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Pasting, Phytochemical and Antioxidant Characteristics of Cassava-Bambara Groundnut-Sorghum Flour Blends and Sensory Acceptability of its Dumpling Dough

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Abstract

This study evaluates the effects of supplementation of cassava flour with Bambara groundnut and sorghum flour. Cassava tuber was processed into flour, also Bambara groundnut and sorghum were processed to fermented, germinated and raw flour. The cassava flour was supplemented with the processed flours at ratio 60:20:20 for cassava, Bambara groundnut and sorghum flour respectively. The antioxidants, phytochemical and pasting properties of the flour samples and the sensory properties of the dumpling made from the flours were determined. The pasting properties showed that the control sample has higher values compared to the other samples. The antioxidant properties of flour shows that the phenol ranges from 14.61-19.41mg/g, FRAP 0.38-3.47mg/g and DPPH 48.57-86.96%. The phytochemical properties revealed that tannin ranged from 2.55 to 4.56 mg/g, saponin 4.18 to 30.27 mg/g, terpernoid 7.79 to 18.44 mg/g, glycosides 14.65 to 29.13 mg/g and alkaloids 19.86 to 35.16 mg/g. The control sample recorded the highest score for all the sensory properties evaluated as well as the overall acceptability followed by sample of cassava supplemented with germinated Bambara groundnut and sorghum flour.This findings show the potential use of fermented and germinated Bambara groundnut and sorghum flour in the production of improved cassava flour as dumpling.

Keywords: Cassava flour, Fermentation, germination, pasting, phytochemical.

Introduction

Cassava has been considered to be a good source of dietary fibre which could be used to increase bulkiness and facilitate digestion. It is also a major source of dietary energy for low income consumers in many parts of tropical Africa cassava root is rich in starch (34.7%) with minimal protein (1.2%) and varying amount of other micro nutrient (Nweke *et al.,* 2002; IITA, 2010). Its importance is increasing in Africa because of its high productivity, diverse uses, low cost and its tolerance to environmental stresses such as drought, fire and low soil fertility. Cassava root has been processed into traditionally fermented food products such as 'fufu', 'elubolafun' (cassava flour) 'gari', 'tapioca'.

Bambara groundnut is a leguminous crop which contains high quality protein (Bamshaiye *et al.,* 2011). According to Massawe *et al.,* (2012), its high protein content confers advantage in alleviating nutritional disorders in both humans and animals. The nutritional value derivable from Bambara groundnut is very high. It contains 63 - 65% carbohydrates, 18 - 19% protein and 6.5% fat (Mahazib *et al*., 2015), and thus it is referred to as a complete meal. The reports of Bamshaiye *et al*., (2011), indicate that Bambara groundnut seeds are richer than peanuts in essential amino acids such as isoleucine, lysine, methionine, phenylalanine, threonine and valine. As a result of its rich nutritional quality, Bambara groundnut has high potential for use to complement foods lacking in the above listed essential amino acids. Bambara nut flour can be used in composite flour preparation.

Sorghum contains 10.4% protein, 1.9% fat and about 8.3% total dietary fiber. Most of the fiber is present in the pericarp and cell walls. Sorghum contains 6.5-7.9% insoluble fiber and 1.1-1.2% soluble fiber. Sorghum contains up to 6% phenolic compound (Beta *et al.,* 2000; Dicko *et al.,* 2005; Awika and Rooney*,* 2004). It can be used as composite in flour blend for the production of some food products like bread, biscuitand cookies. Sorghum grains are prepared for a variety of food products including use as a boiled food similar to rice; roasting or popping like maize; threshing and grinding into flour to make breads, porridges, pancake, dumplings and breakfast cereals (Taylor, 2013). The rate of malnutrition in human diet and food insecurity is increasing in the society due to the intake of nutritional deficient foods. There are still some leguminous crops that are underutilized example of which is Bambara groundnut and there is a need to increase the nutritional composition of cassava flour used as dumpling by supplementing it with Bambara groundnut flour and sorghum flour. The objective of this study was to determine the pasting properties, phytochemical constituents and antioxidant activity of flour blends produced from cassava flour, Bambara groundnut and sorghum and also to evaluate sensory acceptability of dumpling produced from the flour blends.

