Food Engineering Progress
Vol. 13, No. 2. pp. 130~137 (2009.5)

산업식품공학
Food Engineering Progress

Wine Production Using Osmotic Solution from Dried Mango Process

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Abstract

This study evaluated the potential of utilizing the osmotic solution from dried mango processing as alternative raw material for mango wine making. Fermentation was carried out using two kinds of yeast strains *Saccharomyces bayanus*, Lalvin EC-1118 and *Saccharomyces cerevisiae*, Lalvin D-47 at 20°C for 28 days. Physicochemical analysis during fermentation was performed for each treatment and the resulting wine samples were analyzed for color, volatiles and sensory properties. Results of physicochemical analysis between the two fermenting samples as well as the wine samples show almost similar results regardless of the yeast strains. Wine color of sample wines after storage were not significantly different at $p<0.05$ and when compared with a commercial mango wine. From the volatile analysis, esters and alcohols constituted majority of the compounds. Production of several esters, alcohols, acids and terpenes were affected by yeast strain used in fermentation. Results of sensory analysis showed that wines fermented by *S. bayanus* EC-1118 strain was more acceptable although sensory scores between the treatments and the reference wine showed significant differences in all the attributes evaluated, except for bitterness. The utilization of osmotic solution from dried mango process could produce similar properties with existing commercial mango wines although there is still need for further work on the improvement of some sensory attributes of the mango wines.

Key words: osmotic solution, mango wine, physicochemical analysis, volatile analysis

Introduction

Mango (*Mangifera indica* L.) is one of the most popular tropical fruits and considered as one of the finest fruits in the world. Considered as the "majestic of the Philippine fruits", the country's national fruit is one of its sources of pride. Mango ranks third among fruit crops in terms of production and value, next to banana and pineapple. In 2005, Philippines ranked as the sixth mango producer in the world based on FAO figures (FAO, 2005). Moreover, the *Carabao* cultivar, best known as "Manila super mango" contains higher vitamin B or thiamine (9 μg) than other foreign mango varieties which only contain 3.5-6.5 μg. However, the protein content of the fruit was determined as low, only 0.2% in 'carabao' and 0.7% in 'pico' (PCCARD, 1994).

The processing of dried mango involves osmotic dehydration before oven drying. The process of osmotic drying (OD) produced a residual fluid or osmotic solution (OS) which was often times discarded as biological waste (Cohen & Yang, 1995). However, this fluid could be recycled (Bolin et al., 1983), or further processed into such products as purée, juice, jelly, jam and fruit leathers or used as a flavoring agent (Cohen & Yang, 1995). Previous studies reveal that the residual fluid is a potential raw material for further processing. The OS used for fruit dehydration formulated with additives could be added to fruit in order to formulate jams. In this way, solutes possibly lost during the OD process was recovered (Shi et al., 1996). Loss of vitamins, polysaccharides and minerals that flow from the fruit to the OS had been observed (García-Martínez et al., 2002). In another study the flow of micronutrients such as acids, minerals and pectins from grapefruit to the OS was quantified (Peiró et al., 2006). The study concluded that the reuse of the OS is a good way of contributing to the economic and ambient profitability of the OD operation based on the characteristics of the obtained dehydrated grapefruit and the observed recovery of the quantified micronutrient loss by the fruit. Moreover, it has been proposed to recycle OD solutions as ingredient in new product formulation, which is very important not only for making the process economical but also environmentally friendly (Valdez-Fragoso et al., 1998). Considering the challenges in the area of food industry, efforts are to be made to optimise processing technologies to mini-

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Received March 31, 2009; revised April 12, 2009; accepted May 6, 2009

mize the amount of waste.

Recently, mango wine has been extensively studied. Mango wine production and development as well as several physico-chemical and sensory analyses have been undertaken (Reddy et al., 2005; Akubor, 1996; Onkarayya & Singh, 1984; Czyhrinciwk, 1966). From this point of view, the same waste material from dried mango processing was proposed to be a potential raw material or ingredient for winemaking. Furthermore, this study was conducted to determine the feasibility of osmotic solution utilization as alternative raw material for mango wine making.

