

# Preparation and Characterization of Toddy Palm Wine and Vinegar

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## Abstract

Vinegar is one of the fermented products. This research focused on the processing of vinegar from toddy palm juice (*Borassus flabellifer L.*) by alcoholic and acetic fermentation process. To identify the quality of toddy palm juice, the physico-chemical properties of the toddy palm juice such as pH, acidity, soluble solids, reducing sugar, total sugar, specific gravity and alcohol contents were determined. Toddy palm vinegar was produced by natural fermentation and also by fermentation of additional yeast culture. In the production of vinegar, the first step was the fermentation of sugar to alcohol by yeast species under anaerobic condition and the second stage was acetic acid fermentation of alcohol to acetic acid by acetic acid bacteria under aerobic condition. The effect of yeast on the acetic content of vinegar was investigated. The maximum yield of acetic acid content 23.6 % was obtained by natural fermentation. The toddy palm vinegar fermented for 5 weeks was found to be more favourable in quality and high acetic acid content.

**Keywords:** toddy palm, wine, fermentation, vinegar, acetic acid

## Introduction

Toddy palm, sugar palm or Asian Palmyra palm (*Borassus flabellifer L.*), is native in Myanmar, India, and Africa (Ariyasena *et al.*, 2001). Toddy palm is one of the tall dioecious palms of the family Palmae, capable of growing up to 30 m high, the leaves are long fan-shaped 2-3 m in length the flowers are small in density clustered spikes followed by brown large round dish fruits Arecaceae (Artnarong, 2016).

Freshly palm juice is white in colour, very sweet and not fermented. Sucrose is the main component of the fresh toddy juice, which is about 12-15% by weight. The fresh juice contains small amount of reducing sugar. It contains natural yeasts, which perform the fermentation of glucose to alcohol, as well as acetobacter, which subsequently converts the alcohol to acetic acid (vinegar). Due to the minimum amount of vinegar content, the suitable time for fresh juice consumption is one day after tapping; beyond this time, the juice becomes increasingly sour ([en.m.wikipedia.org/wiki](http://en.m.wikipedia.org/wiki)). The palm sap ferments immediately after collection due to its own natural yeasts. The fermented product is palm wine and contains about 4% alcohol. Palm sap left in the sun takes roughly two hours to create palm wine. Leaving it longer makes stronger alcohol and the taste will be more acidic. To produce vinegar, it should be left under the sun for a few more time. ([www.live-less-ordinary.com](http://www.live-less-ordinary.com)). The key component of vinegar is acetic acid and it is produced from fermentation of ethanol. The fermented product, ethanol is partially oxidized to acetic acid by *Acetobacter aceti* bacteria (de Ory *et al.*, 2002). The vinegar can be produced from apples, pears, grapes, honey, syrups, cereals, hydrolyzed starches, beer and wine, however, only a few people know about toddy palm vinegar (Falcone, 2008).

The aim of this research was to observe how to prepare wine and vinegar from toddy palm juice; to study the fermentation performance of native yeast and acetic acid bacteria on toddy palm juice; and to investigate the effect of fermentation time on the properties of prepared wine and vinegar.

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## Materials and Methods

### Materials

The toddy palm juice was collected from local palm trees of Chauk Township, Magway Region. All the chemicals and reagents used in the research were purchased from Able chemical shop, Chan Aye Thar Zan Township in Mandalay Region.

### Characterization of Toddy Palm Juice

Physico-chemical characteristics of toddy palm juice such as pH, acidity, soluble solids and reducing sugar, specific gravity and alcohol content were determined by AOAC methods (2000).

### Preparation of Toddy Palm Wine

The toddy palm juice was collected from local palm trees of Taungtha Township, Mandalay Region. The freshly toddy palm juice was placed in the fermentation vessel and left ferment by anaerobic condition at room temperature for three days to convert the sugar to ethanol by the action of the yeasts (*S. cerevisiae*) present in the palm juice. After three days of alcoholic fermentation, the palm wine was filtered through sterilized filter cloth to remove spent yeast. The pH and alcohol content of the palm wine were determined during the fermentation time.

### Alcohol Content

The alcohol content of the palm wine during fermentation was measured by pH meter.

### Preparation of Toddy Palm Vinegar

The acetic acid fermentation was carried out by aerobic fermentation. The fermentation vessel was covered with the cloth to prevent the contamination. After completing the alcoholic fermentation, the palm wine started conversion into vinegar. The palm wine went acetic fermentation involving acetic acid bacteria. The types and numbers of organisms encountered vary widely, from tree to tree. The wine was allowed to ferment for four weeks at room temperature. At the end of fermentation period, a thick film known as mother of vinegar was removed by filtration.

