International Journal of Research (IJR)

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

Effect of Sugar Cane Juice Substrate Formulation and Fermentation Duration on the Quality of Simulated Palm Wine

[1]Casmir C. Okoro
Department of Food Technology, Yaba College of Technology Yaba, Lagos.
Email: emoko102003@yahoo.com
Corresponding Author

[2]Dr. Caroline I. Anyakorah
Department of Biological Sciences
The Bells University of Technology, Otta, Ogun State

[3]Dr. Jimoh Musa O.
Department of Food Science and Technology
The Bells University of Technology, Otta, Ogun State

[4]Dr. Obi Christianah C.
Department of Biological Sciences
The Bells University of Technology, Otta, Ogun State

[5]Dr. Tajudeen A. Bamidele
Department of Molecular Biology and Biotechnology
National Institute of Medical Research Yaba, Lagos

ABSTRACT

Palm wine is obtained from palm sap tapped from oil palm tree (Elaeise guineenses) or raffia palm (Raphia hookeri) and subsequent spontaneous fermentation by yeast (Saccharomyces cerevisiae). This study is aimed at determining the effect of sugar cane juice substrate formulation and fermentation period on the quality of simulated palm wine produced using a locally fabricated fermenter, with yeast isolated from palm wine. Sugar cane juice was blended with water at the ratios of 100:0, 70:30 and 50:50 % and subjected to regulated fermentation in the fermenter for 12, 24 and 48 hours respectively. The quality of the simulated palm wine was determined using sensory evaluation and physiochemical analyses. The result showed that samples containing 70:30 % and fermented for 24 hours ($H_{24}Z$ and $S_{24}T$) had higher ethanol values (8.47 : 7.00%), higher pH (4.34 :4.10), higher sucrose (8.03 :3.65%) and higher total soluble solids (8.35:6.06%) than samples produced from a blend of 100:0 % or 50:50 % and fermented for 12 or 48 hours. Samples $H_{24}Z$ and $S_{24}T$ had values that were not significantly different from those of natural palm wine($P_{24}M$) ; ethanol (6.16 %), sucrose (4.17 %) and pH (4.10) respectively. The sensory evaluation result showed that samples $H_{24}Z$ and $S_{24}T$ were the most preferred by the panelist in terms of taste, smell, color, sweetness and their scores were comparable to those of natural palm wine. Conclusively, the quality of the produced simulated palm wine was influenced by the sugar cane juice: water blend ratio and the fermentation period.

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023
DOI: https://doi.org/10.5281/zenodo.11177860

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

Keywords: *Palm wine, sugar cane juice, simulated palm wine, Saccharomyces cerevisiae, fermentation.*

1.1 INTRODUCTION

There is scarcity of natural palm wine while the demand for palm wine is in the increase (Onuche, 2012; and Ikegwu 2014). The annual demand for palm wine has been reported to be 28.2million litres while the supply is 20% of the annual demand (Mora and Muis 2020). Obtaining good quality palm wine requires climbing the palm tree two or three times a day to tap the sap or to cut down the palm tree. These are entrenched with fatality, injury and loss of palm trees. Up to 18-25% of tappers falling from palm tree have been reported dead (Onuche, 2012).

There is a noticeable dearth of tappers of recent, as the original tappers are getting older the younger men are not showing interest in palm wine tapping as a career (WHO, 2007; Mbuagbaw and Noorduyn, 2012). There is compelling need to fabricate a fermenter that could be suitable for fermentation to produce a beverage with palm wine-like characteristics industrially, with minimal dependence on climbing of palm trees or cutting down palm trees .

1.2 Aim and Objectives of the Research

The study is aimed at producing simulated palm wine from formulated sugar cane juice as an alternative to palm sap and fermenting the juice in the fabricated fermenter using *Saccharomyces cerevisiae* isolated from palm wine. This aim could be achieved using the following specific objectives:

(1) To design and fabricate a basic fermenter for simulated palm wine production
(2) To extract, process and formulate sugar cane juice into fermentable substrate as palm sap substitute for simulated palm wine production.
(3) To isolate S*accharomyces cerevisiae* that will serve as starter culture for simulated palm wine production
(4) To produce fermented simulated palm wine and to compare its quality with that of natural palm wine.
(5) To determine the physicochemical and sensory quality of simulated palm win

2.0 MATERIALS AND METHODS

2.1 Sourcing of Fresh Palm Wine Samples for Isolation of Yeast.

Fresh palm wine samples obtained from oil palm tree species (*Elaeis guineensis*) was sourced from Mowe and Sango in Ogun State, Nigeria. The fresh palm wine samples were purchased from the tappers as they alighted from the palm trees on the arranged days at between 6:30am to 8:00am. The sap were collected in sterile bottles (1500 ml) and placed in ice packed bags and taken to the laboratory for yeast isolation and microbial analysis.

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023
DOI: https://doi.org/10.5281/zenodo.11177860

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

The sourced palm wine samples were stored at room temperature for 12 h, 24 h and 48 h and used as a reference or comparison with produced simulated palm wine samples fermented for 12, 24 and 48 h respectively.

2.2 Description of the designed and fabricated fermenter

The locally fabricated fermemter (Figures 1-3) is made up of three vessels; namely fermentation vessel (FV), which has capacity of 4 L and made of stainless steel with a covering lid. The fermentation vessel is used as the propagation vessel for the yeast and also served as the vessel where initiation of fermentation occurred. The substrate was usually filled into the FV through the feeder funnel (FF). Centrally mounted in the fermentation Vessel (FV) is the triple bladed stainless steel mixer (M) used for the intermittent stirring of the substrate during the propagation and fermentation periods. The fermentation vessel is connected to the immobilization vessel (IV) with stainless steel pipe of 0.01 m diameter. Connected to this pipe are the substrates sampling tap (ST) and a flow control valve (CV_1). The control valve is used to control the flow of the substrate into the immobilization vessel. The sampling tap is used for taking samples for analysis in the course of fermentation process. The immobilization vessel is also made of stainless steel and has capacity of 2 L. The immobilization vessel is stuffed to two-third of its capacity with the loofa-loofa sponge (*Luffa cylindrica*). The loofa sponge has average aperture size of 0.001 m and is made of fibro-vascular reticulated structure with an open network of random lattice of Small cross sections. According to Saeed *et al.,* (2013) loofa-loofa sponge has very high porosity (79-93 %), with very low density 0.02-0.04 g/cm and high specific pore volume 21-29 cm/g and its performance as an immobilization matrix ranks higher than in the conventionally used synthetic polymeric materials for the production of ethanol. The mesh is used to retain, restrain and immobilize most of the yeast within the mesh and to sieve out some of the debris contained in the fermenting substrate as it flows through the immobilization vessel. The immobilization vessel is connected to the retaining vessel (RV) with stainless steel pipe 0.15 M long and 0.01m diameter. The flow through this pipe is regulated with control valve (CV_2) connected to it. The (RV) has 4L capacity and functions as the receiver of the fermented simulated palm wine samples before being dispensed into receiver bottles through the outlet tap (OT) connected to the base of the receiving (RV) vessel. The components of the fermenter are made of stainless-steel pipes, vessels taps, lids and valves as to achieve sanitary conditions required for fermenter design conditions as recommended by Gaikward *et al., (*2018) for fermenter components to prevent rusting and other reactions. These vessels and their piping arrangements were all mounted on the carrier iron stand (IS) and connected to ensure the continuous flow of substrate under gravitational force at a gradient of 1.3:1.2:1.0 (FV: IV: RV).

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023
DOI: https://doi.org/10.5281/zenodo.11177860

International Journal of Research (IJR)

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

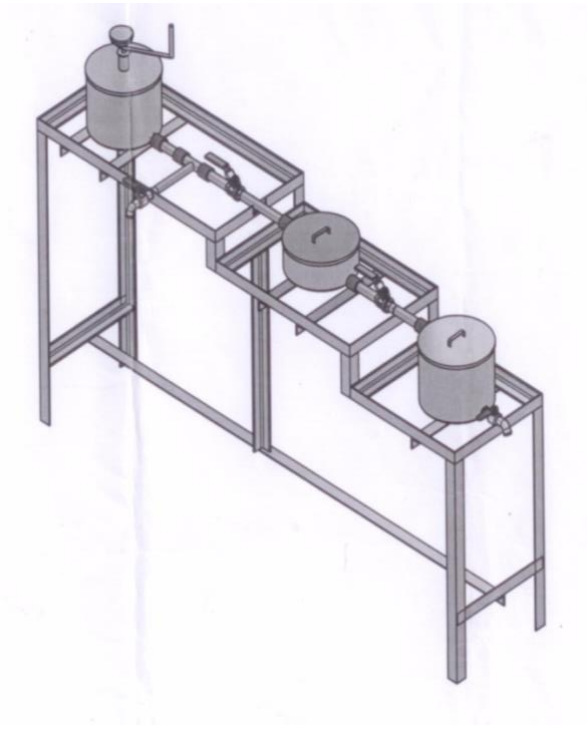


Figure 2.1: Engineering drawing of the locally fabricated fermenter



PART LIST

ITEM	QTY	PART NUMBER	MATERIAL	
1.	1	Fermentation Vessel Cover	Stainless Steel	FVV
2	1	Feeder Funnel	Stainless Steel	FF
3	1	Frame	Mild, Steel	FM
4	1	Fermentation Vessel	Stainless Steel	FV
5	1	Mixer	Stainless Steel	MX
6	1	Funnel Cover	Stainless Steel	CF
7	2	Vessel Cover	Stainless Steel	VC
8	1	Retaining Vessel	Stainless Steel	RV
9	1	Immobilization Vessel	Stainless Steel	IM
10	1	Control Valve	Generic	CY
11	1	Tap	Stainless Steel	TP
12	1	Pipes	Stainless Steel	PP

