International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Development and Physicochemical Evaluation of Wine from Taro Corms *(Colocasia esculenta)*

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Abstract: ***Wines are alcoholic beverages that are produced by fermenting fruits juices, conventionally from grapes. Deviating from the norm, this study produced and analyzed the physicochemical qualities of wine from taro corms (Colocasia esculenta) to maximize its use. Further, the developed wine was enhanced with santol (Sandoricum koetjape), calamansi (Citrofortunella microcarpa) and dalanghita (Citrus nobilis) fruit flavors. Utilizing the experimental research design, the study revealed that the pH of the developed wine ranged from 2.80-3.33 while the wine fermented for 3 weeks at 28°C with 2 g of yeast has the lowest total soluble solids of 7.80°Brix. The wine fermented for 3 weeks at 28°C with 3 g of yeast produced the highest alcohol content with an average value of 7.17%. Results of the study revealed that the length of fermentation, amount of yeast and temperature of fermentation affects the pH of taro corms wine, the total soluble solids and alcohol content are affected by the length of fermentation and temperature of fermentation but not by the amount of yeast. . Further, the duration of aging yields a better color of taro corms wine while the other physical properties like the aroma, clarity and taste were not affected by the length of aging and fruit flavor.***

Keywords: experimental research, fruit flavors, taro corms, wine

1. Introduction

Wine is one of the most popular alcoholic drinks around the world. Traditionally it is prepared using grape juice [1]. However, there are numerous studies available on wine making using different fruits such as banana [2], mango [3], strawberry [4], jamun [5], litchi [6], orange [7], and guava [8]. Aside from fruits, other materials are also a good source of wine such as tea leaves [9], rice [10], and nipa [11]. In the Philippines, the most frequently encountered types of wine produced are from tropical fruits, rice, and sugar cane.

Taro *(Colocasia esculenta)* is one of the oldest [12], staple and important food crops of the world especially in Asia [13][14][15], Pacific Island Countries [16], Africa [17] and the Caribbean [18]. Taro is a root crop with starchy corms commonly used as a vegetable [19] and or processed by steaming or boiling, baking, frying, roasting, making chips, and converting into flour [20]. For the Filipinos, it is best known as gabi [21], the leaves are widely used and less frequently the corms and it has been little studied and poorly known. It is high in carbohydrates, primarily a source of energy in the form of easily digested starch and provide an excellent source of vitamins, amino acids, and minerals [22].

In 2014, taro ranked fourteenth among vegetable crops with about 10 million tons produced globally from about 1.4 million hectares with an average yield of 4.5 million hg/ha [23]. Taro is considered as one of the most important root crops in the Philippines. It is next to cassava and sweet potato regarding production. In the past years the production increases due to its market potential and nutritional value [24].

Reports on the production of alcoholic beverage from taro corms are not available in the literature and yet no significant scientific work has been reported. Because of the high starch content, it seems to be promising for the production of alcoholic beverage from taro corms.

2. Objectives of the Study

This study is conducted to develop wine from taro corms with different fruits as flavor. Specifically, it aims to determine if the taro corms used to produce wine and the length of fermentation, amount of yeast and temperature of fermentation will affect the pH, total soluble solids and alcohol content of taro corms wine. It also aims to determine if the best-produced taro corms wine and length of aging and flavors used will affect the aroma, clarity, color, and taste.

3. Materials and Method

3.1 Research Design

The method of research employed in this study was the experimental method. The quality of taro corms wine was determined through physicochemical evaluation such as pH, total soluble solids, and alcohol content and subjected to sensory assessment regarding aroma, clarity, color, taste, and general acceptability.

The sampling design used in study 1 was the 2x3x2 three-factor factorial experiment in complete randomized design with three replications to test the physicochemical composition of taro corms wine subjected to varying length of fermentation, the amount of yeast added before fermentation and fermentation temperature. The study 2 covers testing the general acceptability of taro corms wine flavored with three different fruits and a control and aged for two months and four months. The 2x4 strip-plot in a randomized complete block design with three replications was used.

