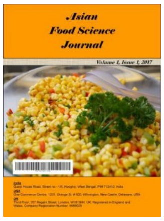

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Evaluation of the Physicochemical, Pasting and Organoleptic Properties of Fufu Flour Produced from Different Varieties of Yellow Root Cassava (*Manihot esculenta* Crantz)

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Authors' contributions

This work was carried out in collaboration between all authors. Author NEO designed the study, wrote the protocol and wrote the first draft of the manuscript. Author CLA managed some of the literature searches and the analyses of the study and Author CJO wrote the last draft and tidied the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The study examined the physicochemical, pasting and organoleptic properties of fufu flour produced from three varieties (TMS 01/1368 (UMUCASS 36), TMS 01/1371 (UMUCASS 37), TMS 01/1412 (UMUCASS 38) and TMS 30570 (control)) of yellow root cassava (*Manihot esculenta* Crantz).

Study Design: Completely Randomized Design was used to achieve this study.

Place and Duration of Study: The study took place at the Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike between January and September 2017.

Methodology: The freshly harvested roots of the experimented cultivars, were obtained from Cassava Programme of National Root Crops Research Institute, Umudike, Abia State, Nigeria. These freshly harvested roots of the experimented cultivars, TMS 01/1368 (UMUCASS 36), TMS

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01/1371 (UMUCASS 37), TMS 01/1412 (UMUCASS 38) and TMS 30570 (control) were obtained from Cassava Programme of National Root Crops Research Institute, Umudike, Abia State, Nigeria. Roots of each variety were processed into fufu flour, which was subsequently made into fufu dough. The determinations of functional and pasting properties were carried out on the fufu flour and proximate, vitamin and sensory analyses were carried out on the fufu dough.

Results: Values of functional properties of the fufu flour ranged from 0.66 g/ml to 0.73 g/ml (Bulk density), 2.21 g/gsample to 3.42 g/gsample (Oil absorption capacity), 1.61 g/g sample to 4.01 g/g sample (Water absorption capacity), 42.6% to 47.6 % (Emulsion capacity), 55.67ºC to 68.67ºC (Gelation temperature),1.13s to 1.24 s (Gelation time). The proximate composition values ranged from 74.54% to 75.47% (Dry matter), 24.53% to 25.46% (Moisture content), 1.83% to 2.37% (Crude protein), 0.74% to 1.02% (Crude fat), 1.52% to 1.81% (Crude fibre), 0.53% to 0.99% (Ash), 68.94% to 70.20% (Carbohydrate) and 291.73 kCal to 295.97 kCal (Energy value). The beta carotene and ascorbic acid values in the fufu ranged from 0.26 mg/100 g to 2.92 mg/100g and 8.8 mg/100 g to 22.01 mg/100 g, respectively. The range of scores for the degree of likings for the fufu dough were 6.28 - 6.40 for colour, 6.08 - 7.28 for hand feel, 6.16 - 7.16 for mouth feel, 5.68 - 6.84 for mouldability, 6.32 - 7.64 for swallowability, 6.32 - 7.32 for odour, 6.64 – 6.92 for flavour and 6.88 - 7.76 for general acceptability. Pasting properties ranged from 92.00 RVU to 2426 RVU (peak viscosity), 76.01 RVU to 2084 RVU (trough), 16.01 RVU to 342.00 RVU (breakdown), 95.01 RVU to 2384 RVU (final viscosity), 19.01 RVU to 300 RVU (setback viscosity), 5.67 min to 6.88 min (peak time) and 50.21ºC to 84.81ºC pasting temperature.

Conclusion: All the samples analyzed in this work were all generally accepted by the 25 panellists that carried out the sensory evaluation, and sample 103 (Umucass 38) can be used in place of the control sample to prepare a fufu with a more acceptable sensory characteristics than the control sample.

Keywords: Physicochemical; pasting; organoleptic properties; fufu flour; yellow root cassava.

