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Physicochemical and organoleptic properties of cooked cassava (*Manihot esculenta L.*) dough enriched with selected defatted legume flours

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Abstract: The study investigated the physicochemical and organoleptic properties of cooked cassava dough fortified with selected defatted legume flours. Four different defatted legume flours were used to produce composite cassava flour while 100 % cassava flour was used as control sample. The five different cassava flours were used to produce cooked cassava dough popularly call "*Amala-lafun*" in Nigeria. The proximate composition, mineral profiles, antinutritional factors, functional and pasting properties of the flours as well as sensory attributes of the cooked cassava dough were determined using standard analytical methods. Results obtained shows that proximate composition and mineral profiles were significantly improved at alpha $P < 0.05$ compared to control sample while determined antinutritional factors of all the samples falls within tolerant levels. Functional and pasting properties of the sample flours and its cooked dough significantly ($p<0.05$) improved than the control sample. Sensory property of the cooked cassava dough shows that using defatted legume of the study samples will be acceptable to consumers especially defatted soybean-cassava flour cooked dough which had overall acceptability score of 7.35. The study result shows that fortifying cassava flour with defatted legume flour enhanced its nutrition density, physicochemical properties and sensory attributes.

[Akinsola, A.O., Taiwo-Oshin, M.A., Oyeleye, B.R, Adepoju, A.F., Afonja, T.E. and Gbadegesin, I.A.. **Physicochemical and organoleptic properties of cooked cassava (*Manihot esculenta L.*) dough enriched with selected defatted legume flours**. *Researcher* 2022;14(3):19-27] ISSN 1553-9865 (print); ISSN 2163-8950 (online). http://www.sciencepub.net/researcher. 3.doi:10.7537/marsrsj140322.03.

Keywords: Composite flour, cooked cassava dough, defatted legume flour, fortifying, sensory attributes.

1. Introduction

Manihot esculenta L. is the most cultivated and consumed in different staple food in Nigeria. It is a rich source of minerals such as Ca, Fe, Mg, Ph but low in fat and protein. It can be consumed as boiled, fried, snacks or when processed into flour and used to prepare local cooked dough meal known as '*amala lafun*'. There are different types of amala in southwest Nigeria which is usually being prepared from their flour viz-a-viz yam tuber (black) amala, cassava tuber (white) amala, cocoyam amala, plantain amala etc, they are all used for socio-cultural, diabolic, nutritional and therapeutic purposes. However, researches have shown that cassava tuber is not a nutrient-dense food for protein-energy rich food except when eating with animal and plant protein. Quite a number of studies have utilized cassava tubers in the production of foods for man consumption and industrial usages but there is dearth of information on the combinations of cassava flour, cassava fiber, defatted legume cake and or its flour. Cassava alone cannot meet adult protein and micronutrient needs which can eventually leads to protein-energy-malnutrition (PEM) in rural and less privilege citizenry, hence there is need to fortify it with protein-micronutrients rich food to make a readily available food product similar but nutrient dense than it tradition cooked dough, wheat cooked dough, etc for consumption.

Considering the health benefits of legume which is rich in lysine and methionine with cassava, a nature given energy dense food in the production of dough meals (staples foods), a close substitute to wheat and raw cassava dough meals will help in improving health status of its consumers and reduce total dependence on wheat flour which could lead to incidence of certain chronic non-communicable disease such as glycermiasis. The increased acceptance of legume and their products is primarily associated with the high nutritional quality especially with respect to protein and amino acids, good functional properties in food applications, high nutritional value, availability and low cost (Gandhi, 2009). Most legume used in this study were underutilized food legume crop in the tropics; not as popular as other major food legumes except soybean. The possibility of producing dough (cooked) meal products from cassava and enriched with legume flour will invariably improve nutritional intake and general wellbeing of the populace especially those that consume it in diverse form. In this study, cassava and defatted selected legume flour were blends to formulate functional cooked-dough meals for their potentials to be used in the prevention and treatment of protein-energy malnutrition (PEM). Protein malnutrition is one of the major nutritional problems in the developing world, so the potential for blending pulses with other locally grown grains or tubers to meet some of the protein malnutrition problem worldwide is; therefore, of tremendous interest. Nevertheless, some of the problems associated with this under-utilized legume are the characteristic hardness of their seed coat which requires either a thorough processing or long cooking time before it can be used. The seeds also contain anti-nutrients like tannins, trypsin inhibitors, hydrogen cyanide, saponins and phytic acid which could hinder the absorption of minerals and nutrients into the body and secondary metabolites (Nwosu, 2013). Processing such as heating, soaking or fermenting have shown to lower anti-nutritional factors and improve their nutritional value. It is therefore imperative to investigate a study on physicochemical and sensory qualities of cassava flour enriched with some defatted selected legume flour and its cooked-dough paste.

