American Journal of Science and Technology
2017; 4(3): 43-48
http://www.aascit.org/journal/ajst
ISSN: 2375-3846

American Association for Science and Technology

Keywords
Alcohol,
Beer,
Burukutu,
Corn,
Fermentation,
Millet,
Sorghurm

Received: March 13, 2017
Accepted: April 18, 2017
Published: June 13, 2017

Comparative Physico-chemical Analysis of Locally Brewed Beer (*Burukutu*) from Corn, Millet and Sorghum

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Citation
Ezeonu Chukwuma Stephen, Nwokwu Chukwumaobim Daniel U., Kadiri Bashir. Comparative Physico-chemical Analysis of Locally Brewed Beer (*Burukutu*) from Corn, Millet and Sorghum. *American Journal of Science and Technology*. Vol. 4, No. 3, 2017, pp. 43-48.

Abstract
Burukutu, an indigenous alcoholic beverage (made from cereals, sometimes in composites), is widely consumed in Nigeria as a close substitute for the expensive labelled beers. This research sought to comparatively quantify the nutritional content of *Burukutu* made exclusively from one of three different cereals. *Burukutu* samples made from a single cereal ingredient (sorghum, millet or corn) were purchased from different brewers in Wukari metropolis, Nigeria. The AOAC standard methods of food analysis were employed in this study. The percentage nutritional contents of the respective cereal drinks (sorghum, millet and corn) were shown to vary significantly ($p < 0.05$) – except for vitamin B_2: carbohydrates (4.78±0.03; 5.56±0.01; 6.08±0.02); fats (1.07±0.01; 0.80±0.01; 0.52±0.01); proteins (2.74±0.01; 1.95±0.01; 1.47±0.01); vitamins B_1 (0.0645±0.0005; 0.0575±0.0005; 0.0515±0.0005) IU/mL; B_2 (0.0625±0.0005; 0.0515±0.0005; 0.0420±0.0010) mg/100mL; B_6 (0.052±0.0010; 0.046±0.0010; 0.035±0.0005) mg/100mL. Despite having the lowest moisture content, sorghum-beer contained the highest levels of Fe (2.460±0.010); Mg (68.350±0.10); Ca (31.57±0.010); Zn (2.485±0.015), with the least levels recorded for corn-beer. However, the higher bioethanol content of sorghum-beer (10.29±0.01), compared to those of millet (9.87±0.02) and corn (8.69±0.02), means it portends higher intoxicating potential, which may pose harmful effects if over-indulged. Based on the findings of this study, sorghum-made *Burukutu* is a richer source of essential nutrients and minerals – many of which act as co-factors in energy and drug metabolism. Thus, beyond its conventional nutritive value, it can be exploited as a functional food due to its greater potential to confer additional health benefits to consumers.

1. Introduction

Beer is the world's oldest and most widely consumed alcoholic beverage and the third most popular drink after water and tea. The name itself was derived from the Latin word *bibere*, which means "to drink" [1]. Brewing is the production of beer by steeping a starch source, commonly cereal grains [2], in water and fermenting the resulting sweet liquid with yeast. It may be done in a brewery by a commercial brewer, at home by a home brewer or by a variety of traditional methods such as communally done by the indigenous peoples in Africa [1]. Since the nineteenth century, the brewing industry has been part of most western economies. Despite the massive technological growth that separates ancient brewing from today's high-tech breweries, the process in its traditional version remains entirely unchanged.

Traditional beers are produced in many countries of Africa [3, 4]. The brewing processes of African traditional beers essentially involves malting, drying, milling, souring, boiling, mashing, alcoholic fermentation, lactic acid fermentation and maturation, but variations may occur depending on the availability of raw materials and geographic location [5,4]. A very varied yeast and lactic acid bacteria flora has been found in African sorghum beers, though *Saccharomyces cerevisiae*, *Saccharomyces chavelieria, Leuconostoc mesenteroides* and heterofermentative *Lactobacillus* usually predominate [6, 7, 8, 9, 10]. However, in the majority of African countries, traditional sorghum beers are less attractive than Western beers brewed with barley malt because of their poor hygienic quality, low ethanol content, organoleptic variation, short shelf-lives and unsatisfactory conservation [12].

