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Development of nutritious, safe and acceptable cassava-soybean flakes

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Abstract

Cassava (*Manihot esculenta)* and soybean (*Glycine max*) utilization is reduced by presence of natural chemical hazards which require processing to lower them to safe levels. In addition, cassava is nutritionally deficient of quality protein and minerals. This study sought to evaluate how formulation of safe Cassava-Soybean flakes could be achieved while striking a balance between maximizing nutrition aspects and sensory aspects. A single Pearson square was employed to give a target of 25% of soybean incorporation that resulted to half of recommended daily intake of protein for age 2-5 yrs. Variation above and below 25% of soybean incorporation level was done to give the following formulations; 0:100, 15:85, 25:75, 35:65 and 50:50 soybean to cassava, respectively. After formulation, the samples were subjected to chemical and descriptive sensory evaluation. Proximate composition of the formulations differed significantly ($p<0.05$). With focus on protein content, as level of incorporation of soybean increased, protein content of the flakes increased too with the highest level in formulation being 22.12%. Mineral content of flakes had a similar trend with the highest level at 4.04% in formulation. Hydrogen Cyanide (HCN) content for all the samples were within safe range of below 10 mg/kg for the formulated samples and significantly differed at ($p<0.05$) with the lowest and highest levels being 8.35 mg/kg and 9.72 mg/kg, respectively. Sensory results showed sample with 65% and 35% cassava and soybean had the highest score of 6.4 on a seven-point hedonic scale for overall acceptability and exhibited significant difference from the rest of samples. There was no significant difference ($p<0.05$) for beany flavor in all the sample formulations an indicator that the objectionable flavor that hamper utilization of soybean and soy related products had been eliminated while processing the soybeans.

Keywords: *Cassava; soybean flakes; cyanide; protein energy malnutrition*

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Introduction

Cassava (*Manihot esculenta*) is the third most crucial source of calories in the tropics, after maize and rice. In Africa, Asia and Latin America millions of people depend on cassava for food. Its ability to grow in a wide range of agro-ecological conditions and produce satisfactory yields where most common food crops are unable to grow gives it a competitive edge to fight food insecurity at the household level and to be an important source of dietary energy. More than half a billion people in the world depend on cassava as a source of livelihood especially for the farmers, processors and traders (Prakash, 2013). In Sub-Saharan Africa (SSA), Protein Energy Malnutrition (PEM) is a significant health problem especially where staple starchy diets are utilized as complementary foods (Müller & Krawinkel, 2005).

Nutritionally, cassava is generally known to contain high content of starch, dietary fiber, riboflavin, nicotinic acid and magnesium. Vitamin A and Iron are usually low in cassava. The roots are of low and poor quality protein especially with regard to limiting essential amino acids such as lysine, methionine and therefore protein from other sources needs to be included if cassava is to be part of a balanced diet (Oboh & Akindahunsi, 2003).

Complementary foods are any liquid or nutritious foods fed to children alongside breast milk. Upon commencement of complementary feeding, PEM can be initiated depending on the nature of staple foods fed to children. Therefore nutritional improvement of staple foods can be used as a suitable avenue of reducing PEM (WHO/UNICEF, 1998). Living standards of most mothers in developing countries are low hence provision of complementary foods containing right proportions of nutrients is a challenge to them.

Consumption of root crops and tubers in these regions has increased tremendously in recent years as complementary foods and studies have shown that these foods are low in protein, minerals and vitamins. Consequently, this puts the children at risk of suffering PEM (Stephenson *et al.*, 2010). Cassava is a staple food crop in SSA where it's able to grow in marginalized soils and in erratic rainfall conditions (Maredia, *et al.*, 2000). With exception of histidine and leucine, research has proven that cassava based diets are deficient in essential amino acids recommended for children undergoing complementary feeding aged between 2-5yrs (Montagnac, *et al.*, 2009).

Cassava roots contain quite a considerable amount of anti-nutrient factors that hinder its utilization and popularity too among communities. Presence of cyanogenic glucoside act as a natural defense mechanism against predators (Hongbété *et al.,* 2009). Study reveals that there exist three sole *cyanogens* in cassava which are free hydrogen cyanide (HCN), *linamarin*, and *acetonehydrin* (*lotaustralin*), the last two undergoes enzymatic hydrolysis by plant endogenous enzyme *linamarase* to release free cyanide which in total contribute to cyanogenic potential of cassava roots (Achidi *et al.*, 2017). According to (Nhassico *et al.*, 2008), other than the genetic factor of cassava roots, stress factors such as movement of a genotype from its locality to a totally new area with different climatic conditions has significant contribution to the amount of cyanide produced by the roots. The concentration of the cyanide has been quantified highest in the leaves followed by roots parenchyma with levels up to 53 to 1300 and 10 to 500 mg cyanide equivalents/kg dry matter respectively (Charles, 2016). Bitter varieties of cassava have cyanide content that exceeds the one recommended by (FAO/WHO, 1991) of 10 mg/ cyanide equivalent/kg dry matter.

