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Evaluation of Extruded Pasta (Spaghetti) Prepared from Acha (*Digitaria exilis*) Enriched with Germinated Bambara Groundnut (*Vigna subterranean*)

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ABSTRACT

Composite flours were prepared by blending acha and Bambara flours in ratios 90:10, 80:20, 70:30 and 60:40. Functional, pasting and chemical properties of the blends were evaluated. Cold extruded spaghetti samples were produced from the composite flours and 100% wheat flour as control. Proximate composition, mineral content, anti-nutritional, colour, cooking qualities and sensory acceptability of the spaghetti samples were determined. There were no significant differences ($p>0.05$) in water absorption and oil absorption capacities between the control and the experimental samples. Loose and packed bulk densities, dispersability, water absorption and oil absorption capacities of the composite flours were as follows: 0.59 to 0.66 g/ml, 0.91 to 0.95 g/ml, 79 to 80 g/ml, 2.14 to 2.26 g/ml and 2.15 to 2.18 g/ml compared with wheat flour 0.48 g/ml, 0.77 g/ml, 75 g/ml, 2.26 g/ml and 2.46 g/ml, respectively. Swelling power of composite flour at 90 and 100°C were essentially the same, while slight differences occurred at 60, 70 and 80°C. Moisture, ash, fat, crude fiber, protein and carbohydrate contents of the blends were 12.58 to 12.91%, 1.00 to 2.50%, 2.30 to 2.40%, 0.25 to 1.00%, 12.58 to 14.63% and 67.09 to 71.20% compared with wheat flour 13.17%, 1.5%, 2.25%, 1.32%, 10.21% and 71.56%, respectively. Phytate, tannin and trypsin inhibitor contents of the extruded products were significantly reduced. The Ca and Zn of the composite spaghetti were higher than that of wheat spaghetti. Significant differences were observed in the colour of experimental spaghetti samples. There were no significant differences ($p>0.05$) between the cooked weight of composite spaghetti and wheat spaghetti. The overall acceptability of the experimental samples was about 60% of the control spaghetti.

Introduction

Pasta is a nutritious food produced from wheat flour, water and other additives. It has been in existence before the first century and this is because of its nutritional values and its ease of cooking (Agnesi, 1996). Gluten which is present in wheat is the main factor that contributed to the effectiveness of cooking attribute of pasta (Dexter and Matsuo, 1978). However, as a result of food consumption such as wheat, rye or barley some people experience a disease called celiac due to their genetic make-up (Lai, 2001), in order to solve this problem, gluten free diets such as acha, maize grain are the only solution to this disease. Moreover, Nigeria is not a wheat cultivation region, but grows a substantial amount of cereals such as acha. Malnutrition has been a major challenge among people, utilizing underexploited local cereals and legumes would solve the problems of wheat importation, malnutrition and employment opportunity which could make developing countries like Nigeria to have a better tomorrow.

Acha known as hungry rice or folio is one of the great nutritious grains. Its seed is very good in methionine and cysteine which are very important to human health and which are deficiencies in most of other cereals such as maize, rice, wheat, rye, barley and sorghum (Jideani and Akingbala, 1993). The proximate analysis showed that the seed contain mean value of 79.05% carbohydrate, 8.05% protein, 5.85% crude fiber, 3.5% ash and other essential elements. Bambara groundnut seed is a bean that is in line with cowpea. In developing country, legume seeds are the main source of macronutrients like protein, carbohydrate and dietary fiber in the meal of many populations. The seed either ripe or immature have 20% protein, 60% carbohydrates and 7% oil (NRC, 2006). Information on enrichment of acha with Bambara groundnut is sparse. The study, therefore, was designed to evaluate the quality attributes of extruded spaghetti produced from blends of acha and germinated Bambara nut flours.

Materials and Methods

Bambara seeds, wheat semolina flour and table salt were purchased from Bodija market, Ibadan while acha seed were obtained from Jos Central Market. Analytical grade Xanthan gum was procured from a chemical store in Ojota Lagos. Acha and Bambara seeds were sorted to remove foreign materials. Acha seed was washed with tap water to remove sand and other extraneous materials and then dried in a Gallenkamp oven at 60°C for 6 h, cooled and milled into flour using an Apex mill with 0.2 mm screen size. Bambara seeds were washed, soaked in water for 12 h at the ambient temperature (28±2°C) and germinated by spread and covered with moistened muslin cloth. Germinated seeds were removed after 48h and the vegetative parts of the dried Bambara were removed by rubbing between palms and then dried in Gallenkamp oven at 60°C for 6 h.

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The dried Bambara groundnut seed were milled using the Apex mill to pass through 0.4 mm mesh size, sieved and packaged in a high density polyethylene bag, sealed and stored till used.

Acha and Bambara composite flours were blended in ratios 90:10, 80:20, 70:30 and 60:40 w/w, respectively and 100 percent wheat flour served as control. Xanthan gum (0.5%) and table salt (0.2g) were added to 100g of each blend, and used in producing spaghetti using the modified method of Kent (1983). Each flour blend was made into a stiff dough using 50 ml of water which was prepared as follow: the blend was pregelatinized in a steamer; small portion of the composite flour was mixed with the quantity of water to be used and heated for 5 minutes. The mixture of the remaining flour was then added to the pregelatinized flour to form the dough. The dough was kneaded to a desired consistency. The dough was then extruded using cold extruder and allowed to rest for about 2 hours. The spaghetti was dried in an oven at 60°C for 3 hours, allowed to cool to the room temperature and packed in polyethylene bags. Spaghetti from "Dangote" was served as the control samples.

Determination of functional properties of the composite flours

The loose and packed densities of the flours were determined using methods of Apphiah *et al.* (2011). Dispersability was determined according to Kulkarni (1997). The oil and water absorption capacities were determined using a modified method of Mepha *et al*. (2007). Swelling power was determined using a modified method of Takashi and Sieb (1998) cited by Abayomi *et al.* (2013). The pasting properties of each of the flour samples were determined using Rapid Viscos Analyzer by Newport Scientific (1998). Peak viscosity, trough, breakdown, final viscosity, set back, peak time, and pasting temperature were read from the pasting profile with the aid of thermocline for windows software connected to a computer.