Materials and Methods

Yeast strains

Commercial yeasts *Saccharomyces bayanus*, Lalvin EC-1118 and *Saccharomyces cerevisiae*, Lalvin D-47, which have low requirement for assimilable nitrogen were used for fermentation. The yeasts were obtained from Lallemand Inc. (Montreal, Canada) and were prepared according to the manufacturer's recommendations.

Preparation of raw material

Firm and slightly ripe mangoes (*Mangifera indica*, 'carabao') from the Philippines were purchased from a local market in South Korea. Fruits of similar ripeness and uniform visual quality were selected, weighed and washed thoroughly in running water. Using a stainless peeler and knife, the mangoes were peeled and sliced into three parts separating the seeds from the flesh. To achieve the desired size for the osmotic dehydration, the mango slices were further cut lengthwise into halves.

The mango slices were then placed in 5 L polycarbonate plastic container and added with 40% refined white sugar (Samyang Co., Daejeon, Korea) by weight. The mixture was set aside for 12 hours at room temperature to allow for steeping and subsequently transferred to stainless pot for heating at 90°C until the syrup became translucent. After which, it was allowed to cool down at room temperature. The osmodehydrated mango flesh were strained out of the mixture to be prepared for oven drying and the heavy syrup was collected and set aside for wine preparation. To check for reliability of the process, the dried mangoes were assessed after oven drying at 60°C for at least 8 hours.

Fermentation of osmotic solution into wine

Eight liters of heavy osmotic solution with pH 3.8 and total soluble solid (TSS) of 45.13°Brix was collected and diluted to 24 °Brix with distilled water. Five-liter mango osmotic solution was separately distributed to its respective fermentation vessel and treated with potassium metabisulfite ($K_2S_2O_5$). Fermentation was carried out using yeast strains *S. cerevisiae* Lalvin D-47 (MW_1) and *S. bayanus* Lalvin EC-1118 (MW_2). Polycarbonate plastic container with an airtight seal cover that has a hole and an airlock at the center was used as fermenting vessel. The samples were analyzed for pH, titrable acidity, TSS and alcohol content at different fermentation periods. Fermentation was terminated after twenty eight days and the wine was filtered using a sterilized 0.5 to 1 micron welded filter bag. The wines were then racked, treated with 100 ppm $K_2S_2O_5$ and stored at 10°C for three months for cold stabilization. After clarification 200 mg/kg of potassium sorbate were added into the mango wines. The mango wines were then siphoned into 750 mL bottles and sealed. Wine samples were subjected to instrumental, sensory and volatile analyses.

Physico-chemical analysis

Total soluble solid (TSS), pH and titratable acidity (TTA) were analyzed using Refractometer (RA-500, Kyoto Electronics Mfg. Co. Ltd, Kyoto, Japan) and Auto-titrator (Mettler Toledo DL50 Titrator, Kusnacht, Switzerland), respectively. Hydrometer was used to measure the alcohol content after distilling the wine samples. Volatile analysis was performed according to the Official Methods of Analysis (AOAC, 2000) and results were reported as % acetic acid.

Color measurement

After storage, the wine color was determined using color reader (JS555, Color TechnoSystem Co. Ltd., Tokyo, Japan) in terms of the hunter color scale values: L* (lightness), a* (redness) and b* (yellowness).

Analysis of volatile compounds

Volatile compounds of the wines were isolated using simultaneous distillation-extracion (SDE) technique with pentane and dichloromethane as solvent (Bosch-Fuste' et al., 2007). Aside from wine, this (SDE) technique has been used in a recent study to analyze volatile compounds in mango flesh (Andrade et al., 2000). Fifty mL of wine sample was placed in 250 mL flask containing 100 mL distilled water. A second flask with 100 mL of 3:1 pentane (Kanto Chemical Co. Inc., Tokyo, Japan): dichloromethane (Junsei Chemical Co. Ltd., Tokyo, Japan) as solvent was attached to the SDE apparatus.

