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Formulation, of cassava root - leaf flakes, acceptability evaluation and determination of nutritional value

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Abstract

Cassava is an important food crop grown for its roots to supply daily needed calories to households in the cassava growing communities including coastal Kenya. The region contributes up to 30 % of the national cassava production though it remains food insecure with high prevalence of malnutrition. Cassava roots are deficient in most nutrients except carbohydrates while the leaves are rich in a range of nutrients including protein but are moderately consumed as vegetables. The study sought to establish the most acceptable cassava root-leaf blend/s with improved nutrients' content. This involved formulation of blends of cassava flakes through mixing roots and leaves in varied levels ranging from 0 % to 50 % that led to 18 different blends, with most accepted being 20%. Fermented and unfermented flakes were developed. A total of 18 formulations were developed before consumer acceptability and nutritional content were determined in the most preferred blends. The results showed cassava root - leaf flakes were best accepted when fermented root material is blended with 20% leaf component. Percent leaf content above 40% was unacceptable as such blends exuded poor smell. A calculation from the nutrients contained in blend 100 5 cassava roots against the blend that contained leaf material showed that the nutritional value showed that cassava root-leaf flakes has vitamins A and C improved by 353% and 53%, minerals- iron and zinc by 5.6% and 85% respectively and protein by 430% when compared with flakes processed from 100% cassava root. It is recommended that more studies be carried out to determine bioavailability and nutritional effect of consumption of the flakes on children and pregnant women.

Keywords: *Acceptability; cassava flakes; fermentation; nutritive value*

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Introduction

Cassava is a food crop that has always remained a crop of hope, providing livelihood to up to 500 million small holder households in the tropical regions, Kenya included (FAO, 2011). It provides up to 500 calories per day to over 70 million households (Chavez *et al.*, 2005; Chavez *et al.*, 2000). It is the third most important source of calories in the tropics, after rice and corn (FAO. (2011) with the coast region of Kenya. contributing 30 % of the national cassava production (Opondo *et al.*, 2020). It is rated, second most important food crop after maize in the region (Githunguri *et al.*, 2017). It grows and produces well under suboptimal conditions (Bechoff, 2018; Burrell, 2003; Cock, 1982). It is commonly grown for its roots that are rich in carbohydrates and therefore have potential to supply much needed calories to the communities that grow it (FAO, 2011). The leaves are moderately utilized (Abok *et al.,* 2016; Tonukari *et al.,* 2004) although they are rich in a range of nutrients including protein (Montagnac *et al.,* 2009). The tropical regions have harsh climatic conditions with Kenya having 88% of its area being Arid and Semi-Arid (ASAL) (Njoka *et al.,* 2016). Coastal Kenya is one of the regions that fall in the ASAL agro ecological zones (Njoka *et al.,* 2016). The harsh climatic conditions have exacerbated poverty levels in this region.

World Bank (2016) reported poverty in coastal region to range from 13% to 90% at sub-county level, across the 140 sub counties. Poverty is a vicious circle that rolls from low incomes, to food and nutrients, and health insecurities. However inasmuch as the region registers high poverty levels, it contributes up to 30% of the national cassava production in Kenya. It is unfortunate that cassava leaves that are rich in a range of nutrients, are still underutilized even in the face of high levels of malnourishment in children and pregnant mothers. Studies have shown that protein content in cassava leaves compares well with protein content in eggs (Montagnac *et al.,* 2009; FAO/ WHO, 2005). The underutilization of cassava leaves is most likely due to the fact that they are only used as a vegetable. A vegetable is mostly eaten as accompaniment to basal diets. This means vegetables are hardly utilized in the absence of the basal diets. A worse scenario is expected in a region that is food insecure. The present study undertook to blend cassava roots and leaves to come up with cassava root - leaf flakes with improved nutrients. Flakes is, an all-time snack that will serve as a means of diversification of cassava based products and utilization of cassava leaves.

