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Effect of Processing on Nutritional Composition of African Locust Bean (*Parkia biglobosa*) and Mesquite Bean (*Prosopis africana*) Seeds

M. O. Aremu[1], E. Y. Awala[2], O. D. Opaluwa[2], R. Odoh[1] and T. O. Bamidele[3]

[1]Department of Chemical Sciences, Federal University Wukari, PMB 1020, Taraba State, Nigeria

[2]Department of Chemistry, Nasarawa State University, PMB 1022, Keffi, Nigeria

[3]Department of Biochemistry and Molecular Biology, Nasarawa State University, PMB 1022, Keffi, Nigeria

Corresponding author: M. O. Aremu, Department of Chemical Sciences, Federal University Wukari, PMB 1020, Taraba State, Nigeria

Abstract: The African locust bean (*Parkia biglobosa*) and mesquite bean (*Prosopis africana*) are both perennial tree legumes which belong to the family Leguminoseae. A comparative study was conducted on them to determine the effect of fermenting on the nutritional composition of their seeds. For this purpose, proximate, mineral and amino acid compositions were determined using standard analytical techniques. The result showed that fermented sample of *Parkia biglobosa* seeds had the highest content of crude protein (25.16%) and crude fat (12.27%) while the raw sample of *Prosopis africana* had the highest values of crude fibre (11.35%). Potassium was the most abundant mineral in all the samples with fermented *P. biglobosa* recording the highest value of 51.00 mg/100g. Generally, raw and fermented samples of *P. biglobosa* and *P. africana* seed flours were found to be a good source of essential minerals, and harmful heavy metals such as lead and cadmium were below the detection limit of atomic absorption spectrophotometer. The amino acid profile revealed that fermenting enhanced total amino acid (TAA), total essential amino acid (TEAA), essential alphatic amino acid (EAAA), essential aromatic amino acid (EArAA) and total sulphur amino acids (TSAA). The limiting amino acids (LAA) for raw and fermented samples of *P. biglobosa* were Met + Cys (TSAA) and Thr, respectively while that of *P. africana* was TSAA for the raw and fermented samples. Sufficient proportions of the essential amino acids were retained after fermenting of *Parkia biglobosa* and *Prosopis africana* seeds to meet FAO dietary requirement.

Keywords: Fermentation, chemical composition, *Parkia biglobosa, Prosopis africana*.

Introduction

The prevailing population pressure in Nigeria as in other less–developed countries has resulted in an increasing demand for wild underexploited nutritious plant products with aesthetic appeal in the daily diet[1]. The common edible portions of most underutilized plants are the seeds, which in some cases are cooked or roasted and eaten directly as snack foods while some are cooked and fermented for use as soup and source ingredients[2].

The seeds of the African locust bean (*Parkia biglobosa*) are covered with a hand, leathery, brown–to–black coat which can be removed only by boiling and pounding or scrubbing with sand. In the fermented form, it is used as a component of soups. The amounts used vary with the custom of the family or tribe. It is estimated that a pot of soup may contain between 20 and 100 g of the fermented bean[3]. The mesquite bean (*Prosopis africana*) is a Leguminosae belonging to the family Fabaceae. The trees of *P. africana* are common in the middle belt and northern parts of Nigeria. The local names are "kiriya" and "okpehe" in Hausa and Idoma/Tiv languages in Nigeria, respectively. In many areas where the trees are grown, the fermented seeds of *P. africana* are used as a food condiment[4]. Other traditional processing of *P. africana* are well known but very little on the nutritional evaluation and functional properties as an ingredient in fabricated foods. The latter is part of the objectives of this study.

Therefore, the aim of the present study was to determine the effect of fermenting on the nutritional composition and nutritive value of African locust bean (*Parkia biglobosa*) and mesquite bean (*Prosopis africana*) in order to provide preliminary information towards effective utilization of these legumes in various food applications in Nigeria and other parts of the world.

Materials and Methods

Sample preparation

Raw seeds

Locust bean seed was cracked, dried and ground with Kenwood food blender while mesquite bean was soaked in water for 14 days, each day the water was changed, and then dehulled, dried, ground with Kenwood food blender. The flours of both samples were kept in a refrigerator at -4^0C prior to use.