### Characterization of Toddy Palm Wine and Vinegar

The properties such as pH, acidity, soluble solids and reducing sugar, specific gravity and alcohol content in toddy palm wine and vinegar were determined by AOAC methods (2000).

### Acetic Acid Content

The acetic acid content of vinegar was determined every week during fermentation periods. 10 mL of the toddy palm vinegar was mixed with 40 mL of distilled water and then added a few drops of phenolphthalein indicator. The mixture was titrated with 0.5N NaOH till the pale pink colour was formed. The volume of titrant NaOH was recorded and the percent of acetic acid in the toddy palm vinegar was calculated (Onuorah Samuel, 2016).

$$\text{Acetic acid \%} = \frac{\text{mass of acetic acid}}{\text{mass of vinegar}} \times 100$$

## Results and Discussion

In this work, vinegar was produced by natural fermentation of toddy palm juice. The physico-chemical properties of fresh toddy palm juice are shown in Table 1. The fresh toddy juice had the pH value of 6.8 and was found to be within the respective limits of pH of 6.00-7.20 in fresh palm sap reported by *Barh*. The main ingredient of the fresh palm sap is sucrose and present 13% in fresh toddy but there was very little reducing sugar of 0.000. The soluble solids content was 24 % and alcohol content was 2.16 % in fresh toddy.

The effect of fermentation time on the some properties of toddy palm wine was determined and the results are shown in Table 2 and Table 3. During fermentation, the fresh toddy was found to be turbid, more whitish in color and fermentative odor. The values of pH were found to be decreased during primary fermentation of about 4 days but the titratable acidity was increased. The maximum alcohol content was obtained after 6 day fermentation time in natural fermentation method and 5 days in additional yeast fermentation. The physico-chemical characteristics of toddy palm wine were presented in Table 4 and compared with literature values. Because of the highest alcohol content, the most suitable fermentation time was 6 days for natural fermentation and 5 days for additional yeast fermentation. It was observed that the microorganism like yeast and lactic acid bacteria were found in the toddy palm wine when they were naturally present in collecting with mud pots and these microorganisms were retained during previous collection of toddy served as an inoculum. The yeast multiplied and also utilized the total soluble solids and carbohydrates in the toddy and fermented to make it alcoholic. Meanwhile, the lactic acid bacteria increased the acidity and ascorbic acid content. It was noted that the presence of high alcohol content in the toddy palm wine were suitable for the production of vinegar.

Tables 5 and 6 showed the effect of fermentation time on acetic acid content, pH and alcohol content of toddy palm vinegar. The acetic acid content of the vinegar was lowest 3.02 % during the first week of fermentation of the alcohol with *Acetobacter aceti* but increased to 23.65 % during the fifth week of fermentation. In addition, the pH decreased progressively from 4.4 during the first week of fermentation of the alcohol to 3.5 during the fourth week of the fermentation. This result indicated that *Acetobacter aceti* has the ability to oxidize significant quantities of ethanol under the acidic conditions created by the presence of acetic acid and agreed with the work of Stanier and Hickey.

The physico-chemical characteristics of prepared toddy palm vinegar were compared with literature value in Table 4. From this result, it was found that the most favourable properties were obtained from the vinegar prepared by natural fermentation.

Table 8 illustrated the comparison of the physico-chemical characteristics of fresh toddy juice, toddy wine and toddy palm vinegar. The results confirmed that the *Acetobacter species* were better adapted to higher ethanol concentrations and thus tolerance of the bacteria to high alcohol content and high production of acetic acid in vinegar. Table 9 indicated that the organoleptic properties of vinegar prepared by natural fermentation were more favourable than additional yeast fermentation.

Table (1) Characteristics of Fresh Toddy Palm Juice

Sr. No.	Properties	Fresh Toddy	Literature Value*
1	pH	5.3	5.5
2	Acidity (%)	0.657	0.2
3	Soluble Solid (°Brix)	24	22
4	Reducing Sugar (g/mL)	6.036	8.5
5	Total Sugar (g/mL)	13.0	10.78
6	Specific gravity	1.00	-
7	Alcohol Content (%)	2.16	0-2

\*Nguuyen, 2014

Table (2) Effect of Fermentation Time on Properties of Toddy Palm Wine by Natural Fermentation