Materials and Methods

Sources of materials

The Cassava roots were sourced from a farm close to Federal Polytechnic, Ado-Ekiti while Sorghum and Bambara Groundnut were procured from a local market in Ado-Ekiti, Ekiti State, Nigeria.

Method

Production of Cassava Flour

Cassava root was washed thoroughly to remove dirt and foreign materials, peeled and washed. The cassava root was cut into small sizes and soaked in water for 2-3 days (72 h). The water was drained and then pressed to remove the excess water from the wet mash the wet mash was dried using hot air oven at 60°C for 48 h followed by milling using hammer mill. The resulting cassava flour was sieved with 300µm mesh, (Oluwole and Adio, 2013; Doporto *et al.,*2012)

Production of fermented Bambara Groundnut and Sorghum Flour

Bambara Groundnut and Sorghum grains were sorted properly to remove dirt and foreign materials such as stones etc. It was washed thoroughly and then soaked in water to ferment for 72 h. The fermented Bambara Groundnut and Sorghum grain was drained from water and then dried at 60°C in hot air oven for 24hrs, it was then milled to fine particles using hammer mill and sieved with 300µm mesh. The flours were packaged separately on high density polyethylene bag and stored until is used.

Production of Germinated Bambara Groundnut and Sorghum Flour

Bambara Groundnut and Sorghum grains were sorted properly to remove dirt and foreign materials such as stones etc. It was washed thoroughly and then soaked in water for 48 h. The soaked Bambara Groundnut and Sorghum grain was drained from water and then spread in a tray for 78 h to germinate, and therefore dried at 60°C in hot air oven, it was then milled to fine particles using hammer mill and sieved with 300µm mesh. The flours were packaged separately on high density polyethylene bag and stored until is used.

Production of Raw Bambara Groundnut and Sorghum Flour

The Bambara Groundnut and Sorghum grains were sorted properly to remove dirt and foreign materials such as stones etc. It was washed, drained and dried at 60°C in hot air oven for 24hrs, then milled to fine particles using hammer mill and sieved with 300µm mesh. The flours were packaged separately on high density polyethylene bag and stored until is used.

Table 1.Formulation ratio

SAMPLE	CS	GSF	FSF	RSF	GBF	FBF	RBF
A	100	-	-	-	-	-	-
B	60	20	-	-	20	-	-
C	60	-	20	-	-	20	-
D	60	-	-	20	-	-	20

Key:

CF - Cassava flour GSF - Germinated Sorghumflour
FSF - Fermented Sorghumflour RSF - Raw Sorghumflour
GBF - Germinated Bambara Groundnutflour FBF - Fermented Bambara Groundnutflour
RBF - Raw Bambara Groundnutflour

Chemical analysis

Pasting characteristics of flour

Pasting characteristic of the four blends was determined according to ICC No 162 method. Rapid visco analyzer (RVA) series 4 (RVA; series 4, Newport Scientific P.T.V., Warriewood, Australia) with the aid of thermocline for Windows (version 1.1. Software, 1996) provided by the instrument manufacturer was used for the analysis.

Phytochemical analysis

Tannin was determined according to method described by Onuekwusi *et al*., 2014, saponin was determined according to method described by Nwali *et al*., 2012, terpenoid and cardiac glycosides were determined as decribed by Sofowora, 2001and alkaloid as described by

Antioxidant properties

The free radical scavenging ability of the beverages against DPPH (1, 1-diphenyl-2-picryhydrazyl) wasdetermined according to the method described by Gyamfi*et al.* (1999).The ferric reducing antioxidant potential of the beverages was determined as described by Pulido*et al.* (2002).The total phenolic content of the extract was determined as described by Singleton *et al*., (1999).

Sensory evaluation of dumpling samples

The flour blends were prepared into dumpling by mixing appropriate quantity of flour with known quantity of water. The mixture was cooked with continuous stirring. Sensory evaluation of dumpling was carried out on each coded sample of dumpling using method described by Ogundele *et al.,* (2016). Assessed qualities include colour, flavour, taste, texture, and general acceptability. Twenty (20) member semi-trained panelists were selected at random. A nine (9) point hedonic scale was used (1for like extremely and 9 for dislike extremely). Coded samples of the same sizes were served in white saucers.

