Research Journal of Food Science and Quality Control (RJFSQC) E-ISSN 2756-5483
P-ISSN 2695-2459 Vol 10. No. 6 2024 www.iiardjournals.org Online Version

Evaluating pH and Electrical Conductivity as Safety Indicators in Palmwine drinks consumed in Onuebom Community, South-South Nigeria

Isaac U. Isaac[1] and Iheoma M. Adekunle[2]
AgriChemTech Research Group, Chemistry Department, Faculty of Science,
Federal University Otuoke
Corresponding Author: adekunleim@fuotuke.edu.ng
DOI: 10.56201/rjfsqc.v10.no6.2024.pg111.118

Abstract

A popular indigenous beverage in Nigeria and other tropical parts of Africa, palm wine is a naturally fermented beverage made from the sap of palm palms. Despite being a culturally significant beverage, the study evaluated the two most important safety factors (pH and electrical conductivity) in locally made, widely consumed beverages in Niger Delta areas. Samples of fresh palmwine obtained from Onuebom, a nearby community around 5 km away, where the beverage is widely available to consumers and retailers, were taken three times in a row with the same volume, location, and interval during the studies, which took place between January 2013 and February 2015. Two liters of palm wine each were bought from five separate vendors in the same neighborhood and delivered to the Federal University Otuoke chemistry laboratory and was preserved in a refrigerated at 4^0C as soon as they arrived. More so, the effect of a common consumer habit (CCH) of dilution of palmwine drink with water before consumption on pH and EC values of the drink was also studied. The percent (%) water to palm wine mix were 0, 50, 67, 75 and 80, corresponding to dilution factors of 0, 1, 2, 3 and 4 respectively. A calibrated pH meter and an electrical conductivity meter were used to analyse the samples following standard procedures in replicates for both parameters. A total of 450 (140 neat and 310 diluted) samples were analyzed for pH and EC. Results revealed substantial variations in both pH (3.19 to 5.96) and EC (424 to 2443 µS/cm). The study employed statistical analyses, including One-Way ANOVA and Kruskal-Wallis tests, to assess the differences between dilution levels. Correlation analysis revealed a moderate inverse relationship between pH and EC ($r = -0.56$, $p < 0.05$), indicating that higher EC values are associated with lower pH. These findings have significant implications for the health and safety of consumers, as low pH and high EC can lead to potential risks such as gastrointestinal discomfort, dental erosion, and mineral toxicity. The study compares these findings with the safety standards set by international and national regulatory bodies, including the International Organization for Standardization (ISO) and the National Agency for Food and Drug Administration and Control (NAFDAC). Based on the findings, recommendations for improving the quality and safety of palm wine are provided.

Keywords: *Palmwine, pH, Electrical Conductivity, Safety, Health Implications, Onuebom Community*

1. Introduction

Palm wine, often referred to as "the drink of the gods," is a traditional alcoholic beverage that has been consumed for centuries across various parts of Africa and other tropical regions (Falade *et al.,* 2012). It is produced by tapping the sap of palm trees such as the oil palm (*Elaeis guineensis*) and the raffia palm (*Raphia spp.*) (Adeoye *et al*., 2020). Palm wine has long been celebrated not only for its nutritional and energizing properties (Ogundele et al., 2018) but also as a symbol of cultural identity and social gatherings (Akpata, 2015).

Despite its widespread popularity, concerns about the safety and quality of palmwine have emerged in recent years. The natural fermentation process of palm wine, which results in the development of both beneficial and potentially harmful compounds, makes it crucial to assess its physicochemical properties regularly. Among the most significant parameters are pH and electrical conductivity (EC), which directly impact the quality, safety, and shelf life of the beverage. Low pH values (i.e., high acidity) can lead to adverse health effects such as gastrointestinal issues and dental erosion, while high EC values can indicate excessive levels of dissolved ions, including potentially harmful minerals and toxins.

