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Effects of rice variety and fermentation method on the physiochemical and sensory properties of rice wine

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Abstract

A study was conducted to investigate the effect of rice variety and fermentation method on rice wine quality. Two rice varieties, waxy pigmented and non-pigmented rice, and two fermentation methods: traditional and multi-parallel fermentation methods were used to study the physicochemical and sensory qualities of wine quality. Wine prepared from waxy non-pigmented rice variety had higher alcohol content (16.7%v/v) using the traditional fermentation method compared with pigmented rice variety but the yield (113.7%) was lower compared with multi-parallel fermentation method (146.1%). Wines from waxy pigmented rice variety produced traditionally and waxy non-pigmented rice variety produced by multi-parallel fermentation method were found to have high overall acceptance (6.2). For rice wine to become a more suitable product, the effect of other factors on its shelf life stability and quality should be thoroughly studied.

Introduction

Rice wine has been developed in various forms, such as the very primitive rice beverages in Thailand and the highly sophisticated alcoholic drinks like the Japanese sake. Even the Korean beverages, yakju and takju, were originally made from rice which are ancient beverages popular among the common people (Park *et al*., 1977). Rice wine has achieved a unique position among beverages of alcoholic fermentation because of flavor and conspicuous brewing process compared to fruit wines (Steinkraus, 1996). The brewing involves saccharification of rice starch by mold, the fungal mycelia of mold grown on rice and simultaneous alcoholic fermentation by yeasts. The enzymes produced by mold such as α-amylases and glucoamylases saccharify the rice starch into fermentable sugars (Yoshizawa, 1982; Anto *et al*., 2005), which in turn are utilized by yeast. Quality of the raw materials used in rice wine production determines the quality of rice wine. Rice being the principle raw material would have a greater impact on rice wine quality. Studies on the effect of rice variety and fermentation method on the production of wine will help generate information on rice wine quality. Thus, the present investigation was taken up to identify suitable rice variety and fermentation method to produce rice wine that has good physicochemical and sensory qualities.

Materials and Methods

Experimental materials and pure starter culture

Completely Randomized Design (CRD) was used as experimental design that generated the parameters studied in two varieties of rice and two methods of fermentation. Waxy pigmented and non-pigmented rice varieties were purchased in Cambodia. Waxy pigmented rice was obtained from Trapeang Ta Moung Village, Prey Sleok Commune, Treang District, Takeo Province known as angkor domneubkhmao or black sticky rice in English. The waxy non-pigmented rice was collected from Teamchas Village, Kompongsvay Commune, Kompongsvay District, Kompong Thom Province, Cambodia locally known as angkor domneubsor or white sticky rice in English.

Pure culture of molds and yeasts namely, *Mucor*

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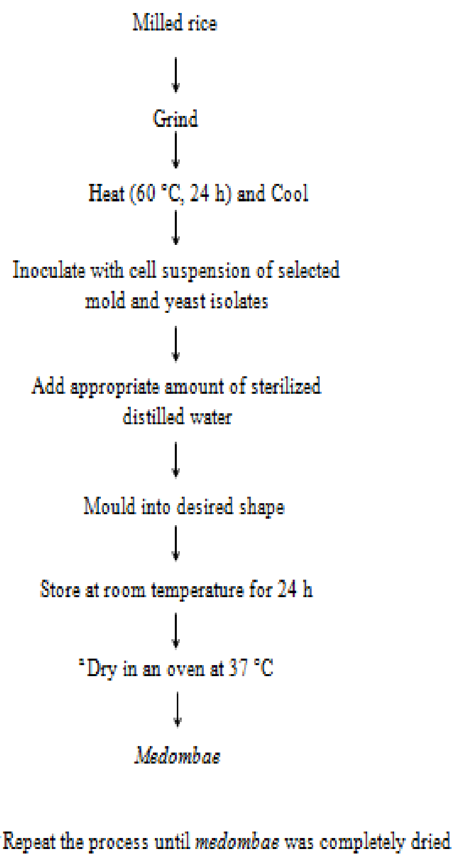

Figure 1. Preparation of medombae using selected mold and yeast isolates

spp., *Rhizopus* oryzae, *Saccharomycopsis* spp., *Candida tropicalis,* and *Saccharomyces cerevisiae* were utilized as inoculants for the preparation of the instant starter culture. These microorganisms were isolated from medombae of Kampong Cham province in a previous work (Chim *et al.*, 2015).

