PRELIMINARY COMMUNICATION

Physico-chemical Properties and akara making potentials of pre-processed Jack Beans *(Canavalia ensiformis)* and Cowpea *(Vigna unguiculata L. Walp)* Composite Flour

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Summary

Akara (deep-fat fried balls) prepared from cowpea (Vigna unguiculata) paste is widely consumed in West Africa as a cheap source of protein. Jack bean (Canavalia ensiformis) is also rich in protein but is under-utilized in many parts of Africa due to the presence of several anti-nutritional factors. Jack bean was therefore subjected to different pre-processing methods (cracked-soaked, cracked-boiled and germinated) to reduce the anti-nutritional content before conversion into flours. Composite blends of the pre-processed jack beans and cowpea flour in different proportions of 95:05, 90:10, 85:15, 80:20 and 50:50 for each of the pre-processing methods was used in the production of akara. The proximate, pasting, functional and anti-nutritional properties of the flours as well as the proximate and anti-nutritional properties of the akara were determined using AOAC methods. The protein content of the cracked-boiled jack bean with 50% cowpea composite flour was the highest (23.65%), while germinated jack bean composite flour with 80% cowpea flour had the lowest (20.85%). Similarly, the protein content of the akara balls produced from cracked-boiled jack bean with 50% cowpea composite flour had the highest protein value (13.15%). Generally, the functional properties, except for water and oil absorption capacities were higher in cracked-boiled than in cracked-soaked and germinated jack bean composite flours. The pre-processing methods significantly ($p \leq 0.05$) affected the pasting properties of the composite flours, while the anti-nutritional factors such as protease inhibitor and saponins were not detected in the akara balls. Germination of jack bean decreased tannin content than cracked-boiled and cracked-soaked, while soaking decreased the phytates levels than germination and boiling methods. Sensory attributes of the akara were significantly different ($p\leq 0.05$) from each other with the germinated jack bean composite flour with 50% cowpea flour having the highest rating for all the attributes measured.

Key words: *Akara, cowpea, jack beans, proximate, functional, pasting, anti-nutritional*

Introduction

Akara is a deep-fat fried ball prepared from whipped cowpea paste, flavoured with pepper, onion and salt (McWatters, 1983; Olapade *et al*., 2004). Whipping of the paste is usually done prior to the addition of other ingredients to incorporate air and enhance the formation of stable foam (Ngoddy, *et al*., 1986; Hung and McWatters 1990). The paste obtained through milling dehulled and cleaned cowpea seeds can be processed into moin moin and akara by steaming or deep-fat frying of the paste respectively (McWatters, 1983). Akara is the most common cowpea-based product in West Africa (Reber, 1983), which makes it contribution to diet particularly significant.

Blending and whipping are important steps in processing of cowpea into *akara*. Blending clearly aids in reducing the particle size of paste to a more acceptable level and thus aiding in better distribution of moisture. Whipping incorporates air into paste, thus making it foam and giving it good dispensing properties and frying qualities (Mbofung *et al*., 2002).

Cowpea is a good source of protein in the tropics with the seed containing appreciable amounts of lysine and tryptophan but is deficient in methionine and cystiene when compared to animal protein. The crop therefore plays a critical role in the lives of millions of people in Africa and other parts of the developing world, where it is a major source of dietary protein that nutritionally complements staple low-protein cereal and tuber crops. It is also a valuable and dependable commodity that produces income for farmers and traders (Singh *et al*., 2002; Langyintuo *et al.,* 2003). While jack bean (*Canavalia ensiformis*) is one of the under exploited tropical dry beans, it is, however, fairly widely distributed, being cultivated in Africa, Asia, the West Indies, Latin America and India (Doss *et al*., 2011). It is a leguminous plant with the seeds and herbage being a good source of protein (Udedibie and Nkwocha, 1990) and mineral elements such as Calcium, Zinc, Potassium, Magnesium and Copper.

The nutritive value of jack bean seed is adversely affected by its anti-nutrients constituents, some of which can be reduced by processing (Essien and Udedibie, 2007). In order to increase the utilization of jack bean, different processing methods such as soaking, cooking and autoclaving (Doss *et al*., 2011) have been explored to investigate the possibilities of reducing the anti- nutrients in the bean. Akande and Fabiyi, (2010) reported the use of soaking, cooking, toasting, autoclaving, microwave cooking, pressure cooking, germination and chemical treatment in improving the quality of legumes. The nutritive value

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of many legumes has been reported to increase after germination (Vanderstoep, 1981; Uwaegbute *et al*., 2000). Germination has been shown to increase digestibility and protein quality (Nnanna and Phillips, 1989). Literature also abounds on the use cowpea starch in noodle preparation (Fasasi and Karim, 2011). Osho and Karim, (2007) compared the composition, physical and sensory properties of akara prepared from cowpea paste and flour, however, there is no information on the use of jack bean flour in the production of "akara". Therefore, the aim of this study was to investigate the "akara" making potentials of composite flour produced from cowpea and jack bean seeds.

Materials and Methods

The Jack bean used for this research was obtained from National Centre for Genetic Resource and Biotechnology (NACGRAB), Ibadan and the cowpea seed was obtained from Bodija market in Ibadan, Nigeria.

Methods

Jack bean processing

Jack beans seed were sorted, picked and cleaned from all dirt's and then divided into three equal parts. Three pre-processing methods (cracked-soaked, cracked-boiled and germinated) were employed. The first portion of the jack bean was cracked and soaked in water for 48 hours after which the soak-water was discarded. It was then rinsed with fresh water and then drained of the water; oven dried and milled Udedibie, (1988). The second portion of the jack bean was cracked and boiled (pressure cooking) for 15 mins, cooking water was drained and the beans oven dried and milled into flour (Udedibie, 1988). The third portion of the seeds was placed on moist cotton wool and was allowed to germinate. Germination was terminated on the sixth day, and the seeds oven dried and milled into flour.