2. Materials and methods

2.1 Materials

The freshly ripe cassava (*Manihot esculenta L.*) used for this study were bought at a farm in Awe town, Oyo State, Nigeria while each of the selected legume seed were obtained at a farmer market in Oyo town known as Ajegunle market, Oyo State, Nigeria prior to subsequent uses.

2.2 Preparation of sample flours

2.2.1 Preparation of cassava flour sample

A 12 hrs freshly harvested cassava tubers were processed into flour. About 5.0 kg of the cassava tubers were sorted, washed in portable water, peeled and sliced to 1 cm thickness using manual kitchen slicer. The sliced were transferred into stainless pot that already has water diluted with ascorbic acid solution for about 5 min. The solute was removed; allow to drain at room temperature (28±2^{o}C) for 5 min, dried in an air oven (Model: DC 500; Serial number 12B154) at 55±5^{o}C for 48 hrs, milled in a laboratory hammer mill (Fritsch, D-55743, Idar-oberstein-Germany), sieved using 250 µm screen, packed in a low density polyethene bag and store at room temperature (28±2^{o}C).

2.2.2 Preparation of each defatted legume seed flour samples

Each selected legume (African yam bean, kidney bean, pigeon pea and soybean) seeds of 2.0 kg were clean by sieved in a plastic colander to remove shaft, hull and defective seeds. The seeds were washed, boiled in 1:3 water (w/v) for 30 min, drained, cooled, soak in 1:2 (w/v) clean water for 10 min, dehulled manually, after which their cotyledon were dried in a Genlab drying cabinet (Model: DC 500; Serial number: 12B154) at 55±5°C for 48 hrs, winnowed, milled and sieved as described for cassava flour above. The each full fat flour obtained was soaked in ethanol at 1:4 (w/v) and allowed to stand overnight at room temperature. The mixture was filtered with filtration apparatus, the solute obtained is the defatted flour of each legume seed used and was spread on a stainless laboratory tray, air dried in a Genlab drying cabinet (Model: DC 500; Serial number: 12B154) at 55±5°C for 6 hrs, milled in a laboratory hammer mill (Fritsch, D-55743, Idar-oberstein-Germany) and sieved using 250 µm screen. Each of the flour was packed in a low density polyethene bag and store at room temperature (28±2^{o}C) prior to further uses.

2.3 Formulation of cassava-selected defatted legume composite flour samples

About 80 % of the cassava flour was blends with each 20 % selected defatted legume seed to give a cassava-legume composite flour and coded as sample B, C, D and E. Each sample was blended using a Kenwood mixer (Model: HC 750D, Kenwood, UK). Sample A served as control and contained 100% cassava flour while samples B, C, D and E consist of cassava flour and 20 % each selected legume seed flour. The composite flours of the four except control were formulated equally to determine their physicochemical and sensory property of their flours and cooked dough meals, respectively.

2.4 Production of cassava-selected defatted legume flour cooked (*amala*) dough samples

Two litres of water was boiled in a pot on a gas cooker. About 300 g of each cassava-selected defatted legume flour sample was poured in the 300 ml boiling water, and stirred continuously until smooth consistency thick dough was attained. It was removed from fire and a little quantity of hot water was added, stirred thoroughly and re-heats to boiling point, to allow the paste cook properly. The paste was taken off the flame, stirred again continuously until smooth consistency thick dough was attained. All the five paste obtained were used for sensory evaluation.

