International Journal of Food Studies | IJFS April 2022 | Volume 11 | pages 71–84

Chemical Composition, Nutritional, Functional and Pasting Properties of Yellow Root Cassava Grits and African Yam Bean Flour Blends

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Received: 21 January 2021; Published online: 18 April 2022

Abstract

The effect of African Yam Bean (AYB) flour substitution on the nutritional, functional and pasting properties of yellow root cassava grits was investigated. Cassava grits were obtained by peeling, washing, cutting (5.5 cm thickness in cubes), soaking (72 h, 28±2 ^{o}C), dewatering, roasting (120 ^{o}C, 20 min), sieving and milling. Roasted AYB flour was obtained by cleaning, roasting (190 ^{o}C, 10 min), dehulling, milling and sieving (425 μm). Simple lattice design was used to generate different formulations, 100:0; 90:10; 80:20; 70:30; 60:40 and 0:100 of cassava grits and AYB flour, respectively. These were analyzed for chemical composition, amino acid profile, minerals, functional and pasting properties. Total ash, protein, β-carotene and hydrogen cyanide were in the ranges of 2.16-2.66%, 2.72-20.43%, 1.33 to 3.97 µg/g and 0.07-4.47 mg/kg, respectively. Total essential amino acids and total non-essential amino acids were in the ranges of 32.51-40.18% and 59.82-67.48%. Potassium, calcium, magnesium, iron, copper, zinc, manganese and sodium of the blends ranged from 338.00-646.75, 188.00-508.00, 358.00-532.50, 59.25-140.00, 0.12-0.19, 1.07-1.71, 7.25-38.25, 25.25-161.50 mg/100 g, respectively. Bulk density, water absorption capacity, swelling capacity and swelling index ranged from 0.67-0.81 g/ml, 151.05-503.29 g/ml, 1.67-5.68 g/g and 2.86-13.32%, respectively. The blends of yellow root cassava grits and African yam bean flour could provide nutritious food formulations and offer good potential for food security.

Keywords: Cassava grit; Yellow root cassava; African yam bean; Anti-nutrients; Malnutrition; Vitamin A

1 Introduction

Cassava (*Manihot esculenta* Crantz) is a starchy crop grown and consumed widely in tropical regions of Africa, Asia and Latin America (Esuma et al., 2019). Due to the high perishability of the fresh cassava tubers, they are usually processed and consumed as food products such as *gari, akpu (fufu), chikwangue, lafun* (fermented cassava flour), cassava cakes, tapioca and alcoholic drinks (Asonye, 2001). The various types of cassava meals provide about 65% of total calorie intake of the people in the lower economic ladder in Nigeria and sub-Saharan Africa (Asonye, 2001; Montagnac et al., 2009). However, consumption of cassava and its products has been implicated in malnutrition problems (Aykroyd et al., 1992; Falade & Akingbala, 2010; Osho, 2003).

 10.7455/ijfs/11.1.2022.a7

African yam bean (*Sphenostylis stenocarpa*) is an underutilized leguminous plant crop that is relatively rich in protein and can supplement the protein requirements of many families throughout the year, especially low and medium income earners (Adebowale et al., 2009; Babarinde et al., 2019). AYB is a good source of protein, fibre, carbohydrate and minerals (Abioye et al., 2015; Baiyeri et al., 2018; Fasoyiro et al., 2006; Ojo et al., 2014). Research has revealed that one of the best ways to lessen nutritional, environmental and financial vulnerability in developing countries is by increasing the use of underutilized crops in the area where they are grown (Jaenicke & Pasiecznik, 2008). The contribution of these crops to food security has been reported to be of great significance (Naylor et al., 2004).
Sayre et al. (2011) reported that a typical cassava-based diet, provides less than 30% of the minimum daily requirement for protein and only 10%-20% of that for iron, zinc, and vitamin A. African yam bean is a highly nutritious legume, high in protein, mineral and fibre contents (Abioye et al., 2015). Also, Vitamin A-biofortified cassava varieties have been developed as a sustainable strategy to reduce the prevalence of vitamin A deficiency in areas where cassava is a staple food. However, information on its nutritional and health promoting potentials is limited (Oluba et al., 2017). Hence, the current trend in terms of acceptability and production of vitamin A-biofortified cassava is low when compared with the white cassava varieties in Nigeria. This study, therefore, investigated the effects of African yam bean supplementation on the nutritional, functional and pasting properties of yellow root cassava grits.