Sample and solvent were heated to their boiling points. These temperature conditions were maintained for 4 hours. The extract was then allowed to cool down before collecting at room temperature, and then dried over sodium sulfate anhydrous (Yakuri Pure Chemicals co., Ltd., Kyoto, Japan). The collected samples were added with 10 μL undecene as internal standard and concentrated up to 1 mL under nitrogen gas.

Volatile compounds were identified on a mass selective detector HP 5973 coupled to a GC system HP 6890. The GC system was equipped with supelcowax 10 capillary column (30 m×250 μm×0.25 μm nominal). Helium was used as carrier gas (1.0 mL/min). Two μg/L of sample extract was injected. Oven temperature was programmed from 80°C to 200°C with a rate of 4°C/min. It was held at 80°C for 5 min and then raised to 200°C. Total run time for each sample was 70 min.

Volatiles were identified by comparing GC retention times with those of the authentic standards from NIST (National Institute of Standards and Technology) library. The volatile compounds were quantified by dividing the peak areas of the compounds of interest by the peak area of the internal standard (IS) and multiplying this ratio by the initial concentration of the IS (expressed as μg/L).

Sensory evaluation

Three different coded samples of wines including a reference sample (commercial mango wine, RW) were evaluated by a panel comprising of students in Department of Food Science and Biotechnology at Andong National University. Wine quality was determined in terms of taste (sweetness, bitterness, and sourness), aroma, color and over-all acceptability using a nine-point hedonic scale.

Statistical analysis

Data were analyzed with SPSS program and differences were considered significant at $p<0.05$. Statistical analysis of the data was performed by one way ANOVA to test the effect of yeast strain on fermentation. Once significance was detected, Turkey's HSD test was used for comparison of difference between groups. Furthermore, Pearson correlation coefficient (r) was calculated to determine relationships between variables.

Results and Discussion

Properties of the osmotic solution

The collected osmotic solution from the 24-kg mango flesh was 9.4 L. The syrup was heavily concentrated with sugar with Brix value of 45.13° (Table 1). By HPLC, it was determined that the sugar types in the syrup were glucose, fructose and sucrose, the latter being the major type in concentration as a result of its addition in the osmotic dehydration process. Color measurement revealed relatively low L* value and high b* value; 42.42 and 20.53 respectively, while a* value was only 2.59. These values indicated deep yellowish color of the osmotic solution as a result of ripening of mango fruits. Without further addition of ingredients, the osmotic solution having properties as listed in Table 1 was utilized for winemaking.

Table 1. Properties of the osmotic solution from dried mango processing

Parameters	Values
Physicochemical[1)]	
pH	3.957±0.103
TTA[2)](%)	0.381±0.228
TSS[2)](°Bx)	45.13±0.643
Color	
L*	42.42
a*	2.59
b*	20.53
Sugar (% w/v)	
Glucose	2.2
Fructose	3.9
Sucrose	42.7

[1)] Results are expressed as mean±SD of triplicate analysis.
[2)] TTA, titratable acidity; TSS, total soluble solid

Physicochemical changes in osmotic solution during fermentation

As the fermentation process progressed, pH in all samples decreased (Table 2). This trend was Akinwale(1999) in agreement with previous reports by Akubor (1996), Alobo (2002), and Maccarone et al.(1993). This effect was due to the gradual decrease in the sugar present in the must as a result of the activities of the fermenting organisms. Along with the decrease in pH was the increase in TA at different rates in all samples.

The remarkable increase in alcohol content by the end of the second week coincided with what is prescribed in references regarding the fermentation period for wine making. The increase in alcohol content corresponded with a decrease in TSS at different rates. The computed *pearson* correlation coefficients (r) for the TSS and alcohol content suggested very strong negative relationship. The r values for MW_1 and MW_2 were -0.971 and -0.951 respectively.