Determination of chemical composition of the samples

Proximate composition and Tannin content were determined using the method of AOAC (2010), phytates was estimated as described by Mega (1983), while Trypsin inhibitor activity was determined the method described by Kakade *et al.* (1974). Mineral Composition analysis was done as described by Obasi and Wogu (2008). The method described by Mestress *et al*. (1988) was used for the cooking properties of the products.

Determination of colour of the samples

Colour was determined with a Minolta Meter CR (Minolta Camera Co., Osaka, Japan). Measured values were expressed as L; a; b colour units. The L* value indicates the lightness, 0 to 100 representing dark to light. The a* value gives the degree of the red to green colour, with a higher positive a* value indicating more red. The b* value indicates the degree of the yellow to blue colour, with a higher positive b* value indicating more yellow. $\Delta E = (\Delta L^2 + \Delta a^2 + \Delta b^2)^{1\backslash 2}$ refers to the total colour difference between the samples.

Sensory evaluation of the samples

Sensory evaluations of the samples were carried out by 40 untrained panelists from the Department of Food Science and Technology, University of Ibadan, who were familiar with spaghetti using 9-point Hedonic scale.

Statistical analysis

Data obtained were subjected to statistical analysis using statistical package for social science (SPSS) version 16.0 which were formed by using one-way analysis of variance (ANOVA).

Results and Discussion

There were significant differences ($p<0.05$) in the bulk density, dispersability and oil absorption capacity, while there was no significant difference ($p>0.05$) in the water absorption capacity of the flour samples. Table 1 shows the functional properties of the composite flours and wheat flour. The loose bulk density values were 0.58-0.66 g/mL and 0.48 g/mL for the composite flours and 100% wheat, while packed bulk density values were 0.9-0.95 g/mL and 0.77 g/mL for the composite flours and 100% wheat, respectively. Bulk density is a tool in determining the ease of packaging and transportation of powder foods (Adebowale *et al.,* 2008; Ajanaku *et al*., 2012). The dispersability of the composite flours were not significantly difference ($p>0.05$) from each other but significant difference ($p<0.05$) from the wheat flour. Dispersability of the composite flours ranged from 78 to 80%, while wheat had 75%. Dispersibility is defined by Kulkarni *et al.,* (1991) and Adebowale *et al.* (2008) as the evaluation of reconstitution of flour in water. The higher the dispersability, the better the sample reconstitutes in water and gives a fine constituent during mixing (Adebowale *et al.,* 2008). The values of dispersability of acha/Bambara samples were comparatively high which implied that the samples would be reconstituted easily to give fine consistency dough during mixing (Adebowale *et al.,* 2008).

There were no significant differences ($p>0.05$) in water absorption capacity between the composite flours and wheat flour. The values for water absorption capacity of acha/Bambara flours ranged from 2.14 to 2.26 g/g, while 100% wheat had 2.26 g/g. In acha/Bambara flours it was observed that as the level of Bambara incorporation was increasing, water absorption capacity was also increasing. Adebowale *et al.* (2005) reported 2.00 g/g for full fat mucuna flour and 2.20 g/g for defatted mucuna flour. Olapade *et al.* (2014) reported that protein content of a food material influenced the flour sample to absorb water. In oil absorption capacity there were no significant differences ($p>0.05$) among acha/Bambara flours and slightly difference from wheat flour. The oil absorption capacity is an important property in food formulations because fats improve the flavour and mouth feel of foods (Kinsella, 1976). Likewise, oil absorption capacity is useful in structure interaction in food especially in flavour retention, improvement of palatability and extension of shelf life of food products (Adebowale and Lawal, 2004). Oil absorption of acha/Bambara flours ranged from 2.15 to 2.18 g/g, while wheat flour had 2.46 g/g. This result was higher than the oil absorption of wheat and full fat soya that was reported by Joel *et al.* (2014) which ranged from 0.51 to 0.68 g/g.

The swelling power of the samples were significantly difference ($p<0.05$) from each other at 60 to 80°C, but significantly the same at 90 to 100°C. The results showed that the swelling capacity increased with increase in temperature. It was observed that as the level of fortification of Bambara flour increased the swelling capacity increased. There was a gradual swelling at 60 to 80°C then, the swelling power increased steadily with temperature from 90 to 100°C. This indicated a two-stages swelling pattern as a result of Bambara fortification. This showed the different mechanisms of interaction force within the starch granules. A first association was relaxed from 60 to 80°C and was followed by a strong interaction from 90 to 100°C. Leach *et al.* (1959) reported that swelling capacity of flour is influenced by the present of lipid and protein.

Table 1. Functional Properties of Composite Flours.

Sample	LBD (g/ml)	PBD (g/ml)	Dispersability(%)	WAC (g/g)	OAC (g/g)
AB1	$0.66^{a} \pm 0.03$	$0.93^{a} \pm 0.04$	$80^{a} \pm 1.15$	2.18a ±0.15	$2.18^{b} \pm 0.05$
AB2	$0.63^{b} \pm 0.005$	$0.95^{a} \pm 0.01$	$80^{a} \pm 0.58$	$2.14^{a} \pm 0.18$	$2.15^{b} \pm 0.04$
AB3	$0.61^{bc} \pm 0.02$	$0.94^{a} \pm 0.01$	$78^{a} \pm 0.58$	$2.15^{a} \pm 0.02$	$2.18^{b} \pm 0.05$
AB4	$0.59^{c} \pm 0.005$	$0.91^{a} \pm 0.03$	$79^{a} \pm 0.58$	$2.26^{a} \pm 0.93$	$2.18^{b} \pm 0.66$
W	$0.48^{d} \pm 0.48$	$0.77^{b} \pm 0.01$	$75^{b} \pm 1.32$	$2.26^{a} \pm 0.10$	$2.46^{a} \pm 0.13$

Values are mean±SD of triplicate determination. Column means with different superscripts are significantly different at 5% probability level (p< 0.05). SD= Standard deviation

LBD = Loose Bulk Density; PBD = Packed Bulk Density; WAC = Water Absorption Capacity; OAC = Oil Absorption Capacity

Sample AB1 = 90/10% Acha/Bambara
AB2 = 80/20% Acha/Bambara
AB3 = 70/30% Acha/Bambara
AB4 = 60/40% Acha/Bambara
W = 100% Wheat

Table 2. Swelling capacity of Acha/Bambara Flours and Wheat Flour.

