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Determination of the Potential of Hydrogen (pH) level and sensory evaluation of locally produced beverages in Maiduguri, Borno State Nigeria

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Abstract

This study determines the pH values and evaluates the sensory attributes of five locally produced beverages: Ginger, Zobo, Kunu Aya, Tamarind, and Kunu Zaki. pH meter was used to determine the pH of each sample and panelists were source from student in the laboratory for evaluating the sensory attributes. pH measurements readings ranged from 4.27 to 5.00, indicating varying levels of acidity. Kunu Aya, with the highest mean pH of 5.00, was the least acidic, while Zobo, with a mean pH of 4.27, was the most acidic. The pH levels of the beverages were measured using a digital pH meter. Ginger, Tamarind, and Kunu Zaki exhibited moderate acidity with mean pH values of 4.67, 4.40, and 4.50, respectively. Sensory evaluation assessed appearance, aroma, taste, sour/bitterness, texture, and freshness, revealing varied acceptability levels. Ginger and Zobo beverages achieved a 50% acceptability rate, excelling in appearance and taste but showing inconsistencies in freshness and sourness. Kunu Aya also recorded 50% acceptability, benefiting from its mild acidity, though challenges with aroma and freshness was noted. Tamarind beverage, despite a pH of 4.40, received a 0% acceptability rate due to imbalances in sourness and freshness, overshadowing its positive appearance and taste ratings. Kunu Zaki had a 25% acceptability rate, with sourness, texture, and freshness negatively impacting its sensory profile. The study highlights the relationship between pH and sensory acceptability, suggesting that beverages with slightly higher pH values tend to have greater consumer appeal. However, factors such as flavor balance, aroma, and freshness play critical roles in overall acceptability. This study evaluates the pH values and sensory characteristics of five locally produced beverages: Ginger, Zobo, Kunu Aya, Tamarind, and Kunu Zaki. pH measurements readings ranged from 4.27 to 5.00, indicating varying levels of acidity. Kunu Aya, with the highest mean pH of 5.00, was the least acidic, while Zobo, with a mean pH of 4.27, was the most acidic. The pH levels of the beverages were measured using a digital pH meter. Ginger, Tamarind, and Kunu Zaki exhibited moderate acidity with mean pH values of 4.67, 4.40, and 4.50, respectively. Sensory evaluation assessed appearance, aroma, taste, sour/bitterness, texture, and freshness, revealing varied acceptability levels. Ginger and Zobo beverages achieved a 50% acceptability rate, excelling in appearance and taste but showing inconsistencies in freshness and sourness. Kunu Aya also recorded 50% acceptability, benefiting from its mild acidity, though challenges with aroma and freshness was noted. Tamarind beverage, despite a pH of 4.40, received a 0% acceptability rate due to imbalances in sourness and freshness, overshadowing its positive appearance and taste ratings. Kunu Zaki had a 25% acceptability rate, with sourness, texture, and freshness negatively impacting its sensory profile. The study highlights the relationship between pH and sensory acceptability, suggesting that beverages with slightly higher pH values tend to have greater consumer appeal. However, factors such as flavor balance, aroma, and freshness play critical roles in overall acceptability. The findings emphasize the need for standardized production techniques to optimize flavor, maintain consistent quality, and enhance the sensory appeal of locally produced beverages.

Keywords: Tigernut; Kunu Zaki; Zobo; Ginger drink; Tamarind drink; Local beverages

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1. Introduction

Beverages are liquid that is meant for human consumption and to add to its basic function of satisfying thirst. The beverage is a drink other than water, locally made beverages, crafted using regional ingredients and traditional methods are an integral part of many cultures around the world. These beverages often reflect the unique flavors and heritage of their origins, offering a taste of local traditions and culinary practices (Aidoo *et al*., 2023). They range from fermented drinks like wine, beer, and sake to non-alcoholic options such as herbal teas, fruit juices, and artisanal sodas, others include Hibiscus drinks (commonly known as zobo drinks in Nigeria),Tiger nut drinks, drinks made from millet (known as kunu zaki in Nigeria). Locally made beverages offer numerous advantages, including fresher and higher quality products due to the use of regional ingredients and shorter supply chains. They help support local economies by providing income for local farmers, producers, and retailers (Okafor *et al.*, 2016). Additionally, these beverages often have a smaller environmental footprint, as they reduce the need for long-distance transportation and excessive packaging. Consuming local beverages also fosters a connection to the region's cultural heritage and traditions, allowing consumers to experience unique flavors and artisanal craftsmanship. Furthermore, it encourages sustainable agricultural practices and biodiversity by promoting the use of indigenous plants and traditional brewing or distilling methods (Adams *et al*., 2017).