Fermented seeds

African locust and mesquite beans were boiled for 10 h and the seeds dehulled. After dehulling, the locust bean seeds were cooked for 2 h, fermented for 4 days, dried in the Oven at 40^{o}C and ground with Kenwood food blender. But mesquite beans were cooked for 30 min after dehulling, fermented for 4 days, dried in an Oven at 40^{o}C and ground with food blender. The two different sample flours were kept in a refrigerator at -4^{o}C prior to use.

Proximate analysis

The moisture, ash, crude fat, crude fibre, crude protein (N x 6.25) and carbohydrate (by difference) were determined in accordance with methods of AOAC[5]. All proximate analyses of the legume flours were carried out in triplicate and reported in percent. All chemicals were of Analar grade.

Mineral analysis

All the metals were determined by Atomic Absorption Spectrophotometer (Solar 969 Unicam) with exception of sodium and potassium that were determined using a flame photometer (Model 405, Corning UK).

Amino acid analysis

The amino acids were quantitatively measured by the procedure of Spackman *et al.*[6] using automated amino acid analyzer (Technicon Sequential Multi–sample Analyzer, TSM). Sample was hydrolyzed for determination of all amino acids axcept tryptophan in consistent boiling hydrochloric acid for 22 h under nitrogen flush.

Estimation of isoelectric point (pI), quality of dietary protein and predicted protein efficiency ratio (P–PER)

The predicted isoelectric point was evaluated according to Olaofe and Akintayo[7].

$$p\,\mathrm{Im} = \sum_{i=1}^{n=1} pI_i X_i$$

Where;

pIm = The isoelectric point of the mixture of amino acid

pI_i = The isoelectric point of the i^{th} amino acids in the mixture

X_i = The mass or mole fraction of the amino acids in the mixture

The quality of dietary protein was measured by finding the ratio of available amino acids in the protein concentrate compared with needs expressed as a ratio[8]. Amino acid score (AMSS) was then estimated by applying the FAO/WHO formula[9].

$$\mathrm{AMSS} = \frac{mg\ of\ a\mathrm{min}o\ acid\ in\ 1g\ of\ test\ protein}{mg\ of\ a\mathrm{min}o\ acid\ in\ 1g\ reference protein}\ x\ \frac{100}{1}$$

The predicted protein efficiency ratio (P–PER) of the fresh sample was calculated from their amino acid composition based on the equation developed by Alsmayer *et al.*[10]: P–PER = 0.468 + 0.454 (Leu) –0.105 (Tyr).

Statistical analysis of the samples

Sodium/potassium (Na/K) and calcium/phosphorus Ca/P ratios were calculated on all the samples. The energy values were calculated by adding up the carbohydrate x 17 kJ, crude protein x 17 kJ and crude fat x 37 kJ for each of the samples. Errors of three determinations were computed as standard deviation for the proximate composition.

Results and Discussion

Table 1 presents the result of proximate composition. Processed mesquite bean has the highest moisture content, the order being processed mesquite bean > raw mesquite bean > raw African locust bean > processed African locust bean. The value of 5.59 ± 0.07 % moisture content obtained for processed mesquite bean was higher than those reported for cranberry bean (1.7 ± 0.51%)[11] and comparable with those reported for *Luffa cylindrica* (5.8%)[12], fluted pumpkin seed (5.5%)[12], and fluted pumpkin flour (5.02%)[13]. The high moisture content may make the bean highly susceptible to microbial attack. Ash content ranged from 6.21 ± 0.05% in processed locust bean to 6.91 ± 0.53% in raw mesquite bean. These values are higher when compared with those values obtained for *Luffa cylindrical* (4.3%)[12] and *Anarcadium occidentale* (4.4 ± 0.1%)[14]. However, lower compared to the reported value of type of fish *Oreochromis niloticus* (25.33%)[15]. It was recommended that ash content in nuts, seeds and tubers should fall in the range of 1.5–2.5% in order to be suitable for animal feeds[16]. Crude fat value ranged from 7.93 ± 0.04 % in raw Africa locust bean to 12.27 ± 0.07 % in processed one, this did not qualify raw and processed African locust bean and, mesquite bean as an oil – rich legume when compared with soybean (22.8 – 23.5 %)[17 – 18] or other seeds such as pumpkin seed (47.0 – 49.2%)[19 – 20] and *Citrullus Vulgaris Schrad* (47.9 – 51.1%)[19 – 21] grown in Nigeria. Fats are important in diet because they promote fat soluble vitamin absorption and are high energy nutrient[22]. Moreover, the effort to reduce the amount of calories consumed as fat

in some countries such as the United States accentuates the significance of understanding the lipid components of food[23].