Production of Cowpea Flour

Cowpea seeds were manually sorted to remove impurities; it was soaked in water at room temperature (35±2^{o}C) for 10 mins to soften the testa, which was manually removed and washed off. The cleaned cotyledons were oven dried at 60^{o}C for 24 hours and milled into four using disc attrition mill, followed by sieving (300-µm aperture). All flour samples were kept in high density polythene until analysis.

Production of "akara"

Composite flour of cowpea and jack bean was prepared using the formulation in Table 1 below while akara was prepared using methods described by McWatters, (1983). The composite flour was mixed with measured volume of water. This was allowed to form batter or slurry. The batter was whipped severally to incorporate air for about 2 mins. Other ingredient like pepper, onion, salts, spices were then added. This was then scooped to make ball into already heated oil. The scooped balls (fritters) were turned frequently until deep fried (193^{o}C) and golden brown colour is obtained.

***Table 1**: Formulation of flour blends for the production of "akara"*

Cowpea Flour (%)	Jack Bean Flour (%)
95	5
90	10
85	15
80	20
50	50
-	100

Proximate Composition

Proximate compositions of the composite flour and akara were determined using AOAC, (1990) methods.

Functional Properties

Bulk Density was determined using method described by Mpotokwane *et al*., (2008), water absorption capacity (WAC) and oil absorption capacity (OAC) by Sosulski *et al.,* (1976) method, swelling capacity by Falade and Olugbuyi, (2010) method, least gelation concentration by Coffman and Garcia, (1977) method, foam capacity and foam stability by Fagbemi and Oshodi (1991) method.

Pasting Properties

Pasting characteristics were determined using standard methods with a Rapid Visco Analyser (RVA) (Model RVA 3D+, Newport Scientific, Narrabeen, Australia) (Newport Scientific, 1995).

Anti-Nutritional Factors

Protease inhibitors, phytate, oxalates, tannin and saponin were determined using methods described by Joslyn, (1970).

Sensory evaluation

Coded samples were presented to twenty members of panels which are familiar with "akara" for sensory evaluation. The panelists rated the taste, flavor, aroma, texture, colour and overall acceptance using a nine point hedonic scale, where 9 indicated 'like extremely' a nd 1 'dislike extremely' (Iwe, 2002).

Statistical Analysis

Experiments were carried out in triplicates and data were subjected to analysis of variance. Mean scores of some of the results and their standard deviations were reported. Duncan's multiple range test was used to separate the means.

Results and Discussion

Proximate composition of composite flours

The proximate composition of the composite flours from cowpea and pre-processed jack bean flour is presented in Table

2. The result showed that the pre-processing methods (cracking-soaking, germination and cracking-boiling) affected the proximate composition significantly. The moisture content of 100% cowpea flour was the highest (9.55%) while composite flour from cracked-boiled jack bean with 50% cowpea flour had the lowest moisture content (4.12%). The addition of pre-processed jack bean to cowpea flour decreased the moisture content of the composite flours.

The protein content of the cracked-boiled jack bean flour with 50% cowpea flour was the highest (23.65%), while germinated jack bean composite flour with 80% cowpea flour was the lowest (20.85%). Although, all the cracked-boiled jack bean composite flour had higher protein values than cracked-soaked and germinated composite flours, the cracked-soaked and germinated composite flours had comparable protein content with 100% cowpea flour. The low value obtained for germinated composite flours may be attributed to the breakdown of proteins and other macromolecules that occurs during germination. According to Esonu *et al*., (1998), sprouting initiates breakdown of food materials, transports of materials from one part of the seed to another especially from the endosperm to the cotyledon to the growing parts and the synthesis of new materials. Germination of seeds has also been reported to enhance protein hydrolysis into amino acids (Akande and Fabiyi, 2010).

The fat, ash, crude fibre and carbohydrate content of the complete flours ranged from 1.95-2.95%, 2.15-3.35%, 1.55-2.05% and 59.25-64.40% respectively. It was observed that the addition of pre-processed jack bean flours at different ratio did not affect the carbohydrate content significantly. Generally, cracked-boiled composite flours had relatively lower values of carbohydrate than cracked-soaked and germinated samples.

Proximate composition of akara

The proximate compositions of the akara prepared from the composite flours are presented in Table 3. All the samples had lower moisture content than values (45.3%) reported for akara processed from cowpea paste and Nigerian cowpea flour as reported by Mcwatters, (1983). The lower moisture content may be attributed to the difference in the quantity of water used in the recipe formulation and the initial moisture content of the flours.

The moisture content ranged between 35.30 and 39.40%, while protein content of the akara differed significantly from each other with value ranging between 12.15 and 13.75% for germinated composite flours with 90% and 80% cowpea flour and cracked-soaked composite flour with 95% cowpea flour respectively. Akara prepared from cracked-soaked composite flours had higher protein values than germinated and cracked-boiled akara. The higher value recorded for germinated and cracked-boiled composite flours may be due to the reduction in protein content as a result of protein hydrolysis during germination and possible denaturation of proteins by heat. Lower crude protein values recorded by Akingbade *et al*., (2009) for soaked jack bean seeds was attributed to solubilisation and possible loss of nitrogenous compounds.

