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Research Article

Nutritive Profiles of a Blend of Balanites aegyptiaca and Sorghum Beer residue consumed by some communities in Uganda: The Case of Karamoja sub-region

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Abstract

Sorghum and Balanites (*B. aegyptiaca)* are drought-resistant crops and wild plants widely consumed in arid and semi-arid part of Africa and Uganda. We determined the nutritive profile and microbial content of B. aegyptiaca leaves, sorghum beer residue, and a blend of B. aegyptiaca leaves and Sorghum beer residue using samples obtained from Moroto district in Karamoja under Standardized Analytical Methods and Procedures. Leaves of B. aegyptiaca, Sorghum beer residue, and blend of the B. aegyptiaca leaves and sorghum beer residue are good sources of carbohydrates, proteins, fats, Ca, Fe, K, Zn and Vitamin B with considerably high levels of Mesophyllic bacteria. The energy content (Kcal), and levels of proteins and potassium (K) did not vary -averaging 115Kcal, 16.5%wt, and 215mg/100g respectively. The levels of aflatoxins and E. coli were low and no salmonella was detected. Sorghum beer residue contained more fat (8% wt DMB), Ca (770mg/100g), Zn (2.4 mg/100g), and total carbohydrate 30.6(%wt) compared to B. aegyptiaca leaves which has substantially higher Iron (Fe) content (46.2mg/100g). B. aegyptiaca enriches the blend with significant amounts of iron and vitamin B, critical for the body immunity. Blending improves the nutritive profile.

Keywords: B aegyptiaca, Sorghum beer residue, Blending, Nutrient contents, Karamoja

Introduction

In Africa, sorghum grain is the major cereal crop used to produce the traditional “opaque” beers (Novellie, 1976; Asiedu, 1991) [5, 31]. It is Africa’s second most important cereal and it provides the majority of daily calorie consumption for millions of residents (Belton &Taylor 2004) [7]. Sorghum is very well adapted to the semi-arid and sub-tropical conditions prevailing over most of the African continent (Agu et al., 1998) [1]. While sorghum provides a large number of carbohydrates for local diets, it lacks a key nutrient: vitamin A (Lindsay, 2010) [25]. The manufacturing processes of African traditional sorghum beer essentially involve malting, drying, milling, souring, boiling, mashing, and alcoholic fermentation, but variations may occur depending on the geographic localization (Haggblade et al., 2004) [17]. These types of beer differ from European (lager) types in the fact that lactic fermentation also occurs during sorghum beer processing. Besides, African traditional sorghum beer is consumed while it is still fermenting, and the drink contains large amounts of fragments of insoluble materials (Akingbala et al., 1981) [2]. These fragments are mainly starch residues and dextrins that are not digested during mashing and fermentation (Glennie& Wight, 1986) [15].Traditional African sorghum beers are very rich in calories, B-group vitamins including thiamine, folic acid, riboflavin, and nicotinic acid, and essential amino acids such as lysine (Chevassus-Agnes et al., 1979) [9].Traditional sorghum beer is mainly consumed by the poorest in society and contributes significantly to the diet of millions of African people (Kayodé et al., 2007b).

B. aegyptiaca is one of the most important wild plant species of the arid and semiarid areas of Africa. It is commonly known as desert date, and an important source food, medicine and wood fuel in most African countries, stretching from arid and semi-arid regions to sub-humid savanna. Its fruit has an edible mesocarp and a hard-woody endocarp enclosing an edible oil-rich seed kernel. The leaves are eaten as a vegetable in the dry season in many countries throughout its range in dryland

