produce fermented foods. Cha *et al.*[5] applied lactic acid fermentation on oriental melon juice. In addition, since oriental melon contains 13~14 °Brix of sugar, it is considered to be suitable for manufacturing alcoholic beverage. However, according to the results of Hernandez-Gomez *et al.*[6,7], the final alcohol degree after fermentation of melon juice was only 4.2%, which is not adequate to produce melon wine. Although Lee *et al.*[8] tried alcoholic fermentation using melon, it was only used to prepare melon vinegar because of low alcohol production. In making melon-wine, the application of fermentation method of Korean traditional rice wine could be a solution to the problem of alcohol production yield. Rice wines are made from various cereals like rice, wheat, barley, and corn and the final alcohol content is generally 12~16%, an important fact in melon-wine manufacturing for alcohol production. Moreover, in making rice wine, other materials are sometimes added in mash to enhance flavor, taste, and functional properties.[9-11] Application of such fermentation method type as used in Korean traditional rice wines seems to enable the production of high quality melon-wine. In this study we, therefore, investigated the fermentation conditions using non-commercial melon to produce alcoholic beverage.

Materials and Methods

Materials. Oriental melon harvested between June and August of 2000 was collected from Yeoju-Gun region in Korea. Rice and *Nuruk* used for melon-wine mash were purchased from a local store and Hankook Enzyme Co. (Hwaseung, Korea), respectively.

Alcoholic fermentation process. Alcoholic fermentation using oriental melon was carried out by 2 methods. First, melon wine was produced from pressed and filtered melon

*Corresponding author
Phone: 82-31-299-0582; Fax: 82-31-299-0553
E-mail: salutsh@hanmail.net

juice. After controlling the sugar content of melon juice to 24-28% by addition of sucrose, 5% seed starter of yeast (*Saccharomyces cerevisae*) was inoculated and then the melon juice was fermented at 18 ± 1°C for 10 days. In second method, we applied the fermentation method of traditional rice wine to manufacture of melon wine. Non-glutinous rice (1 kg) was steeped for 4 hours and then cooked with steam. After cooling to 40°C, *Nuruk* (30 g), 0.3% dry yeast (0.25 g) and water (1.5 *l*) were added and then the mixture was fermented at 25°C for 2 days. For 2nd mash, three times quantity of non-glutinous rice, *Nuruk* and water was used, and after 2 days of fermentation 10-50% melon juice was added on mash. To monitor the fermentation, conventional parameters, such as pH, acidity, Brix, reducing sugar, alcohol, and specific gravity, were measured every 24 hours according to Official Methods of National Tax Service (Korea, 2000).

Free sugar and organic acid determination. After filtration (TOYO No. 5) of mash, an aliquot was treated with Sep-Pak (Waters Co., USA) and then the quantity of free sugar and organic acid was determined using HPLC (Waters Co., USA). HPLC operation conditions for free sugar were shown as follows: Column-LC-NH_2 (Supelco Co.), Detector-RI(8×), Mobile phase-acetonitrile : water = 75 : 25, Flow rate -1.5 m*l* min^{-1}, Injection volume-10 μ*l*. For organic acid, they were shown as follows; Column-Ion pak KC-811, Mobile phase-0.1% H_3PO_4, Column temperature-40°C, Detector-RI ×64, Injection volume –20 μ*l*.

Free amino acid determination. Ten percent TCA (60 m*l*) were added to fermented mash (10 m*l*) and the mixture was stirred for 1 min. An aliquot of supernatant was dried with rotary evaporator and after addition of 10 m*l* 0.02 N HCl, the content of amino acid was measured using amino acid analyzer (Hitachi Model 835, Japan).

Volatile flavor determination. For determination of the volatile compounds, an aliquot (1 μ*l*) of distilled melon wine was injected directly into Hewlett Packard 5890 Series II Gas Chromatograph. The compounds were separated in a Stabilwax (30 m × 0.32 mm) capillary column. The temperature of injector was 200°C and the oven was programmed 4 min holding at 50°C, 10°C/min up to 210°C and 4 min holding at 210°C. The carrier gas was nitrogen at a flow rate 2 m*l* min^{-1}. Detector condition is as follows; Temperature: 200°C, H_2: 30 m*l* min^{-1}, Air: 400 m*l* min^{-1}.

Sensory analyses. Sensory analyses were performed on freshly made melon wine. Samples made with different conditions were rated for taste, flavor, color and total acceptability, respectively, on the following scale: + = undesirable, ++ = acceptable and +++ = desirable. The results showed average value of each evaluation. All tests were conducted by 9 tasters chosen in our laboratory.

