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THE NUTRITIONAL AND ANTI-NUTRITIONAL COMPOSITION OF THE COMMON CASSAVA RECIPES IN MTWARA RURAL DISTRICT, TANZANIA

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Abstract: This study was conducted to determine the nutritional and anti-nutritional composition of the common cassava recipes in Mtwara Rural District. Cassava recipes and the consumption patterns were identified using 24 hours dietary recall and Food Frequency Questionnaire (FFQ). Proximate composition, anti-nutrient contents and mineral composition were also determined. Data were analyzed using IBM SPSS Statistics version 20 using descriptive statistics to describe the main features and summarize the data. ANOVA was used for mean comparison and the differences between means were separated using Duncan Multiple Range Taste. Four cassava recipes with their consumption frequencies were identified which included plain cassava recipe (96.9%), coconut cassava recipe (40.7%), tomato cassava recipe (6.7%) and groundnuts cassava recipe (0.6%). The nutrients (proximate and minerals) and anti-nutrients (cyanides and phytates) contents among recipes varied significantly ($p \leq 0.05$). Coconut cassava recipe was nutritionally the most superior recipe compared to other recipes. Cyanide contents in all the recipes were within the acceptable level of 10ppm but phytate contents were above the tolerable level of 25 mg/100 g in all four recipes, with the lowest phytate content being (78.73mg/100g) in CCR. Higher phytate levels suggest possibility of micronutrient deficiency especially minerals due to reduced bioavailability through interaction.

Keywords: cassava recipes, nutrients, anti-nutrients, consumption pattern.

1.0 Introduction

Cassava (Manihot esculenta Crantz) is a cheap and reliable source of food for more than 700 million people in the developing countries and is Africa's second most important staple food after maize in terms of calories consumed. Around 70 percent of Africa's cassava output is harvested in Tanzania (Felix, 2004). It is an increasingly important crop in Tanzania and is the second most important food crop after maize in terms of production volume and per capita consumption, supporting the livelihood of 37% farmers in rural areas (Bennett *et al.,* 2012). Cassava root can be cooked, eaten fresh or processed into flour (Montagnac *et al.,* 2009). Preparation of cassava roots prior to consumption varies according to preferences. However, processing can affect the nutritional value of cassava roots through modification and losses in nutrients of high value. Analysis of the nutrient retention for each cassava edible

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product has been conducted in South Africa (Montagnac *et al.,* 2009) and indicated that raw and boiled cassava root kept the majority of high-value macro and micronutrients compared to processed cassava. However, no nutritional and anti-nutritional evaluation has been done for the different consumed cassava based recipes in areas where cassava is a staple food like Mtwara district, thus calling for the present research. According to Hambwe *et al.,* (2009) in their evaluation of the iron content of the selected East African indigenous vegetables formulated into different recipes, they indicated the importance of examining the nutrient content of the developed recipes when the effort is towards improving nutrition security which further supports the present study. The findings of the present study would thus form a foundation for optimizing the nutrient content of cassava based recipes through various formulations. This could in turn improve the nutritional value of cassava and address the issue of malnutrition. Furthermore, cassava roots have also raised concerns about the effects of anti-nutrients on human health. Common examples are phytates which form insoluble complexes with calcium, zinc, iron and copper and flavonoids which are a group of polyphenolic compounds that include tannins (Sarkiyayi and Agar 2010). These compounds chelate metals such as iron and zinc, and reduce their absorption. They also inhibit digestive enzymes and may precipitate proteins (Beecher, 2003). In view of all these, this study was therefore undertaken to determine the nutritional and anti-nutritional composition of the identified cassava recipes in Mtwara Rural District.

2.0 Methodology

2.1 Study area and study population

The current study was conducted in Mtwara Rural District which was purposively selected due to its high cassava production in Mtwara region (NBS 2007) and high malnutrition (stunting) rate of 45% (TFNC, 2010). The study employed a cross-sectional design in which data was collected only once. The study population constituted of the under five children and their mothers/caregivers who are responsible for preparing their foods. The sample size of the population was computed from the formula $n = t^2 \, x \, {(1-p)}/{m^2}$ as reported by Magnani, (1997) where n= required sample size, t=Confidence Interval level 95% (standard value 1.96), p=estimated malnutrition prevalence which is 31.65% (TFNC, 2014) and m=margin error at 5% (0.05). This gave a sample of 332 under five children whose parents / care givers were to be interviewed but only 329 mothers / caregivers participated in the study. Participants were made aware of the objective of the study and clarification was given regarding their involvement. Informed consent was obtained from each mother / caregiver who agreed to participate in the study.