Development of dried starter culture

Microbial strains found to have important role in rice wine fermentation were selected and incorporated in the preparation of instant/dried starter culture (Figure 1). Optimization of the temperature and time of drying, moisture content and other factors affecting the viability of microorganisms in ground rice during starter preparation were determined. After preparation, drying and cooling of the medombae starter cultures, they were packed in PE plastic bag and were stored at refrigerated temperature (5-8°C).

Rice wine processing using traditional method

The traditional process for making rice wine at laboratory scale was done. Two (2) kilograms of waxy pigmented rice and waxy non-pigmented rice were soaked in water for 2 hours, drained and steamed for 60 minutes and cooled. Then, 1% of developed starter culture was inoculated in steamed rice. The mixture was placed in gallon jars for solid state fermentation (72 hours), then 2.8 L of mineral water was added for liquid state fermentation (2 weeks). Subsequently, the fermented mixtures were filtered, and kept standing for 2 weeks for sedimentation. The yield was calculated and then the wines were subjected to physiochemical analysis and sensory evaluation.

Rice wine processing using multi-parallel method

Waxy pigmented rice and waxy non-pigmented rice wine processing was conducted using multi-parallel method. The method initially used 75 g saccharified rice, 187.5 g steamed rice and 262.5 mL water inoculated with 1% developed starter culture. After 72 hours, first parallel addition was done using a mixture of 300 g steamed rice, 120 g of saccharified rice, and 232.5 mL of water. The mixture was transferred to a glass with provision of enough space for the succeeding additions. The main fermentation mash was further added with steamed rice (600 g), saccharified rice (255 g) and 1890 ml water. After another 72 hours, a third addition of steamed rice (1072.5 g), saccharified rice (255 g) and 1890 ml water was done. After the 3rd addition, the mixture was allowed to ferment for two weeks undisturbed in the fermentation glass bottle. The yield was calculated and then the wines were subjected to physicochemical analysis and sensory evaluation.

Analysis of physicochemical properties

The physicochemical properties of rice wine using waxy pigmented and non-pigmented rice through traditional and multi-parallel fermentation using the developed starter culture were analyzed. The rice wine samples were subjected for analysis of pH, total titratable acidity (TTA), total solids (TSS), % alcohol, amino-nitrogen, total and reducing sugars. The pH was measured using an Orion 3 Star pH Benchtop (Thermo Electron Co., Beverly, MA, USA). After measuring the pH, 10 mL of the sample combined with the indicator Bromthymol blue and neutral red and titrated with a 0.1 N NaOH solution. The amount of NaOH (mL) was then converted to total acid (Woo *et al*., 2010). The total soluble solid content was measured using a digital refractometer (Model Dr−103L, Bellingham+ Stanley Ltd., Tumbridge Wells, UK) and measured in Brix (°Bx).

The alcohol content of the Makgeollis or fermented brothwas determined using the procedures adapted from Woo *et al.* (2010). Briefly, 100 mL of the sample was run through a distiller until around 70 mL was collected. The collected sample was set to 100 mL with distilled water and the alcohol content (%) was measured using an alcohol hydrometer. The

Table 1. Physicochemical properties of rice wine at varying fermentation method and rice variety

Parameter	Rice variety					
	Waxy pigmented rice			Waxy non-pigmented rice		
	TD	MD	TM	TD	MD	TM
pH	4.2^{b}	3.7^{c}	4.3^{b}	4.4^{b}	4.5^{a}	4.6^{b}
TSS (°Brix)	9.5^{bc}	6.3^{d}	9.3^{bc}	10.5^{ab}	8.3^{c}	11.3^{a}
TTA (%)	12.0^{a}	11.9^{a}	9.9^{b}	8.2^{bc}	5.7^{e}	6.3^{d}
Amino-N (mg%)	0.066^{b}	0.054^{c}	0.048^{c}	0.050^{c}	0.071^{a}	0.067^{b}
Alcohol (%)	13.5^{b}	4.8^{c}	13.5^{b}	16.7^{a}	14.6^{b}	13.6^{b}
Protein (%)	1.1^{c}	1.0^{c}	1.2^{b}	1.3^{a}	1.2^{b}	1.3^{b}
Total sugar (%)	6.6^{c}	7.2^{c}	30.1^{a}	12.1^{b}	2.6^{d}	30.1^{a}
Reducing sugar (%)	3.0^{c}	2.8^{c}	2.0^{d}	11.1^{b}	0.9^{e}	28.6^{a}