Tropical beers are known by different names in different parts of the continent and are consumed at various festivals and African ceremonies, constituting a source of economic returns for the female beer producers [1]. *Burukutu*, a cereal food drink, is one of such food products that is locally brewed and widely consumed by the populace in Nigeria. It is an alcoholic beverage of vinegar-like flavor, produced and consumed mainly in the northern region of Nigeria, in the republic of Benin, and in Ghana [9]. Produced mainly from starchy grains such as sorghum (guinea corn), millet and maize, this age-long drink, also known as BKT, serves as a source of alcohol for those who lack the financial means to patronize refined beer and imported drinks. In *burukutu* production, the grains are usually steeped for about 18 – 24 hours at 30°C and germination takes place at 30°C for 5 days. Kilning however can be carried out under the sun or in the oven at 50°C within 24 hours [12].

It is known that food and food products provide the much needed carbohydrates, proteins, lipids, dietary fibers, and essential elements required by humans. Beers are very rich in calories, B-group vitamins including thiamine, folic acid, riboflavin and nicotinic acid, and essential amino acids such as lysine [12, 13]. Several studies into the microbiological composition of traditional sorghum beers as well as their technologies have been carried out and documented in different African countries [6, 7]. However, few researches on the biochemical and nutritional content of these locally brewed beers have been conducted [12, 9, 14]. These few studies also had failed in the comparison of the biochemical composition of *burukutu* produced from different grain sources. It is the reckoning of the present researchers that the variety of grains used and some processing variables may have influences on the biochemical compositions of these beers, necessitating the following investigational parameters: proximate analysis, total sugars, bioethanol content, pH value, vitamin and mineral compositions. This study attempts to quantify and compare the biochemical compositions of *burukutu* brewed within Wukari metropolis, Nigeria, and made exclusively from each of three different grains (sorghum, corn and millet).

The results of this study would serve as a reference source to prospective researchers interested in studying the applicability and nutritional status of different grain varieties in the production of *burukutu*.

2. Materials and Methods

2.1. Sample Collection and Preparation

Freshly prepared *burukutu* samples made separately from sorghum, millet and corn were bought from different producers and vendors from Wukari metropolis. The samples were collected into clean, properly labelled sample bottles and frozen. The frozen samples were then transported to the Food Research Laboratory of the Adamawa State University, Mubi, Adamawa State, Nigeria, where the sample analyses were carried out.

2.2. Traditional Method of *Burukutu* Processing in Wukari Area

Beers are brewed using a process based on a basic formula. Key to the process is malted grains mainly barley or sorghum, although other cereals, such as wheat, corn, millet or rice, may be used [15]. *Burukutu* is a traditional indigenous brown cloudy alcoholic beverage produced from commonly available grains like sorghum, millet or corn, and mostly produced at household level. It has an opaque colour due to suspended solids. The production process is time consuming, complex and sometimes carried out under unhygienic conditions. The unit operations in the traditional preparation of burukutu in Wukari area is shown in the flow chart below (figure 1). Back slopping (the addition of an old fermented batch of a previous brew to serve as an inoculum) is usually done to hasten the fermentation process. *Burukutu* has a very short shelf-life and is expected to be consumed within five days after back slopping. It can however stay much longer (about a week or two) if not back slopped, and tightly covered. Souring of the left-over beverage after five days is usually overcomed by mixing it with a freshly prepared one to make it fresh again for consumption, thus nothing is wasted.