2 Materials and Methods

UMUCASS 37 variety of yellow root cassava used for this study is as shown in Figure 1. Fresh yellow cassava tubers were obtained from Ladoke Akintola University of Technology Teaching and Research farm, Ogbomoso, Oyo State Nigeria. African yam bean (AYB) seeds were obtained from a local market in Oyo State and identified at the LAUTECH teaching and research farm. African yam bean seeds are as shown in Figure 2.

2.1 Production of Cassava grits and African yam bean flour

Cassava grits were produced from yellow root cassava using the method of Sanni and Jaji (2003) with some modifications as shown in Figure 3a while African yam bean flour was produced as described by Aniedu and Aniedu (2014) as shown in Figure 3b.

2.2 Supplementation of yellow root cassava grits with African yam bean flour

Simplex lattice design was used to obtain different formulations from blends of yellow root cassava grit and AYB flour. The formulations were produced with (60-100%) cassava grit and (0-40%) AYB flour, while 100% AYB flour and 100% cassava grits were used as controls. The blends were thoroughly mixed for about 20 minutes using a Kenwood mixer (Model: Chef XL KVL4100S, made in China) to achieve uniform blending. The samples were then taken into the laboratory for further analyses.

2.3 Analyses

Protein and total ash content of the blends were determined as described by the standard methods of AOAC (1990). The method of Rodriguez-Amaya and Kimura (2004), using extraction with acetone, was used to determine the β-carotene content of the flour blends. Hydrogen cyanide was determined by the simple picrate method as described by Nwokoro et al. (2009). The method of AOAC (1990) was used for the mineral analysis of the samples, which were previously ashed in a furnace for 5 h at 600 ^{o}C, and then refluxed with 20% hydrochloric acid. The mixture was filtered into a 100 mL standard flask; the filtrate was then made up to the mark with deionized water. The resulting digest was filtered with Whatman No. 1 filter paper. Filtrate from each sample was analyzed for mineral (potassium, calcium, magnesium, iron,

Figure 1: Yellow root cassava

Figure 2: African yam bean seeds

copper, zinc, manganese and sodium) contents using an Atomic Absorption Spectrophotometer (AA Analyse Perkin Nerma) at standard wavelengths. The amino acid composition of the samples was measured on hydrolysates using an amino acid analyzer (Sykam-S7130) based on the high performance liquid chromatography technique according to the method of Moore and Stein (1963). The bulk density of the samples was determined as described by Onwuka (2005). The water absorption capacities of the formulated samples were determined using the method described by Onwuka (2005). The methods described by Hirsch and Kokini (2002) were used to determine the swelling power and solubility index. Pasting properties of the blends were determined using a Rapid Visco Analyzer (Model RVA-4; Newport Scientific Pty. Ltd, Warriewood, Australia) as described in the Newport Scientific report (1998). All analyzes were performed in triplicate.

2.4 Statistical Analysis

All analyses were performed in triplicate and data obtained were subjected to Analysis of Variance (ANOVA). The means were separated using Duncan's multiple range test to detect significant difference ($p<0.05$) among the samples.

