EFFECT OF FERMENTATION ON THE CHEMICAL QUALITY OF *BURUKUTU* A TRADITIONAL BEER IN GHANA

Amy **Atter**[1*], Kwesi **Obiri-Danso**[2], George Anabila **Anyebuno**[1], Wisdom Kofi **Amoa-Awua**[1]
[1]Food Research Institute, Council for Scientific and Industrial Research, P.O. Box M20, Accra, Ghana
[2]Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology Kumasi, Ghana
*Email: amykuus@yahoo.com

Abstract
The consumption of burukutu a traditional indigenous brown cloudy alcoholic beverage produced from sorghum in some parts of Ghana and West African countries is widespread. This beverage in the unfermented and fermented state is popular among people of all ages.The purpose of this work was to evaluate the proximate and mineral (toxic and beneficial) composition of unfermented burukutu and determine the effect of 120 h fermentation on the product The result of the proximate analyses for unfermented and 120 h fermented burukutu samples showed that as fermentation proceeded, the fermentable sugars in the unfermented sample were used in the formation of alcohol. As a result, the percentage of carbohydrate, reducing and total sugars decreased significantly. There was a significant increase in total titratable acidity and a reduction in pH of the fermented burukutu. There were variations in the level of the minerals Fe, Zn, Ca, P, Cu and Pb in the fermented and unfermented beverage. The level of calcium and phosphorus in the unfermented burukutu increased after fermentation whilst high levels of Zn were recorded in both the unfermented and fermented burukutu samples. Aflatoxins were not detected in both the unfermented and fermented beverage. This work has shown that unfermented burukutu contains significant amount of nutrients but this is further enhanced after fermentation which makes it a good and a cheap supplementary source of minerals and energy for its consumers.

Keywords: Fermentation, *burukutu*, proximate, minerals, aflatoxins

Received: 25.04.2017 Received in revised form: 19.06.2017 Accepted: 18.07.2017

1. INTRODUCTION

Traditional alcoholic beverages are usually produced from cereals such maize, millet, sorghum and rice which contributes to the diet of many people in the developing world. These beverages are usually given different names and their characteristics also differ.

Burukutu is one of such traditional indigenous brown cloudy alcoholic beverage produced from sorghum grains in Ghana even though it is not as popular as *pito*. It is also produced and consumed in some West African countries. The production and consumption of this beverage in its unfermented or fermented state is widespread among poor rural and urban population. People consume this beverage because it is affordable and one does not feel intoxicated when the freshly prepared batch is consumed. Due to its thick consistency, it is taken in as a low-cost meal at any time of the day. It is largely sold and consumed in a microbiologically active state at the place of production (mostly located in densely populated areas). This beverage is popular with people of all ages including children and pregnant women. Whilst most consumers prefer the fermented type, people down with malaria or fever are sometimes urged to consume the unfermented type for cure.

The process of *burukutu* production in Ghana is similar to that of *pito*, they differ in consistency as the ratio of flour to water is about 1:3 for *burukutu* and 1:5 for *pito*, the malted grain is also dried before milling in the preparation of *pito* thereby making the latter lighter. Its production process in Ghana is similar to what is done in Nigeria (Ekundayo, 1969) where the thicker consistency of *burukutu* is obtained by the addition of *gari*

lumps popularly known as 'kpokpo-gari' as an adjunct. Also the malted grain is not spread out in thin layers to dry in the sun before grinding into flour. In Ghana, production of *burukutu* from sorghum grains mainly involves malting, mashing, straining, souring, wort concentration and fermentation. Both lactic acid and alcoholic fermentations are involved in yielding a sour alcoholic beverage of a thick consistency and has an alcohol yield of 4.47% in 120 h (Atter et al. 2014). *Burukutu* produced in Nigeria is reportedly rich in vitamins, minerals, carbohydrate and protein (Faparusi, 1970; Oke and Ijebor, 1997; Jideani and Osume, 2001; Egemba and Etuk, 2007; Eze et al. 2011; Fadahunsi et al.2013).