The pH level of a beverage is a critical factor influencing its taste, preservation, and overall quality pH a measure of acidity or alkalinity, is pivotal in determining the chemical stability and sensory properties of a beverage. The scale ranges from 0 to 14, with values below 7 indicating acidity, values above 7 indicating alkalinity, and a value of 7 representing neutrality (McKay *et al*., 2016).

The pH of a beverage significantly affects its taste, preservation, and overall quality. Acidic beverages (low pH) often have a sharp, tangy flavor desirable in drinks like citrus juices and soft drinks, while higher pH levels result in a smoother, less tart taste, making pH balance essential for achieving consumer-preferred flavors (Belewu *et al*., 2018). Additionally, pH plays a crucial role in preservation, as acidic environments inhibit the growth of spoilage microorganisms and pathogens, extending the shelf life of non-alcoholic beverages, which are particularly susceptible to microbial contamination. The overall quality of a beverage, including attributes such as color, aroma, and mouth feel, is also closely tied to its pH, as it can affect the stability of color pigments, the release of aroma compounds, and the sensory experience. Thus, maintaining an optimal pH is vital to ensure and enhance the quality attributes that consumers expect (Hopkins *et al*., 2023).

Sensory evaluation is a scientific method used to measure, analyze, and interpret reactions to the characteristics of foods and beverages as perceived by the senses of sight, smell, taste, touch, and hearing. This approach is vital for understanding consumer preferences and acceptance, guiding product development, and ensuring quality control. By identifying the sensory attributes most appealing to consumers, such as taste, aroma, color, and texture, producers can tailor their products to meet consumer expectations in a competitive market where sensory quality can determine a product's success or failure. During the development of new beverages, sensory evaluation provides valuable insights into how modifications in ingredients, formulations, or processing methods affect the final product, allowing producers to optimize their formulations to meet desired sensory criteria and consumer acceptance (Okafor *et al*., 2016).

Furthermore, sensory evaluation is integral to quality control, helping to ensure consistency in the sensory attributes of beverages. Regular sensory testing can detect variations in production that may affect taste, aroma, or appearance, allowing producers to take corrective actions and maintain high-quality standards. Understanding the sensory attributes that drive consumer preference also enables producers to position their products more effectively in the market. (Adejuiitan *et al*., 2021).

(Ginger) *Zingiber officinale* the underground rhizome of the zingiberous herbaceous plant *(Ahammed et al., 2014),* is a rhizobium plant belonging to the family *Zingiberaceae*. Its origin is southeast districts of Asia *(Maher et al., 2020).* Ginger *Zingiber officialis rosoe* is an important spice crop of the world and plays valuable roles as food additives (spices) in foods *(Adeyanju et al., 2014).*Essential micronutrients like potassium, magnesium, copper, manganese, and silicon can be found in good amounts in ginger. Small amount of vitamins A, E and some amounts of B- vitamins and Vitamin C are also found in ginger rhizome (Adel and Prakash, 2016).

Various dried petal and succulent aqueous acid extracts of (Roselle calyx are used to make Zobo), a crimson, non-alcoholic beverage from the area (Zumbes *et al*., 2014). The Hausa native word Zoborodo is where the term "Zobo" came from (Ayandele, 2015). This non-alcoholic beverage is very popular, especially in Northern Nigeria (Egbere *et al*., 2017). Zobo is rich in minerals, calcium, iron, riboflavin, niacin, protein, carbs, vitamin A, and other antioxidants (Ehsemokha, 2020).

