BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, December 2011. Vol. **8**(2), p. 529-537

The Comparative Evaluation of Amino Acid Profiles of the Dehulled and Hull Parts of *Irvingia gabonensis* Seeds

E.I. Adeyeye* and A.M. Kenni[1]

*Department of Chemistry, Ekiti State University, P.M.B. 5363, Ado-Ekiti (Nigeria).
[1]Department of Chemistry, College of Education, Ikere-Ekiti, P.M.B. 250, Ikere-Ekiti (Nigeria).

(Received: 10 September 2011; accepted: 22 October 2011)

The seeds of *Irvingiagabonensis* are a major raw material in the preparation of *ogbono* soup or as a condiment in the preparation of sauces used with African foods prepared from major staples such as *amala*, *eba*, pounded yam, etc. In view of this, an investigation into the concentrations of amino acids of the hull and dehulled seed parts of *Irvingiagabonensis* was carried out using standard methods to determine amino acid profiles; quality of dietary protein was determined using various methods like: amino acid scoresdetermination [(in three different ways; (i) amino acid score based on the whole hen's egg, (ii) essential amino acid score based on the provisional amino acid scoring pattern, (iii) essential amino acid score based on suggested school child requirement)], essential protein efficiency ratio as well as the determination of the isoelectric point. Glutamic acid was the most abundant amino acid (10.1-15.2 g/100 g) and Leu (6.39-7.05 g/100 g) was the most abundant essential amino acid. The total essential amino acid in dehulled sample was 39.2 g/100 g (47.4 %) and 29.8 g/100 g (46.6 %) in the hull. The limiting essential amino acid (based on provisional scoring pattern) was Lys (0.64) in dehulled and Met + Cys (0.49) in hull. The essential amino acid index ranged from 0.87 (hull) to 1.21 (dehulled); the predicted protein efficiency ratio was 2.10 in hull and 2.42 in the dehulled whereas the isoelectric point ranged between 3.56 in hull and 4.53 in dehulled. At $r_{0.05}$, significant differences existed in the samples in amino acid profiles and calculated isoelectric point (pI). The results of this study indicated that the amino acid profiles of *Irvingia gabonensis* seed hull and cotyledons are complementary in nutrition. There may therefore be no need to remove the hull in the seed when used as soup ingredient.

Key words: *Irvingia gabonensis*, Amino acid profiles, Dehulled seed and Hull.

Irvingiagabonensis belongs to the Irvingiaceae family. Recent work has shown that this family is closely related to the Ixonanthaceae and in some works the two families are combined[1].

* To whom all correspondence should be addressed.

Key to Genara

1a Fruits large and fleshy, containing 1 or more hard woody stones

2a Fruits flattened from top to bottom, usually 5-lobed and containing 5 stones:

Klainedoxa

2b Fruits mango-like and containing 1 stone: 2. Irvingia

1b Fruits winged and remarkably leaf-like: 3. Desbordesia

Irvingia *Hook. f.*

After Dr.E.G.Irving, R.N., who died at Abeokuta in 1855. The flowers in this small genus resemble those of *Klainedoxa* but the fruits are quite different. Three species occur in Nigeria, one of which, *I. grandifolia*, has leaves and stipules very similar to those of *Klainedoxa*. The Irvingias, however, never have spines.

1a Leaves cuneate or slightly rounded at base; flowers with distinct stalks: 1. *gabonenesis*

1b Leavescordate or broadly rounded at base

2a Leaves 2.5-12.5 cm long; flowers with distinct stalks: 2. *smithii*

2b Leaves 10-25 cm long; flowersstalkless: 3. *grandifolia*

Irvingiagabonenesis (O' Rorke) Baill.- FWTA (Flora of West Tropical Africa) ed. 2, 1: 693. The Wild Mango or Dika Nut, with mango-like fruits. The tree may be readily recognised by its dense dark green evergreen foliage and characteristic stipules which are similar to those of *Klainedoxa* but smaller. J.C. Okafor in Bull. Jard. Bot. Nat. Belg. 45: 211-21 (1975) has distinguished two varieties as follows:

Fruits with sweet edible scanty fibrous pulp; bole fluted or cylindrical; lateral branches ascending, making the crown spherical or narrow: *var. gabonensis*.

