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Quality Evaluation of Cassava Crackers Made From Yellow Root Cassava (*Manihot esculenta*)

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Abstract:*Starches extracted from cassava varieties TME419, the new pro-vitamin A cassava variety (UMUCASS 36 (TMS 01/1368), and UMUCASS 38 (TMS 01/1371) were used for the production of Cassava crackers with sample 419 (TME 419) as the control. The proximate composition, vitamin A, mineral and hydrogen cyanide contents of the crackers were analyzed in triplicate. The Vit. A content retained in the crackers sample made from the starch were 1.61µgfor UMUCASS 36 and 1.81µg for UMUCASS 38and none for TME 419. The values of protein rangesfrom (1.41-1.73%); fat (0.36-0.84%); ash content (0.11-0.75%); crude fibre (1.06-1.13%); moisture content (6.18%-7.32%); andcarbohydrate (89.41-89.57%).There is no significant difference in taste, crispness and general acceptability of all the samples ($p<0.05$). The minerals values obtained are sodium (2.87-3.59mg/g), calcium (2.00-2.61mg/g), magnesium (0.24mg/g) and iron (0.56-0.63). The hydrogen cyanide content of the samples ranged from (0.15-0.23mg/100g) with crackers from the new yellow root varieties UMUCASS 36 and UMUCASS 38 having the least hydrogen cyanide content of 0.15 mg/100g and 0.16 mg/100g respectively. The result obtained from this study shows good potential for exploration of the new yellow root cassava variety in snacks production.*
Keywords: *Cassava, Crackers, Pellets, Starch, Yellow root.*

I. Introduction

1.1 Background of study

Cassavais one of the most important staple food crops in the humid tropics, being particularly suited to conditions of low nutrient availability and able to survive drought.[1] It is a widely grown crop in most countries in the tropical regions of Africa, Latin America and Asia; and ranks as one of the main crops in the tropical countries [2]. Cassavaplays a major role in efforts to alleviate the African food crisis because of its efficient production of food energy, year-round availability, tolerance to extreme stress conditions, and suitability to present farming and food systems in Africa [3, 4].

Among the starchy staples, cassava gives a carbohydrate production which is about 40% higher than rice and 25% more than maize, with the result that cassava is the cheapest source of calories for both human nutrition and animal feeding [5].Three yellow root cassava varieties, UMUCASS 36 (TMS 01/1368), UMUCASS 37 (TMS 01/1412) and UMUCASS 38 (TMS 01/1371) are being grown (under the Harvest Plus Project)in Nigeria for their high concentrations of β-carotene[6, 7].

Third generation snacks (3G), also referred to as "half products" or pellets provide an alternative to fully prepared puffed snack foods. Third generation snacks or half products are extrusion cooked, and formed at low pressure to prevent expansion, and then dried to a final moisture content of about 10% to form a glassy pellet. In developing third generation snacks, "half" of the process is completed to prepare "pellets" which are shelf stable for periods of up to a year without refrigeration, provided they are properly packed to retain their moisture. Many types of proteins and protein enrichment may be added to third generation snack type recipes such as meats (whole fresh shrimp, fresh chicken, beef, etc.), dairy products (cheese, yoghurt, milk solids) and legume proteins (soy, pea, bean). Up to 30 to 35% levels may be added and still maintain high quality final products [8]. Drying is very critical in the production of good quality third generation snacks. Proper drying will reduce the moisture content of the pellets to approximately 12 percent. Temperatures of 70-95^{o}C and retention time of one to three hours are required. These products are economical to run and have built-in-marketability due to their high bulk density. Third generation snacks can be prepared in homes or restaurants. Unlike typical snack foods, half products do not yet contain oil that can oxidize to give off-flavour to the products. These pellets can be shipped from a central manufacturing distribution point, held until needed for the market, and then puffed, flavoured and packed fresh and locally[9].

1.2 Statement of problem

African countries arefaced with different forms ofmicronutrient deficiencies in the diet, thus, producing more food is not enough but the need to ensure enhanced food nutrition and health.