Cyperus esculentus (Tiger nut) belongs to the family *Cyperaccae*. It is a tuber that grows freely and is consumed widely in Nigeria and in various other parts of West and East Africa *(Umar et al., 2014).*Tiger-nut was found to be a cosmopolitan perennial crop of the same genus as the papyrus plant. Tiger nut juice is whitish and very refreshing especially when chilled. It is prepared mostly for domestic and public consumption. In every society, drinks of indigenous origin are produced in different ways and served sometimes in several occasions *(Umar et al., 2014).*

Tamarindus indica (Tamarind) is a leguminous tree that belongs to the family *Fabaceae* with Subfamily *Caesalpiniaceae* (*Van-der-Stege et al.,2011)* which is the third largest family of flowering plants *(Manjula etal., 2017).Tamarindus indica* is a tropical fruit found in Africa and Asia, is highly valued for its pulp *(Nguyen Phuoc, 2015).* The plant is believed to be indigenous to the tropical *(Chimsah et al., 2020).* Tamarind fruit pulp has a sweet acidic taste due to a combination of high contents of tartaric acid and reducing sugars *(Nguyen Phuoc, 2015).*Tamarind is known in various languages as "imli" in Hindi, "tamarin" in French, "taman" in the Philippines, "tsamiya" in Nigeria, and "djabbe" in Cameroon. The fruit is good source of calcium, phosphorus, iron and vitamins and also contains small amounts of vitamin A and C *(Manjula et al., 2017).*

Kunu-zaki is the traditional Hausa name of an indigenous non-alcoholic fermented beverage, which is produced and commonly consumed by adults and children in Nigeria particularly, in the northern region as a refreshing drink, an appetizer, and food complement and to quench thirst (Oranusi *et al*., 2013). Kunun-zaki is prepared from any of the following cereal grain: (guinea corn) *sorghum bicolour*, (millet) *pennisetum typhoides*, (maize) *zea mays*, (rice) *oryza sativa*, or (wheat) *triticum aestivum* (Akoma *et al*., 2016). It is used as an alternative for or to complement soft drinks and wines at traditional, religious, marriage, funeral and other social gathering, markets, offices, and schools (Abegaz, 2017). Kunun-zaki is a major source of calories and an excellent source of energy in form of carbohydrates. It provides source of income and a means of poverty alleviation and contributes to variety in the diet and the food security of million people (Ajao and Yakubu, 2011).

The determination of pH and Sensory evaluation are intertwined aspects of beverages production that directly influence consumer satisfaction and market success. This study will therefore determine the pH level and evaluate the sensory attributes of locally produced and sold beverage within Maiduguri, Borno State.

2. Material and methods

Five different freshly prepared beverages were purchased from five different markets across Maiduguri Borno State. The beverage was transported inside a cool chain block so as to maintain the integrity of the beverages and brought to the Microbiology laboratory for further analysis. Analysis of pH and sensory evaluation was done the same day the beverages were purchased. Also, when the beverages were brought to the laboratory, they were kept inside the fridge of the laboratory.

2.1. Determination of pH values of Beverages

Prior to the determination of pH values for each beverage, the beverages was kept at room temperature. The pH of the beverages was determined using a digital pH meter. The pH meter rod was cleaned properly and then dipped into distilled water contained in the transparent plastic cup; the distilled water was used as control. The reading was taken in triplicates and recorded appropriately.

After taking the pH reading of the distilled water the beverages was poured into each transparent plastic cup and the pH rod was dipped into each of the beverages while cleaning intermittently after each dip into the beverages. The readings was taken in triplicates and recorded.

2.2. Selecting of Sensory Panelist

Sensory panelist was selected at random from the Microbiology Students within the department.

2.3. Sensory Analysis

The sensory analysis was carried out by arranging six plastic transparent cups. One cup was for distilled water and the other five cups were for each beverage. First the panelist took water to rinse his mouth after which he throws out and took the first beverages then indicated his findings either as 'Yes' or 'No'. Then he took a cracker to maintain the taste of his mouth, drink water again and took the next beverage after which he repeated the same process as above for the whole beverages.

