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Physicochemical and Sensory Properties of Cassava *Mahewu* improved with Beetroot *(Beta vulgaris L)*

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ABSTRACT

Background: A popular traditional method in which cassava is consumed in Mozambique is mahewu - a non-alcoholic fermented beverage, and it's known to be poor in micronutrients. Objective: The objective of this study was to examine the nutritional effect and quality attributes of integrating beetroot pulp into cassava mahewu. Methods: Mahewu was prepared from cassava flour by controlled fermentation using starter culture. Three different blends of cassava mahewu were produced by beetroot pulp at adding 5, 7.5, and 10 g after fermentation; 100% cassava mahewu was used as control. Mineral analysis, sensorial properties and proximate were carried out on the blends using standard methods. Results: The results showed that mineral contents range as follows; Fe (0.942 to 8.05 mg/L), K (155.67 to 331.36 mg/L), Na (30.57 to 65.03 mg/L) and Zn (0.104 to 0.328 mg/L) with 7.5 g of beetroot having the highest value and most acceptable to consumers based on sensory evaluations. Proximate analysis showed a significance ($p<0.05$) increase in protein (0.5 to 2.9g/100 g), total ash (0.36 to 1.90g/100 g), fibre content (0.41 to 2.11g/100 g) and vitamin C (3.13 to 6.6%). It was observed that cupper and fat content was not affected ($p>0.05$) by beetroot addition. Conclusion: The overall results showed that 7.5 g beetroots addition is the most acceptable and nutritious fruit blend for improving cassava mahewu.

Introduction

Nutritional deficiencies are common, affecting an estimated 2 billion people worldwide [1]and the most vulnerable population subgroups are pregnant women and children. The availability of nutritious foods serves as direct remedy to malnutrition and micronutrient deficiencies and can as well reserve most of the nutrient deficiencies by providing the missing micronutrients [2]. This has been traditionally practised through supplementation, fortification or improvement approaches including dietary diversification.

Most tropical countries are faced with the problem of malnutrition due to population growth and enhanced dependence on cereal and tuber-based diet. It is estimated that about 800 million malnourished people exist in the least developed countries [3]. In Mozambique for example, it is estimated that 45% of the population are iron deficient [1]and 44% of children less than five years were found to be malnourished [3]. All effort is directed towards promoting the value of indigenous food materials in order to reduce the level of malnutrition and over dependence on imported foods. There is need for evidence-based approaches to the prevention of malnutrition and micronutrient deficiency diseases in other to reverse or reduce this effect.

Considerable efforts to improve the health and nutritional status of growing children in developing countries (where malnutrition remains a major problem) have focused on the production of nutritious food or improving the quality of indigenous foods. Foods with micronutrients stability are essential to sustain life, contribute to a healthy lifestyle, maintain a consumer's well-being, and help to reduce the risk of chronic diseases [4]which in turn reduces the cost of health care.

Cassava is a carbohydrate staple which is mainly cultivated in Africa and Latin American countries. It is widely consumed in various part of Africa as the second most staple food after maize. Cassava is a strategic crop for Africa's food security and supports more than 350 million people [5]. The diet is poor in micronutrients due to lower content and loss during processing [6], as a result, deficiency diseases and lack of dietary diversity becomes a particularly severe problem in these regions where diets are based predominantly on cassava staples[7,8]. Therefore, cassava and cassava product are a major target for enrichment because of its importance as a staple crop.

The Mozambican diet is mainly composed of cassava which is the major staple but with low protein and micronutrients and the supply of micronutrient rich foods (fruits and vegetables) to supplement this effect are dramatically low [3]. One of the ways in which cassava is consumed in Mozambique is mahewu, which is a non-alcoholic fermented beverage also consumed traditionally in most African nations and Arabian Gulf countries [9,10]. It is a refreshing drink that is largely consumed at schools, farms, homes and also acts as a weaning food for infants. However, it is low in proteins and micronutrients [11]

Beetroot (Beta vulgaris L) is a vegetable plant that belongs to the family Chenopodiaceae and its edible part is the root which is consumed as part of normal diet. This tuber is a rich source of fiber, vitamins and minerals and has a high nutritional value [12, 13]. The intense red color of beetroots is derived from high concentrations of betalains, a group of phenolic secondary metabolites [13]. Betalains are used as natural colorants by the food industry, but have also received increasing attention due to possible health benefits in humans, especially their antioxidant and anti-inflammatory actions[14, 15]. Due to its nutritional composition, beetroot consumption contributes to the improvement and maintenance of human health.

