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Comparative Study on Chemical Composition and Functional Properties of Three Nigerian Legumes (Jack Beans, Pigeon Pea and Cowpea)

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Abstract

The chemical composition and functional properties of two underutilized legume seeds (Jack bean and Pigeon pea) flours were compared with that of the popularly consumed Cowpea seed flour found in Nigeria. The three seeds were sampled from the six geo-political zones in Nigeria and each of them was separately ground and sieved into powder and analyzed for proximate composition, minerals and functional properties. The result revealed that Jack bean seed flour had the highest composition of ash (6.51±0.28%), protein (26.20±0.40%), carbohydrate (57.83±0.80%), potassium (2.20±0.40mg/g),foam capacity (20.67±0.41%) and emulsion capacity (71.73±0.44%); Pigeon pea had the highest composition of fat (4.78±0.22%), fibre (1.10±0.10%), energy(369.38±0.05kcal/100g), calcium (0.65±0.03mg/g), sodium (2.20±0.01mg/g), magnesium (1.55±0.01mg/g), phosphorous (55.00±0.20mg/g),least gelation concentration (6.00±0.10%), oil and water absorption capacity(148.17±%0.37; 189.77±0.28% respectively) and Cowpea had the highest value of iron (0.80±0.03mg/g), zinc (1.62±0.03mg/g), copper (0.57±0.10mg/g), foam (15.70±0.31%) and emulsion (15.20±0.37%) stability. There was no significant difference (P<0.05) only in the crude fibre and carbohydrate content of the three seed flours. Cowpea seed flour had the highest protein solubility in all the pH range examined except in pH 3, 4 and 11 where Jack bean seed flour had the highest protein solubility. Jack bean and Pigeon pea seed flours are good functional foods for nutrition and utilization.

Keywords: chemical composition, functional properties, jack bean, pigeon pea, cowpea, Nigeria

INTRODUCTION

Legumes belong to the plant family Leguminosae and the name for the fruit produced by the members of the family is idealized in a bean or pea pod (Baj, 1990). The legumes and grains families are by far the world's most important sources of food; grains supply starch while legumes which include bean, peas and alfalfa supply protein and fats (John, 2005). Legumes are very important not only as food crops but possess high propensity to grow in depleted soils thereby serving as a medium of fertilizing succeeding crops through their unique symbiotic capability with nitrogen-fixing rhizobium bacteria which are inhabited in root nodules of the legumes, and the nitrogen balance in the soil is thereby preserved (Okara *et al*., 2002). In nutritive wise, legumes can supply significant amount of energy, vitamins and minerals in addition to protein. They are 2-3 times richer in protein than cereal grain (Adeyeye, 1995) even some of these legumes are very rich in oil and they are most called oil seeds (Baj, 1990).

Jack bean is botanically known as Canavalia ensiformis and the plant is known in different countries with different names. It is called Jack bean in Southern Africa and Zimbabwe; Sword bean in Australia, One eye bean in West Indies and Feijaode porco in Brazil (Odetokun, 2000). It is a tropical climber producing long pendant green beans. It is native to the West Indies and Central America but is now found scattered throughout the tropics and sub tropics (Kay, 1979). It tolerates a wide range of rainfall (650 – 2000mm) evenly distributed throughout the year. The climber tolerates droughts, survives salinity and water logging. It grows best at altitude, up to 1800m, temperature of 15-30^{0}C, soil pH of 4.5 – 8.0, and tolerates a wide range of soils. As a legume, it fixes nitrogen in the soil and so needs artificial nitrogen. Agronomically, it is sown as an annual cover crop. If grown as a perennial intercrop, the plant needs such strong durable support as cocoa, coffee, sugar cane, maize, millet or sorghum. Young pods and beans of Jack bean are eaten as vegetable (Anon, 2007) but only after much preparation and cooking as they contain mild poison in the form of anti C. (Eke *et al*., 2007). Jack bean seed is white in colour and nearly oblong in shape and its coat is not to be eaten. Presently in Nigeria, there are no farms where the Jack bean is commercially cultivated. People plant Jack bean as a flower around their homes while some grow wild.