3. Results

3.1. Mean pH values of Locally Produced Beverages

The mean pH values of locally produced beverages, determined in triplicate per sample. Among the beverages, Kunun Aya (Tiger nut drink) has the least acidic mean pH (5.00), while Zobo is the most acidic with a mean pH of 4.27.

Table 1 Mean pH values of Locally Produced Beverages

Beverages	Sample Code	Reading 1	Reading 2	Reading 3	Mean pH value
Ginger	G-0244	5.50	4.50	4.00	4.67
Zobo	ZO-0321	4.60	4.40	3.80	4.27
Kunun Aya	KA-0882	5.30	5.00	4.70	5.00
Tamarind	TA-0445	4.80	4.50	3.90	4.40
Kunun Zaki	KZ-0770	5.20	4.20	4.10	4.50

Table 2 Presents the sensory evaluation and acceptability of Ginger beverage (Code: G-0244), showing a 50% acceptability rate based on assessments of six parameters: appearance, aroma, taste, sour/bitterness, texture, and freshness. All samples scored positively for appearance, aroma, taste, and texture, indicating strengths in these areas. However, mixed responses were observed for sourness and freshness, which likely contributed to the variation in acceptability, with two samples rated as "OK" and two as "NOK" (not OK).

Table 2 Sensory for Ginger Beverage Acceptability Rate: 50%

Beverage Code	Appearance		Aroma		Taste		Sour/Bitterness		Texture		Freshness		Comment
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	
G-0244	√		√		√		√			√	√		NOK
G-0244	√		√			√	√		√		√		NOK
G-0244	√		√		√		√		√		√		OK
G-0244	√		√		√		√		√		√		OK

Key Color Code:

ACCEPTABLE = YES | NOT ACCEPTABLE = NO | ACCEPTABLE = BASED ON NATURAL

Table 3 Sensory for Zobo Beverage Acceptability Rate: 50%

Beverage Code	Appearance		Aroma		Taste		Sour/Bitterness		Texture		Freshness		Comment
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	
Zo-0231	√			√	√			√		√	√		OK
Zo-0231		√	√		√		√			√	√		NOK
Zo-0231	√		√		√		√		√		√		OK
Zo-0231	√		√			√		√		√	√		NOK

Key Color Code:

ACCEPTABLE = YES | NOT ACCEPTABLE = NO | ACCEPTABLE = BASED ON NATURAL

Table 3: the sensory evaluation of Hibiscus drink (Zobo beverage), revealing a 50% acceptability rate based on six sensory attributes: appearance, aroma, taste, sour/bitterness, texture, and freshness. The assessments show consistent positive ratings for appearance and taste, while aroma and freshness exhibited mixed results across samples. Texture and sour/bitterness were also variable, contributing to the divide between two samples rated "OK" and two deemed "NOK" (not OK).

Table 4: Outlines the sensory evaluation of Kunu Aya beverage (Code: K-A 0882), showing a 50% acceptability rate based on six attributes: appearance, aroma, taste, sour/bitterness, texture, and freshness. The beverage consistently scored well for appearance, indicating strong visual appeal, and showed positive ratings for taste across all samples. However, aroma and freshness were mixed, with some samples receiving negative ratings. Variability was also noted in sour/bitterness and texture, contributing to the split in overall comments, with two samples rated as "OK" and two as "NOK" (not OK).

Table 4 Sensory for Kunu Aya Beverage Acceptability Rate: 50%

Beverage Code	Appearance		Aroma		Taste		Sour/Bitterness		Texture		Freshness		Comment
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	
K-A 0882	√				√			√		√	√		NOK
K-A 0882	√		√			√		√	√		√		NOK
K-A 0882	√		√		√			√	√		√		OK
K-A 0882	√		√		√			√	√		√		OK

Key Color Code:

ACCEPTABLE = YES | NOT ACCEPTABLE = NO | ACCEPTABLE = BASED ON NATURAL

Table 4.5: presents the Sensory evaluation of kunu Zaki beverage(code Kz-0770),which recorded a 0% acceptability rate.despite consistent positive ratings for the appearance and some favorable scores for taste,all samples were marked NOK(not ok) in the overall assessment.