The methods of processing cassava include chipping roots and drying, steeping and fermentation (Quaye *et al.,* 2009; Nweke, 1996; Montagnac, 2009). Steeping is however not very common as it requires substantial amount of water for it to be undertaken, more so, steeping is traditionally carried out in rivers (Oyetayo, 2006). This method allows the moving water to rinse out any anti- nutrients present in the roots (Hahn *et al.,* 1986). Fasuyi et al. (2005) indicated that traditional methods such as drying, pounding and long periods of boiling could remove anti-nutrients in cassava. The ultimate goals in processing include elimination of anti- nutrients, improving shelf life (Quaye, 2009; Cardoso *et al.,* 2005), improving quality, palatability and general acceptability, reducing bulkiness as well as product differentiation. It is important to note that fermentation method is the most commonly practiced in cassava processing since it is not only efficient in removing anti nutrients but also improves palpability of the end product Quaye *et al.,* 2009). Fermented cassava products include- *gari,* in East and West Africa, *chikwangue* or *fufu* in Central Africa, and sour starch in Latin America. Fermentation method also bio conserves cassava through acidification by lactic acid bacteria (Rainbault *et al.,* 1996). Fermentation has been reported to be responsible for product stability, flavor development, and cyanide elimination (Westby, 1994). The current study undertook to develop cassava root-leaf flakes using fresh processing and fermentation methods to generate different blends of cassava flakes.

Materials and methods

Harvesting and preparation of cassava roots and leaves

Cassava roots were harvested from plants that were at the age of 6 months up to 12 months after planting while the leaves were harvested at an early crop age - 3 months after planting up to 9 months after planting. Cassava leaves having no documented maturity indices, counting of the tender leaves from the tip of the plant up to leaf five was the criterion used to maintain maturity uniformity. Both the roots and the leaves were randomly harvested from three cassava varieties; Karembo, Tajirika and Kibanda Meno. Before undertaking major processing, the roots were chipped using a manual chipper with chipping plate that has mesh size of 10 mm as guided by Dziedzoave *et al.,* (2003). The leaves were pounded to mash using a motor and pestle as recommended by other researchers (Bokanga, 1994: Bradbury, 2014).

Processing methods

Cassava roots and leaves were processed differently, using fresh and fermentation methods.

The fresh method (method 1) involved harvesting of roots, washing before and after peeling (roots) as guided by Dziedzoave *et al.*, (2003), chipping of roots using manual chipper sun drying root chips on raised beds in open sun before milling and grinding using a hammer mill. Processing of leaves in the fresh method involved harvesting of leaves which were then washed and destalked as guided Bradbury. (2014). Pounding of leaves was done using mortar and pestle before the leaf mash was dried in drying mesh under shade according to Bokanga (1994) and Bradbury (2014). Drying of both the root and leaf materials was up to 13% moisture content.

All steps followed in fresh method were also undertaken in the fermentation method (method 2) but in this case, roots and leaves mashes were subjected to spontaneous fermentation for 3 days as described by Bokanga *et al.*, (1994) and Quaye (2009) before drying and milling.

Formulation of cassava roots and leaves flakes

The mixing was done as shown in Table 1.

Cassava roots and leaves were mixed in different ratios using a linear model for food formulation model ($C_T = C_r.W + C_l.W + E$) Where C_T = Total nutrient content; Cr. W= cassava roots by weight; C_l.W = cassava leaves by weight and E = error tag that would allow for additives and consequential product improvement as guided (FAO / WHO, 2016: De Carvalho *et al.*, 2015). The linear model was however modified where by cost factor was exempted. The mixing of roots and leaf majorly targeted protein RDA for mothers. The mixing of roots with leaves both differently processed resulted to different blends of root-leaf flakes.

Table 1. Showing percent leaf composition in cassava root leaf flakes and the method of processing

Blends of Flakes	Processing Method		Percent Leaf	Name of Blend
Root flakes	Fresh - root	No leaf	0	Control 1 (X0)
Root -leaf flakes	Fresh - root	Fresh - leaf	20	X14
Root - leaf flakes	Fresh - root	Fresh - leaf	30	X 15
Root - leaf flakes	Fresh - root	Fresh - leaf	40	X16
Root - leaf flakes	Fresh - root	Fresh - leaf	50	X17
Root -leaf flakes	Fresh - root	Fermented leaf	20	X8
Root - leaf flakes	Fresh - root	Fermented leaf	30	X 1
Root - leaf flakes	Fresh - root	Fermented leaf	40	X6
Root - leaf flakes	Fresh - root	Fermented leaf	50	X11
Root flakes	Fermented- root	No leaf	0	Control 2 (X13)
Root -leaf flakes	Fermented- root	Fresh - leaf	20	X2
Root - leaf flakes	Fermented- root	Fresh - leaf	30	X 5
Root - leaf flakes	Fermented- root	Fresh - leaf	40	X9
Root - leaf flakes	Fermented- root	Fresh - leaf	50	X7
Root -leaf flakes	Fermented- root	Fermented leaf	20	X4
Root - leaf flakes	Fermented- root	Fermented leaf	30	X 12
Root - leaf flakes	Fermented- root	Fermented leaf	40	X3
Root - leaf flakes	Fermented- root	Fermented leaf	50	X10

Processing of cassava root - leaf flakes

The blends were put in separate labeled jars. Each blend at a time was mixed with vegetable oil at the ratio of 5: 2 (blend: Oil). After mixing, the mixtures were separately molded using a double sleeve molding mat to extra thin sheets. The thin sheets were then transferred into baking trays for baking. Baking was done at 250°C for 12 to 17 minutes, with continuous monitoring to ensure uniform browning of the flakes.

