Nutritional composition of cocoyam (Colocasia Esculenta), grown in manicaland province in Zimbabwe

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ABSTRACT
Cocoyam is one of the important root food crops especially in Eastern parts of Zimbabwe. However, the nutritional composition of the Zimbabwean cocoyam has not been ascertained. A field trial was conducted in Rusape, Makoni District, Manicaland Province, Thandi Area under Chief Makoni in Maramwidze Village, 10km from Rusape town in 2015/16 season. Treatments consists of the control, cowdung manure, inorganic fertilizer, and a combination of cowdung manure and inorganic fertilizer, and was laid out in a split-plot design with cocoyam types (Madhumbe, Magogoya and Ghana) assigned to the main plots and manure type as the sub-plots with three replications. The results showed that nutrient supply to the cocoyam crop influenced the quality of the crop in a non-synchronously form. Proximate nutrition composition of cocoyam were in the range of 65 – 78% (moisture), 2 – 5 % (ash), 0.2 – 1.10% (fat), 2 – 5% (fibre), 14 – 23% (carbohydrates), 390 – 460 mg/100g (potassium), 24 – 43 mg/100g (calcium), 79 – 91 k/cal (energy), 0.3 – 4.8% (protein) and 79 – 110 mg/100g (magnesium). The high carbohydrate content in the cocoyam shows that the crop is superior compared to other tubers like sweet potatoes and cassava. In conclusion, the utilization of cocoyam combined with other foods with high protein content like cowpea will be beneficial to the nutrition of vulnerable groups considering the resultant high nutritive values.

Contribution/ Originality
The current study ascertained the nutritional composition of the Zimbabwean cocoyam. The study also shows that cocoyam is superior as compared to other tubers like sweet potatoes and cassava.

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1. INTRODUCTION

Cocoyams are tubers that are widely cultivated in both the tropical and sub-tropical regions of the world. It is a wetland herbaceous plant which grows to a height of 1 – 2m and it is perennial. Cocoyam can be distinguished into two main groups; the “eddoes” and the “dasheen” types (Onwueme, 1994). The eddoes type which is refered to madhumbe in Zimbabwe, have side tubers (cormels) that may be 5 – 20 in number and they become as big as the mother corm. In Manicaland Province where it is mainly grown, cocoyam ranks second in importance after sweet potato among the root and tuber crops cultivated and consumed in that area. The tubers are edible and they provide carbohydrates for human consumption. Usually they are used as a substitute for bread just like cassava and sweet potatoes (Kusena, 2002). In Nigeria, being the largest producer of cocoyam, and other West African countries it is an important staple food crop commonly grown by women (Eze and Okorji, 2003).

Food is one of the people’s basic necessities of life, therefore cocoyam represents important vital economic food value in most rural households, farmers produce their crop mainly for consumption and family upkeep, and they also sell and preserve for replanting in the subsequent cropping season. Nutritionally, cocoyam is superior to cassava and yam because of its high protein content, minerals and vitamins in addition to more digestible starch (Onyenweaku and Okoye, 2007). The main nutrient provided by cocoyam, as with many other root and tuber crops, is the dietary energy supplied by carbohydrates (O’Hair, 1990). The protein fraction content of corms and cormels is low (1-3%) and like other tuber crops proteins, sulphur containing amino acids are limiting (Mwenye et al., 2011). The mature corms are mostly boiled in Zimbabwe, while in West African countries they can be roasted, baked and fried. They can be eaten alone or with stew and they are served in some five star hotels (personal observation). The boiled corms are sometimes mashed like Irish potatoes and used as a weaning diet for babies. In West Africa, the mature corms are also processed into flour, which is used to prepare “fufu” that is commonly eaten with stews. The leaves of cocoyam are also nutritionally rich, containing about 23% protein on a dry-weight basis (Onwueme, 1994). Young cocoyam leaves are mixed with coconut cream to prepare a dish, which is then eaten with the boiled or roasted cocoyam, breadfruit or plantain. The leaves and sometimes stems are eaten as spinach and provide a supplement to maize (Coetze and Allenmann, 1996). Cocoyam can be used as an industrial raw material in the manufacture of alcohol and drugs (Okwuowulu et al., 2000).

Recent studies in other crops have revealed that use of intergrated use of organic and inorganic fertilizer influences yield and nutritional composition of the crops (Hota et al., 2016). However, there is need to apply both inorganic and organic fertilizers to increase the performance and chemical properties of soil such as pH, total nutrient content and nutrient availability (Usman et al., 2015). Hence there is need to ascertain the nutritional composition of cocoyam in this study.