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz*)* is a staple food crop in tropical Africa and a vital source of calories to about 500 million to 1 billion people in tropical countries [1]. The edible part of flesh cassava root is low in other nutrients but high in carbohydrate and small amounts of calcium, phosphorus and vitamin C [2]. It has been reported to contain 32-35% carbohydrate, 2-3% protein, 75-80% moisture, 0.1% fat, fibre, 1.5%- 4% and 0.70-2.50% ash [2]. In Nigeria, Cassava is used mainly for food, especially in the form of garri, lafun, fufu and starch. Its derivatives are applicable in many types of products such as foods, confectionary, sweeteners, glues, plywood, textiles, papers, biodegradable products, monosodium glutamate, ethanol, raw materials in livestock feed and drugs. However, these products are tradable in the international market.

Factors which affect the processing of cassava roots into different products like garri, lafun and fufu, which are consumed widely in Nigeria and other West African countries include custom, local preference and available technology [3].

Fufu is a fermented wet– a paste made from cassava. It ranks next to garri as an indigenous food of most Southern Nigerians [4].

The persistent rise in the population of Nigeria and the world at large will definitely increase demand of Cassava, hence the introduction of high breeds of cassava by National Root Crops Research Institute, Umudike and the International Institute for Tropical Agriculture (IITA), Ibadan. Among the high breeds of Cassava is the yellow root cassava, which is yellow fleshed. Three yellow root cassava varieties IITA-TMS-IBA011368 (UMUCASS 36), IITA-TMS-IBA1371 (UMUCASS 37) and IITA-TMS-IBA011412 (UMUCASS 38) are grown under the Harvest Plus Project [5,6] in Nigeria because of their high concentrations of Beta-carotene.

Yellow cassava is similar to ordinary varieties of cassava (*Manihot esculentum*), but it has a yellow flesh inside the root, which is generally white in ordinary varieties [6].

A major challenge common with cassava is the post-harvest reduction in quality, which renders it unacceptable as food. Deterioration causes the quick consumption or processing of cassava shortly after harvest.

Vitamin A deficiency is a major problem, in Africa. Nigeria sees a prevalence of vitamin A deficiency in about 20% of pregnant women and 30% of children under five [7]. This problem can be overcome if cassava that naturally contains high quantity of vitamin A is introduced into their diet. Since cassava is a major food staple and commonly consumed as fufu, yellow cassava when used to produce fufu shows great potential to alleviate Vitamin A deficiency in Africa. Moreover, the new yellow varieties have high yields and are resistant to many pests and diseases.

Fufu is processed by steeping whole or cut and peeled cassava roots in water for fermentation to take place for a maximum of three days. This depends on ambient temperature. It is stirred in boiling water to form a dough and eaten with flavoured sauces.

However, one major challenge associated with processed fufu is its odour which may be undesirable to many people and has reduced the potential of the product. Furthermore, the beneficial food and pharmaceutical uses of flours from plants directly depend on their functional and pasting properties [8]. Functional properties affect the physical behaviour of food or its ingredient during processing, preparation and storage, thus changing the texture, consumption importance, appropriateness and sensory qualities of the food [9]. The objective of this study was therefore to study the physicochemical and pasting properties of fufu flour and the vitamin A content and organoleptic properties of the fufu dough produced from three varieties of yellow root cassava, compared to a popular white variety.

2. MATERIALS AND METHODS

2.1 Sources of Raw Materials

Freshly harvested roots of the four experimental cassava cultivars, TMS/01/1368 (UMUCASS 36), TMS/01/1371 (UMUCASS 37) and TMS/01/1412 (UMUCASS 38) and the control, TMS 30570 were gotten from the Cassava Programme of National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria.

2.2 Production of Fufu Flour

The method of Aniedu and Oti [10] was employed (see Fig. 1) to process the cassava roots into fufu flour. A quantity of 10 kg fresh roots from each of the cassava varieties was used for the production of the fufu. Roots of each variety were peeled, cut into small sizes of about 7 cm average size and washed. The roots were soaked in clean water for 48 h. The fermented roots were grated into cassava mash. The mash was covered for 24 h for fermentation to take place. The mash was pressed in a clean bag to remove water. The cake mash was disintegrated and dried in an oven (Shellab Model VWR=1370G) at 77ºC. The dried cassava granules were milled with a hammer mill (Tiger extruder, 6.5 horse power) and sieved using a 250 µm mesh size sieve into the fine flour, packaged in a transparent polyethene bag and stored for further use.