Pigeon pea is taxonomically known as Cajanus cajan. It is chiefly grown in India where it is probably originated and extensively in Africa and other warm climate areas and it is usually grown for seeds which is a popular food (John, 2005). It is not well grown in larger quantity in Nigeria but it is fairly common in middle belt southern plateau, Onitsha, Benin and Ondo provinces as a garden crop. Pigeon pea is a useful fallow and fodder plant with edible seeds doing best on medium good soils (Philip, 2002). Its tall stalk provides abundant fodder for livestock or an abundance of vegetation for green manure. Pigeon pigs is commonly known as "Earth almond", "Chufa", "Arhar", "Chewfa" and "Tiger nut". Other English names of pigeon pea are Cango pea, Angola pea, Goongo, Puertorico and Red gram. It is known in Nigeria as "Ayaya" in Hausa, "Ofio" in Yoruba and "Akiausa" in Igbo. (Okafor *et al*.,2003). Pigeon Pea is grown locally and also has a limited consumption by some rural population (local farmers) during the period of food scarcity (January - April) when other popular agricultural products (yam, maize, plantain etc) are scarce and very expensive. Actually it has been grown as a traditional crop in the semi-arid tropics but it is under-utilized because of lack of knowledge of its nutritional potentials.

Cowpea (Vigna sinesis var unguiculata) is popularly known as Southern pea, China pea, Black-eye bean or pea, Cowgram in Unites State or Nìébé in French speaking Africa (Henshaw *et al*., 2002; Sigh and Rachie, 1997; Kay, 1979). Cowpea is well known for its good source of dietary protein for human consumption and of animal feed in the tropics, especially in Africa, Brazil and India. It thrives well in hotter more arid climates and more infertile soils than other food legume crops due to its symbiotic nitrogen fixing abilities which helps maintaining soil fertility in peasant cropping systems. Over 65% of the Cowpea crop is produced in Africa; Nigeria and Niger producing 50% of the world supply. The United States is the only developed country producing large amount of Cowpea (Henshaw, 2008). The main centres of cultivation of Cowpea in Nigeria are Kano, Katsina, Bauchi, Bornu, Sokoto and Niger States in the North; and Ibadan, Owo and Benin in the West (Oyenuga, 1968).

Generally, developing countries do not produce enough foods which have the right nutritional quality to meet daily needs. Therefore there is a great need to search for more nutritionally good food in order to ensure that all the potentials sources of foods are exploited effectively and utilized industrially as food supplement which will meet up consumer acceptability. Hence the objective of this research work is to compare the chemical composition and functional properties of underutilized Leguminous seed flours (Jack bean and Pigeon pea) with that of Cowpea with the intention of using them as foods of plant source to overcome the acute food shortage of animal protein as encountered in under developing countries.

MATERIALS AND METHODS

Source and Preparation of Samples

The legume seeds of Jack beans, Pigeon pea and Cowpea were obtained from the six Geo-political zones (North, North-East, North-West, South, South-East and South-West) in Nigeria. The seeds of each legume were mixed together and a representative sample was taken. Extraneous matter such as unhealthy seed, infected seed, sand and chaff were removed from the samples. The Jack beans and Pigeon pea were poured in hot water at 50^0C and the water was allowed to cool to room temperature in order to allow easy dehulling but the Cowpea was dehulled with water at room temperature (27^0C). The dehulled samples were sundried for 2 days and then dried at 70-80^0C for 2 hours in an oven. Finally the dried dehulled samples were separately mixed with an attrition mill (Model no ED-5) and sieved to a particle size of 1mm. Flour samples were packed and stored in an air tight labeled plastic bottles prior to analysis.