2. MATERIALS AND METHOD

The experiment was carried out in Rusape, Makoní District, Manicaland Province, in Thandi Area under Chief Makoni in Maramwidze Village, 10km from Rusape town in 2015/16 season, on three farmer fields. Makoní District is in Natural Region II and receives about 1250 – 1800mm rainfall per annum falling between November and March with dry spells in mid-January. Most soils in the area are loamy with high land-use potential. The cropping season starts around November and lasts until the end of April. Cropping, gardening, livestock rearing, fruit production and forestry are integrated on these communal farms. Mechanisation is very low and family labour is the main labour sources.
2.1. Description of varieties used in the experiment

2.1.1. Madhumbe (Eddoes)
The eddoes type which is referred to madhumbe in Zimbabwe, have side tubers (cormels) that may be 5 – 20 in number and they become as big as the mother corm. The corm is small, globoid, and surrounded by several cormels (stem tubers) and daughter corms. The cormels and the daughter corms together constitute a significant proportion of the edible harvest. Corms, cormels and daughter corms are quite similar in their internal structure.

2.1.2. Magogoya (Dasheen)
The dasheen type is known as magogoya in Zimbabwe, the cormels are usually absent and it is the mother corm which is the main storage organ (Tumuhimbise et al., 2009). In the dasheen types of taro, the corm is cylindrical and large. It is up to 30cm long and 15cm in diameter, and constitutes the main edible part of the plant. The crop can grow up to 1.5m in height than the eddoes. The crystal oxalates in the dasheen type is less than in the eddoes (Onwueme, 1994).

2.1.3. Ghana variety (Mankani brobe)
Mankani brobe is an indigenous variety to West Africa (KariKari, 1976). It is a stout herbaceous plant, tuberous rhizomes, erect, semi-erect or horizontal, up to 3 m high, leaf-blade up to 35 cm broad, 30-50 cm long, bottom nerves nearly marginal at petiole. The leaves arise from a broad corm; offshoots appear on short rhizomes extending from the corm. The corms have mixed colours of white and pink.

2.1.4. Soil analysis
At the experimental site soil samples were taken on-farm station in Rusape sites for physical and chemicals analysis at the Chemistry and Soils Research Institute of Zimbabwe.

Table 1: Summary of the soil analysis results for the experimental site in the 2015 -2016 rainy season

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Karumbidza</th>
<th>Maramwidze</th>
<th>Makuvaza</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (CaCl₂)</td>
<td>5.65</td>
<td>5.63</td>
<td>6.10</td>
</tr>
<tr>
<td>Nitrogen (mg/Kg)</td>
<td>18</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Phosphorus (mg/Kg)</td>
<td>29</td>
<td>23</td>
<td>32</td>
</tr>
<tr>
<td>Calcium (me%)</td>
<td>18.78</td>
<td>17.22</td>
<td>21.45</td>
</tr>
<tr>
<td>Magnesium (me%)</td>
<td>5.89</td>
<td>6.03</td>
<td>6.34</td>
</tr>
<tr>
<td>Potassium (me%)</td>
<td>0.67</td>
<td>0.84</td>
<td>0.51</td>
</tr>
<tr>
<td>Sodium (me%)</td>
<td>0.35</td>
<td>0.28</td>
<td>0.43</td>
</tr>
<tr>
<td>Clay %</td>
<td>27</td>
<td>31</td>
<td>22</td>
</tr>
<tr>
<td>Silt %</td>
<td>10</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>Sand %</td>
<td>63</td>
<td>66</td>
<td>70</td>
</tr>
<tr>
<td>Soil Texture</td>
<td>SCS</td>
<td>SCS</td>
<td>SCS</td>
</tr>
<tr>
<td>Soil Colour</td>
<td>Black</td>
<td>Black</td>
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</tr>
</tbody>
</table>

2.2. Experimental design and treatments
The trial was laid out as a split-plot design consisting of control, cowdung manure and inorganic fertilizers and the other with inorganic fertilizer only. Cocoyam varieties were assigned to the sub-plots with three replications and 12 plants in each sub-plot.

2.3. Establishment and maintenance of experimental plots
The experiment was set up in a swampy area. The field was manually cleared on the land which a crop of maize had been grown previously. The land preparation was done using ox-drawn mould board ploughs and harrowed to a fine tilth. Main plots measuring 6m x 6m were laid out with 1m border between plots. Holes were made with a hoe with a circumference of about 45cm and depth of 15-20cm. Each replication contained four main plots accommodating the cowdung
manure, inorganic fertilizer, cowdung manure and inorganic fertilizer and the control. Three varieties namely: Madhumbe, Magogoya and Ghana V1 were the sub-plots. The plant spacing was 1m x 1m (10,000 plants ha$^{-1}$) and contained 36 plants. The crop was planted on 05 August 2015. The experiments were kept weed-free throughout the experiment by hand-hoeing. While weeding the plants were heaped with soil so that they have room for tuber growth. This was done three times. At 90 days (DAP) amoerilites were added to the plants as top dressing.

2.4. Harvesting and measurements
Plant growth was evaluated at 60, 90, 120 days after planting (DAP). Data collected included plant height, number of shoots, number of corms, corm fresh weight. Corms were harvested on maturity on the 15 May 2016. The fresh corms were thoroughly washed with tap water and sent to Food Science Department for nutritional analysis.