Fruits with bitter inedible very fibrous pulp; bole buttressed; lateral branches horizontal, making a wide umbrella-shaped crown: var. excelsa (Mildbr.) Okafor. Names are, Hausa: *goronbiri*; Nupe: *pekpear*; Yoruba: *oro*; Edo: *ogwe*; Ijaw: *ogboin*; Igbo: *obono*; Efik: *oyo*;Ekoi: *osing*; Boki: *bojep*. The plant extends from Senegal to Sudan and south to Angola.

The fruit is widely used as a complement to other foods in most parts of southern Nigeria. Its kernels are a major raw material in the preparation of *ogbono* soup or as a condiment in the preparation of sauces used with African foods prepared from major staples such as *amala*, *eba*, pounded yam, etc[2]. Some reported pioneering workson the uses were[3], ecological studies [4, 5]; other works included the nutritional studies of pulp and kernel[2] and nutritional value of the pulp[6] and most recently the determination of the amino acid contribution of the hull of *Irvingia gabonensis* seed as food ingredient[7].

MATERIALS AND METHODS

Collection and treatment of samples

The seeds of the fruit were purchased from Ado-Ekiti, Nigeria, market. The seeds were dried, dehulled, separately pulverised, sieved and kept in freezer (-4^{o}C) in McCartney bottles pending analysis.

Crude protein determination and fat extraction

The micro-Kjeldahl method[8] was followed to determine the fat-free crude protein. The fat was extracted with a chloroform/methanol (2:1 v/v) mixture using Soxhlet extraction apparatus[9] lasting 5-6 h.

Determination of amino acids

Hydrolysis of samples

About 30 mg of defatted sample was weighed into glass ampoules. 7 ml of 6 MHCL was added and oxygen expelled by passing nitrogen gas into the samples. The glass ampoules were scaled with a Bunsen flame and put into an oven at 105±5^{o}C for 22 h. The ampoule was allowed to cool; the content was filtered to remove the humins. The filtrate was then evaporated to dryness at 40^{o}C under vacuum in a rotary evaporator.

Analysis of samples

Amino acid analysis was by ion exchange chronmatography (IEC)[10] using the Technicon Sequential Multisample (TSM) Amino Acid Analyser (Technicon Instruments Corporation, New York). The period of analysis was 76 min for each sample. The gas flow rate was 0.50 ml/min at 60^{o}C with reproducibility consistent within ± 3 %. The net height of each peak produced by the chart recorder of the TSM (each representing an amino acid) was measured and calculated. The amino acid determinations were in duplicate. Tryptophan was not determined due to cost. Norleucine was the interval standard.

Estimation of quality of dietary protein

Amino acid score

The amino acid score was calculated in three different ways.

(a) The amino acid score based on the whole hen's egg[11]. It was calculated by using the ratio of test protein to the reference protein for each amino acid.

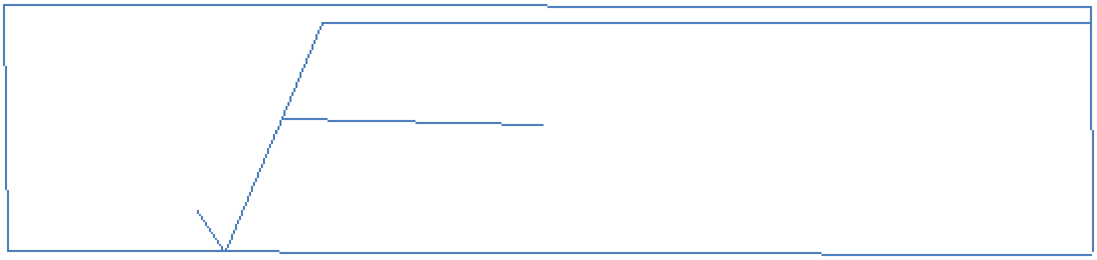
(b) The essential amino acid score based on the provisional amino acid scoring pattern using the following formula[12]:

Amino acid score = Amount of amino acid per test protein [mg/g]/Amount of amino acid per protein in reference protein [mg/g].