2.3 Functional Properties Analysis

2.3.1 Water/ Oil absorption capacity

This was determined as described by Onwuka [11].

2.3.2 Bulk density

The method of Matil [12] was used.

2.3.3 Emulsion capacity

The method described by Okezie and Bello [13] was used.

2.3.4 Gelatinization temperature and time

The method described by Onimawo and Egbekun [14] was adopted.

2.3.5 Gelatinization temperature

The method described by Onimawo and Egbekun [14] was adopted.

2.4 Proximate Analysis

Proximate compositions of the fufu samples were determined in duplicate using standard methods.

2.4.1 Moisture Content Determination

Moisture content of the samples was determined according to the gravimetric method of AOAC [15].

2.4.2 Fat Content Determination

Fat content of the test samples was determined by the continuous solvent extraction method using a Soxhlet extractor's method of James [16].

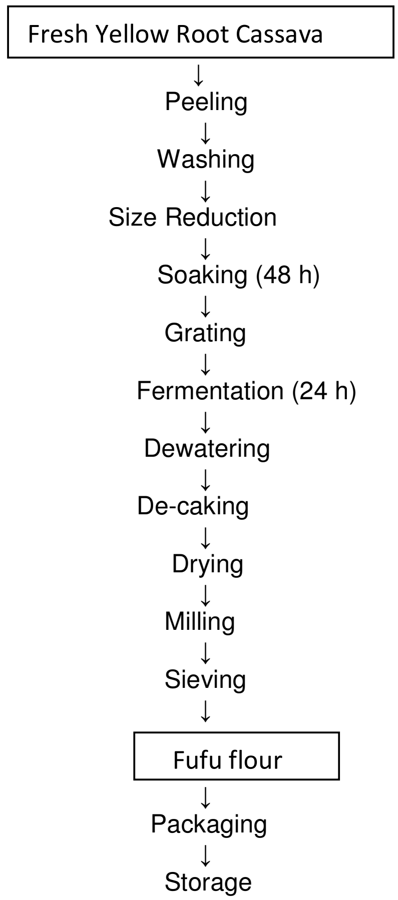

Fig. 1. Flow chart for the production of fufu flour [10]

2.4.3 Crude fibre determination

AOAC [15] method was used in the crude fibre determination.

2.4.4 Ash content determination

Ash content of the test samples was determined by the method of AOAC [15].

2.4.5 Crude protein determination

The crude protein content of the test sample was determined by the Kjeldahl method reported by Pearson [17].

2.5 Vitamin Analysis

2.5.1 Vitamin A determination

This was determined using the method described by Delia et al. [18].

2.5.2 Determination of ascorbic acid (Vitamin C)

The method described by AOAC [15] was used.

2.6 Pasting Properties Analysis

Pasting properties of the fufu flour samples was determined with the aid of a Rapid Visco Amylograph (RVA Model 3C, Newport Scientific PTY Ltd, Sydney) as described by Sanni et al. [4]. Parameters that were determined include peak viscosity, final viscosity, trough, peak time (min) and pasting temperature,while set back viscosity (RVU) and breakdown (RVU) were calculated.

2.7 Sensory Evaluation

Twenty-five panellists were randomly selected from the staff and students (between the ages of seventeen and fifty years) of Michael Okpara University of Agriculture, Umudike. The panellists were trained on how to go about the exercise. Quality attributes such as colour, hand feel, mouldability, odour, flavour and general acceptability of the products were scored on a 9-point hedonic scale. The degree of likeness was expressed as follows; Like extremely 9, like very much 8, like moderately 7, like slightly 6, neither like nor dislike 5, dislike slightly 4, dislike moderately 3, dislike very much 2, dislike extremely 1.