Although palmwine is often considered a safe beverage, few studies have comprehensively assessed its physicochemical properties in relation to its safety for human consumption. This research, therefore, seeks to address this gap by investigating the pH and EC of palmwine samples from the Onuebom community in Ogbia Local Government Area, Bayelsa State, Nigeria. By comparing these results with international and national safety standards, including those set by the International Organization for Standardization (ISO) and the National Agency for Food and Drug Administration and Control (NAFDAC), this study aims to highlight potential risks associated with its consumption and recommend guidelines for ensuring its safety.

The findings from this study will contribute to the growing body of knowledge on the safety of naturally fermented beverages and will inform public health policies and consumer practices in Nigeria and similar tropical regions.

2. Materials and Methods

2.1 Sample Collection and Preparation

The study was conducted at Federal University Otuoke in Bayelsa State, Nigeria, and samples of fresh palm wine were purchased from Onuebom, a nearby community around 5 km away, where the beverage is widely available to consumers and retailers. Samples were taken three times in a row with the same volume, location, and interval during this period of study, which took place between January 2013 and February 2015. Two liters of palm wine each were bought from five separate vendors in the same neighborhood and delivered to the Federal University Otuoke chemistry laboratory. As soon as they arrived, the samples were kept in a refrigerator at 4^0C prior to analysis. Ten litres of samples were homogenized each time in a 20-liter receptacle to provide enough room for mixing.

2.2 Determination of pH level of palm wine

Determination of pH for the palm wine samples was carried out following standard procedure as described in the reports of Adekunle & Isaac (2019), Isaac & Adekunle (2024a) and Lawn & Prichard (2003) with slight modification. Exactly 40 ml of sample was measured using a Pyrex measuring cylinder and transferred into a 100 mL Pyrex beaker. The probe of a pH meter (Model: Hanna HI 96107), standardized using appropriate buffer solutions (4, 7 and 10) was inserted into the sample contained in the beaker and readings were taken. The probe of the pH meter was rinsed using deionized water after each measurement before taking reading of the next aliquot. Measurements were taken for (i) neat palm wine samples and (ii) palm wine samples diluted with water at water - palm wine percentage compositions of 0, 50, 67, 75 and 80.

2.2 Determination of electrical conductivity level of palm wine

Determination of electrical conductivity for the palm wine samples was carried out following standard procedure as described in the reports of Adekunle & Isaac (2019) with slight modification. Exactly 40 ml of sample was measured using a Pyrex measuring cylinder and transferred into a 100 mL Pyrex beaker. The probe of an electrical conductivity meter (Model: Hanna 96302), standardized using appropriate standard (0.01 M potassium chloride solution) was inserted into the filtrate contained in the receiving ware. The readings were then taken.

2.3 Assessing the Effect of Common Consumer Habit (Water Dilution) on Palm wine

Common consumer habit (CCH) of adding water into the palm wine before taking was studied via focused group discussion and interaction with relevant stakeholders cutting across age groups (Isaac & Adekunle, 2024a). Similarly, the CCH was more common with consumers of 50 years of age and above who expressed concern about sugar content with respect to health issues. Dilution with water was done at water – palm wine mix ratios 0:1, 1:1, 1:2, 1:3 and 1:4 corresponding to dilution factors of 0, 1, 2, 3 and 4 respectively and percent compositions of 0:100, 50:50, 33:67, 25:75 and 20:80 respectively. The total volume of samples analysed was 450L (10L of neat samples and 140L of diluted samples per interval =150L X3) as described in Table 1. Note that 10 L of neat samples were collected three times in the course of the analysis while 140L were used for dilution at different ratios per interval (Table 1).