Statistical Analysis

The data obtained were analysed using the analysis of variance (ANOVA) and means were separated using the Duncan multiple range test at the level of $p<0.05$ (Kiin-Kadari and Giami, 2015).

Result and Discussion

Pasting properties of cassava-bambara groundnut-sorghum blends

The result of the pasting properties of cassava flour supplemented with raw, fermented and germinated sorghum and Bambara groundnut flour is showed in Table 2. The peak viscosity, trough viscosity, breakdown viscosity, setback viscosity, final viscosity, peak time and pasting temperature of the flour samples ranged from 184.00 to 3637.00 RVU, 69.00 to 1302.00 RVU, 115.00 to 2335.00 RVU, 85.00 to 476.00 RVU, 154.00 to 1778.00 RVU, 3.63 to 4.87 min and 75.10 to 76.70^{o}C respectively. The value obtained for all the pasting attributes were significantly different ($p>0.05$) for all the flour samples. The control sample (100% cassava flour, CF) has the highest value for all the pasting parameters followed by cassava flour supplemented with raw sorghum flour and raw Bambara groundnut flour (CRSB) while the least value was in sample of cassava flour supplemented with germinated sorghum flour and Bambara groundnut flour

(CGSB). The flour exhibits high peak and final viscosity, the high viscosity suggest that the proportion of starch in the flour carbohydrate is high and the high final viscosity indicates that the flours will form viscous paste after cooking and cooling. Pasting viscosity is influenced by starch concentration, size of starch granules, ionic charge on starch, ratio of amylose and amylopectin, branching of amylopectin, kind and degree of granules chrystallinity, size and strength of hydrogen bonds, interaction within the granules and presence of other non-starch components (Alcazar-Alay and Meireless, 2015). Higher values of final viscosity have been attributed to the aggregation of the amylose molecules in the paste (Oluwamukomi *et al*., 2004). The breakdown viscosity, which measures the extent to which starch paste can withstand shear thinning during heating (Karim *et al.,* 2007), was high (115.00 to 2335.00 RVU). The high breakdown viscosity compared with peak viscosity suggests that the starch granules of the flour samples readily disintegrate under shear and heat. The setback viscosity of the flour samples ranged from 85.00 to 476.00 RVU, setback viscosity indicates the extents to which starch molecules can reassociate or retrograde during cooling, for instance the lower the setback viscosity the lower the tendency to retrograde (Sanni *et al*., 2014). The value obtained in this study shows that CGSB flours will have low tendency to retrograde. The pasting parameters obtained in this study is high compared to the report for raw and dehulled Bambara groundnut flour by Abiodun and Adepeju, (2011). The peak time of starch pasting analysis is a measure of cooking time (Adebowale *et al*., 2005). The peak time reported in this work (3.63 to 4.87 min) was similar with the peak time (4.52 min) reported for plantain flour by Oluwalana *et al.,* (2011), but lower compared to the time (5.13-6.73 min) reported for raw and dehulled bambara groundnut flour by Abiodun and Adepeju, (2011). The pasting temperature, which is a measure of the minimum temperature required to gelatinized food sample, ranged from 75.10 to 76.70^{o}C. This relative high pasting temperature could be as a result of strong associative forces within the starch granules of the flour sample. The pasting temperature was low compared to the report for raw and dehulled Bambara groundnut flour (93.65 to 95.00 ^{o}C) by Abiodun and Adepeju, (2011).These results suggest that the flour samples have high starch content with high viscosity.