Figure 2.2: Exploded drawing of the components of the fermenter

DOI: https://doi.org/10.5281/zenodo.11177860

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

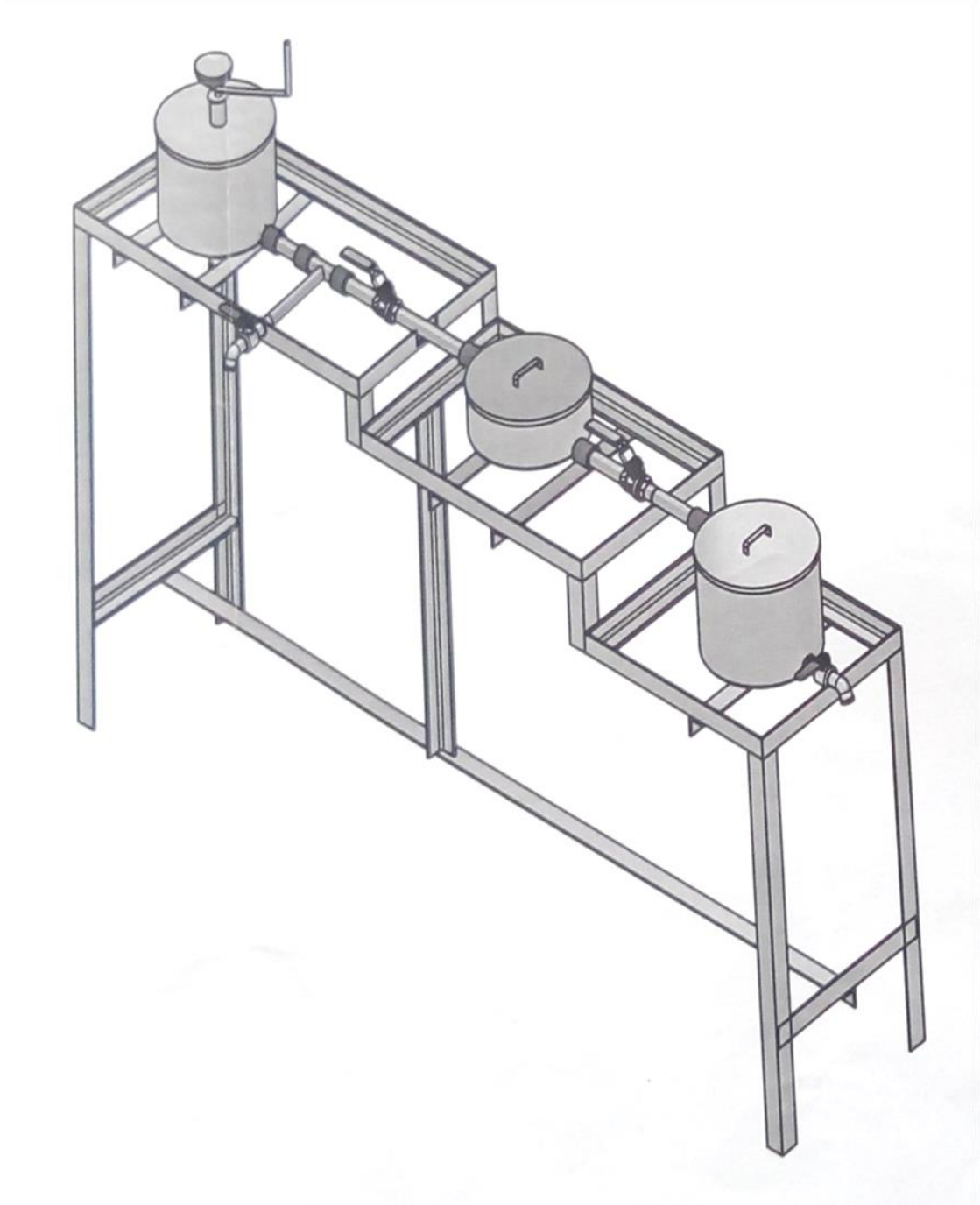


Figure 2.3: 3D design of the fermenter

2.3 Sugar cane Juice Extraction and Formulation for simulated palm wine production

Freshly harvested sugarcane stalk *(Saccharum officinarum)* of the purple-red variety was purchased from Idi-oro market, Mushin Lagos State .The sugar cane juice was extracted following the modified procedure of Geremias-Andrades, (2014). The process involved washing the canes with sterile water, then sorting the stems; after which they were peeled with sharp stainless-steel knives. The canes were cut and their juice expressed out using the sugar cane juice extractor (Model: Omega NC800HDS).The extracted juice was pasteurized at 70 ^{o}C for 10mins and allowed to cool to room temperature (25 ± 2 ^{o}C) after which, the juice was filtered to remove sediments in the juice.

The sterilized sugarcane juice was blended with sterilized water at the ratio of 50% sugar cane juice to 50% water (50:50) FOF; 70% sugar cane juice to 30% water SOT (70:30) and 100% sugar cane juice to 0% water HOZ (100:0). These blend ratios were formulated respectively as substrate for producing the simulated palm wine

Sugar Cane Juice	(The purple red variety)
↓	
Washing	(with clean water)
↓	
Extracting	(using the compressive juice extractor)
↓	
Formulating	(HOZ, SOT, FOF)
↓	
Pasteurizing	(at 70^{o}C for, 10mins)
↓	
Cooling	(to 25^{o}C ± 2^{o}C)
↓	
Filtering	(to remove sediments)
↓	
Filling	(into fermentation vessel)
↓	
Seeding	(at ratio of 1:3, yeast to substrate)
↓	
Propagation	(with intermittent stirring)
↓	
Fermenting	(for 12, 24, 48 h respectively)
↓	
Filtering	(with loofa sponge)
↓	
Filling/Corking	(into 50cl bottle)
↓	
Pasteurizing	(at 70^{o}C for 10mins)
↓	
Cooling	(to room temperature 25 ± 2^{o}C)

Figure 2.4: Extraction of sugar cane juice and Formulation of substrate for simulated palm wine production

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023
DOI: https://doi.org/10.5281/zenodo.11177860

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

2.4 Microbial Analysis

2.4.1 Identification, characterization and isolation of palm wine yeast

Pure *Saccharomyces cerevisiae*a was isolated from fresh palm wine sourced from Mowe ($P_{12}M$) and Sango ($P_{12}S$). The yeast was identified using serial dilution and morphological characterization as described by Ben David et al., (2014); Allen (2013) and Onwuamah et al., (2019). The isolated *Saccharomyces cerevisiae*a were further confirmed using molecular characterization procedure of Ebabhi (2013) and as elaborated using DNA extraction protocol, PCR-amplification and sequencing procedures (Zymo Research purification procedure, 2012)

2.4.2 Propagation of Isolated *Saccharomyces cerevisiae*

Pure *Saccharomyces cerevisiae* colony was obtained from the pure culture plate and dispensed in 10ml sterile water contained in 10ml sterile tube. The quantity of cells dispensed was sufficient to create a turbidity equivalent to 2% McFarland standard solution turbidity. 2% McFarland solution turbidity is equivalent to 4.0×10^{-4} CFU/ml. Twenty (20) ml of the suspended yeast cells (equivalent of 4.0×10^{8} cfu/ml) was dispensed in one (1) L sterile sugarcane juice and placed in water bath shaker at $28 \pm 2\ ^{\circ}C$ (Clifford digital water-bath shaker, UK). The yeast was allowed to grow aerobically under constant agitation for 24 h. This enabled the yeast to grow and build up actively to be used as the starter culture for the simulated palm wine production.

2.5 Fermentation of simulated palm wine using the locally fabricated fermenter

The locally fabricated fermenter was first sanitized by washing it thoroughly with water containing detergent; after which, it was cleaned up with 98% ($^{v}/_{v}$) ethanol, before it was finally flushed with boiled water. After the sanitization operation, 3 L respectively of the formulated sterilized sugar cane juice substrate sterilized sugar cane juice substrate was poured into the fermentation vessel followed by inoculating one 1 L of the propagated vigorously growing *Saccharomyces cerevisiae* into the vessel and these were mixed very well and subjected to a regulated fermentation period. The fermentation period was split into three periods; namely, the 12 h, 24 and the 48 h fermentation period for each of the blend ratios of 100:0 %, 70:30 % and 50:50 % respectively.

The fermentation process involved allowing the substrate to flow at predetermined velocities from the FV into IV and then into the RV respectively .For the 12 h fermented simulated palm wine, the flow rate was regulated to allow the fermenting substrate to flow from the fermentation vessel (FV) into the immobilization vessel (IV) at the predetermined rate of 0.33 ($^{L}/_{h}$) and from the (IV) into the retainer vessel (RV) at the rate of 0.17 ($^{L}/_{h}$) over a period of 12 h and this sample were designated as 12 h fermented simulated palm wine samples ($F_{12}F$, $S_{12}T$ and $H_{12}Ƶ$) respectively. For the 24h fermented simulated palm wine, the substrate was made to flow from the fermentation vessel (FV) at the rate of 0.17($^{L}/_{h}$) into the immobilization vessel (IV) and from the IV into the retainer vessel (RV) at the rate of 0.08 ($^{L}/_{h}$) over a period of 24 h. The samples collected were designated as samples $F_{24}F$, $S_{24}T$ and $H_{24}Ƶ$ respectively. For the 48 h fermented simulated palm wine samples, the substrate were made to flow from the fermentation vessel (FV) into the immobilization vessel IV at the rate of 0.083 ($^{L}/_{h}$) and from the (IV) into the retainer vessel (RV) at the rate of 0.043 ($^{L}/_{h}$) over a period of 48 h. The samples collected from the RV were designated samples $F_{48}F$, $S_{48}T$ and $H_{48}Ƶ$ respectively.

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

DOI: https://doi.org/10.5281/zenodo.11177860

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

Each set of fermented simulated palm wine samples were filtered and filled into 350 cm^3 bottles, they were corked, pasteurized at 70°C for 10 min and cooled to 25 °C and kept for further use in the refrigerator at 5 ± 2 °C. The quality of the samples produced ($F_{12}F$, $S_{12}T$, $H_{12}Ƶ$, $F_{24}F$, $S_{24}T$, $H_{24}Ƶ$,$F_{48}F$, $S_{48}T$, and $H_{48}Ƶ$; $P_{12}M$,$P_{24}M$ and$P_{48}M$) were determined by carrying out physiochemical studies and sensory evaluation on the samples.

The parameters determined included: Total soluble solids, total sugar, ethanol, total acidity, pH, Invert sugar , ash and protein content .These were determined using the AOAC(,2019) methods of analysis.

