Research Article

CHEMICAL, FUNCTIONAL AND AMINO ACID COMPOSITION OF PERIWINKLE (*TYMPANOTONUS FUSCATUS VAR RADULA) MEAT*

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ABSTRACT

The proximate, nutritionally valuable minerals, functional properties and amino acids composition of periwinkle (*Tympanotonus fuscatus var radula*) meat were studied. The results showed that the sample contains 9.56% ash, 13.45% moisture, 74.74% protein, 1.32% fat, 0.74% crude fibre and 0.18% carbohydrate. The highest mineral was magnesium with 176.86mg per 100g sample, followed by sodium with 90mg per 100g sample while the sample was low in manganese and zinc. There was no detection of lead in the sample. The protein solubility was found to have minimum solubility at pH 4 and maximum at pH 2. The sample also contains 100% water absorption capacity, 250% oil absorption capacity, 6% foaming capacity, 83.3% emulsion capacity and 2.00% w/v least gelation concentration. The total amino acid amounts to 770.3mg/g crude protein while the total essential amino acid amounts to 357.3 mg/g crude protein.

Keywords: Chemical, Functional, Amino acid, Periwinkle.

INTRODUCTION

Periwinkle (*tympanotonus fuscatus var radula)* is a relatively cheap source of animal protein and is mostly consumed in the South East of Nigeria and some riverine areas of West Africa. Molluscs are generally soft-bodied animals that contain external skeleton called shell[1]. Some mollusks are found mostly in shallow waters and sometimes in inter-tidal zone where they burrow into beds of the river thereby serves as their habitat and they feed majorly on algae and diatoms[2]. Periwinkle is commercially valuable in the Niger Delta area of Nigeria. The value compares favourably with those of domestic livestock and fish. A lot of publications are available on the nutritional qualities of Nigerian snails which are in the same class with the Nigerian periwinkle. However, scanty information can only be found on the nutritional qualities of Nigerian periwinkles. Considering the enormous commercial, nutritional and industrial importance of periwinkle, the fish industry cannot continue to remain neglected. Also, with the current rate of population increase, there would be a need for snail meat substitution so as to prevent their extinction due to consumption. Hence, it is expedient to create awareness to the people about high proportion of nutritional indices of periwinkle consumed in Nigeria. Periwinkle meat is domestically used as human food, livestock feed and the shell can be painted with various colours and used as ornament for decoration. This paper reports the proximate composition, minerals, functional properties and amino acids of periwinkle.

MATERIALS AND METHODS

The periwinkle used for this study was harvested in a river near Onisha and purchased in Onisha town market in south east, Nigeria. The periwinkle was later scrubbed, rinsed and meat extracted [3].The edible parts were dried and blended into flour.

The proximate analysis of the sample for total ash, moisture, crude fibre and ether extract were carried out using the method[4]. The nitrogen content was determined by microkjedahl method[5] and nitrogen content was converted to protein by multiplying by 6.25. Carbohydrate was determined by difference. All determinations were done in triplicate.

The minerals were analysed by dry-ashing the sample at 550^{o}C to constant weight and dissolving the ash in 100 ml standard flask using distilled deionised water with 3ml of 3M HCl. Sodium and potassium were determined by using a flame photometer (model 405, corning, U.K). All other minerals were determined by Atomic Absorption Spectrophotometer (Perkin & Elmer model 403, USA).

The method of Sathe *et al*[6] was used to determine gelation property with slight modification. The water and oil absorption capacities of the sample were determined as described[7]. The emulsion capacity and stability were determined[8] while foaming capacity and stability were determined[9]. The protein solubility as a function of pH was determined by method[10]. The graph of protein solubility (%) against pH was plotted using the data obtained.

The amino acid profile was determined using the method[11] using Technicon Sequential Multi sample Amino acid Analyser (TSM, Taryton, USA).The sample was dried to constant weight, and defatted using soxhlet extractor as described[4].

Hydrolysis of Sample

Five grams of the defatted sample were weighed into glass ampoule. 7ml of 6MHCl was added and oxygen was

expelled by passing nitrogen into the ampoule (this is to avoid possible oxidation of some amino acids during hydrolysis e.g. methionine and cystine). The glass ampoule was then sealed with burnsen burner flame and put in an oven present at 105°C ± 5°C for 22 hours. The ampoule was allowed to cool before opened at the tip and the content was filtered to remove the humins. The filtrate was then evaporated to dryness at 40°C under vacuum in a rotary evaporator. The residue was dissolved with 5ml of acetate buffer (pH 2.0) and stored in plastic specimen bottles and kept in the freezer.

Loading of the Hydrolysate into the TSM Analyser

The amount loaded was 7.5 microlitre. This was dispensed into the cartridge of the analyzer. The TSM analyzer is designed to separate and analyze free acidic, neutral and basic amino acids of the hydrolysate. The period of an analysis lasted for 76 minutes.