Africa. According to Mbah and Retallick (1992) [29], *B. aegyptiaca* is a promising economic plant for both the arid and semi-arid regions of tropical Africa, the Middle East, and India. As a multipurpose tree, B. aegyptiaca offers food, medicines, cosmetics, fodder, fuelwood, and pesticides valued for subsistence living in the arid and semiarid areas where other options are few (NRC, 2008) [32]. Balanites leaves, flowers, fruits, and oil have been utilized for many generations by both rural and peri-urban communities across the Balanites range in dryland Africa (Hall and Walker, 1991) [18]. In Uganda, the young succulent leaves are eaten as dry season vegetable by the Itesots (Nilo-harmites ethnic group), while the fruits and oil are popular among the Ma'di, Lugbara (West nilotes), and Karamojongs (Katende et al., 1999; Teklehaimanot, 2008) [22, 41]. These products are also traded in both local and urban markets in Karamoja, Teso, and West Nile sub-regions of Uganda (Katende et al., 1999) [22], thus providing an income and a source of livelihood to many rural households.

Statement of the problem

Nearly half of all households (46%) in Karamoja are food insecure (WFP and UNICEF January 2016) [45]. Although there are several interventions in place to address food insecurity and malnutrition, these programs have not effectively improved the nutrition situation in the sub-region. To cope with challenges of food insecurity, the communities have adopted different coping strategies including selling of natural resources (firewood and charcoal), mining, collection of wild leaves and fruits among others to avert hunger. Local beer brewing is a very common economic activity taken on by most women in Karamoja sub-region as livelihood income activities to provide for their families. It has also been known that most poor households have limited or lacks income to access available foods in the local market due to their low purchasing power (WFP/UNICEF-FSNA, 2016) [45] and as a result, most household families resort to either buying or exchanging firewood for beer residue which is relatively cheaper. While other households do consume this beer residue as it is, others have gone the extra mile to process and add value. This has been done by drying and grinding the residue and then boiling it together with tender leaves of B. aegyptiaca. On the other hand, the desert date (*B. aegyptiaca*.) is one of the neglected wild plants of growing importance in drought and famine-prone areas of Uganda. Unfortunately, information on its nutritional composition is still lacking, thus limiting its wider use and promotion. Therefore, if the nutrition profile of this blend is determined it could unlock a local solution to the nutritional problem such as anaemia, which is prevalent among children less than 5yrs and women in reproductive age (15-49yrs) in this drought /famine prone sub-region. This was an operational study undertaken by Andre Foods International (AFI), an indigenous NGO with a long presence in Karamoja implementing integrated nutrition-specific and nutrition sensitives programs with support from the WFP and Government of Uganda.

Study Objectives

The Overall objective of this study was to determine if the blend of B. aegyptiaca and sorghum beer residue commonly consumed by some communities in Karamoja offers peculiar nutritional benefits. Specifically, we determined i) the nutritive profile of tender leaves of *B. aegyptiaca,* a wild edible tree plant, ii) the nutritive profile of sorghum beer residue (locally known as adakai), and iii) the nutritive profile of a blend of *B. aegyptiaca* leaves and sorghum beer residue. The findings will contributes to the knowledge base for an innovative program design and planning for nutrition-sensitive interventions aimed at addressing chronic food insecurity and malnutrition in Karamoja sub-region using locally available resources.

Materials and Methods

Study site

This study was conducted in the Moroto district, Karamoja region, Northeastern Uganda (Figure 1). Moroto district is located in central Karamoja which is characteristically a semi-arid savannah with bush and mountainous areas. The study area receives an average annual rainfall of not more than 1000mm and intense climate variability owing to its semi-arid conditions (Egeru et al, 2014) [11]. As such, erratic drought patterns and resulting food shortfalls are rampant.