Table 2.Pasting properties of cassava-bambara groundnut-sorghum blends

Sample	**CF**	**CRSB**	**CFSB**	**CGSB**
Peak viscosity (RVU)	3637.00±3.15^{a}	1723.00±2.38^{b}	1002.00±1.52^{c}	184.00±1.04^{d}
Trough viscosity (RVU)	1302.00±4.00^{a}	887.00±3.00^{b}	385.00±1.00^{c}	69.00±1.00^{d}
Breakdown viscosity (RVU)	2335.00±5.00^{a}	836.00±2.00^{b}	617.00±2.00^{c}	115.00±1.00^{d}
Final viscosity (RVU)	1778.00±4.00^{a}	1309.00±2.00^{b}	662.00±3.00^{c}	154.00±2.00^{d}
Setback viscosity (RVU)	476.00±2.00^{a}	422.00±2.00^{b}	277.00±1.00^{c}	85.00±1.00^{d}
Peak time (min)	4.20±0.52^{c}	4.87.00±0.36^{a}	4.40±0.22^{b}	3.63±0.19^{d}
Pasting time (^{o}C)	75.15±0.81^{b}	76.70±0.48^{a}	75.10±0.37^{b}	75.10±0.76^{b}

Values are expressed as mean ± standard deviation of duplicate determination. Mean with the same Superscript along the same roll are not significantly different (p>0.05)

Key:

Sample CF - 100% Cassava Flour
Sample CRSB - 60% Cassava flour: 20% Raw sorghum: 20% Raw Bambara Groundnut
Sample CFSB - 60% Cassava: 20% Fermented sorghum: 20% Fermented Bambara Groundnut

Sample CGSB - 60% Cassava: 20% Germinated sorghum: 20% Germinated Bambara Groundnut

Phytochemical constituents of cassava-bambara groundnut-sorghum blends

The phytochemical constituents of the flours according to Table 3 showed that Tannin content ranged from 2.55-4.56 mg/g, saponin content; 4.18-30.27 mg/g, terpernoid content; 7.79-18.44 mg/g, cardiac glycosides content; 14.65-29.13 mg/g and alkanoid content; 19.86-35.16 mg/g. The result obtained for tannin showed that sample CRSB (60% cassava: 20% raw sorghum: 20% raw bambara groundnut) has the highest tannin content while sample CA (100% cassava flour) has the lowest tannin content. Tannin exhibits anti-nutritional properties by impairing the digestion of various nutrients and preventing the body from absorbing beneficial bioavailable nutrients (Hendek and Bektas, 2018). Tannin can also bind and shrink proteins. Tannin-protein complexes may cause digestive enzymes inactivation and protein digestion reduction caused by protein substrate and iron interaction (Aneta and Dasha, 2019). The tannin content of all the flour samples were low and processing (germination and fermentation) of sorghum and Bambara groundnut reduced the tannin content further. Sample CFSB (60% cassava: 20% fermented sorghum: 20% fermented bambara groundnut) has the highest saponin while sample CGSB (60% Cassava: 20% Germinated sorghum: 20% Germinated Bambara Groundnut) was found to be the least, the saponin contents of all the samples were significantly different ($p>0.05$). Some saponin (steroid or triterpene glycosides compounds) can be used for food while others are toxic. Saponin with a bitter taste is toxic in high concentration and can affect nutrient absorption by inhibiting enzymes (metabolic and digestive) as well as binding with nutrients such as zinc (Ikewuchi, 2012). In the presence of cholesterol, saponin exhibits strong hypo-cholesterolamic effect (Ikewuchi, 2012). They can also lead to hypoglycemia (Barky *et al.*, 2017) or impair the protein digestion uptake vitamins and minerals in the gut, as well lead to the development of a leaky gut (Aneta and Dasha, 2019). When used at low level, the values obtained for saponin in the samples can help to reduce blood glucose and plasma cholesterol and triacylglycerols. Also, saponins are reported to act effectively in maintaining liver function, preventing steoporosis as well as platelet agglutination (Kao, 2018).

Table 3.Phytochemical Properties of cassava-bambara groundnut-sorghum blends (mg/g)

Samples	Tannin	Saponin	Terpernoid	Cardiac Glycosides	Alkaloid
CF	2.55 ± 0.01^{d}	8.18 ± 0.36^{c}	9.95 ± 0.36^{c}	14.65 ± 0.08^{d}	21.14 ± 0.04^{c}
CRSB	4.56 ± 0.01^{a}	30.27 ± 0.45^{a}	13.28 ± 0.09^{b}	24.86 ± 0.01^{b}	35.16 ± 0.04^{a}
CFSB	4.25 ± 0.01^{b}	21.36 ± 0.09^{b}	18.44 ± 0.04^{a}	29.13 ± 0.06^{a}	22.65 ± 0.01^{b}
CGSB	2.61 ± 0.03^{c}	4.18 ± 0.36^{d}	7.79 ± 0.08^{d}	16.21 ± 0.03^{c}	19.86 ± 0.01^{d}