Method of Calculating Amino acid Values from the Chromagram Peaks

The net height of each peak produced by the chart recorder of TSM (each representing an amino acid) was recorded. The half height of the peak on the chart was found and the width of the peak at the half height was also accurately recorded. Appropriate area of each peak was then obtained by multiplying the height with the width at half–height.

The Nor leucine equivalent (NE) for each amino acid in the standard mixture was calculated using the formula;

$$NE = \frac{\text{Area of Nor leucine peak}}{\text{Area of each amino acid}}$$

A constant "S_{std}" was calculated for each amino acid in the standard mixture.

$S_{std} = NE_{std} \times \text{Molecular Weight} \times \mu \text{ Moles Amino Acid}_{std}$

The amount of each amino acid present in the sample was calculated in g/100g protein using the formula

$$\text{Concentration (g/100g protein)} = NH \times W \text{ at } NH/2 \times S_{std} \times C$$

$$\text{Where } C = \frac{\text{Dilution} \times 16}{\text{Sample wt (g)} \times N\% \times 10 \times \text{volume loaded}} / NH \times W \text{ (N -leu)}$$

Where NH = Net Height

W = Width at half height

N-leu = Nor leucine

RESULTS AND DISCUSSION

Data on the proximate composition of periwinkle (*Tympanotomus fuscatus var radula)* are shown in table 1. It indicates that *periwinle* contains crude protein of 74.74%, which is higher than those of four different breeds of snail; *Archachatina Marginata* (A.M), *Achatina Achatina* (A.A), *Achatina fulica* (AF) and *Limicolaria specie* (LM) which was 19.53%, 17.20%, 10.08% and 5.86% respectively as reported[11]. The crude protein value is higher than other livestock meat like mutton, duck and chicken which have protein contents of 16.9, 18.6 and 20.5% respectively[12]. The crude protein value of periwinkle is higher than *Archachatina marginata* which ranged between 17-21%[13-15]. The crude protein of periwinkle (74.74%) is higher than *that of* male (20.48%) and female (18.40%) muscles and appendages of African fresh water crab reported[16], any diet containing periwinkle will perform the functions of both repairs of worn-out tissue and body building. The crude protein (74.74%) is equally higher than those of locust (49 – 61%), termites (35.2 – 45%)[17] and grasshopper (54.9%)[18]. The crude fibre content of periwinkle is 0.74% which is highly comparable to P*achymelania aurita* between 0.28 and 0.32%[19]. The crude fibre of periwinkle (0.74%) is lower than the male (16.32%) and female(16.03%) body part of African fresh water crab with small thoracic appendages but compared favourably well with the cheliped muscle male (0.47%) and female (0.49%)[16]. It has been discovered that dietary fibre has a number of beneficial effects related to its indigestibility in the small intestine[20,21]. The fibre content is also lower than that of grasshopper[18]. This indicates that the meal would be suitable as a weaning food. The fat content of periwinkle (1.32%) is lower than *Archachatina Marginata (2.44%)* and *Achatina Achatina (2.21%)*[11]. The fat content obtained from *periwinkle* is also lower than 9.6% for egg, 21.4% for mutton and 23.0% for duck products respectively[11]. However, the present result is higher than that of *Oryctes rhinoceros* larva (0.55 – 0.68%)[22]. The fat content of *Periwinkle* (1.32%) is lower than the male (3.00%) and female (1.69%) body part of African fresh water crab with small thoracic appendages; muscle and exoskeleton of male (2.18%) and female (3.79%) and muscle cheliped male (8.88%) and female (6.11%)[16]. The low fat content makes periwinkle meat a good antidote for hypertensive patient and those that have fat related diseases like arteriosclerosis[23].

Table 1: Proximate Composition of Periwinkle

Components	%
Ash	9.56
Moisture	13.45
Crude Protein	74.74
Crude Fat	1.32
Crude Fibre	0.74
Carbohydrate (By difference)	0.19

The moisture content of periwinkle (13.45%) is lower than *Archachatina Marginata (73.67%), Achatina Achatina (75.28%), Achatina fulica (79.28%)* and *Limicolaria specie (84.91%)* respectively[11]. The ash content of periwinkle (9.56%) is lower than the male (41.66%) and female (44.62%) body part of African fresh water crab with small thoracic appendages and *Oryctes rhinoceros* larva (12.70-15.25%)[22] but higher than that of grasshopper (3.1%)[18].