2.5. Determination of nutritional composition
The nutritional analysis was conducted in the Department of Food Science, Faculty of Science at the University of Zimbabwe. The nutritional composition (protein, ash, fibre, carbohydrate and moisture) were determined by the methods of Association of Official Analytical Chemists (2005). The minerals composition (calcium and magnesium) were determined using Atomic Absorption Spectrophotometer as outlined (AOAC, 2005). Pottasium was determined using flame photometer. Atwater factors were used to calculate the energy value of the samples. Samples were analysed in triplicates.

2.6. Data analysis
Data obtained was subjected to analysis of variance (ANOVA). Significance difference was accepted at 5% probability level.

3. RESULTS

3.1. Effects of organic and inorganic manure on nutritional composition of cocoyam (colocasia esulenta) in rusape district on three varieties
There was a highly significant ($P<.001$) interaction between variety and fertilization with respect to all the nutritional composition measured (Figure 1). The nutritional composition responded according to the type of fertilization that was applied. For moisture content, treatment 1 with cowdung manure produced the highest moisture content on Ghana variety and also Magogoya produced the lowest moisture content on that same treatment. As for ash content, the Ghana variety produced the lowest and as for Magogoya and Madhumbe it was almost the same. Ghana variety produced the highest fat content on treatment 2, 3, 4 and there were small differences on the two varieties. However, on treatment 1 the Madhumbe and Magogoya varieties produced the highest.
Figure 1: Variety and treatment interaction on nutritional composition of cocoyam. Variety V1, V2, V3 represents Madhumbe, Magogoya and Ghana respectively. Treatment 1, 2, 3 and 4 represents cowdung manure, inorganic fertilizer, cowdung and inorganic fertilizer and control respectively. Bars indicate SED values

4. DISCUSSION

Nutritional composition of crops is a highly challenging trait due to both the different properties which determine crop quality and the various factors that affects them (Wiesler et al., 2002). The determination of proximate and mineral compositions of cocoyam will go a long way in providing substantive information on the crop for effective guide on dietics in Zimbabwe. In this study, nutrient supply to the cocoyam crop influenced the quality of the crop in a non-synchronously form. Observations made in this study revealed that, the difference in mineral composition of the cocoyam grown could be probably due to the differences in the potential of each variety to obtain nutrients from the soil. The moisture content obtained is consistent with earlier research conducted in South Africa and Nigeria (Mwenye et al., 2011 and Aregheore and Perera, 2003). Both authors obtained moisture contents that was between 65% - 80%, the variation may be attributed to the cocoyam variety used, environmental factors and agronomic practices. The low moisture content for Treatment 1 on Magogoya variety and Treatment 3 on Ghana Variety is important as it enables...
long storage by minimizing fungal contamination and spoilage on cocoyam and also during transportation to the markets. The percentage ash content fall within the range reported in the literature, (Lewu et al., 2010) which is between 1 – 5%. The ash content of Ghana variety was however lower than the other two local varieties. The ash content helps to determine the amount and type of minerals in cocoyam (reference), whereby minerals are essential for growth and metabolism in humans and helps in preventing mineral deficiency disease like anemia, goiter, cretinism and myocardopathy and reducing the risk of contracting other chronic diseases like cancer and cardiovascular (Wiesler et al., 2010). The local varieties had the highest fibre content than the Ghana variety confirming that they are good source of fiber compared to other root and tubers especially potato (Bradbury and Holloway, 1988). The high fiber content found in the local varieties is good for the Zimbabwe population as this highlights protection against some health problems. Conversely, low fibre is undesirable as it can cause constipation resulting in diseases of the colon like piles, appendicitis and cancer (Olaleye et al., 2013). The high carbohydrate content in the cocoyam shows that the crop is superior compared to other tubers with low carbohydrates (reference). Generally, cocoyam is a carbohydrate/energy source with very low protein content (Aregheore and Perera, 2003); this agrees with the fact that tuber and other root crops in rich in carbohydrates hence their high caloric values. The makes the crop to be of high value both nutritionally and economically hence it is food of major importance in the Eastern parts in Zimbabwe. The low protein in the first three treatments by the Ghana variety could be due to low intake of nitrogen by the plant. The mineral composition of cocoyam showed high percentage of potassium, calcium and magnesium on the Ghana variety and the other varieties had almost similar percentages. This indicates that the Ghana variety had the capacity to take more of these minerals from the soil than the other two.

5. CONCLUSION AND RECOMMENDATION

It is evident from this study that cocoyam can be consumed with other staple foods with higher protein to make up for the deficiency. Cocoyam production and consumption should be encouraged and popularized nationally as an additional tuber crop next to sweet potato, cassava and Irish potato to help curb malnutrition and lower incidence of other diet related diseases. This will extend the utilization options for this underutilized tuber beyond its current use in Zimbabwe hence increased source of income for farmers and market stall vendors. The results of this study will help nutritionists, hospitals, government and non-governmental organizations with data in their planning. The study also revealed that conjunctive use of soil amendments, balanced fertilizers and organic manure improves the physio-chemical and biological properties hence obtaining a sustainable crop with good nutritional values for good health.

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