



Vol. 10(1), Pp. 69-74, February 2025,

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<https://journals.directresearchpublisher.org/index.php/drjphet>

Research Article
ISSN: 2734-2182

Qualitative and Quantitative Analysis of Various Alcoholic and Non-Alcoholic Beverages Brewed in Nigeria

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ABSTRACT

Alcoholic and non-alcoholic drinks are widely consumed daily in Nigeria due to their affordability, unique flavours, and ability to quench thirst. Additionally, some people enjoy these beverages for their intoxicating effects. However, the high demand for these drinks can compromise production quality, potentially leading to contamination. Such contamination can cause intoxication and, in severe cases, may lead to death in humans. This study aimed to qualitatively and quantitatively analyze various alcoholic and non-alcoholic beverages produced in Nigeria. The parameters investigated include organoleptic properties, such as alcohol content (both by volume and by weight), as well as attenuation limit. In addition, physicochemical properties are analyzed, including colour intensity, total acidity, volatile acidity, fixed acidity, and pH concentration. This investigation aims to compare the quality of these beverages and assess their compliance with established international standards. The results of the analysis indicate that the apparent extract percentages were found to be 5.621%, 1.005%, 1.004%, 1.004%, and 1.004% for Stout, Gulder, Star, Harp, and Kronenbourg, respectively. For the soft drinks, the apparent extracts were found to be 1.0021% for Fanta, 1.0017% for Maltina, 1.0017% for 7Up, 1.0009% for Maltonic, and 1.0016% for Coke. The results show that most parameters met international standards set by American Society of Brewing Chemists (ASBC) and the European Brewery Convention (EBC). The findings of this study will equip consumers and industries with the necessary information to make informed choices about their beverage selections.

Keywords: Beverages brewed, Alcoholic drink, Non-alcoholic drink, Quantitative analysis, Qualitative analysis

Article information

Received 5 January 2025

Accepted 10 February 2025

Published 14 February 2025

DOI: <https://doi.org/10.26765/DRJPHET13393831>

Citation: Ibrahim, M., Issa, B. R., Kani, Z. I., and Apollos, O. A. (2025). Qualitative and Quantitative Analysis of Various Alcoholic and Non-Alcoholic Beverages Brewed in Nigeria. Direct Research Journal of Public Health and Environmental Technology. Vol. 10(1), Pp. 69-74. This article is published under the terms of the Creative Commons Attribution License 4.0.

INTRODUCTION

Alcoholic and Non-alcoholic drinks are highly consumed in Nigeria. In 2007, the consumption of non-alcoholic beverages in Nigeria was estimated at 159.85 grams per person per day according to the United Nations Food and Agriculture Organization in 2011. The high consumption rate of these beverages can be attributed to their distinctive taste, and flavour, intoxicating properties, as well as their ability to quench thirst (Abdullahi and Yakubu, 2013). These characteristics are largely defined by their ingredients, such as sugar, which provides sweetness;

carbonated water, which is water infused with carbon dioxide, enhancing its thirst-quenching ability; and various flavouring and alcoholic agents that contribute to the overall taste of the beverages (Bola and Aboaba, 2004). A beverage is a liquid intended for drinking, and liquids are an essential part of our diet (Macmillan, 1986). Beverages are among the most common liquids in the world and serve various purposes. They can refresh and quench thirst, stimulate the senses (e.g., tea, coffee, and beef tea), and provide nourishment (e.g., milk, egg drinks, cereal drinks,

etc.). Beverages can be served hot or cold, and due to their diverse uses, their consumption is increasing rapidly among people. Beverages are typically classified into two categories: alcoholic and non-alcoholic. Although alcoholic beverages are only marginally considered food, they have a close association with the food industry due to their protein and carbohydrate content (Sutherland and Varnam, 1994). Ordinioha, (2008) reported that alcoholic beverages account for more than half of the gross value of fermented products worldwide.