Determination of Proximate composition

The proximate analysis of samples (flours) for moisture, crude fat, fibre, protein and ash were determined using the methods described by AOAC (2005). The protein content was determined using micro kjeldhal method (N x 6.25) and the carbohydrate was calculated by difference. The gross food energy was estimated by multiplying the crude protein, crude fat and total carbohydrate by At water factors 4, 9 and 4 respectively. (Okwu, 2006; Osborne and Vooget, 1998).

Determination of Mineral composition

Using the method described by AOAC (2005). The ash of each sample was digested with 5mL of 2M HNO_3 and heated to dryness on a heating mantle. 5mL of 2M HNO_3 was added again, heated to boil and filtered through a Whatman No 1 filter paper into a 100ml volumetric flask. The filterate was made up with distilled water. Calcium, Potassium and Sodium was determined using Jenway Digital Flame Photometer (PFP7 model) while other minerals apart from phosphorus were determined using Buck Scientific Atomic Absorption Spectrophotometer

(BUCK 210VGP model). The Phosphorus in the sample filterate was determined by using Vanadomolybdate reagent at 400nm using colorimetric method (Colorimeter SP 20, Bausch and Lamb).

Determination of Functional properties

Oil and Water absorption capacities

One gram of sample was mixed with 10ml refined soybean oil (Executive cheff, Nigeria; density 0.916g/mL) or distilled water in a weighed 20mL centrifuge tube. The slurry was agitated on a Vortex mixer for 2 minutes, allowed to stand at 28^0C for 30 minutes and then centrifuged at 500×g for 30 minutes. The clear supernatant was decanted and discarded. The adhering drops of oil or water were removed and the tube was weighed. The weight of oil or water absorbed by 1g of flour of protein was calculated and expressed as oil or water absorption capacity (Beuchat 1977; Eke and Akobundu 1993).

Foam Capacity and Stability

The method described by Narayana and Nara singa RaO (1982), modified by Fagbemi and Oshodi (1991) was used to determine the foam capacity and foam stability. Two grams of flour sample was added to 50mL distilled water at 30 ± 2^0C in a 100mL measuring cylinder. The suspension was mixed and properly shaken to foam and the volume of the foam after 30 seconds was recorded. The foam capacity was expressed as a percentage increase in volume. The foam volume was recorded 2 hours after whipping to determine the foam stability as a percentage of the initial foam volume.

Emulsion Capacity and Stability

Emulsion capacity was determined using the procedure described by Kinsella (1979). Flour sample of 0.5g was made into slurry in 5mL of distilled water in an Erlenmeyer flask stirring at 1,000 rpm for 15 minutes with a magnetic stirrer. 5mL of refined soybean oil was added over a period of 5 minutes, stirring at 1,000 rpm, stirring as continued for an extra minute. The system was transferred into a centrifuge tube treated in a water bath maintained at 85^0C for 15 minutes with occasional stirring and then cooled for 15 minutes in a water bath maintained at 25^0C. The tube was finally centrifuged at 3,500 rpm until the height of the oil (separated from emulsion) was constant. Results were expressed as a percentage of the emulsion after separating the upper layer from emulsion.

Emulsion stability was determined by following the method described by Sathe and Salunkhe (1981). Flour sample of 0.5g was blended in a Beltone blender with 50mL of distilled water for 30 seconds at high speed. Oil was added to 50mL proportion with continued blending. The addition of the oil was stopped when the nature of the emulsion changes, as marked by decreased homogeneity. The emulsion prepared was allowed to stand on a graduated cylinder for 24 hours, after which the emulsion capacity was calculated to give the emulsion stability expressed as a percentage, it was calculated as the ratio of the weight of the emulsified layer to the total height of mixture.

Least Gelation Concentration

Appropriate sample suspension of 2, 4, 6, 8, 10, 12, 14 and 16%w/v were prepared in 5mL distilled water. The test tubes containing these suspensions were heated for 3 hours. The least gelation concentration was determined as concentration when the sample from the inverted test tube did not fall down the slip (Coffman and Garcia, 1977).