Means within row with the same superscripts are not significantly different at P≤0.05.
TD- Traditional fermentation method using developed starter culture;
MD-Multi-parallel fermentation method using developed starter culture;
TM-Traditional fermentation method using traditional medombae as starter culture
TSS – total soluble solids
TTA – total titratable acidity

alcohol-temperature correction table was used with the sample's alcohol content and temperature. Amino-nitrogen (mg%) was obtained by the Formol method (AOAC, 2000) and the total (TS) and reducing sugar (RS) were determined by phenol-sulfuric and dinitrosalicylic acid methods, respectively.

Sensory evaluation of rice wine

After standing the harvested wine for natural sedimentation, the rice wine product from waxy pigmented and non-pigmented rice varieties was evaluated following the standard general procedure of sensory evaluation as described by Tand and Mabesa (1998). About 15 mL of the prepared rice wine for the different treatments were dispensed in a clean, "shot" glass coded with 3-digit random numbers and placed on serving plates. Panel of judges consisting of 20 Bachelor of Science in Food Science students/staff who had classroom training and are always involved in sensory tests, evaluated the sensory attributes of the prepared rice wine. The panels of judges were asked for preferences tocolor, clarity, aroma, sweetness, sourness, bitterness, flavor, and overall acceptability using a score sheet with scale of 1 to 9, where: Color: 1= Extremely light color, 9 = Extremely dark color; Clarity: 1 = Extremely clear; 9= Extremely cloudy; Aroma: 1 = Extremely weak, 9 = Extremely strong; Sweetness: 1 = Extremely not sweet, 9 = Extremely sweet; Sourness: 1 = Extremely not sour, 9 = Extremely sour; Bitterness: 1 = Extremely not bitter, 9 = Extremely bitter; Flavor: 1 = Like extremely, 9 = Dislike extremely; General Acceptability: 1 = Extremely unacceptable, 9= Extremely acceptable.

Data analysis

Data on physicochemical and sensory tests were analyzed using Analysis of Variance (ANOVA) and correlation between physicochemical property and sensory property were evaluated. Samples found to be significantly different were further subjected to Duncan's New Multiple Range Test (DNMRT) to locate the difference among samples.

Results and Discussion

Physicochemical properties of rice wine as influenced by fermentation method and rice variety

The observations recorded on physicochemical analysis of wine prepared from different rice varieties clearly indicated that there was significant difference (Table 1). Maximum pH (4.5) was recorded for rice wine prepared from waxy non-pigmented rice using developed starter culture for multi-parallel fermentation method and it showed the lowest total titratable acidity. Highest total titratable acidity (12.0%) was reported for rice wine prepared from waxy pigmented rice using developed starter culture with traditional fermentation method. The optimum pH for rice wine should fall within the range of 4.0-4.5 (Latayan, 2002). The final pH values of rice wine fall within the range of 3.4 to 4.5 (Lee *et al.*, 2007; Jin *et al.*, 2008; Seo *et al.*, 2008). Generally, pH of the wines depends on the acid and sugar content of the wines.