2.6 Physiochemical Analysis of the Samples

The physiochemical compositions of the natural palm wine, sugar cane juice substrate and the produced simulated palm wine were determined using the AOAC (2019) method of analysis. The parameter analyzed included the total soluble solids, sucrose, invert sugar and ethanol content, total ash, crude fat, crude protein, vitamin C, pH and total acidity.

2.7 Sensory Evaluation of the Produced Simulated Palm Wine Samples

The samples produced ($F_{12}F$, $S_{12}T$, $H_{12}Ƶ$, $F_{24}F$, $S_{24}T$, $H_{24}Ƶ$, $F_{24}F$, $S_{24}T$) and samples from natural palm wine ($P_{12}M$, $P_{24}M$, $P_{48}M$ were presented to a-40 member sensory panelist selected from ladies and gentlemen above 18 years of age who are used to drinking palm wine and could distinguish sensory attributes of palm wine. These panelists were further trained on the quality characteristics of good palm wine.

They were instructed to evaluate the sensory characteristics of the samples based on their colour, taste, palm wine smell, sweetness and overall acceptability, using a 9-point hedonic scale that ranged from 9-like extremely, 8-like very much, 7-like moderately, 6-like slightly, 5-neither like nor dislike; 4-dislike slightly, 3-dislike moderately, 2-dislike very much and 1-dislike extremely. They were asked to express their perception of the samples presented and score the parameters on their resemblance to natural palm wine samples using the accompanying questionnaire.

2.8 Statistical Analysis

Data obtained from physiochemical and sensory analysis were collated, means were determined and the level of differences between means were statistically analyzed for significant effect on the analyzed parameters at 5% level of significance using analysis of variance (ANOVA) of SPSS version 2.1 as described in the method of Akinjayeju (2017).

3.0 RESULTS AND DISCUSSION

3.1 Fermenter Design and Fabrication

The locally fabricated fermenter (figure 2.1 – 2.6) was designed to create a bioreactor environment conducive for yeast fermentation in order to produce an acceptable simulated palm wine. The variation in the volume capacities of the vessels was to ensure continuous flow of substrate from the fermentation vessel (FV) to the immobilization vessel (IV) and from the immobilization vessel (IV) to the retainer vessel (RV) under a batch fermentation process. This

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

DOI: https://doi.org/10.5281/zenodo.11177860

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

process ensured that sugars in the substrate are in real time contact with the yeast, thereby facilitating fermentation. According to Saheed and Igbal (2013) the continuous real time contact of sugar with yeast enhanced the rate of fermentation rate and alcohol yield. This is further enhanced by ensuring that at all times during the fermentation period the substrates flowed from the FV into the IV and then into the RV. The continuous contact of the substrate with the yeast is engineered into the design by incorporation of the loofa sponge in the (IV) and by making the FV to have the same volume with the retainer vessel (RV). The volume of the FV and RV were made equal (4L) to ensure that even as the samples dripped into the retainer vessel, fermentation will still be going on until the whole fermenting batch volume discharges completely into the retainer vessel.

The flow regime across the vessels during the various fermentation periods was continuous all through the respective 12, 24 and 48 h fermentation period. This created a non – stagnant flow situation, thereby bringing about intimate contact between the yeast and the sugar in the substrate, with resultant increase in alcohol yield and diminished product inhibition. According to (Saheed and Igbal, (2013) and Gaikward *et al.*, (2018) the longer the contact time between substrate and the yeast the higher the rate of fermentation and the higher the alcohol yield.

The regulated slow flow rate (0.048 - 0.17 $^{L}/_{h}$) achieved in the design of the locally fabricated fermenter is akin to the drip-drop pattern of palm sap as it oozes out from the cut base of the inflorescent flower during the taping of the palm sap and this is consistent with the description of the flow pattern of palm sap during the taping of palm sap (Onuche *et al.,* 2012 and Ikeagwu *et al 2014).*

The effectiveness of the locally fabricated fermenter was further enhanced by the in-built Loofa sponge in the immobilization vessel. The sponge had mesh aperture size of between 0.0048 – 0.0062 m that could trap, retain and delay the rate of yeast cell escape and flow rate. As the substrate flowed through the sponge matrix, it experienced slow flow rate and longer contact time, larger surface area, increased fermentation rate and higher alcohol yield in the product. This is consistent with the report of Saheed et al., (2013) that loofa sponge acts as immobilizer of yeast cells in bioreactors to enhance the rate of fermentation and alcohol yield.

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

DOI: https://doi.org/10.5281/zenodo.11177860

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

Table 3.1:
Design parameters and results obtained from the locally fabricated fermenter

Parameters	FV	IV	RV
Height (m)	0.154	0.075	0.154
Radius (m)	0.091	0.091	0.091
Volume (πr^2h) (m^3)	4	2	4
Flow rate during 12 h fermentation($^{L}/_{hr}$)	0.33	0.17	
Flow rate during 24 h fermentation($^{L}/_{hr}$)	0.17	0.08	
Flow rate during 48 h fermentation($^{L}/_{hr}$)	0.083	0.043	
Distance between FV – IV (m)		0.3	
Distance between IV – RV (m)			0.15
Distance between FV – RV (m)			0.45
Fermenter elevation (m)	0.80	0.80	0.67
Gradient ratio	1.3	1.2	1.0
Fermentation Temperature ^{o}C	25-28 ℃	25-28 ℃	25-28℃

FV: Fermentation vessel
IV: Immobilization vessel
RV: Retainer vessel

3.2 Physiochemical Composition of Extracted and Formulated Sugar Cane Juice Substrate

The sugar cane variety *Saccharum officianarum*, was particularly used for the research because of its high yield of sugar cane juice (35% - 46% $^{v}/_{wt}$) and its high content of sucrose (9.03% - 12.5%), other sugars and minerals useful for fermentation. Table 3.2 showed that the concentration of sucrose obtained was in the range of 9.01 – 9.02% which compared well with the yield of 10 – 12% sucrose reported by Arif *et al.,* (2019).

The pasteurization of the juice of 70^{o}C for 10 mins was necessary in order to denature enzymes that could cause enzymatic browning reactions. The pasteurization of the sugar cane juice also helped to destroy microorganism that causes diseases and that could be antagonistic to yeast during fermentation (Kunitak *et al.,* 2014). It also contributed to the denaturation of suspended organic matters contained in the sugar cane juice. The pasteurization of the juice not only kills microorganism but also helps produce a more clear coloured sugar cane juice as according to Geremias –Andrades et al.,(2014) the denatured organic materials clog together on cooling and are easily filtered off leaving behind a clearer juice suitable for fermentation operation.

The dilution of the pasteurized sugar cane juice with water was in other to formulate three blends of the substrate (100:0 %, 70:30% and 50:50 %) water there by formulating three levels of substrate concentration that may be suitable for yeasts growth and fermentation and may lead to production of different qualities of simulated palm wine. This is corroborated by Barnett et al., (2016) that the dilution of sugar cane juice with water not only reduces the osmotic effect of high

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

DOI: https://doi.org/10.5281/zenodo.11177860

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

sugar concentration on yeast cells but may improve higher ethanol yield. The addition of water caused a dilution effect by lowering the sugar concentration in the 100% sugar cane juice from (9.03 %) to 5.15 % (SOT) and 4.46 % (FOF) respectively. However, these values were within the compositional range reported for palm sap by Karamako *et al.*(2016), which ranged from 2.5 – 9.5% for sucrose. The specific gravity (1.03 – 1.01), total soluble solid (9.7 – 4.46), pH (4.46 – 9.7 %) (Table 4.2) obtained in the sugar cane juice substrate formulation were also comparable to those reported as being contained in palm sap; specific gravity (1.013 – 1.025), TSS (6.89 – 9.8 %) and pH (4.45 – 4.87) (Djeni *et al*., 2020).

These compositional variations occasioned by the dilution effect of water were to subject the yeast to various levels of sucrose, pH and other solids concentration in the different substrate samples in order to produce different variations in the quality of simulated palm wine that could be comparable to natural palm sap, from which an acceptable simulated palm wine samples could be selected based on their physiochemical analysis and sensory evaluation. This variation in the expected quality of the simulated palm wine could create variety in the samples and create different preference levels to the consumers. According to Santiago-Urbina and Ruiz-Terran, (2014) Ikegwu (2014) that palm wine quality varied depending on the source of palm sap, type of palm tree, stage of tapping, season of the year and method of tapping.

The pH (4.85 – 5.23) and total acidity (0.36 – 0.39) of sugar cane juice substrate were not significantly different amongst the samples blends and were also comparable to those reported for palm sap (pH 3.6 – 5.23) (TTA 0.1 – 0.3%) Ibegbulam et al., (2007) These pH and TTA ranges were also reported to be suitable for optimum yeast activity Ghosh *et al*., (2012). Table 3.3 further showed that the proximate composition of the formulated sugar cane juice substrate contained proteins (0.27 – 0.33%), fat (0.22 – 0.32%) Ash (0.16 – 0.20%), and vitamin C 40.05 – 40.70 mg/100ml that were comparable to those contained in the natural palm sap (Endo *et al.*, (2014) and Lucky *et al.*, 2014). The presence of these nutrients in the substrate at levels comparable to those in the natural palm sap showed that the formulated substrate could support the growth of yeast and could support yeast ability to ferment the sugars to alcohol. It is therefore most probable that an acceptable simulated palm wine could be produced using formulated sugar cane juice substrate and *Saccharomyces cerevisiae.*

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

DOI: https://doi.org/10.5281/zenodo.11177860

Table 3.2 Extraction and formulation of Sugar cane juice parameter

Parameter	Results
Mean juice yield	25 % - 46 %
Sucrose content	9-12 %
Pasteurization Temperature	70 ^{o}C for 10 mins
Storage temperature	5± 2 ^{o}C
Sugar cane juice:	water blend ratio
100 % sugar cane juice:	0 % water (HOZ)
70 % sugar cane juice:	30 % water (SOT)
50 % sugar cane juice:	50 % water (FOF)

Table 3.3: Physicochemical composition of formulated Sugar cane juice substrate

Means of sample with same alphabet superscripts on a row are not significantly different (P ≤ 0.05)

