

## Research Article

# Chemical Composition and Microbial Contaminants of Poha Beer: A Local Nonalcoholic Beverage in the Bolgatanga Municipality, Ghana

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Microbial and physicochemical analysis was performed on randomly sampled Poha Beer manufactured and vended in the Bolgatanga Municipality, Ghana. Poha Beer as it is referred to in Dagbani, is a *Tamarindus indica* fruit extract, a local nonalcoholic beverage originally processed and sold by rural women of the Dagomba ethnic descend. Morphological examination of bacterial cultures, Gram staining, and biochemical confirmatory tests were used to detect the presence of microbial pathogens in 45 samples of Poha Beer. A refractometer, a flame photometer and an atomic absorption spectrometer were used for the elemental analysis. All Poha Beer samples obtained from the Bolgatanga Municipality were positive for yeast, *E. coli*, *Enterobacter* sp. and *Bacillus cereus*. Pb was not detected in any of the samples. Chemical components detected include Zn<sup>2+</sup> (average, 0.154 mg/L), Cd<sup>2+</sup> (0.056 mg/L), Na<sup>+</sup> (1.723 mg/L), Ca<sup>2+</sup> (2.262 mg/L) and K<sup>+</sup> (3.96 mg/L). All samples were acidic with an average pH value of 3.55. The Brix value of samples, however, was between 9.0 and 11.4 % per 40 mL of Poha Beer. Therefore, Poha Beer processed and sold in the Bolgatanga Municipality is acidic and contains detrimental amounts of Cd<sup>2+</sup> and bacterial pathogens which may render it unwholesome for human consumption.

## 1. Introduction

Tamarind fruit drink, commonly known as tankwanbia in Hausa, Poha Beer in Dagbani and Pusa daam in Waale (Dagaare), is a local nonalcoholic beverage mostly processed and sold by people of the Dagomba ethnic descend. Poha Beer is now sold in all parts of the country particularly in northern Ghana. In the northern region, a sunny, warm region predominated by Muslims, for whom alcohol is forbidden and where poverty is high, Poha Beer is an ideal refreshing drink in place of more expensive bottled non-alcoholic beverages, such as Coca-Cola, Sprite and Fanta. Tamarind (*tamar-e-hind* literally means “dates from India”) is a famous tree in India [1, 2]. It is believed to have

originated from tropical Africa [3]. *T. indica* bears pods containing about 10 brown seeds surrounded by an abundant acid pulp. Its fruits contain relatively 30% pulp, 40% seeds and 30% hull by weight [4]. Trees can produce up to 15 tonnes of fruits per hectare on an annual basis [5]. Tamarind grows wild in the four regions in the north of Ghana.

Among indigenes of northern Ghana, *T. indica* has commercial, industrial, domestic and medicinal uses. Its tender leaves are used for the preparation of soup. Its sour fruit extract is used in the preparation of “tuo zaafi” (TZ, their staple food) and as a preservative for storing TZ, whereas the fruit pulp is used to process the local beverage, Poha Beer. Poha Beer is brewed in six major steps including threshing, fermentation, moulding, soaking, mashing and

sieving, after which the filtrate is bagged and sold to consumers by street vendors (Figures 1 and 2).

In India, tamarind is used as a flavor and stabilizer and also in the preparation of curries, jam, pickles, sauce, syrup, and so on [1, 6]. The phytochemistry, pharmacological properties, and therapeutic values of different parts of *T. indica* have been extensively reported, some of which are expected to reflect in its fruit extracts [3, 7]. Some medicinal properties of *T. indica* include antiviral [8], analgesic [9], antinociceptive [10], anthelmintic [11], antiulcer [12], antidiabetic [13], antiemetic [14], anti-inflammatory [9], antimicrobial [15], hypolipidemic [16], antiatherosclerosis [17], hepatoprotective [18], fungicidal [19], antioxidant [20], and immunomodulatory [21] properties. Tamarind is a rich source of vitamins (for example carotenes, vitamin C, flavonoids, and B vitamins including thiamine, riboflavin, and niacin), fibre, and other nutrients necessary for good health [22, 23]. It is also a good source of essential minerals, for example, Ca, Fe, Zn, Cu, Co, and Mn, but may contain potentially toxic metals, such as Pb, Cd, Ni and Hg [5, 6, 24–26].