Significant difference was observed for total soluble solids of wines prepared from waxy non-pigmented rice using traditional Medombae as starter culture with traditional fermentation method which had maximum total soluble solids (11.3 °Brix). The

Table 2. Percentage yield of rice wine at varying fermentation method and rice variety

Parameter	Rice variety					
	Waxy pigmented rice			Waxy non-pigmented rice		
	TD	MD	TM	TD	MD	TM
Steamed rice (g)	3700	2790	3000	3250	2790	3000
Water (mL)	2800	3337.5	2100	2800	3337.5	2100
Wine (ml)	2972.5	3082.5	1907.5	3690	4077.5	3410
Lees (g)	1550	1200	675	950	385	295
Yield (%)	80.2cd	110.5b	63.6d	113.7b	146.1a	113.7b
FE	43.45c	15.15d	28.1d	62.75a	60.8ab	47.15bc

Means within row with the same superscripts are not significantly different at $P \leq 0.05$.
TD- Traditional fermentation method using developed starter culture;
MD-Multi-parallel fermentation method using developed starter culture;
TM-Traditional fermentation method using traditional medombae as starter culture
FE-Fermentation efficiency

least total soluble solids (6.3 °Brix) was observed with the wine from the waxy pigmented rice with multi-parallel fermentation method using developed starter culture. On the other hand, maximum total sugar (30.1%) was reported for wine prepared from both rice with traditional fermentation method using traditional Medombae as starter culture and lowest total sugar (2.6%) was observed with the wine from the waxy non-pigmented rice using developed starter culture with multi-parallel fermentation method.

Maximum amino-nitrogen (0.071mg%) was recorded for rice wine produced from waxy non-pigmented rice using developed starter culture with multi-parallel fermentation method but highest protein (1.3%) was found in wine prepared from waxy non-pigmented rice with traditional fermentation method using traditional Medombae as starter culture. This value is higher compared to the amino-nitrogen in sake which is about 0.0288 mg% (Kodama and Yoshizawa, 1979). The wine samples in the study had amino-nitrogen ranging from 0.048-0.079 mg%. This difference in values is probably due to the degree rice polishing, variety of rice and method of fermentation. Protein denaturation may also contribute to positive correlation of amino nitrogen with time (Belandres, 1985). The high sugar and protein content of wine could facilitate the Maillard browning reaction as well as caramelization especially when stored at room temperature.

Alcohol is an important parameter to measure wine quality. The alcohol content of rice wine was significantly different between rice variety and method of fermentation. In this study, wine prepared form waxy non-pigmented rice for traditional fermentation using developed starter culture recorded the highest alcohol content (16.7%) followed by multi-parallel fermentation method using developed starter culture (14.6%), traditional fermentation method using traditional medombae as starter culture (13.6%), and wine prepared from waxy pigmented rice for traditional fermentation method using developed starter culture (13.5%) and traditional medombae as starter culture (13.5%). These results are in line with Dung (2013) who stated that the alcohol content of rice wine reach to 15% depending on the fermentation performance and these values fall within the range of alcohol content given by Jin *et al.* (2008) of 15~18%. Wine from waxy pigmented rice variety with multi-parallel fermentation method revealed lowest alcohol content (4.8%). The amount of alcohol produced depends on the fermentable sugars of the variety, fermentation efficiency of yeast, capacity of sugar uptake and alcohol tolerance limit. Alcohol content is one of the factors that affect the quality of rice wine and can also be used to show the degree of fermentation throughout the fermentation process (Kim *et al.*, 2007).

Nunokawa (1972) reported the chemical composition of 45 sake types. On the average, samples contained 4.2% total sugar (as glucose), 3.46% direct sugars (as glucose), 1.52 meq/100ml acidity, 0072% total nitrogen, 0.0288% formol nitrogen and 15.0% (v/v) alcohol content. In the Philippines, chemical analysis of local rice wine (tapuy) collected from different tapuy-producing areas revealed that the quality of the product varied (Tanimura *et al.*, 1977; Sanchez *et al.*, 1985). The TSS ranges from 9.8-18.2 oBrix, pH from 3.3-5.0, reducing sugar from 2.5-6.33%, total sugar from 2.0-8.2%, total acidity from 6.7-20.0%, and alcohol content from 13.5-16.0% (v/v). Results of the study suggest that most of the values fall within the levels of the previous reports for both sake of Japan and tapuy from the Philippines.