Values are expressed as mean ± standard deviation of duplicate determination. Mean with the same Superscript along the same column are not significantly different ($p>0.05$)

Key:

CF - 100% Cassava Flour
CRSB - 60% Cassava flour: 20% Raw sorghum: 20% Raw Bambara Groundnut
CFSB - 60% Cassava: 20% Fermented sorghum: 20% Fermented Bambara Groundnut
CGSB - 60% Cassava: 20% Germinated sorghum: 20% Germinated Bambara Groundnut

Antioxidant activities of cassava-bambara groundnut-sorghum blends

The Antioxidant Properties of Flour (Fig 1-3) shows that the total phenol 14.61-19.41mg/g, FRAP 0.38-3.47mg/g and DPPH 48.57-86.96%. The total phenol, FRAP and DPPH content increased with the levels of sorghum and Bambara groundnut in the flour blends. The sample with germinated sorghum and Bambara groundnut (CGSB) had the highest values for these parameters while sample CA had the least samples. These antioxidant indices are used are used to depict the ability of food samples to scavenge free radicals. The relatively high values of these indices suggest that the flour blends may contribute health benefit to the body.

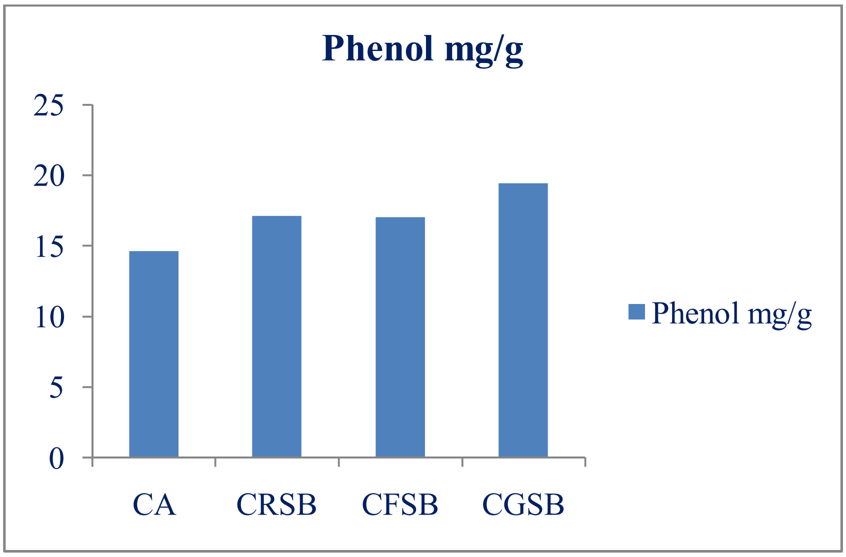

Figure 1.Total phenol content of cassava-bambara groundnut-sorghum blends

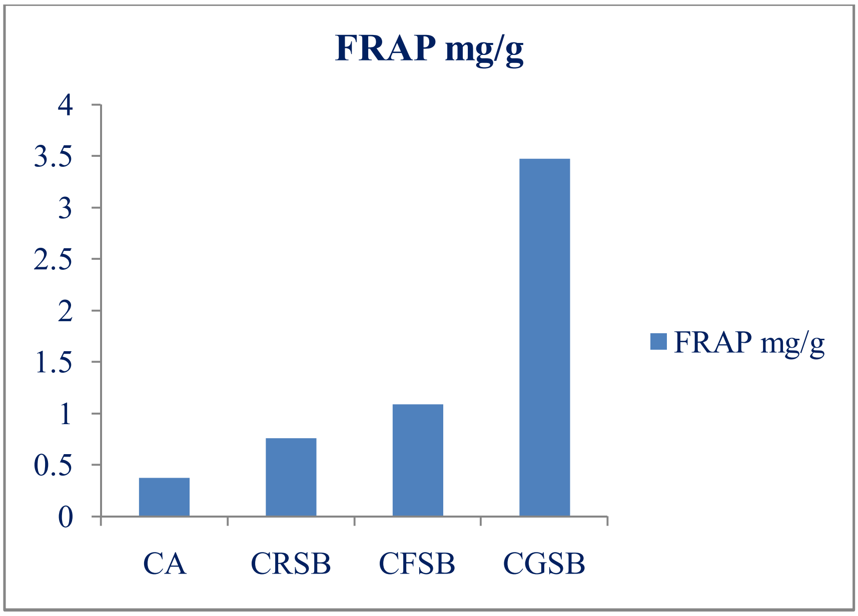