2.2 Recipes identification

The common cassava recipes and methods for their preparations were identified through a dietary pattern assessment method using the 24hours dietary recall and food frequency questionnaire. The name and proportion of each ingredient used in preparation of cassava food were recorded in the 24 hours dietary recall in which mothers/caregivers responsible for food preparation and feeding children were interviewed. The questionnaires were administered to mothers/caregivers of the physically and mentally able under-five children who could describe properly the diet fed to their children daily.

2.3 Recipes preparation

Two households from among the households that constituted the study sample were selected for preparation of the identified recipes. The recipes/samples were prepared in duplicates by each household. The ingredients and other raw materials used for preparation of the various cassava based recipes described during the interview were obtained from a local market. After cooking, the recipes (meals) were left at room temperature 30◦C to cool down for about one hour then packed in duplicates in the freezer bags which were then stored in the freezer model WestPoint (Tropical, made in France) with the temperature set at -20ºC.

2.4 Laboratory analyses

During laboratory analysis the frozen samples were defrosted at room temperature 30◦C and were then pooled together and homogenized using an electric blender in a well cleaned and dried container and analysed as per the analytical method.

2.5 Analysis of Nutrients and Anti-nutrients content

The proximate analysis of moisture, ash content, fat and protein content was carried out using AOAC (1990) methods. Kjeldahl method was used for the analysis of protein and Soxhlet method for the determination of fat. Crude fiber was determined by Kirk and Sawyer (1991) method. The total carbohydrate (in percentage) was calculated by subtracting the sum of the percentage values of moisture, crude protein, ash and crude fat from 100% (McDonald *et al.*, 1973).Cassava recipes were analyzed for the minerals (iron, zinc, copper, potasium, calcium, magnesium and manganese) using the atomic absorption spectrophotometer model iCE3000series as described by Eslami *et al.* (2007). Phytate content of the samples was done as escribed by Davis (1981) and total cyanide content in the samples was analyzed using the alkaline titration method as stated in the AOAC (1990).

2.6 Statistical analysis

IBM SPSS Statistics version 20 was used for the analysis of data. Descriptive statistics was used to analyze the cassava recipes. The variability of nutrient contents among cassava based recipes / test treatments were analyzed by using ANOVA and the difference between means were separated by using the Least Significant Difference (LSD) at ($p \leq 0.05$).

3.0 Results

3.1 Cassava based recipes and consumption frequencies

The survey covered 329 mothers / caregivers with children aged 6-59 months out of 332 who were sampled for the study. This indicates a participation rate of 99.1%. Four most commonly consumed cassava recipes were identified which included plain cassava recipe (PCR), coconut cassava recipe (CCR), groundnuts cassava recipe (GCR) and tomato cassava recipe (TCR) (Table 1). Several other recipes were mentioned and described but only those four were identified as the most commonly consumed recipes. Of the four identified recipes it was indicated that PCR was the most commonly consumed cassava based recipe and GCR was the least consumed cassava based recipe.

Table 1: Types of cassava recipes and consumption frequencies among the respondents

Recipe	N (329)	%
CCR	134	40.7
PCR	319	96.96
GCR	7	0.02
TCR	22	6.7

CCR-Coconut cassava recipe, PCR-Plain cassava recipe, GCR-Groundnuts cassava recipe, TCR-Tomato cassava recipe