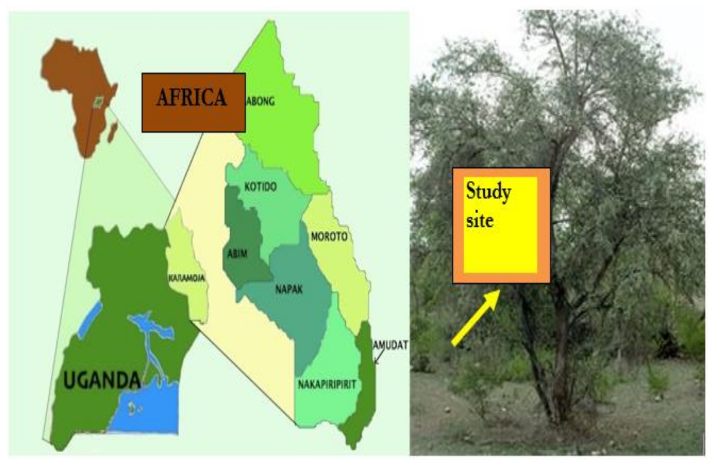

Figure 1: Map of Uganda showing the Karamoja region and study site

Sorghum and millet constitute are the most common staple foods among the population. Aside from these traditional cereals, the Karamojong have several plant-based foods consumed depending on seasonal availability. Among these, leaves of B. aegyptica (Ekorete) are cooked as a vegetable to cope with food shortagesduring the dry season (Figure 2) (Ojelel et al, 2019) [33]

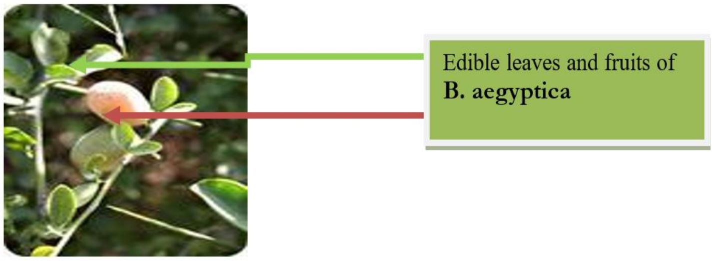

Figure 2. Showing edible leaves and fruits of B. aegyptica (Ekorete)

Materials and Methods

The material for this study included fresh leaves of B. aegyptica and sorghum beer residue (locally called adakai). Samples of fresh B. aegyptica leaves (sample 1) and beer residue (sample 2) were collected from the vegetation and local market in Moroto town respectively. A third sample was obtained by mixing sample 1 and sample 2 in equal proportions to form a blend of Balanite Sorghum Beer Residue, BSBR (sample 3). Moisture content was determined before drying, thereafter; each of the samples was dried and grounded for further analysis on a Dry Matter Basis (DMB). Different scientific analyses were performed on the three (3) samples separately to determine nutrient contents and microbial quality parameters using standardized analytical methods summarized in Table 1

Test	Units	Method
Protein Content (N x 6.25) (DMB)	% Wt.	AOAC 2001.11
Fat Content (DMB)	% Wt.	Gafta No.3*
Carbohydrates	% wt.	Calculation
Energy	Kcal	Calculation
Iron as Fe	mg/100g	AOAC 999.11
Zinc as Zn	mg/100g	AOAC 999.11
Calcium as Ca	mg/100g	AOAC 999.11
Potassium as K	mg/100g	AOAC 999.11

Table 1. Analytical Test to ascertain nutrient and quality parameters

Results and Discussions

Proximate Analysis

Table 6.1 provides a summary of the moisture content of each sample before drying and the nutritional profile (protein, fat, ash, iron, calcium, potassium, zinc, carbohydrate, and energy) of *B. aegyptiaca* leaves, sorghum beer residue and the BSBR blend on dry matter basis.

Tests	Units	Fresh B. aegyptiaca leaves ('*Ekorete*')	Sorghum beer residue (‘*adakai*’)	Blend of B. aegyptiaca leaves and Sorghum Beer Residue (BSBR)
Moisture Content (MC)	% wt.	58	76.3	69.8
Protein Content (Nx6.25)	% wt.	16.3	17	16.5
Fat Content (DMB)	% wt.	2.1	8	5.3
Ash Content (DMB)	% wt.	9.3	2.4	5.5
Iron as Fe	mg/100g	46.2	8.8	32.6
Calcium as Ca	mg/100g	197	770	531.9
Potassium as K	mg/100g	216.7	217	214.7
Zinc as Zn	mg/100g	1.3	2.4	1.8
Total Carbohydrate	% wt.	0	30.6	17.4
Energy	Kcal	112	118.8	115.1

Table 6.1: Nutrient content samples

Microbial content Analysis

In addition to the proximate analysis, a microbial content analysis was undertaken on all three samples. The resulting microbial profile is presented in Table 6.2.