Soybean cultivation and utilization is gaining popularity in SSA and hence its addition to cassava-based diets like porridges and flour would improve the protein quality of cassava. Soy-bean is rich in protein and has a good balance of amino acids that would complement the limiting essential amino acids in cassava (Zarkadas *et al.*, 2007). Attempts have been made by scientists to fortify various staple foods used in complementary feeding. An example is use of soybean to fortify cassava based complementary porridge food by (Muoki *et al.*, 2012) who noted that mothers preferred instant or precooked foods which requires minimal preparation such as addition of warm water. Soybean is a crucial legume crop in the world owing to its nutritional, economic and functional importance especially in Sub-Saharan Africa where food insecurity and Protein Energy Malnutrition (PEM) is still a threat, case study of Kenya where about 30% of the children are malnourished. According to (Goyal *et al.,* 2012), soybean contains about 40-45% protein, 18-22% oil content and also a rich source of minerals and vitamins. (Fabiyi & Hamidu, 2011) reported that protein quality from soybean can be compared to that of animal sources such as milk, eggs and meat with respect to lysine which is deficient in many cereals. Its protein profile also contains substantial levels of methionine which is higher than that of other cereals and vegetables. Consequently, it can be viewed as an excellent source of affordable protein for supplementation of predominantly cassava diets which are deficient in protein.

Soybean is the principal source of cheap and affordable high-quality plant protein among all other legumes. However, it is faced with a major limitation diverse compounds which have anti-nutritional properties especially if consumed in large amounts. As reported by (Yasothai, 2016), these anti-nutrients decrease the nutritive value of the soybean and if taken in large amounts for can be fatal to both human and animals and also results to health problems. Consequently, this has elicited research on breeding programs to develop varieties which have low amounts of these anti-nutrient factors. Processing methods have been shown to reduce the anti-nutrient though not completely (Samuel *et al.*,2012). Main Anti- nutrients factors include: protease inhibitors (Trypsin) – Kunitz trypsin inhibitor (KTI) and Bowman-Birk inhibitor, and lectins. Of the total protein content in Soybean, 6% is composed of protease inhibitors. Others are Glycinin 150-200 mg/g and 40-70 mg/g; β-conglycin 50-100 mg/g and 10-40 mg/g; Saponins 0.5% and 0.6%; Oligosaccharides 14% and 15%; Phytic acid 0.6% and 0.6%.

About, 80% of the trypsin inhibition is caused by KTI, which strongly inhibits trypsin and hence lowers intake of food by decreasing their digestion, absorption and utilization. In addition, KTI causes, hyper secretion, induction of pancreatic enzyme and the fast stimulation of pancreas growth, hyperplasia and hypertrophy (Miki, *et al.*, 2009).

Heat treatment of soybean before utilization denatures trypsin inhibitors. According to (Samuel *et al.*, 2015) right heat treatment lowers the levels of trypsin inhibitors by more than 90%. Plant breeders have managed to develop varieties of Soybean with low amount of trypsin inhibitors. Consequently, this has lowered significantly amount of heat treatment that is subjected to the raw soybean before utilization which to an extent can denature the proteins. This has also reduced the processing cost of feeds to animal feed manufacturers.

In plant kingdom, there is a wide distribution of lectins which are proteins with specific characteristic to bind specific molecules containing carbohydrates which results to agglutination of red blood cells (Pan *et al.*, 2013). In soybean the agglutinin present reduces functionality of the microvilli. According to (Kaviani & Kharabian, 2008), this leads to increase in weight of small intestines due to hyperplasia of crypt cells and also reduction in viability of the epithelial cells. It has been shown that soybean agglutinin can be destroyed by moist heat during processing. However, they are resistant to dry heat.

Phytate levels in Soybean ranges between 1-2.3%. They have an effect of complexing with mineral elements such as magnesium, calcium, phosphorous, zinc, iron and copper (Trimble & Trimble, 2009). Among the mentioned minerals the most chelated is phosphorous where about two thirds is bound to phytic acid. Phytates are not destroyed by heat but a breakthrough has been found by developing Soybean genotypes with low phytate levels through genetic engineering (Spear, 2006). Other than the mentioned anti nutrients, physiologically active compounds are also found in soybean which include tannins, saponnins, antivitamins and isoflavones which have small or unknown effects.