3.2 Proximate composition of the cassava recipes

The proximate composition results for the four cassava recipes are presented in Table 2. The fat content indicated significant differences ($P < 0.05$) between CCR and the rest (TCR, PCR, GCR) but no significant differences ($P \geq 0.05$) were observed among TCR, PCR and GCR. The highest fat content was recorded in CCR (3.67$\pm$0.20%) and the lowest in PCR (0.18$\pm$0.13%). The protein content did not show significant variations among the four cassava recipes. The recorded protein content ranged from 0.06$\pm$0.00% in TCR to 0.53$\pm$0.47% in CCR. The minimum and maximum fibre content was 3.20$\pm$0.78% and

1.87±0.05% for CCR and TCR respectively but the differences were however insignificant ($p<0.05$). The moisture content ranged from 67.28±0.18% to 73.55±0.27%. The highest moisture content was recorded for PCR and the lowest for CCR. Significant difference in moisture contents ($P <0.05$) was observed between PCR and the other recipes. However, no significant difference was recorded ($P \geq 0.05$) between CCR, GCR and TCR. Carbohydrate content ranged from 21.69±0.67 to 24.4±0.39% with the lowest carbohydrate content found in PCR and the highest in CCR The variations were however insignificant ($P < 0.05$) between CCR, GCR and TCR but were significant between CCR and PCR.

Table 2: Proximate composition of cassava recipe

Proximate Composition	Cassava Recipes			
	CCR	PCR	GCR	TCR
% Protein	0.53 ± 0.47^{a}	0.07 ± 0.01^{a}	0.12 ± 0.00^{a}	0.06 ± 0.00^{a}
% Fat	3.67 ± 0.20^{a}	0.18 ± 0.13^{b}	0.39 ± 0.02^{b}	0.32 ± 0.04^{b}
% Fibre	3.20 ± 0.78^{a}	2.63 ± 0.55^{a}	3.06 ± 0.12^{a}	1.87 ± 0.05^{a}
% Moisture	67.28 ± 0.18^{b}	73.55 ± 0.27^{a}	71.64 ± 0.21^{a}	72.47 ± 0.39^{a}
% Ash	1.34 ± 0.01^{c}	1.87 ± 0.02^{a}	1.53 ± 0.03^{b}	1.23 ± 0.01^{c}
% Carbohydrates	24.4 ± 0.39^{a}	21.69 ± 0.67^{b}	23.25 ± 0.37^{ab}	24.05 ± 0.36^{ab}

- CCR-Coconut cassava recipe, PCR-Plain cassava recipe, GCR-Groundnuts cassava recipe, TCR-Tomato cassava recipe
- Values are means of ± standard deviations of triplicate determinations. Values with different superscript letters in the same row are significantly different ($P \leq 0.05$)

3.3 Minerals Composition

The results for mineral contents are presented in Table 3. The calcium content ranged from 70.95+2.42 to 96.5±0.14 mg/kg, with the highest content found in CCR and the lowest in TCR. Significant variations in Ca ($P < 0.05$) were recorded between CCR and both GCR and TCR and between TCR and both PCR and GCR. Magnesium content varied between 243.77+7.48 and 309.62+0.02mg/kg. The highest content was recorded in GCR and lowest in PCR. Significant difference ($P < 0.05$) in magnesium content was observed between CCR and PCR and between PCR and GCR but no significant variation ($P \geq 0.005$) were observed between CCR, GCR and TCR. On the other hand, potassium content ranged from 0.02+0.00 to 0.03+0.00 mg/kg, with the lowest amount recorded in PCR and the highest in CCR. The variation was significant ($P < 0.05$) between PCR and the rest (CCR, TCR and GCR). The highest zinc content was found in CCR (2.78+0.26mg/kg) and the lowest in PCR

(1.91+0.48mg/kg), however the variations were insignificant (P≥0.05) among the four recipes. In terms of copper, TCR had significantly high levels of copper (3.04+0.67mg/kg) compared to the other recipes. However, no significant variations (P≥0.05) were observed among CCR, PCR and GCR. The lowest copper content was recorded in GCR (1.52+0.16mg/kg). Iron content on the other hand varied between 4.41+1.12 and 7.46+0.25mg/kg with the highest iron content quantified in TCR and the lowest in PCR. Iron content varied significantly (P < 0.05) between CCR and TCR and between PCR and TCR but no significant differences were observed between CCR, PCR and GCR. Manganese content varied between 1.77+0.06 and 3.71+0.01mg/kg, with the highest content recorded in CCR and the lowest in TCR. Significant variations (P < 0.05) were found between CCR and the rest and between PCR and TCR but were insignificant (P≥0.05) between GCR and TCR.