Table 2: *Proximate Composition of the composite flour*

Sample			Quality Parameter					
Treatment on Pigeon Pea	Pigeon pea flour (%)	Cowpea flour (%)	Moisture Content (%)	Protein (%)	Fat (%)	Ash (%)	Crude Fibre (%)	Carbohydrate (%)
Cracked-soaked	5	95	$6.44\pm0.74_{d}$	$22.35\pm0.07_{bc}$	$2.35\pm0.07_{d}$	$3.05\pm0.07_{c}$	$1.90\pm0.00_{ab}$	$61.65\pm0.35_{a}$
Cracked-soaked	10	90	$8.67\pm1.21_{b}$	$21.70\pm0.14_{c}$	$2.25\pm0.07_{de}$	$3.05\pm0.07_{c}$	$1.85\pm0.07_{b}$	$62.20\pm0.00_{a}$
Cracked-soaked	15	85	$7.30\pm2.81_{c}$	$21.60\pm0.14_{c}$	$2.15\pm0.07_{e}$	$3.10\pm0.00_{bc}$	$1.85\pm0.07_{b}$	$62.50\pm0.14_{a}$
Cracked-soaked	20	80	$7.99\pm0.48_{c}$	$21.75\pm0.07_{c}$	$2.05\pm0.07_{e}$	$3.05\pm0.07_{c}$	$1.90\pm0.00_{a}$	$62.50\pm0.00_{a}$
Cracked-soaked	50	50	$8.27\pm1.37_{b}$	$21.45\pm0.07_{c}$	$2.05\pm0.07_{e}$	$3.05\pm0.07_{c}$	$1.80\pm0.00_{bc}$	$62.85\pm0.07_{a}$
Germination	5	95	$6.37\pm0.00_{d}$	$21.55\pm0.07_{c}$	$2.00\pm0.00_{e}$	$2.40\pm0.14_{d}$	$1.65\pm0.07_{d}$	$63.50\pm0.14_{a}$
Germination	10	90	$7.62\pm0.14_{c}$	$21.15\pm0.07_{c}$	$1.95\pm0.07_{f}$	$2.35\pm0.07_{d}$	$1.75\pm0.07_{c}$	$63.40\pm0.14_{a}$
Germination	15	85	$7.33\pm0.74_{c}$	$21.00\pm0.00_{c}$	$2.00\pm0.00_{e}$	$2.25\pm0.07_{de}$	$1.65\pm0.07_{d}$	$63.85\pm0.07_{a}$
Germination	20	80	$7.79\pm0.88_{c}$	$20.85\pm0.07_{d}$	$1.95\pm0.07_{f}$	$2.15\pm0.07_{e}$	$1.65\pm0.07_{d}$	$64.40\pm0.14_{a}$
Germination	50	50	$5.34\pm0.18_{de}$	$21.10\pm0.00_{c}$	$2.00\pm0.00_{e}$	$2.15\pm0.07_{e}$	$1.55\pm0.07_{e}$	$63.30\pm0.14_{a}$
Cracked-boiled	5	95	$6.32\pm0.67_{d}$	$23.05\pm0.71_{a}$	$2.95\pm0.07_{a}$	$3.20\pm0.00_{a}$	$2.05\pm0.07_{a}$	$59.40\pm0.14_{c}$
Cracked-boiled	10	90	$5.50\pm0.63_{de}$	$23.25\pm0.71_{a}$	$2.70\pm0.00_{bc}$	$3.25\pm0.07_{a}$	$1.90\pm0.00_{ab}$	$59.25\pm0.71_{c}$
Cracked-boiled	15	85	$5.05\pm0.00_{e}$	$23.50\pm0.00_{a}$	$2.50\pm0.14_{c}$	$3.25\pm0.07_{a}$	$1.90\pm0.00_{ab}$	$59.70\pm0.00_{c}$
Cracked-boiled	20	80	$5.35\pm0.46_{e}$	$23.50\pm0.14_{a}$	$2.35\pm0.07_{d}$	$3.35\pm0.07_{a}$	$1.80\pm0.14_{bc}$	$59.60\pm0.42_{c}$
Cracked-boiled	50	50	$4.12\pm0.92_{f}$	$23.65\pm0.71_{a}$	$2.15\pm0.07_{e}$	$3.35\pm0.07_{a}$	$1.75\pm0.07_{c}$	$60.00\pm0.14_{bc}$
Cowpea flour	0	100	$9.55\pm0.00_{a}$	$21.80\pm0.14_{c}$	$2.14\pm0.07_{e}$	$3.00\pm0.00_{c}$	$1.70\pm0.14_{c}$	$62.30\pm0.28_{a}$

Values are mean of triplicate determination and values with the same subscript within a column are not significant different ($p\leq0.05$).