Table 2 presents the mineral content of periwinkle in mg per 100g of sample. Magnesium is the highest mineral with value of 176.86mg per 100g sample. The value is found to be higher than *Archachatina Marginata,*

Achatina Achatina, Achatina fulica and *Limicolaria Specie* (four breads of land snail in Nigeria) whose magnesium values are 25.01mg/100g, 19.28mg/100g, 15.13mg/100g and 5.28mg/100g respectively[11] and 0.04% reported for *Oryctes rhinoceros.*[22]

Table 2: Mineral content of periwinkle

Minerals	mg/100g
Calcium (Ca)	41.98
Magnesium (Mg)	176.86
Zinc (Zn)	0.70
Copper (Cu)	1.40
Manganese (Mn)	0.40
Sodium (Na)	90.00
Potassium (K)	36.00
Iron (Fe)	3.00
Lead (Pb)	ND

ND-Not Detected (Detection limit 0.001ppm)

The magnesium content of periwinkle (176.86mg/100g) is higher than those of male and female body part of African fresh water crab with small thoracic appendages (55.68mg/100g and 76.34mg/100g), cheliped (muscle and exoskeleton) male (53.50mg/100g) and female (109.57mg/100g) but lower than cheliped muscle male (264.12mg/100g) and female (214.27mg/100g)[16] and grasshopper (7.00 mg/100g)[18]. Magnesium is involved in the formation of the bone structure in the body, therefore a meal containing periwinkle would assist in bone formation. Calcium is also high in *periwinkle* with value 41.98 mg per 100g. This value is higher than *Limicolaria specie* whose calcium content is 36.20 mg per 100g[11]. However the result is lower than *Achatina Achatina, Archachatina Marginata* and *Achatina fulica* which have calcium content of 106.30mg/100g, 126.40mg/100g and 66.30mg/100g respectively[11]. The calcium content of periwinkle is also found to be lower than *Archachatina Marginata* (212.38mg per 100g)[24] and snails (22.2 – 212 mg/100g)[25] but far higher than grasshopper(8.4 mg/100g) and *Illisha Africana* (1.38 – 1.81 mg/100g)[26]. Calcium helps in the calcification of bones and teeth. Its shortage therefore can affect the structure of bones which become weakened. Calcium ions are needed for blood clotting and successful functioning of nerves and muscles[27]. The high content of calcium in periwinkle suggests that its consumption can increase the calcium in the body and help in blood clotting process. The iron content of 3.00 mg/100g in periwinkle compared favourably well with corresponding values in conventional animal products like kidney (6.0mg/100g), beef (1.9mg/100g), eggs (2.1mg/100g) and Milk (0.1mg/100g)[27]. Iron facilitates the oxidation of carbohydrates, proteins and fats. Iron is one of the mineral elements which may be lacking in an average diet and so there is a need to be conscious of taking diets rich in iron, most especially the vulnerable group of people, that is, women, who are in child bearing age, pregnant and nursing women. The iron content is fairly comparable with that of grasshopper (3.7mg/100g)[18] but less than that in various West African edible snails (4.6 – 9.3 mg/100g)[25] but better than those reported for some fresh water fish (0.2 – 0.5 mg/100g[24]. The copper content of periwinkle is 1.40mg/100g. The requirement per day is 1-3 mg/100g[27]. Therefore consumption of 100g of periwinkle per day is able to supply the daily requirement of copper. The present value is lower than that *Oryctes rhinoceros (*4.50mg/100g)[22] but higher than those of grasshopper (0.9 mg/100g)[18] and Nigeria fresh water fish (0.03 – 0.35 mg/100g)[28]. Copper and Iron are present in the enzyme cytochrome oxidase which is involved in energy metabolism[29]. Copper deficiency is of little concern since it is widely distributed in other types of food[25] but its absorption failure can lead to mankes disease. It is also needed to form red blood cells (with vitamin C)[30]. The sodium content (90.0mg/100g) is above the range 12.5 – 63.1 mg/100g reported for Nigeria freshweater fish[24] and 20.29mg/100g reported for *Oryctes rhinocerus*[22], but the potassium value of 36.0mg/100g is lower than that 45.0 mg/g of grasshopper[18] and greater than the freshwaster fish (14.8mg/100g) and *Illisha Africana* (8.7mg/100g)[26].

Table 3 shows the functional properties of periwinkle. The water absorption capacity (100%) is lower than the values obtained from the larva of *Cirina forda* (300%)[31] and fresh crab claw meat (154.49%)[32]. The high water absorption capacity reported in this study suggests that periwinkle meat can be used in the formulation of some food such as sausage, doughs, processed cheese, soups, baked products[33-35]. The oil absorption capacity (OAC) of periwinkle (250%) is lower than the value obtained for the larva of *cirina forda* (Westwood) with (358%)[31]. Oil absorption capacity is important since oil acts as flavour retainer and improves the mouth feel of foods[36]. This value is higher than that of grasshopper (33.3%)[18], pigeon pea (89.78%)[33], wheat and soy flours (84.2 and 84.4%)[37] but highly comparable with varieties of cowpeas (281-310%)[38].