3.2 Special Techniques and Procedure

Collection of Raw Materials

The taro corms specifically the San Fernando varieties were obtained directly from the vendors of crops at Santa Maria,

Laguna, and the fruits were purchased at the public market of Siniloan, Laguna.

Preparation of the Processing Conditions for Fermented Taro Corms

All materials used during the experiment were sterilized by boiling. The taro corms were placed in a large pot filled with water. It was boiled and simmered for 1 h then cooled to room temperature. The taro corms were peeled, mashed and weighed. For every treatment 1 kg of mashed taro corms was place in a blender with 1 L of water and put into a jar with 3 L of water and 1 kg of sugar. Ten percent of the taro corms mixture per treatment was separated and used as a yeast starter. The remaining 90% of the solution was left to stand out for 24 h, and the total soluble solids were determined using a refractometer. Twelve treatments with 3 replications were set up in this experiment. The yeast starters were placed in separate glasses and 1 g, 2 g and 3 g of yeast were added. After 24 h, the yeast starter was mixed with the taro corms mixture and subjected for 3 weeks and 5 weeks fermentation at 28 and 5°C. After 3 and 5 weeks the pH and alcohol content of the taro corms wine were analyzed using the pH meter and distillation and specific gravity method and conversion table.

Aging Process of Wine

The analyzed taro corms wine with the highest alcohol content was subjected for 2 and 4 months of aging and was flavored with santol, calamansi, and dalanghita fruit juice. In aging flavored taro corms wine, 8 treatment combinations with 3 replications were set up in this study.

Sensory Evaluation of Wine

The physical properties of flavored taro corms wine such as aroma, clarity, color, and taste were determined through organoleptic testing or evaluation of consumer acceptability of wine. To assess the consumer acceptability of the final product, 30 young male and female drinkers who claimed to be physically fit acted as taste panelists were selected using purposive sampling to evaluate the produced wine using a 5-point Hedonic Scale Quality Scoring. The taste panelists were asked to rate the wine samples using the score sheet rubrics as they perceive it. Three testing were conducted where each testing composed of 8 wine samples and was served in clean, transparent wine glasses which is randomly labeled.

3.3 Statistical Treatment and Analysis of Data

Data on the physicochemical characteristics of wine developed from taro corms at different length of fermentation with various amount of yeast at varying temperature and sensory evaluation of taro corms wine with different fruit flavors and duration of aging were analyzed using Analysis of Variance. The Duncan's Multiple Range Test was used to locate the significant difference among the treatment means.

4. Results and Discussion

Physicochemical Evaluation of Taro Corms Wine

pH of Taro Corms Wine

The average pH of taro corms wine is presented in Table 1. Taro corms wine fermented for 3 weeks at 28°C with 3 g of yeast obtained the highest pH value of 3.33 and taro corms wine fermented for 3 weeks at 5°C with 1 g of yeast obtained the lowest pH value of 2.80. The temperature of fermentation, the length of fermentation, and the amount of yeast can affect the pH of taro corms wine. The mean pH of the taro corms wine produced with 1 g of yeast, fermented for 3 weeks at 5°C is significantly lower than the pH of all the other treatments. This very low pH value is due to the least amount of yeast used in the experiment, low temperature during fermentation and short duration of fermentation. This finding is similar to the study of Maragatham and Panneerselvam [25] on papaya wine. The results of the study proved that the decrease in the acidity during fermentation of the juice was due to the amount of yeast used for the production of carbon dioxide and water. A similar finding is also reported on white cheese wood wine [26], at the end of 10 day- fermentation the pH of the wines slightly decreased.