Results of previous studies were consistent on yeast

Table 2. Physicochemical changes in osmotic solution during fermentation[1)]

Fermentation period	pH		TTA[2)]		%TSS[2)] (Bx)		% alcohol	
	MW_1[3)]	MW_2[3)]	MW_1	MW_2	MW_1	MW_2	MW_1	MW_2
Day 0	3.615[a 4)]	3.685[d]	0.404[d]	0.406[de]	24.0[h]	24.0[i]	0.0[a]	0.0[a]
Day 2	3.470[a]	3.538[cd]	0.412[d]	0.405[e]	21.6[g]*	20.6[h]	1.0[a]	0.5[a]
Day 4	3.510[a]* [5)]	3.545[cd]	0.421[d]*	0.409[de]	19.3[f]*	18.5[g]	2.0[b]	2.0[b]
Day 6	3.575[a]	3.490[cd]	0.409[d]	0.419[cde]	17.5[e]	17.1[f]	2.3[b]	2.5[bc]
Day 8	3.360[a]	3.260[abc]	0.413[d]	0.411[de]	16.5[d]	16.1[e]	3.3[c]	3.0[c]
Day 10	3.475[a]*	3.335[abcd]	0.412[d]	0.419[cd]	15.3[c]	15.2[d]	5.8[d]	5.5[d]
Day 12	3.325[a]	3.310[abc]	0.461[c]*	0.429[c]	15.1[c]	15.0[d]	6.5[de]	7.0[e]
Day 14	3.430[a]*	3.140[ab]	0.496[b]*	0.465[b]	13.7[b]	14.1[c]	7.3[e]	7.5[e]
Day 21	3.245[a]*	3.080[a]	0.518[a]	0.508[a]	9.0[a]*	10.5[b]	9.8[f]	10.0[f]
Day 28	3.270[a]	3.255[abc]	0.522[a]*	0.500[a]	9.0[a]	9.2[a]	11.0[f]	11.0[f]

[1)] Results are presented as means from three independent experiments.
[2)] TTA, titratable acidity; TSS, total soluble solid.
[3)] MW_1 and MW_2 are mango wine samples fermented with *Saccharomyces bayanus*, Lalvin EC-1118 and *Saccharomyces cerevisiae*, Lalvin D-47, respectively.
[4)] Means along the same row with same superscripts are not significantly different at $p<0.05$.
[5)] Indicate significant difference between yeast strains in each parameter at different fermentation period at $p<0.05$.

utilization and their findings revealed that commercial yeasts were more glucophilic, therefore they metabolize glucose faster than other sugar. Decreasing the glucose to fructose ratio faster or metabolizing glucose faster was the major cause of sluggish and stuck fermentations (Wang et al., 2004). In this study where sucrose was the primary substrate, sugar uptake based on TSS and alcohol contents at different stages of fermentation show similar pattern between the two yeast strains. Obtaining 11% alcohol content by the end of fermentation might indicate that stuck fermentation was prevented.

Physicochemical properties of mango wine

The physicochemical characteristics of wines produced from the osmotic solution are presented in Table 3. The alcohol content for both MW_1 and MW_2 was 11% which is comparable to most commercial wines. The wines tended to have low volatile acidity (0.02% and 0.03%, respectively) while TSS values (8.9 and 9.3 ^{o}Brix, respectively) were higher compared to other mango wines which adds to the sweetness of the wines. There were no significant differences in titratable acidity, pH and alcohol content for both wine samples which could be attributed to the same preparation condition and processing of mango wines.

Table 3. Physicochemical properties of mango wine samples after three months of storage

Parameters	MW_1	MW_2
pH	3.42[a 1)]	3.39[a]
% TTA	0.475[a]	0.489[a]
TSS (^{o}Bx)	8.9[b]	9.3[a]
VA (% acetic acid)	0.02[b]	0.03[a]
% Alcohol (v/v)	11.0[a]	11.0[a]

[1)]Means along the same row with same superscripts are not significantly different at $p<0.05$.
Abbreviations refer to Table. 2.