2.5 Methods

2.5.1 Determination of chemical composition of the cassava-selected defatted legume flour samples

Proximate analysis of the samples was carried out using AOAC methods (AOAC, 2012) while carbohydrate content was determined by difference while energy value of each sample was determined by calculation from fat, carbohydrate and protein content using the Atwater's conversion factor (Iombor *et al.,* 2009). The standard method described by Association of Official Analytical Chemists was used for mineral content analysis of the samples (AOAC, 2005). The samples were ashed separately at 550 ^{o}C. The ash was boiled with 10 ml of 20 % hydrochloric acid in a beaker and then filtered into a 100ml standard flask. This was made up to the mark with deionized water. Mineral profiles (sodium, potassium, calcium, phosphorus, iron and magnesium) were determined from the resulting solution using an inductively-coupled plasma atomic emission spectrometer (ICPAES, TL 6000 USA). All values were expressed in mg/100g.

2.5.2 Determination of anti-nutritional factors of the cassava-selected defatted legume flour samples

Anti-nutritional factors determination of alkaloid, phytate, oxalate and tannins was carried out as described by Nwosu (2013) method while trypsin inhibitor of the composite flour was determined as described by the method of Famakin *et al.* (2016).

2.5.3 Determination of functional properties of cassava-selected defatted legume flour samples

The functional properties of the cassava composite sample flours determined included bulk density, water absorption capacity, swelling index by Onwuka (2005) while forming and wettability index of the composite flours were determined following the methods described by Okezia and Bello (1988). Least gelation capacity was determined using the method of Coffmann and Garciaj (1977).

2.5.4 Determination of pasting characteristics of cassava-selected defatted legume flour samples

A Rapid Visco Analyser, RVA (Model RVA-SUPER3, USA) was used to determine the viscosity of the composite flours according to Ikegwu (2010) method. About 3 g of sample were weighed into a dried empty canister, and then 25 mL of distilled water was dispensed into the canister containing the sample. The suspension was thoroughly mixed so that no lumps were obtained and the canister was fitted into the rapid visco-analyzer. A paddle was then placed into the canister. The measurement cycle was initiated by depressing the motor tower of the instrument. Samples were pasted according to a programmed heating and cooling cycle. The dispersions were heated from 50 to 95^{o}C with constant stirring at 2.67 Hz, and were held at 95^{o}C for 2.5 min (breakdown). Then, the block temperature was cooled to 50^{o}C and held for 2 min. The total cycle was 13 min. Parameters estimated were peak viscosity, setback viscosity, final viscosity, trough, breakdown viscosity, pasting temperature and time to reach peak viscosity.

2.6 Determination of sensory evaluation of the cassava-selected defatted legume cooked dough samples

Sensory attributes of the cassava- selected defatted legume flour samples were determined using preference test as described by Akinsola *et al.* (2018). Twenty un-trained panelists but familiar with yam tuber amala, a similar product to the study samples were drawn from the College community. The panelists were asked to indicate their preference for the samples in term of appearance, colour, flavour, taste, texture and overall acceptability on 9-point Hedonic scale where 9 =like extremely and 1=disliked extremely. Each panellist sat in an enclosed cubicle designed for sensory evaluation and water was provided to rinse mouths before and after tasting each of the samples.

2.7 Statistical analysis

Data were statistically analyzed using SPSS version 17.0, mean and standard error of means (SEM) of the triplicate analyses were calculated. The analysis of variance (ANOVA) was performed to determine significant differences between the means, while the means were separated using the Duncan Multiple Range Test (DMRT) at $p < 0.05$. For each sample, triplicate determinations were carried out.