In Kenya soybean is mainly grown in two regions, Central Highlands and western regions with the latter being the higher producer than the former. Coincidentally the western region is also the largest producer of cassava in the country with much of it being utilized locally by the communities and also as a weaning food. According to a study carried out to assess nutrition status of Children under five years in Cassava consuming communities in Nambale, Busia Western Kenya it was suggested that cassava helps to cushion hunger but however a need arises to improve it nutritionally with regard to protein content and quality (Nungo *et al.*, 2012).

Sensory evaluation is the scientific discipline that is employed to evoke, measure, analyze and interpret responses perceived via the five senses of hearing, touch, smell, sight and taste to assess and determine the quality aspects of food product (Johan, *et al.*, 2012). Study done by (Johan *et al.* 2012) revealed that marketers and practitioners use consumers' senses to influence their decision making and eventually their behavior. In addition, marketing and advertisement has exhibited biasness when it comes to employment of senses whereby the higher senses like sight and hearing are preferred to others (Lindstrom, 2012). It would be worth to take advantage of other senses apart from hearing and sight to improve sensation and appeal of a product to make it interesting to targeted group (Lindstrom, 2012).

With this in mind it's therefore worth noting that acceptability of a product by its consumers is highly dependent on its sensory characteristics irrespective of the reason behind its formulation, for example: improvement of nutrition characteristics of a food product. Adjustment and changes in ingredient levels brings about differences in various sensory parameters which is established by descriptive analysis (Duizer & Walker, 2015).

Incorporation of soybean into cassava flour to make cassava soybean breakfast flakes aimed at improving the protein, zinc and iron content of the final product which is known to be a cheap source of quality protein and mineral content (Ugwu & Ukpabi, 2002). In addition the flakes are ready to eat, hypoallergenic compared to other common wheat based breakfast cereals and probably shelf stable and palatable. Further, if the project is adopted by community in which these raw materials are grown, it would result into improving nutrition with respect to PEM, creation of employment opportunities among other economic benefits.

The present study therefore sought to develop a flaked product from cassava and soybean which is nutritious, ready to eat, acceptable and with extended shelf- life. The study also sought to strike a balance between sensory characteristics and nutrition aspects of the developed flakes through product formulation.

Materials and Methods

Sampling and processing of cassava roots and soybean

Cassava roots from Meru region were purposively sampled at City park market in Westlands, Nairobi, putting consideration of availability since it was an off season for cassava roots. They were then hygienically packaged in airtight bags and transported to University of Nairobi Kabete Campus pilot plant for processing and analysis. Soybean was sourced from Nyamakima market, a major cereals market in Nairobi and packaged in kraft papers then transported to same venue for analysis and processing. Both raw materials were processed as illustrated in schematic Figure 1. The processing methods aimed at lowering hydrogen cyanide levels in cassava to safe levels of 10mg/kg and anti-nutrients in soy-bean to levels that improves its nutrients bioavailability and palatability as in figure 1.

Cassava

Cleaning, peeling and size reduction- This was done to remove physical dirt and unwanted debris from the roots that could cause contamination of the roots. Removal of peels was done as an initial means of lowering cyanogenic glucosides. Normally peels have higher cyanide levels than the pulps. By peeling alone, 50% of the cyanide levels can be reduced. Size reduction was meant to increase surface area of the roots during fermentation and also make it easier to process the roots in the downstream stages.

Soaking- Submerged fermentation was used to detoxify the tubers to remove the free and soluble cyanide. Ratio of soaking water to tubers was 1:3. The soaking water provides a medium of fermentation and removal of the free cyanide into the soaking water. Small pieces of cassava roots were soaked into clean water and the water changed every day for four days at a temperature of 24-26^{0}C to help maintain a steep gradient of extraction of free cyanide. The process is very important process in cassava processing and whose main aim is to lower cyanide levels to allowable limits. The process also plays part in flavor development and product stability.