Crude protein values for raw African locust bean and mesquite bean were 10.17 ± 0.04 % and 11.77 ± 0.25 %, respectively .They are low when compared with some selected legumes such as wild jack bean (*Canavelia ensiformis*) (28.9 – 35.0%)[24] and *Baulinia nonander* (33.0)[25]. Processing method enhance crude protein. 25.16 ± 0.05 % protein value for processed African locust bean is high when compared with those protein – rich foods such as groundnut, pigeon peas, bambara groundnut and some oil seeds[11,18]. Processed African locust bean and mesquite bean could therefore be used as an alternative source of protein in the diet/protein supplement especially in nation like Nigeria where the majority of the populace lives on starchy food and cereals.

Crude fibre values were 9.17 ± 0.03 % and 11.35 ± 0.44 % for raw African locust and mesquite bean, respectively and 10.34±0.05 and 8.22±0.03 for processed African loust bean and mesquite bean, respectively .These values are high compared with reported crude fibre for pigeon pea (3.8 %)[26], Africa yam bean (3.5 %)[27]. There is evidence that dietary fibre has a number of beneficial effects related to its indigestibility in small intestine[28]. It is well known that the dietary fiber plays an important role in the maintenance of internal distention in intestinal tract as its physiological effect. Adequate consumption of dietary fibers from a variety of foods will help the protection against colon cancer and also help normalize blood lipids, thereby reducing the risk of cardiovascular diseases. Fibers help to prevent the constipation and diverticular diseases. It is an essential component of a well-balanced diet that will help minimize some common health problems. Some type of fibers can also slow D-glucose absorption and reduce insulin secretion, which is of great importance for non–diabetics as well[23]. Thus, it is important to avoid consumption of poor foods in fibers.

Carbohydrate is nitrogen free extract (NFE) calculated by difference accounted for 39.77 ± 0.43 % in processed African locust bean to 54.18± 0.02 % in raw African locust bean. This level was favorably comparable with an acceptable range mean values of legumes, 20-60 % of dry weight[29]. The carbohydrate content gave an indication that the bean studied here can be considered as a rich source of energy and was able for supplying the daily energy requirements of the body in children and adult. On the other hand, carbohydrates are easily digested, they provide the necessary and need calories in the diet of most people, promote the use of dietary fats and reduce waste of proteins[30]. The carbohydrate content suggests that these seed could be a good supplement to scarce cereal grains as sources of energy and feed formulations. The carbohydrate values compare well with the range values of 44.6 – 47 % of different varieties of *Sesbania* seeds[31] and 43.3 – 60.3 % reported for the jack bean[32]. The values are higher than those of soybean (26.3 %)[33] and cranberry bean (31.5%)[11]. The values of raw mesquite bean (53.36 ± 0.83 %), raw African locust bean (54.18 ± 0.02 %), and processed mesquite bean (50.12 ± 0.02 %) compared well with those reported for lima bean (66.9%), pigeon pea (66.8) and Jack bean (57.3%)[34]. The calculated fatty acid values ranged from 6.8 in raw African locust to 9.8 in processed African locust bean; these values suggest that the oil may be edible and suitable for industrial purposes[14]. The metabolizable energy in this study showed that the sample has an energy concentration more favourable than cereals[27].

Mineral content of raw and processed African locust been and mesquite been is presented in Table 2. Potassium was found to be the most abundant mineral in all the samples with the highest found in processed locust bean (51.00 mg/100g). This is in agreement with the observation of Olaofe and Sanni[35] that potassium was the most predominant mineral in Nigerian agricultural products. The high level of this mineral element in these seed indicates that the seeds can be utilized beneficially in the diets of

people who take diuretic medicines for the treatment of hypertension and suffer from excessive loss of potassium through the body fluid[36]. Calcium was found to be the next highest mineral component; from the result it was found that processed sample has an increase in calcium component. Calcium in conjunction with other mineral is involved in bone formation[37]. Calcium is also important in blood clotting, muscle contraction and in certain enzymes in metabolic processes. Magnesium content of raw mesquite been (15.80 mg/100g) is higher than the processed mesquite been (4.55 mg/100g) while the magnesium content of processed African locust been (12.55 mg/100g) is higher than the raw African locust been (5.50 mg/100g). Magnesium is an activator of many enzyme systems and maintains the electrical potential in nerve[38]. The value for manganese, copper and iron in all the samples were low.