Steps and procedures

Step 1; Mixing of cassava root material with leaf meal at different ratios

Step 2; Each mixture put in a separate jar

Step 3; 200 g of each mixture weighed and put in to a bowl and added with 40 g (equivalent to 4table spoons) vegetable oil

Step 4; Molding done using a double sleeve mat to thin shits and transferred to baking trays

Step 5; Baking done at 250^{o}C for 12 to 17 minutes

Pairwise ranking of formulated flakes

Sensory evaluation of flakes was undertaken in order to test acceptability in terms of colour, taste, aroma and texture (Meilgaard *et al.*, 1999). However, non-professional tasters have a tendency to object sensory evaluation when the list of samples to be evaluated is long. In this study the list of blends of cassava flakes totaled 18. Therefore, a criterion was participatory developed that would allow for elimination of some of the blends with outright low acceptability qualities in order to reduce the list to a manageable number of below 10 samples. A total of 30 panelists were asked to participatory identify one parameter among the four (colour, taste, aroma and texture) that would be used as a "knock out" criterion. The exercise was carried out according to participatory methods by Guijt. (2014). In this case the panelists were also required to indicate reason/s for their choice of the parameter they felt was more powerful. Each panelist was given a questionnaire that had the list of four parameters and they were instructed to choose and tick one parameter they felt was most powerful in product acceptability. They were also asked to give one or two reason/s to justify their choice. The outcome results (selected parameter) was used to carry out pairwise ranking.

Participatory development of "knock out" criterion

The results from the 30 panelists showed that 76% indicated aroma to be the most powerful parameter to be used as "knock out" criterion (Figure 1). One of the reasons indicated by most of the panelists as means of justifying their choice on aroma as the most powerful parameter rather than important was; "because aroma can draw the attention of a consumer to look for and find a product even when the product is hidden out of sight". It was further justified as "It is after finding the product that a consumer can appreciate its colour, then taste and final feel its texture". Upon discussion however panelists agreed synonymously that the most important parameter in acceptability is taste. Additional reasons that were indicated by panelists as a way of justifying their choice are as follows:

(i) Aroma is part of the flavor that influences the taste of a product
(ii) A consumer first smells a product before they taste it especially when it is not a common one.
(iii) An offensive aroma leads to a product being rejected before it is tasted
(iv) Aroma ignites appetite
(v) Aroma is one of the major factors commonly used for product differentiation i.e. yogurt tastes the same but different blends have different aroma that influences the flavours.

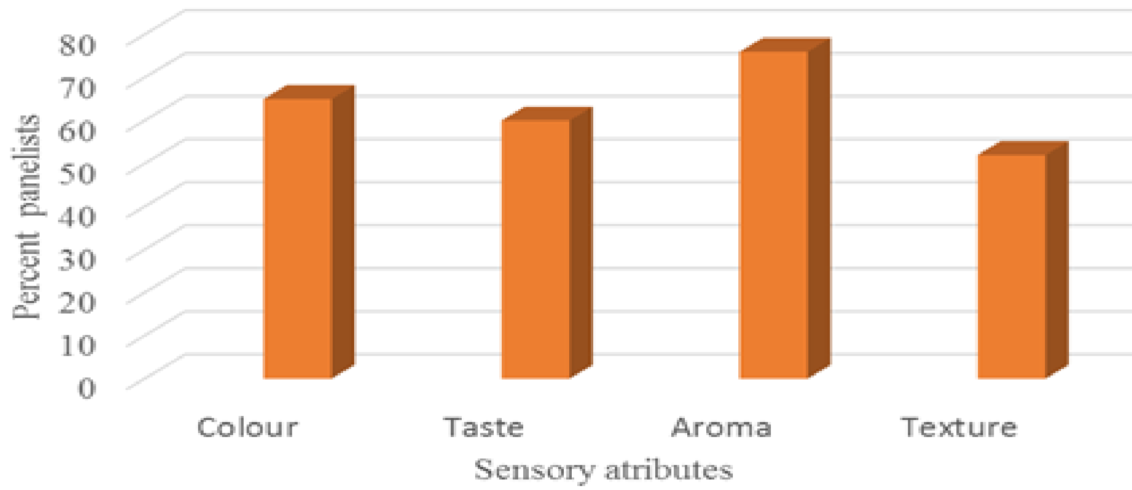

Figure 1. Showing knock out criterion as decided by sensory evaluation panelists; source: field data 2020

Aroma was therefore adopted as the knock out criterion.