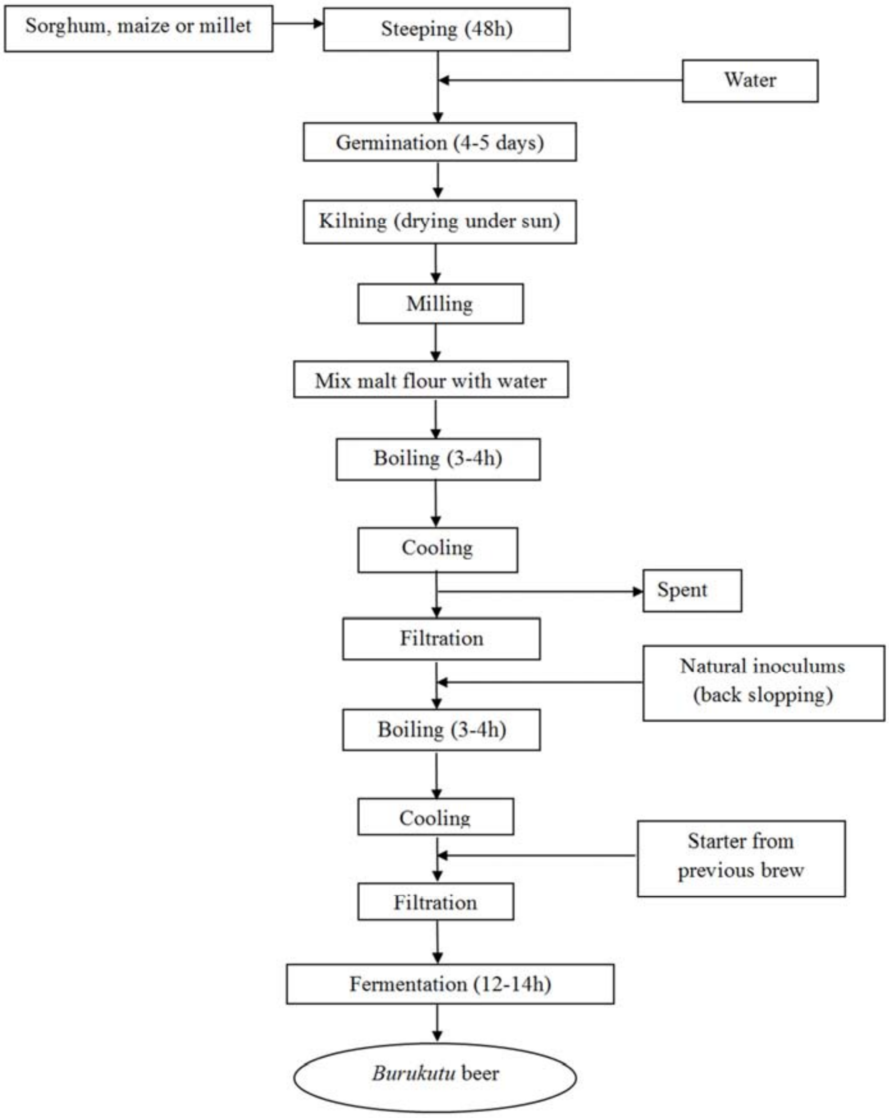

Figure 1. *A process flow chart of Burukutu production.*

2.3. Proximate Analysis

The locally prepared sorghum, corn and millet-beers were subjected to proximate analysis (total carbohydrate, crude protein, crude fats, ash and moisture content) using the AOAC standard methods. Total carbohydrate content of each sample was determined according to the method described by Bryant et al. [16]. Crude protein was determined by Kjeldahl method described by AOAC [17].

2.4. Determination of Bioethanol Content and pH

The total alcohol content was determined according to the method proposed by AOAC [18]. The pH was measured using a digital pH-meter (Jenway 3505, UK) calibrated with buffers of pH 4 and 7.

2.5. Vitamin Content Analysis

Vitamin content of each sample was determined using isocratic high performance liquid chromatography equipment (BLC10/11-model, USA). The prepared sample (2 mL) was taken into a 250 mL volumetric flask and made up its mark with mobile phase mixture, and refluxed. The mixture was centrifuged and the supernatant was collected and filtered using HPLC filter paper. The samples were then analyzed by injecting 20 µL of carefully prepared sample into the HPLC equipped with a UV detector set at 254 nm. A C_{18}, 4.6 x 150 mm, 5 µm column and a mobile phase composition of 95.5:4.5(methanol: water) was used at a flow rate of 1.00 mL/minute at ambient temperature. A 0.1 mg of mixed standard for each element was analyzed in a similar manner for identification. Peak identification was conducted by comparing the retention times of authentic standards and those obtained from the samples. Sample concentration for each mineral was then calculated using a four point calibration curve.

2.6. Mineral Composition Analysis

The mineral contents were analyzed using the method described by the AOAC [17]. Iron, zinc, magnesium, and calcium were analyzed from the triple acid digestion (wet digestion method). Exactly 5.0 g of the samples was weighed into a porcelain crucible and the crucible with the sample was placed into a muffle furnace. Then, the temperature was increased gradually until it reached 550°C. The samples were ashed until a white or grey ash was observed in the crucible. The ash was then dissolved by adding 2 mL of conc. HNO_3 to the crucible. The dissolved ash was transfer into 100 mL volumetric flask and diluted to the volume with 100 mL of distilled water, agitated and filtered. The standard and unknown samples were then analyzed with an atomic absorption spectrophotometer (Shimadzu AA, 650 model) with specific lamps (for all mineral elements and heavy metals) and flame photometer (for Na and K) using air acetylene flame integrated mode. The mineral concentration of each sample was then determined using the calibration curve of standards.