Table 1: Average pH of Taro Corms Wine

Amount of Yeast	Temperature of Fermentation				Mean
	28°C		5°C		
	Length of Fermentation		Length of Fermentation		
	3 weeks	5 weeks	3 weeks	5 weeks	
1 gram	3.20[a]	2.90[a]	2.80[b]	3.23[a]	3.03
2 grams	3.07[a]	3.10[a]	3.30[a]	3.20[a]	3.17
3 grams	3.33[a]	2.87[a]	3.13[a]	3.07[a]	3.10
Mean	3.20	2.96	3.08	3.17	

*means followed by the same letter are not significantly different
**length of fermentation (p=0.2079), amount of yeast (p=0.2148), temperature of fermentation (p=0.4667), length of fermentation x amount of yeast (p=0.0875), length of fermentation x temperature of fermentation (p=0.0106), amount of yeast x temperature of fermentation (p=0.3622), length of fermentation x amount of yeast x temperature of fermentation (p=0.0234)

Total Soluble Solids of Taro Corms Wine

The average total soluble solids of taro corms wine is presented in Table 2. Taro corms wine fermented for 3 weeks at 5°C with 1 g of yeast obtained the highest total soluble solids of 17.40°Brix and taro corms wine fermented for 3 weeks at 28°C with 2 g of yeast obtained the lowest total soluble solids of 7.80°Brix.The length of fermentation and temperature of fermentation affect the taro corms wine total soluble solids content. Taro corms wine placed under 5°C fermented for 3 weeks has significantly higher total soluble solids. The total soluble solids of taro corms solution on the initial day of fermentation was 20°Brix, and it decreased during fermentation. Similar results were observed by Maragatham and Panneerselvam [25] on papaya wine fermented at 24°C to 26°C for 9 days and Ogunjobi and Ogunwolu [27] on cashew apple powder wine fermented at 28°C for 15 days.

Table 2: Average Total Soluble Solids of Taro Corms Wine

Amount of Yeast	Temperature of Fermentation				Mean
	28°C		5°C		
	Length of Fermentation		Length of Fermentation		
	3 weeks	5 weeks	3 weeks	5 weeks	
1 gram	10.47	8.60	17.40	11.23	11.93
2 grams	7.80	10.33	16.73	13.10	12.00
3 grams	11.87	8.77	15.10	12.87	12.15
Mean	10.05[b]	9.23[b]	16.41[a]	12.40[ab]	

*In a row, means with the same letter are not significantly different
**length of fermentation (p=0.0365), amount of yeast (p=0.9665), temperature of fermentation (p=<.0001), length of fermentation x amount of yeast (p=0.1418), length of fermentation x temperature of fermentation (p=0.0027), amount of yeast x temperature of fermentation (p=0.4778), length of fermentation x amount of yeast x temperature of fermentation (p=0.1639)

Alcohol Content of Taro Corms Wine

The average alcohol content of taro corms wine is presented in Table 3. Taro corms wine fermented for 3 weeks at 28°C with 3 g of yeast produced the highest alcohol content with an average value of 7.17%. Taro corms wine fermented for 3 weeks at 5°C with 1 and 2 g of yeast and taro corms wine fermented for 5 weeks at 5°C with 2 and 3 g of yeast produced 0.0% alcohol. The alcohol content of taro corms wine from the different treatments was significantly affected by the length of fermentation and temperature of fermentation. Wines fermented for 3 weeks at 28°C yields higher alcohol content than those wines fermented for 5 weeks at 28°C and wines fermented for 3 weeks and 5 weeks at 5°C. Higher alcohol contents were found highest at high fermentation temperature. This finding is similar to the reports of other researchers (Srivastava [28]; Ulaiwan [29];Sener et al. [30]; Yu and Zhang [31]; Sevda and Rodrigues [32]; Okeke et al. [33].

Table 3: Average Alcohol Content of Taro Corms Wine

Amount of Yeast	Temperature of Fermentation				Mean
	28°C		5°C		
	Length of Fermentation		Length of Fermentation		
	3 weeks	5 weeks	3 weeks	5 weeks	
1 gram	6.50	2.67	0.00	0.33	2.38
2 grams	5.83	3.67	0.00	0.00	2.38
3 grams	7.17	1.83	0.17	0.00	2.30
Mean	6.50[a]	2.72[ab]	0.06[b]	0.11[b]	

*In a row, means with the same letter are not significantly different
**length of fermentation (p=0.0267), amount of yeast (p=0.9950), temperature of fermentation (p=<.0001), length of fermentation x amount of yeast (p=0.6895), length of fermentation x temperature of fermentation (p=0.0229), amount of yeast x temperature of fermentation (p=0.9803), length of fermentation x amount of yeast x temperature of fermentation (p=0.7343)