Sr. No.	Properties	Fermentation Time (days)						
		1	2	3	4	5	6	7
1	pH	5.5	5.3	4.32	3.96	3.95	3.93	3.93
2	Acidity	0.10	0.31	0.48	0.53	0.66	0.77	0.45
3	Specific gravity	1.020	1.035	1.040	1.050	1.060	1.065	1.060
4	Alcohol Content (%)	2.8	4.3	5.1	6.5	7.9	8.6	7.9

Table (3) Effect of Fermentation Time on Properties of Toddy Palm Wine by Additional Yeast Fermentation

Sr. No.	Properties	Fermentation Time (days)						
		1	2	3	4	5	6	7
1	pH	5.3	4.95	4.21	3.74	3.94	3.93	3.84
2	Acidity (%)	0.26	0.48	0.56	0.63	0.77	0.75	0.47
3	Specific gravity	1.030	1.040	1.045	1.055	1.065	1.060	1.055
4	Alcohol Content (%)	3.6	5.1	5.8	7.2	8.6	7.9	7.2

Table (4) Characteristics of Toddy Palm Wine

Sr. No.	Properties	Prepared Toddy Palm Wine		Literature Value*
		Natural Fermentation	Additional Yeast Fermentation	
1	pH	3.93	3.94	4.79
2	Acidity	0.77	0.77	0.99
3	Soluble Solid (°Brix)	6.0	6.2	6.0
4	Reducing Sugar(g/mL)	0.81	0.76	0.24
5	Total Sugar (g/mL)	3.80	3.65	0.33
6	Specific gravity	1.065	1.065	-
7	Alcohol Content (%)	8.6	8.6	12.5

\*Nguuyen, 2014

Table (5) Effect of Fermentation Time on Acetic Acid Content of Vinegar by Natural Fermentation

Sr. No.	Properties	Fermentation Time (weeks)					
		1	2	3	4	5	6
1	Acetic acid (%)	3.022	5.8	11.2	17.81	23.65	23.65
2	pH	3.93	3.70	3.61	3.50	3.09	3.10
3	Alcohol content (%)	8.6	5.8	2.8	1.2	0.4	-

Table (6) Effect of Fermentation Time on Acetic Acid Content of Vinegar by Additional Yeast Fermentation

Sr. No.	Properties	Fermentation Time (weeks)					
		1	2	3	4	5	6
1	Acetic acid (%)	3.1	4.5	10.9	15.5	19.1	19.2
2	pH	3.84	3.71	3.63	3.56	3.08	3.13
3	Alcohol content (%)	7.9	5.1	3.6	1.2	0.4	-

Table (7) Characteristics of Toddy Palm Vinegar

Sr. No.	Properties	Prepared Toddy Palm Vinegar		Literature Value*
		Natural Fermentation	Additional Yeast Fermentation	
1	pH	3.10	3.13	3.5
2	Acidity (%)	0.045	0.046	0.049
3	Soluble Solid (°Brix)	6.5	6.8	6.7
4	Reducing Sugar (g/mL)	0.45	0.21	0.3
5	Total Sugar (g/mL)	-	-	-
6	Specific gravity	1.01	1.015	-
7	Alcohol Content (%)	-	-	-
8	Acetic Acid (%)	23.65	19.2	7.1

\*Nguuyen, 2014

Table (8) Characteristics of Fresh Toddy Palm Juice, Toddy Palm Wine and Toddy Palm Vinegar

Sr. No.	Properties	Fresh Toddy Palm Juice	Toddy Palm Wine	Toddy Palm Vinegar
1	pH	5.3	3.59	3.10
2	Acidity	0.0657	0.5037	0.045
3	Soluble Solid	24	6.0	6.5
3	Reducing Sugar	6.036	0.81	0.45
4	Total Sugar	13.0	3.80	-
5	Specific gravity	1.02	1.065	1
6	Alcohol Content	2.16	8.8	-
7	Acetic Acid (%)	0.39	3.022	23.65
8	Microbial Examination	Lactobacilous	Lactobacilous	Acetobacilous & Lactobacilous

Table (9) Organoleptic Properties of Toddy Palm Vinegar

Sr. No.	Properties	Toddy Palm Vinegar	
		Natural Fermentation	Additional Yeast Fermentation
1	Colour	white	Pale yellow
2	Odour	Sharp smell	Sharp smell
3	Taste	sour	Sour with slightly yeasty

### Conclusion

It is believed that this research would be a valuable contribution to the production of vinegar from toddy palm juice by naturel fermentation. The native yeast *Saccharomyces cerevisiae* produced a high ethanol with 8.8 % at 24 °Brix toddy palm juice within 7 days. Moreover, *Acetobacter aceti* bacteria in toddy palm juice produced high acetic acid 23.65 % after 5 weeks. The native yeast and bacteria have efficiency to ferment the toddy palm juice to alcohol and oxidation of alcohol to vinegar. It can be concluded that this research will fill the gap of the local requirement of food additive for the appropriate purposes. Therefore, the processing of vinegar would be an alternative way, and toddy palm juice was a promising source of vinegar for the healthy food.