3.0 Results and discussions

3.1 Proximate composition of the cassava-selected defatted legume flour samples

Proximate composition of the enriched cassava with selected defatted legume flour samples is presented in Table 1. Moisture content, crude protein, crude fat, fibre, ash carbohydrate and energy values ranged from 10.2 - 10.6; 8.3 - 16.3; 1.7 – 2.4; 3.8 - 4.3; 3.3 - 4.4; 62.0 - 72.6 g/100g and 332.2 - 338.3 kcal, respectively. Moisture content (M.C) according to Adebowale *et al.* (2008) is an indicator for storage stability while high moisture content predisposes solid particles to problem of lump and mould formation within requires short period. Akinsola *et al.* (2018) and Adegunwa *et al.* (2014) reported that a moisture safe level of 8-13 % for storage of solid composite flour. The M.C of all the samples in this fall within this ranged which indicated that chemical and mould activities of the samples flour will be reduced and its shelf life increase. Koua *et al.* (2005) reported that low M.C lowers than 10 % is generally accepted as a standard value for dry food products with a better shelf life. Significant differences at p<0.05 were observed in protein content of the samples especially between the control sample and other composite samples. Research have shown that protein play a vital role in organoleptic properties of food products, boost immune system and play a key role in cell division and growth (Okorie *et al.*, 2015). The protein and fat obtained in this study shows that adding defatted legume protein flour to cassava flour and its cooked dough will increase it biological value during consumption. Moreover, the low value of fat contents of the samples is an index for its good storage stability by reducing rancid flavour development during storage. In addition, adding protein based food product to cassava flour or its products will have beneficial effect on protein-energy-malnutrition of the populace especially among low earners citizen.

The crude fibre of all the samples falls within the ranges of 2.5-5.0 g/100g. Researches have shown that fibre plays an important role during and after digestion in the body by preventing constipation and many other health related disorders. Fibres slow down rate of glucose absorption into blood stream and reduce risk of hyperglycaemia such as lowering blood cholesterol, maintain blood sugar level and helps in reducing body weight (Soetan & Olaiya, 2013). Ash content is an indication of organic residual after burnt of organic matter or material which shows presence of mineral profiles in the samples. The increase in the ash content of the composite samples obtained shows that its consumption will reduces micronutrients in-balance than when consume whole cassava dough. According to Ibeanu *et al*. (2016), ash content is useful tool in maintain acid-base (ionic) balance of the body fluid system. Carbohydrate values of the enriched samples flour show an energy dense food products and protein sparing potential of the sample flours. Akinsola *et al*. (2018) and Sushma *et al*. (2016) reported that carbohydrate supplies energy to cells such as brains, muscles, blood, contributes to fat mechanism, acts as mild natural laxative and spare protein as an energy source. There are no significant differences at p<0.05 between the control sample and other composite samples in term of carbohydrate and energy supply of the sample flours. The energy supply of the flour will be proportional to carbohydrate content of the food sample components.

Table 1: Proximate composition of the cassava-selected defatted legume flour samples, g/100g

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E
Moisture	10.31±0.21	10.42±0.28	10.23±0.21	10.63±0.32	10.33±0.04
Protein	8.25±0.03	13.36±0.16	15.20±0.24	14.52±0.13	16.78±0.15
Crude fat	1.68±0.10	2.20±0.01	2.08±0.02	2.16±0.00	2.43±0.12
Crude fibre	3.33±0.16	4.02±0.01	4.10±0.11	4.28±0.05	4.12±0.14
Ash	3.82±0.22	4.26±0.08	4.41±0.13	4.32±0.21	4.33±0.17
Carbohydrate	72.61±0.14	65.74±0.63	63.98±0.24	64.09±0.18	62.01±0.32
Energy, kcal	338.73±3.15	332.20±4.10	335.48±4.32	333.94±3.05	337.27±2.19

All values are expressed as mean ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different (p< 0.05). Sample A = Control (Cassava tuber); sample B = Cassava-AYB; sample C = Cassava-kidney bean; sample D = Cassava-pigeon pea; sample E = Cassava-soybean; AYB = African yam bean.