Cassava is primarily grown and eaten in rural areas [10]. Since it is highly perishable, it is not a good export crop and its distribution requires a localized approach.

Consumption of large amounts of a staple food poor in micro-nutrient has unfavourable health and nutrition effects especially in children less than 5 years of age and reproductive women [11].

Eye problems are very common among Nigerians these days and medical experts admonish that diet intake, somehow, determines people's susceptibility to various eye diseases, as with other ailments.

1.3 Justification

Yellow root cassava varieties are being propagated in Nigeria to aid in combating dietary vitamin A deficiency inthe country due to their high content of β-carotene (a precursor of vitamin A). This research work will help create an awareness of the Yellow fleshed cassava and its utilization while creating a new product.

1.4 Objectives

The primary objective of this research is to extract starch from the new pro vitamin A cassava varieties and to use the starch to produce cassava crackers. The specific objectives include;

i. To determine the proximate composition and mineral contents of the raw materials and the snacks.
ii. To determine sensory acceptability of the snacks.

II. Materials And Methods

2.1 Source of Raw Materials

Three cassava varieties UMUCASS 36 (TMS 01/1368), UMUCASS 38 (TMS 01/1371) and TME 419 (*Manihot esculenta*) were used for this work. The cassava varieties were harvested from National Root Crops Research Institute, Umudike, while crayfish and other ingredients were bought from Umuahia Main market in Abia State Nigeria.

2.2 Sample Preparation

2.2.1Production of cassava starch

The cassava starch was produced using standardmethods [12]. The process is shown in Fig.1. Here the cassava roots were washed, peeled, rewashed (washing of the peeled cassava roots under running water), gratedand sieved with substantial quantity of water (10 times the volume of the mash) using a muslin cloth. The solution was allowed for some time to settle after which the supernatantwas decanted. The starch obtained was dewatered and then dried in a hot air oven (Gallenkamp Co. ltd London England) at 70°C for 4 h. The dried starch was then milled into powder using a milling machine (Holbart SY80) and sieved (US sieve aperture, 0.4mm) to obtain fine flour which was packaged for production.

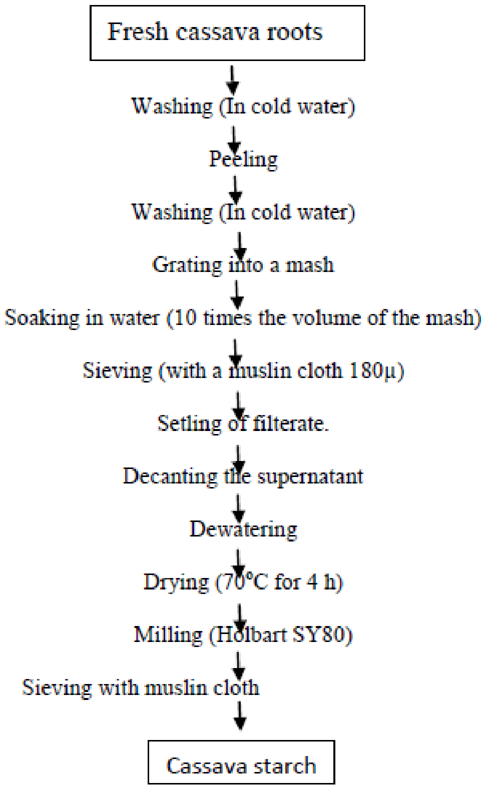

Fig.1: Flow chart for production of food quality starch.

2.2.2 Production of cassava crackers

2.2.2.1 Preparation of crayfish stock

The crayfish stock used was prepared by adding water (200ml) to crayfish (50g) in a pot. It was cooked to boil and concentrated to half, of the original volume.

2.2.2.2 Preparation of Cassava Crackers:

Standard method [13], for the production of puffed snacks was used with modification (Fig. 2).