Table 3: Mineral content of the cassava recipes

Minerals (mg/kg)	CCR	PCR	GCR	TCR
Ca	96.5 ± 0.14^{a}	91.24 ± 5.74^{ab}	$84.23+2.62^{b}$	$70.95+2.42^{c}$
Mg	288.24 ± 2.37^{ab}	$243.77+7.48^{c}$	$309.62+0.02^{a}$	$261.59+10.84^{bc}$
K	$0.03+0.00^{a}$	$0.02+0.00^{b}$	$0.03+0.00^{a}$	$0.03+0.00^{a}$
Zn	$2.78+0.26^{a}$	$1.91+0.48^{a}$	$1.99+0.18^{a}$	$1.98+0.07^{a}$
Cu	$1.63+0.00^{b}$	$1.66+0.42^{b}$	$1.52+0.16^{b}$	$3.04+0.67^{a}$
Fe	$6.78+0.82^{cb}$	$4.41+1.12^{c}$	$5.28+0.87^{cb}$	$7.46+0.25^{b}$
Mn	$3.71+0.01^{a}$	$2.90+0.37^{b}$	$2.24+0.01^{cb}$	$1.77+0.06^{cd}$

- CCR-Coconut cassava recipe, PCR-Plain cassava recipe, GCR-Groundnuts cassava recipe, TCR-Tomato cassava recipe
- Values are means of ± standard deviations of triplicate determinations. Values with different superscript letters in the same row are significantly different (P≤0.05)

3.4 Anti-nutritional factors

The results for anti-nutritional factors (cyanide and phytate) content are presented in Table 4. Cyanide contents ranged from (0.32µmol/g or 7.44ppm) to 0.43µmol/g(9.99ppm). The highest content was found in CCR and GCR (which had equal amounts) and the lowest cyanide content was recorded in PCR. Cyanide content varied insignificantly (P≥0.05) between CCR and GCR and between PCR and TCR but varied significantly (P < 0.05) between those two sets of recipes. Phytate contents varied significantly (P < 0.05) among all four recipes with GCR registering the highest content (712.18+16.0 mg/100g) and CCR the lowest phytate content (78.73+0.57 mg/100g).

Table 4: Anti-nutrients composition of cassava recipes

Anti-nutrients composition	CCR	PCR	GCR	TCR
Cyanide (µmol/g)	0.43+0.00[a]	0.32+0.00[b]	0.43+0.00[a]	0.38+0.05[ab]
Phytate (mg/100g)	78.73+0.57[c]	319.78+0.48[a]	712.18+16.00[b]	677.10+3.31[d]

- CCR-Coconut cassava recipe, PCR-Plain cassava recipe, GCR-Groundnuts cassava recipe, TCR-Tomato cassava recipe
- Values are means of ± standard deviations of triplicate determinations. Values with different superscript letters in the same row are significantly different (P≤0.05)

4.0 Discussion

The results have indicated that cassava based dishes were the most commonly consumed dishes in Mtwara rural district either alone or as cassava blends. Four cassava based recipes were identified which included CCR, GCR, TCR and PCR. Of the four recipes it was indicated that PCR was the most commonly used recipe at the frequency of about 97% and GCR was the least consumed recipe with a consumption frequency of 0.02%. Davidson *et al.* (2017) also indicated 92% of the study population to have consumed cassava-based dish within 24 hours prior to an interview in the study conducted in Nigeria. The reasons for the high consumption frequency of PCR and CCR in the present study were indicated to be affordability of the former (was the cheapest of all) and also the availability of coconut for CCR preparation. Coconut is one of the mostly cultivated perennial crops in the district. Despite PCR being the most consumed recipe the mostly liked recipe (Per personal comm.) was indicated to be CCR due to its delicious taste which was attributed to coconut as one of the ingredients. CCR is also the mostly consumed recipe in special occasions especially during fasting seasons, and is famously locally known as Futari (*Iftar*). According to Usmal *et al.* (2015) dietary fats have been shown to enhance the taste and acceptability of foods, slows gastric emptying and intestinal motility thereby prolonging satiety and facilitating the absorption of liquid soluble vitamins. This could as well explain the high preference of CCR due to considerable amounts of fats in coconut juice.