(c) The essential amino acid score based on suggested school child requirement[13].

Essential amino acid index (EAAI)

It was calculated by using the ratio of test protein to the reference protein for each of the eight essential amino acids plus histidine in the equation that follows[14]:



Predicted protein efficiency ratio (P-PER)

This was determined using one of the equations developed by Alsmeyer *et al.*[15],

P-PER = -0.468 + 0.454 (Leu)- 0.105 (Tyr)

Determination of other quality parameters

Determination of the total essential amino acid (TEAA) to the total amino acid (TAA) (TEAA/TAA); total sulphur amino acid (TSAA); percentage cystine in TSAA (% Cys/TSAA); total aromatic amino acid (TArAA); etc., the Leu/Ile ratios were also calculated.

Estimation of isoelectric point (pI)

The pI for the mixture of the amino acids was estimated from the equation of the form[16]:

$$IPm = \sum_{i=1}^{n} IPiXi$$

whereIPm is the isoelectric point of the mixture of amino acids, IPi is the isoelectric point of the ith amino acid in the mixture and Xi is the mass or mole fraction of the ith amino acid in the mixture.

Statistical analysis

Calculations made were the mean, standard deviation (SD), coefficient of variation in percent (CV %), linear correlation coefficient (r_{xy}), coefficient of determination (r_{xy}^2), linear regression coefficient (R_{xy}), coefficient of alienation (C_A), index of forecasting efficiency (IFE) and the comparison of r = value (computed from the analytical data) with tabular value at $r_{0.05}$ with n-2 degrees of freedom[17].

RESULTS AND DISCUSSION

In Table 1, the amino acid (AA) profiles of the two samples are shown. The protein levels in the two samples had a variation of 76.8 % and the dehulled: hull amino acid being 3.4:1. This is an indication that bulk of the protein had been concentrated in the dehulled sample. With this observation, it would be interesting to look at the distribution of the amino acids on corresponding comparison. Glutamic and aspartic acids were in the highest concentrations among their groups and are both acidic AA. Phenylalanine and tyrosine constituted the highest essential amino acid (EAA) concentration in both samples. The coefficient of variation percent (CV %) values were low with exception of Cys with a value of 52.2 %, whilst the rest ranged from 3.43-38.5 %.

Glu, Asp and Phe +Tyr trends in the present study followed the trend as observed in *Gymnarchusniloticus* (Trunk fish)[18], *Clariasanguillaris, Oreochromisniloticus* and *Cynoglossus senegalensis*[19] as well as aril and seed of *Blighiasapida* fruit[20]. Out of 17 parameters determined, 15 (88.2 %) amino acids were correspondingly higher in the dehulled sample with only 2 (11.8 %; Ala, 4.30 against 2.89 g/100 g crude protein, cp and Tyr, 3.17 against 3.02 g/100 g) being higher in the hull. Arg (4.00-5.10 g/100 g cp) is essential for children and reasonable levels were present here particularly in the dehulled. The Lys content of samples (3.02-3.51 g/100 g) were about half of the content of the reference egg protein (6.3 g/100 g cp), so the samples would only serve complementary roles in nutrition. The Met range was 1.02 (hull) – 1.66 g/100 g cp (dehulled) which compared favourably with 1.25-1.25 g/100 g cp in aril and seed of *B. sapida*[20]. Cys had the highest variation of 0.70-1.52 g/100 g cp or 52.2 %; this was also observed in the reference above[20].