Determination of Protein Solubility as a function of pH

5mL of distilled water was added to 0.2g of flour sample in a test tube and stirred thoroughly using a stirring rod. The pH of the slurries of the sample was adjusted to pH values of 1-12 using either 0.1M HCl or 0.1M NaOH solution. Insoluble materials were removed by centrifuging at 3500rpm for 30 minutes. The sample solution was decanted to separate the insoluble material. 1mL of the sample solution was pipetted into tubes 1 to 12 followed by addition of 2mL of Biuret reagent and 3mL of distilled water. The blank solution was made by pipetting 2mL of Biuret reagent to 4mL of distilled water. Colorimeter (SP 20 Bausch and Lamb) was used to read the absorbance of wavelength 540nm (Knisella, 1976; Solsuski, 1962)

ANALYSIS OF DATA

The result of the three replicates were polled and expressed as mean±standard error a one way analysis of variance (ANOVA) and the Least Significance Difference (SLD) were carried out (Zar, 1984). Significance was accepted at $P<0.05$.

RESULTS AND DISCUSSION

Table 1: Proximate Composition of Jack Bean, Pigeon Pea and Cowpea Seed Flours Found in Nigeria.

Parameter	Jack bean	Pigeon pea	Cowpea
Moisture (%)	6.44±0.07[c]	8.45±0.95[b]	9.20±0.10[a]
Ash (%)	6.51±0.28[a]	4.58±0.40[b]	4.73±0.30[b]
Crude Protein (%)	26.20±0.40[a]	24.46±0.32[b]	24.13±0.31[b]
Crude Fat (%)	1.95±0.04[b]	4.78±0.22[a]	4.37±0.18[a]
Crude Fibre (%)	1.07±0.10[a]	1.10±0.10[a]	0.97±0.09[a]
Carbohydrate (%)	57.83±0.80[a]	56.63±0.48[a]	56.60±0.50[a]
Energy (Kcal/100g)	353.67±0.03[b]	369.38±0.05[a]	362.25±0.04[a]

Means±standard error of mean for triplicate determination. Values not followed by the same superscript in the same row are significantly different (P<0.05).

The data presented in Table 1 showed the proximate composition of Jack bean, Pigeon pea and Cowpea seed flours found in Nigeria. The three seeds had high value of carbohydrate content ranged between 56.60-57.83% and there was no significant difference in carbohydrate content of the seed flours at P<0.05.Crude protein of the three seed flours was within the range 24.13-26.30%.There was no significant difference between the crude protein content of Pigeon pea and Cowpea seed flours at P<0.05. Crude protein of Jack bean was the highest (26.20±0.40%) and showed significant difference at P<0.05 from the seed flours of Pigeon pea and Cowpea. Ash content of Jack bean seed flour (6.51±0.28%) was higher than that of Pigeon pea (4.58±0.40%) and Cowpea (4.73±0.30%) seed flours and it was significantly different at P<0.05. The crude fat of the three seed flours ranged between 1.95-4.78%. Jack bean seed flour had the lowest value of crude fat (1.95±0.04%) while that of Pigeon pea had the highest value (4.78±0.22%).There was no significant difference (P<0.05) in crude fat of Pigeon pea and Cowpea seed flours. The three seed flours showed no significant difference (P<0.05) in crude fibre. The crude fibre of Pigeon pea (1.10±0.10%) was the highest while that of Cowpea (0.97±0.09%) was the lowest. The energy value (Kcal/100g) of Pigeon pea seed flour was 369.38±0.05, followed by 362.25±0.04 for Cowpea and least in Jack bean (353.67±0.03).There was no significant difference in energy value of pigeon pea and Cowpea seed flours at P<0.05.Generally, it was clearly observed that there was no significant difference (P<0.05) in proximate composition (expect in moisture content) of Pigeon pea and Cowpea seed flours. There was also no significant difference (P<0.05) in the crude fibre and carbohydrate contents of the three seed flours. Pigeon pea seed flour had the highest value in crude fat, crude fibre and energy while Jack bean had the highest value of ash, crude protein and carbohydrate. It was only in moisture content that Cowpea had the highest value.