Results and Discussion

Melon juice characteristics. When 20 kg oriental melon was crushed and pressed, approximately 14.9 *l* melon juice was approximately obtained, indicating 74.5% of yield. The melon juice contained 10.8% of sugar and 0.07% of total acid, indicating that these values were less than other fruits used for alcoholic fermentation and therefore needing the addition of sugar and acid before fermentation. The content of reducing sugar was 7.8% and a small quantity of minerals, needed for yeast growth, was also determined.

Properties of alcohol fermentation. The addition of sugar in melon juice is essential, because only 5% of alcohol was produced from melon juice having about 11% of sugar content. In order to observe the effect of sugar content on alcohol fermentation of melon juice, the sugar content was controlled to 24, 26, and 28% and the results on changes of

Table 1. Effect of initial sugar content on alcoholic fermentation of melon juice

Sugar content	Fermentation period (day)	Temp (°C)	pH	Acidity (0.1 N-NaOH m*l* 10ml^{-1})	°Brix	Alcohol (%)	Specific gravity
24%	0	18.2	4.06	7.8	24.2	-	1.098
	2	19.3	4.04	7.9	20.1	-	1.087
	4	23.7	3.95	8.2	7.8	7.4	1.041
	6	27.2	3.90	8.4	1.2	10.5	1.005
	8	24.2	3.91	8.4	-	11.0	0.998
	10	18.3	3.90	8.5	-	11.2	0.994
26%	0	18.2	4.07	7.8	26.1	-	1.107
	2	19.1	4.02	7.9	22.4	-	1.091
	4	23.5	3.91	8.3	8.9	7.5	1.043
	6	27.6	3.87	8.5	0.9	10.6	1.002
	8	24.3	3.90	8.5	-	11.4	0.998
	10	18.4	3.89	8.6	-	11.6	0.996
28%	0	18.0	4.07	7.8	28.1	-	1.112
	2	19.2	4.05	7.8	23.8	-	1.093
	4	23.3	3.95	8.1	9.6	7.1	1.047
	6	27.5	3.92	8.3	1.4	10.1	1.003
	8	24.8	3.93	8.8	-	11.5	1.000
	10	18.6	3.92	8.4	-	12.4	0.998

Table 2. Color and sensory properties of melon wine made from juice

Initial sugar content	Final alcohol (%)	Color[a]			Sensory properties
		L	a	b	
24%	11.2	89.43	-1.58	9.93	○ Unpleasant smell of herbage in all samples ○ Original color of melon ○ Not suitable flavor and taste to fruit alcoholic beverage
26%	11.6	89.73	-1.71	10.31	
28%	12.4	86.78	-1.50	10.25	

[a]L: Lightness ~100 (0: Black, 100: White), a : Redness -60~+60 (-: Green, +: Red), b: Yellowness -60~+60 (-: Blue, +: Yellow).

Table 3. Effects of addition[a] of melon juice on the alcohol fermentation using rice mash

Addition of melon juice	pH	Alcohol (%)	Acidity (0.1 N-NaOH m*l* 10ml^{-1})	Amino acidity (0.1 N-NaOH m*l* 10ml^{-1})	Reducing sugar (mg ml^{-1})
Control	4.56	15.4	2.8	1.0	2.4
10%	4.58	14.1	2.7	0.9	6.2
20%	4.64	12.7	2.6	1.0	6.7
30%	4.74	11.9	2.4	1.1	7.6
40%	4.78	10.9	2.3	1.2	8.4
50%	4.76	10.2	2.1	1.1	8.8

[a]Melon juice was added after 4 day of fermentation.

mash properties are indicated in Table 1. Although room temperature was maintained at 18°C during fermentation, the temperature of fermented mash was remarkably increased to 27°C but after maximum value at 6 day it was closer to room temperature. After 8 day, it is found that most sugar was consumed, so that specific gravity of fermented mash was decreased and alcohol production reached almost maximum. These changes were due to the conversion of sugar into alcohol. The behavior of the acidity was generally inverse with pH changes. Similar changes during fermentation were found in previous studies on the production of grape wine,[12] rice wine,[13,14] and wine with dried persimmon.[15] The effect of initial sugar content on the changes in temperature, pH and acidity was not observed, but final alcohol content was co-dependent. Melon juices containing 24, 26 and 28% of sugar contents gave the alcohol productions of 11.2%, 11.6% and 12.4%, respectively. The addition of sugar before fermentation is generally used to obtain sufficient alcohol content in final products.[12,15] According to studies of Lee *et al.*[8] and Hwang *et al.*[16], it was found that the increase of initial sugar concentration led to the production of more alcohol but the final alcohol content, on the contrary, was decreased in the mash having high concentration above 24°Brix.