Table 1. Amino acid composition of the hull and dehulled seeds parts of *Irvingia gabonensis* (g/100 g crude protein dry weight)

Amino acid	Concentration		Mean	SD	CV %
	Dehulled	Hull			
Lys*	3.51	3.02	3.27	0.35	10.6
His*	2.90	1.45	2.18	1.03	47.1
Arg*	5.10	4.00	4.55	0.78	17.1
Asp	10.5	8.25	9.38	1.59	17.0
Thr*	5.20	3.00	4.10	1.56	37.9
Ser	2.80	2.66	2.73	0.10	3.63
Glu	15.2	10.1	12.7	3.61	28.5
Pro	3.56	2.65	3.11	0.64	20.7
Gly	4.04	2.31	3.18	1.22	38.5
Ala	2.89	4.30	3.60	1.00	27.7
Cys	1.52	0.70	1.11	0.58	52.2
Val*	5.03	4.40	4.72	0.45	9.45
Met*	1.66	1.02	1.34	0.45	33.8
Ile*	3.62	2.85	3.24	0.54	16.8
Leu*	7.05	6.39	6.72	0.47	6.94
Tyr	3.02	3.17	3.10	0.11	3.43
Phe*	5.10	3.68	4.39	1.00	22.9
Protein (fat free)	34.1	10.1	22.1	17.0	76.8

*Essential amino acids.

Table 2. Summary of some amino acid quality parameters of *Irvingia gabonensis* hull and dehulled seeds parts (g/100 g crude protein)

Parameter	Concentration		Mean	SD	CV %
	Dehulled	Hull			
Total amino acid (TAA)	82.7	64.0	73.4	13.2	18.0
Total essential aminoacid (TEAA)					
-with His	39.2	29.8	34.5	6.65	19.3
-without His	36.3	28.4	32.4	5.59	17.3
Total non-essential amino acid (TNEAA)	43.5	34.2	38.9	6.58	16.9
% TNEAA	52.6	53.4	53.0	0.57	1.07
Total acidic amino acid (TAAA)	25.7	18.4	22.1	5.16	23.4
% TAAA	31.0	28.7	29.9	1.63	5.45
Total basic amino acid (TBAA)	11.5	8.47	9.99	2.14	21.5
% TBAA	13.9	13.2	13.6	0.49	3.65
Total aromatic amino acid (TArAA)	8.12	6.85	7.49	0.90	12.0
% TArAA	9.82	10.7	10.3	0.62	6.06
Total neutral amino acid (TNAA)	45.5	37.1	41.3	5.94	14.4
% TNAA	55.0	58.0	56.5	2.12	3.75
Total sulphur amino acid (TSAA)	3.18	1.72	2.45	1.03	42.1
% TSAA	3.85	2.69	3.27	0.82	25.1
% Cys/TSAA	47.8	40.7	44.3	5.02	11.3
% TEAA					
-with His	47.4	46.6	47.0	0.57	1.20
-without His	45.5	45.4	45.5	0.07	0.16

Table 3. Summary of some amino acid quality parameters of *Irvingia gabonensis* hull and dehulled seeds parts

Parameter	Values		Mean	SD	CV %
	Dehulled	Hull			
Predicted protein efficiency ratio (P-PER)	2.42	2.10	2.26	0.23	10.0
Leucine/isoleucine ratio (Leu/Ile)	1.95	2.24	2.10	0.21	9.79
Leu-Ile %	48.7	55.4	52.1	4.74	9.10
Isoelectric point (pI)	4.53	3.56	4.05	0.69	17.0
Essential amino acid index (EAAI)	1.21	0.87	1.04	0.24	23.1

Table 4. Amino acid scores of *Irvingia gabonensis* samples based on whole hen's egg

Amino acid	Samples		Mean	SD	CV %
	Dehulled	Hull			
Lys	0.57	0.49	0.53	0.06	10.7
His	1.21	0.60	0.91	0.43	47.7
Arg	0.84	0.66	0.75	0.13	17.0
Asp	0.98	0.77	0.88	0.15	17.0
Thr	1.02	0.59	0.81	0.30	37.8
Ser	0.35	0.34	0.35	0.01	2.05
Glu	1.26	0.85	1.06	0.29	27.5
Pro	0.94	0.70	0.82	0.17	20.7
Gly	1.35	0.77	1.06	0.41	38.7
Ala	0.54	0.80	0.67	0.18	27.4
Cys	0.84	0.39	0.62	0.32	51.7
Val	0.67	0.59	0.63	0.06	8.98
Met	0.52	0.32	0.42	0.14	33.7
Ile	0.65	0.51	0.58	0.10	17.1
Leu	0.85	0.77	0.81	0.06	6.98
Tyr	0.76	0.79	0.78	0.02	2.74
Phe	1.00	0.72	0.86	0.20	23.0
Total (no Try*)	0.84	0.65	0.75	0.13	18.0

*Try was not determined.