3.2 Mineral profiles of the cassava-selected defatted legume flour samples, g/100g

Table 2 shows the mineral profiles of the enriched cassava composite flour samples. The mineral contents of the samples show significant differences at alpha 0.05 in all the flour samples. Iron content of the flour samples ranged from 4.9 - 8.9 g/100g for sample B and D, respectively. Presence of iron in food helps to fight impaired physical and cognitive development and morbidity during foetus and child development (Rohner, 2010). It presence in foods also activate molecule of several enzymes includes ferritin and hemosiderin (Pharma, 2019) while magnesium content of the samples ranged from 4.3 in sample A to 28.1 g/100g in sample E. Magnesium have been reported to be crucial in cells constituents and necessary for functioning of enzymes in bone formation and utilization (Ibeanu *et al*., 2016). The values of Mg reported in this study are higher than 12.66 - 18.16 mg/g reported by Akinsola *et al*. (2018) in their plantain-African yam bean flour blends work. The study results show that calcium and phosphorus values of the enriched flour samples ranged from 114 - 154 mg/100g and 123 - 132 mg/100g for sample A to E, respectively. Calcium has been reported to perform many biological processes and stabilizes many protein reactions in the body while its deficiency is link to weak bone formation and other nutrition related diseases. Phosphorus is an important mineral in multiple biological reactions such as generation of ATP, maintenance of acid-base homeostasis, nucleic acids production and others (Penido & Alon, 2012). The molar ratio of Ca:P ranged from 0.93 - 1.11 which according to Koua *et al*. (2018) suggested a good absorption of dietary available calcium while values less than 0.5 indicates a poor calcium uptake. In the present study, the ratios Ca:P in all the samples were higher than 0.5, this constitute a great advantage and an indication of good intestinal absorption of calcium.

Sodium and potassium contents of the enriched samples ranged from 14.0-18.4 mg/100g for samples A to E, respectively. Sodium is crucial in fluid and acid-base balance; osmosis, regulates muscle, nerve irritability and glucose absorption while potassium is an essential constituent, apart from osmosis fluid balance, in regular heart rhythm and nerve impulse conduction; cell metabolism (Ihekoronye and Ngoddy, 1985) while potassium is an important element in osmosis fluid balance, heart rhythm, nerve impulsion regulation and cell metabolism (Eleazu *et al*., 2013). Results of the study shows that potassium contents of all the samples were higher than sodium contents of all the samples which is an indication of good health promoter by inhibit hypertension according to Chen *et al*. (2010) who reported that intake of diets with higher sodium to potassium ratio has been related to the incidence of hypertension.

Table 2: Mineral profiles of the cassava-selected defatted legume flour samples, mg/100g

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E
Iron	6.41±0.07	4.93±0.26	6.90±0.18	8.92±0.23	8.53±0.10
Magnesium	4.32±0.11	20.20±0.51	14.03±0.06	27.51±0.15	28.05±0.09
Calcium	28.01±0.29	72.04±0.16	81.01±0.41	94.08±0.31	118.10±1.52
Phosphorus	221.06±2.16	211.03±1.09	236.05±2.83	312.02±2.10	304.11±0.88
Ca/P	0.13±0.02	0.34±0.00	0.34±0.00	0.30±0.01	0.39±0.01
Sodium	14.02±0.21	16.10±0.16	18.05±0.21	18.37±0.34	13.60±0.13
Potassium	338.08±3.14	152.14±2.34	186.05±1.65	165.16±2.18	158.09±1.93
Na/K	0.04±0.00	0.11±0.01	0.10±0.00	0.11±0.01	0.09±0.00

All values are expressed as mean ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different ($p< 0.05$). Sample A = Control (Cassava tuber); sample B = Cassava-AYB; sample C = Cassava-kidney bean; sample D = Cassava-pigeon pea; sample E = Cassava-soybean; AYB = African yam bean.