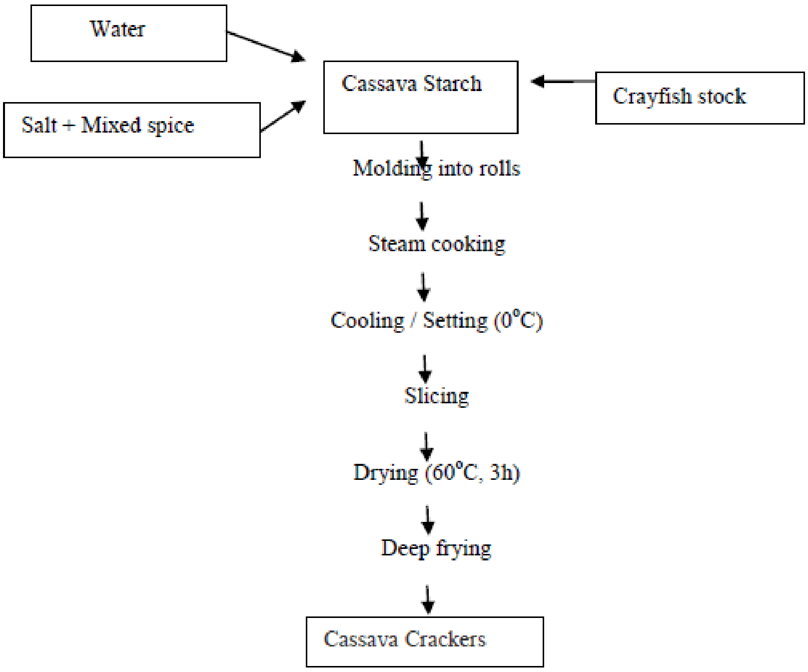

Fig. 2: Flow chart for production of Cassava crackers

2.3 Sample Analysis

2.3.1 Proximate composition

The proximate compositions of the Crackers samples: the moisture, the ash, the crude fibre, the crude protein, the crude fat and the carbohydrate contents were done in three replicates. The Moisture content was determined [14].The percentage ash , crude fibre, crude protein and fat were also determined [15].
The percentage of carbohydrate was estimated by “difference”.

2.3.2Mineral Determination: Standard methods[15] were adopted for mineral analysis.

2.3.3 Vitamin A determination: Vitamin A of the samples was determined using Spectrophotometric Method based on UV inactivation[15].

2.3.4 Determination of hydrogen cyanide content: This was done following the Alkaline picrate method [15].

2.4 Sensory evaluation: The following sensory attributes: appearance, texture, taste, aroma and general acceptability were determined [16]. The panel comprised of 30 man panelists to test the parameters on the snacks. A 9 point hedonic scale was used where 9 represented like extremely and 1 dislike extremely.

2.5 Statistical analysis

Data obtained from the chemical analysis and sensory analysis were subjected to statistical analysis of variance (ANOVA) with the mean value separated by Turkey’s test at $P<0.05$[17].

III. Results And Discussion

The result of the proximate compositions of the Cassava starch samples are shown in Table 1;

Table 1: Proximate composition of cassava starch samples

Parameter %	TME 419	UMUCASS 36	UMUCASS38
Moisture	10.23 ^{a} ±0.06	9.79 ^{b} ±0.01	9.71 ^{b} ±0.05
Ash	0.15 ^{c} ±0.01	2.04 ^{b}±0.01	2.24 ^{a} ±0.01
Crude fibre	1.14 ^{c} ±0.01	2.24 ^{a} ±0.01	1.87 ^{b} ±0.01
Protein	1.76 ^{b} ±0.01	2.15 ^{a} ±0.01	1.49 ^{c} ±0.01
Fat	0.37 ^{c} ±0.01	0.93 ^{b} ±0.01	1.30 ^{a} ±0.01
Carbohydrate	86.47 ^{a} ±0.18	82.85 ^{c} ±0.03	83.41 ^{b} ±1.69

^{a,b,c,} means with different superscripts within the same row, are significantly different (P≤0.05). LSD = Least Significant Difference

The moisture content of the cassava starch samples ranged from 9.71 to 10.23% placing the technological classification of this product as a moderately hygroscopic product. There was no significant difference between the starch content of UMUCASS 36 and UMUCASS 38. TME 419 differed significantly from both samples in its moisture content. Amongst the three cassava starches analyzed, starch from TME 419 had the highest moisture content followed by UMUCASS 36 and UMUCASS 38 with the least moisture content. This moisture content of the starch samples falls within range of the moisture content of starch samples [13] for good quality starch, and is also within the range acceptable for effective flour storage [18]. The moisture content is generally low and this is an indication of stable shelf life if properly packaged and stored. Low moisture is necessary in starch for good keeping quality and longer shelf life [19].