In countries where street food vending is prevalent, there is often lack of information on the incidence of food-borne diseases related to street vended foods. Microbial studies on such foods in American, Asian, and African countries have revealed increased bacterial pathogens in these foods. There have been documented outbreaks of illnesses in humans associated with the consumption of unpasteurized fruit and vegetable juices [27, 28]. Consumers have high preference for juices that are unpasteurized given that they are crisp in flavor [29]. Fresh fruit juices are easily made by blending and extraction of the juice and pulp mash of ripe fruits and vegetables. The finished fruit juice is often not fermented with a cloudy appearance and with no additives. Notably, contamination may arise as a result of scratches and bruises on fruit and vegetables that might have occurred at the time of harvesting. Contamination could emanate in the process of the production of the fruit juice and it is often advisable to carry out production under very hygienic conditions.

On the other hand, environmental pollution is the main cause of heavy metal contamination of the food chain. Pb and Cd are two potentially harmful metals that have aroused considerable concern [30–37]. According to Mehmet [38], atmospheric contamination, excessive use of fertilizers, pesticides, sewage sludge, and/or irrigation with residual waters are among the causes of physico-chemical contamination of raw foodstuffs as these metals are absorbed by the plants and persist through the food chain. Owing to their high toxicity at certain concentrations, the levels of these heavy metals in food and beverages require quantification [39]. In view of the threat posed by chemical pollutants and bacterial pathogens and the flourishing demands for such locally produced and street vended juices such as Poha Beer, this investigation was designed to assess the microbial quality and standard chemical composition (Na, K, Ca, Cd, Zn, and Pb) of freshly prepared Poha Beer from street vendors in the Bolgatanga Municipality.

## 2. Materials and Methods

**2.1. Collection of Samples.** Five locations in Bolgatanga Municipality vending Poha Beer were zoned for picking samples. Nine street vendors were randomly selected from each of the five marked zones between February and June, 2016. A total of forty-five (45) sample drinks freshly processed by local producers were therefore purchased randomly from Estates, Zongo, Taxi Rank, Dapotindongo, and Dagweo, chilled in an ice chest and transported to the laboratories for investigation. Fifteen samples each were transported to three different laboratories for both microbial and chemical analysis.

**2.2. Bacteriological Analysis of Samples.** All media were prepared essentially as described by Cheesbrough [40] and sterilized by autoclave. A loopful of each of the fifteen samples was inoculated in triplicate on MacConkey agar and blood agar. Inoculated plates were incubated for 24–48 h at 37°C. There were mixed morphological growth colonies of large or small rods or oval cells on all plates when visualized under the microscope. As such, further investigations on pure culture and Gram staining techniques were carried out. With the pure culture technique, a sterile loop was used to carefully pick each colony and replated in triplicate. Colonies that could not be observed easily nor confirmed by microscopic examination were further investigated using biochemical and antibiotic sensitivity tests.

Microscopically, the smaller growth colonies showed Gram-negative rods (pink) and Gram-positive oval-shaped structures (dark). The larger growth colonies showed Gram-positive rods. Therefore, morphological characterizations of isolates coupled with microscopic examination were used as confirmatory tests (Table 1).

**2.3. Antibiotic Sensitivity Test on Selected Samples.** Modified Kirby-Bauer sensitivity testing technique was employed to identify *Bacillus cereus* [40].

**2.4. Total Colony Count.** The total colony count of bacteria was determined by the pour-plate method using nutrient agar [41]. Ten ml of each sample was taken with a sterilized pipette and gently lowered into the petri dish. The drinks were inoculated in triplicate and swirled gently to mix. The plates were then incubated at 37°C for 24–48 h, after which the total colonies were counted with a colony counter (Servo Enterprises, India).

**2.5. Faecal Coliform Test and Isolation of *E. Coli*.** Fermentation tubes in rows of five were each inoculated with 10 ml of samples using a sterilized pipette. The samples were incubated at 37°C for 24 h, after which they were observed for the presence of faecal coliform. Tubes that were positive for faecal coliforms were cultured in EC broth and incubated at 44°C for 24–48 h, after which *E. coli* was confirmed (Regional Water Quality Assurance Laboratory, Bolgatanga, Upper East Region, Ghana).