The highest significant amount of fat recorded in CCR could be attributed to coconut milk. The study conducted by Okorie *et al.* (2012) also observed higher fat content in coconut than in groundnuts. A similar observation was also documented by Ayoolo *et al.* (2012). On the other hand, Omosuli (2014) in his research on nutritional content of raw and boiled cassava indicated a reduction in fat content in boiled cassava compared to raw cassava. This reflects the effect of boiling on fat content. Similarly the lowest fat content was recorded in PCR in the present study. The fat contents in the present study which ranged from 0.18±0.13 to 3.67±0.20% compare well with that reported by Odebunmi *et al.* (2007) for cassava (0.18±0.03%).

Protein content did not show any significant variations between recipes. However, contrary to these results, Awad (2013) found higher protein content in pure groundnuts than in pure coconut and attributed the variation to the inclusion of groundnuts. Bankole *et al.* (2013) demonstrated increased protein content when cassava was fortified with groundnut flour. The inconsistencies with previous results could be attributed to several factors that influence the protein contents of groundnuts such as environmental conditions that affect protein viability during storage like temperature, moisture content, initial quality and mycoflora (Jyoti and Malik, 2013). Generally the protein content recorded in the present study (0.06±0.00 to 0.53±0.47%) was lower than those reported by Odebunmi *et al.* (2007) for cassava of 2.84±0.00%. According to Salvador *et al.* (2014) the nutritional content of cassava depends on specific plant part (roots or leaves), geographic location, variety, age of the plant and environmental conditions.

In terms of fibre, CCR had the highest contents though no significant variations were observed. High fibre content was also recognized by Usman *et al.* (2015) who recommended addition of coconut in breakfast cereals which served as a nutritious and healthy source of dietary fiber in the food products that were under study. Fibers are recognized for their physiological role of maintaining an internal distension for peristaltic movement of the intestine (Makori *et al.,* 2017) nevertheless they tend to reduce nutrient digestibility and increase mal-absorption of micronutrient. This could lead to growth retardation thus higher fiber contents are not advisable in infant foods. The fiber content for the recipes understudy which ranged from 1.87±0.05 to 3.20±0.78% was slightly higher than that reported by Odebunmi *et al.* (2007), 1.38±0.03% for cassava. This could well be due to the inclusion of other ingredients and / or due to factors explained by Salvador *et al.* (2014) as determinants of nutritional variations in cassava.

The moisture content indicated significant differences ($P < 0.05$) between PCR (which had the highest content) and the other recipes. The low moisture in other recipes could be attributed to significant electrolyte contents of the added ingredients. On the other hand, the moisture content reported in the current study (67.28±0.18 to 73.55±0.27%) compare well with that reported by Odebunmi *et al.* (2007) of 68.8±0.08%.

Carbohydrate contents also did not show significant difference ($P < 0.05$) between CCR, GCR and TCR but varied significantly between CCR and PCR. The higher carbohydrate content in CCR and its richness in fat contents imply a high calorific value of the recipe (CCR). Carbohydrate is also indicated to contribute to the taste, texture and appearance of foods and helps to make the diet more varied and enjoyable (EUFIC, 2012). This could as well assist to explain the higher consumers' preference of CCR to other recipes. On the other hand the carbohydrate content recorded in the present study (21.69±0.67 to 24.4±0.39%) was slightly lower than that reported by Odebunmi *et al.* (2007) (28.05±0.06%). Salvador *et al.* (2014) on the other hand linked the variations in nutritional content of cassava with specific plant part (roots or leaves), geographic location, variety, age of the plant and environmental conditions.