The federal definitions and standards for non-alcoholic beverages encompass all so-called "soft drinks." Soft drinks are a category of non-alcoholic beverages that are typically, but not necessarily, carbonated. They contain sweetening agents, edible acids, and natural or artificial flavours. Natural flavours are derived from fruits, nuts, berries, cocoa, and undiluted fruits and vegetables (Abdullahi and Yakubu, 2013). It is important to note that juices are not classified as soft drinks. The term "soft drink" originated to differentiate flavoured beverages from hard liquor or spirits. Soft drinks were recommended as a substitute in efforts to change the excessive drinking habits of early Americans (Philip et al., 2013). Generally, soft drinks can be produced in a form suitable for immediate consumption or as a concentrate that is intended to be diluted with water multiple times before drinking (damle et al., 2011; Wojcicki and Heyman, 2010). With the exception of strictly Islamic nations, alcohol is produced and consumed in various forms across many regions of the world. Overall, per capita alcohol consumption is increasing, which has raised concerns in several countries, including Nigeria, particularly regarding rising rates of alcoholism among women and teenagers (Okaru et al., 2019). Research has shown that individuals who consume alcohol frequently often suffer from malnutrition, especially from vitamin B deficiencies. High alcohol consumption can lead to serious health issues, such as cirrhosis of the liver, as well as depressive effects and even brain damage (Francis et al., 2020). In contrast, soft drinks containing caffeine a powerful stimulant from the bitter alkaloids family can increase the basic metabolic rate (BMR) by 10% (Vicki Peterson, 2020). However, regular consumption of large quantities of these drinks may lead to health problems such as high blood pressure, hyperacidity, nausea, increased heart rate, and anxiety. These effects prompted the British medical journal "Lancet" in 1977 to advise medical doctors to be vigilant for symptoms of caffeine addiction among patients seeking medical help (Vicki Peterson, 2020; Okiwelu, 2008).

Many Nigerians, especially those who are literate, tend to prefer beer over other available soft drinks and alcoholic beverages (Umunna, 2019). However, in tropical regions, some individuals favour soft drinks. This preference is partly due to diets in these areas often lacking sufficient protein. To address this issue, soft drinks flavoured with soya beans have been marketed as an affordable way to supplement protein intake. As a result, there has been a notable increase in the demand for soft drinks among the

general population in recent years (Israel and Abel, 2017). With the expansion of market which resulted in the movement of different brands of beverages, it is important to conduct both qualitative and quantitative analyses of various alcoholic and non-alcoholic beverages produced in Nigeria. Due to the introduction of various beverage brands, especially beer and soft drinks, this had created a need to verify the quality and contents of these drinks to ensure consistent taste and clarity over time. Customers expect their favorite brands to deliver the same quality regardless of where they make their purchases in this growing market. The aim of this study is to analyze some brands of beverages both alcoholic and non-alcoholic from various industries within Nigeria.

MATERIALS AND METHODS

Sample collection

Samples of commonly available alcoholic beverages (beer) and non-alcoholic beverages (soft drinks) were purchased from military barracks and corner shops at Federal University of Technology in Minna, located in the North-Central zone of Nigeria. Different batches of samples were collected weekly for duration of six weeks. The analyzed samples included Gulder, Star, and Maltina from Nigerian Breweries Limited in Kaduna; Harp, Kronenbourg, and Miltonic from International Breweries and Beverages in Kaduna; Stout from Nigeria Guinea Stout Limited in Lagos; 7Up from the 7Up Bottling Company in Lagos; and Coke and Fanta from Coca-Cola Bottling Company. All samples were stored in a refrigerator to prevent contamination by fungi and bacteria, which could affect their original quality and characteristics (Asogwa and Eze, 2022; Oladimeji et al., 2021).

Laboratory analysis

Due to the growing interest in methods and instruments for continuous analysis and monitoring of bottled beverages for specific parameters, such as the automatic continuous determination of alcohol content (ethanol), specific gravity, hydrogen ion concentration (pH), color, and other organoleptic properties, the methods recommended by the European Brewery Convention and the official methods of analysis from the Association of Official Analytical Chemists have been adopted for this work.