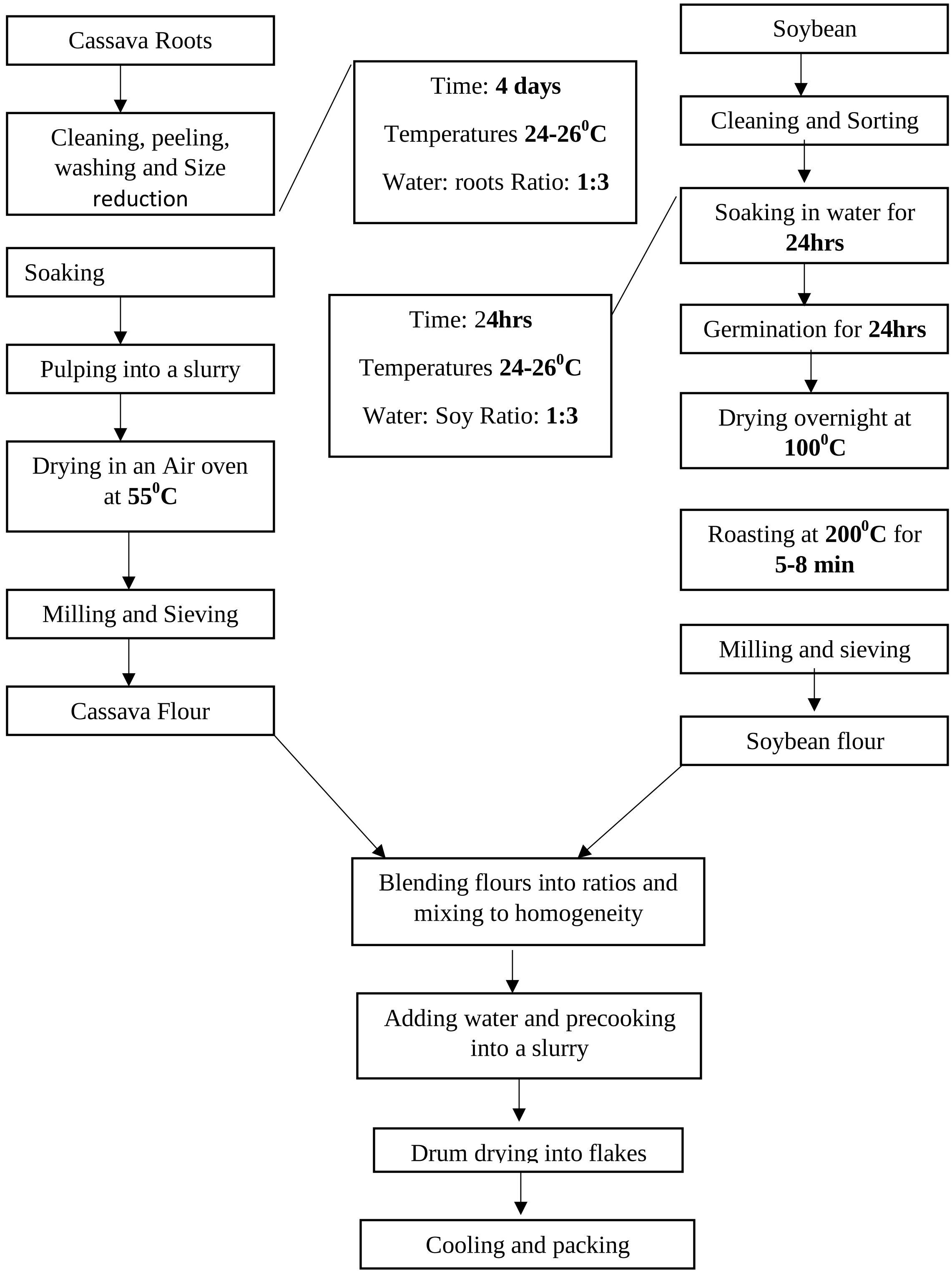

Figure 1. Schematic flow diagram showing how CSB flakes were processed

Pulping- A fruit pulp with mechanical blades was used to macerate the fermented roots into a slurry. The aim is to increase surface area of enzyme linamarase to hydrolyze bound cyanide which would in turn breakdown the cyanogenic glucoside into free cyanide and a sugar moiety. The free cyanide would then evaporate into atmosphere or removed in downstream processes as described below.

Drying- The slurry was thinly spread in air oven and dried at 50-55^0 C to a moisture content was of between 13-14 % to ensure stability and prevent mold growth that would cause contamination Caution was taken to maintain the temperatures to prevent denaturation of enzyme linamarase and as well as maintain an increased reaction rate. It is at this stage free cyanide escapes to atmosphere through evaporation. The dry slurry was hygienically packaged in clean polythene bags ready for milling into flour.

Milling- A shear mill was used to further reduce the size of dry slurry into flour to facilitate blending with soybean flour. The flour was then sieved to remove foreign matter and packaged in polythene bags.