Several reviews have appeared in the literature about fortification and enrichment of cassava products using various techniques [10, 16, 17]. However, no reports are available on the possibility of enriching cassava mahewu with natural fruits such as beetroots, which are packed with micronutrients and bioactive compounds. Therefore, the objective of this present study was to improve the nutritional quality of cassava mahewu by adding beetroot juice. The improvement of micronutrients in cassava mahewu can contribute to welfare and reduce micronutrient deficiencies among the populace as well as the diversification of cassava-based products.

Materials and Methods

Sample collection

The cassava flour used for mahewu preparation was purchased from the bakery Unit of Food Technology section, Department of Chemical Engineering, Eduardo Mondlane University in Maputo, Mozambique. The fresh beetroot was purchased directly from the local market in Xipamanine and transported to the Food Technology Laboratory same day for processing.

Sample Preparation

The beetroots were sorted to remove debris, washed thoroughly in tap water, peeled, sliced, rinsed again with tap water, grinded with blender to produce juice and stored in refrigerator at temperature range from 4°C to 8°C until when used for enrichment.

Mahewu preparation and improvement

Cassava flour was fermented under controlled conditions (45°C for 24 h) using the method described by Salvador et al. [10]. 20 g cassava flour was mixed with 49 mL of distilled water and transferred to 150 mL of boiling water. The mixture was boiled for 10 min to gelatinize the starch then cooled to a temperature of 25°C. The porridge was transferred to a 250 mL Erlenmeyer flask and 1.25 g of starter culture was added and mixed thoroughly and allowed to ferment while monitoring the PH. After fermentation, 5, 7.5 and 10 g beetroot pulp was added in three ratios and mixed thoroughly using mixer equipment and thereafter stored under refrigerator until used for analysis; 100% cassava mahewu used as the control.

Mineral analysis

Mineral contents were analyzed by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) after acid digestion of the ashed samples. All glassware was cleaned with %10 (v/v) HNO3 solutions for one day and rinsed with distilled water. 1.0 g of each sample was digested with 4.0 mL of 65% (v/v) HNO3 and 0.5 mL of 35% (v/v) H2O2. A blank digest was carried out in the same way. This solution was finally used for elemental analysis and the concentrations of the elements were read and recorded. All samples were analyzed in duplicate and each sample was measured in triplicate by ICP-AES detection against standard solutions of known mineral concentrations

Sensorial analysis

A semi-trained panel of ten members who were used to cassava mahewu evaluated the sensory properties of the enriched mahewu. The panelists were asked to rate each sensory attribute using the control cassava mahewu as the basic for evaluation of the color, appearance, taste, flavor and overall acceptability on a 9-point hedonic scale (9. Like extremely; 8. Like very much; 7. Like moderately; 6. Like slightly; 5. Neither like nor dislike; 4. Dislike slightly; 3. Dislike moderately; 2. Dislike very much; 1. Dislike extremely). Water was provided to rinse the mouth between evaluations. The samples were coded with letters and served to the panelists at random to guard against any bias.

Proximate analysis

Moisture, ash, total dietary fibers, protein, and lipid content were determined by the official AOAC [18]methods. Total carbohydrates were determined by difference which involves the summation of the result obtained from fat, crude fibre, ash and protein contents determination, all subtracted from 100. Each sample was analyzed in triplicate. The results were expressed as mg/100g of wet basis. The proximate analysis was carried out only on the blend (7.5 g) with the highest acceptability score by the consumers.

Determination of vitamin C

The quantity of the vitamin C contained in each sample was determined by titrimetric method using 2, 6-dichlorophenol indophenol reagent until a pink coloration persist for 30s [19]. Results were expressed in percentage.

Data analysis

The experimental data was analyzed using Analysis of Variance (ANOVA) to determine significant difference between the means and these were expressed as mean ± standard deviation (SD). The level of significance was set at $P<0.05$. The data were analyzed using SPSS version 17.0.

Results and Discussion

Mineral composition of improved cassava mahewu:

These results on mineral composition showed that beetroot addition significantly ($p<0.05$) increased the Fe content of the blended samples. The same trend was observed for other minerals analysed except for Cu which recorded no significant increase ($P>0.05$) in all the three ratios as shown in Table I. Again, the amount for Mn and Zn were not significant ($p>0.05$) at 10 g BR substitution. Majority of the minerals analysed had highest values at the second blend of 7.5 g beetroot.