Table 5. Essential amino acid scores of *Irvingia gabonensis* samples based on provisional amino acid scoring pattern

Amino acid	Samples		Mean	SD	CV %
	Dehulled	Hull			
Lys	0.64	0.55	0.60	0.06	10.7
Thr	1.30	0.75	1.03	0.39	37.9
Val	1.01	0.88	0.95	0.09	9.73
Met + Cys	0.91	0.49	0.70	0.30	42.4
Ile	0.91	0.71	0.81	0.14	17.5
Leu	1.07	0.91	0.99	0.11	11.4
Phe + Tyr	1.35	1.14	1.25	0.15	11.9
Try	-	-	-	-	-
Total	1.02	0.81	0.92	0.15	16.1

The contents of TEAA of 39.2 and 29.8 g/100 g cp without tryptophan (which was not determined) (Table 2) were slightly close to the value for egg reference protein (56.6 g/100 g cp)[11] particularly for the dehulled sample. The present contents of TEAA are comparable to some literature values (g/100 g cp): 33.6 in *Anacardium occidentale*[21]; 31.2 in *Parkiabiglobosa* seeds[22]; 22.1 in endosperm of ripe coconut [23], 37.6-51.8 in six different varieties of dehulled*Sphenostylis stenocarpa* flour[24]; values from oil seeds such as 45.2 in pigeon pea[25], 53.4 (melon seeds), 38.3 (pumpkin seed), and 53.6 (gourd seed) respectively[26]; and soy bean with 44.4[27]. The contents of TSAA were generally lower than the 5.8 g/100 g cp recommended for infants[12]. The TArAA range suggested for ideal infant protein (6.8-11.8 g/100 g)[12] has current values greater than the minimum, that is 6.85-8.12 g/100 g cp. The ArAA are precursors of epinephrine and thyroxin[28].

Table 6. Essential amino acid scores of *Irvingia gabonensis* samples based on suggested pre-school child requirement

Amino acid	Samples		Mean	SD	CV %
	Dehulled	Hull			
Lys	0.61	0.52	0.57	0.06	11.3
His	1.53	0.76	1.15	0.54	47.6
Thr	1.53	0.88	1.21	0.46	38.1
Val	1.44	1.26	1.35	0.13	9.43
Met + Cys	1.27	0.69	0.98	0.41	41.8
Ile	1.29	1.02	1.16	0.19	16.5
Leu	1.07	0.97	1.02	0.07	6.93
Phe + Tyr	1.29	1.09	1.19	0.14	11.9
Try	-	-	-	-	-
Total	1.18	0.90	1.04	0.20	19.0

Table 7. Summary of statistical analysis from Tables 1, 3, 4, 5 and 6

Table	r_{xy}	r_{xy}^2	R_{xy}	$\overline{X}$		C_A	IFE	n-2	Remark
1 (whole sample)	0.9460	0.89	0.43	4.86	3.76	33.2	66.8	15	Significant
1 (TEAA)	0.9381	0.88	-0.79	4.35	3.31	34.6	65.4	7	Significant
3 (pI only)	0.8958	0.80	0.98	26.7	20.9	44.7	55.3	15	Significant
4	0.5794	0.34	0.33	0.84	0.63	81.2	18.8	15	Significant
5	0.7407	0.55	0.08	1.03	0.78	67.1	32.9	6	Significant
6	0.5215	0.27	0.39	1.25	0.90	85.4	14.6	7	Not significant

r_{xy} = correlation coeificient; R_{xy} = regression coefficient; = mean of dehulled sample; = mean of hull sample; C_A = coefficient of alienation; IFE = index of forecasting efficiency; n-degrees of freedom. Results significantly different at $r_{0.05}$ and n-2 degrees of freedom.