Sample	60°C	70°C	80°C	90°C	100°C
AB1	$2.51^{ab} \pm 0.08$	$3.00^{b} \pm 0.05$	$5.25^{ab} \pm 0.04$	$6.01^{a} \pm 0.26$	$6.49^{a} \pm 0.33$
AB2	$2.31^{b} \pm 0.03$	$2.61^{a} \pm 0.1$	$3.62^{c} \pm 0.72$	$6.08^{a} \pm 0.01$	$6.77^{a} \pm 0.14$
AB3	$2.45^{ab} \pm 0.18$	$2.50^{a} \pm 0.02$	$3.46^{c} \pm 0.41$	$5.76^{a} \pm 0.34$	$7.24^{a} \pm 0.70$
AB4	2.97ab±0.62	$3.16^{b} \pm 0.19$	$4.56^{b} \pm 0.25$	$6.17^{a} \pm 1.43$	$6.87^{a} \pm 0.75$
W	$3.48^{a} \pm 0.64$	$5.66^{a} \pm 0.13$	$5.88^{a} \pm 0.87$	$5.94^{a} \pm 0.43$	$7.15^{a} \pm 0.69$

Values are mean±SD of triplicate determination. Column means with different superscripts are significantly different at 5% probability level (p< 0.05). SD= Standard deviation

Sample AB1 = 90/10% Acha/Bambara
AB2 = 80/20% Acha/Bambara
AB3 = 70/30% Acha/Bambara
AB4 = 60/40% Acha/Bambara
W = 100% Whea

Oluwatoyin *et al.* (2016) and Adebowale *et al.* (2011) reported similar result that swelling power increased as the temperature increased.

Pasting properties of composite flours

The results of the pasting properties of the flour samples are presented in Table 3. The peak viscosity of the composite flour ranged from 247 to 274 RVU for 40% and 10% Bambara inclusion, respectively, while wheat flour had 2078 RVU. These differences in the peak viscosity can be attributed to the different rates of water absorption and swelling of starch granules of these flours during heating. In acha/Bambara flour sample 60/40% acha/Bambara had highest peak viscosity which implies that the swelling capacity is high than others. This means it has weaker cohesive forces within the granules and would be easily disintegrated (Hoover, 2001). The trough showed an increased within the range of 156.5 to 201 RVU for acha/Bambara flour, while wheat flour had 1073 RVU. There were no significant differences (p>0.05) among the composite flours. The breakdown viscosity is a measure of the degree of disintegration of starch granules during heating. The breakdown viscosity of the acha/Bambara flours ranged from 73 to 97.5 RVU, while wheat flour had 1004.5 RVU. The composite flours were not significantly different (p>0.05). As the level of fortification of Bambara increased the breakdown viscosity decreased.

The final viscosity of the acha/Bambara flour samples ranged from 1078 to 1230.5 RVU, while wheat had 2489 RVU. Sample 90/10% acha/Bambara had the highest final viscosity in acha/Bambara ratio. This implies that the higher values of final viscosity of the sample could be attributed to the aggregation of the amylose molecules in the paste (Oluwamukomi *et al.*, 2005). The least final viscosity of sample 90/10% acha/Bambara could be attributed to the presence and interaction of high fat and protein. The viscosity when the dough is cooled is called setback viscosity.

There were no significant differences (p>0.05) between acha/Bambara flour and wheat flour. The setback viscosity of acha/Bambara flour ranged from 107.4 to 1033 RVU while wheat flour had 916 RVU. The increased in the viscosity of acha/Bambara flour on cooling reflected the retrogradation tendency of the product. The apparent pasting temperature of acha/Bambara composite flours ranged from 56.5 to 61.35°C, while wheat had 78.63°C. There were no significant (p>0.05) differences in the pasting temperatures of acha/Bambara flours. The pasting temperature shows the minimum temperature required for cooking sample.

Anti-nutritional Factors of Extruded Pasta

The results of anti-nutritional factors are presented in Table 5. Generally, Bambara ground nut like other legumes contains anti-nutritional factors such as trypsin inhibitor, tannins (polyphenols),phytates, hemagglutinins. These ant-nutritional factors have been greatly reduced by some processing methods such as deshelling, milling, soaking, cooking, germination, fermentation, autoclaving/roasting and frying (FAO, 1982). The result of this study was in agreement with this observation. Also Armour *et al.* (1998) and Alonso *et al.* (2000) reported elimination of antinutritional factors, such as tannins, trypsin inhibitors, hemagglutinins and phytates that inhibit protein digestibility during extrusion. The processing methods had significant (p<0.05) effect in reducing these anti-nutritional factors. In phytates and trypsin inhibitor acha/Bambara spaghetti was significantly difference (p<0.05) from wheat spaghetti. The results of phytates and trypsin inhibitor of acha/Bambara blend ranged from 0.007 to 0.012% and 0.007 to 0.28% respectively while wheat spaghetti had 0.001% and 0.005% respectively. It was discovered that as the level of Bambara groundnut increased the phytates and trypsin inhibitor level also increased though the value is in minute quantity. In trypsin inhibitor wheat spaghetti and sample ABI (90/10% acha/Bambara) were significantly the same due to the lower quantity of legume fortification.

Table 3. Pasting properties of Acha/Bambara flours and Wheat flour.