Although *burukutu* is widely consumed in Ghana and thought to be nutritious, there is a dearth in information on its chemical composition. It is usually processed using crude methods inherited from past generations such as cooking in locally fabricated unlined cookware's and sometimes fermenting or storing in basins and other metal containers. These crude processing methods are therefore likely to affect the chemical composition. Generally, fermentation is known to improve the concentration of nutrients such as vitamins, minerals and proteins in food products. But because its fermentation is spontaneous and uncontrolled, this may lead to a depletion of the sugars yielding higher amounts of alcohol than expected. The aim of this work therefore was to evaluate the effect of the fermentation process on the chemical quality of *burukutu* produced in some parts of the Accra-Tema metropolis of Ghana.

2. MATERIALS AND METHODS

2.1 Sampling Sites

A total of four study areas were used for this work in the Accra and Tema Metropolis. These were; Tema, geographically located on 5° 37' 0" North, 0° 10' 0" West; Zenu, geographically located on 5° 43' 0" North, 0° 30' 0" West, Ashaiman, geographically located on 5° 42' 0" North, 0° 20' 0" West and Accra Newtown, geographically located on 5° 5' 0" North, 3° 5' 0" West, all within the Greater Accra Region of Ghana.

2.2 Sampling

Freshly brewed unfermented *burukutu* samples were purchased from four processors on different occasions into sterile sampling bottles and transported on ice to the laboratory. The samples were immediately analysed for the various parameters after which they were allowed to ferment at room temperature (28°C) for 120 h.

2.3 Proximate composition

The moisture, crude protein, crude fat, ash and alcohol were determined using standard procedures of the AOAC international. Energy was calculated using the Atwater factor i.e. (4× protein) + (9 × fat) + (4 × carbohydrate) and carbohydrate was estimated by difference. Total sugars, reducing sugars, sucrose and specific gravity were determined according to the conventional methods by Kirk and Sawyer (1991).

2.4 Determination of pH and Total Titratable Acidity

The pH of samples were determined directly with a pH meter (Radiometer PHM 92 Radiometer Analytical A/S, Bagsvaerd, Denmark) after calibration using standard buffers. The total titratable acidity was determined by the method described by AOAC (2005). One millilitre of 0.1 N NaOH was taken as equivalent to 0.009 g lactic acid.

2.5 Determination of Soluble Solids

Soluble solids were determined by placing a drop of the sample on the lens of a hand held refractometer and the reading taken through the eye piece as Brix.

2.6 Mineral Elements

Flame Atomic Absorption Spectrophotometer method was used for mineral analysis. Six (6 ml) of *burukutu* samples were weighed into porcelain crucibles and evaporated to dryness on hot plate. The crucible with sample was placed in the Muffle furnace at a temperature of 550 ^{o}C for 8 h till a grey ash is obtained. 5 ml of concentrated nitric acid was added to the ash and then heated on hot plate at 80-100 ^{o}C till all the ash dissolved. 10 ml of 0.1 M Nitric acid solution was added and filtered into 50 ml

volumetric flask and topped up to the mark with 0.1 M Nitric acid. The blank solution was treated the same way as the sample. The absorbance reading of the sample solutions were read using the Flame Atomic Absorption Spectrophotometer (Buck Scientific 210 VGP). The cathode lamps used were Cu (wavelength 324.8 nm, lamp current 1.5 mA), Fe (wavelength 248.3 nm, lamp current 7.0 mA), Pb (wavelength 217.0 nm, lamp current 3.0 mA) and Zn (wavelength 213.9 nm, lamp current 2.0 mA). The metal content of the samples were derived from the calibration curves made up of four points.