2.8 Statistical Analysis

Data got from the analyses was subjected to statistical analysis of variance (ANOVA) of a completely randomized design, using SPSS (statistical package for social sciences) version 20 for personal computers. While treatment means was separated using Duncan multiple range test at 95% confidence level (P<0.05).

3. RESULTS AND DISCUSSION

3.1 Functional properties of the fufu flour samples from TMS/01/1368 (UMUCASS 36), TMS/01/1371 (UMUCASS 37), TMS/01/1412 (UMUCASS 38) and TMS 30570

3.1.1 Bulk density

The bulk density values ranged from 0.67 g/ml to 0.73 g/ml in which Umucass 37 had the lowest bulk density value (Table 1) but was not significantly different (P=0.05) from Umucass 36. The control sample (TMS 30570) had the highest bulk density value of 0.73 g/ml. The value range compares favourably with result of Etudaiye et al. [19] on fufu processed from cassava mosaic disease-resistant varieties.

3.1.2 Water absorption capacity

The highest value of water absorption capacity (Table 1) was observed in Umucass 38, while Umucass 36 had the lowest water absorption value. The result is similar with the observation of Sanni et al. [20] on standard for cassava products and guideline for export.

3.1.3 Oil absorption capacity

The oil absorption capacity values ranged from 2.21 to 3.43 g/ml. The lowest value was observed in the sample Umucass 37 while the sample Umucass 36 had the highest oil absorption value.

3.1.4 Emulsion capacity

The values of the emulsion capacity of the various samples ranged from 42.60 to 47.60% in which the control sample had the lowest emulsion capacity but was not significantly different (P=0.05) from the sample Umucass 38. The sample Umucass 37 had the highest emulsion capacity value.

3.1.5 Gelatinization temperature and time

The gelatinization temperature values ranged from 63.10ºC to 68.67ºC. The highest gelatinization temperature value was observed in the sample Umucass 38 but with lowest gelatinization time (1.13s). While the sample Umucass 37 had the lowest value of 55.67 g/ml, hence took the longest duration to form gel (1.24s). This may be attributed to the compositional differences especially with regards to their starch content. High gelation gives a good formulation to food.

3.2 Proximate Composition of the Fufu Samples

The result of the proximate composition of the fufu samples produced from different varieties of cassava roots is presented in Table 2.

3.2.1 Moisture content

The highest moisture level was observed in the sample Umucass 36 with 25.46% moisture level. The lowest moisture level was observed in the control sample, TMS 30570 with a moisture of 24.53%. Generally, the low moisture level is an indication of a good stable shelf life if packaged and stored [21].

3.2.2 Crude protein

The highest protein value was observed in the sample Umucass 38. This shows that Umucass 38 variety could be a rich protein source probably due to the presence of higher amino acids in the variety and therefore can help to reduce protein-energy malnutrition, especially among women and children. The lowest protein value (1.83%) was observed in the control sample.

3.2.3 Crude fat and fibre

The fat content values ranged from 0.82 to 0.74% in which the control sample (TMS 30570) had the lowest fat value (0.74%) while the sample Umucass 38 had the highest fat value but with lowest fibre value of 1.52%. The highest fibre value was observed in the sample Umucass 37 with 1.18%. Diet low in crude fibre is undesirable and may cause constipation and that such diet has been associated with disease of colon like piles, appendicitis and cancer [22]. It is recommended that an average adult should consume about 18-32 g percentage fibre daily [23]. Therefore the sample Umucass 37 having the highest fibre value is recommended because it shows tendencies of facilitating bowel movement.

3.2.4 Ash content

The ash level shown in Table 2 ranged from 0.53 to 0.99% in which the sample Umucass 38 had the lowest ash value while the sample Umucass 37 had the highest ash value.

3.3 Vitamin Composition of the Fufu Samples

The result of the vitamin contents determination on the various fufu samples is presented in Table 3. The result showed that significant differences (P=0.05) exist in the vitamins A and C contents of the samples. The carotenoids and vitamin C contents of Umucass 36, Umucass 37 and Umucass 38, were all observed to be higher than the control sample (TMS 30570). The highest concentration of vitamins A and C was observed in the sample Umucass 38. The mean values ranged from 0.26 to 2.92 mg/100g (vitamin A) and 8.81 to 22.01 g/mg (Vitamin C). Abiodun et al. [24] reported that losses of vitamins occur during processing operations such as soaking and fermentation due to leaching. The result indicated that Umucass 38 could be a rich source of vitamin A and ascorbic acid. The high content of vitamins could be as a result of high carotenoid content in the variety as carotenoid is a precursor to vitamin A [24].