Table 5 Sensory for Tamarind Beverage Acceptability Rate: 0%

Beverage Code	Appearance		Aroma		Taste		Sour/Bitterness		Texture		Freshness		Comment
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	
Ta 0445	√			√	√		√			√	√		NOK
Ta 0445		√	√			√	√		√		√		NOK
Ta 0445	√			√	√			√		√	√		NOK
Ta 0445	√		√		√		√			√	√		NOK

Key Color Code:

ACCEPTABLE = YES | NOT ACCEPTABLE = NO | ACCEPTABLE = BASED ON NATURAL

Table 6: Highlights the sensory evaluation of Kunu Zaki beverage (Code: Kz-0770), which achieved a 25% acceptability rate. Appearance and aroma received generally favorable ratings, with three out of four samples scoring positively for both attributes. Taste, texture, and freshness showed inconsistent ratings, with mixed responses across samples. Sour/bitterness exhibited more variability, potentially influencing the low overall acceptability. Of the four samples assessed, only one was rated "OK," while the remaining three were marked "NOK" (not OK).

Table 6 Sensory for Kunu Zaki Beverages Acceptability Rate: 25%

Beverage Code	Appearance		Aroma		Taste		Sour/Bitterness		Texture		Freshness		Comment
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	
Kz-0770	√		√			√		√	√		√		NOK
Kz-0770	√		√		√		√		√		√		OK
Kz-0770		√	√		√		√			√	√		NOK
Kz-0770	√			√	√			√		√	√		NOK

Key Color Code:

ACCEPTABLE = YES | NOT ACCEPTABLE = NO | ACCEPTABLE = BASED ON NATURAL

Table. 7: Comparison of pH value with Acceptability of Sensory evaluation

Table 7 Comparison of pH and Beverages Acceptability

Beverages	Sample Code	Mean pH value	% Acceptability
Ginger	G-0244	4.67	50
Zobo	ZO-0321	4.27	50
Kunun Aya	KA-0882	5.00	50
Tamarind	TA-0445	4.40	0
Kunun Zaki	KZ-0770	4.50	25

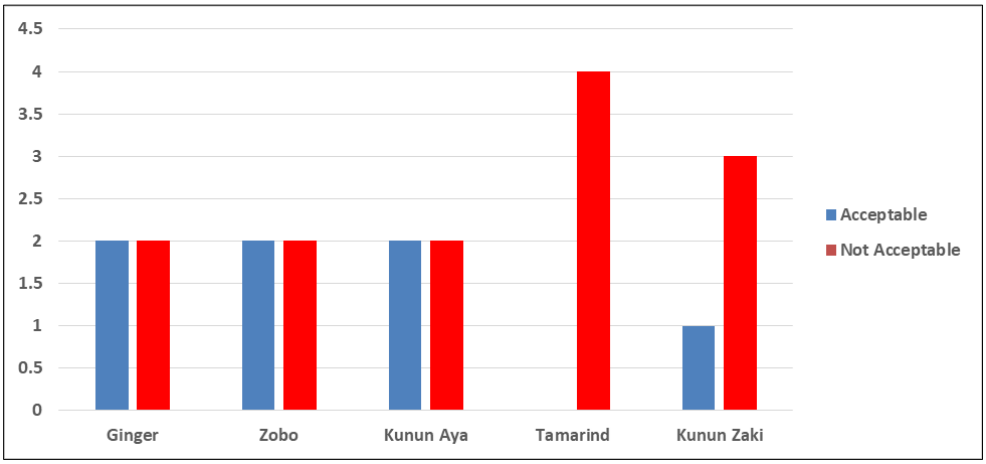

Figure 1 Sensory Evaluation of Beverages

4. Discussion

Table 1 presents the mean pH values of five locally produced beverages, determined from three readings per sample. The beverages analyzed include Ginger, Zobo, Kunun Aya, Tamarind, and Kunun Zaki, with mean pH values ranging from 4.27 to 5.00. The least acidic beverage was Kunun Aya, with a mean pH of 5.00, while Zobo was the most acidic, recording a mean pH of 4.27. The other beverages exhibited moderate acidity, with Ginger, Tamarind, and Kunun Zaki having mean pH values of 4.67, 4.40, and 4.50, respectively. The slight variations in the pH readings within each sample suggest potential differences in preparation methods, ingredient ratios, or fermentation stages.