2.7 Extraction and HPLC analysis for aflatoxin concentrations

The extraction procedure used for the determination of aflatoxins was by Stroka and Anklam (1991). A test portion (50 g) was extracted with a 200 ml methanol/water solvent solution containing 5 g of sodium chloride. The sample extract was filtered, diluted with phosphate buffered saline to a specified solvent concentration, and applied to the immunoaffinity column (R-Biopharm Rhone Ltd. Easi-Extract Aflatoxin) containing antibodies specific for
aflatoxins B1, B2, G1, and G2. Aflatoxins were eluted from the immunoaffinity columns with neat methanol. Aflatoxins were quantified by reverse-phase high performance liquid chromatography with post column derivatisation involving bromination. The post column derivatisation was achieved with pyrimidinum hydrobromide perbromide followed by fluorescence detection. The instrument system used for the HPLC analyses was from Waters Associates (Milford, MA, USA) and included Waters 1525 Binary HPLC pump, Waters 2707 Auto-sampler, Waters Model 1500 Column Heater, Waters 2475 Multi l Fluorescence Detector and Breeze 2 software. Separation of the aflatoxins was carried out on a Spherisorb S5 ODS-1 column of dimensions 25 ×4.6 mm packed with 5 µm particles (Phase separations Inc., Norwalk, USA) maintained at 35 °C. The HPLC mobile phase flow rate was 1.0 ml/min and post column bromine derivatization of Aflatoxin B1 and G1 was achieved by PBPB dissolved in 500ml of distilled water pumped at a flow rate of 0.5 ml/min using Eldex precision metering pump (Eldex Laboratories Inc., San Carlos, USA). The excitation and emission wavelengths used were 360 nm and 440 nm respectively. The aflatoxins were identified by their retention times, and peak areas were used to determine their concentrations in the samples by reference to standard curves obtained by chromatographing pure aflatoxin standard (obtained from R-Biopharm) solutions under identical conditions.

2.8 Statistical analysis

Statistical analysis was done using Excel spreadsheet and SPSS,version 21.0. Analysis of Variance (ANOVA), followed by Duncan Multiple Range Test were used to test significant differences between samples ($P< 0.05$).

3. RESULTS AND DISCUSSION

The fermentation process had significant effect on the chemical composition of *burukutu* samples analysed. The freshly brewed unfermented *burukutu* contained high levels of total soluble solids, total sugars, reducing sugars and sucrose as shown in Figure1. As fermentation proceeded, the available sugars in the unfermented samples were utilised in the formation of the alcohol by the activity of yeast. As a result, the amount of reducing and total sugars decreased significantly ($P < 0.05$) in the unfermented *burukutu* whereas the concentration of alcohol increased significantly ($P < 0.05$) as expected in the fermented *burukutu*. The mean alcohol content of 4.76 % recorded in this beverage after fermentation is similar to 4.10 % recorded by Mbajiuka et al. (2014) but lower than 2-3 % reported for *pito* (Akyeampong, 1995; Sefa-Dedeh, 1999).

A significant increase ($p< 0.05$) in TTA with a corresponding reduction in pH was recorded in the fermented *burukutu* (Table 1). These values are lower than what was reported by Mbajiuka et al. (2014).The production of lactic acid and other important organic acids during

fermentation may account for the trends recorded. Foods with high moisture levels are usually susceptible to microbial proliferation which determines the shelf life. This explains why *burukutu* with its high moisture content (90.90 - 94.25 %) has a short shelf life of 5 -7 days. These results are similar to others reported earlier (Mbajiuka et al.2010; Igyor et al.2006; Inyang and Idoko, 2006).There were significant increases in the crude protein and ash levels whilst a decrease in energy, fat and carbohydrate levels were recorded (Table 2). This may have resulted from the utilization of sugars by lactic acid bacteria and yeast for the production of acid and alcohol, there was a corresponding increase in protein as well. A combination of cooking and fermentation as is done with *burukutu* according to Obizoba and Atii (1991) improves the nutrient quality of sorghum and reduces the content of anti-nutritional factors to a safe level in comparison with other methods of processing.

The mean concentrations of zinc (Zn) in the unfermented and fermented samples were 3.66 and 4.00 mg/L respectively. The results showed variations in iron (Fe), calcium (Ca) and phosphorus (P) levels of the fermented and unfermented beverage. Whereas the concentration of copper (Cu) was lower in the fermented *burukutu*, the levels of lead (Pb) was significantly higher ($p \leq 0.001$) in the fermented samples (Table 3). The Zn concentrations in the unfermented and fermented samples were higher than the safe limit of 3 mg/L set by World Health Organization (WHO, 2006) guidelines for drinking water quality. These high levels of Zn may be due to the malting process involved in *burukutu* production.