3.4 Pasting Properties of the Fufu Flour

The result of the pasting properties of the various fufu flour samples is shown in Table 5. The result showed the peak viscosity to range from 92 to 2426 RVU in which the sample Umucass 38 was noticed to have the lowest peak value of 92 RVU, while the control (TMS 30570) had the highest peak viscosity value of 2426 RVU. The differences observed in the peak viscosity could be due to different rates of water absorption and swelling of starch granules of these flours during heating [25]. Significant difference (P=0.05) existed in trough property of the various varieties of cassava investigated. The trough mean values ranged from 76 to 2084 RVU in which the sample Umucass 38 was noticed to have the lowest trough value while the sample TMS 30570 had the highest trough value of 2084 RVU. The trough mean value range observed in the present study was lower than 1477 to 4405 RVU earlier reported by Olapade et al. [26] on fufu flour supplemented with Bambara flour. There were significant differences (P=0.05) in the breakdown property of the different flour samples of fufu. The control sample (TMS 30570) was seen to have highest breakdown mean value (342RVU) while the sample Umucass 38 had the least value of 16 RVU. The breakdown viscosity is reported to be a measure of the degree of starch granules disintegration or paste stability during heat application [26]. Hence, the higher the breakdown in viscosity, the lower the ability of the sample to withstand heating and shear stress during cooling. Final viscosity is the parameter most often used to determine a particular starch-based sample quality. It gives an idea of the ability of a material to gel after cooking [26]. The control sample (TMS 30570) was observed to have the highest final viscosity mean value (2384RVU) followed by the sample Umucass 36 (1492RVU) while the sample Umucass 38 had the lowest value of 95 RVU final viscosity. The final viscosity values got in the present study were greater than those earlier reported by Nwabueze and Anirudh [27] on cassava flours from mosaic disease-resistant varieties. Fufu flours with high viscosities showed that the associative forces between the starch molecules are relatively weak. The water molecules have the ability to penetrate their starch granules much easier, and the granular swell enormously leading to weakening of associated forces which in turn makes them susceptible to breakdown. The long cohesive nature of the cassava paste [26] is attributed to breakdown.

There are significant differences in the setback property of the various samples. The control sample (TMS 30570) was observed to have the highest set back value (300 RVU), while the sample Umucass 38 had the least value.

Low set back of fufu paste indicates high stability. The values obtained were quite high except for fufu paste obtained from Umucass 38. Hence, fufu paste obtained from the sample Umucass 38 with set back value of 19.01 RVU will be most stable after cooking. Peak time is the time at which the viscosity peaks. It measures the time it takes for the fufu pastes to gel during cooking. Peak time of the fufu paste obtained from the various varieties ranged from 5.67 to 6.88 min, which was obtained at a temperature range of 50.21 to 84.81ºC.

Table 1. Functional properties of the fufu flour samples

Sample	Bulk density (g/ml)	Oil absorption capacity (g/ml)	Water absorption capacity (g/ml)	Emulsion capacity (g/ml)	Gelatinization temperature (ºC)	Gelatinization time (s)
Umucass 36	0.68^{b}±0.01	3.42^{a}±0.03	1.61^{d}±0.01	44.19^{b}±0.01	63.10^{c}±0.10	1.21^{b}±.02
Umucass 37	0.67^{b}±0.01	2.21^{d}±0.02	3.62^{b}±0.02	47.60^{a}±0.01	55.67^{d}±0.58	1.24^{a}±0.01
Umucass 38	0.66^{c}±0.01	2.81^{b}±0.01	4.01^{a}±0.01	42.62^{c}±0.04	68.67^{a}±0.58	1.13^{d}±0.01
TMS 30570	0.73^{a}±0.01	2.29^{c}±0.01	1.76^{c}±0.01	42.60^{c}±0.17	66.67^{b}±0.58	1.15^{c}±0.01