The crude protein content of the three cassava starch samples ranged from 1.49% to 2.15%, with significant differences between the lowest values 1.49% (UMUCASS 38) and 1.76% (TME 419), and the highest value 2.15%, UMUCASS 36. These protein values obtained are higher than those seen in other cassava genotypes (0.53%) [20] and(1.1%)[21], in root tubers. Lower protein values have been reported [22] for similar cassava genotype starches subjected to different treatments and processing conditions. Protein effects on starch propertiesdepend on its content with high protein negativelyaffecting the pasting properties [23].

According to published data, the fat content was 0.47% [21] to 0.53% in root tubers [20]. The cassava starches have a high fat content except for TME 419 with the lowest fat content (0.37%). However, the values were higher than those of other cassava genotype starches (0 to 0.01%) [24] and 0.03–0.15% [22]. Means were significantly different ($p \leqslant 0.05$) from one another. Increased lipid content improves starch texturalproperties and leads toviscosity stability hence improvingthe quality properties of starch [25].

Crude fibre ranged between the minimum value of 1.14% for TME 419 and the maximum values of 2.24% for UMUCASS 36. These values were higher than the range 1.10% [21] to 1.4% [26] for root tubers, but lower than sweet cassava (10.31%) and comparable with bitter cassava (3.09%) [20]. Increase in dietary fibre results in reduction in peakviscosity and increase in the pasting temperature [27].

Values for ash contents were lower than those of peeled bitter cassava (2.41% dry weight basis), and sweet cassava (4.44% dry weight basis) [20] but higher than those of root tubers (0.84%) [26] except for TME 419.There is a significant ($p \leqslant 0.05$) variation in the carbohydrate content among the starch samples. These carbohydrate content values presented here were higher when compared with fresh cassava (34.7%, edible portion) [20]. The results are higher than the value of 35% in root tubers [20].

Low protein, ash and fats and high carbohydrate contents of the cassava starch confirm with the nutritionalcomponent of cassava roots where carbohydrate is mainly the nutritional component of which 80% is starch [28, 29]. The result of the proximate composition of the cassava crackers is shown in Table2.

Table 2: Proximate composition of cassava crackers samples

Parameter %	TME419	UMUCASS 436	UMUCASS 438
Moisture	7.32 ^{a} ±0.01	6.28 ^{b} ±0.01	6.18 ^{c} ±0.01
Ash	0.11 ^{c} ±0.01	0.73 ^{b} ±0.01	0.75 ^{a} ±0.01
Crude fibre	1.06 ^{c} ±0.01	1.13 ^{a} ±0.01	1.10 ^{b} ±0.01
Protein	1.58 ^{b} ±0.01	1.41 ^{c} ±0.01	1.73 ^{a} ±0.01
Fat	0.36 ^{c} ±0.01	0.52 ^{b} ±0.01	0.84 ^{a} ±0.01
Carbohydrate	89.57 ^{a} ±0.02	89.42 ^{b} ±0.02	89.41 ^{b} ±0.02

[a,b,c,] means with different superscripts within the same row, are significantly different (P≤0.05). LSD = Least Significant Difference.

There was a significant difference (P≤0.05) in the moisture content of the crackers samples with TME 419 having the highest moisture content followed by samples UMUCASS36 and UMUCASS38. This variation in moisture content is also seen in the raw materials used. There was a decrease in the moisture content of the crackers sample in comparison to that of the cassava starch. This could be attributed to the losses during processing. The moisture content decreased after frying because the frying process caused moisture to evaporate from the samples. This phenomenon was supported by a previous work[30], which reported that during the frying process, heat is transferred from the hot oil to the product surface by convection, then from the surface to the center of the chip by conduction. Liquid water moves from the inside of the chip to the evaporation zone, leaving the surface as vapour. This is a good attribute for storage. Moisture determination is one of the most common tests in foods since the water content in foods has an important relationship between conservation and the chemical, physical and microbiological changes during the storage [31].