Tests	Units	Fresh B. aegyptiaca leaves ('*Ekorete*')	Dried Sorghum beer residue (‘*adakai*’)	Blend of B. aegyptiaca leaves and Sorghum Beer Residue (BSBR)
Total aflatoxin	ppb	<1.0	5.0	3.2
Mesophyllic aerobic bacteria	cfu /g	2100	2900	2750
Escherichia coli	cfu/g	690	Nil	345
Salmonella	/25g	Absent	Absent	Absent

Table 6.2: Microbial content of samples

Discussions

Proximate Analysis

The moisture content of the three samples was 58%, 76%, and 70% for B. aegyptiaca leaves, sorghum beer residue, and the BSBR blend respectively. Both B. aegyptiaca leaves and sorghum beer residue had relatively high moisture content (>50%). Previous studies have reported moisture contents of 62% for sorghum beer straining (Van Heerden, 1987) [43] and 43.3 % for B. aegyptiaca flowers (Umar et al, 2014) [42]. Audu et al., 2018 [44] found a much lower moisture content of 2.7% in B. aegyptiaca leaves, however, his analysis was on DMB. However, moisture content of <80% can be considered low when compared with fresh leafy vegetables. B. aegyptiaca leaves are less moist than vegetables like amaranth and kale that have over 80% moisture content (Olumakaiye, 2011) [35]. This could be attributed to the fact that B. aegyptiaca grows amidst heatwaves and minimal rainfall. While higher moisture content is associated with ease of digestion, it may result in an escalation in microbial activity during storage (Hassan et al, 2009) [19]. B. aegyptiaca leaves, therefore, tend to have a longer shelf life than other leafy vegetables even without preservation. The sorghum beer residue has a moisture content of 76%. This is much higher than the moisture content in sorghum grain, which was estimated at 8% in storage (Ape et al, 2016) [4] mainly due to the addition of water and other ingredients during the fermentation and brewing processes.

There was a notable difference in total carbohydrate in fresh B. aegyptiaca leaves and dried sorghum beer residue. Our analysis showed that B. aegyptiaca leaves did not contain any carbohydrates. The sorghum beer residue had 31% carbohydrate content, comparable with 65.9%wt DMB found by Van Heerden in 1987. The carbohydrate in the blend (17%) is therefore primarily derived from the dried sorghum beer residue rather than fresh B. aegyptiaca leaves. Although sorghum grain has a higher carbohydrate content of 76.51% (Ape et al, 2016) [4], there is a significant breakdown of carbohydrates in the preparation of beer. Nevertheless, 31% of carbohydrate from the residue does contribute considerably in complementing daily dietary energy needs, especially during food shortages.

There was no wide variation in the crude protein content of all three samples as crude protein contents were within a similar range for all three samples (16.3% -17%). The crude protein value in the leaves reported in this study is close to that reported by Okia et al. (2013) and Kubmarawa et al. (2008) [24] who found 14.3% in Teso/Karamoja/Adjumani and 15.86% in Niger respectively. However, Dougal et al. (1964) reported much higher protein content (20.8 – 27.5%) in Kenya. These levels of crude protein in Balanites leaves are within the range reported for most tropical vegetables (Saka and Monthi, 1994; Omujal, 2008; Kubmarawa et al., 2008; Okia et al., 2013) [24]. Thus, leaves of B. aegyptiaca, are generally good sources of protein that compare well with other tropical leafy vegetables. Proteins play an important role in nutrition and diet since they are the major structural components of all body cells. They function as enzymes, membrane carriers, hormones, and provide energy. According to NAS (2005), the recommended daily allowance (RDA) for proteins is 0.8 g kg-1 of body weight for adults and an increased value of 1.1 g kg-1 of body weight for pregnant and breast-feeding women (WHO, 2007). According to WHO (2004), there is inadequate protein consumption in many developing countries, including Uganda and Karamoja in particular. Wide-spread consumption of the leaves of B. aegyptiaca mixed with adakai (beer residue) could alternate other protein sources such as meat, beans, and groundnuts that are rarely eaten by the vulnerable member of the community (children, women and elderly) in Karamoja.