Determination of specific gravity (SP.G)

The specific gravity bottle was first, thoroughly cleaned by immersion in a chromic acid bath, then washed with distilled water and rinsed a little with ether. The bottle was weighed empty and then filled with freshly boiled and cooled distilled water using a thistle funnel. The specific gravity bottle was immersed in a thermostatic water bath, maintained at 20°C and allowed to come to equilibrium after 30 minutes. The level of water in the specific gravity

bottle was gently adjusted so that the meniscus lied immediately above the graduation mark on the neck. The specific gravity bottle was then returned to the water bath for a few minutes. The inside of the neck above the meniscus was wiped dry with a piece of filter paper and the exterior of the bottle was carefully dried with a clean cloth. The weight of the water was determined. The sample was also weighed using the same procedure and the specific gravity determined using the formula:

$$\text{Specific gravity} = \frac{\text{weight of sample}}{\text{weight of equal volume of water}}$$

Determination of alcohol content by volume (ALC%VOL.)

100ml of the sample was measured into 500ml distillation flasks and the temperature noted. 50ml of distilled water was added. The flask was attached to a vertical condenser by means of a bent tube. The flask and its content were diluted to 100ml with distilled water at the same temperature. When foaming occurred it was prevented by the addition of small amounts of antifoam material. The specific gravity of the distillate was then determined (Ogah, et al., 2019).

Determination of alcohol content by weight (ALC%WT)

50g of the sample was accurately weighed using clean and dried specific gravity bottle, the stopped. The weighed sample was transferred quantitatively to 500ml distillation flask containing 50ml of distilled water and few glass beads. The specific gravity bottle was rinsed three times bringing the contents of the distillation flask to 125ml. this was then distilled and its specific gravity was used to determine the percentage alcohol by weight.

Determination of colour

250ml of distilled water was brought to boil and this was continued for two minutes. From a fast-flowing pipette, 25ml sample, previously decarbonated (by shaking and filtering) was introduced. After emptying the pipette, heating was continued for 60sec. with the regulation of the heat so that the solution resumed boiling the final 30sec. It was then removed from the heat, stirred for 5sec and cooled rapidly to room temperature. 0.5ml of 0.5% phenolphthalein indicator was added and the sample solution was titrated with 0.1ml sodium hydroxide solution against white appropriate anticipated amount of alkali but no indicator was added. Titration was carried out to first appearance of a faint pink coloration. The burette was read and 0.2ml more alkali was added to obtain a permanent definite pinkish-red color (an indicative of over- titration). The first burette reading was taken as the end-point. Results were reported as % lactic acid to nearest 0.01% (1ml alkali = 0.0090g lactic acid).

Official Publication of Direct Research Journal of Public Health and Environmental Technology: Vol. 10, 2025; ISSN: 2734-2182

Determination of apparent attenuation

100ml of sample was accurately weighed to 0.1g and was evaporated on a water bath maintained at temperature of about 80°C to about half the original volume. This was cooled and made to original weight with distilled water and the specific gravity was determined with a specific gravity bottle at 20°C. from this specific gravity value the corresponding extract was determined. This was used to determine the other extracts using De Clericks table.

$$\text{Apparent extract (AE)} = \frac{\text{specific gravity of dealcoholised beer}}{\text{specific gravity of beer}}$$

$$= \frac{\text{g extract}}{100\text{g beer}}$$

Extract of original wort (O) was calculated as follows

$$O = \frac{A \times 2.0665 + E \times 100}{100 + (A \times 1.066)}$$

Where O = extract of original wort

A = % alcohol by weight of 100ml of beer

E = % real extract

Apparent attenuation is then calculated as followed:

$$A = \frac{(\text{original extract} - \text{apparent extract}) \times 100}{\text{original extract}}$$

Determination of total acidity (TA)

CO₂ was removed using the following procedure, 25ml of the sample was placed in a small conical flask and connected to a water aspirator. This was then agitated for 1min. under vacuum. 1ml phenolphthalein indicator solution was added to 200ml boiled waster in 500ml wide mouth Erlenmeyer. This was neutralized to distinct pink colour. 5ml of degassed sample was added and titrate with 0.1mol/dm⁻³ standardized NaOH to same end point.