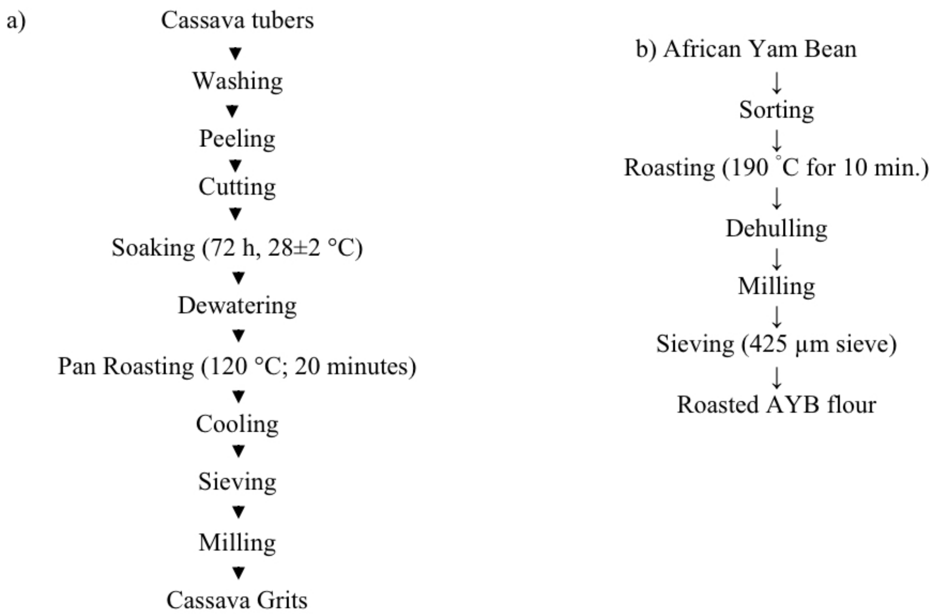

Figure 3: a) Flow chart for the preparation of yellow root cassava grits (Source: Sanni and Jaji (2003); and b) flow chart for the production of AYB flour (Source: Aniedu and Aniedu (2014).

3 Results and Discussion

3.1 Nutritional Properties of cassava grits and AYB flour blends

The amino acid profile of the samples is as shown in Table 1. Essential amino acids identified in AYB flour were valine, threonine, phenylalanine, histidine, isoleucine, leucine, lysine, methionine and tryptophan. The AYB flour is rich in leucine and glutamate. There were significant ($p<0.05$) differences in the leucine content among different blends of cassava grits and African yam bean flour except for the blends with 80:20 and 70:30, of cassava grits and African yam bean flour, respectively. All essential amino acids are significantly present in the blended samples. This is in line with the reports of other researchers that AYB flour contain all the essential amino acids (Atinuke, 2015; Esan & Fasasi, 2013; Oshodi et al., 1995). However, tryptophan is relatively low when compared to other essential amino acids and significantly different ($p<0.05$) among the samples except with samples made from 100:0 and 80:20, of cassava grits and African yam bean flour, respectively. The amino acid content in the formulations increased with increase in level of AYB flour substitution. The percentage of essential amino acids increased from 32.51% in 100% cassava grits to 39.56% in 40% AYB flour substitution. The total essential amino acids of the flour blends ranged from 37.6% to 39.56%. This is higher than the 36% considered for an ideal protein (FAO, 2007; Iyenagbe et al., 2017) but slightly lower than the egg reference of 51.2%. The most abundant amino acid in all the samples evaluated was glutamic acid. Ade-Omowaye et al. (2015) also reported that glutamic acid was the most abundant amino acid in some legumes that were evaluated. The most concentrated essential amino acid in all the formulations was leucine, which increased as the level of substitution of AYB increased from 3.6 g/kg in 100% cassava grit to 7.01g/kg in the sample substituted with 40% AYB flour. Leucine is a nutritionally essential branched-chain amino acid in animal

Table 1: Amino acid profile of yellow root cassava grits and African yam bean flour blends (g/kg)