Figure 2.FRAP content of cassava-bambara groundnut-sorghum blends

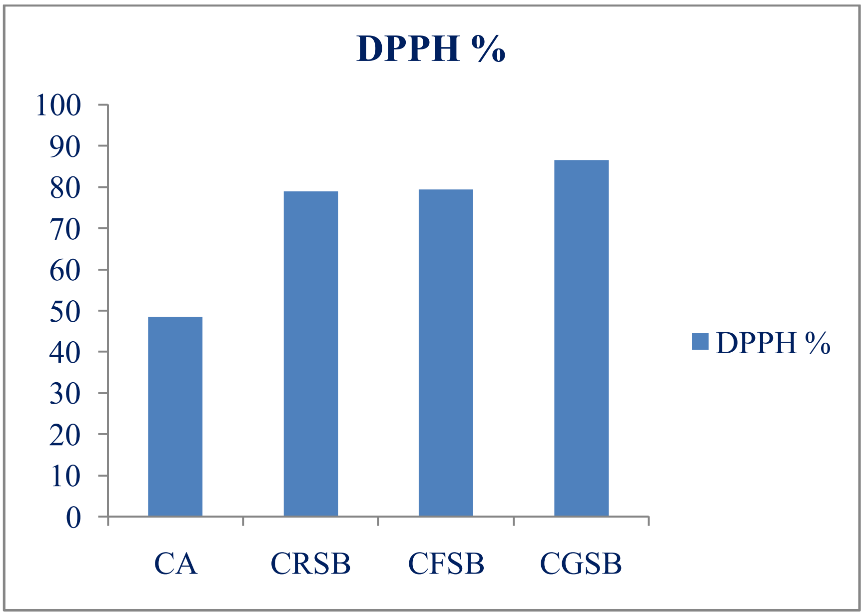

Figure 3.DPPH content of cassava-bambara groundnut-sorghum blends

Key:

CF - 100% Cassava Flour
CRSB - 60% Cassava flour: 20% Raw sorghum: 20% Raw Bambara Groundnut
CFSB - 60% Cassava: 20% Fermented sorghum: 20% Fermented Bambara Groundnut
CGSB - 60% Cassava: 20% Germinated sorghum: 20% Germinated Bambara Groundnut

Sensory attributes of cassava-bambara groundnut-sorghum blends

The result of the sensory attributes of dumpling produced from cassava flour supplemented with raw, fermented and germinated sorghum and Bambara groundnut flour is showed in Table 4. The result show that sample CF (control sample) was significantly (P>0.05) higher in terms of colour, aroma, and overall acceptability except texture which is not significantly different (P<0.05) when compared with other samples. Lower overall acceptability of other samples apart from CF may be due to the colour and aroma of the Bambara groundnut flour added. Addition of bambara groundnut in the blend had resulted in browning of the samples, which had been triggered by mallard reaction of protein of bambara nut and some carbohydrates of cassava and sorghum during heating.