Table 2: Mineral Composition (Mg/G) Of Jack Bean, Pigeon Pea And Cowpea Seed Flours Found In Nigeria.

Minerals	Jack bean	Pigeon pea	Cowpea
Ca	0.18±0.04[c]	0.65±0.03[a]	0.44±0.01[b]
K	2.20±0.40[a]	1.41±0.40[b]	1.00±0.10[c]
Na	1.98±0.12[b]	2.20±0.01a	1.20±0.01[c]
Mg	1.35±0.30[ab]	1.55±0.01[a]	0.95±0.01[b]
Fe	0.18±0.04[c]	0.36±0.03[b]	0.80±0.03[a]
Zn	1.58±0.30[b]	1.54±0.10[b]	1.62±0.03[a]
Co	ND	ND	ND
Mn	ND	ND	ND
Cu	0.26±0.05[b]	0.56±0.03[a]	0.57±0.10[a]
P	37.60±0.10[ab]	55.00±0.20[a]	29.40±0.08[b]

ND= Not Detected (below 0.005); Means±standard error of mean for triplicate determination. Values not followed by the same superscript in the same row are significantly different (P<0.05).

The result of mineral composition (mg/g) of Jack bean, Pigeon pea and Cowpea seed flours found in Nigeria is shown in Table 2, the result of the study revealed that Pigeon pea seed flour had the highest value of calcium (0.65±0.03mg/g), sodium (2.20±0.01mg/g), magnesium (1.55±0.01mg/g) and phosphorous (55.00±0.20mg/g) while Jack bean seed flour had the highest value of potassium (2.20±0.04mg/g).On the other hand, Cowpea had the highest value of iron (0.08±0.03mg/g), zinc (1.62±0.03mg/g) and copper (0.57±0.10mg/g). Cobalt and manganese were not detected (that is below 0.0005mg/g) in all the three seed flours. The calcium content of the seed flours ranged between 0.18-0.65mg/g and there was significance difference at P<0.05. The calcium content of Jack bean (0.18±0.04mg/g) was the least, followed by Cowpea (0.44±0.01mg/g) and highest in Pigeon pea (0.65±0.03mg/g).The potassium content was within 1.00-2.20mg/g in the seed flours with the least value in Cowpea (1.00±0.10mg/g), followed by 1.41±0.40mg/g in Pigeon pea and highest in Jack bean (2.20±0.40mg/g). Within the Jack bean seed flour, calcium and iron had the lowest value (0.18±0.04mg/g) while phosphorous had the highest value (37.60±0.10mg/g). In Pigeon pea , iron had the lowest value (0.36±0.03mg/g) and phosphorous had the highest value (55.00±0.20mg/g); and in Cowpea ,calcium had the lowest value (0.44±0.01mg/g) and phosphorous had the highest value (29.40±0.18mg/g). There was significant difference at P<0.05 in all the minerals determined except in zinc (for Jack bean and Pigeon pea) as well as in copper (for Pigeon pea and Cowpea). Jack bean and Pigeon pea seed flours had the highest values of potassium, sodium, magnesium and phosphorous than Cowpea seed flour. While cowpea seed flour had higher calcium, iron, zinc and copper contents than Jack bean seed flour.

Table 3: Functional Properties of Jack bean, Pigeon pea and Cowpea seed flours found in Nigeria.