The amount of rice (g) and water (mL) used

Table 3. Mean scores of different sensory attributes of rice wine at varying fermentation method and rice variety

Sensory attributes	Rice variety					
	Waxy pigmented rice			Waxy non-pigmented rice		
	TD	MD	TM	TD	MD	TM
Color	3.7[bc]	5.3[a]	4.2[b]	3.1[cd]	2.7[de]	2.2[e]
Clarity	3.9[ab]	5.0[a]	2.6[c]	2.8[bc]	3.8[b]	2.6[c]
Aroma ns	3.4	3.9	4.2	3.9	4.3	3.7
Sweet	4.4[ab]	3.8[ab]	4.1[ab]	4.6[a]	4.3[ab]	3.7[ab]
Sour	5.3[a]	5.2[a]	5.7[a]	5.8[a]	4.3[b]	5.0[a]
Bitter ns	4.7	4.5	4.8	5.5	4.7	5.0
Flavor	4.4[a]	4.2[ab]	4.4[a]	4.0[ab]	3.5[b]	3.9[ab]
General acceptability	6.2[a]	5.4[bc]	5.2[c]	5.7[bc]	6.2[a]	5.6[bc]

Means within row with the same superscripts are not significantly different at P≤0.05.
TD- Traditional fermentation method using developed starter culture;
MD-Multi-parallel fermentation method using developed starter culture;
TM-Traditional fermentation method using traditional medombae as starter culture

Range of scores:
Color: 1= Extremely light color; 9 = Extremely dark color
Clarity: 1 = Extremely clear; 9= Extremely cloudy
Aroma: 1 = Extremely weak; 9 = Extremely strong
Sweetness: 1 = Extremely not sweet; 9 = Extremely sweet
Sourness: 1 = Extremely not sour; 9 = Extremely sour
Bitterness: 1 = Extremely not bitter; 9 = Extremely bitter
Flavor: 1 = Like extremely; 9 = Dislike extremely
General Acceptability: 1 = Extremely unacceptable; 9= Extremely acceptable

during rice wine production are presented in Table 2. Similarly, the volume (mL) of extracted liquid (rice wine) after fermentation and the amount of residual mash (lees) after filtration were noted to determine the percent yield. Percentage yield was calculated based on the amount of steamed rice used for wine fermentation. Analysis of the data shows significant differences on the yield. The wine made from waxy non-pigmented rice through multi-parallel fermentation method using the developed starter culture as inoculant expressed the highest percentage yield of 146.2% followed by the traditional method that used developed and commercial starter culture, medombae (113.7%). The wine made from waxy pigmented rice through multi-parallel fermentation method obtained the highest percentage yield (110.5%) that used developed starter culture and lowest yield was observed in wine made from pigmented rice using the traditional method inoculated with medombae. The waxy non-pigmented rice produced higher volume of wine than waxy pigmented rice through both traditional and multi-parallel fermentation method.

Sensory evaluation

Results revealed that wine from waxy pigmented with traditional fermentation method using developed starter culture and waxy non-pigmented with multi-parallel fermentation method using developed starter culture showed significant difference with maximum overall acceptance (6.2) (Table 3). In comparison, the wine from waxy pigmented rice with traditional fermentation method using traditional Medombae as starter culture was found the least overall acceptance (5.2). As a result, wine from waxy pigmented with traditional fermentation method using developed starter culture and waxy non-pigmented with multi-parallel fermentation method using developed starter culture was superior in the sensory characteristics of color, clarity, sweet, sour, flavor and general acceptability.

Correlation of physicochemical and sensory properties on the quality of rice wine

The relationship between physicochemical properties and sensory attributes were determined in Table 4. There were significant negative relationships between TSS and pH (r = -0.596,) and pH with TTA (r = -0.547) at $p<0.05$. This indicated that as the value of TSS increase the pH decrease with corresponding increase in TTA. The alcohol content, on the other hand, has a strong positive relationship with pH and TSS with r = 0.657 and 0.731, respectively. In the same manner, the TSS was found to have positive relationship with TS and RS, r = 0.67 and 0.546, respectively at $p<0.01$.