The sensory properties of melon wines made from melon juice added sugar were measured and the results are shown in Table 2. It is found that the addition of sugar led to alcohol production of melon wines acceptable for *Yakju*-type alcoholic beverage and they had proper color similar to that of original fruit. The results of lightness (L) and yellowness (b) presented that melon wines have bright yellow color. However, they showed sensory properties insufficient for acceptance, because of unpleasant smell of herbage. The results of Hwang *et al.*[16] showed that the final watermelon wine product had different color and flavor from original raw material after alcoholic fermentation with only watermelon juice and, thus they determined the additives type and sufficient concentration in order to improve sensory quality. Therefore, in subsequent works, the fermentation method using melon juice has to be modified to improve the quality of melon-wine.

Table 4. Sensory properties of melon wine prepared with different additions[a] of melon juice on rice mash fermentation

Addition of melon juice	Panel[b]			Total acceptability
	Taste	Aroma	Color	
Control	+++	+	++	++
10%	+	++	+	+
20%	++	++	+++	++
30%	+++**	++*	+++**	+++**
40%	+++**	+++**	+++**	+++**
50%	++	+++	+++	++

[a]Melon juice was added after 4 day of fermentation.
[b]+++: desirable, ++: acceptable, +: undesirable.
*significative at level of 0.05, **significative at level of 0.01.

Table 5. Effect of addition time of melon juice[a] on sensory properties of melon wine

Addition time (day)	Panel[b]			Total acceptability
	Taste	Aroma	Color	
3	++	+	+++	+
4	++*	++*	+++	++*
5	+++**	+++**	+++	+++**
6	+++**	+++**	+++	+++**

[a]30% melon juice was added in mash.
[b]+++: desirable, ++: acceptable, +: undesirable.
*significative at level of 0.05, **significative at level of 0.01.

Table 6. Concentration of free sugar (mg%), organic acid (mg%), amino acid (mg%) and volatile compounds (ppm) in melon wine

Classification	Control	Melon wine[a]
Free sugar		
Glucose	642	854
Fructose	65	21
Sucrose	198	202
Maltose	1101	240
Total	2005	1317
Organic acid		
Citric acid	161	138
Tartaric acid	48	37
Succinic acid	424	369
Lactic acid	869	705
Malic acid	88	65
Acetic acid	48	56
Total	1638	1370
Amino acid		
Cystein	3.92	2.97
Methionine	7.01	5.31
Aspartic acid	13.15	10.14
Threonine	17.79	12.83
Sernine	13.82	9.81
Glutamic acid	46.27	36.52
Glycine	14.84	11.57
Alanine	34.83	28.56
Valine	12.63	10.26
Iso-leucine	5.70	4.73
Leucine	19.66	15.53
Tyrosine	20.94	17.14
Phenylalanine	27.84	21.72
Lysine	24.90	20.16
Histidine	11.49	8.20
Arginine	45.37	33.57
Proline	29.47	24.92
Total	349.64	264.67
Volatile compounds		
n-Propanol	68	54
Iso-butanol	142	168
Iso-amyl alcohol	184	216
Ethyl acetate	75	51
Iso-butyl acetate	46	40
Iso-amyl acetate	82	62

[a]Melon wine was produced by 30% melon juice addition on rice mash after 4 day of fermentation.

Effect of melon juice addition on alcohol fermentation. To overcome the lack of melon wine made from only melon juice, we modified the production process as follows: rice mash was used for alcoholic fermentation and melon juice was added for obtaining the taste and flavor of oriental melon. The effects of the amount of melon juice added on the alcohol fermentation (Table 3) and sensory properties (Table 4) were investigated. As the amount of added melon juice was increased, alcohol production was significantly decreased whereas remaining sugar content was increased. These results were due to the fact that the extraction of various unknown substances from melon could inhibit alcohol fermentation. In contrary of these results, it was reported in many studies that slightly higher or similar ethanol was produced in alcoholic beverage when another material was added in mash and the ethanol content after fermentation was different with the type of additives.[9,11,17,18] This difference may be presumed by the fact that a number of substances extracted from additives during fermentation had a diverse influence on enzyme and yeast activity.

From the results of sensory evaluation, it is found that total acceptability was improved by increase in melon juice added but was somewhat decreased when melon wine was added 50% juice. Moreover, addition time of melon juice had an influence on sensory properties of final product (Table 5). Melon wine added after 3 day of fermentation showed very low acceptability, particularly on aroma, but if added after 5-6 day, it presented extremely good sensory properties. Therefore, when alcohol production and sensory properties of melon wine were simultaneously considered, the optimum addition concentration and time of melon juice for melon wine production were 30% and 4-5 day after fermentation, respectively.