Parameter	Jack bean	Pigeon pea	Cowpea
Oil Absorption Capacity (%)	113.50±0.29[b]	148.17±0.37[a]	113.15±0.35[b]
Water Absorption Capacity (%)	128.29±0.50[b]	189.77±0.28[a]	188.20±0.09[a]
Foam Capacity (%)	20.67±0.41[a]	3.53±0.36[c]	16.33±0.37[b]
Emulsion Capacity (%)	71.73±0.44[a]	28.73±0.12[c]	46.40±0.22[b]
Least Gelation Concentration (%)	4.00±0.10[b]	6.00±0.10[a]	4.00±0.30[b]
Foam Stability after 2hours (%)	10.33±0.41[b]	3.05±0.10[c]	15.70±0.31[a]
Emulsion Stability after 24hours (%)	13.19±0.10[b]	13.93±0.18[ab]	15.20±0.37[a]

Mean±standard error of mean for triplicate determination Values not followed by the same superscript in the same row are significantly different (P<0.05).

Conophor flour (340%) reported by Odoemelan, 2003. The lower value of WAC in Jack bean seed flour suggests that it is less hydrophobic than the other seed flours. Therefore Jack bean seed flour has more useful functional ingredient in viscous foods like baked products, gravies, soups etc to increase viscosity (Abulude *et al*., 2006).

The foam capacity (FC), oil emulsion capacity (OEC) and foam stability (FS) after 2hours of the three seed flours were significantly different (P<0.05). The FC, OEC and FS ranged between 3.53-20.67%, 28.73-71.73% and 3.05-15.70 % respectively. The FC of Pigeon pea (3.53± 0.36%) was the highest. The FC of the three seed flour was comparatively much lower than 40% reported for wheat flour (Akubor and Badifu, 2004). However the FC of Jack bean and Cowpea seed flour is comparatively higher than 11.30% and 9% reported for pear millet and quinoa flours respectively (Oshodi *et al*., 1999). The high value of FC in Jack bean and Cowpea seed flours showed that they would be useful more than Pigeon pea seed flour as aerating agents in food systems such as "akara" and "moi moi" which require the reproduction of stable high foam volumes when whipped (Kinsella, 1979). The oil emulsion capacity (OEC) was highest in Jack beans seed flour (71.73± 0.44%) and lowest in Pigeon pea (28.73±0.12%) while that of Cowpea was 46.40±0.22% .The foam stability (FS) after two hours was highest in Cowpea (15.70± 0.31%), followed by 10.33± 0.41% for Jack bean and least in Pigeon pea (3.05±0.10%). These

Some functional properties of Jack bean, Pigeon pea and Cowpea seed flours found in Nigeria are depicted in Table 3. Oil absorption capacity (OAC) of the three seed flours ranged between 113.15-148.17%. The OAC of Jack bean seed flour (113.50±0.29%) was not significantly different (P<0.05) from the Cowpea flour (113.50±0.35%) but Pigeon pea seed flour (148.17±0.37%) was significantly different (P<0.05) from the other seed flours. The result shows that Jack bean and Cowpea seed flours have lower flavour retainer than Pigeon pea seed flour and this may be due to low hydrophobic protein in Jack bean and Cowpea seed flours which show superior binding lipids (Kinsella, 1976).The high value of OAC of Pigeon pea seed flour shows that it increases the mouth feel when used in food preparations, such as sausages than others. There was no significant difference (P<0.05) in water absorption capacity (WAC) of Pigeon pea (189.77±0.28%) and Cowpea (188.20±0.09%) seed flours. However, the WAC of Jack bean (128.29±0.50%) seed flour was significantly different (P<0.05). The values of WAC obtained for the three seed flours were much less than that of raw values were lower than 60% and 80% reported for Wheat flour and African breadfruit kernel flour (Akubor and Badifu, 2004). The least gelation concentration (LGC) of the three Legumes flour ranged between 4.00- 6.00% and that of Pigeon pea flour (6.00 ± 0.01%) was significantly different from 4.00±0.03% for both Jack bean and Cowpea flours. The LGC values were lower than that of bread nut flour (8%), Cocoyam flour (8.10%), *Adenopus breviflorus* (16%) and locus bean (16%) (Abulude *et al*., 2006). These three legumes have good gelating ability of protein ingredient but the gelation capacity of both Jack bean and Cowpea flours are better than that of Pigeon pea flour. The emulsion stability (ES) after 24 hours showed that Cowpea flour had the highest value (15.20± 0.37%) while that of Jack bean flour had the lowest value (13.19±1.0%). The three legume flours had stable emulsion for a period more that twelve hours.