3.3 Anti-nutritional factor of the cassava-selected defatted legume flour samples

The antinutritional factors of the enriched cassava composite flour samples are as shown in Table 3. Antinutritional factors of legume are the major barrier of using its as fortifying food products agent in the formulation of new food products development. According to Nwozu (2011) who reported lethal doses of some selected antinutritional factors in his study as 50-60 mg/kg for phytate, 30 mg/kg (tannin), 10 mg/kg (cyanogenic glycoide), 2-5 g/kg (oxalate) and 2.50 g/kg (trypsin inhibitor). All the values obtained in this study were far less than those lethal doses reported by Nwozu (2011) which indicated that all the sample flours nutrients and micronutrients will be well absorbed by the body. The antinutritional values of selected factors determined varied as follows: alkaloids (0.18-11.1 mg/g), phytate (0.06-8.17 mg/g), oxalate (0.12-0.54 mg/g), tannins (0.04-0.19 mg/g) and trypsin inhibitor (0.03-8.69 TIU). Research have shown that alkaloids can cause gastrointestinal and neuronal disorders (Tadele, 2015) while phytate form stable complexes with mineral ions like Ca, Fe, Mg, Zn and lower their intestinal absorption (Banso & Adeyemo, 2010). Oxalate according to Adeniyi *et al.* (2009) prevent the body absorption of Ca^{++} by forming insoluble calcium-oxalate complex while tannins form insoluble complexes with protein and reduces its biological values (Akande *et al*., 2010). Trypsin inhibitors in large quantity cause hypertrophy and hyperplasia of the pancreas (Ologhobo *et al*., 2003).

Table 3: Anti-nutritional factor of the cassava-selected defatted legume flour samples

Parameter, mg/g	Sample A	Sample B	Sample C	Sample D	Sample E
Alkaloid	0.18±0.00	10.32±0.21	10.51±0.00	11.08±0.30	10.49±0.23
Phytate	0.06±0.01	8.17±0.14	6.22±0.14	7.15±0.19	6.38±0.01
Oxalate	0.12±0.00	0.48±0.00	0.54±0.03	0.52±0.01	0.54±0.03
Tannins	0.04±0.00	0.13±0.01	0.19±0.01	0.11±0.00	0.13±0.00
Trypsin inhibitor, TI	0.03±0.01	8.69±0.23	8.11±0.00	8.62±0.11	8.51±0.14

All values are expressed as mean ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different ($p< 0.05$). Sample A = Control (Cassava tuber); sample B = Cassava-AYB; sample C = Cassava-kidney bean; sample D = Cassava-pigeon pea; sample E = Cassava-soybean; AYB = African yam bean.

3.4 Functional properties of the cassava-selected defatted legume flour samples

The functional properties of the enriched cassava composite flour samples are presented in Table 4. Functional properties are those parameters that determine application and end-uses of food materials for food product development. The results shows that values of bulk density, swelling index, water absorption capacity, wettability and least gelation capacity for all the samples ranged from 0.74-0.84 g/cm^3, 5.35-6.48, 501-584, 5.10-6.20 sec and 51.80-58.61 ^{o}C, respectively. Bulk density is an indication of particle size and density of flour, its blends and a good indicator for handling, transportation and packaging while swelling index shows the extent of associative forces like protein, oil and carbohydrate within the food sample composition as it affect water needed to change a given dry flour to its viscoelastic form. According to Akinsola *et al*. (2018), swelling index is largely controlled by the strength and character of the micellar network within the granules. Swelling index and water absorption capacityy are important parameters which ultimately determine sample consistency and compositional structure (Ayo-Omogie & Ogunsakin, 2013).

Water absorption capacity (WAC) indicates ability of flour to absorb water and swell for improved consistency in food; it is desirable in food systems to improve yield, consistency, and give body to the food (Osundahunsi *et al*., 2003). The high WAC observed in the samples could be due to the high quality protein content of the blends with the addition of some defatted legume flour, which has high affinity for water molecules. It has been suggested that flours with such high water absorption capacity as seen in this study will be very useful in bakery products, as this could prevent staling by reducing moisture loss (Yusuff *et al*., 2008) while wettability time shows the time required for sample flour to be wetted. Its shows the hydrophilic power of the food sample and the ease at which a flour dispersed in water. Least gelation capacity (LGC) according to Akinsola *et al*. (2018) is the lowest protein concentration at which gel remains in the inverted tubes. The decreases in LGC of the sample in respect to control may be as a result of low protein hydrolysis during preparation and product formulation used. These results are in line with Mbaeyi and Onweluzo (2013) who worked on sorghum and pigeon pea flake breakfast formulated blends. Gelling properties of the food sample can be attributed to the relative ratio of protein, carbohydrates, lipids and interaction between such components as reported by Sathe *et al*. (1982).