***Table 3:** Proximate Composition of Akara*

Sample			Quality Parameter					
Treatment on Pigeon Pea	Pigeon pea flour (%)	Cowpea flour (%)	Moisture Content (%)	Protein (%)	Fat (%)	Ash (%)	Crude Fibre (%)	Carbohydrate (%)
Cracked-soaked	5	95	$36.70\pm0.00_{c}$	$13.75\pm0.21_{a}$	$18.45\pm0.07_{cd}$	$2.85\pm0.07_{c}$	$0.91\pm0.00_{b}$	$27.50\pm0.00_{d}$
Cracked-soaked	10	90	$37.40\pm0.00_{b}$	$12.75\pm0.07_{bc}$	$18.09\pm0.00_{de}$	$2.90\pm0.00_{bc}$	$1.00\pm0.00_{d}$	$26.95\pm0.07_{e}$
Cracked-soaked	15	85	$35.60\pm0.00_{d}$	$13.05\pm0.07_{a}$	$19.15\pm0.21_{b}$	$3.00\pm0.00_{a}$	$0.95\pm0.07_{b}$	$28.20\pm0.14_{c}$
Cracked-soaked	20	80	$36.20\pm0.00_{c}$	$13.05\pm0.21_{a}$	$19.50\pm0.00_{b}$	$2.85\pm0.07_{c}$	$1.00\pm0.00_{d}$	$27.60\pm0.00_{d}$
Cracked-soaked	50	50	35.30 ± 0.00	$12.75\pm0.07_{bc}$	$18.40\pm0.14_{cd}$	$2.85\pm0.07_{c}$	$0.90\pm0.00_{b}$	$29.30\pm0.42_{c}$
Germination	5	95	$37.50\pm0.14_{b}$	$12.20\pm0.00_{c}$	$17.00\pm0.00_{e}$	$2.20\pm0.00_{g}$	$0.55\pm0.07_{c}$	$30.40\pm0.14_{bc}$
Germination	10	90	$36.75\pm0.07_{d}$	$12.15\pm0.07_{c}$	$17.50\pm0.14_{e}$	$2.35\pm0.07_{fg}$	$0.50\pm0.14_{c}$	$30.80\pm0.14_{bc}$
Germination	15	85	$36.15\pm0.35_{c}$	$12.40\pm0.00_{c}$	$17.55\pm0.21_{e}$	$2.45\pm0.07_{f}$	$0.55\pm0.07_{c}$	$30.95\pm0.21_{bc}$
Germination	20	80	$36.20\pm0.00_{c}$	$12.15\pm0.07_{c}$	$16.60\pm0.14_{f}$	$2.35\pm0.07_{f}$	$0.50\pm0.07_{c}$	$32.20\pm0.28_{a}$
Germination	50	50	$36.60\pm0.00_{c}$	$12.35\pm0.21_{c}$	$17.15\pm0.21_{e}$	$2.45\pm0.07_{f}$	$0.55\pm0.07_{c}$	$31.40\pm0.14_{ab}$
Cracked-boiled	5	95	$38.35\pm0.21_{b}$	$12.35\pm0.21_{c}$	$19.25\pm0.07_{b}$	$2.85\pm0.07_{c}$	$1.00\pm0.14_{b}$	$26.25\pm0.07_{e}$
Cracked-boiled	10	90	$39.40\pm0.14_{a}$	$12.65\pm0.07_{bc}$	$18.55\pm0.07_{c}$	$2.80\pm0.00_{c}$	$1.05\pm0.07_{ab}$	$25.60\pm0.28_{fg}$
Cracked-boiled	15	85	$38.55\pm0.21_{b}$	$12.60\pm0.28_{bc}$	$20.60\pm0.14_{a}$	$2.70\pm0.00_{d}$	$1.10\pm0.00_{ab}$	$24.45\pm0.07_{g}$
Cracked-boiled	20	80	$37.85\pm0.07_{b}$	$12.75\pm0.21_{bc}$	$18.60\pm0.00_{c}$	$2.70\pm0.00_{d}$	$1.05\pm0.71_{ab}$	$26.80\pm0.14_{e}$
Cracked-boiled	50	50	$39.35\pm0.21_{a}$	$13.15\pm0.07_{a}$	$20.90\pm0.14_{a}$	$2.65\pm0.07_{e}$	$1.15\pm0.07_{a}$	$22.70\pm0.14_{h}$
Cowpea flour	0	100	$36.70\pm0.00_{c}$	$12.65\pm0.07_{bc}$	$19.10\pm0.14_{b}$	$2.80\pm0.00_{c}$	$0.95\pm0.07_{b}$	$28.65\pm0.21_{c}$

Values are mean of triplicate determination and values with the same subscript within a column are not significant different ($p\leq0.05$).

Fat content of the akara were lower than values reported for akara made from California black eye peas, Dixiecream peas and Nigerian cowpea flour as reported by McWatters (1983). The fat content of the akara ranged between 16.60 and 20.90% with akara prepared from cracked-boiled composite flours having higher fat content than akara prepared from germinated and cracked-soaked composite flours. However, they all compare favourably well with akara prepared from 100% cowpea flour with regard to their fat content except for akara prepared from germinated composite flour with 80% cowpea flour with a lower fat content.

Similarly, the ash, crude fibre and carbohydrate content of the akara varied significantly. All the akara prepared from cracked-soaked composite flours had higher ash content than akara prepared from germinated and cracked-boiled composite flours. The ash content ranged between 2.20 and 3.00%, crude fibre between 0.50 and 1.15% and carbohydrate content between 22.70 and 32.20%.

Functional Properties of the composite flours

The bulk densities of the composite flours (Table 4) showed that the loose bulk density (LBD) ranged from 0.45 to 0.48gcm^{-3}, while the packed bulk density (PBD) ranged from 0.63 to 0.66gcm^{-3}. Generally, cracked boiled composite flours had higher LBD and PBD than cracked-soaked and germinated composite flours.

The higher bulk densities indicated greater compactness of the particles because particle size is inversely proportional to bulk densities (Falade and Olugbuyi, 2010). Although, LBD and PBD varied among the treatments method, the addition of the pre-processed jack bean flours had no significant effect on the composite flours.

Generally, the swelling capacity (SC) of the flours varied significantly ($p\leq0.05$) between and among the processing methods. The SC ranged between 1.30 and 1.60% with all the samples irrespective of the pre-processing method having comparable values with the 100% cowpea flour except for germinated composite flour with 80 and 50% cowpea flour (Table 4). Although the SC differs among the samples the values are comparable with 100% cowpea flour. Prinyawiwatkul *et al.*, (1994) and Cheftel *et al.*, (1985), attributed reduced swelling capacity to high fat content. The difference in the swelling capacity of the composite flours may be attributed to the differences in the starch component and the possible starch modification caused by the pre-processing methods (Crosbie, 1991). The SC for the samples is lower than values (2.07-6.88%) reported by Falade and Olugbuyi, (2010) for plantain flours dried at different stage of maturity and drying methods, and values (3.15-3.79) reported by Oluwamukomi and Jolayemi, (2012) for soy-melon enriched gari

Similarly, the least gelation concentration (LGC) of all the composite flours had comparable values with 100% cowpea flour except for cracked-soaked composite flour with 95% cowpea flour with lower LGC value (4.00%). Germinated composite flours with 50% cowpea flour and cracked-boiled composite flour with 50% cowpea flour had higher values than all the samples including the 100% cowpea flour.