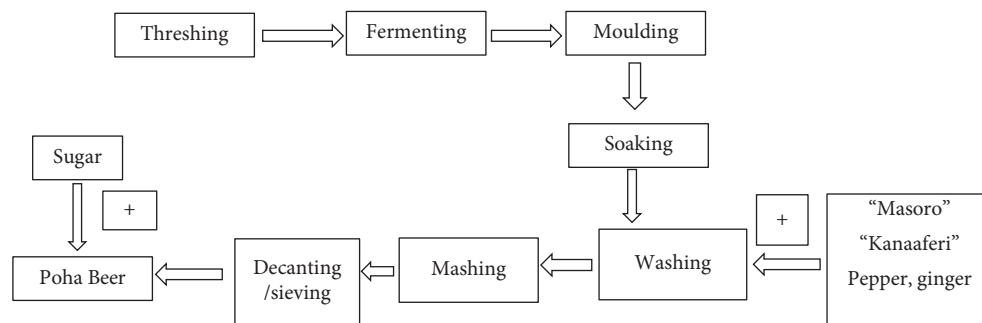


FIGURE 1: Schematic representation of the preparation of Poha Beer. Poha Beer is brewed in six distinct steps, which include the following. Threshing: due to its sticky nature, the outer case of the fruit is manually removed with care in order to prevent contact with particles. Fermentation: the fruits are sprinkled with water and allowed to stand for 24 h for fermentation to occur. Moulding: the fruits are preserved by moulding into balls and stored until required for use. Moulding reduces the surface area and prevents development of bacterial and fungal spores. Soaking: the fruits are soaked with either cold or warm water for between ~4 and 12 h to ensure efficient pulp extraction and dissolution. Mashing: in order to efficiently extract a high amount of pulp, the soaked fruits are mashed with clean hands, after which the required spices such as the local spices (“masoro” and “kanaaferi,” with pepper, ginger, and lime) are added. Decanting: the mashed mixture is then sieved, after which sugar is added to the filtrate, bagged, and sold to consumers by street vendors.



FIGURE 2: Brewing: Poha Beer production process. Moulded tamarind fruits are shown in (a), while the sieving process is shown in (b). Poha Beer bagging and the bagged and chilled products for sale are, respectively, shown in (c) and (d).

### 2.6. Assessment of the Chemical Composition of Poha Beer.

Following filtration of samples with grade 1 Whatman filter paper (Voigt Global Distribution Inc., Kansas, USA), each filtrate was used for elemental analysis. Each sample filtrate was analysed for Brix value, pH, Na, K, Ca, Zn, Cd, and Pb. The portable refractometer (SKU: CBX032, Jiangsu, China) was used to determine the Brix value of each sample, while the Basic 20 pH meter (Crison, Barcelona, Spain) was used to determine the pH. Na, K, and Ca concentrations were determined using

the flame photometer (Jenway, model PFP7 Flame Photometer, Nicosia, Cyprus), whereas the concentrations of Zn, Cd, and Pb were determined using the iCE 3000 series atomic absorption spectrometer (ThermoFisher Scientific, Waltham, USA).

2.7. Carbohydrate Analysis. Three drops of each sample drink were placed onto the refractometer prism plate and lidded. The instrument was then turned towards the light,

TABLE 1: Biochemical sensitivity test on selected samples.

Media	Test
Indole	From the pure culture, a sterile loop was used to inoculate each small and large growth colonies and incubated for 24–48 h at 35–37°C
Citrate	The inoculum was stabbed with a sterile loop and incubated at 35–37°C for 24–48 h
Triple sugar iron agar (TSI)	The pure inoculum was stabbed into the medium and incubated at 35–37°C for 24–48 h

after which the eye piece was focused until a clear image was observed. The position at which the demarcation line between the light and blue regions crossed the vertical scale represented the percentage readings and noted to one decimal place. After each test, the prism plate was cleaned with deionized water and wiped dry with a soft tissue.