As is the case with vegetables, B. aegyptiaca leaves have relatively low-fat content (2.1%) compared to sorghum beer residue (8.0%) and the blend (5.3%). This is consistent with CA. Okia et al. (2013) and Kubmarawa et al [24]. (2008) also reported a similar fat content (2.21%) and (2.9%) in B. aegyptiaca leave respectively. This suggests that a blend of B. aegyptiaca leaves and residue of cereal beer mainly from sorghum, maize, and millet could be a better source of fat. The importance of lipids (fat/oil) in human nutrition and health has been long known. Fats are a major source of energy for the body and aid in vitamin absorption and tissue development. They also play an important role as antioxidants (Anhwange et al., 2004; NAS, 2005). For a body to meet its daily nutritional needs while minimizing the risk of chronic diseases, NAS (2005) recommended that adults should obtain 20 – 35% of their calories/energy from fat. Though the quantity of fat in a blend of B. aegyptiaca leaves and residue of sorghum beer is somehow low (10.1%), this could still be vital as energy supplements during the dry season when alternatives are few. Moreover, their consumption could have a substantial cumulative effect thus sustaining rural diets.

The ash content in the leaves of B. aegyptiaca, beer residue, and blend varied between 2.4% and 9.3%. The leaves of B. aegyptiaca had the highest ash content (9.3%) compared to the sorghum beer residue (2.4%). The ash content is indicative of the levels of minerals present in the sample. Okia et al. (2013) and Kubmarawa et al [24]. (2008) reported ash content of 9.26% in leaves while Lockett et al. (2000) found higher ash content in leaves (12.27%). The results of Lockett et al (2000) compares well with other locally consumed leafy vegetables as proposed by Dhello et al., (2006). From these findings, we can loosely say that the B. aegyptiaca leaves have a higher mineral density than sorghum beer residue and the blend subject to a more rigorous micronutrient analysis. However, since most leafy vegetables tend to have alkaline ash, the consumption of B. aegyptiaca leaves can also contribute to healthier diets by neutralizing the effect of complementary acidic foods.

Calcium (Ca) is very abundant in the residue (770mg/100g) compared to 197mg/100g in Balanitesaegyptiaca leaves, Iron (Fe) was found to be the most abundant in the leaves of B. aegyptiaca (46.2mg/100g). Conversely, there were low levels of zinc (Zn) in these leaves (1.3mg/100g) than in the sorghum beer residue (2.3% mg/100g) (Figure 3).

The role of trace elements, including those reported above, in human nutrition and disease control has long been emphasized. Even though they form a small proportion of the nutrients required by the body and do not contribute to the energy value of food, they are of great physiological importance particularly in body metabolism (Schwart, 1975; Saura-Calixto and Canellas, 1982; WHO, 2004; NAS, 2005). Potassium is very important in the human body where, along with sodium, it regulates the water balance and the acid-base balance in the blood and tissues. In the nerve cells, sodium-potassium flux generates the electrical potential that aids the nerve impulses. A low Na/K ratio is recommended in a diet. In the drylands of Uganda like Karamoja region, this can be achieved through the consumption of the tender leaves of B. aegyptiaca, sorghum beer residue or the blend of both since the amounts of potassium do not vary much among all of them (Figure 3).