Sample	(HOZ)	(SOT)	(FOF)	F – Statistics (p)
TSS (%)	9.70± 0.14^{a}	7.19 ± 0.04^{b}	6.93 ± 0.05^{b}	594.66 (<0.001)
Sucrose (%)	9.03 ± 0.01^{a}	5.15 ± 0.04^{b}	4.46 ± 0.50^{b}	143.547 (0.001)
Invert sugar (%)	8.35 ± 0.07^{a}	4.80± 0.02^{b}	4.10± 0.16^{c}	979.092 (<0.001)
pH	5.23 ± 0.04^{a}	4.91 ± 0.15^{a}	4.85 ± 0.07^{a}	8.694 (0.056)
Total Acidity as Lactic acid (%)	0.36 ± 0.001^{a}	0.37 ± 0.01^{a}	0.39 ± 0.02^{a}	24.039 (0.014)
Vitamin C (mg/100ml)	49.05 ± 0.07^{a}	41.90± 0.28^{b}	40.70± 0.71^{b}	209.034 (0.001)
Specific gravity	1.03 ± 0.002^{a}	1.02 ± 0.001^{b}	1.01 ± 0.001^{b}	34.357 (0.009)
Glucose (%)	3.63 ± 0.05^{a}	2.71 ± 0.14^{b}	2.47 ± 0.07^{b}	81.197 (0.002)
Protein (%)	0.33 ± 0.01^{a}	0.31 ± 0.03^{a}	0.27 ± 0.01^{a}	6.333 (0.084)
Fat (%)	0.32 ± 0.01^{a}	0.30± 0.^{01a}	0.22 ± 0.01^{b}	112.000 (0.002)
Ash (%)	0.16 ± 0.03^{a}	0.20± 0.02^{a}	0.20± 0.02^{a}	1.441 (0.364)
Sodium	3.58 ± 0.01^{a}	3.77 ± 0.08^{a}	3.75 ± 0.07^{a}	6.032 (0.089)

HOZ: 100% Sugar cane juice with zero fermentation
SOT: 70% Sugar cane juice 30% water, with zero fermentation
FOF: 50% Sugar cane juice 50% water with zero fermentation

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

DOI: https://doi.org/10.5281/zenodo.11177860

3.3 Isolation and Characterization of Yeast Used For the Simulated Palm Wine Fermentation

The results obtained for the microbial population count from the sourced palm wine samples (Table 3.4) showed that all samples contained high population of yeast and lactic acid bacteria. The total lactic acid bacteria count ranged from 4.8 x 10^2cfu/ml to 5.2 x 10^3 CFU/ml, while the total yeast count ranged from 4.3 x 10^4 CFU/ml to 8.0 x 10^6 CFU/ml.

The morphological characteristics of the yeast obtained from palm wine sourced from Mowe $P_{12}M$ and Sango $P_{12}S$ (Table3.5) had morphological characteristics had oval shape; smooth texture, mucoid consistency, raised elevation and entire margin. The yeast was also gram positive and catalase positive. The result of the sugar fermentation test showed that the yeast could ferment sucrose, glucose, Lactose and maltose confirming them to be *Saccharomyces cerevisiae*.

Generally, the ability of yeast isolated from palm wine sourced from Mowe ($P_{12}M$) and palm wine from Sango ($P_{12}S$) (Table 3.6) to ferment, sucrose, glucose and lactose confirms the capacity of the yeast to ferment sugar and they may be very suitable for the production of simulated palm wine. According Ojo-Omoniyi (2020), *Saccharomyces cerevisiae* is mostly responsible for the fermentation of sugar in palm sap to alcohol. This also confirms their ability to utilize sugars and convert them to alcohol. This is consistent with the report of Ebabhi *et al*., (2013) and Ngoc *et al*., (2014) that *Saccharomyces cerevisiae* can utilize the carbon sources mostly from hexose sugars.

Table 3.4 Total microbial cell count of palm wine samples from different sources

Samples	Total Lactic Acid Bacteria Count TLABC (Cfu/ml)	Total Yeast and Mold Count TMYC (Cfu/ml)
$P_{12}M$	4.0 x 10^2	8.0 x 10^6
$P_{12}S$	3.4 x 10^3	7.25 x 10^5

Table 3.5: Morphological characterization of yeast isolates from palm wine samples from different sources

Palm wine Source	Consistency	Shape	Texture	Margin	Elevation	Gram test	Catalase Test	Colour
$P_{12}M$	Mycoid	Oval	Smooth/moist	Entire	Raised	+	+	Creamy white
$P_{12}S$	Mycoid	Oval	Smooth/moist	Entire	Raised	+	+	Creamy

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
DOI: https://doi.org/10.5281/zenodo.11177860
Copyright © authors 2023

International Journal of Research (IJR)

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

white

Table 3.6: Sugar Fermentation characterization of yeast isolates from palm wine samples

	Xylose	Dextrose	Sucrose	Glucose	Lactose	Galactose	Maltose
$P_{12}M$	-	-	+	+	+	+	-
$P_{12}S$	-	-	+	+	+	+	-

$P_{12}M$: palm wine from Mowes

$P_{12}S$: palm wine from sang

3.4 Effect of Fermentation Duration on Physiochemical Characteristics of the Simulated Palm Wine.

The physiochemical composition of simulated palm wine samples (Table 3.8 – 3.10) showed that during the 12 – 48 h fermentation period, there was observed decrease in the total soluble solid, total invert sugar, sucrose contents and specific gravity values of the samples with increasing fermentation period. The decrease of the fermentable sugars with fermentation duration gave a corresponding increase in alcohol production, hence the noticeable differences in percentage alcohol content of different samples (3.49 – 3.31% $^{v}/_{v}$) for 12 h fermented samples and (3.50 – 8.47% $^{v}/_{v}$) for 24 h fermented samples and (4.46 – 7.20% $^{v}/_{v}$) for the 48 h fermented samples. This increase in alcohol content may be as the result of fermentation of the sugar by yeast to produce alcohol and carbon dioxide. This is corroborated by works of Ejimofor *et al.,* (2023) where they obtained similar ethanol values ranging from 5.7-9.44 % ($^{v}/_{v}$)

This is also consistent with the report of Karamoko *et al.,* (2016) that 50% of sugars in palm sap are fermented to alcohol within few hours of tapping of the palm sap. The result showed that the alcohol content obtained after 12 h to 24 h fermentation of the sugar cane juice substrate (7.00 – 8.47%) were comparable to those obtained from 12 h old natural palm wine obtained from different sources; $P_{24}M$ (6.16) $P_{24}S$ (6.95). This is consistent with the result reported by Endo *et al.,* 2014 and Opara *et al.,*(2013) for alcohol content of 24 h fermented palm wine (7.10 % $^{v}/_{v}$). The alcohol content of samples $H_{24}Ƶ$ (8.47 %) was higher than that of samples $S_{24}T$ (7.00 %) and $F_{24}F$ (3.3%). The alcohol content of $H_{24}Ƶ$ (8.47 %) and $S_{24}T$ (7.00) were higher and significantly different from those obtained from natural palm wine samples $P_{24}S$ (6.95 %) and $P_{24}M$ (6.16 %). This could confirm the possibility of producing simulated palm wine from sugar cane juice diluted with 30 % water. Diluting the sugar cane juice with 50 % water with consequent

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023
DOI: https://doi.org/10.5281/zenodo.11177860

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

reduction in sucrose concentration may have caused the low yield of alcohol (3.31 – 4.6 % $^{v}/_{v}$) in the simulated palm wine samples.

Fermentation of the sugar cane juice substrates for 48 h produced simulated palm wine samples that had lower alcohol content 7.20 % ($H_{48}Ƶ$), 6.35 % ($S_{48}T$) 4.46 % ($F_{48}F$) than samples fermented for 24 h, $H_{24}Ƶ$ (8.47%), (7.00%) and $F_{24}F$ (3.50%). These results may have arisen from the possibility of lowering the activity of yeast due to the inhibitory effect of high alcohol concentration and additional oxidation of the alcohol to acetic acid. This may have resulted in the lowering the fermentation ability of yeast under these conditions. This is in tandem with the findings of Ubong and Godwin, (2017) and Opara *et al.*, (2013) that alcohol can be oxidized to acetic acid and the combined inhibitory effect of high acid and alcohol concentration may affect the metabolic activity of yeast.

The pH of the simulated palm wine samples varied very slightly from its initial high level of 4.45 – 4.91 for the 12 h fermented samples to 4.60 – 3.95 for the 48 h fermented simulated palm wine samples. As sugars in the substrate were fermented acids were also produced and the pH lowered. This may have resulted in the high values of pH of 12 h fermented simulated palm wine 4.45 ($H_{12}Ƶ$), 4.45 ($S_{12}T$) and 4.49 ($F_{12}F$); and the lower values of the 48 h fermented simulated palm wine samples $H_{48}Ƶ$ (4.35), $S_{48}T$ (4.15) and $F_{48}F$ (4.46). Generally, the pH of the simulated palm wine samples was comparable to the pH of natural palm wine (pH 4.3 -5.0) as reported by Ukwuru and Awah (2013). These values were consistent with the pH values obtained from palm wine sourced from Mowe $P_{12}M$ (4.05) and palm wine sourced from Sango $P_{12}S$ (4.10).

The acidity of the simulated palm wine which varied from the 12 h fermented simulated palm wine (0.30 – 0.37%) increased to (0.37 – 0.47%) for the 24 hr fermented simulated palm wine samples and to 0.40 – 0.50 for the 48 hr fermented simulated palm wine. The total acidity obtained for the fermented simulated palm wine samples (0.30 – 0.50%) were comparable to the TTA obtained by Karamako *et al.*, (2016) for natural palm wine (0.17 – 0.88%). This further showed that the acidity of the simulated palm wine were within the range acceptable for palm wine. Generally, as the acidity of the simulated palm wine increased, its pH decreased and the level of souring of the palm wine increased.