### 3. Results

Microscopic examination results by virtue of cell morphology are summarized in Table 2. Apparently, two Gram-negative rod-like species (*Enterobacter* sp. and *E. coli*), including two Gram-positive oval-shaped fungus (yeast) and rod-like structures (*Bacillus cereus*), were observed. Confirmatory morphological characterization of isolates coupled with microscopic examination revealed the presence of the three species of the bacteria as expected, namely, *Enterobacter* sp., *E. coli*, and *Bacillus cereus* (Table 3).

Total bacterial colony count determined with the colony counter was directly calculated as coliform density (Figure 3). This was obtained as the number of coliforms counted from the formula,  $CFU/10\text{ mL} = N \times 10/V$ , where,  $N$  is the number of colonies counted and  $V$  is the sample volume in mL. In cases where no colonies were observed, the coliform colonies were reported as 0 CFU/10 mL. Data obtained was then entered into a Microsoft Excel spread sheet and analysed. The highest coliform density was recorded in Dapotindongo, while samples obtained from Estates had the lowest coliform density. There was no significant difference in the colony densities recorded among the triplicates conducted in the three laboratories (Figure 3).

The mean concentration of Zn in Poha Beer samples obtained from all five zones was generally higher compared with Cd (Figure 4). Samples obtained from Dagweo recorded the highest mean Zn concentration of 0.200 mg/L, whereas processed Poha Beer samples obtained from Taxi Rank contained the least mean Zn concentration of 0.116 mg/L. Average concentration of Zn within marked zones was in decreasing order: Dagweo > Dapotindongo > Zongo > Estates > Taxi Rank. Average Cd concentration was also fairly equal in samples from all zones ranging from Taxi rank (highest, 0.068 mg/L) to Estates (0.041 mg/L). Pb was not detected in any of the samples. No particular correlation between Zn, Cd, and/or Pb concentrations in samples was observed (Figure 4).

There was, however, a trend in the occurrence of electrolytes ( $K^+ > Ca^{2+} > Na^+$ ) through all five zones (Figure 5). The highest average concentration of K (4.64 mg/L) was detected in Dagweo, while the lowest (3.52 mg/L) was detected in Estates and Taxi Rank. The average amount of Ca

present in samples was fairly equal in all five zones (2.19 mg/L in Estates, 2.28 in Zongo, 2.29 in Taxi Rank, 2.27 in Dapotindongo and 2.27 in Dagweo). Na concentration was comparatively lower in all zones, ranging from 1.54 to 1.87 mg/L, an indication that Na concentration was also fairly equal in samples (Figure 5). The pH of all individual samples determined was within acidic range ( $pH < 7$ ). The highest pH value of 5.53 was recorded in a sample obtained from Dagweo. Apparently, only samples obtained within Dagweo had  $pH > 5.0$  but lower than 6.0. The remaining pH of individual samples ranged from 2.91 to 3.32. Average pH value was 3.55. Average zonal pH values are compared in Figure 6 and in Table 4 with literature. The Brix values of all the samples ranged from 9.0 to 11.4% per 40 mL with an overall average Brix value of 10.5%. Zonal averages are compared in Figure 7. Samples obtained in Zongo (average per 40 ml, 11.1%), Dapotindongo (11.0%), and Dagweo (11.1%) recorded equal average Brix values. On the other hand, Estates (9.8%) and Taxi Rank (9.7%) were lower than the three zones aforementioned and also similar in Brix values (Figure 7).

### 4. Discussion

Morphological characterizations of isolates coupled with microscopic examination and biochemical confirmatory tests were used to establish the presence of yeast, *Enterobacter* sp., *E. coli*, and *Bacillus cereus* (Tables 2 and 3) in Poha Beer sampled from five zones within the Bolgatanga Municipality, including Estates, Zongo, Taxi Rank, Dapotindongo, and Dagweo. Pink ring on the indole confirmed the presence of *E. coli*, while bright-blue colonies on the citrate agar confirmed the presence of *Enterobacter* sp. On the triple sugar iron agar test however, phenol red indicator turning yellow indicated the presence of large amount of acid resulting from fermentation of lactose and release of gas also confirmed the presence of *Enterobacter* sp. in samples.