Soybean

Cleaning, Sorting and Soaking – Foreign matter and dirt were removed from the soybean. Soybeans were soaked in water at a temperature of between 24-26^{0}C for 24 hrs. The ratio of water to roots was 1:3. This was a very critical process as it targeted removal of some of anti-nutrients that hinders utilization of soybean. Phytates leaches in soaking water as they are soluble. During imbibition there is also activation of phytase enzymes that are present in soybeans that hydrolyze phytates. Trypsin inhibitors among the most important anti-nutrients are also removed during soaking as they hinders utilization of proteins.

Germination – After removal of soaking water, the soybean seeds were allowed to germinate for 24hr by spreading them thinly over porous trays to facilitate aeration. The process was also very important in reduction of anti -nutrients such as phytates. During germination, minerals such as phosphorous are needed and enzymes are mobilized to hydrolyze it from phosphoric acid.

Drying- The germinated seeds were dried overnight for 24hrs at a temperature of 100^{0}C. This was meant to halt further germination that if allowed to continue would degrade nutritional compounds present in soybean. It was also meant to reduce moisture content in preparation of roasting process.

Roasting- The dry soybean seeds were roasted in an oven at a temperature of 200^{0}C for 5-8 minutes until golden brown. Roasting process is crucial in removing considerable amounts of phytates. Phytates are heat labile and when soybean is roasted, it is further degraded. It is also during roasting where flavor and aroma of roasted soybean is acquired via maillard reactions and caramelization of sugars present.

Flakes

Milling and Sieving- Roasted beans were milled in a shear mill and sieved to remove any foreign and unwanted matter then packaged in polythene bags awaiting blending with cassava flour.

Blending- Cassava and soybean flours were then mixed in ratios as described in Table 1. They were then blended to homogeneity.

Table 1: *Formulation of cassava-soybean flakes*

	Formulations				
	A	B	**C**	D	E
Soybeans (%)	0	15	**25**	35	50
Cassava (%)	100	85	**75**	65	50

Cooking- Water was added to each flour blend and cooked in low heat until gelatinization point. This was noted when the paste formed a sticky slurry.

Experimental design

A controlled experimental study design was used to formulate the Cassava-Soybean flakes with RDI of proteins of age 2-5 years as the target for formulation. A single Pearson square was used to calculate the recommended daily intake (RDI) of protein targeted to be 23 g/day on average as recommended by (WHO/FAO/UNU Expert Consultation, 2007). Pearson square calculations showed that if 25% of Soybean and 75% of cassava was used as formulation ratio, it would result in Cassava-soybean breakfast flakes with approximately 12g/ day of protein which provided 50% of the WHO RDI assuming total assimilation. Formulations involved variation of soybean and cassava above and below the target (25% soybean and 75% cassava) to evaluate the best accepted sample and at the same time improving the protein content. Variation above and below 25% of soybean incorporation level was done to give the following formulations; 0:100, 15:85, 25:75, 35:65 and 50:50 soybean to cassava, respectively (**Table 1**). Cassava flakes were used as the control sample.

Sample preparation for sensory evaluation

Cassava-soybean flakes (CSB) samples were prepared and presented for sensory evaluation. In addition pasteurized whole milk was served alongside each set of sensory samples which was used to rehydrate the flakes before consuming to simulate a real breakfast session. Panelists who did not like using milk as a hydrant were provided with clean drinking water.

Sensory analysis

Descriptive sensory evaluation of control and experimental CSB flakes was employed and involved a panel of 15 randomly selected semi-trained individuals who included; lecturers, students and non-teaching staff at University of Nairobi Upper Kabete Campus in the Department of Food Science, Nutrition and Technology. Consent of the panelist was verbally sought while explaining what the study was about and its aim. A brief training session was carried out with the aim of enlightening the panelist on predetermined descriptors of the CSB flakes namely; taste (sweet and sour), Flavor (beany and roasted), texture (crispiness and smoothness), color (general appearance) and overall acceptability. Flakes samples were randomly marked with three digit numbers for blinding purposes in duplicate and presented to the panelist for evaluation. A seven point hedonic scale was used to evaluate the intensity of each attribute: 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = neither like nor dislike, 5 = like moderately, 6 = like very much, 7 = like extremely. Clean water was provided to refresh the palate after successive evaluation of samples.