Table 4: *Functional properties of the composite flour*

Sample			Quality Parameter							
Treatment on Pigeon Pea	Pigeon pea flour (%)	Cowpea flour (%)	Loose Bulk Density g/cm^3	Pack Bulk Density g/cm^3	Swelling Capacity (%)	Least Gelation Concentration (%)	Foaming Capacity (%)	Foaming Stability	Water Absorption Capacity (%)	Oil Absorption Capacity (%)
Cracked-soaked	5	95	0.46±0.00$_b$	0.64±0.00$_c$	1.60±0.00$_a$	4.00±0.00$_c$	43.20±0.28$_c$	9.75±0.07$_c$	160±0.00$_b$	140±0.00$_a$
Cracked-soaked	10	90	0.46±0.00$_b$	0.64±0.00$_c$	1.60±0.00$_a$	6.00±0.00$_b$	42.80±0.14$_c$	9.70±0.14$_c$	160±0.00$_b$	130±0.00$_b$
Cracked-soaked	15	85	0.46±0.01$_b$	0.64±0.00$_c$	1.50±0.00$_b$	6.00±0.00$_b$	41.95±0.35$_d$	9.45±0.11$_d$	165±0.00$_a$	130±0.00$_b$
Cracked-soaked	20	80	0.46±0.00$_b$	0.64±0.00$_c$	1.50±0.00$_b$	6.00±0.00$_b$	40.85±0.21$_d$	9.25±0.07$_e$	165±0.00$_a$	140±0.00$_a$
Cracked-soaked	50	50	0.46±0.00$_b$	0.65±0.00$_b$	1.50±0.00$_b$	6.00±0.00$_b$	40.60±0.14$_d$	9.10±0.14e	165±0.00$_a$	140±0.00$_a$
Germination	5	95	0.45±0.00$_c$	0.63±0.00$_d$	1.40±0.00$_c$	6.00±0.00$_b$	36.25±0.35$_e$	5.25±0.35$_g$	165±0.00$_a$	140±0.00$_a$
Germination	10	90	0.45±0.00$_c$	0.63±0.00$_d$	1.40±0.00$_c$	6.00±0.00$_b$	35.40±0.57$_{fg}$	5.70±0.14$_f$	165±0.00$_a$	140±0.00$_a$
Germination	15	85	0.45±0.00$_c$	0.64±0.00$_c$	1.40±0.00$_c$	6.00±0.00$_b$	35.30±0.14$_{fg}$	5.50±0.71$_g$	165±0.00$_a$	140±0.00$_a$
Germination	20	80	0.45±0.00$_c$	0.64±0.00$_c$	1.30±0.00$_d$	6.00±0.00$_b$	34.80±0.28$_g$	5.65±0.21$_f$	165±0.00$_a$	130±0.00$_b$
Germination	50	50	0.45±0.00$_c$	0.64±0.00$_c$	1.30±0.00$_d$	8.00±0.00$_a$	34.65±0.21$_g$	5.10±0.14$_g$	160±0.00$_b$	130±0.00$_b$
Cracked-boiled	5	95	0.48±0.00$_a$	0.66±0.00$_a$	1.50±0.00$_b$	6.00±0.00$_b$	46.65±0.14$_a$	11.65±0.00$_a$	160±0.00$_b$	140±0.00$_a$
Cracked-boiled	10	90	0.48±0.00$_a$	0.66±0.00$_a$	1.50±0.07$_b$	6.00±0.00$_b$	46.25±0.12$_a$	11.30±0.00$_a$	160±0.00$_b$	130±0.00$_b$
Cracked-boiled	15	85	0.48±0.00$_a$	0.66±0.00$_a$	1.50±0.00$_b$	6.00±0.00$_b$	45.85±0.21$_b$	11.25±0.00$_a$	160±0.00$_b$	130±0.00$_b$
Cracked-boiled	20	80	0.48±0.00$_a$	0.66±0.00$_a$	1.40±0.00$_c$	6.00±0.00$_b$	45.45±0.71$_b$	10.75±0.00$_b$	155±0.00$_c$	130±0.00$_b$
Cracked-boiled	50	50	0.48±0.00$_a$	0.66±0.00$_a$	1.40±0.00$_c$	8.00±0.00$_a$	45.05±0.14$_{bc}$	10.35±0.00$_b$	155±0.00$_c$	130±0.00$_b$
Cowpea flour	0	100	0.46±0.01$_b$	0.65±0.00$_b$	1.50±0.00$_b$	6.00±0.00$_b$	41.40±0.14$_d$	9.15±0.07$_e$	165±0.00$_a$	140±0.00$_a$

Values are mean of triplicate determination and values with the same subscript within a column are not significant different ($p \leq 0.05$).

The foaming capacity (FC) for cracked-boiled composite flour ranged from 45.05 to 46.65%, germinated composite flour ranged from 34.65 to 36.25% while cracked-soaked composite flour ranged from 40.60 to 43.20% (Table 4). The FC varied significantly among the samples with cracked-boiled composite flour (95% cowpea flour) having the highest value (46.25%) and germinated composite flour (50% cowpea flour) has the lowest value (34.65%).

Cracked-boiled composite flour with 95% cowpea flour had the best foam stability (FS) with a value of 11.65% while germinated composite flour with 50% cowpea flour had the lowest (5.10%). The FS values ranged between 9.10 -9.75%, 5.10-5.70% and 10.35-11.75% for cracked-soaked, germinated and cracked-boiled composite flours respectively (Table 4). The FS for cracked-soaked and cracked-boiled composite flours were higher than germinated composite flours and have comparable values with 100% cowpea flour.