The MPN index (faecal coliform/*E. coli*/100 mL) for standard drinking water recommended by WHO is 0. The Ghana Standards Authority (GSA) has also specified that drinking water should contain no *E. coli* or thermotolerant bacteria, and total coliform should be 0 CFU/100 mL. However, our examination showed high load of bacteria in the samples and this is corroborative of earlier findings elsewhere [42–44]. The presence of these microorganisms at the reported levels indicates that Poha Beer sold within the sampled zones may be unwholesome for consumption and potentially hazardous [45]. The presence of *Bacillus cereus* was confirmed in samples using the antibiotic sensitivity test. Its morphological characteristics were identified (Table 2).

TABLE 2: Colony and cell morphology of isolates on blood agar and MacConkey agar.

Media	Colonial morphology	Cell morphology	Identification
Blood agar	Creamy, tiny, and pin-pointed colonies	Gram-positive oval-shaped structures	Yeast
	Large, flat colonies of about 3–7 mm in diameter $\beta$ -haemolytic with dry-white colonies surrounded by areas of white precipitate	Gram-positive rods	<i>Bacillus cereus</i>
MacConkey agar	Pink lactose-fermenting round, raised, entire colony of about 2–3 mm in diameter	Gram-negative rods	<i>Enterobacter</i> sp.
	Pink, lactose-fermenting, shiny, round entire convex colony of about 1 mm in diameter	Gram-negative rods	<i>Escherichia coli</i>

TABLE 3: Identification of microbial contaminants.

Media	Observation	Identification
Indole	Pink ring surface layer; indole positive	<i>Escherichia coli</i>
Citrate	Bright-blue	<i>Enterobacter</i> sp.
Triple sugar iron agar (TSI)	Acid: positive; lactose: positive; gas: present; colour turned yellow	<i>Enterobacter</i> sp.
Mueller	Resistant to penicillin and cephalosporin	<i>Bacillus cereus</i>
Hinton agar	Susceptible to clindamycin, erythromycin, gentamicin, and vancomycin	<i>Bacillus cereus</i>

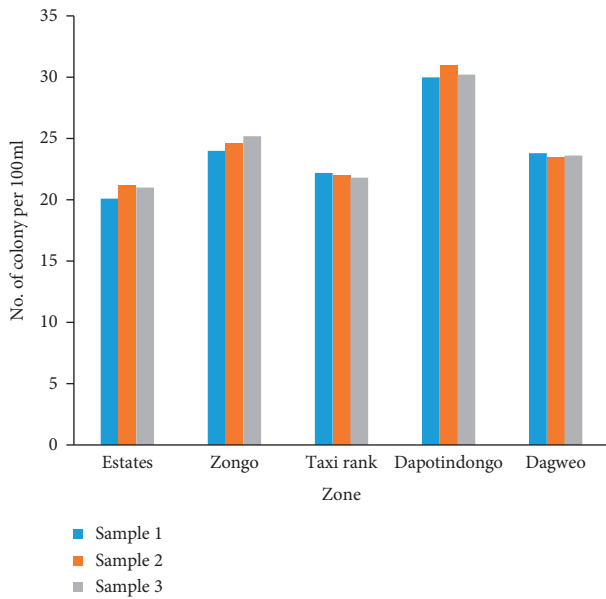


FIGURE 3: Number of colonies per 100 mL sample compared among zones and individual samples.

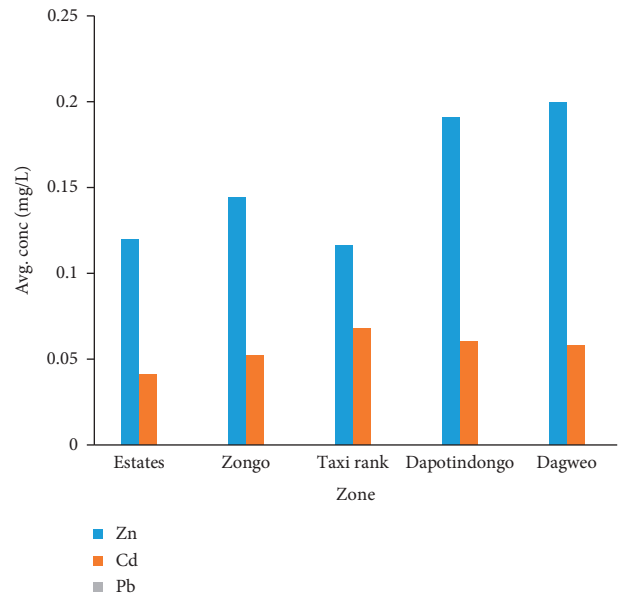


FIGURE 4: Proximate analyses of Zn, Cd, and Pb by atomic absorption spectroscopy.