Color properties of mango wine

The mango wines produced showed light golden yellow color with brilliant appearance. Cold storage at 10^{o}C for three months was effective to clarify the wines by sedimentation even without using clarifying agent. Results for color are shown in Table 4. Color properties of mango wine as L* (lightness), a* (redness) and b* (yellowness) values measured in this study were consistent with results obtained by Srisamatthakarn (2003). Hulme (1971) stated that low L* and high a* and b* values indicated higher level of carotenoids in mango flesh as a result of ripening. The ripening stage of mango fruit is an important factor in dried mango processing. To attain the chewy nature of dried mango, half yellow and half green mango fruits are used. The same selection method for mango fruits was employed in this study nevertheless, the resulting wines had similar color properties as the reference mango wine (RW) which indicated high carotenoid contents in

Table 4. Color properties of the mango wines

Attributes	MW_1	MW_2	RW
L*	96.79[a 1)]	95.72[a]	96.38[a]
a*	-1.99[a]	-1.18[a]	-3.07[b]
b*	7.63[a]	6.98[a]	10.38[b]

[1)]Means along the same row with same superscripts are not significantly different at $p<0.5$.

fruits utilized for this study.

Color properties of the wine samples were also compared with RW and L* a* b* values were not significantly different from RW. The reference wine was commercially available, made from *carabao* mango and was purchased from Philippines. As wine color is considered an important factor in wine quality, it can be concluded that the use of osmotic soltution in mango wine processing could produce similar color properties as commercial mango wines which generally utilized mango flesh and puree.

Table 5. Average concentrations of volatile compounds in mango wine samples

Compound, μg/L	MW_1	MW_2	RW[1)]
Esters			
Ethyl caproate	2.041	0.552	0.886
Ethyl caprylate	4.892	1.272	3.822
Ethyl caprate	1.094	0.320	nd
Ethyl 9-decanoate	nd[2)]	0.335	nd
ethyl 4-hydroxybutanoate	0.626	0.212	4.426
ethyl octanoate	4.527	nd	nd
Total	13.180	2.692	9.134
Alcohols			
Ethanol	1.115	0.119	nd
2-Butanol	0.292	0.240	nd
Propanol	2.113	0.510	6.616
Isobutylalcohol	2.734	1.828	23.710
1-Butanol	50.922	124.742	272.880
4-Penten-1-ol	nd	nd	nd
1-Propanol	0.334	1.848	6.693
Bezeneethanol	109.364	175.513	584.728
isoamyl alcohol	80.715	16.945	nd
cis-3-hexenol	1.091	0.812	12.069
1-Pentanol	18.829	0.175	nd
Total	267.509	322.733	906.697
Acids			
Butanoic acid	0.821	nd	nd
Benzoic acid	nd	0.242	nd
Butanoic acid	0.268	12.131	10.959
Acetic acid	0.459	nd	nd
caproic acid	4.199	1.271	nd
Caprylic acid	6.071	nd	nd
Hexadecanoic acid	1.584	0.509	22.115
Decanoic acid	2.527	0.442	nd
octanoic acid	nd	1.839	1.142
Octadecanoic acid	nd	0.162	nd
9-octadecenoic acid	0.395	0.141	7.392
Propanoic acid	1.145	1.955	3.508
Hexanoic acid	3.313	0.225	nd
Dodecanoic acid	0.251	0.132	nd
9 Decenoic acid	0.348	0.295	nd
Total	21.381	19.345	45.117
Terpene			
Linalool	1.386	0.397	nd
alpha-terpineol	0.598	0.136	nd
alpha-cadinol	nd	1.124	4.051
T-Muurolol	0.640	1.622	15.313
gamma terpineol	nd	nd	nd
elemol	0.320	0.414	nd
alpha copaene	0.309	0.142	nd
T-cadinol	1.282	nd	nd
gamma-terpinene	0.220	nd	nd
beta-cubebene	0.328	nd	nd
limonene	nd	1.012	nd
Geranial	nd	0.550	nd
Total	5.083	5.398	19.364
Aldehyde			
Isobutyraldehyde	0.116	0.314	nd
2-Furaldehyde diethyl acetal	1.299	8.671	nd
2- Furancarboxaldehyde	7.613	3.272	8.482
5-Methylfurfural	0.411	0.416	nd
Total	9.439	12.673	8.482
Phenol			
4-vinyl-2-methoxy-phenol	0.955	1.825	nd
Phenol	0.238	0.099	nd
Total	1.193	1.924	nd