Table 4.Mean Sensory Scores of Dumpling Samples from cassava-bambara groundnut-sorghum blends

Sample	Colour	Taste	Aroma	Texture	Overall Acceptability
CF	7.80 ± 0.89^{a}	7.35 ± 1.27^{a}	7.80 ± 1.15^{a}	7.15 ± 1.50^{a}	8.10 ± 1.02^{a}
CRSB	6.10 ± 1.81^{bc}	6.10 ± 1.79^{ab}	6.00 ± 1.79^{b}	5.24 ± 1.87^{b}	6.33 ± 2.08^{b}
CFSB	6.68 ± 1.42^{b}	6.47 ± 1.07^{ab}	5.84 ± 1.50^{b}	6.11 ± 1.57^{bc}	6.79 ± 1.13^{ab}
CGSB	5.75 ± 1.77^{c}	6.00 ± 1.84^{ab}	5.90 ± 1.48^{b}	6.85 ± 1.42^{a}	6.60 ± 1.59^{b}

Values are expressed as mean ± standard deviation of triplicate determination. Mean with the same Superscript along the same column are not significantly different (p>0.05)

Key:

Sample CA - Cassava Flour
Sample CRSB - 60% Cassava flour: 20% Raw sorghum: 20% Raw Bambara Groundnut
Sample CFSB - 60% Cassava: 20% Fermented sorghum: 20% Fermented Bambara Groundnut
Sample CGSB - 60% Cassava: 20% Germinated sorghum: 20% Germinated Bambara Groundnut

Conclusion

Supplementation of cassava flour with sorghum and Bambara groundnut has helped inimproving the phytochemical constituents and antioxidant activity of the flours. The pasting properties suggest that the flour samples have high starch content with high viscosity and low tendency to retrograde. Acceptable dumpling can be produced from the cassava flour supplemented with raw, fermented and germinated Bambara groundnut and sorghum flour.

References

Abiodun A.O. &Adepeju A.B. (2011): Effect of Processing on the Chemical, Pasting and Anti Nutritional Composition of Bambara Nut (*Vignasubterranea* L. Verdc) Flour, Advance. *Journal of Food Science and Technology* 3(4): 224-227.

Adebowale, A.A., L.O. Sanni& S.O. Awonarin, (2005): Effect of texture modifiers on the physicochemical and sensory properties of dried fufu. *Food Sci. Technol. Int*., 11: 373 382.

Alcazar-alay, S.C. & Meire less, M.A.A. (2015): Physicochemical properties, modifications and applications of starches from different botanical sources. *Food Sci. technol, campinas*. 35(2): 215-236.

Aneta, P. & Dasha M. (2019):Antinutrients in plant-based foods: A review, The open BiotechnologyJournal, 13, 68-76.

Awika, M.A. & Rooney, L.W. (2004): Sorghum phytochemicals and their potential impact on human health. Phytochemistry 65: 1199-1221

Bamshaiye, O.M., Adegbola, J.A. &Bamishaiye, E.I. (2011): “Bambara groundnut: an Under-Utilized Nut in Africa”, Advances in Agricultural Biotechnology, No. 1, pp. 60-72.

Barky, A. Hussein, S. &Alm-Eldeen Y, (2017): Saponins and their potential role in diabetes mellitus, Diabetes Manag (Lond), 7, 148-158.

Beta T, Rooney L.W, Marovatsanga L.T & Taylor J.R.N. (2000): Effect of chemical treatments on polyphenols and malt quality in sorghum. *J Cereal Sci*.; 31(3):295-302.

Dicko, M.H., Gruppen, H., Traoré, A.S., Voragen, A.G.J. &Berkel, W.J.H. (2005): Sorghum grain as human food in Africa: relevance of content of starch and amylase activities. *African Journal of Biotechnology* 5: 384-395.

Doporto M.C., Dini C., Mugridge A., Vina S.Z. &Garcia M.A. (2012): Physicochemical, thermal and sorption properties of nutritionally differentiated flours and starches. *Journal of Food Engineering,* 113:569-576.

Gyamri, M.A., Yonaire, M. &Aaniya, Y. (1999): Free radical scavenging action of medicinal herbs from Ghana: thonningia sanguine on experimentally induced liver injuries. General Pharmacology, 32,661-667.

Hendek, E. M. &Bektaş, M. (2018): Enhancement of bioavailable micronutrients reduction of antinutrients in foods with some processes, Food and Health, 4, 1, 59-165.

IITA. Post- harvest Technology. Annual report. 2010; 62-80.

Ikewuchi, C.C. (2012): Hypocholesterolemic effect of an aqueous extract of the leaves of Sansevieriasenegambica Baker on plasma lipid profile and atherogenic indices of rats fed egg yolksupplemented diet, *Excli Journal,* 11, 346-356.