Table 8. Summary of the amino acid profiles into factors A and B

I. gabonensis	Factor (Factor A)		
	B means	Dehulled	Hull
Amino acid composition (Factor B)			
Total essential amino acid	39.2	29.8	34.5
Total non-essential amino acid	43.5	34.2	38.9
Factor A means	41.4	32.0	36.7

The ratios of TEAA to the TAA in the samples were 46.6 % (hull) and 47.4 % (dehulled) which were well above the 39 % considered to be adequate for ideal protein food for infants, 26 % for children and 11 % for adults[12]. The TEAA/TAA percentage contents were strongly comparable to that of egg (50 %)[29], 43.6 % reported for pigeon pea flour[27]. The percentage of total neutral AA (TNAA) ranged from 55.0-58.0 indicating that these formed the bulk of the AA; total acidic AA (TAAA) ranged from 28.7-31.0 which was lower than the % TNAA, whilst the percent range in total basic AA (TBAA) was 13.2-13.9, which made them the third largest group among the samples. The present % TNAA was better than in *B. sapida* fruit: 50.9-54.5; close to % TAAA, 29.5-29.9 but lower than % TBAA, 16.0-19.2[20].

Most animal proteins are low in Cys and hence in Cys in TSAA. For example, (Cys/TSAA) % were 35.5 % in *Archachatinamarginata*, 38.8 % in *Archatinaarchatina* and 21.0 % in *Limicolaria* sp., respectively[30]; 29.8 % in *G. niloticus*[18]; 23.8 % in *C. anguillaris*, 28.4 % in *O. niloticus* and 30.1 in *C. senegalensis*, respectively[19]. In contract, many vegetable proteins contain substantially more Cys than Met, for examples, 62.9 % in coconut endosperm[23]; 44.4 % in *P. biglobosa*[22]; 44.3 % in cola acuminate., 37.8 % in *Garcinia kola*; 50.5 % in *A. occidentale*[21]; 40.8 % in aril and 66.8 % in seed, both from *B. sapida* fruit[20]. Our present results of 40.7-47.8 % were within the group of the values mostly prevailent in plant samples. Although FAO/WHO/UNU[13] did not give any indication of the proportion of TSAA which can be met by Cys in man, for rats, chicks and pigs, the proportion is about 50 %[13]. Information on the agronomic advantages of increasing the concentration of suphur-containing amino acids instaple foods shows that Cyshas positive effects on mineral absorption, particularly zinc[31, 32].

The P-PER values were higher than 1.21 (cowpea), 1.82 (pigeon pea); 1.62 (millet *ogi*) and 0.27 (sorghum *ogi*)[33] and close to 2.0 (*P. biglobosa*)[22]; reference casein with PER of 2.50[33]; 1.89-2.22 in three different fish samples[19]; but much lower than 4.06 in modified corn *ogi*[33] (see Table 3).

In the consumption of maize and sorghum, it has been suggested that an amino acid imbalance from excess Leu might be a factor in the development of pellagra[34]. The present Leu/Ile ratio range was 1.95-2.24 with a difference of 3.43-3.54 g/100 g cp or 48.7 – 55.4 % (Table 3).

Clinical, biochemical and pathological observations in human and rat experiments showed that high Leu in the diet impairs the metabolism of Try and niacin and is responsible for the niacin deficiency in sorghum eaters. High Leu is also a factor contributing to the pellagra-genic properties of maize. Excess Leu could be counteracted by increasing the intake of niacin or Try and also with supplementation with Ile. These studies suggested that the Leu/Ile balance is more important than dietary excess of Leu alone in regulating the metabolism of Try and niacin and hence the disease process[34]. The present Leu/Ile ratios were low in value. Also all of the present Leu values were less than 11.0 g/100 g cp; with actual range of 6.39-7.05 g/100 g cp, and could be beneficially exploited to prevent pellagra in endemic areas.

The essential amino acid index (EAAI) ranged between 0.87-1.21 (Table 3). The EAAI method can be useful as a rapid tool to evaluate food formulations for protein quality. However, it does not account for differences in protein quality due to various processing methods or certain chemical reactions[35]. Essential amino acid index for defatted soy flour is 1.26[35]. The EAAI values here were close to the values in *B. sapida* aril and seed with values of 1.08-1.62.