[1)] RW, reference mango wine
[2)] nd, not detected

Volatile compounds in mango wine

Aroma is a highly important aspect determining the quality of wine. The volatile compounds detected in this study were inspected by their chemical classes (Table 5). Results show formation of esters, higher alcohols, acids, aldehyde and phenol compounds. Alcohols and esters were the largest groups among quantified volatiles. Some authors attributed the basic odour of wines to four esters (ethyl acetate, isoamyl acetate, ethyl hexanoate and octanoate) and two alcohols, (isobutyl and isoamyl alcohol), all of which are fermentation products (Ferreira et al., 1995). The production and retention of these aromas were dependent on fermentation temperature and yeast strain. Previous studies showed that fermentations at low temperatures usually at 10°C was desirable for enhancing the aromatic characteristics of the wines (esters and acetates) probably because of greater synthesis (Santamaria et al., 1995) and a greater retention of the volatile flavors (Ribéreau-Gayon et al., 1998).

Comparing the concentrations of each volatile between MW_1 and MW_2, it could be noted that ester formation or retention was greater when *S. bayanus* strain was used. According to literature, the greatest differences in production of aroma compounds correspond to different yeast species, while yeast of the same species tends not to differ significantly (Antonelli et al., 1999). Thus, the differences in ester formation in this study were greatly attributed to yeast strain. Relatively higher ester concentration was produced by *S. bayanus* than *S cerevisiae* although several ester compounds in MW_1 were not detected in MW_2 and vice versa. On the other hand, among the higher alcohols benzene ethanol, 1-butanol and isoamyl alcohol were analyzed in more abundant amounts in both wine samples although concentrations of each volatile vary greatly between samples. No clear trend was observed with volatile acids due to the several undetected acids.

Volatiles in all samples also consisted of terpene compounds. It has been reported that terpenes along with geraniol, á-ionone, 3-ethoxy ethanol and benzaldehyde can contribute to the spicy and cherry flavor in grape wine (Miranda-Lopez et al., 1992). Furthermore, some authors considered terpenes, especially 3-carene, as the most important aroma constituents in mango, due to the high percentage in the volatile fraction (50–60%) (Andrade et al., 2000). These claims confirmed and supported the findings that retention of terpenoid compounds in osmotic solution was efficient and that the syrup could be fermented into wine that has fruity aroma. In a study by Torres et al. (2007) they concluded that the use of highly concentrated osmotic solutions and the high level of sample osmodehydration induced losses of volatiles with respect to fresh samples in dehydration of mango. In this sense, lixiviation (diffusion from samples to the osmotic solution) is responsible for mango aroma retention in the syrup. Moreover, enzymatic action as triggered by osmotic stress promotes generation of volatile compounds (Zabetakis & Holden, 1997). In the same analysis, it was also noted that certain terpene volatiles like limonene and geranial were detected in *S. bayanus* but not in *S cerevisiae*. This implies that yeast strain has greater influence in the production of such volatiles.

The volatile compounds detected in the commercial mango wine (RW) are also shown Table 5. Many volatiles in the treatments were not detected in RW. Nevertheless, the sum of esters and alcohols were greater in RW than in the treatments. This was somewhat expected considering the raw material used. Mango wine processing usually makes use of mango puree and/or flesh as raw material. Moreover, the low concentrations of volatiles in the treatments could be also due to losses during subsequent processing.

Table 6. Sensory properties of mango wine samples compared with a reference wine

Attributes	MW_1	MW_2	RW
Sweetness	$5.50^{b\ 1)}$	5.42^{b}	8.08^{a}
Sourness	5.75^{b}	5.67^{b}	7.08^{a}
Bitterness	5.55^{a}	5.92^{a}	4.58^{a}
Aroma	5.08^{b}	4.67^{b}	6.97^{a}
Color	6.17^{a}	5.42^{b}	7.25^{a}
Overall Acceptability	6.25^{a}	5.83^{b}	7.42^{a}

[1)]Means along the same row with same superscripts are not significantly different at $p<0.5$.