It has also been reported that there is a correlation of aflatoxin contamination with high Zn content (Jones et al.1984).This wasn't the case in this study, as aflatoxins B1, B2, G1 and G2 were not detected in any of the unfermented and fermented samples contrary to reported incidence in sorghum grains and some African traditional brewed beers (Odhay and Naicker, 2002; Matumba, et al. 2011).

Table 1: Specific gravity and acidity of *burukutu*

	Unfermented *Burukutu*	Fermented *Burukutu*
Specific Gravity	0.99±0.01[a]	1.05±0.04[a]
Titratable Acidity (mg/100 g)	0.67±0.03[a]	0.97±0.04[b]
pH	3.41±0.02[a]	2.93±0.02[b]

Means and standard deviations within the same row having different superscripts are significantly different

Table 2: Proximate composition of *burukutu*

Proximate composition	Unfermented *Burukutu*	Fermented *Burukutu*
Moisture (g/100 g)	90.90±0.08[a]	94.25±0.03[b]
Ash (g/100 g	0.19±0.01[a]	0.24±0.01[b]
Fat (g/100 g)	0.13±0.01[a]	0.12±0.02[a]
Protein (g/100 g)	0.40±0.01 [a]	0.76±0.01[b]
Carbohydrate (g/100 g)	8.38±0.03 [a]	3.52±0.01[b]
Energy (kcal)	34.29±0.01[a]	17.65±0.01[b]

Means and standard deviations within the same row having different superscripts are significantly different

Table 3: Vitamin C and minerals content of *burukutu*

Component	Unfermented *Burukutu*	Fermented (120 h) *Burukutu*
Vitamin C (mg/100g)	0.88±0.01[b]	1.04±0.01[a]
Copper (mg/L)	0.72±0.04[a]	0.52±0.01[b]
Iron (mg/100g)	0.97±0.03[b]	2.23±0.04[a]
Lead (mg/L)	1.40±0.02[b]	2.26±0.01[a]
Calcium (mg/100g)	4.96±0.01[b]	36.61±0.01[a]
Phosphorus (mg/100g)	24.28±0.01[a]	40.75±0.01[b]
Zinc (mg/L)	3.66±0.02[b]	4.00±0.03[a]

Means and standard deviations within the same row having different superscripts are significantly different

Malting helps to improve the Fe and Zn levels of the grains, and the levels are further enhanced after fermentation. Fe, Ca, P and Cu are critical micronutrients required for the formation of strong teeth and bones as well as maintenance of good health.

The micronutrients levels recorded in both the unfermented and fermented samples far exceeded the levels (0.6–1.5 mg/100g) reported for *burukutu* produced in Nigeria (Eze et al.2011). The variety of sorghum grains used may account for this difference. It was observed at some of the production sites that over 6 h of cooling of the wort and fermentation were carried out in metal containers. Some of these minerals in the containers can be solubilised by the fermented product and cause an increase in the mineral content (Sahlin, 1999).