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### References

- Ariyasena, D. D., Jansz, ER., Jayesekera, S. and Abeysekara, AM. 2000. Inhibitory effect of bitter principle of palmyrah (*Borassus flabellifer* L) fruit pulp on the growth of mice: evidence using bitter and non-bitter fruit pulp. *Journal of the Science of Food and Agriculture* 80: 1763-1766.
- Artnarong, S., Masnuyom. P., and Maneesri.J., (2016), Isolation of yeast and acetic acid bacteria from palmyra palm fruit pulp (*Borassus flabellifer* Linn.), *International Food Research Journal* 23(3): 1308-1314
- Chandrasekhar, S, Sreevani. P, Seshapani. J and Pramodhakumari, (2012), A Review on palm wine. *International Journal of Research in Biological Sciences* 2(1): 33-38.
- Falcone, P. M., and Giudici. P., (2008),. Molecular size and molecular size distribution affecting traditional balsamic vinegar aging. *Journal of Agricultural and Food Chemistry*, Vol. 56, No. 16, 7057-7066, 2008. DOI: 10.1021/jf800706g.
- Ghosh, S., Chakraborty. R., and Raychaudhuri. U., (2012), Study on Fermentation Conditions of Palm Juice Vinegar by Response Surface Methodology and Development of a Kinetic Model, *Brazilian Journal of Chemical Engineering*, Vol 29, No 03< pp 461-472, www.abeq.org.br/bjche
- Morton, J. F., (1988), The Palmyra or Toddy Palm (*Borassus flabellifer* L.), Notes on Distribution, Propagation, and Products of *Borassus* Palms (Arecaceae). *Economic Botany* (1988) 42(3): 420-441
- Nguyễn thị Minh Ngọc, Nguyen Phuoc Minh, Dong Thi Anh Dao, (2014), Different Processing Conditions Affect Palm (Thot Not) Wine Fermentation, *American Journal of Research Communication*, 2(1): 142-157, www.usa-journal.com ISSN:2325-4076
- Pearson, D., 1976, "The Chemical Analysis of Foods", 7<sup>th</sup> Edition, Medical Division Longman Group Limited.

- Onuorah, S., Josen. L., Obika. I., (2016), Production of Vinegar from Oil-palm Wine Using Acetobacter Aceti Isolated from Rotten Banana Fruits, Universal Journal of Biomedical Engineering 4(1): 1-5, DOI: 10.13189/ujbe.2016.040101, <http://www.hrpub.org>
- Shetty, P., Souza.A.D., S Poojari.S., Narayana.J., Rajeeva.P., (2017), Study on Fermentation Kinetics of Palm Sap from Cocos nucifera, International Journal of Applied Sciences and Biotechnology (IJASBT), Vol 5(3): 375-381, ISSN:2091-2609
- Singaravadivel, K., Alagusundaram. K., and Harlharan. B., (2012) Physicochemical Properties of Fresh and Stored Coconut Palm Toddy, 1:397, <http://dx.doi.org/10.4172/scientificreports.397>
- Vengaiiah. P.C., Ravindrababu. D., and Prasad. KR., (2017), Jaggery from Palmyrah palm (Borassus falbellifer L.) Present status and scope, Indian Journal of Traditional Knowledge, Vol 12 (4) pp 714-717
- Walter, S., and Charles, M., Determination of Acetic Acid Content of Vinegar, Natural Sciences, Baruch College, New York, NY 10010

### Websites

<http://www.wikipedia.org/wiki/Borassus>  
[www.live-less-ordinary.com](http://www.live-less-ordinary.com)  
[http:// www.traveltomyanmar.com](http://www.traveltomyanmar.com)  
<http://www.en.wikipedia.org/wiki>  
[http:// www.practicalaction.org](http://www.practicalaction.org)  
<http://www.sstmyanmar.com>  
<http://www.winemakersacademy.com>  
<http://www.gwi.missouri.edu/publications/2013spring.pdf>  
<http://www.research.wineaustralia.com>  
[http://www.cc.edu/ruthrusso /files/Reducing-Sugars2.p.com](http://www.cc.edu/ruthrusso/files/Reducing-Sugars2.p.com)  
<http://www.livestrong.com>