The WAC of all the flours have comparable values with 100% cowpea flour except for cracked-boiled composite flours with 80% and 50% cowpea flours. WAC ranged between (155-165%) while OAC ranged between 130-140%. OAC has been reported to be important for the development of new food products and have influence on their storage stability, particularly for flavour binding and on the development of rancidity (Falade and Kolawole, 2012). High protein contents in flours and the nature of the proteins also contribute significantly to the oil retaining properties of food materials (Ravi and Sushelamma, 2005). Therefore, the high OAC of the flours could be attributed to the high protein contents in the two flours used.

Pasting properties of composite flours

The pasting properties of the composite flours as shown in Table 5 differ significantly ($p \leq 0.05$) among the samples. The peak vis-

Table 5: *Pasting properties of the composite flour*

Sample			Quality Parameter						
Treatment on Pigeon Pea	Pigeon pea flour (%)	Cowpea flour (%)	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak Time (RVU)	Pasting Temperature (RVU)
Cracked-soaked	5	95	$1203.5\pm27.58_{cd}$	$828.5\pm24.75_{c}$	$375.00\pm2.83_{b}$	$1334\pm46.67_{d}$	$505.5\pm21.92_{e}$	$4.90\pm0.05_{c}$	$83.23\pm0.18_{b}$
Cracked-soaked	10	90	$1014\pm21.21_{d}$	$672.00\pm9.10_{e}$	$333.00\pm1.41_{c}$	$1084\pm19.8_{f}$	$407.5\pm3.54_{f}$	$4.80\pm0.00_{de}$	$83.98\pm0.04_{b}$
Cracked-soaked	15	85	$1855.50\pm3.54_{b}$	$586.50\pm9.19_{f}$	$269.00\pm5.66_{d}$	$919.00\pm11.31_{g}$	$332.5\pm2.12_{h}$	$4.73\pm0.00_{e}$	$83.95\pm1.41_{b}$
Cracked-soaked	20	80	$802.00\pm15.56_{f}$	$467.5\pm21.92_{g}$	$334.50\pm6.36_{c}$	$692.00\pm33.94_{i}$	$224.5\pm12.02_{i}$	$4.53\pm0.0_{g}$	$83.55\pm0.64_{b}$
Cracked-soaked	50	50	$442.50\pm3.54_{i}$	206.00 ± 1.41	$236.50\pm2.12_{e}$	$297.50\pm0.71_{k}$	$91.50\pm0.71_{k}$	$4.43\pm0.05_{g}$	$67.33\pm23.6_{d}$
Germination	5	95	$893.00\pm67.88_{ef}$	$859.00\pm87.68_{b}$	$34.00\pm19.80_{i}$	$1630.00\pm82.02_{b}$	$771\pm5.66_{c}$	$4.97\pm0.23_{c}$	$84.13\pm0.04_{ab}$
Germination	10	90	$690.50\pm16.26_{g}$	$582.50\pm7.78_{f}$	$108.00\pm8.49_{f}$	$1425.\pm31.11_{cd}$	$842.5\pm23.34_{b}$	$4.63\pm0.05_{f}$	$84.13\pm0.04_{ab}$
Germination	15	85	$548.00\pm8.49_{h}$	$786.00\pm4.24_{d}$	$102.00\pm5.66_{f}$	$1058.00\pm19.80_{f}$	$612\pm16.97_{d}$	$4.50\pm0.05_{g}$	$84.00\pm0.00_{b}$
Germination	20	80	$460.50\pm4.95_{i}$	$390.50\pm3.54_{h}$	$70.00\pm1.41_{h}$	$835.50\pm16.26_{h}$	$445\pm12.73_{f}$	$4.47\pm0.00_{g}$	$84.03\pm0.00_{b}$
Germination	50	50	342.00 ± 21.21	$333\pm15.56_{i}$	$9.00\pm5.66_{g}$	$765.00\pm28.28_{h}$	$432\pm12.73_{f}$	$6.90\pm0.14_{a}$	$85.58\pm0.04_{a}$
Cracked-boiled	5	95	$1129.00\pm1.41_{d}$	$786.00\pm4.24_{d}$	$343.00\pm5.66_{c}$	$1136.5\pm20.51_{e}$	$350\pm2475_{g}$	$4.83\pm0.05_{c}$	$83.55\pm0.56_{b}$
Cracked-boiled	10	90	$1165.50\pm4.95_{d}$	$832\pm11.31_{c}$	$1333.5\pm6.36_{a}$	$1206.50\pm3.54_{e}$	$374.5\pm7.28_{g}$	$4.83\pm0.05_{c}$	$83.60\pm0.57_{b}$
Cracked-boiled	15	85	$1078.5\pm16.26_{d}$	$731.50\pm0.71_{de}$	$347\pm16.97_{c}$	$1059.00\pm5.66_{f}$	$327.5\pm4.95_{h}$	$4.70\pm0.05_{d}$	$83.18\pm0.04_{c}$
Cracked-boiled	20	80	$984.00\pm15.56_{e}$	$642.50\pm12.02_{e}$	$341.5\pm3.54_{c}$	$904.50\pm17.68_{g}$	$262\pm5.66_{i}$	$4.67\pm0.00_{f}$	$83.53\pm0.62_{b}$
Cracked-boiled	50	50	$685.50\pm2.12_{g}$	$329.50\pm0.71_{i}$	$356\pm1.41_{c}$	$463.00\pm0.00_{j}$	$133.5\pm0.71_{j}$	$4.50\pm0.05_{g}$	$83.83\pm0.04_{b}$
Cowpea flour	0	100	$2008\pm0.00_{a}$	$1758\pm22.63_{a}$	$250\pm0.071_{d}$	$2754.50\pm27.58_{a}$	$996.50\pm4.95_{a}$	$5.50\pm0.05_{b}$	$83.58\pm0.60_{b}$

Values are mean of triplicate determination and values with the same subscript within a column are not significant different ($p\leq0.05$).

cosity, trough viscosity, breakdown viscosity, final viscosity and setback viscosity of the flours ranged between 342 and 2008RVU, 206 and 1758RVU, 34 and 133.5RVU, 297.50 and 2754.50RVU and 91.50 and 996.50RVU respectively. On the whole, 100% cowpea flour had higher values for peak viscosity, trough viscosity, final viscosity and setback than all the composite flours. A decrease in peak, trough, breakdown, final and setback viscosities of the composite flours were observed as the percentage of pre-processed jack bean flour increased. This may be attributed to a reduction in the starch content of the composite flours. Sanni *et al*., (2004) reported that peak viscosity is largely dependent on the starch content and indicates the ability of starch to swell freely before breakdown.