*Bacillus cereus* is a soil-dwelling, Gram-positive, rod-shaped,  $\beta$ -haemolytic bacterium which is resistant to penicillin and cephalosporin but susceptible to vancomycin, gentamicin, erythromycin, and clindamycin (Table 3) [46, 47].

There are several routes through which bacteria and viruses may come into contact with Poha Beer. Processing units are the primary causes of high bacterial contamination of the juice (Figure 2). These include the use of crude stands and carts, use of unwholesome water due to unavailability of running water for dilution and washing, prolonged storage without refrigeration, and unhygienic surroundings with swarming flies and airborne dust among others [48]. Improper personal hygiene of producers and vendors may also result in contamination of products ranging from improper

washing of fruits to the use of unclean hands by vendors, including contaminated dry ice used for chilling the bagged juice for sale [49]. Manual bagging of Poha Beer creates more avenues for microbial contamination of the juice. The materials, rubber containers, packaging bags, and equipment used in the processing and bagging are unsterilized. The production environment is unsuitable for processing of juices meant for public consumption, and the water used for processing is unchecked for contaminations. The moulded seeds are sold in the open exposed to dust and pathogenic microbes (Figure 2).

The presence of some chemical compounds in drinking water or juices is a potential hazard [50]. At low concentrations, Pb remains a toxic contaminant [51]. The WHO

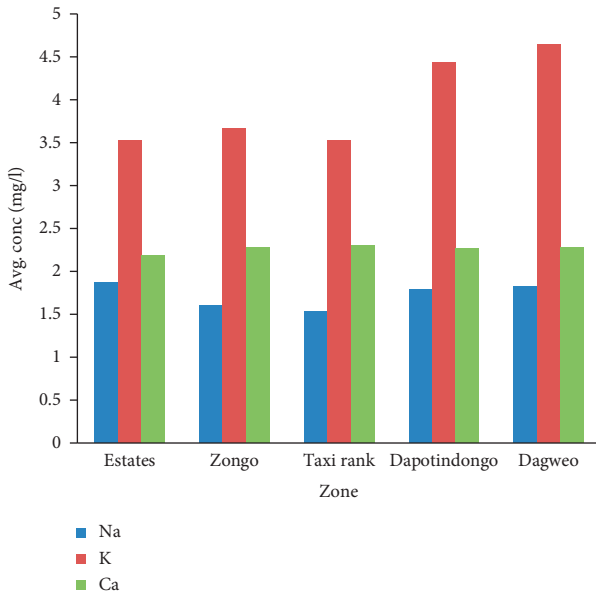


FIGURE 5: Average concentration of Na, K, and Ca in samples.

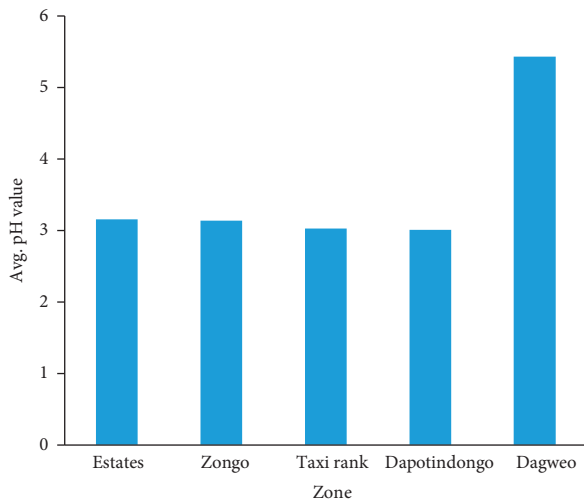


FIGURE 6: Average zonal pH values.

TABLE 4: Compared pH values of tamarind and tamarind drinks obtained in the literature.