Minerals are inorganic compounds which have to exist in the human body for vital activities. Addition of beetroot was observed to increase the mineral contents of the cassava mahewu. The values obtained for Fe was promising and revealed that beetroot is a good source of Fe, which is in agreement with the report of Petek et al. [13]. Fe is an essential trace element for the production of red blood cells and the oxygenation of red blood cells whose deficiencies cause anaemia. Fe content in the enriched samples will contribute immensely in meeting the recommended daily allowance (RDA) of iron for infants and children which ranges between 6 and 15mg/day [20], if sufficient amount is consumed.

Zn is generously considered to be an antioxidant and is found in most specific enzymes [13]. It is the second most abundant transition metal in organisms after Fe. There was significant increase ($P<0.05$) in Zn at 7.5 g BR substitution only. The results revealed that beetroot is a poor source of Zinc and copper. This is in agreement with the report of Petek et al. [13]. Na is an essential element for normal cell function, continuation of plasma volume, acid-base balance, and transmission of nerve impulses [21]. Sodium is considered the backbone of body fluid, because the quantity of water in the extracellular fluid is regulated by the quantum of sodium in circulation, nerve and muscle function. In this study, Na content increased appreciably and was highest at 10 g beetroot added mahewu.

Functions of calcium include healthy teeth formation, bone mineralization, muscle contraction, cell signaling and regulation of cell metabolism. The Recommended Daily Allowance (RDA) of calcium ranged between 400 and 1,200 mg per day for infants, children and young adults [20]. In this study, calcium concentration was found to increase from 37.43mg/L to 64.73mg/L following the addition of beetroot, and the highest concentration was at the second blends of 7.5 g. Consuming beetroot substituted cassava mahewu will contribute towards meeting the DRA of calcium better than the traditional mahewu.

Potassium participates in several essential physiological processes, such as the transmission of nerve impulses, contraction of cardiac, smooth and skeletal muscles. The potassium contents in this study ranged between 87.47 and 331 mg/L and the highest value was recorded at 7.5 g BR, however, there was a sharp decrease ($p < 0.05$) in potassium concentration at 5%BR. This might be due to the differential amount of potassium contents of the beetroot and cassava mahewu. The addition of more beetroot at 7.5 g reversed this effect.

Sensorial analysis of improved cassava mahewu with beetroot

The result of sensory evaluation of the drinks produced from the samples is shown in Table 2. The original nature of traditional cassava mahewu somehow influenced the choice made by panellists since appearance of food is usually the first sign that determines edibility of the food. For taste, the sample with 7.5 g substituted beetroot were mostly preferred and was significantly ($p<0.05$) from other samples. Flavour preference increased with increase in substitution level of beetroot. In terms of color, there was a significant difference ($p<0.05$) in the samples. This showed that the addition of beetroot to the cassava mahewu at 5, 7.5 and 10 g affected the color of the drinks which supports the usefulness of beetroot as food colorant. For general acceptability, the 7.5 g beetroot substituted sample was most accepted followed by the 5 g BR sample.

Proximate and Vitamin C composition

The results of proximate compositions of 7.5 g BR sample were presented in Table 3. The values increased significantly ($p< 0.05$) for all parameters under this category except for moisture and fat content. There was no significant difference ($P>0.05$) in fat content of the enriched sample and the control mahewu. The low crude fat content of the samples is advantageous because rancidity of the products will be significantly minimal. The protein contents of the enriched samples increased significantly ($P<0.05$) from 0.5 to 2.9% with the addition of beetroot which showed an improvement in protein contents. There is a drop in carbohydrate contents of the sample from 8.4 to 2.92 % on the addition of beetroot at weight basis. This could be attributed to the increase in protein and ash contents of the sample compared with the control mahewu. The crude fiber contents increased significantly ($p<0.05$) with addition of beetroot. Dietary fiber from vegetable sources has been inversely associated with the risk of cardiovascular disease [22]. This shows that beetroot is good source of dietary fiber as reported by USDA [12], wruss et al. [23]and Teixeira da Silva et al. [24]

Ash content is a measure of inorganic mineral elements in food. The ash contents of the samples ranged between 0.36 and 1.90% wish showed a significant ($p<0.05$) increase with the addition of 7.5 g beetroot juice. This signified that beetroot is packed with lots of essential minerals as earlier reported by Petek et al. [13]. The high moisture contents of the sample indicated that the sample must be properly preserved either by refrigeration, to avoid microbial contamination and to prolong its shelf-life.