It is interesting to note that harmful metals such as lead and cadmium were not at detectable range of atomic absorption spectrophotometer (AAS) in all the samples. Lead even at low concentration is known to be toxic and has no known function in biochemical process. Lead can impair the nervous and affect foetus, infants and children in lowering of intelligent quotient even at its lowest dose. The value for zinc in the processed African locust bean (0.28 mg/100g) and mesquite bean (0.13 mg/100g) were low. The values for arsenic in raw African locust bean (0.10 mg/100g) and (0.20 mg/100g) for raw mesquite bean are low. Processing affected the content of sodium in African locust bean and also mesquite bean from 6.00 mg/100g and 9.00 mg/100g to 1.95 mg/100g and 0.70 mg/100g respectively. The reduction may be due to leaching and metabolic activity, whereas processing increases the phosphorus value from 2.75 mg/100g and 4.05 mg/100g in raw African locust bean and raw mesquite bean to 7.90 mg/100g and 4.10 mg/100g in processed African locust bean and mesquite bean respectively. Sodium and potassium are required for the maintenance of osmotic balance of the body fluids, control glucose absorption and enhance normal retention of

protein during growth. The ratio of sodium to potassium, Na/K in the body is of great concern for prevention of high blood pressure. Na/K ratio less than one, is recommended[39]. The Na/K ratio of raw processed African locust bean 0.15 mg/100g and 0.04 mg/100g respectively and raw, processed mesquite bean (0.29 mg/100g) and 0.02 mg/100g, respectively which are less than one indicate that these seeds would probably have the capacity to reduce high blood pressure.

Modern diets that are rich in animal proteins and phosphorus may promote the loss of calcium in the urine. This has led to the concept of the calcium to phosphorus ratio. If the calcium ratio is low (low calcium, high phosphorus intake) more than the normal amount of calcium may be lost in the urine. Food is considered "good" if the Ca/P ratio is above 1 and "poor" if the ratio is less than 0.5 while a Ca/P ratio above 2 helps to increase the absorption of calcium in small intestine. The result of Ca/P ratio in raw and processed bean of both African locust bean and mesquite bean in the present study are desirable.

Amino acid profile of raw and processed African locust bean and mesquite bean is shown in Table 3. Leucine and lysine were the most concentrated essential amino acid in all the samples. Aspartic and glutamic acid had the highest concentration among the group of amino acid (AA) in both raw and processed African locust bean and mesquite bean seeds as is expected in legumes[11]. Tryptophan concentration could not be determined. The least concentrated amino acid is methionine (0.76 g/100g crude protein) and cystine (0.79 g/100g protein) in raw African locust bean while methionine (0.86 g/100g and 1.04 g/100g protein) is the least in the processed mesquite bean and African locust bean, respectively.

Processing increased all the amino acids in the entire sample. The calculated isoelectric point (pI) varied between 4.35 in raw mesquite bean to 5.44 in processed mesquite bean. This is useful in predicting the pI for protein in order to enhance a quick precipitation of protein isolate from biological sample[7]. The predicted protein efficiency ratio (P-PER) is one of the quality parameter used for protein evaluation. The P-PER values in this report ranged from 1.67 in raw African locust bean to 2.68 in raw mesquite bean. These values are higher than the reported P-PER values of some legumes such as *Lethynis sativus L* (1.03)[40], cowpea (1.21)[17], millet ogi (1.62)[41]. However, it can be said that both raw and processed African locust and mesquite bean seeds under investigation satisfied the FAO/WHO/UNU standard[42].