There was a significant difference between the samples, though there was a reduction in the ash content of the samples. This can be compared with the reported ash content range of biscuits (0.5% to 4.3%) [32], except for TME 419which had the least ash content.

The amount of crude fibre varied significantly (p<0.05) among the samples. It was lowest in TME 419 (1.06%) and highest in UMUCASS 36 (1.13%). Maintenance of internal distension for a normal peristaltic movement of the intestinal tract is the physiological role which crude fibre plays. It has been reported that a diet low in fibre is undesirable as it could cause constipation and that such diets have been associated with diseases of colon like piles, appendicitis and cancer [33].

Fats are vital to the structure and biological functions of cells and are used as alternative energy source. The fat content ranged from 0.36 to 0.83% with a slight decrease in the fat content as compared to the starch. In cracker production, the processing method affects the results of fat content, especially the draining time after frying. Prolonging the draining process after frying will improve the removal of oil from the crackers [34]. Several factors affect oil absorption in fried foods, including process conditions (temperature and residence time), the initial moisture content of the product, raw material composition, slice thickness, pre-frying treatment, degree of starch gelatinization prior to frying and oil quality[30]. UMUCASS 38 had a higher fat content than other samples.

UMUCASS 38 had the highest protein content followed by TME 419 and UMUCASS 36 respectively. There was a slight decrease in the protein content which can be attributed to losses during processing as a result of heat denaturation of protein. The decrease in the percentage of protein content after frying was relative, perhaps due to the increase in fat content after frying from the absorption of fat, also is the heat denature of protein. This occurrence is similar to crackers made from the big-eye fish *Brachydeuterusauritus*[35].Thereportalso stated that the protein content of fried crackers was lower than that of dried crackers because of the absorption of oil during frying. Although a slight increase in UMUCASS38 was observed.

There was an increase in the carbohydrate content of the crackers. Cooking has been reported to cause the granules to break down, soften the cellulose and makes the starch more available [36].The mineral composition of the starch samples are shown in Table 3.

Table 3: Mineral composition of cassava starch samples

Parameter (mg g^{-1})	TME 419	UMUCASS 36	UMUCASS38
Sodium	$4.21^{a} \pm 0.01$	$2.90^{c} \pm 0.01$	$3.16^{b} \pm 0.01$
Calcium	$2.16^{c} \pm 0.01$	$2.19^{b} \pm 0.01$	$2.75^{a} \pm 0.01$
Magnesium	$1.31^{b} \pm 0.01$	$1.21^{c} \pm 0.01$	$1.43^{a} \pm 0.01$
Iron	$1.28^{a} \pm 0.01$	$1.17^{b} \pm 0.01$	$1.08^{c} \pm 0.01$

[a,b,c,] means with different superscripts within the same row, are significantly different (P≤0.05). LSD = Least Significant Difference

The data indicate that Calcium and Sodium (Table 3) were the major mineral constituents in the flours. Calcium content ranged from 2.16 to 2.75 mg g^{-1}; and was highest in UMUCASS 38 and lowest in TME 419. All genotypes showed significant difference ($p \leqslant 0.05$) variability in Calcium. Starch from the cassava varieties differed significantly ($p \leqslant 0.05$) [21] 7.6 mg g^{-1} (fresh weight basis) of sodium content is reported[21]. Magnesium ranged from 1.21 to 1.43 mg g^{-1}. UMUCASS 38 and TME 419 were higher in Magnesium; however, all genotypes were significantly different in their Magnesium contents. [26] and [21] reported 30 mg/100 g fresh weight basis of Magnesium content.

The iron content ranged from 1.07 to 1.28 mg g^{-1}, which was markedly higher than the values reported on a fresh weight basis by [26] (0.23 mg g^{-1}), and 0.7 mg g^{-1}[20] and 1.7mg g^{-1}[21].