Means in the same column with different superscript are significantly different (P<0.05)

Table 2. Proximate composition of the fufu samples

Sample	Dry matter (%)	Moisture (%)	Protein (%)	Fat (%)	Crude Fiber (%)	Ash (%)	Carbohydrate (%)	Energy value (%)
Umucass 36	74.54^{d}±0.04	25.46^{a}±0.04	2.14^{b}±0.02	0.82^{b}±0.01	1.73^{b}±0.03	0.91^{b}±0.01	68.94^{c}±0.02	291.73^{c}±0.03
Umucass 37	75.13^{b}±0.03	24.87^{c}±0.03	2.37^{a}±0.02	0.76^{c}±0.01	1.81^{a}±0.01	0.99^{a}±0.01	69.20^{bc}±0.01	293.15^{bc}±0.11
Umucass 38	74.76^{c}±.05	25.24^{b}±0.05	2.01^{c}±0.02	1.02^{a}±0.01	1.52^{d}±0.02	0.53^{d}±0.02	69.68^{ab}±0.03	295.97^{a}±0.25
TMS 30570	75.47^{a}±0.06	24.53^{d}±0.06	1.83^{d}±0.02	0.74^{c}±0.03	1.67^{c}±0.01	0.70^{c}±0.02	70.20^{a}±0.57	294.77^{ab}±2.69

Means in the same column with different superscript are significantly different (P<0.05)

Table 3. Vitamin contents of the fufu samples

Sample	Vitamin A (mg/100 g)	Vitamin C (mg/100 g)
Umucass 36	2.07^{c}±0.02	17.62^{c}±0.01
Umucass 37	2.21^{b}±0.02	19.85^{b}±0.05
Umucass 38	2.92^{a}±0.02	22.01^{a}±0.02
TMS 30570	0.26^{d}±0.01	8.81^{d}±0.01

Means in the same column with different superscript are significantly different (P<0.05)

Table 4. Sensory evaluation of the fufu samples

Sample	Colour	Hand feel	Mouth feel	Mouldability	Swallowability	Odour	Flavour	Acceptability
Umucass 36	6.28^{a}±1.79	6.88^{ab}±1.64	7.16^{a}±1.21	6.84^{a}±1.07	7.08^{ab}±1.87	7.24^{a}±1.76	6.88^{a}±1.72	7.44^{a}±1.26
Umucass 37	6.40^{a}±1.73	7.24^{a}±1.23	6.92^{a}±1.66	6.68^{a}±1.62	6.92±^{ab}1.47	6.32^{a}±1.97	6.64^{a}±1.58	7.20^{a}±1.61
Umucass 38	7.16^{a}±1.46	7.28^{a}±1.46	7.12^{a}±1.79	6.76^{a}±1.76	7.64^{a}±1.35	7.32^{a}±1.49	6.84^{a}±1.68	7.76^{a}±1.36
TMS 30570	6.32^{a}±1.84	6.08^{b}±1.85	6.16^{a}±2.01	5.68^{b}±1.89	6.32^{b}±1.91	6.88^{a}±1.62	6.92^{a}±1.53	6.88^{a}±1.59

Means in the same column with different superscript are significantly different (P<0.05)

Table 5. Pasting properties of the fufu flour samples

Sample	Peak 1 (RVU)	Trough 1 (RVU)	Break down (RVU)	Final Viscosity (RVU)	Setback(RVU)	Peak time(min)	Pasting temperature (ºC)
Umucass 36	1190.01^{c}±0.01	997.01^{c}±0.01	193.01^{b}±0.01	1075.02^{c}±0.02	78.01^{c}±0.01	6.08^{c}±0.01	82.24^{b}±0.01
Umucass 37	1546.01^{b}±0.01	1400.00^{b}±0.01	146.01^{c}±0.01	1492.01^{b}±0.01	92.01^{b}±0.01	6.14^{b}±0.01	82.25^{b}±0.01
Umucass 38	92.00^{d}±0.01	76.01^{d}±0.01	16.01^{d}±0.01	95.01^{d}±0.01	19.01^{d}±0.01	6.88^{a}±0.01	50.21^{c}±0.01
TMS 30570	2426.02^{a}±0.02	2084.01^{a}±0.01	342.00^{a}±0.00	2384.0^{a}±10.01	300.01^{a}±0.01	5.67^{d}±0.01	84.81^{a}±0.01