Amino Acid	Type	100% CG	100% AYB	90%CG 10%AYB	80%CG 20%AYB	70%CG 30%AYB	60%CG 40%AYB
Glycine	N	2.310 ± 0.127^{a}	3.370 ± 0.099^{d}	2.730 ± 0.042^{b}	2.920 ± 0.028^{c}	2.980 ± 0.014^{c}	3.310 ± 0.014^{d}
Alanine	N	3.630 ± 0.042^{a}	4.750 ± 0.070^{d}	4.060 ± 0.085^{b}	4.520 ± 0.028^{c}	4.460 ± 0.085^{c}	4.190 ± 0.127^{b}
Serine	N	1.640 ± 0.057^{a}	3.560 ± 0.014^{d}	2.820 ± 0.028^{b}	3.250 ± 0.071^{c}	3.320 ± 0.028^{c}	2.830 ± 0.042^{b}
Proline	N	2.070 ± 0.099^{a}	4.060 ± 0.085^{d}	3.200 ± 0.283^{b}	3.420 ± 0.283^{bc}	3.540 ± 0.057^{c}	3.940 ± 0.056^{d}
Valine	E	1.620 ± 0.028^{a}	3.040 ± 0.056^{c}	2.760 ± 0.085^{b}	2.780 ± 0.113^{b}	2.820 ± 0.028^{b}	4.150 ± 0.071^{d}
Threonine	E	2.730 ± 0.042^{a}	2.620 ± 0.028^{ab}	2.540 ± 0.057^{a}	2.560 ± 0.000^{a}	2.650 ± 0.071^{ab}	2.620 ± 0.028^{ab}
Isoleucine	E	1.550 ± 0.071^{a}	2.620 ± 0.028^{ab}	2.540 ± 0.057^{a}	2.560 ± 0.000^{a}	$2.650\pm0.071a^{b}$	2.620 ± 0.028^{ab}
Leucine	E	3.620 ± 0.028^{a}	8.760 ± 0.028^{d}	7.060 ± 0.085^{b}	7.770 ± 0.099^{c}	7.700 ± 0.000^{c}	7.040 ± 0.056^{b}
Aspartate	N	8.140 ± 0.056^{d}	8.760 ± 0.028^{e}	7.940 ± 0.057^{c}	6.860 ± 0.085^{b}	6.920 ± 0.028^{b}	5.820 ± 0.028^{a}
Lysine	E	3.560 ± 0.085^{c}	6.860 ± 0.028^{d}	3.200 ± 0283^{b}	3.540 ± 0.057^{c}	3.510 ± 0.014^{bc}	2.860 ± 0.085^{a}
Methionine	E	1.070 ± 0.099^{a}	1.640 ± 0.057^{c}	1.450 ± 0.071^{b}	1.440 ± 0.056^{b}	1.440 ± 0.056^{b}	2.650 ± 0.070^{d}
Glutamate	N	13.600 ± 0.141^{a}	15.770 ± 0.099^{c}	15.160 ± 0.141^{b}	15.760 ± 0.085^{c}	15.300 ± 0.424^{bc}	17.390 ± 0.014^{d}
Phenylalanine	E	3.470 ± 0.099^{a}	4.740 ± 0.056^{c}	3.730 ± 0.042^{b}	4.620 ± 0.282^{c}	4.060 ± 0.085^{b}	5.030 ± 0.042^{d}
Histidine	E	2.480 ± 0.014^{a}	3.680 ± 0.028^{d}	3.270 ± 0.07^{c}	3.060 ± 0.08^{b}	3.740 ± 0.000^{b}	2.540 ± 0.057^{a}
Arginine	N	8.898 ± 0.007^{f}	5.850 ± 0.071^{b}	7.500 ± 0.000^{e}	6.150 ± 0.071^{c}	6.510 ± 0.14^{d}	5.100 ± 0.141^{a}
Tyrosine	N	1.530 ± 0.042^{a}	2.470 ± 0.099^{b}	2.290 ± 0.127^{b}	2.320 ± 0.023^{b}	2.350 ± 0.707^{b}	3.780 ± 0.113^{c}
Tryptophan	E	0.150 ± 0.071^{a}	0.360 ± 0.084^{b}	$0.300\pm0.000a^{b}$	0.340 ± 0.057^{b}	0.550 ± 0.071^{c}	1.050 ± 0.071^{d}
Cystine	N	0.850 ± 0.071^{c}	0.800 ± 0.000^{b}	0.770 ± 0.099^{a}	0.740 ± 0.566^{a}	0.770 ± 0.099^{a}	7.900 ± 0.042^{ab}
Total AA		63.33	79.35	74.35	75.11	75.64	80.50
Total EAA		20.59	31.88	27.94	29.15	29.52	31.84
Total NEAA		42.73	47.47	46.41	45.96	46.12	48.66

Mean values with different superscript along the rows are significantly different from each other ($p<0.05$)
AA - Amino acid, EAA - Essential amino acid,NEAA - Non essential amino acid, CG - cassava grit, AYB flour - African yam bean flour.

nutrition and it is usually one of the most abundant amino acids in high-quality protein foods (Duan et al., 2016).

3.2 The mineral content of cassava grits and AYB flour blends

The mineral content of cassava grits and AYB flour blends is as shown in Table 2. Higher values were recorded for potassium, calcium, magnesium, sodium and iron while lower values were recorded for copper, zinc and manganese in AYB flour. The calcium content obtained for the samples ranged between 188.02 to 508.00 mg/100 g and the values were significantly ($p<0.05$) different from each other. The calcium content of all the samples increased as the level of substitution of AYB flour increased. This may be attributed to the high calcium content of AYB flour as reported by other researchers (Anya & Ozung, 2019; Atinuke, 2015; Ndidi et al., 2014). The current recommended nutrient intake (RNI) for calcium is 600 mg a day for children and 1000 mg a day for adults (FAO, 2002), indicating that these food products could help in meeting the daily recommended intake. The high calcium content in these food products could help bone and teeth development in infants and youths. The iron content of the blended samples ranged from 59.25 to 140.00 mg/100 g, which increased with increasing addition of AYB flour. The potassium content of the blended samples ranged from 338.00 to 646.75 mg/100 g, which is line with the value reported for African yam bean flour (Atinuke, 2015; Ene-Obong & Carnovale, 1992; Oshodi et al., 1995). This may be attributed to the high potassium content in AYB flour. The copper and the zinc contents of the blended samples ranged from 0.12-0.19 mg/100 g and 1.07-1.71 mg/100 g, respectively.