Table 1: Detailed information on the total volume of samples for palm wine and water – palm wine percent composition

S/N	Percent water in the Water – Palm wine Mixture					Total Sample population
	0	50	67	75	80	
1.	10	20	30	40	50	150
2	10	20	30	40	50	150

3	10	20	30	40	50	150
Total	**30**	**60**	**90**	**120**	**150**	**450**

2.4 Quality Assurance and Quality Control

The pH and electrical conductivity meters used in these determinations were properly calibrated and the probes rinsed with double distilled-deionized water before use. All glass ware (Pyrex) were thoroughly washed with detergent, rinsed with distilled water followed by soaking overnight with acidified water and then properly rinsed with double distilled – deionized water. The glasswares were dried in the oven at 105^0C before use. The pH probe was properly rinsed after each determination

2.5 Statistical Analysis

In this study, IBM SPSS 21.0 for Windows® was used for statistical processing of data, which were subjected to descriptive statistics, including the range, mean, and standard deviation (SD), were calculated for both pH and EC at each dilution level. One-Way ANOVA and Kruskal-Wallis tests were performed to assess statistical differences between the dilution levels. The correlation between pH and EC was analysed using Pearson's correlation coefficient, and a significance level of $p < 0.05$ was adopted for all tests.

3. Results and Discussions

3.1 pH Levels of the Palm wine

The pH values of palm wine samples across the five dilution levels ranged from 3.19 to 5.96. The mean pH ± standard deviation for each dilution level is presented in Table 2. It was observed that the pH increased with increasing dilution, with the lowest pH recorded at the 0% dilution level and the highest at the 80% dilution level. The results of this study provide valuable insights into the physicochemical characteristics of palmwine produced in the Onuebom community. The observed range of pH values (3.19 to 5.96) suggests that palmwine is generally acidic, with pH values in some cases falling below the threshold of 4.5, as recommended by NAFDAC for safe consumption. The low pH values indicate that palmwine could pose a risk to consumers, particularly with respect to gastrointestinal health, as excessive acidity may lead to discomfort, acid reflux, or even tooth erosion over time (Jin et al., 2019). The pH values observed in this study are consistent with findings from other studies on locally produced beverages in Nigeria. For example, Adekunle et al. (2017) reported pH values for locally fermented beverages ranging from 3.5 to 5.8, while Olawale and Ibrahim (2016) observed a pH range of 3.4 to 5.7 for fresh palm wine. Similarly, Ihenetu and Nwachukwu (2018) found pH values of 3.8 to 5.5 in palm wine samples collected from various communities. Further corroborating these findings, research by Ezeh et al. (2020) recorded a pH range of 3.6 to 5.9 for locally brewed beverages, and Okechukwu and Okoro (2019) documented pH values of 3.3 to 5.8 for palm wine stored under varying conditions. Additionally, studies by Amadi and Chukwu (2021) and Bello and Ojo (2022) confirmed similar pH ranges for

traditional Nigerian beverages, indicating that these acidic levels are typical of locally produced drinks in Nigeria.

Table 2. pH Levels of palm wine samples

Water Dilution (%)	Range	Mean ± SD	ISO Standard	NAFDAC Standard
0	3.19-4.67	4.07 ± 0.45	4.0-7.0	4.5-5.5
50	3.98-5.12	4.70 ± 0.36	4.0-7.0	4.5-5.5
67	4.04-5.30	5.12 ± 0.38	4.0-7.0	4.5-5.5
75	4.3-5.43	5.22 ± 0.32	4.0-7.0	4.5-5.5
80	3.96-5.96	5.22 ± 0.45	4.0-7.0	4.5-5.5

3.2 Electrical Conductivity Levels

The EC levels of the palm wine samples varied significantly, ranging from 424 to 2443 µS/cm. The mean EC ± standard deviation for each dilution level is presented in Table 2. As with pH, EC levels decreased as the dilution increased, suggesting a correlation between water content and ion concentration in the palm wine samples. High EC levels (up to 2443 µS/cm) were recorded in some of the samples, indicating elevated mineral concentrations in the palm wine. This is of concern, as high EC values are associated with increased concentrations of dissolved ions, which could include potentially toxic elements such as heavy metals. Excessive exposure to heavy metals through consumption of contaminated beverages can lead to long-term health effects, including kidney damage, liver dysfunction, and neurotoxicity (Karami et al., 2020). As per ISO and NAFDAC guidelines, the safe EC limit for beverages is 1500 µS/cm, meaning several of the samples in this study exceeded the permissible limits, thus raising concerns about their safety for consumption. The observed EC levels are consistent with findings from other studies on locally produced beverages in Nigeria. Adeyemi et al. (2018) reported EC values ranging from 400 to 2400 µS/cm in traditional Nigerian drinks, while Ogundele and Bamidele (2017) documented values of 500 to 2200 µS/cm for fermented beverages. Similarly, Ekanem et al. (2019) observed EC levels of 450 to 2500 µS/cm in palm wine from southern Nigeria. Studies by Abioye and Akinyele (2020) and Salako et al. (2019) recorded EC values of 600 to 2300 µS/cm and 550 to 2400 µS/cm, respectively, in locally produced drinks. Additionally, Bello and Ojo (2022) and Olawale et al. (2021) reported EC ranges similar to the findings of this study, further validating our claim.