Kao, T.H. Huang, S.C. Inbaraj, B.S. & Chen, B.H. (2008): Determination of flavonoids and saponins in Gynostemmapentaphyllum (Thunb.) Makino by liquid chromatography-mass spectrometry, *AnalChimActa*, 626, 200-211.

Karim, A.A., Nor Nadiha, M.Z., Chen, F.K., Phauh, Y.P. &Fazilah, A. (2007): Pastting and retrogradation properties of alkali-treated sago (Metroxylonsagu) starch. *Food hydrocolloids.* 22:1048-1053.

Kiin - Kabari D.B.&Giami, S.Y. (2015): Porduction and quality assessment of enriched cookies

from plantain flour and Bambara groundnut protein concentrate. *European Journal of Food Science and Technology,* Vol 3, No 4, pp 32-40.

Mahazib, A.M., Nuha, M.O., Salawa I.S. &Babiker, E.E. (2015): "Some nutritional attributes of bambara groundnut as influenced by domestic processing", *International Food Research Journal,* 20(3), 1165-1171.

Massawe, F.J., Dickson, M., Roberts, J.A. &Azam-Ali, S.N. (2012): Genetic diversity in Bambara groundnut (Vigna subterranean [L.] Verdc.), landraces revealed by AFLP markers. Published on NRC Research Press. Website http//:www.genome.nrc.ca, Canada.

NwaliB.U., Okaka A.N.C., Ibiam U.A. &Aja P.M. (2012): Phytochemical composition of *Bryophyllumpinnatum* leaves, *International Journal of Advanced Biology*

Nweke F.I., Dunstan S.C., Spencer D.S.C.& Lyman T.K., (2002): The Cassava Transformation. University Press, Michigan State, USA. 272.

Ogundele, O.M.A., Awolu, O.O., Badejo, A.A., Nwachukwu, I.D., &Fagbemi, T.N., (2016): Development offunctional beverages from blends of Hibiscus sabdariffa extract and selected fruit juices foroptimal antioxidant properties. *Food Science and Nutrition*, 4, 679-685.

Oluwalana , I.B., Oluwamukomi, M.O., Fagbemi T.N. &Oluwafemi, G.I., (2011): Effect of temperature and period of blanching on the pasting and functional properties of plantain (Musa parasidiaca) flour. *Journal of Stored Products and Postharvest research* 2(8): 164-169.

Oluwamukomi, M.O., Eleyinmi, A. F.,&Enujuigha V.N.,(2004): Effect of soy supplementation and its stage of inclusion on the quality of ogi-a fermented maize meal. *Food Chemistry,* 91: 651-657.

Oluwole O.O.&Adio M.A. (2013): Design and construction of a batch cassava peeling machine. *Journal of Mechanical Engineering and Automation* 3(1): 16-21.

Onuekwusi, E.C. Akanya, H.O. &Evans, E.C. (2014): Phytochemical constituents of seeds of ripe andunripe *Blighia Sapida*(k. koenig) and physicochemical properties of the seed oil, *International Journal of Pharmaceutical Science Invention*, 3, 31-40.

Pulido, R., Bravo, L., &Saura-Calixto, F. (2002): Analysis of resistant starch: a method for foods and foodproducts. Journal of Agriculture and Food Chemistry, 48, 3396- 3402.

Sanni, L.O., Kosoko, S.B., Adebowale A.A., & Adeoye R.J. (2014): the influence of palm oil and chemical modification on the pasting and sensory properties of fufu flour. *International journal of food properties*. 7(2): 229-237.

Singleton V.L, Orthofer R & Lamuela-Raventós R.M (1999): Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. *Methods in Enzymology,* 299, 152-178.

Sofowora, A. (2001): Medicinal plants and traditional medicine, Africa. *Journal of Phytochemical*, 34, 223-230.

Taylor, J.R.N. (2013) Overview: Importance of sorghum in Africa. In AFRIPRO Workshop on the proteins of sorghum and millets: enhancing nutritional and functional properties for Africa. Pretioria, South Africa, 2-4.