Parameters	AB1	AB2	AB3	AB4	W
Peak (RVU)	254^{b} ±1.41	247.5^{c}±4.95	269^{b}±4.24	274^{b}±4.14	2078^{a}±7.07
Trough(RVU)	156.5^{b}±0.71	157.5^{b}±3.54	183^{b}±5.66	201^{b}±9.89	1073.5^{a}±53.5
Breakdown (RVU)	97.5^{b}±0.71	90.00^{b}±1.41	86.00^{b}±1.41	73.00^{b}±4.24	1004.5^{a}±60.10
FinalViscosity (RVU)	1230.5^{b}±4.95	1190.5^{b}±13.44	1192.5^{b}±0.71	1078^{c}±50.91	2489.5^{a}±43.13
Set Back Viscosity(RVU)	107.4^{a}±4.24	1033^{a}±9.89	1009.5^{a}±6.36	1078^{c}±50.91	916^{a}±717.0
Peak Time (Min)	7.00^{a}±0.00	7.00^{a}±0.00	7.00^{a}±0.00	7.00^{a}±0.00	6.13^{b}±0.94
Pasting Temp (^{o}C)	56.5^{b}±2.83	59.5^{b}±00	57.75^{b}±1.77	61.35^{b}±4.74	78.63^{a}±13.19

Values are mean±SD of duplicate determination. Column means with different superscripts are significantly different at 5% probability level ($p < 0.05$). SD= Standard deviation

Sample AB1 = 90/10% Acha/Bambara
AB2 = 80/20% Acha/Bambara
AB3 = 70/30% Acha/Bambara
AB4 = 60/40% Acha/Bambara
W = 100%

Table 4. Proximate Composition of Acha/Bambara Flours and Wheat Flour before and after Extrusion.

Sample	Moisture (%)	Ash (%)	Fat (%)	Crude fiber (%)	Protein (%)	Carbohydrate (%)
		Before	Extrusion			
AB1	12.68^{a}±0.01	1.00^{a}±0.00	2.30^{a}±.00	0.25^{c}±.00	12.58^{b}±0.19	71.20^{a}±0.18
AB2	12.84^{a}±0.84	1.25^{a}±0.35	2.30^{a}±.14	0.38^{bc}±0.18	12.79^{b}±0.13	70.20^{ab}±0.57
AB3	12.91^{a}±0.02	2.25^{a}±0.35	2.30^{a}±.28	1.00^{ab}±0.00	13.67^{ab}±0.00	67.87^{ab}±0.05
AB4	12.53^{a}±0.13	2.50^{a}±0.13	2.40^{a}±.28	0.85^{abc}±0.22	14.63^{a}±1.36	67.09^{b}±1.99
W	13.7^{a}±0.66	1.50^{a}±1.41	2.25^{a}±.07	1.32^{a}±0.45	10.21^{c}±0.01	71.56^{a}±2.61
		After	Extrusion			
AB1	7.22^{a}±0.18	2.25^{c}±0.35	1.86^{ab}±.06	1.00^{a}±0.00	12.79^{c}±0.00	74.88^{b}±0.59
AB2	6.76^{ab}±0.06	2.50^{c}±0.00	2.06^{c}±0.05	0.89^{a}±0.16	13.63^{b}±0.69	74.17^{b}±0.96
AB3	5.84^{b}±0.08	3.50^{b}±.00	1.84^{b}±0.02	0.59b±0.12	14.02b±0.00	74.22^{c}±0.15
AB4	5.79^{b}±0.08	4.00^{a}±.00	1.95^{ab}±.07	1.00^{a}±0.00	15.16^{a}±0.00	72.11^{c}±0.15
W	6.42^{ab}±0.81	1.00^{d}±.00	2.00^{ab}±.14	0.42^{b}±0.12	12.10^{c}±0.14	78.07^{a}±1.21

Values are mean±SD of duplicate determination. Column means with different superscripts are significantly different at 5% probability level ($p < 0.05$). SD= Standard deviation

Sample AB1 = 90/10% Acha/Bambara
AB2 = 80/20% Acha/Bambara
AB3 = 70/30% Acha/Bambara
AB4 = 60/40% Acha/Bambara, W = 100% Wheat

In acha/Bambara spaghetti as the ratio of legume increased the phytates level also increased. Generally, the level of anti-nutritional was very low.

Tannin content also was significantly reduced. There was no much significant difference between acha/Bambara spaghetti and wheat spaghetti. Wheat spaghetti and sample AB1 (90/10% acha/Bambara) and sample AB2 (80/20% acha/Bambara) were the same, they all had tannin content of 0.001% which is significantly difference ($p<0.05$) from sample AB3 (70/30% acha/Bambara) and sample AB4 (60/40% acha/Bambara). Sample AB3 had tannins content of 0.006% while sample AB4 had 0.008%. This was due to the high level of Bambara fortification. It was noted that as the ratio of Bambara fortification increased the tannins content increased. According to Nnanna and Philips (1990) germination/malting have been recorded to improve protein quality. This reduction brought about improvement in nutritional quality. This increased in protein digestibility upon germination may likely due to decrease in these anti-nutritional factors such as tannins, phytates and trypsin inhibitors, modification and degradation of storage proteins by the action of proteolytic enzymes. Generally, Tannins are defined as soluble astringent, complex and phenolic substances of plant origin, which play significant role in the reduction of dietary protein digestibility. A report was carried out by Archana and Kawata (1998) and Salunkhe *et al.* (1985) who reported reduce in phytates by 38 to 46% after germination. This reduction was attributed to leaching of phytates ions and increased activity of phytase enzyme during germination.

Table 5. Anti-nutritional Factors of Extruded Pasta.