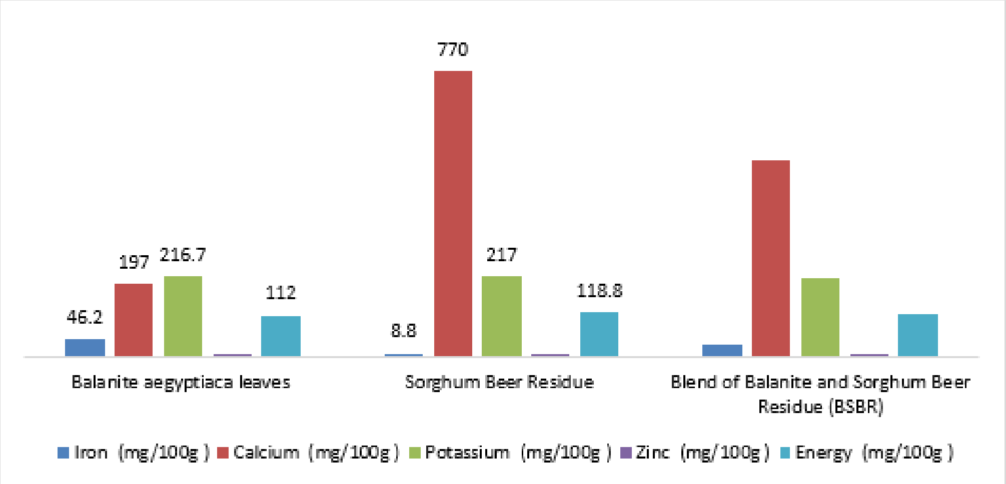

Figure 3: Energy and Mineral contents

Iron is a constituent of haemoglobin, myoglobin and some enzymes, which catalyse oxidation and reduction processes in body cells and its deficiency causes anaemia (Dallman, 1986; Christian and Ukhun, 2006). The availability of a significant amount of iron in B.aegyptiaca leaves, flowers, and pulp are therefore of nutritional and health benefit to dryland communities since their consumption during the dry season helps in reducing incidences of anaemia or need for iron supplementation particularly among children and pregnant women. Zinc is an essential component of many enzymes participating in the synthesis and degradation of carbohydrates, lipids, proteins, and nucleic acids as well as the metabolism of other micronutrients. Zinc also plays a central role in the immune system by modulating increased susceptibility to infection (Aggarwal et al., 2007; Prasad et al., 2007).

Sorghum beer residues (strainings) are sold while still wet and can contain up to 75% moisture, and are rich in calories, B-group vitamins including thiamine, folic acid, riboflavin, and nicotinic acid (F Lyumugabe., 2012) [26]. While a study by S Mukaila et al, 2017, to ascertain the general uses and nutritional composition of desert date (Balanites aegyptiaca) in the West Gonja District of Ghana found 0.490mg/g of vitamin C in the leaves of B. aegyptiaca.

Microbial Analysis

Total aflatoxin in the leaves, residue and blend varied from <1.0cfu/g (fresh leaves) to 5cfu/g (dried residue) and 3.2cfu/g in the blend. There were high levels of Mesophilic bacteria which varied from 2100 cfu/g in the fresh leaves to 2900cfu/g in the beer residue of traditionally made sorghum beer. The blend has 2750 cfu/g of Mesophyllic bacteria. E. *coli* were reported VERY high fresh leaves of B. aegyptiaca (690cfu/g) and 'Nil' in the dried residue. Whereas there was no salmonella detected in all the samples.