Sample type	pH value			Reference
	Min	Max	Average	
Tamarind drink	1.8	3.7	2.8	[27]
Tamarind pulp	2.94	2.96	2.95	[74]
Poha Beer	2.91	5.53	3.55	Current study

standard for Pb in drinking water is a maximum of 1.5 mg/L. Pb poisoning is associated with a variety of developmental impairments. Exposure to Pb causes impaired neuro-behavioral development, lower intelligence, reduced birth weight and slower nerve conduction velocity among several others [52, 53]. However, Pb was not detected by AAS apparatus in any of the samples. This implies that the fruits

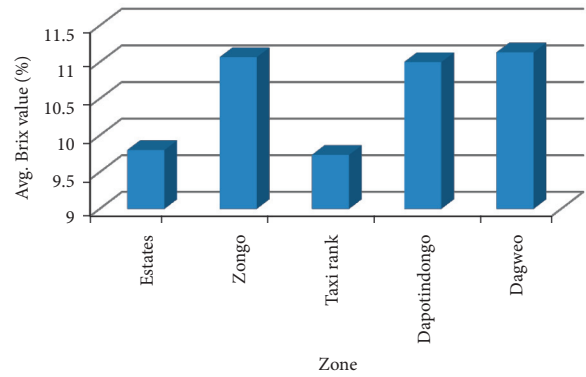


FIGURE 7: Average zonal percentage Brix value.

contain insignificant amounts of Pb or that tamarind trees selectively absorb minerals excluding Pb and that the water used for preparation of Poha Beer also contains insignificant quantities of Pb. These metals are absorbed by plants, which accumulate within the food chain, ultimately reaching man [54, 55]. Its absence in samples is therefore advantageous for consumers. Cd is an extremely toxic metal commonly found in industrial work places, where Cd is extensively used in electroplating and in industrial paints and may represent a health hazard when sprayed [56]. Cd may also be released from black polyethylene and black rubber manufacture or contained in drinking water, dust, fungicides, Ni-Cd batteries, paint pigments, paper, pesticides, rubber tires, sewage sludge and so on into drinking water used for Poha Beer preparation. Consuming a significant amount of Cd may lead to respiratory, kidney and liver disease [57, 58]. Average amount of Cd determined from all samples was 0.056 mg/L, which is higher than the required standard and therefore raises concerns (Figure 4) [59]. Standards set for Cd exposure by the National Drinking Water Quality Management Framework for Ghana is 0.003 mg/L [60] and 0.005 mg/L in the USA [61].

The toxic effects of Cd are reported to be kept under control in the human body and brain by Zn, its primary antagonist [62–64]. Zn is protective against Cd absorption in the intestines [65]. The average concentration of Zn obtained in our findings was 0.154 mg/L with a Zn: Cd ration of 2.79. The toxic metal strongly displaces Zn from its proper sites in the body. It replaces Zn in the arteries causing stiffness, inflammation and high blood pressure. High Cd and low Zn in the arteries can promote aneurysms [66, 67]. Zn<sup>2+</sup> is essential in the biological activity of over 300 enzymatic reactions involved in several cellular processes in respiration, protein and carbohydrate metabolism, nucleic acids, and protein biosynthesis where it is an essential component of RNA and DNA polymerases [68]. Zn content of tamarind pulp reported globally ranged from 0.1 to 1.5 mg/100 g W/W compared with 0.154 mg/L in tamarind extract in our findings [26]. Our data therefore indicate that Poha Beer will compensate ~2.0% per L of the recommended dietary allowance (RDA) for Zn in adults 19+ years, which is 8–10 mg [69]. The major source of Zn in tamarind pulp however may solely be the soil.

Electrolytes ( $\text{Na}^+$ ,  $\text{K}^+$  and  $\text{Ca}^{2+}$ ) are important mineral constituents of the human circulatory system. They play important roles in the transduction of signals and hence modulation of smooth muscle and muscle fibre contractions, gene expression, and so on [70]. There were significant quantities of electrolytes examined in the order  $\text{K}^+ > \text{Ca}^{2+} > \text{Na}^+$  through the zones, which is in turn reflective of the trend examined in tamarind pulp [5, 24–26]. The major source of these electrolytes therefore is the pulp of tamarind (Figure 4). Our results also confirm earlier reports that tamarind contains high amounts of  $\text{Ca}^{2+}$  and  $\text{K}^+$  as such Poha Beer is a good source of minerals, especially K and Ca [27, 71]. The ratio of  $\text{Na}^+/\text{K}^+ < 1$  was recorded through all the samples and is highly recommended by WHO due to its importance in the body for controlling high blood pressure [72].