Sensory Evaluation of Taro Corms Wine

Aroma of Taro Corms Wine

The average aroma scores of taro corms wine is presented in Table 4. The highest aroma score was obtained from taro corms wine with calamansi aged for 4 months with an average of 3.26, and the lowest aroma score was obtained from taro corms wine with santol aged for 4 months with an average of 2.80. All the mean scores indicate that the panelists slightly liked the aroma of the taro corms wine since it has a pleasant odor. The aroma scores of taro corms wine could not significantly alter by the duration of aging and flavors used. This study is in contrast with the report of Pandell [34] who stated that the faster the aging of the wine it increases the rate of undesirable chemical reactions which can produce compounds with foul odors.

Table 4: Aroma Scores of Taro Corms Wine

Flavor	Duration of Aging		Mean
	2 months	4 months	
Santol	2.86	2.80	**2.83**
Calamansi	2.91	3.26	**3.08**
Dalanghita	3.04	3.14	**3.09**
Control	2.91	3.13	**3.02**
Mean	**2.93**	**3.08**	

*aging duration x flavor (p>0.05), aging duration (p>0.05), flavor (p>0.05)
** 1.00 – 1.80 (Dislike Very Much), 1.81 – 2.60 (Dislike Moderately), 2.61 – 3.40 (Like Slightly), 3.41 – 4.20 (Like Moderately), 4.21 – 5.00 (Like Very Much)

Clarity of Taro Corms Wine

The average scores for clarity of the taro corms wine is shown in Table 5. The table displays that taro corms wine with calamansi aged for 2 months got the highest clarity score with a value of 3.52, and the lowest clarity score of 3.00 was obtained from taro corms wine with santol aged for 2 months. These values show that the control and calamansi flavored taro corms wine were moderately liked because of its clear appearance while the santol and dalanghita flavored taro corms wine were liked slightly by the taste panelists because although its appearance is clear the taste panelists saw residues on the wine. The result of the study is similar to the report of Paul et al. [35] who stated that the low clarity scores of sweet potato wine were due to lack of aging and presence of polysaccharide molecules. However, the clarity scores of taro corm wines could not be significantly altered by the duration of aging and flavors used.

Table 5: Clarity Scores of Taro Corms Wine

Flavor	Duration of Aging		Mean
	2 months	4 months	
Santol	3.00	3.24	**3.12**
Calamansi	3.52	3.39	**3.46**
Dalanghita	3.10	3.39	**3.25**
Control	3.32	3.51	**3.42**
Mean	**3.24**	**3.38**	

*aging duration x flavor (p>0.05), aging duration (p>0.05), flavor (p>0.05)
** 1.00 – 1.80 (Dislike Very Much), 1.81 – 2.60 (Dislike Moderately), 2.61 – 3.40 (Like Slightly), 3.41 – 4.20 (Like Moderately), 4.21 – 5.00 (Like Very Much)

Color of Taro Corms Wine

Table 6 shows the mean color scores of the wines from the 8 treatment combinations. The highest score was obtained from taro corms wine with dalanghita aged for 4 months with a value of 3.68, and the least color score is 3.06 and was obtained from taro corms wine with santol aged for 2 months. Only the dalanghita flavored taro corms wine was moderately liked by the taste panelists due to its yellow to slightly orange color. The wine with the other two flavors and the control

were liked slightly because its color is pale gold. The duration of aging could significantly alter the color scores of taro corms wine, however, could not be significantly altered by the different flavors used. Wines aged for 4 months got the good quality of color than the wines aged for 2 months. This finding is similar to the report of Paul et al. [35] on sweet potato wine who stated that at longer storage period the wine developed recognizable alteration in the quality of wine.