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023
DOI: https://doi.org/10.5281/zenodo.11177860

International Journal of Research (IJR)
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

Table 3.8: Physiochemical Composition of Simulated Palm Wine and Natural Palm Wine after 12 hours fermentation

Parameters	$H_{12}Ƶ$	$S_{12}T$	$F_{12}F$	$P_{12}M$	$P_{12}S$	F(p)
Total soluble solids (TSS %)	8.60 ± 0.73^{a}	6.19 ± 0.04^{ab}	5.93 ± 0.5^{c}	7.04 ± 0.20^{b}	5.70 ± 0.14^{c}	20.339 (0.003)
Sucrose %	8.80 ± 0.14^{a}	4.11 ± 0.02^{d}	4.09 ± 0.02^{d}	6.30 ± 0.28^{b}	5.70 ± 0.14^{c}	311.709 (<0.001)
Total sugar (as % invert)	8.35 ± 0.07^{a}	5.70 ± 0.00^{b}	3.75 ± 0.07^{c}	5.10 ± 28^{c}	5.70 ± 0.14^{b}	254.159(<0.001)
Glucose %	2.63 ± 0.05^{a}	2.71 ± 0.14^{a}	2.56 ± 0.01+	2.70 ± 0.14^{a}	1.95 ± 0.21^{b}	97.017 (< 0.001)
Specific gravity (SPG)	1.053 ± 0.00^{a}	1.036 ± 0.01^{b}	1.035 ± 0.01^{b}	1.020 ± 0.00^{c}	1.038 ± 0.00^{b}	13.695 (0.007)
Ethanol (% vv)	3.49 ± 0.10^{ab}	3.50 ± 0.04^{ab}	3.31 ± 0.01^{b}	3.57 ± 0.21^{ab}	3.74 ± 0.16^{a}	2.999 (0.130)
Ph	4.45 ± 0.07^{b}	4.45 ± 0.07^{b}	4.71 ± 0.15^{a}	4.05 ± 0.07^{c}	4.10 ± 0.14^{c}	20.689 (0.003)
Total Acidity (as Lactic) %	0.30 ± 0.01^{b}	0.37 ± 0.01^{b}	0.30 ± 0.2^{b}	0.69 ± 0.03^{a}	0.60 ± 0.14^{c}	15.360 (0.005)
Fat content (%)	0.22 ± 0.01^{c}	0.42 ± 0.01^{b}	0.22 ± 0.01^{c}	0.61 ± 0.04^{a}	0.33 ± 0.08^{b}	30.791 (0.001)
Protein (%)	0.33 ± 0.01^{c}	0.32 ± 0.04^{a}	0.37 ± 0.02^{a}	0.29 ± 0.01^{a}	0.19 ± 0.20^{a}	1.064 (0.451)
Total ash (%)	0.23 ± 0.02^{b}	0.20 ± 0.02^{b}	0.24 ± 0.01^{b}	0.30 ± 0.01^{a}	0.37 ± 0.08^{a}	5.890 (0.039)
Sodium (mg/100ml)	2.53 ± 0.064^{d}	3.77 ± 0.08^{c}	3.75 ± 0.07^{c}	27.10 ± 0.28^{a}	23.43 ± 0.21^{b}	10425.469 (<0.001)
Vitamin C (mg/100ml)	41.25 ± 0.78^{a}	41.30 ± 0.57^{a}	42.00 ± 0.14^{a}	8.95 ± 0.07^{c}	18.10 ± 0.99^{b}	1272.608 (<0.001)
Sodium chloride (%) 2.20 ± 0.14b	0.016 ± 0.01^{b}	0.018 ± 0.00^{b}	0.020 ± 0.00^{b}	0.075 ± 0.01^{a}	0.065 ± 0.01^{a}	50.544 (<0.001)
Sulphur dioxide (mg/kg)	2.00 ± 0.02^{b}	1.70 ± 0.72^{b}	2.20 ± 0.14^{b}	1.55 ± 0.07^{b}	3.25 ± 0.07^{a}	8.165 (0.020)

Sample of means with same alphabet superscripts on a row are not significantly different ($P \leq 0.05$)

Legend:

$H_{12}Ƶ$: 100% sugar cane juice; 0% added water, substrate fermented for 12 h
$S_{12}T$: 70% sugar cane juice; water substrate fermented for 12 h
$F_{12}F$: 50% sugar cane juice; 50% added substrate fermented for 12 h
$P_{12}M$: Fresh palm wine sourced from Mowe analyzed after 12 h
$P_{12}S$: Fresh palm wine sourced from Sango analyzed after 12 h

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

International Journal of Research (IJR)
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

Table 3.9: Physiochemical properties of Simulated palm wine juice and natural palm wine sample after 24 h fermentation

Parameters	$H_{24}Z$	$S_{24}T$	$F_{24}F$	$P_{24}M$	$P_{24}S$	F(p)
Total soluble solids (TSS %)	8.35 ± 0.07^{a}	6.06 ± 0.07^{a}	4.71 ± 0.01^{c}	4.23 ± 0.21^{c}	4.10 ± 0.24^{d}	341.333 (<0.001)
Sucrose %	8.03 ± 0.01^{a}	3.65 ± 0.07^{a}	3.36 ± 0.01^{b}	4.17 ± 0.30^{c}	2.21 ± 0.16^{a}	601.671 (<0.001)
Total sugar (as % invert)	8.35 ± 0.07^{a}	5.70 ± 0.00^{b}	3.75 ± 0.07^{c}	1.17 ± 0.21^{a}	1.63 ± 0.17^{d}	1056.945 (<0.001)
Glucose %	1.67 ± 0.01^{b}	0.11 ± 0.00^{d}	1.50 ± 0.01^{b}	2.50 ± 0.14^{a}	0.75 ± 0.07^{c}	331.650 (< 0.001)
Specific gravity (SPG)	1.03 ± 0.00^{a}	1.01 ± 0.01^{a}	1.01 ± 0.01^{a}	1.01 ± 0.02^{a}	0.01 ± 0.02^{a}	1.453 (0.341)
Ethanol (% vv)	8.47 ± 0.08^{a}	7.00 ± 0.14^{b}	3.50 ± 0.01^{d}	6.16 ± 0.08^{c}	6.95 ± 0.21^{b}	426.807 (<0.001)
pH	4.34 ± 0.02^{b}	4.10 ± 0.00^{b}	4.70 ± 0.07^{a}	4.10 ± 0.14^{b}	4.10 ± 0.14^{c}	17.661 (0.004)
Total Acidity (as Lactic) %	0.39 ± 0.001^{c}	0.37 ± 0.01^{c}	0.50 ± 0.01^{c}	0.77 ± 0.17^{a}	0.61 ± 0.01^{ab}	9.540 (0.015)
Fat content (%)	0.12 ± 0.00^{b}	0.06 ± 0.01^{b}	0.37 ± 0.02^{c}	0.29 ± 0.01^{a}	0.33 ± 0.08^{b}	26.025 (0.002)
Protein (%)	0.45 ± 0.01^{a}	0.37 ± 0.02^{ab}	0.45 ± 0.01^{a}	0.30 ± 0.3^{b}	0.32 ± 0.07^{b}	7.412 (0.025)
Total ash (%)	0.16 ± 0.03b^{c}	0.13 ± 0.03^{c}	0.22 ± 0.02^{b}	0.29 ± 0.01^{a}	0.32 ± 0.07^{b}	27.859 (0.001)
Sodium (mg/100ml)	3.62 ± 0.12^{d}	6.46 ± 0.32^{b}	4.20 ± 0.14^{c}	22.99 ± 0.01^{a}	23.43 ± 0.21^{a}	5806.940 (<0.001)
Vitamin C (mg/100ml)	49.05 ± 0.07^{a}	40.90 ± 0.57^{c}	44.10 ± 0.14^{b}	8.97 ± 0.17^{d}	8.97 ± 0.30^{d}	8464.569 (<0.001)
Sodium chloride (%) 2.20 ± 0.14b	0.018 ± 0.02^{a}	0.016 ± 0.001^{c}	0.017 ± 0.001^{c}	0.045 ± 0.01^{b}	0.065 ± 0.01^{ab}	19.620 (<0.003)
Sulphur dioxide (mg/kg)	2.11 ± 0.01^{b}	1.27 ± 0.92^{d}	1.50 ± 0.15^{cd}	1.60 ± 0.14^{c}	3.15 ± 0.07^{a}	118.499 (<0.001)

Sample of means with same alphabet superscripts on a row are not significantly different ($P \leq 0.05$)

Legend:
$H_{24}Z$: 100 2 % sugar cane juice; 0% added water, substrate fermented for 24 h; $S_{24}T$: 70% sugar cane juice; water substrate fermented for 24 h; $F_{24}F$: 50% sugar cane juice; 50% added substrate fermented for 24 h; $P_{24}M$: Fresh palm wine sourced from Mowe analyzed after 24 h; $P_{24}S$: Fresh palm wine sourced from Sango analyzed after 24 h

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

International Journal of Research (IJR)
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

Table 4.10: Physiochemical composition of Simulated Palm Wine and Natural Palm Wine after 48 hours fermentation

Parameters	$H_{48}Z$	$S_{48}T$	$F_{48}F$	$P_{48}M$	$P_{48}S$	F(p)
Total soluble solids (TSS %)	6.40 ± 0.00a	3.75 ± 0.00b	3.30 ± 0.00c	3.70 ± 0.14b	3.95 ± 0.21b	501.654 (<0.001)
Sucrose %	6.09 ± 0.01a	3.75 ± 0.21b	2.35 ± 0.07c	2.75 ± 0.07a	2.60 ± 0.28d	294.284 (<0.001)
Total sugar (as % invert)	5.40 ± 0.00a	3.55 ± 0.07b	1.30± 0.14c	1.26 ± 0.07c	0.30 ± 0.01c	1407.722 (0.001)
Glucose %	1.35 ± 0.03a	0.26 ± 0.00c	0.65 ± 0.07b	1.27 ± 0.08a	1.32 ± 0.13a	72.288 (< 0.001)
Specific gravity (SPG)	1.008 ± 0.01a	1.005 ± 0.00b	1.003 ± 0.00c	1.002 ± 0.00d	1.002 ± 0.00d	72.185 (<0.001)
Ethanol (% vv)	7.20 ± 0.00a	6.35 ± 0.07b	3.16 ± 0.00c	4.05 ± 0.21d	4.47 ± 0.06c	335.271 (<0.001)
pH	4.35 ± 0.07b	4.15 ± 0.07c	4.00 ± 0.00a	3.95 ± 0.04d	3.88 ± 0.01c	72.692 (0.001)
Total Acidity (as Lactic) %	0.40 ± 0.001c	0.47 ± 0.00d	0.49 ± 0.01c	0.73 ± 0.01a	0.66 ± 0.01b	2237.750 (<0.001)
Fat content (%)	0.16 ± 0.01c	0.07 ± 0.00d	0.03 ± 0.01a	0.60 ± 0.01a	0.29 ± 0.02b	691.433 (<0.001)
Protein (%)	0.45 ± 0.01a	0.42 ± 0.03a	0.42 ± 0.01a	0.29 ± 0.01b	0.31 ± 0.01b	41.481 (0.001)
Total ash (%)	0.20 ± 0.01b	0.11 ± 0.01c	0.12 ± 0.01c	0.29 ± 0.01a	0.31 ± 0.00a	172.850 (<0.001)
Sodium (mg/100ml)	4.91 ± 1.39a	7.84 ± 0.04a	3.85 ± 0.07a	21.60 ± 0.28a	12.89 ± 14.86a	2.367 (0.185)
Vitamin C (mg/100ml)	47.30 ± 0.42a	42.25 ± 0.21	38.80 ± 0.14c	8.16 ± 1.34d	8.81 ± 0.08d	1776.797 (<0.001)
Sodium chloride (%)	0.015 ± 0.01b	0.020± 0.001b	0.016 ± 0.001b	0.45 ± 0.01a	0.045 ± 0.01a	16.151 (0.005)
Sulphur dioxide (mg/kg)	2.11 ± 0.00a	1.36 ± 0.911	1.02 ± 0.53a	0.32 ± 0.00c	0.29 ± 0.00c	19.781 (0.003)