2.7. Stastistical Analysis

The results of the various indices of locally brewed beer samples made from sorghum, maize and millet were analyzed using a one way analysis of variance (ANOVA) method. Statistical significance was set at $p < 0.05$.

3. Results

The results of the biochemical analysis of the locally brewed beers made from corn, millet and sorghum are presented in tables and charts below. All values are represented as mean ± standard error of mean of duplicate determinations.

Table 1. *Proximate Analysis and Total Alcohol Content of Samples (%).*

Samples	Crude Protein	Fat	Ash	Moisture	Carbohydrate	Total Alcohol
Corn	1.47±0.01^a	0.52±0.01^a	0.92±0.01^a	91.05±0.00^a	6.08±0.02^a	8.69±0.02^a
Millet	1.95±0.01^b	0.80±0.01^b	1.25±0.01^b	90.41±0.01^b	5.56±0.01^b	9.87±0.02^b
Sorghum	2.74±0.01^c	1.07±0.01^c	1.74±0.01^c	89.71±0.01^c	4.78±0.03^c	10.29±0.01^c

Values are Means ± Standard Error of Mean from Duplicate Determinations

Table 2. *Vitamins Content of Samples.*

Samples	Vit B1 (IU/mL)	Vit B2 (mg/100mL)	Vit B6 (mg/100mL)
Corn	0.0515±0.0005	0.0420±0.0010	0.035±0.0005
Millet	0.0575±0.0005	0.0515±0.0005	0.046±0.0010
Sorghum	0.0645±0.0005	0.0625±0.0005	0.052±0.0010

Values are Means ± Standard Error of Mean from duplicate determination

Table 3. *Minerals content (mg/100g) and pH of samples.*

Samples	Fe	Mg	Ca	Zn	pH
Corn	1.865±0.005	48.675±0.015	24.625±0.005	1.040±0.010	4.740±0.010
Millet	2.055±0.015	61.965±0.015	29.80±0.010	1.680±0.010	4.960±0.000
Sorghum	2.460±0.010	68.350±0..10	31.57±0.010	2.485±0.015	5.295±0.015

Values are means ± standard error of mean from duplicate determinations

4. Discussion

4.1. Biochemical Composition of the *Burukutu* Samples

The results of the proximate analysis and total alcohol contents of the *Burukutu* samples (table 1) lend credence to the discoveries by previous researchers. Cereals, grains or cereal grains, are grasses (members of the monocot families Poaceae or Gramineae), cultivated for the edible components of their fruit seeds, consisting of the endocarp, germ and bran. Cereal grains are grown in greater quantities and provide more food energy worldwide than any other type of crop; they are therefore, staple crops. In their natural form (as in whole grain), they are rich sources of vitamins, minerals, carbohydrates, fats, oils and proteins [19]. According to Ihekoronye [20], cereal grains are the major food sources of the peoples of the tropics, providing them with about 75% of their total caloric intake and 67% of their total protein intake.

The crude protein quantification showed that there were significant differences ($p < 0.05$) in the means of all *burukutu* samples. This may be due to variations in the nutritional quality of grains used and/or other processing variables. The local beer made from sorghum was found to have the highest value of crude protein (2.74±0.01%), a value that approximates those reported by Kolawale and co-workers [9] for commercial (3.1%) and laboratory (3.2%) brewed *burukutu* made from sorghum. The percentage of fats and ash content were also found to be significantly higher in the sorghum-beer than those of millet and corn, making it the most lipogenic of the three.

However, the percentage of carbohydrate obtained for sorghum beer (4.780±0.03) was statistically shown to be significantly lower than those of millet (5.560±0.01) and corn (6.080±0.02). The higher value obtained for corn may be as a result of more free enzymes (alpha and beta amylases) activated in the grains during the malting and mashing process for starch breakdown. The low carbohydrate content of sorghum beer may account for its significantly higher alcohol levels (10.29±0.01%) compared to millet-beer

(9.87±0.02%) and corn-beer (8.69±0.02%), as most of the available sugars present in the mash are being metabolized to alcohol. This could be attributable to the ease of conversion of carbohydrates present in sorghum by the fermentative yeast as a readily utilizable substrate than those of the other two grains. Some other researchers [9, 21] recorded the percentage alcohol of *burukutu* made from sorghum to be 1.8% and 4.6% respectively. The disparity may be due to some environmental or other variations in production processes. One may even ascribe it to the moisture content variability: the trend shows that the corn with the least alcohol content revealed the highest water content, and vice versa with the other grains. If this is the case, the water content acts as a diluent. Therefore, the corn-made *burukutu* may be recommended medically as a diuretic and energy booster for dehydrated patients and convalescents.