Table 6: Color Scores of Taro Corms Wine

Flavor	Duration of Aging		Mean
	2 months	4 months	
Santol	3.06	3.18	**3.12**
Calamansi	3.14	3.38	**3.26**
Dalanghita	3.18	3.68	**3.43**
Control	3.11	3.60	**3.36**
Mean	**3.12a**	**3.46b**	

*aging duration x flavor (p>0.05), aging duration (p>0.05), flavor (p>0.05)
** 1.00 – 1.80 (Dislike Very Much), 1.81 – 2.60 (Dislike Moderately), 2.61 – 3.40 (Like Slightly), 3.41 – 4.20 (Like Moderately), 4.21 – 5.00 (Like Very Much)

Taste of Taro Corms Wine

As shown in Table 7, taro corms wine with dalanghita aged for 4 months yielded the highest mean score for taste with a value of 3.44. This value is further described the taro corms wine as having a tart taste and the other 7 treatments of taro corms wine have a bitter taste. The taste scores of taro corms wine could not be significantly altered by the duration of aging and flavors used. This finding is similar to the result of the study of Ogunjobi and Ogunwolu [27] on cashew apple powder wine who stated that during aging more deposits settled from wine and become clearer and the taste was less harsh.

Table 7: Taste Scores of Taro Corms Wine

Flavor	Duration of Aging		Mean
	2 months	4 months	
Santol	2.86	2.80	**2.83**
Calamansi	2.91	3.26	**3.08**
Dalanghita	3.04	3.14	**3.09**
Control	2.91	3.13	**3.02**
Mean	**2.93**	**3.08**	

*aging duration x flavor (p>0.05), aging duration (p>0.05), flavor (p>0.05)
** 1.00 – 1.80 (Dislike Very Much), 1.81 – 2.60 (Dislike Moderately), 2.61 – 3.40 (Like Slightly), 3.41 – 4.20 (Like Moderately), 4.21 – 5.00 (Like Very Much)

General Acceptability of Taro Corms Wine

The mean scores of the general acceptability of the taro corms wine is exhibited in Table 8. Taro corms wine with calamansi aged for 4 months topped the 8 treatment combinations with a mean score of 3.24. The lowest mean score of 2.82 was obtained from taro corms wine aged for 2 months. All the taro corms wine produced from the experiment of this study were liked slightly by the taste panelists. This finding is similar to the reports of Bridgebassie and Badrie [37] on carambola wine with an overall acceptability of liked slightly to like moderately and Ogunjobi and Ogunwolu [27] on cashew apple powder wine rated quite acceptable.

Table 8: Mean Scores of Taro Corms Wine Regarding General Acceptability

Flavor	Duration of Aging		Mean
	2 months	4 months	
Santol	2.94	3.07	**3.01**
Calamansi	3.11	3.24	**3.18**
Dalanghita	2.96	3.22	**3.09**
Control	2.82	3.08	**2.95**
Mean	**2.96**	**3.15**	

*aging duration x flavor (p>0.05), aging duration (p>0.05), flavor (p>0.05)
** 1.00 – 1.80 (Dislike Very Much), 1.81 – 2.60 (Dislike Moderately), 2.61 – 3.40 (Like Slightly), 3.41 – 4.20 (Like Moderately), 4.21 – 5.00 (Like Very Much)

5. Conclusion and Recommendation

The study revealed that the taro corms have a potential to be used as raw material for wine production. The pH of taro corms wine is significantly affected by the temperature of fermentation, amount of yeast, and length of fermentation. The total soluble solids and alcohol content of taro corms wine are significantly affected by the temperature and length of fermentation but not by the amount of yeast. The aroma, clarity, and taste of the developed taro corms wine were not significantly affected by two months and four months duration of aging and santol, calamansi, and dalanghita flavors. The color of the developed taro corms wine was significantly affected by the duration of aging but not by the flavoring material used.

Based on the results of the study the following are the recommendations of the researchers: taro corm is recommended to be used as raw material in making wine; the amount of yeast used in fermentation for the production of wines should be considered as an important factor in stabilizing the pH; in the fermentation of taro corms wine, it is recommended that 3 grams of yeast should be used; three weeks length of fermentation at room temperature (28°C) should be used to attain maximum conversion of total soluble solids and most importantly on the production of alcohol from fermentation of taro corms; and further studies on the utilization of other fruits as flavoring to wine should be considered.

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