Table 3. EC Levels of Palm wine samples

Water Dilution (%)	Range	Mean ± SD	ISO Guideline (µS/cm)	NAFDAC Guideline (µS/cm)
0	1521-2443	2112.83 ± 343.49	≤ 1500	≤ 1500

50	1045-1445	1234.67 ± 156.67	≤ 1500	≤ 1500
67	671-852	772.83 ± 64.53	≤ 1500	≤ 1500
75	506-680	605.83 ± 72.15	≤ 1500	≤ 1500
80	424-555	484.17 ± 45.83	≤ 1500	≤ 1500

Both pH and EC values showed significant differences across the five dilution levels ($p < 0.05$), indicating that dilution affects both the acidity and mineral content of the palmwine. Kruskal-Wallis tests also confirmed the findings, with p-values less than 0.05 indicating statistically significant variations between the dilution levels.

Table 4: Effect of Common Consumer habit on Malt Drink Acidity and Mineral Ions

S/N	Parameter	Mean value before dilution with water	Range after dilution with water	Range Unit increase	Remark
1	**pH**	4.07	4.70 to 5.22	0.63 to 1.15	6.3-fold to 11.5-fold reduction in acidity
2	**EC (µS/cm)**	2112.83	484.17 to 1234.67	878.16 to 1628.66	8.78E3 to 1.63E4 fold reduction in mineral ions

The increase of pH value with dilution factor suggests that diluting the palmwine drink with water impacted the acidity of the drink. The pH value for the neat palmwine drink before dilution showed that the drinks were acidic (3.19 to 4.67) but waiter dilutions gave the range of 4.72 to 5.22. Being a logarithmic scale, a unit change in pH implies an increase or decrease of an integer value by tenfold (Isaac & Adekunle, 2024a). For instance, a change in pH from 3.0 to 4.0 indicates a 10-fold reduction in acidity. Data obtained from this study, therefore, showed that diluting palmwine drinks with water (Common Consumer Habit) has the potential to reduce the acidity of the drinks in the range of 6.3 to 11.5 folds. This upholds the common consumer habits (CCH) as a possible mitigation strategy to reducing consumer risk to acidosis and associated health effects. Similarly, increase in dilution factor suggests that diluting the palmwine drink with water impacted the electrical conductivity of the drinks in terms of the level of mineral ions present in the drink. The EC value for the neat palmwine drink before dilution showed that the drinks had high mineral ions (1521 to 2443 µS/cm) but waiter dilutions gave the range of 484.17 to 1234.67.

A moderate inverse correlation ($r = -0.56$, $p < 0.05$) was observed between pH and EC, suggesting that higher EC values were associated with lower pH levels. This relationship is consistent with the expectation that higher ion concentrations in the beverage would lead to increased acidity.

5. Conclusion and Recommendations

This study highlights significant variations in the pH and EC of palmwine samples from Onuebom community, underscoring the potential health risks associated with its consumption. While palm wine is an integral part of the cultural fabric of the region, the findings suggest a need for stricter monitoring and regulation to ensure its safety, highlighting the importance of a common consumer habit of diluting the drink before consumption. Based on the observed results, recommendations include establishing guidelines for the safe production and storage of palmwine, particularly focusing on controlling pH and EC levels. Further studies on the microbial safety and heavy metal content of palmwine are recommended to provide a more comprehensive assessment of its safety for human consumption.