Sample of means with same alphabet superscripts on a row are not significantly different ($P \leq 0.05$)

Legend:

$H_{48}Z$: 100% sugar cane juice; 0% added water, substrate fermented for 48 h
$S_{48}T$: 70% sugar cane juice; water substrate fermented for 48 h
$F_{48}F$: 50% sugar cane juice; 50% added substrate fermented for 48 h
$P_{48}M$: Natural palm wine sourced from Mowe analyzed after 48 h
$P_{48}S$: Natural palm wine sourced from Sango analyzed after 48 h

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

3.5 Effect of Substrate Formulation and Duration of Fermentation on the Sensory Quality of the Simulated Palm Wine.

The result of the sensory evaluation of the simulated palm wine samples in terms of taste, colour, palm wine smell, sweetness and overall acceptability are recorded in table 3.11 – 3.14.

The result of the sensory evaluation of the simulated palm wine samples for taste showed that the low score for taste of samples $F_{12}F$ (5.60) $S_{12}T$ (6.88) and $H_{12}Ƶ$ (8.13) when compared to their corresponding substrate blends fermented for 24 h, $F_{24}F$ (6.16), $S_{24}T$ (7.20) and $H_{24}Ƶ$ (7.84) could be due to the shorter fermentation period of the substrate. This may have resulted from the shorter contact time and the adjustment of the yeast to the high sucrose concentration and fermentation environment at the commencement of fermentation leading to the low alcohol content produced after 12 h fermentation (Table 4.12);$F_{12}F$ (3.31% $^{v}/_{v}$), $S_{12}T$ (3.31% $^{v}/_{v}$) and $H_{12}Ƶ$ (3.49% $^{v}/_{v}$). The high concentration of unfermented sucrose $F_{12}F$ (4.09%) $S_{12}T$ (4.11%) and $H_{12}Ƶ$ (8.80%) may have also combined to influence the low mean score for taste as scored by the panelist for the 12 h fermented simulated palm wine samples(Table 4.12). These may have made the samples to be sweeter tasting than alcoholic in taste.

Generally, with increased rate of fermentation over a 24 h period there was observed increase in alcohol content (Table 3.12) of the samples $F_{24}F$ (3.50% $^{v}/_{v}$), $S_{24}T$ (7.00%$^{v}/_{v}$) and $H_{24}Ƶ$ (8.47% $^{v}/_{v}$) and reduced sucrose content $F_{24}F$ (3.36%), $S_{24}T$ (3.65%) and $H_{24}Ƶ$ (8.03%). This may have influenced the higher mean sensory score for taste for the 24 h fermented samples $F_{24}F$ (6.16), $S_{24}T$ (7.20) and $H_{24}Ƶ$ (7.84) (Table 3.13).

The mean score for taste of the 24 h fermented simulated palm wine samples $H_{24}Ƶ$ (7.84) and $S_{24}T$ (7.20) were not significantly different from the taste of natural palm wine $P_{24}M$ (7.92) and they were the most preferred by the panelist in terms of the taste.

The sensory evaluation results (Table 3.12-3.14) showed that the mean score for colour of the samples increased to creamy white with longer fermentation period, as the panelist score for the 12 h fermented samples were lower than 24 h fermented samples and the 24 h fermented samples were lower than that of 48 h fermented samples. This increase in the creamy white colour of the samples with fermentation was an acceptable development as their colour tended towards the whitish colour of natural palm wine. The white colour of the samples which improved with fermentation duration may be attributed to the growth of more yeast and accumulation of yeast biomass. The is consistent with the report of Legras *et al.*, (2017) that yeast is morphologically white in colour and their heavy suspension in the palm wine gave a milky white appearance and contribute to the whitish turbidity of palm wine. According to Okeke and Obi (2021) the accumulation of yeast biomass may create a more whitish colour and this improves with fermentation. Adamu-Governor *et al.*, (2018) reported that within 12 to 24 h, yeast utilized the sugar in the substrate to simultaneously grow in large biomass, and the production of gums from glucans and fructans during the fermentation of the sugars in palm sap substrates, resulted in the development of the creamy white colour of natural palm wine. These colour changes may have contributed the high mean score for the colour of simulated palm wine samples which were

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

DOI: https://doi.org/10.5281/zenodo.11177860

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

comparable to the colour of natural palm wine, particularly samples $H_{24}Ƶ$ (7.20) and $S_{24}T$ (7.20) which have mean scores comparable to that of natural palm wine (7.88) $P_{24}M$.

The sensory score obtained for the smell (palm wine smell), showed that there was a progressive increase in palm wine smell with longer fermentation period. This may have arisen due to the fermentation of the sugar in the substrate to alcohol and acid and the associated reaction of the produced alcohol with the acid to produce esters. The strength of this smell according to Bitrus *et al.,* 2020 and Laseken *et al.,*(2013) depends on the duration of fermentation period, the kind of esters formed and their quantity.

Therefore, the lower mean scores for smell recorded for the 12 h fermented simulated palm wine samples $F_{12}F$ (6.28), $S_{12}T$ (7.00) and $H_{12}Ƶ$ (6.20) may be due to the lower development of alcohol and their esters within 12 h fermentation. Noticeably too, the mean score for smell of samples fermented for 24 h. were higher than that of 12 h fermented samples $F_{24}F$ (6.32), $S_{24}T$ (6.80) and $H_{24}Ƶ$ (7.48) and these were higher than the 48 h fermented samples $F_{48}F$ (6.73), $S_{48}T$ (6.56) and $H_{48}Ƶ$ (6.88).

The lower mean score obtained for 48 h fermented simulated palm wine samples may have arisen due to oxidation of alcohols due to longer fermentation period hence lower yield of esters and continued increase on acidity with time, leading to the development of more acidic smell and according to Joshi *et al.,* (2017), if palm wine is allowed to ferment longer than 24 h it starts develops vinigery smell.

As the sugar content was depleted and alcohol was produced the less sweet the samples become with longer fermentation period. This may be responsible for the lower score for sweetness for samples fermented for 24 h and 48 h respectively. $F_{24}F$ (6.04), $S_{24}T$ (5.88) and $H_{24}Ƶ$ (5.96) and $F_{48}F$ (6.04), $S_{48}T$ (5.88) and $H_{48}Ƶ$ (5.96) when compared to samples fermented for 12 h $F_{12}F$ (6.88), $S_{12}T$ (7.64) and $H_{12}Ƶ$ (7.80). The observed decrease in sucrose concentration with increasing fermentation duration could be attributed to the fermentation of the sugar contained in the substrate which resulted from the conversion of sugar to alcohol thereby reducing the sweetness of the fermented samples.

The mean sensory score for sweetness of the samples may have been influenced by the reduction in the concentration of sucrose in the samples as shown in tables 4.8 where sucrose content decreased from the samples fermented for 12 h $H_{12}Ƶ$ (8.80%), $S_{12}T$ (4.11%) and $F_{12}F$ (4.09%) to $H_{24}Ƶ$ (8.03%), $S_{24}T$ (3.65%) and $F_{24}F$ (3.36%) and further decreased with 48 h fermentation $H_{48}Ƶ$ (6.09%), $S_{48}T$ (3.75%) and samples $F_{48}F$(2.35%) with fermentation is consistent with the report of Djeni *et al.,* (2020) that the sugar in palm sap was utilized over a period of 24 h fermentation, making the palm sap lose its sweetness. This observed trend conformed with the finding of Adekaren *et al.,* (2017) that palm sap is very sweet and non-alcoholic tasting as it is been tapped from palm tree and becomes less sweet and alcoholic within 24 h.

Result showed that the overall acceptability scores for the 24 h fermented simulated palm wine samples $S_{24}T$ (7.48) and $H_{24}Ƶ$ (7.88) were comparable to the mean score for the natural palm wine $P_{24}M$ (7.88). This showed that the simulated palm wine samples ($H_{24}Ƶ$ and $S_{24}T$) were the

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

DOI: https://doi.org/10.5281/zenodo.11177860

most preferred and acceptable. Their sensory characteristics compared very closely with that of natural palm wine $P_{24}M$ (7.88). This assertion is consistent with results of the sensory evaluation scores for sample $H_{24}Ƶ$ colour (7.20), taste (7.84), and smell (7.48) and sweetness (7.24) and also for sample $S_{24}T$ for colour (7.8), taste (7.20), smell (6.80) and sweetness (7.24).

These values compared closely with the sensory evaluation scores obtained for natural palm wine sample fermented for 24 h $P_{24}M$, for colour (7.88), taste (7.92) smell (7.88) and sweetness (7.92). These results showed the consistent resemblance between the panelist preference for taste, colour, smell, sweetness and overall acceptability of the simulated palm wine samples with that of natural palm wine samples. Indicatively, simulated palm wine samples $H_{24}Ƶ$ and $S_{24}T$ were the most preferred and their sensory characteristics compared very closely with that of natural palm wine.