Table 2: Mineral content of yellow root cassava grits and African yam bean flour blends (mg/100 g)

Sample	K	Ca	Mg	Fe	Cu	Zn	Mn	Na
100%CG	338.00^{a}	188.0^{a}	358.00^{a}	59.25^{a}	0.14^{c}	1.26^{c}	7.25^{a}	25.25^{a}
100%AYB	646.75^{f}	508.00^{f}	532.50^{e}	140.00^{e}	0.19^{f}	1.71^{f}	38.25^{f}	161.50^{f}
90%CG10%AYB	402.50^{b}	353.25^{b}	477.20^{b}	60.45^{a}	0.12^{a}	1.07^{a}	10.50^{b}	45.00^{b}
80%CG20% AYB	440.50^{c}	389.00^{c}	490.20^{c}	80.75^{b}	0.13^{b}	1.18^{b}	13.00^{c}	61.25^{c}
70% CG30%AYB	510.00^{d}	422.50^{d}	511.00^{d}	96.00^{c}	0.15^{d}	1.38^{d}	16.65^{d}	74.25^{d}
60%CG40%AYB	585.00^{e}	492.75^{e}	533.70^{e}	103.25^{d}	0.16^{e}	1.55^{e}	18.90^{e}	93.95^{e}

Mean values with different superscript along the same column are significantly different from each other ($p<0.05$). CG - cassava grit,AYB flour - African yam bean flour

3.3 The chemical composition of cassava grits and AYB flour blends

The chemical composition of the flour blends is as shown in Figure 4. The total ash (mineral content) ranged from 2.16 to 2.66% with the highest value recorded in 100% AYB flour. There was a gradual increase in the mineral content of yellow cassava grits with increase in AYB substitution. This confirms the report of other researchers that AYB is an excellent source of minerals (Anya & Ozung, 2019; Ekpe et al., 2018; Mbah et al., 2015; Ndidi et al., 2014). The protein content of the samples ranged from 2.72 to 20.43% with the highest protein content recorded in 100% AYB flour and there was significant ($p<0.05$) difference in the blends with increase in AYB substitution. There was an increase of about 43% in protein content of yellow root cassava grits with 40% AYB flour substitution. Mbah et al. (2015) also reported an increase in yam pottage with increase in AYB flour substitution. This is a reflection of the protein content of AYB flour which is in line with the reports of other researchers (Ajibola & Olapade, 2021; Anya & Ozung, 2019).

The values of beta-carotene are in the range of 1.33 to 3.97 μg/g. The hundred percent yellow root cassava grit had the highest value of beta-carotene due to the variety of the cassava used which was enriched with beta-carotene. The value obtained is within the range reported for food products obtained from bio-fortified yellow root cassava (Odoemelam et al., 2020). As the substitution level of AYB flour increased, the beta-carotene content of the blended samples decreased. Consumption of these blended samples could serve as a contributor to the daily intake of Vitamin A. Hydrogen cyanide levels ranged from 0.07 to 4.47 mg/kg. JECFA (1995) reported that a level of up to 10 mg hydrogen cyanide/kg is the Codex Standard for cassava flour and it's not associated with acute toxicity (Mburu et al., 2012). This indicates that the formulated samples are within the safe level and will pose no hazard to the consumers.

3.4 Functional properties of cassava grits and AYB flour blends

The functional properties of the flour blends are as shown in Table 3. The functional properties indicate how a food material will interact with other food components which directly or indirectly affect the processing, application, food quality, and ultimate acceptance of the food material (Awoyale et al., 2021). The bulk density of the flour blends ranged between 0.67-0.81 g/ml, and there was a gradual increase with increase in AYB flour substitution. Samples made with 100% cassava grits, 100% AYB and 90% cassava grits and 10%AYB were significantly ($p<0.05$) different while there was no significant differences among the samples substituted with 10-30% AYB. Bulk density measures the heaviness of solid samples, which is important in determination of packaging requirements, material handling and its application in the food industry (Falade & Okafor, 2015; Oladele & Aina, 2007).