Our investigation revealed that Poha Beer drinks sold in the Bolgatanga Municipality are acidic with an average pH value of 3.55 (Figure 6) consistent with literature [73]. Tamarind drink examined by Nassereddin and Yamani [27] had a similar acidity with pH ranging from 1.8 to 3.7 and a mean value of 2.8, while Hamacek et al. [74] recorded 2.95 (Table 4). The titratable acidity and soluble solids of tamarind pulp are 0.19 g/g W/W tartaric acid and 44.00 Brix value, an indication that high acidity of Poha Beer may have originated from the high tartaric acid contained in tamarind pulp, which also accounts for its sour nature [74]. Higher average pH = 5.4 is recorded in samples obtained from Dagweo compared with samples from Estates (pH = 3.2), Zongo (3.1), Taxi Rank (3.0), and Dapotindongo (3.0), which were much similar, maybe due to increased dilution of pulp in the products. As a result, samples from Dagweo were much lighter in colour and probably compensated with higher amounts of sugar for taste. Brix values of all samples examined ranged from 9.0 to 11.4% per 40 mL with an overall average of 10.5% per 40 mL of Poha Beer. From our investigation therefore, a serving volume of tamarind juice of 310 mL will contain a Brix of 48 comparable with a Brix of 44 in tamarind pulp [74]. Intercontinental differences are attributable to differences in the climate and soil type which affect composition of a food.

Perhaps, the medicinal properties associated with tamarind have not been fully explored. Molecular typing methods could be used to identify organisms responsible for spoilage of the fruit juice to enhance shelf-life with a long-term objective to support bottling of locally produced alcoholic and nonalcoholic drinks. Possible viral contaminants of Poha Beer (for example, rotavirus, norovirus, and astrovirus) require investigation. Further research will focus on Poha Beer production to ascertain the source of high bacteria loads. There may be other chemical components of Poha Beer that may also require attention. Quality control laboratories should be established specifically for locally produced drinks because they may pose health threats to consumers. Local small scale producers of fruit drinks should be educated and advised to operate within the standards of the country's quality governing bodies (The Food and Drug Authority and The Ghana Standards Authority) towards attaining acceptable quality products. Poha

Beer producers in the Bolgatanga Municipality should be given routine training in basic methods of sterilizing their equipment before and after the production process and helped to adopt hygienic practices in order to avoid contaminations. Registration and routine medical screening of food vendors of not only Poha Beer producers but bisop (sobolobo), iced kenkey, and so on should be enforced by the Municipal and Metropolitan Health Directorates in Ghana.

## 5. Conclusion

Colony and cell morphological examination of isolates including biochemical confirmatory tests identified the presence of *E. coli*, *Enterobacter* sp., *Bacillus cereus*, and yeast in all samples of Poha Beer produced and vended within the Bolgatanga Municipality. Poha Beer produced and sold within Dapotindongo contained the highest bacterial load of 30.5 colonies per 100 mL. Chemical components detected include  $\text{Zn}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Na}^+$  and  $\text{K}^+$ .  $\text{Pb}^{2+}$  was not detected in any of the samples. There was a similar trend in the occurrence of  $\text{K}^+ > \text{Ca}^{2+} > \text{Na}^+$  in all the zones, from where Poha Beer samples were obtained. The pH of samples determined was in the acidic range (pH = 2.91–5.53). The Brix value of samples however, was between 9.0 and 11.4 % per 40 mL of Poha Beer. Our study suggests that Poha Beer processed and sold in the Bolgatanga Municipality is acidic, contains detrimental amount of  $\text{Cd}^{2+}$  and bacterial pathogens, and may therefore be unwholesome for human consumption.

## Data Availability

The integer numbers data used to support the findings of this study are included within the article and openly available at [https://doi.org/.\[doi\]](https://doi.org/.[doi])

## Conflicts of Interest

The authors declare that there are no potential conflicts of interest.

## Authors' Contributions

JTD conceived the idea. Implementation of the research was done by JTD and JA. CAA performed all experiments and analysis under supervision of JTD and JA. All authors discussed the results and contributed to the final manuscript.

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