Sample	Phytate (%)	Tanninn (%)	Trypsin inhibitor (%)
AB1	0.007^{d}±0.001	0.001^{d}±0.000	0.007^{d}±0.001
AB2	0.008^{c}±0.001	0.001^{c}±0.000	0.105^{c}±0.007
AB3	0.010^{b}±0.001	0.006^{d}±0.000	0.235^{b}±0.007
AB4	0.012^{a}±0.007	0.008^{a}±0.000	0.280^{a}±0.014
W	0.001^{e}±0.007	0.001^{e}±0.000	0.005^{d}±0.000

Values are mean±SD of duplicate determination. Column means with different superscripts are significantly different at5% probability level ($p < 0.05$). SD= Standard deviation

Sample AB1 = 90/10% Acha/Bambara
AB2 = 80/20% Acha/Bambara
AB3 = 70/30% Acha/Bambara
AB4 = 60/40% Acha/Bambara
W = 100% Wheat

Mineral Composition (mg/100g)

The mineral contents of acha/Bambara spaghetti and wheat spaghetti are presented in Table 6. There were no much difference in the mineral content of acha/Bambara spaghetti and wheat spaghetti. In acha/Bambara blend Fe contents ranged from 0.005 to 0.06 mg/g while wheat had 0.2 mg/g. Acha/Bambara blend had 2.49 to 5.71 mg/g Ca contents while wheat had 3.47 mg/g. Acha/Bambara blend had 3.64 to 4.00 mg/g Mg contents while wheat had 4.11 mg/g. Acha/Bambara blend had 0.29 to 0.46 mg/g Zn contents while wheat had 0.37 mg/g. In acha/Bambara blend the mineral content increased with the addition of Bambara flour except in Zn while sample AB1 (10% Bambara fortification) had the highest Zn contents. The calcium contents of sample AB2 (80/20% acha/Bambara) (5.71 mg/g) and sample AB3 (70/30% acha/Bambara) (3.78 mg/g) were significantly higher than wheat spaghetti (3.47 mg/g). The zinc contents of wheat spaghetti and sample AB3 (70/30% acha/Bambara) were very close, Wheat had 0.37 mg/g while sample AB3 had 0.36 mg/g but sample AB1 (90/10% acha/Bambara) and AB4 (60/40% acha/Bambara) had high zinc content (0.46 mg/g and 0.41 mg/g respectively) than wheat spaghetti due to the incorporation of Bambara nut. Fortification of Bambara into spaghetti improved the mineral contents. Calcium is very important for development of bones and teeth formation and iron is good for red blood formation and healthy living.

Table 6. Mineral Composition of Extruded Spaghetti.

Sample	Fe	Ca	Mg	Zn
AB1	0.05±0.09	2.49±0.03	3.64±0.01	0.46±0.00
AB2	0.05±0.11	5.71±0.04	3.89±0.03	0.29±0.02
AB3	0.05±0.01	3.78±0.01	4.02±0.01	0.36±0.02
AB4	0.06±0.00	3.36±0.00	4.00±0.01	0.41±0.00
W	0.20±0.05	3.47±0.02	4.11±0.05	0.37±0.04

Fe = Iron; Ca = Calcium; Mg = Magnesium; Zn = Zinc
Sample AB1 = 90/10% Acha/Bambara
AB2 = 80/20% Acha/Bambara
AB3 = 70/30% Acha/Bambara
AB4 = 60/40% Acha/Bambara
W = 100% Wheat

Colour Determination of Extruded Spaghetti

The mean value of CIE tristimulus L*, a*, b*, delta chroma (C), colour intensity (E) and the angle, colour parameters of acha/Bambara spaghetti are shown in Table 7. L* indicate the degree of lightness of the sample. The L* (lightness) value of the acha/Bambara spaghetti ranged from 53.83 to 60.04 while there was decreased in L* value as the fortification of Bambara flour is being increased. Sample AB1 (90/10% acha/Bambara) had the highest L* value of 60.04 which indicated highest degree of lightness (whiter) while sample AB4 (60/40% acha/Bambara) had the lowest L* value of 53.83 which showed darker colour. Due to the decreased in the value of L* as the concentration of Bambara is being increased the degree of lightness is decreased. This is because lightness increase toward 100 according to hunter L, a, b colour scale. The a* value is the degree of (-) greenness to (+) redness of a commodity. The a* value of acha/Bambara spaghetti ranged from 3.42 to 4.33. Increased in a* value was observed as the concentration of Bambara value increased. The value showed the degrees of redness of the spaghetti which implies that sample AB4 (60/40% acha/Bambara) had the highest degree of redness (4.33) while sample AB1 (90/10% acha/Bambara) had the lowest degree of redness (3.42). The degree of redness increased as the concentration of Bambara increased from 10 to 40%.

There were increased in b* value of the samples from sample AB1 to sample AB4. The b* value is the degree of yellowness. The b* value of acha/Bambara spaghetti ranged from 15.59 to 17.59. There were no significant differences (p<0.05) except sample AB1 (90/10% acha/Bambara). As the concentration of Bambara nut increased the yellowness also increased. This implies that sample AB1 (90/10% acha/Bambara) had the lower level of yellowness due to the low level Bambara nut fortification while sample AB4 (60/40% acha/Bambara) showed brighter yellow colour. The intensity of sample AB4 is an indication of concentration of beta carotene pigment. In delta Chroma significant difference (p<0.05) was observed. The obtained for delta Chroma (ΔC) for acha/Bambara ratio ranged from 77.62 to 76.33. Decreased in delta Chroma was observed as the fortification of Bambara flour was increasing.

The colour intensity (ΔE) ranged from 20.26 to 13.99 (10/40% Bambara fortification). Decreased in colour intensity was observed as the level of Bambara was increasing. Sample AB1 (90/10% acha/Bambara) had highest level of intensity. Hue value obtained ranged from 1.90 to 1.09 (10/40% Bambara inclusion). The samples were significant difference (p<0.05) from each other. Sample AB1 (90/10% acha/Bambara) had highest hue value. The value obtained showed that acha/Bambara spaghetti were yellow in colour.