The result of the mineral content of the cassava crackers is shown in Table 4.

Table 4: Mineral composition of cassava crackers samples

Parameter (mg g^{-1})	TME 419	UMUCASS 36	UMUCASS38
Sodium	$3.59^{a} \pm 0.01$	$2.87^{b} \pm 0.01$	$2.87^{b} \pm 0.01$
Calcium	$2.00^{c} \pm 0.01$	$2.02^{b} \pm 0.01$	$2.61^{a} \pm 0.01$
Magnesium	$0.24^{a} \pm 0.01$	$0.24^{a} \pm 0.01$	$0.24^{a} \pm 0.00$
Iron	$0.62^{a} \pm 0.01$	$0.56^{b} \pm 0.03$	$0.63^{a} \pm 0.01$

^{a,b,c,} means with different superscripts within the same row, are significantly different ($P \leq 0.05$). LSD = Least Significant Difference

The major mineral content of the cassava crackers was found to be Sodium and Calcium with TME 419 having the highest sodium content of 3.59 mg/g and the least value for calcium (2.01 mg/g). The sodium content of UMUCASS 36 and 38 were significantly ($P \leq 0.05$) the same and differed from TME 419. The decrease in the sodium content of the samples can be attributed to processing loss, leaching during steam cooking and frying. The sodium content of the samples is lower than that of some biscuits 123.8 ± 0.6 mg% (chocolate wafer) to 1483 ± 17 mg% ham flavoured biscuits [32]. Reducing dietary sodium intake is a recognized method for treating and preventing hypertension for some individuals [37].

The Calcium content of the crackers ranged from 2.00 mg/g (TME 419) to 2.60mg/g (Sample 438) with Sample 438 having the highest calcium content and differing significantly from Sample 419 and Sample 436 which had no significant difference. Calcium is essential for bone formation in children. Values obtained in this study compare favourably with (0.10% fresh weight basis) [21].

It has been reported that calcium and magnesium contents in different kinds of biscuit ranged from 204.3 to 879.2 µg g^{-1} and from 172.9 to 595.3 µg g^{-1}, respectively [38].

The iron content ranged from 0.56mg/g to 0.63 mg/g, which was higher than the values(0.23 mg g^{-1}), reported on a fresh weight basis [26].UMUCASS 38 had the highest calcium level (0.63mg/g) and is significantly the same with TME 419. UMUCASS 36 had the least iron content (0.56 mg/g). The mean concentrations of iron in the different crackers in this study were lower than the upper limits (36.2 µg $g^{-1)}$ reported by previous work[39]. The result of the β-carotenoid composition of the starch and crackers are shown in Table 5

Table 5:β-carotene(µg) composition of cassava starch and crackers

Cassava Sample	starch	crackers
TME 419	-	-
UMUCASS 36	3.13±0.01	1.61± 0.01
UMUCASS 38	2.26±0.01	1.81± 0.04

The yellow cassava varieties UMUCASS 36 and UMUCASS 38 had significantly higher quantities of carotenoids than the white variety (TME 419) which had none and this may confer antioxidant potentials on these yellow cassava varieties. This can be attributed to the composition of the cassava roots as UMUCASS 36 and UMUCASS 38 are among the vitamin A fortified cassava varieties [6, 7]. The reduction in the vitamin A content UMUCASS 36 and UMUCASS 38 could be as a result of loses during processing as most of the yellow carotenoid content of the roots was bleached off during starch extraction.

The decrease in the β-carotenoid content of the samples can be said to result from the starch extraction and production process. A reduction in the β-carotene content of a standard solution at 98°C for 60 min was previously observed[40].

Cassava crackers from UMUCASS 36 and UMUCASS 38 were found to contain 1.61µg and 1.81µg respectively of β-carotene. The difference in carotenoid content of the starch and crackers observed may be as a result of losses during processing. It has been observed [41] that as much as 41% of carotenoid content of orange flesh sweetpotato was lost during dehydration and boiling of the food.Table 6 shows the hydrogen cyanide contents of the cassava starch and crackers.