Vitamin C contents

The vitamin C contents of the samples are shown in Table 3. The values increased significantly ($p<0.05$) as beetroot is added to the traditional mahewu at 7.5 g. The Vitamin C content of sample may contribute towards the high preference in taste compared to the control. Vitamin C is the single most important vitamin that has an anti-oxidant property, an important factor in collagen production and useful in wound healing and can help regulate blood sugar levels in people with diabetes [25].

Table 1: Mineral composition (mg/L) of cassava mahewu enriched with beetroot

Samples	Ca	Cu	Fe	K	Mn	Na	Zn
Control	37.43±1.16^{c}	0.11±0.02^{c}	0.94±0.08^{c}	155.67±2.5^{c}	0.05±0.09^{c}	30.5±0.5^{c}	0.10±0.02^{c}
5 g BR	49.93±1.07^{b}	0.12±0.02^{c}	3.32±0.03^{b}	87.47±0.9^{b}	0.08±0.15^{b}	40.1±0.6^{b}	0.14±0.06^{c}
7.5 g BR	64.73±0.09^{a}	0.12±0.02^{c}	8.05±0.09^{a}	331±3.61^{a}	0.11±0.02^{a}	52.3±0.7^{a}	0.33±0.07^{a}
10 g BR	47.43±0.55^{d}	0.12±0.02^{c}	5.08±0.11^{d}	100.5±1.8^{d}	0.07±0.01^{c}	65.03±1.2^{d}	0.11±0.02^{c}

Values with the same superscript in the column are not significantly different ($p<0.05$). **K,** potassium, **Na,** sodium, **Ca,** calcium, **Zn,** zinc. **Mn,** manganese, **Fe**, iron, **Cu**, cupper, Letters **a-d** show the degree of significant difference

Table 2: Sensory evaluation of cassava mahewu drinks enriched with beetroot puree

Sample	Colour	Flavour	Taste	Overall acceptability
Control	6.0±0.06[a]	5.80±0.04[a]	6.20±0.02[a]	6.10±0.03[a]
5 g BR	7.20±0.04[b]	6.50±0.03[b]	6.50±0.02[a]	7.20±0.02[b]
7.5 g BR	8.40±0.11[c]	7.40±0.02[c]	7.60±0.03[b]	8.20±003[c]
10 g BR	7.80±0.09[c]	7.90±0.04[c]	5.90±0.04[a]	6.60±0.04[a]

Values in the same column followed by the same letter are not significantly different according to Duncan's multiple range test (p<0.05). Letters **a-d** show the degree of significant difference

Table 3: Proximate and vitamin C (%) composition of 7.5% beetroot substituted cassava mahewu

Sample	protein	Carbohydrate	Fat	Fibre	Ash	Moisture	Vit.C
Control	0.5±0.5[a]	8.4±0.6[a]	0.05±0.01[a]	0.41±0.06[a]	0.36±0.17[a]	90.28±0.33[a]	3.13±0.5[a]
7.5 g BR	2.9±0.6[b]	2.92±0.5[b]	0.06±0.01[a]	2.11±0.02[b]	1.90±0.01[b]	90.04±0.05[a]	6.6±1.3[b]

Values in the same column followed by the same letter are not significantly different according to Duncan's multiple range test (p<0.05) Letters **a-d** show the degree of significant difference. Letters **a-b** show the degree of significant difference

Conclusion

This study concludes that beetroot is a very good source of essential minerals, dietary fibre and protein. The compositions of the formulated blends of beetroot and cassava mahewu showed a significant nutritional influence on the final products. With regards to the sensory properties and acceptability, mahewu with 7.5 g beetroot incorporated recorded the highest preference followed by the 5 g. It was therefore recommended that, at most, 7.5 g beetroot pulp can be added to cassava mahewu to achieve higher quality sensory attribute and to improve the nutritional value of mahewu. The increased consumption of this value added mahewu will be of great health benefit to the populace and will help to combat against the problems of nutritional deficiencies in developing countries.

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