Table 4: Functional properties of the cassava-selected defatted legume flour samples

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E
Bulk, g/Cm^3	0.74±0.03	0.82±0.06	0.84±0.02	0.81±0.01	0.83±0.16
Swelling index	6.48±0.10	5.35±0.02	5.67±0.01	5.53±0.05	5.43±0.31
WAC	584±4.03	501±3.18	513±2.47	545±2.79	562±2.48
Wettability, sec	6.10±0.05	5.20±0.13	5.10±0.03	5.30±0.11	5.40±0.03
LGC, ^{o}C	52.30±1.32	59.11±1.10	61.42±1.54	60.61±0.89	58.33±0.65

All values are expressed as mean ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different ($p< 0.05$). Sample A = Control (Cassava tuber); sample B = Cassava-AYB; sample C = Cassava-kidney bean; sample D = Cassava-pigeon pea; sample E = Cassava-soybean; AYB = African yam bean. WAC = Water absorption capacity; LGC = Least gelation capacity.

3.5 Pasting property of the enriched cassava-selected defatted legume flour samples

Table 5 presented the pasting property of the enriched cassava composite flour samples. Pasting property of peak viscosity, trough, breakdown, final viscosity, viscosity setback, peak time and temperature of all the samples ranged from 148.5 - 169.4 RVU, 83.2 - 109.3 RVU, 60.1 - 69.3 RVU, 153.2 - 198.1 RVU, 68.9 - 86.1 RVU, 3.2 - 4.6 min and 58.6 - 65.2 ^{o}C, respectively. Peak viscosity shows swelling index of starch-based food product on or before reaching their diminishing point. High PV in the control sample indicates high starch based food material and this could explain why 100 % cassava flour sample had the highest PV. Trough as reported by Adebowale *et al.* (2008) is the minimum viscosity value in the constant temperature phase of the RVA. It measures the ability of the paste to withstand breakdown during cooling while breakdown viscosity measures the ability of paste in RVA to withstand breakdown during cooling. Sample D had the highest breakdown value which indicates that its starch granules will have greater ability to withstand breakdown than other developed samples of the study. Final viscosity indicates its starch ability in viscous paste after cooling or gel to shear force during stirring. The decrease in their values compared to control sample might be due to kinentic effect after cooling of viscosity and re-association of starch molecules in the sample is in agreement with the work of Nwokeke *et al*. (2013) who worked on blending on the proximate, pasting and sensory attributes of cassava-African yam bean fufu flour. Setback viscosity is an indication of staling and retrogradation effect of starch based food product during storage after cooling. Peak time is the time used in cooking the sample flour while pasting temperature indicates minimum temperature required to cook the sample. There were significant differences at p<0.05 alpha among the samples compared to control sample (100 % cassava flour) in the peak time and temperature of all the samples.

Table 5: Pasting property of the cassava-selected defatted legume flour samples

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E
Peak, RVU	169.42±1.13	148.55±0.88	156.29±0.78	158.93±1.32	156.17±0.69
Trough, RVU	109.30±1.38	83.22±0.67	92.11±0.51	89.65±0.39	91.63±1.08
Breakdown, RVU	60.11±0.17	65.31±0.22	64.18±0.30	69.28±0.23	65.43±0.81
Final viscosity, RVU	198.09±0.32	168.63±0.41	161.15±0.18	153.22±0.37	158.16±0.43
Viscosity setback, RVU	86.13±0.14	69.54±0.08	73.72±0.32	68.94±0.6	77.62±0.25
Peak time, min	3.17±0.06	4.32±0.11	4.48±0.07	4.63±0.08	4.51±0.19
Pasting temp, ^{o}C	58.56±0.33	69.14±0.19	73.16±0.12	72.47±0.21	74.69±0.11
Mean value	97.83±0.15	86.96±0.24	89.30±0.02	88.16±0.07	89.74±0.28