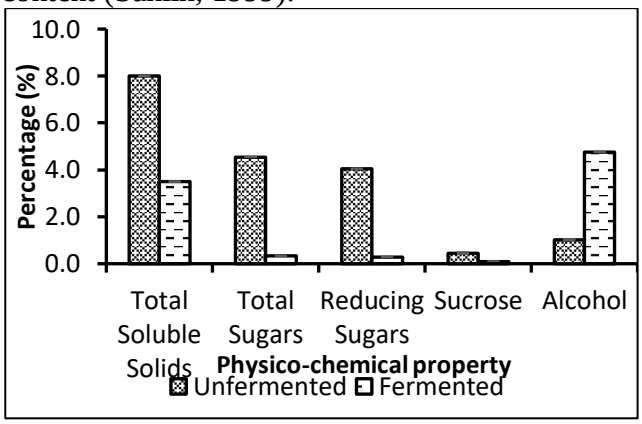

Fig. 1: Chemical composition of *burukutu*

Pb concentration in the *burukutu* samples were above the permissible maximum limit of 0.01 mg/L set by WHO (2006) and also higher than the 0.01 - 0.272 mg/L reported by Duodu et al. (2012) for *pito* samples from some parts of Ghana. The values obtained in this study are alarming in view of the toxic effect of Pb on humans.These high level of Pb may have been as a result of leaching from the processing vessels which are fabricated from different metal alloys by local artisans. The quality of the water used in processing may also be a contributory factor since most of the processing sites lack access to running tap water thereby buying water from lorry tankers which may be of varying quality. Furthermore, the Pb concentration in the soil for cultivation could also contribute to these high level in the sorghum grains which translated in the *burukutu* samples analysed. Vitamin C was significantly higher ($p<0.05$) in the fermented than the unfermented beverage. *Burukutu* may be an unlikely source of vitamin C but the yeast may have produced those very low levels during the fermentation process. Vitamin C is an antioxidant and a water-soluble vitamin which is needed for the growth and repair of tissues in the body and so these low levels are still essential for consumers of *burukutu*.

Despite the presence of toxic minerals in this product, the study has buttressed the fact that fermentation improves the nutritional value of food products. It also lowers the proportion of dry matter in foods and increases the concentrations of vitamins, minerals and protein. The conversion of carbohydrates and sugars present in unfermented beverages into alcohol, organic acids and carbon dioxide accounts for the variations in the chemical constituents observed between the fermented and unfermented beverages (Adams, 1990; Iwuoha and Eke, 1996; Holzapfel, 2002; Blandino et al. 2003; Edema and Sanni, 2008; Nout, 2009).

4. CONCLUSION

The outcome of this work has shown that *burukutu* in the unfermented state contains significant amount of nutrients which is further enhanced after fermentation. *Burukutu* either in the unfermented or fermented state is hence a good and a cheap supplementary source of minerals and energy for its consumers as its intake may address some of their dietary deficiencies. The product can however be made safer with the reduction in the level of Pb by sensitizing producers.

5. REFERENCES

[1] Adams, M.R. (1990). Topical aspects of fermented foods. Trends in Food Science and Technology, **1**: 141-144.

[2] AOAC. (2005). Official methods of analysis. Association of Official Analytical Chemists, Washington, DC.