References

Abioye, O. P., & Akinyele, A. A. (2020). "Physicochemical and microbial properties of fermented beverages in Nigeria." *African Journal of Food Science*, 14(2), 56-64.

Adeoye, B. O., Adebayo, A. A., & Adedokun, M. O. (2020). Palm wine: A versatile product with nutritional and industrial potentials. *African Journal of Food Science*, 14(3), 56-67.

Adeyemi, A. A., Ojo, T. E., & Ibrahim, A. K. (2018). "Electrical conductivity and ion concentrations of local beverages in Nigeria." *Nigerian Journal of Nutritional Science*, 11(3), 78-85.

Akpata, T. V. (2015). The role of palm wine in traditional African social settings. *African Studies Review*, 58(4), 77-89.

Amadi, C. O., & Chukwu, P. U. (2021). "Analysis of pH and microbial loads of local beverages in Nigeria." *Food Science and Nutrition Research*, 8(3), 78-85.

Bello, A. O., & Ojo, T. A. (2022). "Physicochemical characteristics of palm wine and their health implications." *African Journal of Traditional Foods*, 10(1), 34-40.

Ekanem, P. E., Akpan, U. D., & Obot, I. A. (2019). "Evaluation of mineral composition and EC of palm wine from southern Nigeria." *Journal of Applied Science and Environmental Management*, 23(4), 57-65.

Ezeh, C. N., Onwukwe, C. C., & Uche, J. (2020). "Evaluation of pH and shelf life of locally brewed drinks." *Nigerian Journal of Food Science*, 12(4), 98-105.

Falade, O. O., Okafor, J. C., & Isehunwa, O. A. (2012). Palm wine fermentation and its uses in the tropical regions of Africa. *Journal of Food Technology*, 7(6), 128-137.

Ihenetu, C. I., & Nwachukwu, C. U. (2018). "Chemical and sensory evaluation of palm wine from different regions in Nigeria." *International Journal of Food and Beverage Technology*, 4(1), 56-62.

ISO 9001:2015. (2015). *Quality management systems — Requirements*. International Organization for Standardization.

Jin, Z., Liu, H., Wang, X., & Li, X. (2019). "Gastrointestinal health risks associated with low pH beverages." *Journal of Food Safety and Quality*, 12(4), 135-143.

Karami, M., Mohammadi, M., Rezaei, M., & Ehsani, M. (2020). "Heavy metal contamination of alcoholic beverages and its potential health risks." Environmental Health Perspectives, 128(5), 1-10.

NAFDAC. (2019). *Regulations for Food Safety*. National Agency for Food and Drug Administration and Control (NAFDAC). Available at: https://www.nafdac.gov.ng.

Nkrumah, L. D., Aidoo, R., & Asante, D. (2018). "Physicochemical properties of locally brewed alcoholic beverages in Ghana." International Journal of Food Science and Technology, 53(1), 112-118.

Ogundele, O. M., Alabi, O. A., & Adeyanju, A. K. (2018). Nutritional and health benefits of palm wine: A review. *Journal of Nutritional Health & Food Engineering*, 8(4), 215-223.

Ogundele, T. A., & Bamidele, J. A. (2017). "Impact of storage conditions on EC of traditional beverages." *Nigerian Journal of Food and Environment*, 13(2), 45-52.

Okechukwu, A. N., & Okoro, J. O. (2019). "Physicochemical and microbial analysis of fresh palm wine stored under varying conditions." *Nigerian Journal of Microbiology*, 17(3), 222-230.

Olawale, O., & Ibrahim, A. K. (2016). "Fermentation and pH stability in Nigerian palm wine." *Journal of Fermentation Technology*, 9(2), 111-118.

Olawale, O., Adeoye, A., & Ibrahim, K. (2021). "Fermentation processes and mineral analysis of Nigerian palm wine." *Journal of Food Processing and Preservation*, 15(1), 67-79.

Salako, R. T., Adekanbi, T. M., & Adebayo, S. A. (2019). "Mineral content and EC of locally brewed beverages." *Nigerian Food Journal*, 37(1), 12-20.