The peak viscosities of the composite flours are higher than values reported for pupuru (362-430RVU) by Shittu *et al*., (2001) and for composite flour from wheat and sweet potato (131.42-271.08) by Odedeji and Adeleke (2010). Peak viscosity is often associated with final product quality and provides an indication of the viscous load likely to be encountered during mixing (Maziya-Dixon et al., 2004). Hoover, (2001) stated that granules with high peak viscosity have weaker cohesive forces within the granules than those with lower values and would disintegrate more easily. This suggests the existence of stronger cohesive forces in the composite flours than 100% cowpea and thus greater resistant to disintegration during handling and mixing. Cracked-soaked and cracked-boiled composite flours showed higher peak, trough and breakdown than germinated composite flours. However, germinated composite flours had higher setback than cracked-soaked and cracked-boiled flours.

Breakdown viscosity, a parameter which measures the resistance to heat, shear of dough (Falade and Kolawole 2012) stability of starch gel during cooking (Zaidhul *et al*., 2006; Fernande and Berry,

Table 6: *Sensory Evaluation of Akara*

Sample			Quality Parameter					
Treatment on Pigeon Pea	Pigeon pea flour (%)	Cowpea flour (%)	Aroma	Taste	Flavour	Texture	Colour	Overall Acceptability
Cracked-soaked	5	95	$2.70\pm0.90_{f}$	$3.20\pm0.40_{d}$	$2.80\pm0.90_{h}$	$3.50\pm1.00_{f}$	$2.70\pm0.50_{g}$	$3.00\pm0.07_{g}$
Cracked-soaked	10	90	$3.00\pm0.90_{e}$	$2.90\pm1.00_{e}$	$2.70\pm0.50_{h}$	$2.70\pm0.80_{hi}$	$2.50\pm1.30_{g}$	$2.40\pm0.50_{h}$
Cracked-soaked	15	85	$4.80\pm1.90_{b}$	$4.20\pm1.40_{ab}$	$4.50\pm1.50_{bc}$	$4.3\pm1.40_{d}$	$3.60\pm0.80_{d}$	$4.80\pm1.90_{b}$
Cracked-soaked	20	80	$3.80\pm1.80_{de}$	$3.50\pm1.60_{cd}$	$4.00\pm1.20_{d}$	$4.00\pm1.20_{d}$	$3.20\pm0.90_{f}$	$4.10\pm1.70_{d}$
Cracked-soaked	50	50	$5.30\pm2.30_{a}$	$4.00\pm1.70_{b}$	$3.50\pm1.60_{e}$	$4.10\pm1.70_{d}$	$3.90\pm1.20_{bc}$	$4.70\pm2.10_{bc}$
Germination	5	95	$4.10\pm1.80_{c}$	$3.50\pm0.70_{cd}$	$3.20\pm0.90_{g}$	$4.50\pm1.40_{c}$	$3.70\pm0.80_{cd}$	$4.20\pm1.00_{d}$
Germination	10	90	$5.60\pm2.20_{a}$	$3.60\pm0.80_{c}$	$3.70\pm1.60_{e}$	$4.70\pm1.90_{bc}$	$3.50\pm1.40_{d}$	$4.60\pm1.90_{c}$
Germination	15	85	$4.30\pm2.10_{c}$	$3.40\pm1.10_{d}$	$3.20\pm0.80_{g}$	$4.50\pm1.10_{cd}$	$3.80\pm0.60_{bc}$	$4.30\pm1.40_{d}$
Germination	20	80	$4.60\pm1.60_{b}$	$4.10\pm0.70_{ab}$	$3.90\pm1.10_{d}$	$4.60\pm1.60_{cd}$	$4.00\pm1.40_{b}$	$4.70\pm1.70_{b}$
Germination	50	50	$6.10\pm1.90_{a}$	$4.30\pm0.70_{a}$	$4.90\pm0.90_{a}$	$5.70\pm1.50_{a}$	$4.40\pm1.10_{ab}$	$5.80\pm1.60_{a}$
Cracked-boiled	5	95	$3.00\pm0.90_{e}$	$4.00\pm1.30_{b}$	$3.60\pm1.10_{e}$	$3.40\pm1.10_{f}$	$3.00\pm0.70_{f}$	$3.40\pm1.60_{f}$
Cracked-boiled	10	90	$3.80\pm0.80_{de}$	$4.00\pm1.50_{b}$	$3.80\pm0.80_{d}$	$3.40\pm1.10_{f}$	$3.40\pm1.10_{e}$	$3.80\pm1.20_{ef}$
Cracked-boiled	15	85	$4.00\pm0.70_{cd}$	$3.60\pm1.70_{c}$	$4.00\pm0.70_{d}$	$3.80\pm1.50_{e}$	$3.40\pm1.10_{e}$	$3.60\pm1.30_{f}$
Cracked-boiled	20	80	$3.40\pm0.80_{e}$	$4.20\pm1.20_{ab}$	$3.40\pm0.80_{fg}$	$3.20\pm1.00_{g}$	$3.00\pm1.20_{f}$	$3.60\pm1.10_{f}$
Cracked-boiled	50	50	$4.60\pm2.50_{b}$	$4.20\pm1.70_{ab}$	$4.20\pm2.30_{cd}$	$5.80\pm2.50_{a}$	$3.60\pm0.80_{d}$	$4.20\pm1.80_{d}$
Cowpea flour	0	100	$2.20\pm1.30_{f}$	$2.60\pm0.60_{f}$	$3.30\pm0.30_{g}$	$2.00\pm0.80_{i}$	$3.00\pm1.40_{f}$	$2.10\pm1.10_{e}$

Values are mean of triplicate determination and values with the same subscript within a column are not significant different ($p\leq0.05$).