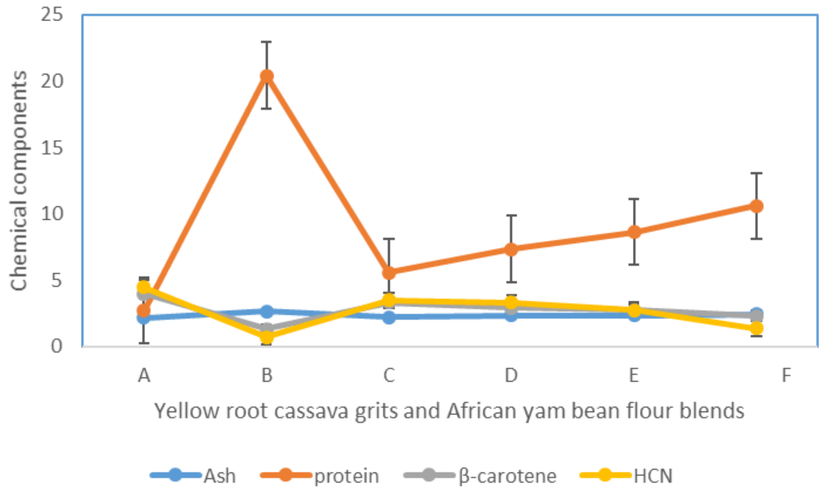

Figure 4: Chemical composition of yellow root cassava grits and AYB flour blends. X-axis Categories: A =100% Yellow root cassava grit, B = 100% AYB flour, C = 90% Yellow root cassava grit and 10% AYB, D = 80% Yellow root cassava grit and 20% AYB, E =70% Yellow root cassava grit and 30% AYB, F = 60% Yellow root cassava grit and 40% AYB.

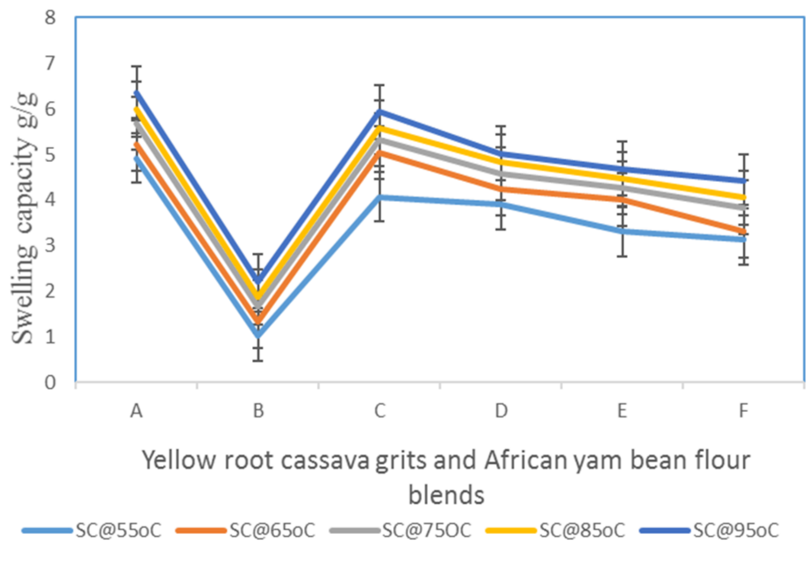

Figure 5: Swelling capacity of yellow root cassava grits and AYB flour blends at different temperatures. X-axis Categories: A =100% Yellow root cassava grit, B = 100% AYB flour, C = 90% Yellow root cassava grit and 10% AYB, D = 80% Yellow root cassava grit and 20% AYB, E =70% Yellow root cassava grit and 30% AYB, F = 60% Yellow root cassava grit and 40% AYB. Legend: SC@55 ^{o}C - Swelling capacity at 55 ^{o}C, SC@65 ^{o}C - Swelling capacity at 65 ^{o}C, SC@75 ^{o}C - Swelling capacity at 75 ^{o}C, SC@85 ^{o}C - Swelling capacity at 85 ^{o}C, SC@95 ^{o}C - Swelling capacity at 95 ^{o}C