Pairwise ranking was conducted according to; Runsell, (2001) and Liu, (2009). Each panelist had a chance to compare one blend against the rest of the blends and indicate the blend they preferred on the basis of aroma that had been adopted as the "knock out" criterion.

Sensory evaluation

A total of 30 adult panelists were randomly selected and recruited within KALRO Mtwapa and its environs. The panelists were invited to KALRO Mtwapa as a central place, where they were first briefed on what was expected of them as they evaluated the flakes. A brief explanation was given on how to evaluate each parameter. The blends of flakes were labeled using random codes and randomly placed in plates. The plates were placed in well-lit panel booths. Each panelist was provided with clean drinking water to use for mouth rinsing every after tasting a sample according to Meilgaard *et al.,* (1999). Every panelist evaluated each blend and translated their preference in terms of scores as guided in Bechoff *et al.,* (2016) using a 7-point hedonic scale. The parameters that were evaluated were color, taste, aroma, texture and overall acceptability. Acceptability and preference levels were measured by use of scores as translated in 7-point hedonic scale preference scores, i.e., 7 = (like extremely), 6 = (like most), 5 = (like), 4 = (neutral), 3 = (dislike) 2 = (dislike most), 1 = (dislike extremely). Sensory evaluation of flakes was undertaken in order to test acceptability in terms of colour, taste, aroma and texture

Determination of nutritional quality of the selected blend

The most preferred blend alongside the controls were taken to the University of Nairobi food laboratories to determine their nutritive values.

Determination of Moisture content

Moisture content determination was carried out using gravimetric method with a few modifications. About 5 g of pounded sample were weighed in crucibles and dried for 4 hours at 105 ^{0}C in an air oven as guided in AOAC, (2001) method 925.10.

Crude Fat Determination

Approximately 2 g sample was extracted using sohxlet extractor for 8 hours using 200 ml petroleum ether (40 - 60 ^{0}C). Crude fat content was calculated after evaporating the solvent and the residue dried in an air oven at 105 ^{0}C for 1 hour as guided in AAFCO, (2014).

Protein Determination

Protein content in the flakes samples was determined as per AOAC, (2005) method. 979.09.

Determination of Crude Fiber

A duplicate of approximately 2.5g sample of flakes samples were weighed and transferred to sohxlet extractor and extracted using petroleum ether, one after the other. The rest of the procedure was then followed according to AOAC. (2000) method 985.29.

Determination of Ash Content

Briefly 4 g sample of cassava flakes (per blend), weighed in duplicate was burnt in porcelain crucible using Bunsen burner (low flame) for 10 minutes then transferred to a Muffle furnace, ashed at 550^{0}C for 4 hours as guided in AOAC. (1995) method 923.03.

Determination of Carbohydrates

Carbohydrates were determined by difference. The total of moisture content, fat, ash, protein and fibre contents were subtracted from 100 as guided in FAO. (2003).

Determination of Hydrogen Cyanide

Hydrogen cyanide determination was carried out using distillation method. Cassava flakes were crashed using motor and pestle, and samples of 10 g per blend were placed into distillation flask and allowed to stand for three hours before distillation. Distillation and consequent determination of hydrogen cyanide was carried out as in AOAC, (2016) method 915.03.

Determination of Vitamin C

Approximately 15 ml (10%) TCA, was added into flat bottomed flask containing cassava flakes samples and filtered. A total of 15 ml filtrate sample was collected. The filtrate sample was then mixed with 5 ml of 4% potassium iodide solution then titrated with N-bromisumccinimide solution. The rest of procedure was followed as described in AOAC. (2012) method 967.21.

Determination of vitamin A

Approximately 2 g sample of crushed flakes was weighed, 25 ml added to extract colour, and the rest of steps followed were as guided in AOAC. (2006) method 98.25.