Cooking Quality of Spaghetti

Cooking quality of spaghetti is presented in Table 8. Cooking time of acha/Bambara blend (spaghetti) was significantly difference (p<0.05) from wheat spaghetti. Cooking time for acha/Bambara blend ranged from 5.5 to 7.min while wheat semolina spaghetti was 15min. Cooking time in acha/Bambara blend were significantly the same. This low cooking time is an advantage. This is in agreement with Galvez and Ressureccion (1992) who reported that starch noodle is expected to be cooked within very short time with loss of solid in the cooking water being minimal. Sample AB1 (90/10% acha/Bambara) had an advantage of fast cooking time even than wheat spaghetti. Cooking loss of acha/Bambara spaghetti was significantly difference (p<0.05) from wheat spaghetti. Cooking loss of acha/Bambara spaghetti ranged from 0.5 to 1.02 g while wheat spaghetti had 0.34 g. In acha/Bambara spaghetti the value for cooking loss decreased as the value of Bambara inclusion increased. This is probably due to the high level of protein in Bambara nut. This result is in agreement with the reports of higher cooking loss in spaghetti samples fortified with legume flour such as pea, lupin, chickpea and lentil (Rayas-*et al*., 1996; Torres *et al*., 2007; Zhao *et al*., 2005). This is an indication that sample AB1 (90/10% acha/Bambara) had good quality attribute in acha/Bambara spaghetti because of its low cooking loss. There were no significant differences (p>0.05) between the cooked weight of acha/Bambara spaghetti and wheat spaghetti. This might be attributed to the structural changes in the protein network due to the substitution of Bambara flour. Acha/Bambara spaghetti ranged from 12.88 to 13.66 g while wheat spaghetti had 14.30 g. There was increased in cooked weight of acha/Bambara as the value of Bambara groundnut increased. After cooking it was observed that acha/Bambara spaghetti did not fall apart or broken.

Sensory Evaluation of Extruded Spaghetti

The sensory scores on a 9 point hedonic scale of the blend sample from 40 member's panelist is shown in Table 9. The sensory scores for appearance, texture, flavour, taste, mouth feel and overall acceptability ranged 3.78 to 8.25. Spaghetti made from acha/Bambara spaghetti differed significantly (p<0.05) in terms of appearance (3.60 to 5.43), texture (3.78 to 5.40), flavour (4.95 to 5.63), taste (4.18 to 5.20), mouthfeel (3.83 to 5.05), overall acceptability (3.95 to 5.30) while wheat flour varies in terms of appearance (8.25), texture (7.95), flavour (7.73), taste (8.00), mouth feel (8.03) and overall acceptability (8.23). The influence of taste on acceptability is very paramount in sensory attribute of food. The taste of acha/Bambara spaghetti ranged from 3.83 to 5.05. Except for sample 123 (90/10% acha/Bambara), there were no significant ($p>0.05$) differences in the blend. Spaghetti sample of 789 (70/30% acha/Bambara) blend scored highest (5.20). Acha/Bambara blend was not too hard and this is in agreement with Galvez and Ressureccion [56] that suggested that cooked starch pasta must not be too hard or too pulpy. This may be in order to prevent spaghetti stickiness after cooking. Acha/Bambara spaghetti overall acceptability ranged from 3.95 to 5.3 while wheat spaghetti had 8.23. There were significant differences ($p<0.05$) among the samples.

In acha/Bambara blend sample 789 (70/30% acha/Bambara) had the highest overall acceptability. The acceptability of the experimental gluten-free spaghetti (acha/Bambara) sample was about 60% of the control semolina spaghetti. Therefore, based on the panelist who participated in the sensory evaluation, gluten-free (acha/Bambara spaghetti) could be considered as a product of good acceptability by consumers. The observation of this study was in close agreement with the study worked on by Pamela *et al.* (2014) who studied gluten free spaghetti with unripe plantain, chickpea and maize: physicochemical, texture and sensory properties. He observed that the control spaghetti received the highest score of acceptability of 7.17, while all the gluten free spaghetti ranged above the mean value of 4.5. Also noticed the acceptability of gluten free spaghetti samples were about 70% of the control semolina spaghetti. Sample 456 (80% acha to 20% Bambara), 789 (70% acha to 30% Bambara), 321 (60% acha to 40% Bambara) were significantly difference ($P<0.05$) and more acceptable than sample 123 (90% acha to 10% Bambara). The relative high score of sample 456, 789 and 321 may attributed to the flavour and taste of high percentage of Bambara groundnut developed during drying. Based on sensory evaluation sample 789 (70% acha – 30% Bambara) was more acceptable in terms of appearance, flavor, taste and overall acceptability.

Conclusion

Blend of 70/30% acha/Bambara composite flour was acceptable for gluten free spaghetti production based on the appearance, flavour, taste and overall acceptability. The products would help to reduce protein energy malnutrition and micro-nutrient malnutrition in Nigeria. It will also assist people with gluten intolerance. The acceptability of the experimental gluten-free spaghetti (acha/Bambara) sample was about 60% of the control semolina spaghetti. Extrusion of the blends brought about significant ($p<0.05$) increase in

Table 7. Spaghetti Colour Determination.

Sample	L*	a*	b*	ΔH	ΔE	ΔC
AB1	$60.04^{a}\pm2.01$	$3.42^{c}\pm0.08$	$15.59^{b}\pm0.52$	$77.62^{a}\pm0.13$	$20.26^{a}\pm2.01$	$1.96^{a}\pm0.14$
AB2	$59.35^{a}\pm0.17$	$3.97^{b}\pm0.07$	$17.31^{a}\pm0.04$	$77.09^{a}\pm0.21$	$19.49^{a}\pm0.18$	$1.27^{b}\pm0.03$
AB3	$55.11^{b}\pm0.19$	$3.88^{b}\pm0.04$	$17.59^{a}\pm0.09$	$77.57^{a}\pm0.08$	$15.34^{b}\pm0.16$	$1.19^{b}\pm0.05$
AB4	$53.83^{b}\pm0.08$	$4.33^{a}\pm0.03$	$17.38^{a}\pm0.04$	$76.33^{b}\pm0.61$	$13.99^{b}\pm0.06$	$1.09^{b}\pm0.01$

Values are mean±SD of duplicate determination. Column means with different superscripts are significantly different at 5% probability level ($p< 0.05$). SD= Standard deviation

Sample AB1 = 90/10% Acha/Bambara
AB2 = 80/20% Acha/Bambara
AB3 = 70/30% Acha/Bambara
AB4 = 60/40% Acha/Bambara

Table 8. Cooking Quality of Extruded Spaghetti.