Calculated gram acid/100ml beer = ml of NaOH × Molar concentration × (0.075 × 100)/5

Determination of total volatile acidity (VA)

1.25cm³ of the beer sample was taken and diluted with 50cm³ of distilled water and titrated against 0.1mol.dm⁻³ NaOH using phenolphthalein. Another 25cm³ of sample solution was taken and placed in a white porcelain evaporating basin and evaluated to a small bull on a water bath. 2.5cm³ of distilled water added and evaporated repeated. Addition of water and evaporation were repeated three times. 250cm³ of distilled water was added and titrated against 0.1mol.dm⁻³ Sodium hydroxide using phenolphthalein as indicator. The difference between the two titres was obtained and they were due to the volatile

Table 1: Parameters found in various non-alcoholic drinks

	Maltonic	Maltina	Fanta	Coke	7UP	P-value
	$\bar{x}\pm SD$	$\bar{x}\pm SD$	$\bar{x}\pm SD$	$\bar{x}\pm SD$	$\bar{x}\pm SD$	
Temp	23.33±3.06	23.00±3.61	25.00±1.00	23.00±6.08	22.67±2.52	p>0.05
pH	4.81±0.28	4.64±0.24	3.82±0.80	3.76±0.80	3.92±0.71	p>0.05
VA	0.02±0.00	0.01±0.00	0.04±0.00	0.02±0.00	0.04±0.00	p>0.05
TA	0.16 ^b ±0.02	0.24 ^a ±0.05	0.24 ^a ±0.01	0.16 ^b ±0.02	0.32 ^a ±0.02	p<0.05
F.A	0.31 ^a ±0.30	0.23 ^b ±0.05	0.19 ^b ±0.01	0.14 ^c ±0.02	0.28 ^a ±0.02	p<0.05
R.E	9.84 ^a ±0.20	9.27 ^a ±0.50	9.43 ^a ±0.46	7.81 ^b ±0.29	7.95 ^b ±0.23	p<0.05
A.E	1.00±0.00	1.00±0.00	1.00±0.00	1.00±0.00	1.00±0.00	p>0.05
C.I	7.29 ^a ±0.00	6.24 ^a ±0.05	0.87 ^b ±0.05	3.69 ^a ±0.00	6.24 ^a ±0.06	p<0.05
ALC%	0.08 ^a ±0.00	0.08 ^a ±0.00	0.04 ^b ±0.00	0.04 ^b ±0.00	0.06 ^a ±0.00	p<0.05
SP.G (g/cm ³)	1.04±0.00	1.04±0.00	1.04±0.00	1.03±0.00	1.03±0.00	p>0.05

*** \bar{x} is the mean and SD is the standard deviation

acidity which was calculated as acetic acid. 1cm^3 of $0.1\text{mol}\cdot\text{dm}^{-3}$ NaOH = 0.006005g acetic acid. (Results were expressed as % acetic acid per 100M).

Determination of fixed ACIDITY (FA)

The fixed acidity was calculated by multiplying the total volatile acidity by 1.25 for tartaric, 1.12 for malic or 1.17 for citric acid (hydrate).

Determination of hydrogen ion concentration (P^H)

The pH of the undiluted sample was determined using glass calomel electrode system (pye unican P^H meter). The P^H meter was checked before and after use against standard acid potassium phthalate buffer.

RESULTS AND DISCUSSION

Tables 1 and 2 illustrate the results for all parameters detected in both alcoholic and non-alcoholic beverages analyzed. Among the alcoholic beverages, Power Stout had the highest alcohol percentage at 5.55%, followed closely by Star at 5.40%. Other values included Gulder at 4.56%, Harp at 4.27%, and Kronenbourg at 3.72%. A similar trend was observed for alcohol by weight. Ojiako et al. (2010) reported comparable results in their analysis of various types of beer production in Nigeria. For the non-alcoholic beverages, the alcohol content measured 0.04% for both Fanta and Coke, while 7Up recorded 0.06%. Maltonic had a value of 0.08%, and Maltina was measured at 0.05%.