Determination of Iron and Zinc Content

Cassava flakes sample (4g) for determining mineral Iron was ashed in a muffle furnace at 500 ^{0}C for 4 hours. This was then digested by adding 10ml of 20% HCL and heated to boiling, then filtered into 100 ml volumetric flask and topped to mark using distilled water. Using atomic absorption spectrophotometer (A.A.S) mineral iron and zinc were determined according to AOAC. (2016) method 99. 10.

Experimental Design

The experimental design that was used for setting up experiment on evaluation of the blend of flakes was Randomised Block Design (RBD). Panelists were treated as blocks and different blends of flakes were studied as treatments against sensory attributes - color, taste, aroma, and texture.

Statistical data analysis

The scores given by panelist were subjected to analysis of variance (ANOVA), using Statistical Analysis System (SAS version 9.1). Means were separated using Least Significant Difference (LSD), the differences being significant at $p \leq 0.05$.

Results

Pairwise ranking

The results from pair wise ranking, showed that the blends with fermented material either root or leaf were scored highly. It was also shown that the less the leaf component, the more the blend exuded appealing aroma hence preferred by panelists. Also, 30% fresh leaf in fermented root was better than (fresh root + 30% fresh leaf) and (fermented root + 30% fermented leaf). Since the leaf content in these three blends was at 30% yet they were rated differently, these results indicate that the processing method also has effect on the acceptability of cassava flakes. The blend that had most preferred aroma was the blend containing 20% fresh leaf combined with fermented root material.

Fermented root +20% fresh leaf, was ranked second after 100% fermented root (control 2) it was, however ranked higher than 100% fresh root (control 1). The blends that had scored 10 points and above, were picked for four parameters sensory evaluation - i.e. (color, taste, aroma and texture). These blends were; a) Fermented root + 30% fresh leaf, b) Fermented root +20% fresh leaf, c) Fermented root + 20% fermented leaf, d)

Fermented root + 30% Fermented leaf, e) Fresh root + 20% fermented leaf, f) Fermented root + 30% fermented leaf, g) Fresh root 0% fresh leaf; h) Control 1- Fresh root 0% leaf; i) fermented root + 0% leaf- Control 2.

Sensory evaluation using 7-point hedonic scale on colour, taste, aroma, Texture, and Overall acceptability:

The results on 4 parameters (color, taste, aroma, and texture) sensory evaluation of the blends showed significant ($p \leq 0.05$) difference in the way the panelists scored and consequently ranked them Table 3.

Table 2. Means of scores for color, taste, aroma, texture and overall acceptability of blends of cassava

Id	Blends of cassava flakes	Color	Taste	Aroma	Texture	Overall Acceptability
X1	30% fermented leaf + fresh root	3.50 ±0.393 ^{d}	3.77± 0.409 ^{d}	2.93± 0.448 ^{e}	3.6± 0.554 ^{e}	3.50± 0.251 ^{e}
X2	20% fresh leaf + fermented root	6.07± 0.392 ^{b}	5.30± 0. 409 ^{bc}	5.33± 0.447 ^{bc}	5.40±0.554 ^{bc}	5.30± 0.251 ^{b}
X4	20% fermented leaf + fermented root	4.77±0.393 ^{bc}	4.73± 0.409 ^{c}	4.97± 0.448 ^{c}	4.70 ± 0.554 ^{dc}	4.97± 0.251 ^{bc}
X5	30% fresh leaf + fermented root	4.90±0.393 ^{bc}	4.83± 0.409 ^{c}	4.70± 0.448 ^{cd}	5.20± 0.554 ^{b}	5.00± 0.251 ^{bc}
X12	30% fermented leaf + fermented root	5.20±0.393 ^{b}	5.57± 0.409 ^{b}	5.37± 0.447 ^{bc}	5.63 ± 0.554 ^{ab}	4.77± 0.251 ^{c}
X8	20% fermented leaf + fresh root	4.43±0.393 ^{c}	3.63± 0.409 ^{d}	4.00± 0.448 ^{d}	4.20± 0.554 ^{de}	4.10± 0.251 ^{d}
X0 Control 1	Fresh root + (0% leaf)	6.30±0.392 ^{a}	5.93± 0.409 ^{b}	6.00± 0.447 ^{ab}	2.30± 0.554 ^{e}	5.03± 0.251^{bc}
X13 Control 2	Fermented root + (0% leaf)	6.63±0.392 ^{a}	6.83± 0.408 ^{a}	6.50±0.447 ^{a}	6.17± 0.554 ^{a}	6.37± 0.250 ^{a}

Source: Field data 2020; *Means followed with different superscript are significantly different at 5% level of significance