All values are expressed as mean ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different (p< 0.05). Sample A = Control (Cassava tuber); sample B = Cassava-AYB; sample C = Cassava-kidney bean; sample D = Cassava-pigeon pea; sample E = Cassava-soybean; AYB = African yam bean. OAC = Oil absorption capacity; WAC = Water absorption capacity; LGC = Least gelation capacity.

3.6 Sensory properties of the cassava-selected defatted legume cooked dough samples

Sensory attributes of the enriched cassava composite cooked dough samples were as presented in Table 6. The mean score for appearance, colour, flavour, taste, texture and overall acceptability of all the samples ranged from 5.7 - 6.5, 6.1 - 6.6, 6.0 - 7.2, 6.0 - 6.4, 6.0 - 6.7 and 6.4 - 7.6, respectively. Sample B is the most preferred in term of appearance followed by sample A > D > E. This result agreed with that of Akinsola *et al*. (2018) who shows that 20 % defatted African yam beans flour added to cassava flour is more preferred in term of colour and taste. Sample E and C are more preferred in term of colour than other study samples while sample A is least preferred. In term of flavour and taste sample E is most preferred by the semi-trained panellists compared to other samples of the study. However, sample C is most preferred in term of texture of the cassava cooked dough while sample E is most acceptable to the semi-trained panellists. Sample E flavour and taste may have influence their decision to choose it as the most preferred cooked dough. According to Sushma *et al*. (2016), taste and flavour have been found to influence the decision of consumer and end-users of food product materials in their preference for such food/material(s). All the semi-trained panelists did not show total dislike for any of the sample dough in term of their sensory property.

Table 6: Sensory properties of the cassava-selected defatted legume flour samples

Attributes	Sample A	Sample B	Sample C	Sample D	Sample E
Appearance	6.54±0.00	6.63±0.01	5.71±0.00	6.02±0.02	5.93±0.00
Colour	6.13±0.02	6.21±0.01	6.53±0.01	6.31±0.00	6.57±0.01
Flavour	7.15±0.01	6.04±0.00	6.81±0.01	6.25±0.01	6.63±0.04
Taste	6.42±0.00	6.02±0.02	6.14±0.03	6.42±0.03	6.11±0.00
Texture	6.51±0.00	5.95±0.00	6.69±0.00	5.93±0.02	6.05±0.02
Overall acceptability	7.18±0.01	6.87±0.01	6.40±0.02	6.66±0.00	7.35±0.11

All values are expressed as mean ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different (p< 0.05). Sample A = Control (Cassava tuber); sample B = Cassava-AYB; sample C = Cassava-kidney bean; sample D = Cassava-pigeon pea; sample E = Cassava-soybean; AYB = African yam bean.

Conclusion

The study examine the potential of less fat legume flour in the production of cassava flour and its cooked dough. Homogenized of defatted legume flour with cassava flour has significant effect on its functional, pasting and sensory properties. However, its nutrition property in term of protein and micronutrients increases considerably compared to 100 % cassava flour or its cooked dough. The study revealed that incorporation of 20 % defatted African yam bean, kidney bean, pigeon pea or soybean flour into cassava flour or its cooked dough will enhance its nutritional quality with acceptable sensory attributes in term of flavour, taste and texture. Therefore, the formulated cassava-based flour or its dough meals have potentials suitable for the prevention and management of protein-energy-malnutrition especially in the rural areas and among low wages earners because of its nutrition and micro nutrients improvement over 100 % cassava flour and its cooked dough.

Acknowledgement

Authors received no direct funding for this project and declare no conflicts of interest. This project was self-sponsored by the authors.

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3/2/2022