According to one study [12], the basic characteristics of *burukutu* include a sour taste due to the presence of lactic acid, a pH of 3.3 - 3.5 and an opaque appearance because of suspended solids and yeasts. Their assertion is correct since African traditional beers are dispensed and consumed while it is still fermenting, and the drink contains large amounts of fragments of insoluble materials. *Burukutu* also contain live microorganisms (probiotic). Significant variations were observed in the pH of all *burukutu* samples. Some researchers had mentioned that after traditional brewing of sorghum beer, the beverage would usually have an overall pH of 4.8 ± 0.5 [22, 23]. The present study showed a higher pH for sorghum beer (5.295±0.015), a development logically traceable to production variables, chiefly the type of inoculums used during back slopping or the strain of lactic acid bacteria which is responsible for the acidity of the beer. Rooney *et al*. [24] posited that indigenous African types of beers differ from European (lager) types in the sense that lactic acid fermentation also occurs during beer processing.

4.2. Vitamin and Mineral Contents of the *Burukutu* Samples

In this study, appreciable levels of vitamins B_1, B_2 and B_6 were obtained for all sampled *burukutu* (table 2). The B-class vitamins often act as co-factors in the body's metabolic processes [25, 26]. Vitamin B_1, also called thiamine, is required for a healthy heart and normal brain function, and protects against Alzheimer's disease. Vitamin B_2 (riboflavin) is essential for healthy skin, hair and nails, and also required for antibodies and red blood cells formation. Vitamin B_6 promotes the immune system [27], aids in normal cell growth and plays key roles as pyridoxal phosphate (PLP) in amino acid metabolism [28]. This study reveals that the vitamins B_1 and B_6 contents of sorghum-made local beer were statistically ($p < 0.05$) shown to be significantly higher than those made from corn and millet. However, the result of the one way analysis of variance (ANOVA) showed that there was no significant difference in the vitamin B_2 contents across all samples analyzed.

Table 3 above shows the levels of Fe, Mg, Ca, and Zn. Sorghum-made *burukutu* demonstrated the highest levels ($p < 0.05$) in Mg (68.350±0.010), Ca (31.57±0.010) and Zn (2.485±0.015) across all samples analyzed. These elements, in trace amounts, play an important role in the physiological and metabolic processes and biomedical functions of the body, and are essential for the general well-being of humans [29]. Iron is the major functional component of the haemoglobin of red blood cells and myoglobin in the muscles which is responsible for oxygen distribution throughout the body [30]. Magnesium promotes a healthier cardiovascular system and maintains water homeostasis necessary for life processes [9]. Calcium's role in bone and tooth formation, maintenance of normal blood pressure and impulse transmission makes it an indispensable element in the body [30]. This study has shown that people who consume the local beers made from sorghum stand the chance of obtaining relatively more mineral benefits than those produced from corn and millet.

5. Conclusion

In this study, the biochemical and nutritional properties of *burukutu* brewed from corn, millet and sorghum have been comparatively evaluated, and shown to vary significantly except for vitamin B_2. Some of the differences observed may be due to discrepancies in production procedures which are non-standardized in terms of raw materials, equipment and handling methods. *Burukutu* made from sorghum had the highest levels in most parameters analyzed, with that of corn coming least in most of the indices. However, sorghum-beer equally contained the highest amount of bioethanol, implying that its over-consumption can lead to intoxication and its attendant health hazards. This calls for moderate consumption. Further work needs to be carried out on effective ways of improving the beers and reducing the alcoholic contents to minimal, non-intoxicable levels, say by shortened fermentation time or addition of adjuncts.

Based on the findings of this study, sorghum-made *Burukutu* is a richer source of essential nutrients and minerals – many of which act as co-factors in energy and drug metabolism. Thus, beyond their conventional nutritive value, the local beer, *burukutu* can be exploited as a functional food due to its great potential to confer additional health benefits to consumers. Given their calorific and calorigenic potential, it can therefore be inferred that sorghum is best suited for the production of these beers to meet the energy and health needs of rural communities who cannot afford a balanced diet and quality healthcare.

Hereafter, it would be very interesting to investigate the levels of the evaluated parameters in beers produced from a combination of these grains. There is an ample scope to assess the beneficial and deleterious properties of these locally brewed beers and to conduct an in-process optimisation with the aim of establishing a standard method of production to encourage reproducibility and commercialization of these products.

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