Sensory properties of mango wine

The effect of yeast strain on final quality of wine is well-studied in wine researches. Depending on the properties of raw material and fermentation conditions, the metabolic activity of the yeast could be optimized. In all the sensory attributes evaluated in this study, scores between MW_1 and MW_2 were not significantly different except for color and overall acceptability (Table 6). MW_1 was more acceptable and perceived to have better color than MW_2. The small variation in sensory scores for sweetness in both samples may be attributed to TSS of the wines which were not significantly different. Furthermore, the sensory attributes of the wines could be related to the major volatile compounds detected especially when it comes to aroma. The high level of alcohols such as propanol, isobutanol and amyl alcohols were rather unpleasant and most authors suggested that they contributed more to the intensity of the odor of the wine than to its quality (Etievant, 1997). Both wine samples contained high levels of alcohol. It was recognized that ethanol played a major role in the volatility of the flavors and the sensory quality of the wine (Voilley & Lubbers, 1998). Thus the amount of volatile compounds perceived by the olfactory system was greatly dependent on the ethanol concentration (Rothe & Schrodter, 1996). High ethanol concentration could enhance perception of esters and acetates giving better aroma quality to the wine. However, when the wine samples were compared with RW, significant difference was observed in all attributes except for bitterness and overall acceptability with MW_2. The difference in raw material and processing condition for RW and the samples could have caused the significant difference in the sensory scores for aroma, sweetness and sourness.

Conclusion

Based on the high alcohol content, the outstanding color and retention of some aromatic compounds in the produced wines, it can be concluded that the osmotic solution derived from dried mango production can possibly be utilized as raw material or ingredient in mango wine making. Thus, the large amount of osmotic solution generated by the dried mango industry may no longer be discarded. Further research is still needed to improve the sensory attributes of the mango wines.

Acknowledgments

This work was supported by Andong National University in 2006.

References

Akinwale TO. 1999. Fermentation and post-fermentation changes in cashew wine. J. Food Technol. Africa 14: 331-332.

Akubor PI. 1996. The suitability of African bush mango juice for wine production. J. Plant Foods Human Nutr. 49: 213-219.

Alobo AP. 2002. Some physicochemical changes associated with the fermentation of lemon juice for wine. J. Sustain. Agri. Environ. 4: 216-223.

Andrade EH, Maia JG, Zoghbi M. 2000. Aroma constituents of Brazilian varieties of mango fruit. J. Food Compo. Anal. 13: 27-33.

Antonelli L, Castellari C, Zambonelli L, Carnacini A. 1999. Yeast influence on volatile composition of wines. J. Agri. Food Chem. 47: 1139–1144.

AOAC. 2000. Official Methods of Analysis of AOAC International. 17th Ed., Method 28.1.30 AOAC International, Gaithersburg, MD, USA.

Bolin HR, Huxsoll C, Jackson R, Ng KC. 1983. Effect of osmotic agents and concentration on fruit quality. J. Food Sci. 48: 202–205.

Bosch-Fuste´ J, Riu-Aumatell M, Guadayol J, Caixach J, López-Tamames E, Buxaderas S. 2007. Volatile profiles of sparkling wines obtained by three extraction methods and gas chromatography–mass spectrometry (GC–MS) analysis. Food Chem. 105: 428-435.

Cohen JS, Yang TCS. 1995. Progress in food dehydration. Trends Food Sci. Technol. 6: 20–25.

Czyhrinciwk N. 1996. The technology of passion fruit and mango wines. Am. J. Enol. Vitic. 17: 27-30.

Etievant XP. 1997. Wine. In H. Maarse (Ed.) pp 490-507, Volatile compounds in foods and beverages. Maarse H(ed) New York: Marcel Dekker. NY, USA, pp. 490-507.