Means in the same column with different superscript are significantly different (P<0.05)

3.5 Sensory Evaluation of the Fufu Samples

The result of the sensory evaluation of the various fufu samples is presented in Table 4. The result showed that, there were no significant difference (P=0.05) in the colour, mouth feel, odour, and flavor of the various samples investigated. Also all the samples studied were generally accepted by the 25 panelists who carried out the sensory evaluation as there was no observed significant difference in the general acceptability of the samples. The mean values ranged from 6.28 to 6.40 (Colour), 6.16 to 7.16 (Mouth feel), 6.88 to 7.32 (Odour), 6.64 to 6.92 (Flavour) and 6.88 to 7.20 (General acceptability). However, there were slight significant differences (P=0.05) in the hand feel, mouldability and swallowability. The hand feel mean values ranged from 6.08 to 7.28 in which the control sample (TMS 30570) had the lowest hand feel value, while the sample Umucass 38 had the highest value of 7.28. The sample Umucass 38 was seen to have the highest mouldability and swallowability values, while the control sample (TMS 30570) had the least values. The mean values ranged from 5.68 to 6.84 (mouldability) and 6.32 to 7.64 (Swallowability). This observation suggests that Umucass 38 can be used in place of the control sample to prepare a fufu with a more acceptable sensory characteristic than the control sample. The sample Umucass 38 was also observed to have higher vitamins A and C, higher fat, energy value and protein value therefore making it a perfect replacement for the control sample.

4. CONCLUSION AND RECOMMENDATION

All the samples analyzed in this work were all generally accepted by the 25 panellists that carried out the sensory evaluation. The significant difference did not exist in the mouth feel, odour and flavour. There were significant differences (P<0.05) in the proximate composition of the various samples. The result showed that the control sample had the highest dry matter level with lowest moisture content giving a more storage advantage. However, Umucass 38 was observed to have the highest protein, fat, and energy level among the samples analyzed. It also showed higher mouldability and swallowability as judged by the 25 panellists. Umucass 38 was also observed to have to the highest vitamins A and C level. Vitamin A helps proper vision, while Vitamin C is thought to help protect the oesophagus, oral cavity, stomach and pancreases and possibly the cervix, rectum and breast from cancer and also acts as an anti-oxidant. This observation suggests that sample 103 (Umucass 38) can replace the control sample to prepare a fufu with a more acceptable sensory characteristics than the control sample. Sample 103 (Umucass 38) also had higher vitamins A and C, higher fat, energy value and protein value, therefore, is recommended to be a perfect replacement for the control sample.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sornyotha S, Kyu KL, Ratanakhanokchai K. An efficient detoxification process of cassava starch by plant cell wall degrading enzymes. Journal of Bioscience and Bioengineering. 2010;109:9-14.
2. Oluwole OB, Olatunji OO, Odunfa SA. A process technology for conversion of dried cassava chips into garri. Nigerian Food Journal. 2004;22:65-73.
3. Hahn SK, Keyser J. Cassava: A basic food for Africa. Outlook Agriculture. 1985;4:95-100.
4. Sanni LO, Kososko SB, Adebowale AA, Adeoye RJ. The influence of palm oil and chemical modification on the pasting and sensory properties of fufu flour. International Journal of Food Properties. 2009;7:229-237.
5. Nascimento PO, Fernandes N, Mauro M, Kimura M. Beta carotene stability during drying and storage of cassava and sweet potato. International Journal of Food Properties. 2007;7(2):229-237.
6. Egesi C. New improved cassava varieties released in Nigeria. Integrated Breeding Platform. 2011;6:17-21.
7. WREN media. Green light for yellow cassava; 2012.
   (Retrieved Aug 17, 2014)
8. Ogungbenle HN, Oshodi AA, Oladimeji MO. Effect of salts on the functional properties of beniseed (*Sesanum radiatum*) seed flour. International Journal of Food Science Nutrition. 2002;53:1-5.
9. Otegbayo BO, Samuel FO, Alalade T. Functional properties of soy-enriched

tapioca. African Journal of Biotechnology. 2013;12(22):3583-3589.