Table 1 shows results on different parameters tested on various beverage brands (soft drinks), including Maltonic, Maltina, Fanta, Coke, and 7UP, analyzed across different parameters. The temperatures of these beverages range from approximately 22.67°C to 25°C, with Fanta being the warmest and 7UP the coolest. Maltonic and Maltina exhibit higher pH levels (4.81 and 4.64, respectively), above the results determined by (Gloria et al, 2010) which shows that malt drinks are quite acidic, indicating lower acidity compared to more acidic beverages like Fanta and Coke, which have pH levels around 3.76 to 3.82. Fanta has the

highest volatile acidity (VA) at 0.042, signifying greater acidity due to fermentation, while Maltina has the lowest at 0.0137. 7UP shows higher total acidity (TA) at 0.32 and fermentation acidity (FA) at 0.282, whereas Maltonic and Coke both share the lowest values for both TA and FA at 0.16, with Coke having a slightly lower FA at 0.14. Maltonic has the highest residual extract (R.E) at 9.84, while Coke has the lowest at 7.95. All the drinks contain minimal alcohol content, with Maltonic and Maltina at 0.08%, the highest among the brands, while Fanta and Coke have the lowest at 0.04%. All the values were still below the recommended 0.5% by EBC for soft drinks. A one-way analysis of variance (ANOVA) revealed significant differences ($p < 0.05$) among certain parameters related to the brands. These differences are indicated by superscripts in (Table 1). Specifically, temperature, pH, VA (volatile acidity), TA (total acidity), and specific gravity (SP.G) showed statistically significant variation ($p < 0.05$) though within P^H 4.0-4.6, volatile acid 0.017-0.020g, total acidity of 0.16% and specific gravity 1.01598g/cm³ guidelines of ASBC. In contrast, the remaining parameters did not exhibit significant differences ($p > 0.05$).

Table 2 shows result on different parameters tested on various beverage brands, including Kronenbourg, Gulder, Star, Harp, and Stout, analyzed across different parameters. The samples were tested at a consistent temperature close to 25°C. Among the brands, Star has the highest pH level (4.56), indicating it is less acidic, while Stout has the lowest pH (3.71), and suggesting higher acidity. These results were in agreement with what was reported by (Francis et al, 2020) ranging between 3.0-4.7 and also fall within standard recommendation of 4.0-4.7 by America Society of brewery Chemist and 8.0 recommended by European Breweries Convention. Gulder shows the highest Alcoholic Acid Total (A.AT) at 98.28, while the A.AT values for Kronenbourg, Gulder, Star, and Harp are relatively similar. Stout has the lowest Volatile Acidity (VA) and Free Acidity (FA) values at 0.013, whereas Kronenbourg has the highest FA at 0.198. Stout also leads in alcohol by volume at 5.55% and weight at 4.31, followed by Star, with Kronenbourg recording the lowest values. Ordinioha (2008) reported alcohol content of 5-7.5% in his work "An evaluation of the volume and

Table 2: Parameters found in various alcoholic drinks.