Minerals are important micronutrients in maintaining human health and have varied roles. Various minerals for the commonly consumed cassava recipes were also quantified. Significant variation in calcium content ($P < 0.05$) was recorded between CCR and both GCR and TCR and also between TCR and both PCR and GCR. The highest calcium content recorded in CCR is supported by the findings of Omotosho and Odeyemi (2012) whose research on coconut bio-nutrients indicated that calcium was significantly high in coconut milk. The literature data show that nuts are good source of calcium but coconut is richer in calcium than groundnuts as evidenced by the present study. The findings of Udeze *et al.* (2014) who measured the minerals content of beverage blended with coconut and groundnuts similarly showed that coconut was making the beverage richer in calcium. In the present study the calcium content which varied between 70.95+2.42 to 96.5±0.14 mg/kg was higher than that reported by Odebunmi *et al.* (2007) for dried cassava flour which had 1.11 mg/kg. The variation could be attributed to processing method, inclusion of other ingredients in the recipes or the factors described by Salvador *et al,* (2014) as determinants of nutrient variations. Calcium is responsible for bone formation in conjunction with phosphorus, magnesium, manganese, vitamin A, C and, chlorine and protein (Omosuli, 2014). This is why education on nutritional diversification is important to ensure a healthy and nutritionally secured community.

On the other hand the findings indicated higher amount of magnesium in GRC than in other recipes. The variation was significant ($P < 0.05$) between GCR and both PCR and TCR but varied insignificantly ($P \geq 0.05$) with that of CCR. The results agrees well with previous findings which indicated groundnuts were richer in magnesium content, that is, 0.176% (Settaluri *et al;* 2012) and 0.18% (Ayoola *et al.,* 2012) as compared to coconut that had less amount, 0.095% (FAO, 2017). In the present study magnesium contents which ranged from 243.77+7.48 to 309.62+0.02mg/kg was extremely higher than that reported by Odebunmi *et al.* (2007) of 12.54mg/kg for dried cassava. This variation could be attributed to the composition of the cassava based recipes, processing methods and other determining factors (Salvador *et al,* 2014).

Similarly, none significant ($P \geq 0.05$) variation in zinc contents was observed among the recipes. Omotosho and Odeyemi (2012) recorded high zinc contents in coconut milk meant for culinary use as was the case with the present study. On the other hand the significantly high ($P < 0.05$) copper content found in TCR is supported by Aydinalp *et al.* (2012) who also found higher copper in tomato than in other plant fruits. Odebunmi *et al.* (2007) reported 0 mg/kg zinc content in dried cassava contrary to the findings of the present study in which zinc content varied from 1.91+0.48 to 2.78+0.26mg/kg. Iron content varied significantly ($P < 0.05$) between CCR and TCR and between PCR and TCR but no significant differences were observed between CCR, PCR and GCR. Omosuli (2014) in his investigation of the nutritive composition of raw and boiled cassava, indicated that mineral contents of cassava tubers were not affected significantly by boiling except iron. This could as well explain the lowest iron contents recorded in PCR. On the other hand the higher content of iron in other cassava based recipes could be attributed to the inclusion of other ingredients which possibly enriched and / or counteracted the effect of boiling. The highest amount of iron was recorded in TCR. The findings of the present study generally indicate that plant products like coconut, groundnuts and tomatoes are valuable sources of minerals and other nutrients which could carter for the nutritional needs of the population at a minimal cost. Nevertheless iron content recorded in the present study (4.41+1.12 to 7.46mg/kg) was lower than that reported by Odebunmi *et al.* (2007) for dried cassava (18.8 mg/kg). This variation could as well be due to the composition of the cassava based recipes, processing methods and other determining factors (Salvador *et al,* 2014). On the other hand the richness of CCR in manganese content which varied significantly from the rest could be explained by the inclusion of coconut juice. Similarly the higher content of manganese recorded in the present study that varied between 1.77+0.06 and 3.71+0.01mg/kg compared to that reported by Odebunmi *et al.* (2007) for dried cassava (0.34mg/kg) could be associated with similar factors explained earlier.