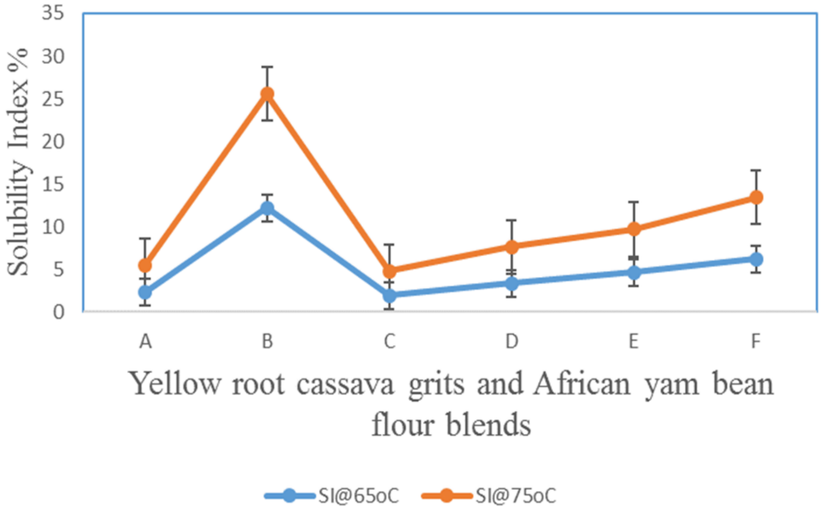

Figure 6: Solubility index of yellow root cassava grits and AYB flour blends at different temperatures. X-axis categories: A = 100% Yellow root cassava grit, B = 100% AYB flour, C = 90% Yellow root cassava grit and 10% AYB, D = 80% Yellow root cassava grit and 20% AYB, E = 70% Yellow root cassava grit and 30% AYB, F = 60% Yellow root cassava grit and 40% AYB. Samples: SI@65 ^{o}C - Swelling capacity at 65 ^{o}C, SI@75 ^{o}C - Swelling capacity at 75 ^{o}C

Table 3: Functional properties' of yellow root cassava grits and African yam bean flour blends

Sample	Bulk Density (g/ml)	WAC (g/ml)
100%CG	$0.70{\pm}0.01^b$	$503.29{\pm}0.99^f$
100%AYB	$0.67{\pm}0.00^a$	$151.05{\pm}0.41^a$
90%CG10%AYB	$0.77{\pm}0.00^c$	$456.97{\pm}1.59^e$
90%CG10%AYB	$0.80{\pm}0.01^d$	$430.50{\pm}0.37^d$
90%CG10%AYB	$0.81{\pm}0.00^d$	$378.37{\pm}1.23^c$
90%CG10%AYB	$0.81{\pm}0.00^d$	$337.27{\pm}27.62^b$

Mean values with different superscript along the same column are significantly different from each other ($p<0.05$). CG - cassava grit, AYB flour - African yam bean flour, WAC - Water Absorption Capacity

Table 4: Pasting properties of yellow root cassava grits and African yam bean flour blends

Sample	Peak viscosity (RVU)	Trough (RVU)	Break down (RVU)	Final viscosity (RVU)	Set back (RVU)	Peak time (min)	Pasting temp (^{o}C)
A	3234.00^f	3000.00^f	266.50^d	3985.00^f	897.00^e	6.40^d	74.58^a
B	1060.00^a	1017.50^a	42.50^a	1276.50^a	259.00^a	7.00^d	84.80^c
C	2618.00^e	2380.00^e	238.50^b	3077.00^e	697.00^d	6.15^b	81.48^b
D	2454.00^d	2105.00^d	248.50^d	2676.00^d	570.50^d	5.85^a	81.83^b
E	2297.00^d	1949.50^d	247.50^d	2479.00^d	529.50^d	5.80^a	81.48^b
F	1942.00^b	1712.00^b	225.00^b	2087.50^b	370.50^b	5.85^a	81.95^b

Mean values with different superscript along the same column are significantly different from each other ($p<0.05$). Keys: A -100% Cassava grit, B - 100% AYB flour, C - 90% Cassava grit and 10% AYB, D - 80% Cassava grit and 20% AYB, E - 70% Cassava grit and 30% AYB, F - 60% Cassava grit and 40% AYB