When compared to findings in previous studies of Lawless, (2010); Cortez *et al*. (2017), there results align with the general acidity range of traditional beverages. For example, studies on Zobo (hibiscus-based drinks) often report pH values between 3.8 and 4.5, emphasizing its acidic nature due to the presence of organic acids like citric and tartaric acids (Cortez *et al*., 2017). Similarly, the pH of Kunun Aya, a beverage made from tiger nuts, is consistent with earlier research of Efiuvwevwere *et al*. (2015) indicating its mild acidity, attributed to its minimal fermentation and inherent nutty composition. Ginger beverages typically exhibit moderate acidity, as seen in this study, due to the natural acids in ginger and additives like lemon or preservatives.

The pH values are critical in assessing the shelf life, microbial stability, and palatability of these beverages (Kordylas *et al*., 2020). Acidic beverages with pH below 4.6 generally inhibit bacterial growth, enhancing preservation. However, overly acidic drinks may affect consumer acceptability due to sharp taste profiles (Kordylas *et al*., 2020). Overall, these findings highlight the need for standardization in beverage production to maintain consistent quality and optimize health benefits while ensuring alignment with consumer preferences and safety standards.

The sensory evaluation of the beverages revealed varying levels of acceptability influenced by attributes such as appearance, aroma, taste, sour/bitterness, texture, and freshness. Ginger and Zobo beverages, both achieving 50% acceptability, were praised for their appearance and taste but showed inconsistencies in freshness and sourness, which impacted their overall appeal. Kunu Aya, with a similarly moderate acceptability rate, excelled in appearance and taste but faced challenges with aroma and freshness, highlighting room for improvement despite its mild acidity. Tamarind beverage, however, recorded a 0% acceptability rate, with imbalances in sourness and freshness overshadowing its strengths in appearance and taste. Kunu Zaki, at 25% acceptability, struggled with sour/bitterness and freshness, suggesting a need for refinement to enhance its sensory profile. Overall, the beverages demonstrated a mix of strengths and weaknesses, with pH levels and flavor balance playing crucial roles in consumer perception and acceptance.

In comparing the sensory evaluation and pH values of the beverages, it was shown that the ginger beverage, with a mean pH of 4.67, exhibited moderate acidity and achieved a 50% sensory acceptability rate, showing strengths in appearance, aroma, and taste, but was affected by inconsistencies in sourness and freshness. The Zobo beverage, being the most acidic with a mean pH of 4.27, also recorded a 50% acceptability rate, with its characteristic sourness influencing mixed sensory responses, particularly for freshness and sourness. Kunu Aya, with the least acidic pH of 5.00, reflected its mild nature in sensory evaluations, also achieving 50% acceptability, though challenges with aroma and freshness highlighted areas for improvement despite strengths in taste and appearance. The Tamarind beverage, with a pH of 4.40, received the lowest acceptability rate of 0%, as all samples were rated "NOK," with its moderate acidity unable to compensate for perceived imbalances in sourness and freshness. Lastly, the Kunu Zaki beverage, with a pH of 4.50, had a 25% acceptability rate, as issues with sourness, texture, and freshness overshadowed its moderate acidity and potential strengths in other sensory attributes.

5. Conclusion

The beverages with slightly higher pH values (Ginger and Kunu Aya) tended to have better sensory acceptability, likely due to their milder acidity. In contrast, beverages with lower pH values, such as Zobo and Tamarind, showed more pronounced sourness, which contributed to mixed or low sensory ratings. This indicates that while pH is an important factor in sensory appeal, other elements such as ingredient balance, freshness, and texture also play critical roles in determining overall acceptability.

Recommendation

The findings of this research recommend for standardized production techniques to optimize flavor, maintain consistent quality, and enhance the sensory appeal of locally produced beverages. This could improve consumer satisfaction while ensuring safety and microbial stability.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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