	Kronenbourg	Gulder	Star	Harp	Stout	p-Value
	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	
Temp(°C)	25.33±1.53	25.00±2.00	25.33±1.53	25.33±1.53	25.33±1.53	p>0.05
PH	3.87±0.62	4.08±0.77	4.56±0.69	3.94±0.71	3.71±0.79	p>0.05
A.AT	97.99±0.01	98.28±0.03	97.71±1.15	98.23±0.06	91.47±0.07	p>0.05
R.AT	94.02±0.29	95.83±0.27	96.18±0.59	95.09±0.94	90.37±0.07	p>0.05
VA	0.03±0.00	0.02±0.00	0.02±0.00	0.02±0.00	0.01±0.00	p>0.05
FA	0.20 ^a ±0.03	0.19 ^a ±0.01	0.17 ^a ±0.01	0.17 ^a ±0.01	0.00 ^b ±0.00	p<0.05
ALC%(WT)	2.05 ^b ±0.00	3.91 ^a ±0.05	4.21 ^a ±0.01	3.46 ^a ±0.02	4.31 ^a ±0.01	p<0.05
ALC%(VOL)	3.72 ^b ±0.00	4.59 ^a ±0.01	5.39 ^a ±0.01	4.26 ^b ±0.01	5.55 ^b ±0.01	p<0.05
T.A	0.23 ^b ±0.03	0.30 ^a ±0.17	0.19 ^b ±0.01	0.19 ^b ±0.01	0.00 ^c ±0.00	p<0.05
C.I	5.47 ^a ±0.46	3.70 ^a ±0.17	4.43 ^a ±0.12	3.60 ^a ±0.00	0.00 ^b ±0.00	p<0.05
P.E	49.83±0.12	58.47±1.10	62.10±1.06	56.17±0.91	65.93±0.46	p>0.05
R.E	2.98 ^b ±0.15	2.44 ^b ±0.17	2.42 ^b ±0.35	2.73 ^b ±0.60	6.35 ^a ±0.00	p<0.05
A.E	1.01 ^b ±0.00	1.00 ^b ±0.00	1.00 ^b ±0.00	1.00 ^b ±0.00	5.62 ^a ±0.01	p<0.05
SP. G	1.00±0.01	1.01±0.00	1.01±0.00	1.01±0.00	1.02±0.59	p>0.05

*** \bar{x} is the mean and SD is the standard deviation

concentration of alcoholic beverage offered for sale in Port Harcourt slightly high than what was obtained in research but fall within standard of 6,7-7.5% recommended value by America Society of Brewing Chemist. Total Acidity (TA) is highest in Gulder (0.3) and lowest in Stout. Kronenbourg has the highest Color Index (C.I) at 5.47, which affects its color. Stout displays the highest Phenolic Extract (P.E) at 65.93 and Residual Extract (R.E) at 6.35, while Kronenbourg and Star recorded the lowest values for P.E and R.E, respectively. Stout also shows high values for other parameters, with an Aroma Extract (A.E) of 5.62 and Specific Gravity (SP.G) of 1.022, although the A.E and SP.G values for the other brands are relatively similar. A one-way analysis of variance (ANOVA) revealed significant differences ($p < 0.05$) among certain parameters concerning the brands. These differences are indicated by superscripts in the summary table (Table 1). Specifically, temperature, FA, alcohol percentage by weight (ALC % WT), alcohol percentage by volume (ALC % VOL), TA, C.I, R.E, and A.E showed statistically significant variation ($p < 0.05$). In contrast, the remaining parameters did not display any significance difference.

The analysis provides information on the quality of the selected alcoholic and Non-Alcoholic beverages brewed in Nigeria based on sets international standard by America Society of Brewing Chemist and European Breweries Convention, Findings also shows significant difference in Alcohol content between Alcoholic and Non-Alcoholic beverages with an indication that consumer interested in becoming intoxicated after minimum amount of bottle can go for power stout. Finally, the analysis reveals varying PH levels across different beverages with some being more acidic.

Conclusion

The conclusions drawn from the qualitative and quantitative analyses of various alcoholic and non-alcoholic beverages brewed in Nigeria are as follows:

All the values obtained for the different brands of samples analyzed were within the recommended ranges when compared to international specifications. For consumers seeking a higher level of intoxication after a minimum number of beer bottles, options like Stout, Gulder, or possibly Star may be preferable, as their alcoholic contents are slightly higher than those of the other brands. Conversely, those interested in very pale beer might prefer Gulder, Star, Kronenbourg, or Harp. If a consumer is looking for a beverage with acidity to aid digestion, options include Maltina, Maltonic, Kronenbourg, Gulder, and Star. In summary, considering factors such as quality (stability), intoxicating potential (alcohol content), and visual appeal (colour), Gulder Lager Beer and Power Stout can be regarded as the top choices for alcoholic beverages. For non-alcoholic options, Maltonic, Fanta, and Maltina were identified as the best among all five brands analyzed.

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