Properties of melon wine. The concentrations of free sugar, organic acid, amino acid and volatile compounds, concerned with taste and flavor of alcoholic beverage and the color properties were measured (Table 6 and 7). As regards to free sugar, there was a significant difference among the amount of each free sugar found in rice wine and melon wine. Contrary to the expectation that free sugar content of melon wine may be increased by addition of melon juice, melon wine had lower quantity of total free sugar than control (rice wine). This result can also explained by the previous supposition that unknown ingredient included in oriental melon could inhibit alcoholic fermentation. This phenomenon may therefore be the result of non-sufficient conversion of starch to sugar, even though melon juice could supply additional free sugar. In addition, there was the difference in the composition ratio of free sugar between two samples; particularly the main sugar was changed from maltose to glucose by melon juice addition. Maltose occupies 50% of total free sugar in rice wine, whereas the contents of sugars in melon wine were high in the order of glucose, fructose, sucrose and maltose, of which glucose occupied the 60% portion of total sugars. The major organic acids and free amino acid in both samples (control and melon wine) were similar as lactic acid, succinic acid, citric acid, malic acids, and acetic acid, and glutamic acid, arginine, alanine, proline and phenylalanine, respectively. From these results, it was found that although total amount was reduced by the addition of melon juice, the composition ratio was not changed by melon juice addition.

When considering these changes due to the addition of melon juice, although there were no remarkable changes induced by melon juice, we found some evidences showing that the addition of melon juice could affect the sensory properties of melon wine. First, the main sugar was changed from maltose to glucose by melon juice addition. Maltose

Table 7. Color properties of melon wine* and rice wine (control)

	Color			ΔE	Munsell Neutral
	Lightness (L)	Redness (a)	Yellowness (b)		
Control	97.79	-1.09	6.18	6.65	7.3Y
Melon wine	93.49	-0.34	11.41	13.38	4.2Y

*Melon wine was produced by 30% melon juice addition on rice mash after 4 day of fermentation.

occupies 50% of total free sugar in rice wine (control), whereas free sugars in melon wine were composed of glucose, fructose, sucrose and maltose, of which glucose occupied the 60% portion. Second, the most notable difference of volatile compositions between two samples was found. A small decrease in ester compound levels and a small increase in *iso*-butanol and *iso*-amyl alcohol levels in samples fermented with oriental melon juice were observed, when compared with those same components in wines fermented without melon juice. Particularly, *iso*-butanol and *iso*-amyl alcohol increase in melon wine were likely produced during fermentation and have an important role for improving flavor properties of alcoholic beverage, even though they were not detected or little contained in oriental melon.[19] These compounds were also observed in high amounts in other alcoholic beverages, red wine[20], melon distillate[6], fruit distillates[21,22] and *Takju*[23], indicating that the presence of these compounds had an influence on sensorial properties of alcoholic beverage. Finally, all compounds generally decreased after fermentation with melon juice except glucose, sucrose, and acetic acid, thus total contents were higher in the sample produced from only rice than that with melon juice. This fact may be justified by the effect of melon juice, as in previous result (Table 3) indicating that alcohol production and enzyme activity were reduced by unknown ingredient contained in melon juice.

Acknowledgments

This works was supported by Agricultural R&D Promotion Center (1999-2000).