Analytical methods

Determination of proximate composition for cassava-soybean breakfast flakes

Proximate composition of cassava-soybean breakfast flakes were determined as per (AOAC 2008) methods in terms of moisture content (AOAC 2008 method 967.08), crude protein (AOAC, 2008 method 988.05), crude fiber (AOAC, 2008 method 958.06), crude fat (AOAC, 2008 method 2003.06), crude ash (2008 method 942.05) and carbohydrate content (by difference method).

Determination of Hydrogen Cyanide content

Determination of Hydrogen cyanide content of flakes was determined as per (AOAC, 1990).

Statistical analysis

The data was statistically analysed using Genstat software Version 15. Means were separated using the Tukey's honest significant difference post hoc test.

Discussion

Proximate composition and cyanide content of cassava-soybean flakes

There was significant difference ($p<0.05$) in moisture content of the five formulations ranging from 7.60% to 10.47% as shown in Table 2. Low moisture content may indicate extended shelf life of the product as moisture is critical in growth of microorganisms. These results are in line with those of Dada et al. (2018) who also suggested extended shelf life for cassava strip with similar range of moisture content. A significant difference ($p<0.05$) existed in protein content of the formulations ranging from 1.38% to 22.12%. This is evidence that as substitution level of cassava with soybean increased, the protein content of the flakes also increased suggesting an improvement of nutrition value of flakes with regard to protein content. These results agree with those of (Siulapwa, 2015) and (Abioye, 2011) who reported an increase in protein content of soy plantain flour and cookies as level of substitution with soybean increased.

Table 2: Proximate composition (dry basis) of cassava-soybean formulated flakes

	Formulations				
	A	**B**	**C**	**D**	**E**
Moisture %	10.47±0.08^{e}	7.98±0.04^{b}	7.60±0.02^{a}	10.26±0.08^{d}	9.78±0.04^{c}
Protein %	1.38±0.05^{a}	11.13±0.07^{b}	13.85±0.18^{c}	17.33±0.05^{d}	22.12±0.09^{e}
Fats %	0.57±0.07^{a}	6.99±0.17^{b}	8.35±0.07^{c}	10.26±0.09^{d}	13.00±0.08^{e}
Ash %	2.33±0.04^{a}	3.01±0.04^{b}	3.29±0.07^{c}	3.71±0.05^{d}	4.04±0.11^{e}
Fiber %	2.21±0.06^{a}	4.41±0.02^{b}	5.27±0.12^{c}	6.17±0.06^{d}	8.71±0.02^{e}
CHO %	83.04±0.31^{e}	66.50±0.03^{d}	62.99±0.18^{c}	52.28±0.18^{b}	42.36±0.10^{a}
Energy Kcal/100g	342.81±0.40^{a}	373.35±1.13^{c}	370.41±0.70^{b}	370.74±0.31^{b}	374.88±0.82^{c}
Cyanide mg/kg	9.72±0.03^{c}	8.35±0.02^{a}	9.68±0.02^{c}	8.69±0.01^{b}	9.06±0.01^{d}

Values with similar superscript across a row are not statistically different at ($p<0.05$). Sample A had 0:100, B had 15:85, C had 25:35, D had 35:65 and E had 50:50 cassava is to soybean ratio.

Fat content of the flakes ranged from 0.57% to 13% with significant difference ($p<0.05$) existing in all formulations. The increase in fat content was attributed to increased content of soybean. Soybean is an oil seed and this also suggests increase in energy value as fat content of flakes increased. Similar results whereby an increase in fat content of biscuits fortified with soy flour increased to 30.5% from 1.6% in 20:80 cassava and soy flour incorporation respectively (Akubor & Ukwuru, 2003). Ash content of the flakes ranged from 2.33% to 4.04% with significant differences existing among all the five formulations ($p<0.05$). This suggested that soybean is a cereal rich in mineral contents, the study sought to improve the mineral content of the cassava flakes. These results agree with those of (Chinma, 2013) who reported an increase of 0.45% to 2.9% in ash content of cassava and soy protein concentrate blend.

There were significant differences in the fiber contents of the flakes ($p<0.05$) with values of 2.21% to 8.71%. From the proximate results of the soybean, it was noted that it had about 2.6 times the fiber content of cassava. This therefore suggested that as substitution of cassava with soybean increased, fiber content also increased. Dietary fiber is important in nutrition as it increases water holding capacity of stool. As a result, stool bulk and softness is increased and transit time is reduced which reduce hemorrhoids, diverticular diseases and probably other diseases of lower gastro-intestinal tract (Lokuruka, 2010). The results of most preferred sample with 6.17% dietary fiber are higher than those reported by (Wireko-Manu, 2016) who reported 3.34% in most preferred sample of a complementary feeding food by weaning mothers that used similar raw materials.