The blend/s of flakes that had most preferred colour were Fresh root 0% fresh leaf and Fermented root + 0% leaf. The two blends however did not contain any leaf material and they were used as controls in the trial (Table 2). There was significant ($p \leq 0.05$) difference in colour of the blends Fresh root + 20% fresh leaf, Fermented root +20% fresh leaf and Fermented root + 20% fermented leaf that contained 20% leaf material but processed differently. The colour of Fermented root + 30% fermented leaf, Fermented root + 30% fermented leaf and Fermented root + 30% fresh leaf was also significantly ($p \leq 0.05$) different in the way the blends were preferred by panelists. The blend that was most preferred in terms of colour was Fermented root + 30% fermented leaf. Inasmuch as blends with less leaf material were more preferred, colour of Fermented root + 30% Fermented leaf was not significantly ($p < 0.05$) different from that of Fermented root +20% fresh leaf that contained fresh leaf.

The results showed significant ($p \leq 0.05$) difference in the way panelists preferred their taste (Table 2). Fermented root + 30% fresh leaf, Fermented root + 30% fermented leaf and Fermented root + 30% Fermented leaf were significantly ($p<0.05$) different in taste though they all contained 30% leaf material. Fermented root + 30% fresh leaf had a mean score of 3.77. Fermented root + 30% fermented leaf had a mean score of 4.83. Fermented root +20% fresh leaf, Fermented root + 20% fermented leaf and Fresh root + 20% fresh leaf were significantly ($p < 0.05$) different in taste though they all contained 20% leaf material. Fermented root +20% fresh leaf had a mean score of 5.30 as rated on taste, was not significantly different to the taste in Fermented root + 30% fermented leaf inasmuch the latter contained higher leaf material at 30 %.

The results showed significant ($p \leq 0.05$) difference in the panelists' preference of the aroma of most blends. The panelists however could not pick the difference in aroma of blends 30% fermented leaf + fermented root and the aroma of the blend with 20% fresh leaf + fermented root (Table 3). Bechoff et al. (2018) postulated that fermentation of cassava is a way to develop specific and appreciated product flavours. It is important to note that panelists in the present study also associated aroma with flavours of a product. Aroma in Fermented root +30% fresh leaf was significantly ($p \leq 0.05$) different from aroma in Fermented root + 30% fermented leaf and Fermented root + 30% fresh leaf, though they contained similar quantity of leaf material. Also Fermented root +20% fresh leaf, Fermented root + 20% fermented leaf and Fresh root + 20% fresh leaf were significantly ($p<0.05$) different in the way panelists preferred their aroma though all had 20% leaf material. The most preferred aroma was in the blend; Fermented root + 30% fermented leaf and Fermented root +20% fresh leaf with scores of 2.93 and 5.37, and 5.33 respectively.

The results showed significant ($p \leq 0.05$) difference on basis of panelists preference on the texture of the blends (Table 2). Fermented root + 20% fresh leaf, Fermented root + 20% fermented leaf and Fresh root + 20% fermented leaf had 20% leaf material but were significantly ($p<0.05$) different according to preference by panelists. A similar trend was also shown in blends Fermented root + 30% fresh leaf, Fermented root + 30% fermented leaf and Fresh root + 30% fermented leaf. That were shown to be significantly ($p<0.05$) different according to preference by panelists. The texture of cassava blends was shown to be preferable when blends are fermented. This was depicted by the fact that the blend that had fermented root + 30% fresh leaf, was rated higher than control 1 that contained fresh root + 0% leaf despite that fact that it contained higher percent leaf material. The most preferred texture was found to be in blend - Fermented root + 30% fermented leaf with a mean score of 5.63 but not significantly different from Fermented root + 0% leaf, the control 2 with mean score of 6.17.

The results showed significant ($p \leq 0.05$) difference in the panelists' preference of the four parameters evaluated in each of the different cassava blends (Table 2). The blend with Fermented root +20% fresh leaf had its attributes significantly ($p \leq 0.05$) preferred by panelists. Its overall acceptability score was 5.30. Fermented root + 20% fermented leaf had an overall acceptability at mean score of 4.97. Blend Fermented root + 30% fermented leaf was shown to have attributes that were significantly ($p \leq 0.05$) different as preferred by panelists. Its best rated attribute was texture in its overall acceptability. Blend Fermented root + 30% Fermented leaf had its parameters' mean scores ranging from 5.20 to 5.63. However, its overall acceptability falls at mean score of 4.77. Blend Fresh root + 20% fermented leaf had its attributes scored at mean score of 4.10 of its overall acceptability.