The change in bulk density is generally affected by the particle size and the density of the flour (Adeoye et al., 2020). Aniedu and Aniedu (2014) reported that when the bulk density is higher, the quality of fufu meals will be better when reconstituted in boiling water. This is because high density determines the ability of the flour to disperse easily when reconstituted in hot water. This indicates a better quality of the meals with AYB substitution. Water absorption capacity of the flour samples ranged from 151.05 to 503.29 g/ml and there were significant differences among all the samples. The lowest value was observed in AYB flour, while cassava grit had the highest value (503.05 g/ml), and there was a significant ($p<0.05$) difference among the blends. The values obtained are within the range (231-610%) reported for cassava grits (Eke et al., 2010; Sanni et al., 2004). Water absorption capacity is important in determining the capacity of flour to take up water and swell to improve uniformity in food. It is also advantageous in food processing for improving yield, uniformity, and giving shape to food products (Ngoma et al., 2019). The swelling capacity and the solubility index are as shown in Figure 5 and Figure 6, respectively. The swelling capacity ranged between 1.33-6.34 g/g and there was an increase with increase in temperature. The highest value was recorded for 100% cassava grits (6.43 g/g) at 95 ^{o}C while 100% AYB flour had the least value (1.33 g/g) at 95 ^{o}C. Inclusion of AYB flour in cassava grits reduced the swelling capacity of the blends. Starch swells on heating in water and the extent of swelling depends on the type of starch. The swelling power of an aqueous suspension of starch is an indication of the strength of the hydrogen bonding between the granules (Eke et al., 2010; Safo-Kantanka & Acquistucci, 1995). This implies that the hydrophilic tendency of the samples decreased with increase in AYB supplementation level. This decrease might also be as a result of the presence of naturally occurring non-carbohydrates such as lipids, protein and others which could restrict swelling. This restriction occurs when amylase lipid complexes are formed (Odunlade et al., 2016), while on the other hand there was an increase in solubility in all the supplemented samples as temperature increased.

3.5 Pasting properties of cassava grits and AYB flour blends

The pasting properties of the flour blends are as shown in Table 4. The peak viscosity ranged between 1060-3234 Rapid Visco Units (RVU). The sample with 100% cassava grits recorded the highest value while the lowest value was recorded with AYB flour. There was a gradual decrease in the peak viscosity with increase in the level of AYB substitution. Higher peak viscosity was recorded with the higher proportion of cassava grits which could be attributed to the higher degree of swelling of cassava starch granules and the amylose content (Chisenga et al., 2019). Peak viscosity is an indication of the thickening power of the starch and the higher the peak viscosity, the higher the thickening power (Chinma et al., 2013; Irondi et al., 2019; Offia-Olua, 2014). The value obtained for the trough ranged between 1017.50 and 3000 RVU, the highest value was observed in 100% cassava grit and the least value was observed in the AYB flour. There was a gradual decrease with increase in the level of AYB flour substitution. Breakdown viscosity ranged between 42.50 and 266.50 RVU with a gradual decrease with increase in the level of AYB substitution. The low breakdown viscosity exhibited by the blends is an indication of their ability to withstand breakdown during heating and shearing (Ocheme et al., 2018). The final viscosity ranged between 1276.50 and 3985.00 RVU and higher values were in blends with a higher proportion of cassava grits The peak viscosity, trough, breakdown viscosity and the final viscosity all generally increased with a higher proportion of cassava grits in the blend which is in line with other reports (Ocheme et al., 2018). The setback value of the samples ranged between 259 and 897 RVU, with cassava grit having the highest (897 RVU) and AYB the lowest (259 RVU). There was a gradual decrease in the setback value with increase in the level of AYB inclusion. This indicates that the higher the level of inclusion of AYB flour, the lower the setback value and hence higher resistance to retrogradation. Pasting temperature of the flour blends ranged between 74.58 and 81.95 ^{o}C. One hundred percent Cassava grit had the lowest pasting temperature which is in line with other researchers (Bassey & Dosunmu, 2003; Onyeneke, 2019). Lower pasting temperature, with inclusion of AYB flour, will form pastes much easier.

4 Conclusions

This study has established that inclusion of AYB flour has the potential to improve the nutritional, functional and pasting properties of yellow root cassava grits. The substitution increased the micronutrients such as calcium and potassium of the yellow root cassava grits. The protein quantity and quality of yellow root cassava also increased while the setback viscosity and retrogradation potentials of the blends reduced. The blends of yellow root cassava grits and African yam bean flour could provide nutritious food formulations and offer good potential for food security.

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