Ferreira V, Fernández P, Peña C, Escudero A, Cacho JF. 1995. Investigation on the role played by fermentation esters in the aroma of young Spanish wines by multivariate analysis. J. Sci. Food Agri. 67: 381–392.

García-Martínez E, Martinez-Monzo J, Camacho M, Martinez-Navarrete N. 2002. Characterisation of reused osmotic solution as ingredient in new product formulation. Food Res. Int. 35: 307–313.

Hulme AC. 1971. The Mango. The biochemistry of fruits and their products. Vol. 2. Academic Press Publishing, London, UK.

Maccarone E, Nicolosi CA, Cataldi MC, Campsi S, Fallico B. 1993. Oranwine: a new wine cooler with blood orange juice. Ital. J. Food Sci. 5: 397-399.

Miranda-Lopez R, Libbey LM, Watson BT, McDaniel MR. 1992. Odor analysis of pinot noir wines from grapes of different maturities by a gas chromatography-olfactory technique (Osme). J. Food Sci. 57: 985-993.

Onkarayya A, Singh H. 1984. Screening of mango varieties for Dessert and Madeira-Style Wines. Am. J. Enol. Vitic. 35: 63-65.

PCCARD. 1994. The Philippine Recommends for Mango. PCARRD Philippines Recommends Series No.38-A Revised Edition. Philippine Agriculture and Resources Research Foundation, Inc. Los Banos, Laguna, Philipine, p. 83.

Peiró R, Diaz VM, Camacho M, Martinez-Navarrete N. 2006. Micronutrient flow to the osmotic solution during grapefruit osmotic dehydration. J. Food Eng. 74: 299–307.

Reddy LVA, Reddy OVS. 2005. Production and characterization of wine from mango fruit (Mangifera indica L.). World J. Microbiol. Biotechnol. 21:1345-1350.

Ribéreau-Gayon P, Dubourdieu D, Donèche B, Lonvaud A. d'Oenologie T. 1998. Microbiologie du vin, Vinifications. Dunod(ed). Paris, France.

Rothe M, Schrodter R. 1996. Flavour contribution of ethanol, a neglected aroma compound. In: Flavour science. Taylor AJ and Mottram DS.(eds). The Royal Society of Chemistry, Cambridge, UK, pp. 348-349.

Santamaria MP, Lopez R, Gutierrez AR, Diez de Bethencourt CA, Garcia-Escudero E. 1995. Incidence de la température de fermentation sur l'évolution des acides gras totaux. J. Int. Sci. Vigne Vin. 29: 101-104.

Shi XQ, Chiralt A, Fito P, Serra J, Escoin C, Gasque L. 1996. Application of osmotic dehydration technology on jam processing. Drying Technol. 14: 841-857.

Srisamatthakarn E. 2003. Effects of Sampee Mango (*Mangifera indica* L.) Ripening Stage and Flesh Ratio on Mango Wine Quality. In: First International Symposium and

Workshop “Insight into the World of Indigenous Fermented Food for Technology Development Food and Safety”. August 13-14: Kasersat University, National Research Council of Thailand, Bangkok, Thailand.

Torres JD, Talens P, Carot J, Chiralt A, Esriche I. 2007. Volatile profile of mango (Mangifera indica L.), as affected by osmotic dehydration. Food Chem. 101: 219-228.

Valdez-Fragoso A, Welti-Chanes J, Giroux F. 1998. Properties of sucrose solution reused in osmotic dehydration of apples. Drying Technol. 6: 1429–1445.

Voilley A, Lubbers. 1998. Flavor–Matrix interactions in wine. In: Chemistry of wine flavor, Waterhouse AL and Ebeler E.(eds). Oxford University Press, New York, NY, USA.

Wang D, Xu Y, Hu J, Zhao G. 2004. Fermentation Kinetics of different sugars by apple wine yeast *saccharomyces cerevisiae*. J. Inst. Brew. 110: 340-346.

Zabetakis I, Holden M. 1997. Strawberry flavour: analysis and biosynthesis. J. Sci. Food Agri. 74: 421-434.