Table 4. Correlation of physicochemical properties and sensory test evaluation in waxy pigmented and non-pigmented rice

		Yield(%)	pH	Brix	TA%	Alc(%)	Amino	Sugar	Reducing	Protein	Color	Clarity	Aroma	Sweet	Sour	Bitter	Flavor	Gen
Yield(%)	Pearson Correlation	1	0.356	-0.069	-.638(**)	0.036	0.135	-0.274	0.224	-0.263	-0.235	0.02	0.049	0.14	-0.411	0.029	-.625(**)	0.278
	Sig. (2-tailed)		0.177	0.801	0.008	0.836	0.618	0.305	0.405	0.326	0.381	0.94	0.856	0.605	0.114	0.914	0.01	0.298
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
pH	Pearson Correlation	0.356	1	.596(*)	-.547(*)	.657(**)	0.216	0.287	0.302	-0.017	-0.374	-0.166	-0.171	0.054	0.148	0.307	-0.184	0.169
	Sig. (2-tailed)	0.177		0.015	0.028	0.006	0.423	0.281	0.255	0.951	0.154	0.54	0.526	0.842	0.584	0.247	0.495	0.533
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Brix	Pearson Correlation	-0.069	.596(*)	1	-0.357	.731(**)	-0.005	.546(*)	.670(**)	0.324	-.660(**)	-.608(*)	-0.164	0.258	0.084	.534(*)	0.065	0.057
	Sig. (2-tailed)	0.801	0.015		0.175	0.001	0.986	0.029	0.004	0.221	0.005	0.012	0.545	0.335	0.757	0.033	0.812	0.833
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
TA%	Pearson Correlation	-.638(**)	-.547(*)	-0.357	1	-0.301	0.375	-0.403	-0.482	0.425	0.302	0.144	0.033	-0.461	0.309	-0.154	0.33	-0.15
	Sig. (2-tailed)	0.008	0.028	0.175		0.258	0.152	0.122	0.059	0.1	0.256	0.595	0.902	0.072	0.245	0.57	0.212	0.58
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Alc(%)	Pearson Correlation	0.036	.657(**)	.731(**)	-0.301	1	0.084	0.172	0.219	0.442	-.679(**)	-.562(*)	0.036	0.28	0.045	0.425	-0.226	0.231
	Sig. (2-tailed)	0.836	0.006	0.001	0.258		0.757	0.524	0.414	0.086	0.004	0.023	0.895	0.294	0.87	0.101	0.401	0.39
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Amino	Pearson Correlation	0.135	0.216	-0.005	0.375	0.084	1	-0.446	-0.104	0.345	-0.264	0.004	0.054	-0.479	-0.183	-0.146	-0.115	0.28
	Sig. (2-tailed)	0.618	0.423	0.986	0.152	0.757		0.084	0.701	0.19	0.323	0.987	0.841	0.06	0.497	0.59	0.673	0.294
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Sugar	Pearson Correlation	-0.274	0.287	.546(*)	-0.403	0.172	-0.446	1	.619(*)	0.027	-0.145	-0.268	-0.066	-0.003	0.182	0.209	0.199	-0.471
	Sig. (2-tailed)	0.305	0.281	0.029	0.122	0.524	0.084		0.011	0.922	0.593	0.315	0.808	0.991	0.501	0.436	0.46	0.065
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Reducing	Pearson Correlation	0.224	0.302	.670(**)	-0.482	0.219	-0.104	.619(*)	1	0.16	-.555(*)	-.589(*)	-0.258	0.034	-0.136	0.285	-0.171	-0.053
	Sig. (2-tailed)	0.405	0.255	0.004	0.059	0.414	0.701	0.011		0.553	0.026	0.016	0.334	0.9	0.615	0.285	0.527	0.847
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Color	Pearson Correlation	-0.235	-0.374	-.660(**)	0.302	-.679(**)	-0.264	-0.145	-.555(*)	-.579(*)	1	.849(**)	-0.066	-0.229	0.495	-0.179	.561(*)	-0.416
	Sig. (2-tailed)	0.381	0.154	0.005	0.256	0.004	0.323	0.593	0.026	0.019		0	0.809	0.393	0.051	0.507	0.024	0.109
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Clarity	Pearson Correlation	0.02	-0.166	-.608(*)	0.144	-.562(*)	0.004	-0.268	-.589(*)	-.658(**)	.849(**)	1	-0.096	-0.219	0.281	-0.146	0.433	-0.235
	Sig. (2-tailed)	0.94	0.54	0.012	0.595	0.023	0.987	0.315	0.016	0.006	0		0.723	0.415	0.291	0.589	0.094	0.381
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Aroma	Pearson Correlation	0.049	-0.171	-0.164	0.033	0.036	0.054	-0.066	-0.258	0.32	-0.066	-0.096	1	0.184	-0.338	0.152	-0.004	-0.142
	Sig. (2-tailed)	0.856	0.526	0.545	0.902	0.895	0.841	0.808	0.334	0.227	0.809	0.723		0.494	0.2	0.575	0.989	0.6
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Sweet	Pearson Correlation	0.14	0.054	0.258	-0.461	0.28	-0.479	-0.003	0.034	-0.253	-0.229	-0.219	0.184	1	-0.364	0.424	-0.015	.506(*)
	Sig. (2-tailed)	0.605	0.842	0.335	0.072	0.294	0.06	0.991	0.9	0.345	0.393	0.415	0.494		0.165	0.101	0.956	0.046
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Sour	Pearson Correlation	-0.411	0.148	0.084	0.309	0.045	-0.183	0.182	-0.136	0.001	0.495	0.281	-0.338	-0.364	1	0.173	0.458	-0.487
	Sig. (2-tailed)	0.114	0.584	0.757	0.245	0.87	0.497	0.501	0.615	0.996	0.051	0.291	0.2	0.165		0.522	0.074	0.056
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Bitter	Pearson Correlation	0.029	0.307	.534(*)	-0.154	0.425	-0.146	0.209	0.285	0.21	-0.179	-0.146	0.152	0.424	0.173	1	0.275	0.007
	Sig. (2-tailed)	0.914	0.247	0.033	0.57	0.101	0.59	0.436	0.285	0.435	0.507	0.589	0.575	0.101	0.522		0.302	0.979
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Flavor	Pearson Correlation	-.625(**)	-0.184	0.065	0.33	-0.226	-0.115	0.199	-0.171	-0.224	.561(*)	0.433	-0.004	-0.015	0.458	0.275	1	-0.357
	Sig. (2-tailed)	0.01	0.495	0.812	0.212	0.401	0.673	0.46	0.527	0.404	0.024	0.094	0.989	0.956	0.074	0.302		0.175
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Gener	Pearson Correlation	0.278	0.169	0.057	-0.15	0.231	0.28	-0.471	-0.053	-0.1	-0.416	-0.235	-0.142	.506(*)	-0.487	0.007	-0.357	1
	Sig. (2-tailed)	0.298	0.533	0.833	0.58	0.39	0.294	0.065	0.847	0.713	0.109	0.381	0.6	0.046	0.056	0.979	0.175	
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