The isoelectric points (pI) as calculated for the AA were 3.56 (hull) and 4.53 (dehulled) (Table 3). The total neutral AA has pI 5.0-6.3, the TAAA has pI of 3.0-3.1 whilst pI for TBAA is 7.6-10.8. Olaofe and Akintayo[16] used this method to predict pI of legume and oilseed proteins from their AA in which the overall average percentage deviation was 23.3 %. This method is, therefore, a good starting point in order to enhance a quick precipitation of protein isolate from a biological sample.

The amino acid scores (AAS) based on whole hen's egg are shown in Table 4. Histidine (His) is a semi-essential AA particularly useful for children growth. This same characteristic also applies to Arg; both His and Arg had high scores in comparison to hen's whole egg. Ser had the lowest score (0.35 or 35.0 %) in dehulled sample whilst met had the least score (0.32 or 32.o %) in hull. The correction ratio[36] for the whole AA in dehulled would be 100/35 x dehulled protein and 100/32 x hull protein or 2.86 xdehulled protein and 3.13 x hull protein respectively in order to bring all the EAA to the required standards when they serve as sole sources of protein. Our results of AAS in whole egg comparison followed the trend also observed in *B. sapida* aril an seeds[20]. Table 5 shows the EAA scores (EAAS) based on provisional amino acid scoring pattern. The limiting EAA (LEAA) was Lys (0.64 or 64.0 %) in dehulled sample and Met + Cys (0.49 or 49.0 %) in the hull. Corrections here would, therefore, be 100/64 x dehulled protein and 100/49 x hull protein or 1.56 x dehulled protein and 2.04 x hull protein respectively in order to bring all the EAA to the required standards when they serve as sole sources of protein. Table 6 shows the EAAS based on the suggested pre-school child requirements. The LEAA for both samples was Lys: 0.61 (dehulled seed) and 0.52 (hull). For correction, each would require 100/61 or 1.64 x dehulled protein and 100/52 or 1.92 x hull protein to satisfy requirement when each serves as the sole source of dietary protein. On the overall scoring pattern, Gly was best in Table 4 (1.35) for dehulled sample, Phe + Tyr was best in Table 5 (1.14-1.35) as we have in *B. sapida* (1.02-1.19)[20] and Val was best in Table 6 (1.26) in hull just as we have it in *B. sapida* fruit (1.15-1.24)[20] respectively.

Table 7 shows the summary of statistical analysis from Tables 1, 3, 4, 5 and 6. The correlation coefficient (r_{xy}) for Tables 1, 3, 4 and 5 values were positively high and significant at $r_{=0.05}$ and n-2 degrees of freedom since r calc. > r table. From Table 6, the value for r_{xy} was low and positive but not significant. The R_{xy} values were low and positive except in Table 1 (TEAA) where R_{xy} was negative. The index of forecasting efficiency (IFE) was high in Tables 1 and 3 thereby making prediction easy because IFE is actually a reduction in the error of prediction. For example error of prediction in Table 1 (whole sample) would be 100-66.8 = 33.2 %. On the other hand prediction of relationship between dehulled samples and hull would be difficult in Tables 4, 5 and 6 where coefficient of alienation was high (67.1-85.4 %) since none relationship was high in Tables 4, 5 and 6.

CONCLUSION

In summary, this study indicates that the amino acid profiles of *Irvingiagabonenesis* hull and dehulled samples have close composition (Table 8 particularly the EAA under both factors A and B means). Both are good sources of many of the essential amino acids. Hence, both samples would complement each other when they are used as soup ingredients.