The highest and equal amounts of cyanide were recorded in both CCR and GCR, nevertheless the levels of cyanide in all recipes were within the safe WHO level of 10ppm (Cardoso *et al;* 2005). These results however, contradict previous findings as fat content did not show any effect on cyanide levels. Olorunfemi and Afobhokhan (2012) indicated that treatment of cassava mash with vegetable oils resulted into 99.8% reduction in the total cyanogenic content at seven days of fermentation. They associated the reduction with increased temperature of grated cassava varieties which in turn led to the breakdown of cyanogenic glycosides and facilitated volatilisation after processing into *garri*. CCR and GCR were richer in fat content but also in cyanide content. This could probably be attributed to the acidic nature of the recipe due to fermentation and the time duration for storage of the recipes.

Phytate contents varied significantly among recipes with GCR (712.18 mg/100g) registering the highest contents and CCR the lowest phytate content (78.73mg/100g). Earlier studies (Mazahib *et al;* 2013) have shown higher contents of phytates in groundnuts than any other anti-nutrient which is in agreement with the present findings. It's also indicated that such toxic substances can be reduced during processing of cassava, through cooking, fermentation and soaking. Sarkayayi and Agar (2010) indicated that cooking and fermentation destroy anti-nutritional factors. Modgil *et al.* (1993) examined the effect of oil treatments (Coconut, groundnut and mustard oil) on the levels of anti-nutritional factors in *Callosobruchus chinensis* (L.) infested stored pulses for 6 months at monthly intervals for anti-nutritional factors (phytic acid, trypsin inhibitor activity (TIA) and saponins). The results indicated changes in anti-nutritional factors from month two to six in which case the controls recorded progressively more anti-nutritional than oil treated samples. They also observed static levels of anti-nutrients in mustard and groundnut oil treated pulses during the same period, however, coconut oil treated pulse had increased anti-nutritional from end of month four onwards. They associated the storage period with the level of insect infestation which in turn influenced the anti-nutritional contents of pulses. Thus the results of the present study can also be attributed to the short storage duration and similarly the acidic nature of the medium. Phytate levels above the tolerable level of 25 mg/100g have nutritional implication. Phytates interact and form insoluble complexes with calcium, zinc, iron and copper and flavonoids (which are a group of polyphenolic compounds that include tannins) chelate metals such as iron and zinc and reduce their absorption (Sarkiyayi and Agar 2010). The complexing of phytate with nutritionally essential elements and the possibility of interference with protolytic digestion have been suggested as responsible for anti-nutritional activity. Phytate is negatively charged with phosphate compound that binds minerals and inhibits absorption (Abebe *et al;* 2014). The results of the present study generally indicate that CCR was richer in various micronutrients (Ca, Mg, K, Zn and Mn) and macronutrients (Protein, Fat and Fibre) compared to other recipes. The amount of cyanide (though within the safe levels), can however be further reduced by the preparation method like boiling of cassava roots (Salvador *et al;* 2014, pp. 29-38). On the other hand, although CCR had the lowest level of phytate was however above the tolerable level of 25 mg/100g. These findings suggest that CCR could make a better recipe from the nutritional point of view. Usman *et al;* (2015) similarly indicated a significant improvement of the nutritional quality of breakfast cereal when anti-nutrient compositions were less than the recommended safe level.

Conclusion

The study identified four commonly consumed cassava based recipes namely CCR, GCR, TCR and PCR. Proximate composition results showed that CCR had the best composition compared to the other cassava recipes whereas the poorest proximate composition was recorded in PCR. Similarly, in terms of mineral composition CCR had the highest Ca, Zn and Mn contents and TCR had the highest amount of Fe and Cu. GCR on the other hand had the highest Mg levels. The results generally suggest that though cassava is an important food crop but its nutritive value can well be improved by blending with other food crops rich in proteins and other nutrients that are deficient such as micronutrients. Data on anti-nutrients indicated that CCR and GCR had the highest and equal contents of cyanide and PCR had the lowest content. GCR on the other hand had the highest phytate content and CCR had the lowest phytate content. Though cyanide contents in all recipes were within the acceptable safe WHO level of 10ppm, phytate contents were above the tolerable level of 25 mg/100g which could thus affect the mineral contents of the recipes due to its interactivity nature. However, a clear distinctive and reflective view of the nutritional value of the recipes can be well gauged based on the evaluation of RDA.

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