Variation in carbohydrate content among the formulations was significant ($p\leq0.05$). As substitution of cassava with soybean increased, the carbohydrate content of the flakes decreased. This resulted in almost 50% reduction in the most substituted formulation sample (E) compared with the control (A). Among all the roots, cassava is known to have the highest content of carbohydrate in form of starch (Burns *et al.*, 2010). Comparing the findings of the present study with the results of (Wireko-Manu, 2016), the carbohydrate content of the most preferred sample was 64.15%, a level higher than the most preferred sample of the CSB flakes of 52.28% ($p \leq 0.05$). Energy content ranged from 342.8 to 374.8 kcal $100g^{-1}$ with formulation C and D having no significant difference, just like B and E ($p \leq 0.05$). Nevertheless, despite lack of significant difference in afore mentioned formulations in terms of energy content, it was noted that protein and fat content significantly differed ($p \leq 0.05$) with increased substitution of cassava with soybean which also plays a big role in energy content of a food ration. A good energy balance from various nutritional components of a food is important (Mashayekh, *et al.*, 2008).

Cyanide content (HCN) of the formulated flakes ranged from 8.35 to 9.72 mg/kg dry weight. Formulation B, D and E had significant difference ($p \leq 0.05$) while C and A exhibited no significant difference ($p > 0.05$). These levels of HCN agree with the WHO/FAO guidelines on the level of HCN present in cassava flour of 10 mg/kg dry weight. These results agree with those reported by (Lambri *et al.*, 2013) who suggested that effectiveness of cyanide removal is achieved when several processing methods are combined. With regard to the results of this study, he reported levels as low as 8 mg/kg dry weight by combining fermentation of grated cassava with oven drying at 55^0 C. He further noted that the final residual HCN content is dependent on initial levels.

Sensory attributes of cassava soybean flakes

Acceptance and rejection of food is highly dependent on colour which gives consumer the first impression. In this study highest colour score was on sample 103 with the highest mean score of 5.53 as shown in Table 3. A significant difference at ($p < 0.05$) existed in sample 104 compared with all other samples. However, the rest of the samples were not significantly different ($p > 0.05$). As incorporation of soybean into cassava increased the colour intensity also improved as evident in the scores. However up to a certain level. These results agree with those of (Alabi *et al.*, 2007), who reported colour improvement of wheat bread fortified with soybean.

Values with similar superscript along a column are not statistically different at ($p < 0.05$). Sample 100 had 0:100, 101 had 15:85, 102 had 25:65, 103 had 35:65 and 104 had 50:50 soybean is to cassava respectively. To an extent, food texture embraces appearance. In this study, both texture parameters crispiness and smoothness exhibited almost a similar trend with mean scores ranging from 4.13 to 6.00 for crispiness and 3.24 to 5.38 for smoothness. Sample 100 and 104 had no significant difference ($p > 0.05$).

However, the two samples significantly differed ($p < 0.05$) from the rest which had no significant difference for crispiness. Sample 104 had the highest score of crispiness of 6. Smoothness was evaluated after hydrating the flakes and from the table, sample 100,101,102,103 and 104 had no significant difference at ($p < 0.05$). However, sample 104 significantly differed ($p < 0.05$) from the rest.

The increasing trend in scores for both crispiness and smoothness were attributed to the increase in incorporation of soybean but with limitation to a certain point where the scores decreased for both texture parameters. The results are comparable to those reported by (Akubor & Ukwuru, 2003); (Oluwamukomi *et al.,* 2011), who found out that there was no significant difference($p > 0.05$) in texture, colour and taste of cassava-soy enriched and un-enriched flour blend biscuits.

Table 3. Sensory attribute scores for the cassava soybean flakes

Sample	Appearance	Texture		Taste		Flavor		Overall Acceptability
	Color	Crispness	Smoothness	Sweetness	Sourness	Beany	Roasted	
100	4.80±1.93^{b}	4.13±1.68^{a}	4.16±0.68^{b}	4.45±0.79^{a}	6.33±0.98^{b}	5.74±1.28^{a}	2.16±1.22^{a}	4.40±1.55^{ab}
101	4.93±1.36^{b}	5.33±0.62^{b}	4.41±1.15^{b}	5.28±0.96^{b}	4.67±1.18^{a}	6.38±1.48^{a}	3.64±1.43^{b}	4.87±1.06^{ab}
102	5.13±1.28^{b}	5.40±0.91^{b}	4.36±1.67^{b}	5.52±1.67^{b}	5.00±1.20^{a}	6.56±0.78^{a}	5.22±0.92^{b}	5.20±0.86^{b}
103	5.53±1.41^{b}	6.00±0.85^{b}	5.38±0.94^{b}	6.13±0.85^{b}	4.20±1.57^{a}	6.48±0.94^{a}	6.78±1.07^{c}	6.40±0.63^{c}
104	3.60±1.80^{a}	4.27±1.62^{a}	3.24±1.96^{a}	3.98±1.03^{a}	4.00±1.73^{a}	6.26±1.12^{a}	6.85±0.96^{c}	4.13±1.68^{a}