Table 6: HCN(mg/100g) composition of cassava starch and crackers

Sample	starch	crackers
TME419	$2.14^{a} \pm 0.01$	$0.23^{a} \pm 0.00$
UMUCASS 36	$2.07^{c} \pm 0.01$	$0.15^{c} \pm 0.00$
UMUCASS 38	$2.11^{b} \pm 0.01$	$2.11^{b} \pm 0.01$

^{a,b,c,} means with different superscripts within the same row, are significantly different (P≤0.05). LSD = Least Significant Difference

The residual cyanide levels in the starch of all the cassava varieties investigated ranged from 2.07 to 2.14 % with TME 419 having the highest hydrogen cyanide content and UMUCASS 36 having the least content of hydrogen cyanide which fall within the acceptable upper limits of 10 mg HCN equivalent/Kg dry weight recommended by FAO in 1988 [42] for safe cassava products. The low cyanide levels of the flours of all the cassava varieties investigated is attributed to their method of processing which employed both grating to mash, washing and decanting and oven drying as both methods of processing have been reported to reduce the cyanide contents of cassava [43, 44]. The implication is that the usage of the starch made from these varieties of cassava for human consumption may not confer any toxic effect to the user.

A decrease in the concentration of hydrogen cyanide in the samples was observed and this could be attributed to the crackers production process, bringing the hydrogen cyanide content to an acceptable ratio. Initial processing of raw samples reduced theirhydrogen cyanide level during extrusion cooking [45].Hydrogen cyanide is volatile.The new yellow root variety UMUCASS 36 and UMUCASS 38 had a lower hydrogen cyanide level (0.15 mg/100g and 0.16 mg/100g respectively) than the white root variety TME 419 (0.23 mg/100g).

This variation can also be attributed to the improvement in lowering hydrogen cyanide content of the new yellow varieties [6]. The cyanide content of the crackers falls within the acceptable limit of 10 mg HCN equivalent/Kg dry weight recommended by FAO in 1988 for safe cassava products[42].

Results of the sensory evaluation of the cassava crackers sample is shown in Table 7.

Table 7: Sensory evaluation of cassava crackers sample

Parameter	Umucass 36	TME419	Umucass438	control
Appearance	$7.30^{b} \pm 1.37$	$7.27^{b} \pm 1.11$	$7.30^{b} \pm 1.32$	$8.00^{a} \pm 1.11$
Texture	$7.27^{ab} \pm 1.36$	$6.80^{b} \pm 1.71$	$6.60^{b} \pm 1.59$	$7.67^{a} \pm 1.15$
Taste	$6.83^{a} \pm 1.29$	$6.83^{a} \pm 1.76$	$6.63^{a} \pm 1.47$	$7.10^{a} \pm 1.21$
Crispiness	$7.07^{a} \pm 1.57$	$6.77^{a} \pm 2.03$	$6.93^{a} \pm 1.60$	$7.17^{a} \pm 1.76$
General acceptability	$7.47^{a} \pm 1.31$	$6.87^{a} \pm 1.70$	$6.93^{a} \pm 1.36$	$7.47^{a} \pm 1.52$

^{a,b,c,} means with different superscripts within the same row, are significantly different (P≤0.05). LSD = Least Significant Difference

The appearance of the control sample (Prawn crackers) was preferred and differed significantly (P≤0.05) in appearance from the other experimental samples which appeared significantly the same.

The texture of the control sample (Prawn crackers) and UMUCASS36 was preferred, and had no significant difference,though they differed significantly (P≤0.05) from UMUCASS 38 and TME 419 which are significantly the same.

On the basis of general acceptability, all the samples were generally accepted by the panellists. There was no significant difference (P≤0.05) in the acceptability scores of the sample. Also for the taste and crispiness of the samples, there was no significant difference.

IV. Conclusion

This work has shown that food quality starch can be obtained from the newly improved variety of cassava (UMUCASS 36 (TMS 01/1368), and UMUCASS 38 (TMS 01/1371) with some quantity of Vitamin A content. The starch obtained can be used in the same capacity as that of TME 419 as well as other cassava varieties for processing and production of cassava crackers and prawn crackers and other forms of extruded snacks.

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