Sample	Cooking time (Min)	Cooked weight (g)	Cooking loss (g)
AB1	$5.50^{b}\pm0.71$	$12.88^{a}\pm1.13$	$1.02^{a}\pm0.06$
AB2	$6.50^{b}\pm0.71$	$13.38^{a}\pm0.76$	$0.81^{ab}\pm0.22$
AB3	$6.50^{b}\pm0.71$	$13.56^{a}\pm1.57$	$0.65^{abc}\pm0.16$
AB4	$7.00^{b}\pm1.41$	$13.66^{a}\pm0.48$	$0.50^{bc}\pm0.19$
W	$15.00^{a}\pm1.41$	$14.30^{a}\pm1.$	$0.34^{c}\pm0.01$

Values are mean±SD of duplicate determination. Column means with different superscripts are significantly different at 5% probability level ($p< 0.05$). SD= Standard deviation

Sample AB1 = 90/10% Acha/Bambara
AB2 = 80/20% Acha/Bambara
AB3 = 70/30% Acha/Bambara
AB4 = 60/40% Acha/Bambara
W = 100% Wheat

Table 9. Sensory Evaluation of Extruded Spaghetti.

Sample	Appearance	Texture	Flavour	Taste	Mouth feel	Overallacceptability
123	$3.60^{c}\pm2.01$	3.78c±1.91	$4.95^{b}\pm1.66$	$4.18^{c}\pm1.88$	$3.83^{c}\pm1.95$	$3.95^{c}\pm2.02$
456	$5.30^{b}\pm41.77$	$5.40^{b}\pm1.77$	$5.53^{b}\pm1.63$	$5.15^{b}\pm1.85$	$5.05^{b}\pm1.87$	$5.23^{b}\pm1.76$
789	5.43b±187	$5.35^{b}\pm1.81$	$5.63^{b}\pm1.82$	$5.20^{b}\pm2.02$	$5.03^{b}\pm2.08$	$5.30^{b}\pm1.88$
321	$4.90^{b}\pm1.86$	$4.78^{b}\pm1.94$	$5.13^{b}\pm1.86$	$5.00^{b}\pm1.93$	$4.65^{b}\pm1.94$	$4.95^{b}\pm1.83$
654	$8.25^{a}\pm0.77$	$7.95^{a}\pm0.93$	$5.13^{b}\pm1.86$	$8.00^{a}\pm0.75$	$8.03^{a}\pm0.86$	$8.23^{a}\pm0.73$

Sample 123= 90/10% Acha/Bambara
456 = 80/20% Acha/Bambara
789 = 70/30% Acha/Bambara
321 = 60/40% Acha/Bambara
654= 100% Wheat

protein and improvement on other nutrients such as minerals, protein and carbohydrate.

References

Abayomi, H.T. Oresanya, T.O. Opeifa A.O. and Rasheed T.R.,2013. Quality Evaluation of cookies produced from Blends of Sweet potato and fermented soybean flour. *International Journal of Biological, Biomoleclear, Agricultural, Food and Biotechmological Engineering* 7: 639 – 644.

Adebowale K.O.and Lawal, O.S. 2004. Comparative study of the functional properties of Bambara groundnut (V oandzeia subterranean), jack bean (Cana valiaen-siformis) and mucuna bean (Mucuna pruriens) flour .*Food Res. Inter* . 37: 355 – 365.

Adebowale,A.A Sanni L.O. and Fadahunsi, E.L. 2011. Functional and pasting properties of cassava – sweetpotato starch blends. A Research Article in AJRTC.9 (1): 6 – 10.

Adebowale, A.A.Sanni L.O.and Awonorin, S.O. 2005. Effect of texture modifies on the physicochemical and sensory properties of dried fufu. *Food Sci. Technol. Int.,* 11: 373 – 385.

Adebowale,Y.A. Adeyemi I.A. and Oshodi, A.A 2008. Functional and physicochemical properties of flours of six Mucuna species.

Agnesi, E.1996. The History of Pasta, In: J.E. Kruger, R.B. Matsuo and J.W. Dick, Eds. Agricultural Organization of the United Nations. Rome, 37 – 126.

Ajanaku, K.O. Edobor-Osoh A. and Nwinyi,O.C. 2012. Nutritive value of Sorghum Ogi fortified with groundnut seed (*Arachis hypogaea* L.). *Am. J. Food Technol*., 7: 82 – 88.

Alonso, R. Orue, E. Zabalza, M.J. Grant G. and Marzo, F. 2000. Effect of extrusion cooking on structure and functional properties of pea and kidney bean proteins. *Journal of Science of Food and Agriculture* 80: 397 – 403.

AOAC,2010.Association of Official Analytical Chemists. Official method of Analysis 18th Ed.Washington DC.

Appiah F., Asibuo J.Y. and Kumah, P. 2011.Physical and functional properties of bean flours of three cowpea (*Vigna unguiculata* L. walp) varieties in Ghana. *African Journal of Food Science,* 5 (2): 100-104.

Archana S.S.and Kawata, A. 1998.Reduction of polyphenol and phytic acid content of pearl millet grains by malting and blanching.Plant Food for Human Nutrition 53: 93 – 98.

Areas,J.A.G.1992. Extrusion of proteins.*Critical Reviews in Food Science and Nutrition* 32: 365 – 392.

Armour, J.C.Perea, R.L.C.Buchan W.C.and Grant,G.1998. Protease inhibitors and lectin in soya beans and effect of aqueous heat-treatment.*Journal of the Science of Food and Agriculture* 78: 225 – 231.

Dexter,J.E. and Matsuo R.R., 1978. The effect of gluten protein fractions on pasta dough Rheology and Spaghetti Making Quality," *Cereal Chemistry*, 55:44 -57.