Taste is also an important sensory characteristic of a food. The study evaluated sweetness and sourness of the CSB flakes as main parameters of taste. Sweetness is a sensory characteristic primarily associated with sucrose or non-nutritive sweeteners though other compounds such as sugar alcohols, ketones, aldehydes and amino acids such as glycine, alanine and serine have also been reported to bring about sweetness (Navicha *et al.*, 2018). An increasing trend in scoring the sweetness of flakes was observed as soybean incorporation level increased. Sample 100 and 104 did not differ in score but significantly differed ($p<0.05$) with the rest. The trend could be explained by increasing amount of simple sugars and some specific amino acids in soybean as its level of incorporation increased. However, this is on condition that objectionable flavour such as beany flavour in soybean are eliminated while processing.

Sourness is brought about by pH of below 7 in foods. The highest level of sourness was scored 6.33 on sample 100 which was the control comprising of 100% cassava flour. A significant difference on sample 100 and the rest of the samples existed ($p<0.05$). The scoring decreased as decrease in level of cassava use increased. This was attributed to fermentation of cassava roots during soaking as explained earlier in this study as a method of lowering cyanide content to required level. These results were similar to those reported by (Maziya-Dixon, 2017) who reported a similar trend on a snack made from high quality cassava flour and legume blend.

Regardless of superiority of other sensory attributes, soy based foods can be faced with a dominant beany flavour that discourages its consumption. There was no significant difference in beany flavour scores at ($p<0.05$) where the scores ranged from 5.74 to 6.56. This was an indicator that the processing methods employed eliminated the objectionable beany flavour. Many studies have reported beany flavour with attributes such as painty, grassy, green and rancid among others. Soybean used in formulation of the flakes were subjected to roasting at 200^0 C for 5-8 minutes which inactivated lipoxygenase enzyme activity which brings about the beany flavour. These results are similar to those reported by (Navicha, 2017), who reported a decrease in lipoxygenase activities in soy milk commensurate with increasing roasting temperatures and time.

Good aroma and flavour profile excites the taste buds and makes the food acceptable at sight. The study evaluated roasted flavour in CSB flakes solely attributed to roasted soybeans. Significant difference was observed in samples at ($p<0.05$) with sample 100 being significantly different with the rest, 101 and 102 having no significant difference, also sample 103 and 104 having no significant difference. An increasing trend was observed as level of soybean incorporation increased. This was probably due to production of volatile compounds such as thiazoles, thiopohenes, pyridines, pyrazines, furans, pyrroles and oxazoles generated as a result of maillard reactions of sugars and amino acids (Lee & Shibamoto, 2011). The findings are similar to those reported by (Navicha, 2018), who evaluated the effects of soybean roasting on sensory attributes of soy milk.

Significant difference existed in overall acceptability of the CSB flakes at ($p<0.05$) with sample 104 having the lowest mean score of 4.13 and 103 with the highest of 6.4. However sample 100 and 102 had no significant difference but differed significantly with sample 103. This could be attributed to a balance of other sensory attributes compared to other samples. These results slightly differed with those of (Akubor, 2003), whose study reported a 50:50 cassava and soybean flour ratio used to make biscuits had highest score in overall acceptability but lacked significance difference with all other formulations. This could be as a result of personal opinions of the sensory panellists and also differences in the product and product processing

Conclusion

Incorporation of soybean into cassava flours can be used to make flakes that are safe in terms of cyanide content and anti-nutrients, nutritious with regard to protein content and with high acceptability. As a result, the cassava soybean flakes can be utilized to assist in addressing the problem of protein energy malnutrition, hypo-allergenicity of common wheat-based breakfast cereals among other benefits. The study established that incorporation of soybean flour into cassava flour at a percentage level of 35:65, would at least provide half of the required daily intake of protein level by complementary weaning children aged between 2-5 years. In addition, among all the formulations in the study, this formulation was the most acceptable in terms of sensory characteristics.

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