Table 3.11: Sensory evaluation scores of simulated palm wine after 12 hrs fermentation

Samples	Taste	Colour	Smell	Sweetness	Overall Acceptability
$F_{12}F$	5.60 ± 1.73^{c}	$6.60 \pm 1,63^{b}$	6.28 ± 1.65^{b}	6.88 ± 1.48^{b}	6.08 ± 1.47^{c}
$S_{12}T$	6.88 ± 1.83^{b}	7.40 ± 1.12^{a}	6.40 ± 1.66^{b}	7.64 ± 1.50^{a}	7.12 ± 1.49^{b}
$H_{12}Ƶ$	7.24 ± 1.71^{ab}	5.96 ± 2.03^{b}	6.20 ± 1.87^{a}	7.80 ± 1.78^{a}	7.20 ± 1.78^{ab}
$P_{12}M$	8.13 ± 0.74^{a}	7.96 ± 0.75^{a}	7.92 ± 0.75^{a}	7.92 ± 0.78^{a}	8.25 ± 0.61^{a}
F-statistics (p)	**10.866 (<0.001)**	**9.541 (<0.001)**	**6.329 (<0.001)**	**11.082 (<0.001)**	

Means with same alphabet superscripts on a column are not significantly different ($P \leq 0.05$)

Legend

$F_{12}F$: 50 % sugar cane juice: blended with 50% added water substrate fermented for 12 h

$S_{12}T$: 70 % sugar cane juice blended with 30% added water; substrate fermented for 12 h

$H_{12}Ƶ$: 100 % sugar cane juice blended with 0% adder water; substrate fermented for 12 h

$P_{12}M$: Fresh palm wine sourced from Mowe, analyzed after 12 h

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023
DOI: https://doi.org/10.5281/zenodo.11177860

International Journal of Research (IJR)

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

Table 3.12: Sensory evaluation scores of simulated palm wine after 24 hours fermentation

Samples	Taste	Colour	Smell	Sweetness	Overall Acceptability
$F_{24}F$	6.16 ± 2.17^{b}	6.90 ± 1.76^{b}	6.42 ± 1.25^{c}	6.12 ± 1.94^{b}	6.32 ± 1.68^{b}
$S_{24}T$	7.20 ± 1.55^{a}	7.60 ± 1.19^{a}	6.50 ± 1.68^{b}	7.24 ± 1.54^{a}	7.48 ± 1.48^{b}
$H_{24}Ƶ$	7.84 ± 1.31^{a}	7.30 ± 1.29^{a}	6.88 ± 0.92^{ab}	7.60 ± 1.35^{a}	7.88 ± 1.27^{a}
$P_{24}M$	7.92 ± 0.65^{a}	7.88 ± 0.68^{a}	7.88 ± 0.74^{a}	7.92 ± 0.78^{a}	7.88 ± 0.85^{a}
F-statistics(p)	**6.984 (<0.001)**	**5.574 (<0.001)**	**8.122 (<0.001)**	**7.744 (<0.001)**	**7.325 (<.001)**

Means with same alphabet superscripts on a column are not significantly different ($P \leq 0.05$)

Legend:

$F_{24}F$: 50 % sugar cane juice: blended with 50 % added water, substrate fermented for 24 h

$S_{24}T$: 70 % sugar cane juice blended with 30 % added water, substrate fermented for 24 h

$H_{24}Ƶ$: 100 % sugar cane juice blended with 0% added water, substrate fermented for 24 h

$P_{24}M$: Fresh palm wine sourced from Mowe, analyzed after 24 h

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 10
October 2023

Table 3.13: Sensory evaluation scores of simulated palm wine after 48 hrs fermentation

Samples	Taste	Colour	Smell	Sweetness	Overall Acceptability
$F_{48}F$	5.38 ± 1.47^{b}	6.96 ± 1.66^{ab}	6.73 ± 1.48^{a}	6.04 ± 1.51^{b}	6.27 ± 1.48^{a}
$S_{48}T$	5.84 ± 2.10^{b}	7.16 ± 1.43^{a}	6.56 ± 1.80^{a}	5.88 ± 2.37^{b}	6.28 ± 2.19^{a}
$H_{48}Ƶ$	6.16 ± 1.68^{b}	7.82 ± 1.46^{b}	6.68 ± 1.62^{a}	5.96 ± 1.84^{b}	6.48 ± 1.76^{a}
$P_{48}M$	7.30 ± 0.76^{a}	7.48 ± 0.73^{a}	7.48 ± 0.90^{a}	7.57 ± 0.79^{a}	7.52 ± 0.67^{a}
F-statistics(p)	**3.711 (0.014)**	**3.037 (0.033)**	**1.680 (0.060)**	**5.036 (0.001)**	**2.628 (0.055)**

Sample of means with same alphabet superscripts on a column are not significantly different ($P \leq 0.05$)

Legend:

$F_{48}F$: 50 % sugar cane juice: blended with 50% added water, substrate fermented for 48 h

$S_{48}T$: 70 % sugar cane juice blended with 30% added water, substrate fermented for 48 h

$H_{48}Ƶ$: 100 % sugar cane juice blended with 0% adder water, substrate fermented for 48 h

$P_{48}M$: Fresh palm wine sourced from Mowe, analyzed after 48 h

4.0 Conclusion

The locally - fabricated fermenter could be used to produce an acceptable simulated palm wine with characteristics comparable to that of natural palm wine.

ACKNOWLEDGEMENT

I wish to acknowledge the following institutions: The Bells University of Technology Otta, Ogun State, Nigeria, National Institute of Medical Research Yaba, Lagos and Yaba College of Technology Yaba, Lagos, for providing me with the facilities and laboratories to carry out this research.

Received: *22 September 2023*
Revised: *3 October 2023*
Final Accepted *14 October 2023*
Copyright © authors 2023

DOI: https://doi.org/10.5281/zenodo.11177860

REFERENCES

Adamu-Governor, O.L., Toafik, A.S, Oluwatoyin, R.A., and Uzochukwu S.V.A (2018) Screening for gum-producing Lactic acid bacteria in oil palm (Haeis guineesis) and Rephis palm (*Raphin* Vinifera) Sap from South-West Nigeria. *Food Science and Nutrition. 6(8);* 2047-2045

Adekaren B., Ekhator, J.O., and Ogblechi S.R. (2017). The place of oil palm wine in the alcohol industry in Nigeria. *Mert Research Journal of Agricultural Science and food Science* ISSN-2350-2274; 5(8): 142-146.

Akinjayeju, O., (2017) Quality Control for the Food Industry (A statistical Approach *Concept Publications* revised and reprinted edition 229-273.

Allen, M.E., and Gyure, R.A (2013). An undergraduate Laboratory Activity Demonstrating Microbial specificity. Journal of Microbial Education 14:84-92.

AOAC (2019) *Official Methods of Analysis of American Official Analytical* Apeh, A.A. and Opata, C.C. (2019) The oil palm wine economy of rural farmers in Nigeria; evidence from Enugu Ezike, South Nigeria *Rural History* 30:111-128.

Arif, S., Clark, M.W and Lake, N (2019) . Sugar Cane bagasles ash as a pozzolanic material in concrete. *Construction and building materials Journal* 222:1163.

Babisteng, T.M and Tekatey, K.T. (2013) Impact of wine tapping in the population structure and regeneration of Hyphea *Ethnobotany Research and Application* 11:9-27.

Barnett, T., Artwood, T., Blesdel, B., Bokar, C. and Anderson, T. (2016). Effect of different concentration of sucrose on the growth of yeast. *Journal of Introductory Biology Investigation* 4(3):217-225.

Ben-David, A and Davidson, C.E. (2014) Estimation method for serial dilution experiments. *Journal of Microbiological Methods* 107:214-221

Bitrus, J. Amadi, O.C Nwagu, J.N., Nnamachi, C., Moneke, A.N. and Amadi, O.C. (2020). Application of wild yeast *(Saccheronuces cerevisiae)* isolates from palm wine and honey in baking cassava/wheat composite bread. *Food and Nutrition Sciences* 11(7):895-911.

Dhansu, P., Ram, B., Singh, A.K. Tomer, S.K Rapa, A.R., Kaushik, P., Pandy, S.K. Chhobra, M.L., Kumer, P. and Kamppaiyan, T, (2023) Different treatment for sugar cane juice preservation *Foods* 12(3)311-317.

Djeni, T.N. Kauame, K.H., Ake, F.D.M., Amoikon, I.S.T and Dje, M.K. (2020). Microbial diversity and metabolites profile of palm wine produced from different palm trees species in Cote d'ivore. *Scientific Nature Research* 10:1715-1727.

***Received**: 22 September 2023*
***Revised**: 3 October 2023*
***Final Accepted** 14 October 2023*
Copyright © authors 2023
DOI: https://doi.org/10.5281/zenodo.11177860

Ebabhi, A.M., Adedotun, A.A., Wahab, O.O, and Akinniyi, A.S. (2013). Isolation and Characterization of yeast strains from local food crops. Journal of yeast and fungal research 4(4):38-43.

Ejimofor, C.F., Oladibe, O.J. Afam-Ezeaku, C.E., Mbukwu, O.A (2023). Isolation and characterization of yeast associated with palm wine fermentation Asian *Journal of Food Research and Nuitrition* 2(3):117-127.

Elijah, A.L., Ojinelukwe, P.O., Ekong, U.S., and Asomudo, C.O (2013). Effects of Sacoglottis gabonensis and Aistonia boonai on the Kinetics of Sacharoneyces cerevisiae isolated from palm wine. *African Journal of Biotechnology.* 9:5730-5734.

Endo, A., Tawsupawat, S., Irisawa, T and Dicks, L. (2014) *Encyclopedia of food Microbiology* 2(6): 475-489.

Ezemba, C.C., Onyemalu, V.T., Nwanga, A. Okoye, P.O., Odibo, F.J.C and Ogbonna (2022) characterization of palm wine yeasts and comparison of their dough-raising activity with bakers' yeast *Asian Journal of plant and Soil Science* 7(1):66-72

FAO. Food and Agricultura organization (2013).

Gaikward, U., Panghol, A, Yadhaw, S., Sharmo, P., and Chikara P. (2018) Designing of fermenter and its utilization in food industries. *Fermenters* 124:261-301.