The result of the evaluation of the amino acid content based on classification is in Table 4. Processed mesquite bean had the higher total essential amino acid, TEAA (with His) of 38.30 g/100g. The order being raw African locust bean < processed African locust bean < raw mesquite bean < processed mesquite bean. All samples in this study had TEAA (with His) lower than that of soybean (44.4 g/100g protein)[34]. Essential aliphatic amino acids (EAAA), the Leu and Val, which constitute the hydrophobic region of protein, were more abundant in processed mesquite bean. This means that better emulsification properties maybe expected[34] in processed mesquite bean. The order of essential aromatic amino acid (EArAA) in the samples were processed mesquite bean > raw mesquite bean > processed African locust bean > raw African locust bean. The values are below the range suggested for infant protein (6.8–11.8 g/100g)[42]. The result further revealed that total acidic amino acid (TAAA) was found to be greater than the total basic amino acid (TBAA) in all the samples. This is an indication that the protein is probably acidic in nature. Processed African locust bean had the highest content of total sulphur amino acid (TSAA) which is lower than 5.8 g/100g recommended for infants.

The scoring Table 5 reveals the first limiting amino acid as Met + Cys for raw (0.73 g/100g) and processed (0.79 g/100g) mesquite bean seed, raw (0.44 g/100g) African locust beans while Val is the first limiting amino acid for processed African locust bean seed. The present report on limiting amino acid does not agree with Bingham[43] who has reported that the essential amino acid most often acting in a limiting capacity is Lys. When comparing the essential amino acid in the entire sample with the recommended FAO/WHO provisional pattern, the legumes were superior with respect to Phe + Tyr in all the samples, Leu and Lys in raw and processed mesquite bean and Lys in processed African locust bean.

Conclusion

The findings of this study showed that processing significantly affected the content of crude protein of African locust bean and mesquite bean seeds with an increase of 147.39 and 29.06 %, respectively. Potassium was found to be the most abundant mineral in all the samples and harmful metals such as lead and cadmium were not at detectable range of AAS. Amino acid profile revealed that processing enhanced total essential amino acid, essential aliphatic amino acid, essential aromatic amino acid and total sulphur amino acid.

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Table 1: Mean proximate composition (%)[a] of raw and processed African locust bean and mesquite bean seeds

Parameter	African locust bean		Mesquite bean	
	Raw	Processed	Raw	Processed
Protein	10.17 ± 0.04	25.16 ± 0.05	11.77 ± 0.26	15.19 ± 0.02
Fat	7.93 ± 0.04	12.27 ± 0.07	9.91 ± 0.26	8.92 ± 0.05
Crude fibre	9.17 ± 0.03	10.34 ± 0.05	11.35 ± 0.44	8.22 ± 0.03
Moisture	4.89 ± 0.02	3.20 ± 0.04	4.98 ± 0.11	5.59 ± 0.07
Ash	6.51 ± 0.03	6.21 ± 0.05	6.91 ± 0.53	6.49 ± 0.04
Carbohydrate[b]	54.18 ± 0.02	39.77 ± 0.43	53.36 ± 0.83	50.12 ± 0.02
Fatty acid[c]	6.3	9.8	7.9	7.1
Energy (kJ/100g)[d]	1387.36	1557.8	1473.88	1440.31

[a]Each value parentheses are standard deviations of triplicate determinations; [b]Carbohydrate percent calculated as the (100-total of other components); [c] Calculated fatty acids (0.8 x crude fat); [d]Calculated metabolizable energy (kJ/100g) (protein x 17 + fat x 37 + carbohydrate x 17)

Table 2: Mean mineral composition (mg/100g sample) of raw and processed African locust bean and mesquite bean seeds

Parameter	African locust bean		Mesquite bean	
	Raw	**Processed**	**Raw**	**Processed**
Na	6.00	1.95	9.00	0.70
K	39.05	51.00	30.60	28.05
Mg	5.50	12.55	15.80	4.55
Fe	0.10	0.45	0.80	0.20
Zn	ND	0.28	ND	0.13
Cu	0.08	0.06	0.12	0.06
Pb	ND	ND	ND	ND
As	0.10	ND	0.20	ND
Cr	ND	ND	ND	ND
Cd	ND	ND	ND	ND
Mn	0.60	0.24	1.12	0.06
Ca	10.75	12.30	18.05	5.40
P	2.75	7.90	4.05	4.10
Na/K	0.15	0.04	0.29	0.02
Ca/P	3.91	1.56	4.46	1.32

ND = Not detected; **Na/K =** Sodium to potassium ratio; **Ca/P =** Calcium to phosphorus ratio

Table 3: Mean amino acid composition (g/100g crude protein) of raw and processed African locust bean and mesquite bean seeds