1989) varied significantly ($p\leq0.05$) among the samples. Lower breakdown values recorded for the composite flours indicate greater stability tendencies.

Peak time and pasting temperatures as presented in Table 5 varied significantly ($p\leq0.05$) among the samples with germinated composite flour with 50% cowpea flour having the highest peak time (6.90mins) and pasting temperature (85.58°C), while cracked-soaked composite flour with 50% cowpea flour had the lowest peak time (4.43mins) and pasting temperature (67.33°C). The peak time, a measure of the cooking time (Adebowale *et al*., 2005) decreased with increase in percentage of pre-processed jack bean flour, while the pasting temperature for all the composite flours including the 100% cowpea flour was almost uniform irrespective of the pre-processing method employed. Pasting temperature is a measure of the minimum temperature required to cook a given food sample (Sandhu *et al*., 2005) and accounts for the temperature at which perceptible increase in viscosity occurs and is always higher than gelatinization temperature (Moorthy, 2002). It also has implication for the stability of other components of the paste and energy costs (Newport Scientific, 1998).

Sensory characteristics of composite flours

The mean sensory scores of akara prepared from pre-processed jack bean flour and cowpea flour are presented in Table 6. Generally, all the akara samples had better ratings in aroma, taste, flavour, texture, colour and overall acceptability than 100% cowpea flour. Germinated composite flours had better overall acceptability ratings with germinated composite flour (50% cowpea flour) having the highest score (5.80) in all the parameters measured and 100% cowpea flour with the lowest (2.10). This observation may be attributed to the interaction between the various components of the jack bean and cowpea flour blends.

Anti-nutritional factors of akara

Anti-nutritional factors (ANF) determined in this study in the akara samples with their values are presented in Table 7. Protease inhibitor and saponins were not detected in all the akara. Similarly, oxalate was not detected in akara prepared from cracked-soaked and germinated composite flours but was found in akara prepared from cracked-boiled composite flour. The phytates and tannins content of the akara varied significantly with cracked-soaked composite flours having lower values and cracked-boiled composite flours having higher values. Generally, the tannin content of the akara prepared from cracked-soaked composite flours did not differ significantly. A similar trend was observed for akara prepared from germinated and cracked-boiled composite flours.

Conclusions

Result from this study has shown the possibility of increasing the utilization of jack bean through traditional pre-processing methods that can be employed and adapted for use on a small scale and at household levels. Pre-processing methods and the levels of inclusion of the processed jack bean flours

***Table 7:** Antinutritional Factors in Akara*

Sample			Quality Parameter				
Treatment on Pigeon Pea	Pigeon pea flour (%)	Cowpea flour (%)	Oxalate (%)	Phytates (%)	Protease Inhibitor	Tannins (%)	Saponins
Cracked-soaked	5	95	ND	$1.50 \pm 0.00_e$	ND	$2.50 \pm 0.00_d$	ND
Cracked-soaked	10	90	ND	$2.00 \pm 0.00_e$	ND	$2.50 \pm 0.00_d$	ND
Cracked-soaked	15	85	ND	$2.00 \pm 0.00_e$	ND	$2.50 \pm 0.00_d$	ND
Cracked-soaked	20	80	ND	$2.00 \pm 0.00_e$	ND	$2.50 \pm 0.00_d$	ND
Cracked-soaked	50	50	ND	$2.00 \pm 0.00_e$	ND	$2.50 \pm 0.00_d$	ND
Germination	5	95	ND	$3.50 \pm 0.00_d$	ND	$2.00 \pm 0.00_e$	ND
Germination	10	90	ND	$5.00 \pm 0.00_c$	ND	$2.00 \pm 0.00_e$	ND
Germination	15	85	ND	$5.00 \pm 0.00_c$	ND	$2.00 \pm 0.00_e$	ND
Germination	20	80	ND	$6.00 \pm 0.00_b$	ND	$2.00 \pm 0.00_e$	ND
Germination	50	50	ND	$6.00 \pm 0.00_b$	ND	$2.00 \pm 0.00_e$	ND
Cracked-boiled	5	95	1.00±0.00b	$5.00 \pm 0.00_c$	ND	$3.50 \pm 0.00_c$	ND
Cracked-boiled	10	90	1.00±0.00b	$6.50 \pm 0.00_b$	ND	$4.50 \pm 0.00_b$	ND
Cracked-boiled	15	85	1.50±0.00a	$6.50 \pm 0.00_b$	ND	$4.50 \pm 0.00_b$	ND
Cracked-boiled	20	80	1.50±0.00a	$7.50 \pm 0.00_a$	ND	$5.00 \pm 0.00_a$	ND
Cracked-boiled	50	50	1.50±0.00a	$7.50 \pm 0.00_a$	ND	$5.00 \pm 0.00_a$	ND
Cowpea flour	0	100	ND	$2.00 \pm 0.00_e$	ND	$3.50 \pm 0.00_c$	ND

Values are mean of triplicate determination and values with the same subscript within a column are not significant different ($p \leq 0.05$). ND= Not Detected

had varying effects on some properties of the flours and the akara. Notably among other parameters measured is the effect of the addition of the pre-processed jack bean flours on the sensory properties in which, all the samples had better ratings than 100% cowpea flour with germinated jack bean composite flour (50% cowpea flour) being the most preferred.

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