Geremias-Andrade, I.M., Matos, I.V., Rochets, A.C., Valedao, N.K. and Petrus, R.R. (2014) Standardization of pasteurized sugar cane juice. *Internationa Journal of Agriculture Innovations and Research 2(5):*794-797

Geremias-Andrades, I.M., Rochets, A.C., Gallo, F.A., Petrus R.R. (2019). The Shelf life of standardized sugar cane juice stored under different conditions; *Food Procesing, Technologies Materials and Applications.* 14:302-312.

Gomes, J.L, Kushida, M.M Kamimura, E.S Maldonado, R.R., and Petrus, R.N (2020) sugar cane juice pasteurization: a search for most effective parameter, *Journal of Food Processing and Research and Reservation 44(II) e*/442.

Gosh, S.M., Chakraborty, R., and Raychaudhuri, U. (2021) Optimizing process conditions for palm wine (Borasus flabelliffer) fermentation using response surface methodology. *International food Research Journal* 19(4) 1633-1639.

Ibegbulam, C.O., Igwe, C.U., Okwu, C.O., Ujowundu, E.N., Onyeike, E.N., and Ayalogu, E.O (2013) Total amino acid profile of heat processed fresh *Elaeis guineensis and Raphia hookeri wine food chemistry* 138:1616-1620

Ikegwu, J.U (2014). The value of palm wine tapping in the food production practices of Igbo land; A case study of Idemili South Local Government Area, Anambra State. *Reseach of Humanities and Social Sciences* 4(6):215-219.

***Received**: 22 September 2023*
***Revised**: 3 October 2023*
***Final Accepted** 14 October 2023*
Copyright © authors 2023
DOI: https://doi.org/10.5281/zenodo.11177860

Ikegwu, T.M, Okafor, G.I and Ochiogu (2014). Effects of preservation Methods of oil palm sap (Elaeis guineensis) on the reproductive indices of male wister rals. *Journal of Medical Foods* 17(12):1368-1374

Joshi, U.K. and Panesari K (2017) In: Science and Technology of Fruit Wine. *Elsenvier Incorporated publishers* ISBN 978-0-12-800-850-8: 705-727.

Karamoko D., Aboya, K. Harden, K.F., Dje K.M., and Philomene, K.A. (2019). Analysis of physiochemical parameters and screening of microorganism to formulate ferments from oil palm sap (Elaeis guineensis) in the Korhgo area. *International Journal of Current Microbiology and Applied Sciences* 8(8):3005-3013.

Karomoko, D., Djeri, N.T., Nguessan, K.F. Bourtenin, K.M.J-P, Dje, K.M. (2016) The biochemical and microbiological quality of palm wine samples produced at different periods during tapping and changes which occurred during storage. *Food Control.* 26((2): 504-511.

Kunitake, M., Ditchfield, C., Silvia, C., and Petrus, R.R. (2014). Effect of Pasteurization on the stability of an acidified sugar cane juice beverage Clenciae *Agrotechnology* 38(6) 554-561

Leber, A.L. (2016 Clinical Microbiology Procedure handbook (4th Edition) Washinton DC: ASM Press 1752 NST. N.W.

Legres, J.L, Galeole, V., Comarasa, V., Dequin C and Bruno, B (2017). Ecology diversity and application of Saccharamyces yeast in Food and Beverages. In: *Yeast Diversity in Human Welfare* ISBN: 978-981-102621-8-12

Lesekan, O. (2018) Enantiomeric differentiation of three key volatile compounds in three different palm wine (*Elaeis guineensis & Borassus Flabelliger and Nypa fruiticeas) CyTA Journal of Food* 16(1): 70-75.

Lucky, G.B., Cookey, G.A. Ideriah, T.J.K (2017) Physiochemical and nutritional parameters in palm wine from oil palm tree (Elaeis guineensis) and Raphia palm (Rephia hookeri) in South-South Nigeria. *Chemistry Research Journal.* 2(6): 146-152

Mbah, E.H., Ekpo, A.S., Ozim, E.C and Oladehinde, S.O., (2019). Assessment of Traditional Palm Wine Tapping Practices Effect on Vegetation in Nasarawa State, Nigeria. *International Journal of Environment and Climate change* 9(12) 841-851

Mbaugbaw, L. and Noorduyn (2012) The Palm wine trade: Occupational and health hazards. *The International Journal of occupational and Environmental* 3(4) 157-164

Morah, F.N.I and Robinson, I.G (2015) *Sarcoglottis* as a functional preservative for palm wine. *American Scientific Research Journal for Engineering and Technology* 13(1):97-101.

Mora-Muis, J.R. (2020) Palm wine as a habit for diverse and abundant microbial communities *Nature Microbiology* 5(1):117-126.

***Received**: 22 September 2023*
***Revised**: 3 October 2023*
***Final Accepted** 14 October 2023*
Copyright © authors 2023
DOI: https://doi.org/10.5281/zenodo.11177860

Ngoc, N.M., Nguyen, P.M and Dongi, T.A.D (2014) Different processing conditions affect palm wine fermentation. *Communication* 2(1): 142-157.

Nwachukwu, I., Ekaito, M.U and Stephen, (2016) Microbilogical quality of Palm wine (Elaeis guineensis and Raphia Hookeri) sold within Aba Metropolis, Abia State, Nigeria 3(1) ISBN 2397-2076: 38-40

Nwaiwu, O. and Irumoh, M. (2017). Molecular Phylogeny of yeast from palm wine and enological potentials of the drink. *Annual Research and Review in Biology*

Nwaiwu, O., Aduba, C.C. Igbokwe, V.C, Sam, C.E. and Ukwuru, U.M (2020). Traditional and artisanal beverages in Nigeria: microbial diversity and safety *Beverages.* 6(5)53.

Nwaiwu, O., Ibekwe, V., Amadi, E., Udebuani, A.I., Nwanebe, F.C., Oguoma, O.I and Nnokwe, J.C. (2016) Evaluation of fermentation products of palm wine yeast and role of *sacoglottis Gabonensis supplement on product abundance Beverages* 2 (2) 9 - 15

Obi, C., Ogbulie, J. and Nkwo, A. (2015) Assessment of microbial growth and suravival in fresh raphia palm wine from Umuriaga community, Ikwuano, LGA, Abia State, Nigeria *International Journal of current Microbiology and Applied Sciences* 4(1): 484-494

Ojo-Omoniyi, O. Abayomi, O, Remilekun, R., Tinubi, O., Akinwunmi, O., Owoeye, O.M. and Osho, O. (2030) Evaluation of Microbial flora and Shelf life Stability of two indigeneous palm wine products Elaeis guineensis and Raphia hookeri obtained from south west Nigeria. *International Journal of Current Microbiology and Applied Sciences* 9(8): 154-1558.

Okereke, C.N., Ezereoruye, U.C. and Okereke C.U (2019) Physiochemical Microbilogical and Sensory properties of palm wine from *Raphia Vinifera* in south eastern Nigeria. *Journal of Food Science and Nutrition.* 12(1): 12`-127.

Okereke, I.E (2018). Science, process skill practiced in palm wine tapping *Journal of CUDIMAC (on-line)* 6(1): 21-23. ISBN – 2651-6063.

Omofonmware, E.I., Asholu, O.F., Ayinde, A. and Fakoya, E.O. (2013). Assessment of palm wine Market in Edo State, Nigeria. *Journal of Science and Multidisciplinary Research* 5(2): 141-148

Onuche, P., Shomkegh, S.A., Tee, T.N (2012) Palm wine tapping methods in Nigeria: Implication in conserving palm trees. *Journal of Environmental Issues and Agriculture* 4(1) 86-91

Okoronkwo, C.P and Effiong, E (2019). Molecular Characterization of yeast isolated from palm wine in Alakachia, Rivers State, and Nigeria *World Scientific News* 130:297-304

Opara C.C., Ajoku, G. and Madumolu, N.O., (2013). Palm wine mixed culture fermentation kinetics *Greener Journal of Physical Science* 3(1) 28-37

***Received**: 22 September 2023*
***Revised**: 3 October 2023*
***Final Accepted** 14 October 2023*
Copyright © authors 2023

DOI: https://doi.org/10.5281/zenodo.11177860

Oti, V.O., Okwulehie, I.C. Ogwo, N., Nwankwo B.J. and Ogoke, H.I (2021) Assessment of the Physiochemical properties of oil palm (Elaeis hookeri) palm wine Nigerian *Agricultual Journal* 52(3): 63-68 CISSN:0300-368

Ouoba, L., Kendo, O., Parkonda, C., Sawa-dogo-Linganu, C. Diawara, B., Sutherland, J.P. (2012). The Microbiology of banyi palm wine (Borassus akeasci) *Journal of Applied Microbiology* (11(3) 1428-1444.

Saeed, A. and Igbal, M. (2013) Loofa (Luffa cylindrical) sponge: review of development of the biomatix as a tool ofr biotechnological applications. *American Institute of Chemical Engineers: Biotechnololgy Programme* 29(3): 573-600

Saheed, A and Igbal, M (2013) Loofa (Luffa cylindrical) Sponge: Review of the development of the biometrix as tool for biotechnical application. *American Institute of Chemical Engineers: Biotechnology programme* 29(3) 573-600

Santiago-Urbina, J.A. Ruizteran, F, (2014) Microbiology and biochemistry of tradional palm wine produced around the world. *International Food Research Journal* 21(4): 1261-1269

Santiago-Urbina, J.A., VErdugo, A.G and Buiz-Teren, F, (2013). Physiochemical and microbiology changes during tapping of Onwumuah, M., palm sap to produce alcoholic beverage called “Teberna”. *Food Control* 33(1): 58-62

Santiago-Urbino, J.A., Arias-Garcia, J.A and Ruiz-Teren, F. (2015) yeast species of Teberna- a traditional palm wine from south east of Mexico *Analytical Microbiology* 65:287-299

Sreedall, S., Ogunsanwo, O.A. and Moral, J.O (2018) Palm wine: A potential source of bioactive compounds with health benefits *Food Science and Nutrition*

Ubong, O., and Godwin, E.A (2017) Comparative evaluation of method of palm sap fermentation for bioethanol production, Bioprocessing Engineering. (1(2): 53-58

***Received**: 22 September 2023*
***Revised**: 3 October 2023*
***Final Accepted** 14 October 2023*
Copyright © authors 2023
DOI: https://doi.org/10.5281/zenodo.11177860