REREREN CES

1. Keay, RWJ, *Trees of Nigeria*, Clarendon Press, Oxford, 332-333 (1989).
2. Akande, A, Olowookere, O, *NutrInt*, **2**(5-6): 327 (1986).
3. Irvinge, FR, *Woody plants of Ghana (with special reference to their uses)*, Oxford University Press, Oxford (1961).
4. Okafor, JC, *Forest Eco Mgt*, **3**: 235 (1977).
5. Okafor, JC, *Forest Eco Mgt*, **3**: 45 (1980).
6. Adeyeye, EI, Arogunjo FA, *La RivistaItaliana Delle Sostanze Grasse,* LXXIV-Marco: 117 (1997).
7. Adeyeye, EI, Aknyeye, RO, *Chemical Society of Nigeria,* Conference Proceedings (19th -23rd September, 2011), ANA 237 (2011).
8. Pearson, D, Chemical Analysis of Foods, 7thedn., Churchill, London, 7-11 (1976).
9. AOAC, *Official Methods of Analysis*, 18thedn., Association of Official Analytical Chemists, Washington DC (2005).
10. Spackman, DH, Stein, WH, Moore, S, *Anal Chem*, **30**: 1190 (1958).
11. Paul, AA, Southgate, DAT, *First Supplement to McCance and Widdowson's The Composition of Foods,* HMSO, London, UK, 16 (1976).
12. FAO/WHO, *Energy and Protein Requirements*, Technical Report Series No.522, WHO, Geneva, Switzerland, 1-118 (1973).
13. FAO/WHO/UNU, *Energy and Protein Requirements*, WHO Tech Report Ser. No. 724, Geneva, 205 (1985).
14. Steinke, FH, Prescher, EE, Hopkins, DT, *J Food Sci*, **45**: 323 (1980).
15. Alsmeyer, RH, Cunningham, AE, Happich, ML, *Food Technology*, **28**: 34 (1974).
16. Olaofe, O, Akintayo, ET, *The Journal of Techno-Science*, **4**: 49 (2000).
17. Oloyo, RA, *Fundamentals of Research Methodology for Social and Applied Sciences*, ROA Educational Press, Ilaro, Nigeria, 71-73 (2001).
18. Adeyeye, EI, Adamu, AS, *Biosci Biotech Res Asia*, **3**(2): 265 (2005).
19. Adeyeye, EI, *Food Chem*, **113**: 43 (2009).

20. Adeyeye, EI, *AJFAND*, **11**(3): 4810 (2011).
21. Adeyeye, EI, Asaolu, SS, Aluko, AO, *Int J. Food SciNutr*, **58**(4): 241 (2007).
22. Adeyeye, EI, *J ApplEnviron Sci*, **2**(2): 154 (2006).
23. Adeyeye, EI,*Orient J Chem*, **20**(3): 471 (2004).
24. Adeyeye, EI, *Int J Food SciNutr*, **48**: 345 (1997).
25. Nwokolo, E, *Plant Foods and Human Nutrition*, **37**: 283 (1987).
26. Olaofe, O, Adeyemi, FO, Adeniran, GO, *J Agric Food Chem*, **42**: 878 (1994).
27. Oshodi, AA, Olaofe, O, Hall GM, *Int J Food SciNutr*, **42**: 187 (1993).
28. Robinson, DE, *Food Biochemistry and Nutritional Value*, Longman Scientific and Technical Group Ltd., London, UK, 120 (1987).
29. FAO/WHO, *Protein Energy Evaluation*, Report of Joint FAO/WHO Consultation held in Bethesda, USA, 4-8 December, 1989, FAO/UN, Rome, Italy, 3-5 (1990).
30. Adeyeye, EI, Afolabi, EO, *Food Chem*, **85**: 535 (2004).
31. Mendoza, C, *Int J Food SciTechnol*, 37: 759(2002).
32. Sandstrorm, A, Almgren, A, Kivisto, B, Cederblad, A, *J Nutr,***119**: 48 (1989).
33. Oyarekua, MA. Eleyinmi, AF, *FoodAgric Environ*, **2**(2): 94(2004).
34. FAO, *Sorghum and Millets in Human Nutrition*, FAO Food Nutrition Series No.27, FAO/UN, Rome, Italy, 76-84 (1995).
35. Nielsen, SS, *Introduction to the Chemical Analysis of Foods*, CBS Publishers and Distributors, New Delhi, India, 233-247 (2002).
36. Bingham, S, *Dictionary of Nutrition,* Barrie and Jenkins Ltd., London, 76-281 (1977).