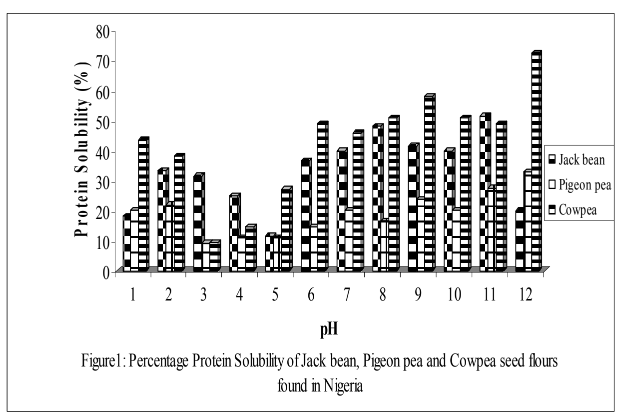

Figure 1: Percentage Protein Solubility of Jack bean, Pigeon pea and Cowpea seed flours found in Nigeria.

Table 4: Percentage Protein Solubility of Jack bean, Pigeon pea and Cowpea seed flours found in Nigeria.

pH	Protein Solubility (%)		
	Jack bean	Pigeon pea	Cowpea
1	18.20±0.30[c]	20.13±0.40[b]	43.39±0.01[a]
2	33.14±0.50[b]	21.96±0.10[ab]	37.97±0.07[a]
3	31.48±0.09[a]	9.15±0.21[b]	9.41±0.05[b]
4	24.86±0.32[a]	10.98±0.10[c]	14.46±0.35[b]
5	11.60±0.13[b]	10.98±0.50[b]	27.12±0.11[a]
6	36.45±0.22[b]	14.64±0.43[c]	48.82±0.41[a]
7	39.77±0.02[b]	20.13±0.40[c]	45.82±0.04[a]
8	48.05±0.20[a]	16.47±0.04[b]	50.62±0.03[a]
9	41.43±0.03[b]	23.79±0.31[c]	57.86±0.14[a]
10	39.77±0.50[b]	20.13±0.20[c]	50.62±0.30[a]
11	51.37±0.05[a]	27.45±0.20[b]	48.82±0.50[a]
12	19.88±0.24[c]	32.94±0.10[b]	72.32±0.05[a]

Table 4 and Figure 1 both reveals the percentage protein solubility of Jack bean, Pigeon pea and Cowpea seed flours found in Nigeria. From pH 1-12, Cowpea seed flour had the maximum protein solubility (27.12-72.32%) except at pH 3, 4 and 11. Cowpea flour had lowest protein solubility at pH 3. Jack bean flour had the maximum protein solubility at pH 3, 4 and 11; and least solubility at pH 5.In all the pH range, Pigeon pea flour had lower protein solubility than Cowpea but it had higher protein solubility at pH 1 and 2 than Jack bean flour. It is observed that protein solubility is relatively higher in alkaline medium than acidic medium for all the three samples. High protein solubility at alkaline medium of these legume flours indicates that they can be useful in formulating protein rich carbonated beverages. In food preparations where maximum solubility of protein is desired, as in aqueous emulsion and gel food preparations, these three legumes look very promising.

CONCLUSION

The result of this study support the consumption and industrial application of under utilized legumes (Jack bean and Pigeon pea) which compete favourable (or even better) in nutritional composition and some functional properties with Cowpea. Therefore there is need to encourage large scale production of these legumes in order to combat the problem of proteineous food shortage in under developing countries where animal protein is costly.

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