References

1. Hwang, Y. S. and Lee, J. C. (1993) Physiological characteristics of abnormal fermentation in melon fruit. *J. Kor. Soc. Horti. Sci.* **34**, 339-343.
2. Suh, D. W. (1998) Effect of Ca^{2+} deficiency on fermented-fruit of oriental melon (*Cucumis melon* L. var. makuwa Makino). *RDA J. Horti. Sci. (Korea)* **40**, 55-60.
3. Shin, D. H., Koo, Y. J., Kim, C. O., Min, B. Y. and Suh, K. B. (1978) Studies on the production of watermelon and cantaloupe melon juice. *Kor. J. Food Sci. Tech.* **10**, 215-223.
4. Lee, G. D., Kwon, S. H., Lee, M. H., Kim, S. K., Joo, G. G. and Kwon, J. H. (2004) Change of organoleptic properties with heating concentration of oriental melon juice. *Kor. J. Food Pres.* **11**, 130-133.
5. Cha, S. K., Chun, H. I., Hong, S. S., Kim, W. J. and Koo, Y. J. (1993) Manufacture of fermented cantaloupe melon with lactic starter culture. *Kor. J. Food Sci. Technol.* **25**, 386-390.
6. Hernandez-Gomez, L. F., Ubeda, J. and Briones, A. (2003) Melon fruit distillates: comparison of different distillation methods. *Food Chem.* **82**, 539-543.
7. Hernandez-Gomez, L. F., Ubeda, J., Garcia-Romero, E. and Briones, A. (2005) Comparative production of different melon distillates: chemical and sensory analyses. *Food Chem.* **90**, 115-125.
8. Lee, G. D., Kwon, S. H., Lee, M. H., Kim, S. K. and Kwon, J. H. (2002) Monitoring on alcohol and acetic acid fermentation properties of muskmelon. *Kor. J. Food Sci. Technol.* **34**, 30-36.
9. Kim, J. H., Lee, D. H., Choi, S. Y. and Lee, J. S. (2002) Characterization of physiological functionalities in Korean traditional liquors. *Kor. J. Appli. Microbio. Biotechnol.* **34**, 118-122.
10. Lee, D. H., Kim, J. H., Kim, N. M. and Lee, J. S. (2002) Manufacture and physiological functionality of Korean traditional liquor by using chamomile (*Matricaria chamomile*). *Kor. J. Food Sci. Technol.* **34**, 109-113.
11. Kim, J. H., Lee, D. H., Lee, S. H., Choi, S. Y. and Lee, J. S. (2004) Effect of *Ganoderma lucidum* on the Quality and Functionality of Korean Traditional Rice Wine, Yakju. *J. Biosci. Bioeng.* **97**, 24-28.
12. Kim, J. S., Kim, S. H., Han, J. S., Yoon, B. T. and Yook, C. (1999) Effects of sugar and yeast addition on red wine fermentation using Campbell Early. *Kor. J. Food Sci. Technol.* **31**, 516-521.
13. Lee, J. S., Lee, T. S., Noh, B. S. and Park, S. O. (1996) Quality characteristics of mash of Takju prepared by different raw materials. *Kor. J. Food Sci. Technol.* **28**, 330-336.
14. Han, E. H., Lee, T. S., Noh, B. S. and Lee, D. S. (1997) Quality characteristics in mash of Takju prepared by using different Nuruk during fermentation. *Kor. J. Food Sci. Technol.* **29**, 555-562.
15. Woo, K. L. and Lee, S. H. (1994) A study on wine-making with dried persimmon produced in Korea. *Kor. J. Food Sci. Technol.* **26**, 204-212.
16. Hwang. Y., Lee, K. K., Jung, G. T., Ko, B. R., Choi, D. C., Choi, Y. G. and Eun, J. B. (2004) Manufacturing of wine with watermelon. *Kor. J. Food Sci. Technol.* **36**, 50-57.
17. Han, K. H., Lee, J. C., Lee, G. S., Kim, J. H. and Lee, J. S. (2002) Manufacture and physiological functionality of Korean traditional liquor by using purple-fleshed sweet potato. *Kor. J. Food Sci. Technol.* **34**, 673-677.

18. Kim, J. H., Lee, S. H., Kim, N. M., Choi, S. Y., Yoo, J. Y. and Lee, J. S. (2000) Manufacture and physiological functionality of Korean traditional liquor by using dandelion (*Taraxacum platycarpum*). *Kor. J. Appl. Microbiol. Biotechnol.* **28**, 367-371.
19. Kim, K. S., Lee, H. J. and Kim, S. M. (1999) Volatile flavor components in watermelon (*Citrullus vulgaris* S.) and oriental melon (*Cucumis melon* L.). *Kor. J. Food Sci. Technol.* **31**, 322-328.
20. Diaz, C., Conde, J. E., Mendez, J. J. and Trujillo, J. P. P. (2003) Volatile compounds of bottled wine with denomination of origin from the Canary Islands (Spain). *Food Chem.* **81**, 447-452.
21. Cortes, S., Gil, M. L. and Fernandez, E. (2005) Volatile composition of traditional and industrial Orujo spirits. *Food Control* **16**, 383-388.
22. Soufleros, E. H., Mygdalia, S. A. and Natskoulis, P. (2005) Production process and characterization of the traditional Greek fruit distillate "Koumaro" by aromatic and mineral composition. *J. Food Composition Anal.* **18**, 699-716.
23. Lee, T. S. and Choi, J. Y. (1998) Volatile flavor components in Takju fermented with mashed glutinous rice and barley rice. *Kor. J. Food Sci. Technol.* **30**, 638-643.