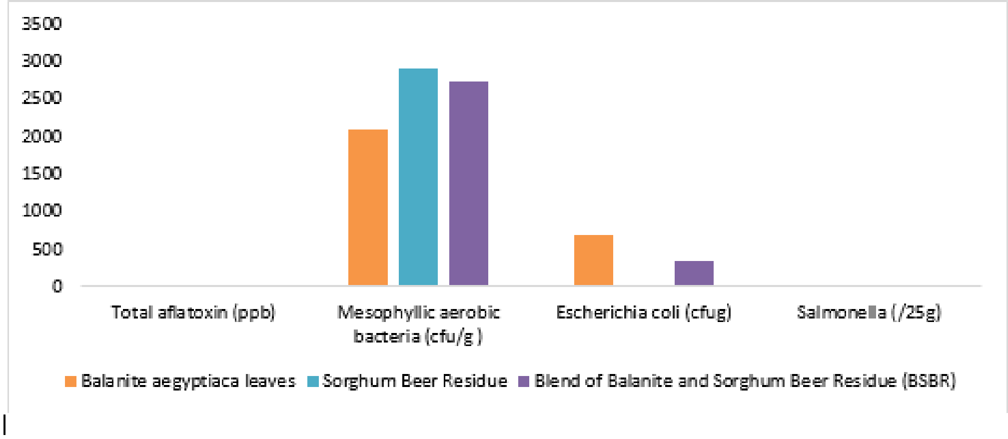

Figure 4. Variation of microbial profile

The level of microorganisms, in this case, fungi and pathogenic bacteria were generally very low in the blend, leaves, and residue. The level of non-pathogenic surface bacteria (Mesophilic bacteria) is higher in sorghum beer residue (2900cfu/g) than in the leaves (2100 cfu/g) and residue (2750cfu/g). Blending decreases the levels of Mesophilic bacteria. Whereas, the levels of aflatoxin in all samples were <10cfu/g and even significantly lower in the leaves (<1cfu/g).

Blending considerably alters the levels of Mesophilic bacteria. The total counts of Mesophilic bacteria reduced from the 2900cfu/g to 2570cfu/g. However, given that these bacteria are not harmful per se, this alteration may not introduce significant nutritional risk. The levels of aflatoxin in all samples is consistently below 10cfu/g and even much lower in the leaves (<1cfu/g). Surprisingly E. *coli* was found present and large amount in the fresh leaves of B. aegyptiaca (690 cfu/g) as compared to the dried sorghum beer residue ('Nil'). Whereas there was no salmonella detected in all the samples analysed.

Conclusion

This study has established that although B. aegyptiaca leaves and sorghum beer residue have relatively similar protein, energy, and potassium contents, there is significant variation in the level of the other nutrients. The sorghum beer residue is higher intotal carbohydrate, fat, calcium, and zinc. Conversely, the fresh B. aegyptiacaleaves had more ash and five times the amount of iron present in the beer residue. The level of macronutrients was generally higher in the sorghum beer residue than in the leaves and /or blend. Although macronutrients are important in the human diet because of their role in providing energy for body functions, the importance of micronutrients like supporting immunity, blood formation/clotting, bone health, and fluid balance among others cannot be underscored. However, by bringing together attributes from B. aegyptiacaleaves and sorghum beer residue, blending enables improvement in nutrient quality. First of all, the blended sample has a relatively reduced moisture content (70%) which is further improved by drying and could reduce microbial activity and improve shelf life. In the context of resource-poor communities, promoting storage alone would enable smoothing of household food consumption especially during the lean season. This wouldenable the communities in Karamoja to cope with food scarcity.

Blending improves the nutritive profile and enhances the intake of micronutrient as opposed to when either B. aegyptiaca leaves or sorghum beer residue is consumed alone. This is because while protein, potassium, and energy remain in the same range, the blend is fortified with more iron from B. aegyptiaca leaves and increased levels of fats, calcium, carbohydrate, and zinc from the beer residue of sorghum beer. On the other hand, although the level of aflatoxin and pathogenic bacteria such as E. coli are generally low, blending reduced the high levels of mesophilic bacteria. Encouraging consumption of B. aegyptiaca leaves together with sorghum beer residue can be nutritionally beneficial to members of the community who are vulnerable to food shortages/outages. Therefore, there will need to increase awareness about the nutritional value of such foods, determine a blend that optimizes nutrient content further, study to understand the level of anti-nutritional factors and the bioavailability of nutrients in these products to guide their wider use in nutrition-sensitive interventions.

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