Nutritive value of preferred cassava root-leaf flakes

The results of the current study showed that there was significant ($p \leq 0.05$) difference in the nutritive value of the most preferred blend of cassava root - leaf flakes; Fermented root +20% fresh leaf and the two controls that did not have any leaf material but 100% fermented and fresh root material. The two played representative roles of the current status of available cassava products i.e. crisps, cassava flour, fried chunks that are processed purely from cassava root. Fermented root +20% fresh leaf had significantly ($p \leq 0.05$) higher content of protein, carbohydrates, vitamin A, minerals iron and zinc, fibre and ash. It had significantly ($p \leq 0.05$) lower vitamin C than the controls. In comparison of cassava root - leaf flakes with flakes made from pure roots, most of the arnerne-nutrients measured were significantly ($p \leq 0.05$) higher in the root - leaf (Table 3). The pure root flakes processed through fresh and fermented methods give an indicator of the common cassava products that are currently available to consumers. Cassava products commonly found in the market such as flour, crisps, roasted and fried chunks and fresh cassava root (Mwamachi *et al.,* 2005). Comparing the results found in this study on vitamin c content with other food products, it was shown that the cassava root - leaf flakes had much higher vitamin C than that found in guava and or green pepper as reported by (Kareem, 2010; Essam *et al.,* 2019)

The Recommended Dietary Allowance (RDA) guides that males depending on their weight, should averagely take protein amounting to between 45 to 63g per day, vitamin A, averagely 1000µg, vitamin C 50 – 60mg, Iron 10 – 12mg, zinc- averagely 15 µg; Females, Children of age 4 – 9 years require 275 µg vitamin A or half of the stipulated quantities also depending on the body weight (FAO/WHO, 2001). The formulated cassava root - leaf flakes meets about a half ($^1/_2$) to three quarters (¾) of the RDA in most of the nutrients. This calls for further fortification of the product as a way of up scaling to fully meet the concerned

Table 3. Nutritive values (mg / 100 g dry weight basis) of cassava root – leaf of flakes

Nutrients	Blends of cassava flakes		
	X2	X13	X0
MC	11.17± 0.45 ^{a}	10.34±0.44 ^{a}	10.34± 0.44 ^{a}
Carbohydrates	40.76±0.45 ^{a}	37.18±0.45 a	28.54±0.57 ^{b}
Protein	26.0±0.99 ^{a}	4.9± 0.44 ^{b}	6.51±0.45 ^{b}
Fibre	8.24±0.44 ^{a}	6.27±0.449 ^{b}	6.88±0.438 ^{b}
Ash	6.22±0.44 ^{a}	6.68±0.45 ^{b}	7.96±0.44 ^{b}
Fat	8.26±0.47 ^{a}	8.67±0.48 ^{a}	8.22±0.44 ^{a}
Vit'-A	488.4±7.61 ^{a}	107.9±2.16 ^{c}	269± 1.879 ^{b}
Vit C	746.58± 5.55 ^{a}	485.32± 27.58 ^{b}	403.05± 1.52 ^{b}
Iron	8.91±0.44 ^{a}	4.8±0.438 ^{b}	5.54±0.45 ^{b}
Zinc	3.61±0.45 ^{a}	3.42±0.438 ^{a}	4.0±0.46 ^{a}
Hydrogen Cyanide	2.7± 0.44 ^{a}	3.5± 0.45 a	3.7± 0.44 ^{a}