FAO, 1982.Legumes in human nutrition,FAO and Food Nutrition Paper, 20.Food and Agricultural Organisation of the United Nations. Rome, 37 – 126.

Galvez F.C.F. and Resurreccion,A.V.A. 1992. Reliability of the focus group technique in determining the quality characteristics of mung bean noodles. *Journal of Sensory Studies,* 7: 315 – 320.

Hoover R. 2001. Composition, molecular structure, and physicochemical properties of tuber and root starches: a review. Carbohydr Polym. 45: 253 – 267.

Jideani I.A. and Akingbala, J.O. 1993. Some physicochemical properties of acha(*Digitaria exilis*) and iburu (*Digitaria iburua*). *J. Sci. Food Agric* 63: 369 – 374.

Joel, N.Fatima K. and Stephen, F. 2014.Production and quality assessment of enriched cookies from whole wheat and full fat soya.*European Journal of Food Science and Technology* 2 (1): 19 – 28.,

Kakade, M.L. Hoffa D.E. and Liener, I.E. 1974.Contribution of trypsin Inhibitors to the deleterious effects of Unheated Soybean fed to rats. *J. Nutr.*103: 1772 – 1779.

Kent, N.L. 1983.Technology of cereal.3rdEd. Pergman Press Ltd. Oxford, England 149 – 205.,

Kent, N.L. 1983.Technology of cereal. 3rdEd. Pergman Press Ltd. Oxford, England 149 -205.

Kinsella, L.E. 1976. Functional properties of protein in foods*: Asurvey . J. Food Sci. Nutrition*. 7: 219 – 28.

Kulkarni, K.D. Kulkarni, N.D, and Ingle, U.M. 1991. Sorghum malt-based weaning food formulations: Preparation, functional properties and nutritive value.*Food and Nutr.* Bull. 13 (4): 322 – 327.

Kulkarni,S.D.1997.Roasted soybean in cookies. Influence on product Quality.*J. food Sci. Technol.,* 34: 503 – 505.

Lai, H.M. 2001. Effects of Rice Properties and Emulsifiers on the Quality of Rice Pasta, *Journal of the Science of Food and Agriculture*, 83 (2001): 203 – 216.

Leach, H.W. Mc Cowen L.D. and Schooh, T.J. 1959. Structure of the starch granule.Swelling and solubility.Cereal Chemistry, 36: 534 – 539.

Maga, J.A. 1983. Phytate:Its Chemistry: Occurrence, Food Interactions, Nutritional Significance and Method of Analysis.

Mepba,H.D.Akpapunam, M.A. and Berepupo,H.A.2007. Production of non-fermented beverage from ripe banana. Chemical content and sensory characteristics.Discovery and innovation.2 (1): 85 – 91.

Mestress, C. Colonna P. and Buleon, A. 1988.Characteristics of starch network within rice flour noodles and mumgbean starch vermicelli. *Journal of Food Science,* 53 (6): 1809 – 1811.

National Research Council, 2006.Lost Crops of Africa, Vol. II: Vegetables (Development, Security, and Cooperation Policy and Global Affairs).The Natl. Academies Press, Washington DC.

Retrieved from: http://www.nap.edu/ open book.php?record_id=11763on 22/06/2012.

Newport Scientific, 1998.Application manual for the rapid visco analyzer using thermocline for windows. Newport scientific pty limited, Aust. Pp. 2 – 26.,

Nnanna I.A. and Philip, R.D. 1990. Protein and starch digestibility and flatulence potential of germinated cowpea, Vigna Unguiculata. *International Journal of Food Science* 55: 151 – 153.

Obasi N.E.and Wogu, C.O. 2008. Effect of soaking time on proximate and mineral composition and anti-nutritional factors of yellow maize (zea mays). *Nigeral Food Journal*, 26 (2): 69 -77.

Olapade, A.A. Babalola Y.O. and Aworh O.C., 2014. Quality attributes of fufu (fermented cassava) flour supplemented with Bambara flour. *International Food Research Journal* 21 (5): 2025-2032.

Oluwamukomi,M.O. Adeyemi I.A. and Oluwalana, I.B. 2005. Effect of soybean enrichment onthe physiochemical and sensory properties of cookies 123.

Oluwatoyin, O.Toyin, A. Temiloluwa, A. Olajumoke, O. Joshua, A. Olubunmi I. Folashade, O. Samuel O. and Sulaiman, K. 2016. Some functional properties of flours from commonly consumed selected Nigerial Food Crops.

*International Research Journal of Agricultural and Food Sciences.*1 (5): 92 – 95.

Pamela Flores-Silva C.,Jose De Berrios, J. James, P. Edith, A. Adelmo M. and Luis Bello-Pérez, A. 2014. Gluten-free spaghetti with unripe plantain, chickpea and maize: physicochemical, texture and sensory properties. *CyTA - Journal of Food.* 13 (2): 159 – 166.

Rayas-Duarte, Mock P. and Satterlee,L. D.1996.Quality of spaghetti containing buckwheat, amaranth, and lupin flours. *Cereal Chemistry* 73 (3): 381 – 387.

Salunkhe,D.K. Kaduna S.S. and Chairman,J.K. 1985. Chemical composition of legumes, in post bio-technology of food legumes CRCPress.INC Bola, Raton, Florida.29 – 125.

Takashi S. and Sieb, P.A. 1998. Paste and gel properties of prime corn and wheat starches with and without native lipids cereal chemistry 65: 47.

Torres, A. Frias, J. Granito M. and Vidal-Valverde, C. 2007. Germinated Cajanus cajanseeds as ingredients in pasta products: chemical, biological and sensory evaluation. Food Chemistry, 101: 202 – 211.

Zhao,Y.H. Manthey, F.A. Chang, S.K.C. Hou H.J. and Yuan, S.H. 2005. Quality characteristics of spaghetti as affected by green and yellow pea, lentil, and chickpea flours. *Journal Food Science* 70: 371 – 376.