10. Aniedu C, Oti E. Cassava based recipes. Extension bulletin. National Root Crops Research Institute (NRCRI), Umudike. Royal Bird Productions. 18, Nwaturuocha street, Ikenegbu Layout, Owerri, Imo State. 2008;12.
11. Onwuka GI. Food analysis and instrumentation. Theory and practice. Naphthali prints. A division of HG support Nigeria LTD. H6 Adentiyi Jones close Surulere, Lagos, Nigeria; 2005.
12. Matil KF. Functional requirements and protein for food. American Oil Chemical Society. 1971;48:477-480.
13. Okezie BO, Kosikowiki FV. Teactability and functionability of protein. 1981;3-11.
14. Onimawo IA, Egbukun MK. Comprehensive food Science and nutrition. Ambik publishers, Benin city. 1998;62-69, 81-88,96-130,193-220.
15. AOAC. Official methods of analysis 15th Edition. Association of Official analytical Chemists. Arlington, Virginia, USA 2. 1990; 142-202.
16. James CS. Analytical chemistry of foods. Blackie academics and professional. Journal of Food Science and Nutrition. 1995;7:217-230.
17. Pearson O. Chemical analysis of foods. New York: Chemical Publishing Co. 1976; 15-24.
18. Delia B, Rodriguez-Amaya, Kimura M. Harvestplus handbook for carotenoid analysis (First ed.). Washington, D.C. and Cali: IFPRI and CIAT. 2004;(Chapter 2):58.
19. Etudaiye HA, Nwabueze TU, Sanni LO. Quality of fufu processed from cassava mosaic disease (CMD) resistant varieties. African Journal of Food Science. 2008; 3(3):061-067.
    Available:http://www.academicjournals.org/ajfs
    (ISSN 1996-0794 ©2009 Academic Journal)
20. Sanni LO, Maziya Dixon B, Akanya CI, Alaya Y, Egwuonwu CV, Okechukwu RU, Ezedinma C, Akoroda M, Lemchi J, Ogbe F, Okoro E, Tarawali G, Mkumbira J, Patino M, Semakula G, Dixon A. Standard for cassava products and guidelines for export. IITA, Ibadan, Nigeria. 2005;11-39.
21. Sefa-Dedeh S, Saalia FK. Extrusion of maize – cowpea blends in a modified oil expeller. Journal of Food and Agriculture. 1997;73:160-168.
22. Ayoola PB, Adeyeye A. Effect of heating on the chemical composition and physico-chemical properties of *Arachis hypogaea* (Groundnut) seed flour and oil. Pakistan Journal of Nutrition. 2010;9(8):751-754.
23. Muller HG. An introduction of tropical food science. Cambridge University Press, Cambridge. 1988;59-64.
24. Abiodun OO, Gbotosho GO, Ajaiyeoba EO, Brun R, Oduola AM. Anti-trypanosomal activity of some medicinal plants from Nigerian ethnomedicine. Parasitol Resource. 2012;110:521-526.
25. Ragaee S, Abdel–Aal EM. Pasting properties of starch and protein in selected cereals and quality of their food products. Food Chemistry. 2006;95:9-18.
26. Olapade AA, Babalola YO, Aworh OC. Quality attributes of fufu (Fermented cassava) flour supplemented with bambara flour. International Food Research Journal. 2014;21(5):2025-2032.
27. Nwabueze TU, Anoruoh GA. Evaluation of flour and extruded noodles from eight Cassava Mosaic Disease (CMD) Resistant Varieties; 2008.
    Available:http://fabt.edmgr.com/

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