[3] Akyeampong, E. (1995). Alcoholism in Ghana: A socio-cultural exploration. Culture, Medicine and Psychiatry, **19**: 261–280.
[4] Atter, A., Obiri-Danso, K. & Amoa-Awua, W. K. (2014). Microbiological and chemical processes associated with the production of burukutu a traditional beer in Ghana. International Food Research Journal, **21**(5): 1769-1776.
[5] Blandino, A., Al-Aseeri, M.E., Pandiella, S.S., Cantero D.&Webb, C. (2003). Cereal-basedfermented foods and beverages. Food Research International, **36**(6): 527-543.
[6] Duodu, G. O., Amartey, E. O., Asumadu-Sakyi A. B., Adjei C. A., Quashie F. K., Nsiah-Akoto, I.& Ayanu, G. (2012). Mineral Profile of Pito from Accra, Tamale, Bolgatanga and Wa in Ghana. Food and Public Health, **2**(1):1-5.
[7] Edema, M.O.& Sanni, A.I. (2008). Functional properties of selected starter cultures for sour maize bread. Food Microbiology, **25**(4): 616-625.
[8] Egemba, C.K. & Etuk, V.E. (2007). A Kinetic Study of Burukutu Fermentation. Journal of Engineering and Applied Sciences, **2**(7): 1193-1198.
[9] Ekundayo, J.A. (1969). The Production of Burukutu. A Nigerian Fermented Beverage. J. Food Technology, **4**: 217-225.
[10] Eze, V.C., Eleke, O.I. & Omeh, Y.S. (2011). Microbiological and nutritional qualities of burukutu sold in mammy market Abakpa, Enugu State, Nigeria. American journal of food and nutrition, **1**(3): 141-146.
[11] Fadahunsi, I. F., Ogunbanwo, S. T. and Fawole, A. O. (2013). Microbiological and nutritional assessment of burukutu and pito (indigenously fermented alcoholic beverages in West Africa) during storage. Nature and Science, **11**(4): 98.
[12] Faparusi, S. I. (1970). Sugar changes during the preparation of burukutu beer. J Sci Food Agric, **21**: 79-81.
[13] Hell, k. and Mutegi, C. (2011). Aflatoxin control and prevention strategies in key crops ofSub Saharan Africa. African Journal of Microbiology Research, **5** (5): 459-466.
[14] Holzapfel, W.H. (2002). Appropriate starter culture technologies for small-scale fermentation in developing countries. International Journal of Food Microbiology, **75**: 197-212.
[15] Igyor, M.A., Ariahu, C.C. & Omale, Y. (2006). Chemical and microbiological characteristics of burukutu, a traditional Nigerian beer. Nig. Food Journal, **24**: 86-91.
[16] Inyang, C.U. &Idoko, C.A. (2006). Assessment of the quality of ogi made frommalted millet. Afri J Biotech, **5**(22): 2334-2337.
[17] Iwuoha, C.I. & Eke, O.S. (1996). Nigerian indigenous fermented foods: their traditional process of operation, inherent problems, improvements and current status. Food Research International, **29**: 527-540.
[18] Jones, F.T., Wunston, M., Hagler, J.R. and Hamilton, P.B. (1984). Correlation of aflatoxin contamination with zinc content of chicken feed. Applied and Environmental Microbiology, 478-480.
[19] Jideani, I.A. & Osume, B.U. (2001). Comparative studies on the microbiology of three Nigerian fermented Beverages: Burukutu, Pito and Nbal: Nigerian Food Journal, **19:25**.
[20] Kirk, R.S. & Sawyer, R. (1991). Pearson's Composition and Analysis of Foods. (9th ed.). Longman Scientific and Technical England, 607-617.
[21] Matumba, L., Monjerezi, M., Khonga, E. B. &Lakudzala, D.D. (2011). Aflatoxins in sorghum, sorghum malt and traditional opaque beer in southern Malawi. Food Control **22**: 266-268.
[22] Mbajiuka, C. S., Omeh, Y. S. & Ezeja, M.I. (2010). Fermentation of sorghum using yeast (Saccharomyces cerevisiae) as a starter culture for burukutu production. Continental J. Biological Sciences, **3**: 63 – 74.
[23] Mbajiuka, C. S., Obeagu E. I., Ochei K. C. & Onyemairo, N. C. (2014). Effect of Ginger and Garlic on the Microbial Load and Shelf- Life of Burukutu. International Journal of Microbiological Research **5** (2): 117-123.
[24] Nout, M.J.R. (2009). Rich Nutrition from the poorest - Cereal fermentations in Africa and Asia. Food Microbiology, **26**: 685-692.
[25] Obizoba, I.C. & Atii, J.V. (1991): Effect of soaking, sprouting, fermentation and cooking on nutrient composition and some anti-nutritional factors of sorghum (Guinesia) seeds. Plant Foods for HumanNutrition, **41**: 203-212.
[26] Odhay, B. & Naicker, V. (2002). Mycotoxins in South African Traditionally Brewed Beers. Food Additives and Contaminants, **19**(1):55-61.
[27] Oke, T.A. & Ijebor, J.A. (1997). Studies of yeast isolates of burukutu and palm wine on table wine production using oranges (Citrus sinensis). Nigerian J. Biotechnol, **4**(1-2):60.
[28] Sahlin, P. (1999). Fermentation as a Method of Food Processing production of organic acids, pH-development and microbial growth in fermenting cereals. Licentiate thesis, Lund University, 13-15.
[29] Sefa-Dedeh, S. (1999). Yeasts in traditional brewing of pito in Ghana. World Journal of Microbiology and Biochemistry, **15**: 593–597.
[30] Stroka, J., & Anklam, E. (1991). Quantitative analysis of aflatoxins. Journal of AOAC, **74**: 81-84.
[31] World Health Organization (WHO). (2006). Guidelines for Drinking Water Quality, Vol. 1, 3rd ed. incorporating 1st and 2nd addenda WHO, Geneva, pp: 296-460.