The correlation of TSS, alcohol content, TTA, and RS on the sensory attributes of wine was examined. The color of rice wine has significant negative correlation with TSS and alcohol content but very much related to RS content with r = -0.669, -0.679, and 0.619, respectively. This showed that the color of wine is lighter or pale with increasing alcohol content and lower TSS but darkens when the RS increase. The TSS, alcohol content, RS and clarity were found to have significant negative relationship while clarity and color are strongly related with r = 0.849, $p<0.01$. Bitterness of wine has something to do with change in TSS. The wine flavor has direct relationship with color but negative relationship with sweetness. This means that the preference for flavor increase with increasing intensity in color and decreasing degree in sweetness.

Conclusion

Alcoholic beverages have played an important role in human spiritual and cultural life. Alcoholic beverages are produced primarily from fruit: like grapes but are also produced from cereals; especially rice. When compared to fruit wine preparation, rice wine preparation has an additional step i.e., saccharification of starch to simple sugars. From the present study, traditional fermentation method has preferable alcohol content (16.7%) of the rice wine prepared from waxy non-pigmented. As a result of the present study, it can be concluded that rice wine qualities differs with rice varieties and fermentation methods and significant differences were observed with respect to various parameters like pH, titratable acidity, total soluble solids, alcohol contents, amino-N, protein, total and reducing sugar and overall sensory acceptance. To achieve consistent good quality and high yields of valuable products like rice wine, the fermentation condition, shelf life and screening of various other rice varieties should be considered in future researches.

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