Amino acid	African locust bean		Mesquite bean	
	Raw	Processed	Raw	Processed
Lysine (Lys)*	5.10	5.62	5.78	6.35
Histidine (His)*	1.77	1.80	2.21	2.24
Arginine (Arg)*	4.49	4.49	5.35	5.44
Aspartic acid (Asp)	16.93	17.15	17.87	19.5
Threonine (Thr)*	2.57	2.90	3.04	3.31
Serine (Ser)	3.96	4.01	3.09	4.80
Glutamic acid(Glu)	12.13	15.91	13.48	17.1
Proline (Pro)	4.37	4.48	3.26	5.09
Glycine (Gly)	3.55	4.01	3.51	4.90
Alanine (Ala)	4.86	4.98	3.95	5.51
Cystine (Cys)	0.79	1.79	1.46	1.92
Valine (Val)*	3.97	1.02	3.71	4.26
Methionine (Met)*	0.76	1.04	1.09	0.86
Isoleucine (Ile)*	3.17	3.30	3.36	3.65
Leucine (Leu)*	5.38	5.90	7.81	7.62
Tyrosine (Tyr)	2.70	3.02	3.49	3.17
Phenylalanine (Phe)*	3.37	3.80	4.22	4.57
Isoelectric point (pI)	4.35	4.74	4.75	5.44
P-PER	1.67	1.87	2.68	2.63

*Essential amino acid; **P-PER =** Calculated predicted protein efficient ratio

Table 4: Amino acid composition (g/100g crude protein) of raw and processed African locust bean and mesquite bean seeds

Parameter	African locust bean		Mesquite bean	
	Raw	Processed	Raw	Processed
Total Amino Acid (TAA)	78.87	88.22	86.68	100.29
Total Non-Essential Amino Acid (TNEAA)	49.29	55.35	50.11	61.99
% TNEAA	61.71	62.74	57.81	61.81
Total essential amino acid (TEAA)				
With Histidine	30.58	32.87	36.57	38.30
Without Histidine	28.81	31.07	34.36	36.06
% TEAA				
With Histidine	38.29	37.26	42.19	38.19
Without Histidine	36.07	35.22	39.64	3596
Essential Alphatic Amino Acid (EAAA)	15.09	16.12	17.92	18.84
Essential Aromatic Amino Acid (EArAA)	3.37	3.80	4.22	4.57
Total Neutral Amino Acid (TNAA)	39.45	43.25	41.99	49.66
% TNAA	49.39	49.03	48.44	49.52
Total Acidic Amino Acid (TAAA)	29.06	33.06	31.35	36.60
% TAAA	36.38	37.47	36.17	36.49
Total Basic Amino Acid (TBAA)	11.36	11.91	13.34	14.03
% TBAA	14.22	13.50	15.39	13.99
Total Sulphur Amino Acid (TSAA)	1.55	2.83	2.55	2.78
% Cystine in TSAA	50.97	63.25	57.25	69.06

Table 5: Amino acid scores of raw and processed African locust bean and mesquite bean seeds

EAA	PAAESP[a] (g/100g protein)	African locust bean				Mesquite bean			
		Raw		Processed		Raw		Processed	
		EAAC	AAS	EAAC	AAS	EAAC	AAS	EAAC	AAS
Ile	4.0	3.17	0.79	3.30	0.83	3.36	0.84	3.65	0.91
Leu	7.0	5.38	0.77	5.90	0.84	7.81	1.12	7.62	1.09
Lys	5.5	5.10	0.93	5.62	1.02	5.78	1.05	6.35	1.15
Met + Cys (TSAA)	3.5	1.55	0.44	2.83	0.81	2.55	0.73	2.78	0.79
Phe + Tyr	6.0	6.07	1.01	6.82	1.14	7.71	1.29	7.74	1.29
Thr	4.0	2.57	0.64	2.90	0.73	3.04	0.76	3.31	0.83
Try	1.0	nd	Na	nd	na	nd	na	nd	na
Val	5.0	3.97	0.79	4.02	0.80	3.71	0.74	4.26	0.85
Total	**36.0**	**27.81**	**5.37**	**31.39**	**6.17**	**33.96**	**6.53**	**35.71**	**6.91**

[a]**Source:** Belschant *et al.*[44]; **PAAESP =** Provisional amino acid (egg) scoring pattern; **EAAC =** Essential amino acid composition; **AAS =** Amino acid scores; **nd =** Not determined; **na =** Not applicable .