Means with similar superscripts are not significantly ($p \leq 0.05$) different

Discussion

Formulation of flakes using fresh and fermented method allowed the current study to develop a wide range of blends of cassava flakes that ranged up to 18 in total. From the perspective of the knock out criterion using aroma, it was observed that the blends that contained fermented root material were scored higher that than those that contained whole fresh. This observation is an indicator that fermentation develops flavor that is in agreement with the argument by Westby-(Westby, 1994). The knock out criterial exercise lead to aroma to be adopted by panelists as a means to remove cassava flakes blends that had low potential to be accepted by consumers, however according to Ross *et al.,* (2011) texture is also one of the most important parameters towards sensory acceptability by end users. In the case of this study, texture was rated lowest. Ross' argument is in reference to potato tubers, it may have been ranked differently when considering processed products such like flakes. McDougall *et al.*, (2007) went further to indicate that texture is influenced by several factors that include genetics, environment and processing. According to Ross et al. (2011), these factors have not been fully investigated, especially where cassava is. Beleia *et al.*, (2006) argue that a large number of factors influence texture of cassava roots. These factors, as the researcher indicates, include starch swelling pressure, cell size, cell wall structure and composition and its breakdown during cooking. This is however an argument that addresses the importance of texture in relation to processing. From the sensory and acceptability perspective, (Chen and Rosenthal, 2015) described texture as a food characteristic that is internally linked to the food structure hence it is a collective term of sensory experiences arising from visual, audio and tactile stimuli. It is also important to realize that the arguments drawn by the researchers cannot be categorized as a feedback from consumers rather than derived from the point of literature and scientific reasoning. The panelists also had a chance to debate within themselves and gave reasons that were rationally justifying their choice. It cannot be refuted that aroma can lead to a consumer to find a product even when the product is hidden. The panelists also went further not to underrate the role played by the taste of a product towards its acceptability, however they argued it out that taste remains to be important but not as powerful as aroma towards a product acceptability. The panelists went further to state that offensive aroma may lead to outright rejection of a product even before it is tasted, thus portraying how powerful aroma is when compared with taste.

Sensory evaluation undertaken to evaluate colour in cassava root- leaf flakes indicated that the two blends that had 100% root with no leaf added had the most preferred colour. However, Bechoff *et al.*, (2018) recognizes food as culture. And culture is defined in oxford dictionary, as "the ideas, customs, and social behavior of a particular people or society". From this argument therefore, end users are bound to always prefer what they are used to eating against that which is new to them. The two blends had mean scores of 6.3 and 6.6, respectively. They were probably highly scored due to the fact that they contained no leaf material. It is common to find pure root cassava products such as flour, crisps, fried cassava root chunks etc. Blending is yet to be fully adopted, in the coast region. It was therefore literal that consumers were going to find pure root blends more likable than those blends that contained leaf material. Taste and aroma of blend 20% fresh leaf blended with fermented root could not be differentiated from the blend that contained 30% fresh leaf in fermented root material. This is an indicator that the consumers accept flakes that contains leaf material up to 30%, beyond which they will reject the product. And this was well demonstrated where all the blends the contained 40% leaf were rated low and or disliked during the sensory evaluation. The overall acceptability also confirmed that the blend with 30% fresh leaf material combined with fermented root, though rated lower than the 20% fresh leaf material combined with fermented root was at acceptable. Sensory data is however subjective and its subjectivity of is well explained by Babicz-Zielińska, (2006) who argues that food acceptance is influenced by Psychological state of individuals. According to Cardello, (2012), acceptance of food relies on physicochemical characteristics of the food interacting with human senses.

Determination of nutritive value of the Fermented root + 20% fresh root showed reduced vitamin C when compared with the controls. This could have been due to the fact that vitamin C is water soluble and heat labile hence could have been lost during processing (Montagnac *et al.*, 2009). The roots that were processed through fermentation method may have resulted in a major loss of the vitamin. Cassava root – flakes, however, had higher protein content than wheat bread and other 4 types of cassava bread that were formulated by Maria *et al.*, (2013). While the pure wheat bread contained 10g / 100g, the cassava based types of bread ranged from 1.3 g / 100 g to 5.4 g /100 g protein. Montagnac *et al.*, (2009) reported on leaf meal that contained 34 g/100 g protein that is a little bit higher than the protein content in cassava root - leaf flakes. Vitamin A content of the root - leaf flakes was much higher than vitamin A content reported by

Motagnac *et al.,* (2009) on raw cassava. The researchers, however, indicated that processing increases vitamin A content in cassava products. Abok *et al.,* (2016) reported vitamin C content in his cassava crisps ranging from 73 mg / 100 g to 136 mg / 100 g that is far much lower than the level of vitamin C contained in the cassava root - leaf flakes. The present study proves that cassava root - leaf flakes is an improved cassava product that is much superior in nutrients than most common pure cassava roots products currently available.

Conclusion and recommendation

The study concludes that cassava root - leaf flakes is a product that is most acceptable when it contains leaf material at the level ranging from 20% to 30%, the lower the leaf composition the more the product is liked. Cassava root – leaf flakes has improved nutritional value in terms of vitamins, minerals and protein, in comparison to the common pure cassava root products. The study recommends that a study be carried out to determine the shelf-life of the formulated flakes. Nutritionists are equally encouraged to study cassava root- leaf flakes, further to determine its nutritional contribution on school going children and pregnant mothers, who are the targeted beneficiaries of the product

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