Table 3: Functional properties of periwinkle

Functional Properties	Parameter
Water Absorption Capacity (%)	100
Oil absorption Capacity (%)	250
Foaming Capacity (%)	6.0
Emulsion Capacity (%)	83.3
Foaming Stability (%)	2.0
Emulsion Stability (%)	80.0
Least gelation concentration (%W/V)	2.0

The foaming capacity and stability of periwinkle (6% and 2% respectively) are in close agreement with the larva of *Cirina forda* (Westwood) which values are 7% and 3% respectively[31]. Akubor and Chukwu[39] reported that foams are used to improve the texture, consistency and appearance of food but the periwinkle value is lower than that of grasshopper foaming capacity (12.0%)[18]. This sample would not be attractive for products like cakes in whipping and toppings where foaming is important[40].

The emulsion capacity and stability of periwinkle (83.3% and 80% respectively) are higher than values obtained

for the larva of *Cirina forda* (Westwood) which are 36.67% and 45.36% respectively[31] and grass hopper (25.6% and 46.7%)[18]. This is far better than the range 7.0 – 11.0% reported for wheat flour and 18.0% for soy flour[37]. This suggests that periwinkle meat may be useful as an additive for the stabilization of fat emulsions in production of sausages, soups and cakes[41]. The least gelation concentration of periwinkle (2.00%w/v) is lower than that of *Cirina forda larva* (6.00%w/v)[31]. The effect of pH on protein solubility (ps) of periwinkle is shown in figure 1. There was minimum solubility at pH of 4.0 and maximum at pH of 2.

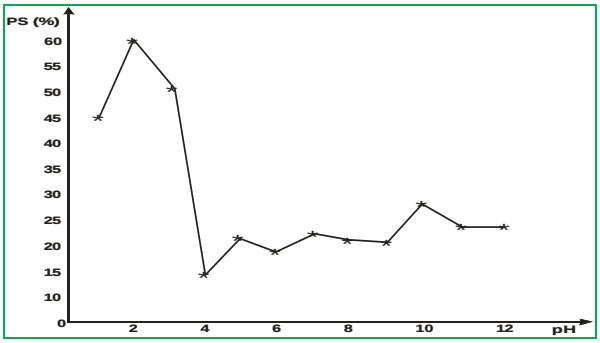

Figure 1: The dependence of Protein Solubility (PS) on pH of Periwinkle.

The periwinkle has high solubility in both acid and alkali media indicating that it may be useful in formulating carbonated beverages[37] and very low acid foods such as meat products[38]. The pattern of the curve is similar to that of *Telcifera occidentalis* with both minimum and maximum solubilities[42]. The amino acid profile of periwinkle is shown in table 4.

Table 4: Amino Acid Composition of Periwinkle

Amino Acids	Concentration (mg/g Crude protein)	+ Suggested pattern of amino acid requirement for infant range
Lysine*	42.0	53 - 76
Histidine*	20.0	18 - 36
Arginine*	54.3	
Aspartic acid	86.0	
Threonine*	33.2	40 - 50
Serine	35.5	
Glutamic acid	134.8	
Proline	30.7	
Glycine	40.5	
Alanine	38.5	
Cystine	11.7	29 - 60
Valine*	37.9	44 - 77
Methionine*	11.7	29 - 60
Isoleucine*	25.2	41 - 53
Leucine	87.5	83 - 107
Tyrosine	35.3	58 - 118
Phenylalanine*	45.5	58 – 118

+FAO/WHO (1985) * Essential Amino Acids

The result indicates that the total essential amino acid is 357.3mg/g crude protein (with histidine) which is comparable with different types of snails consumed in Nigeria which ranged from 361 to 450mg/g crude protein (with histidine)[25] which are different types of snails consumed in Nigeria. In addition the value 357.3mg/g is on the low side of the range (408-588mg/g) of the total essential amino acid required for infant[30]. The result indicates further that aspartic acid, glutamic acid and leucine were the major abundant amino acids in the sample with values 86.0, 134.8 and 87.5mg/g crude protein respectively. The total essential amino acid (357.3mg/g crude protein) suggests that periwinkle will contribute significantly to the supply of essential amino acids in the diet (Table 5).

Table 5: Percentage of the essential, acidic, basic and neutral amino acids of periwinkle

Amino Acids	mg/g Crude Protein
Total Amino acid	770.3
Total Non-Essential Amino Acids (TNEAA)	413
Total Estial Amino Acids with Histidine	357.3
Total Essential Amino Acids without Histidine	337.3
Total Acidic Amino Acid (TAAA)	220.8
Total Basic Amino Acid (TBAA)	116.3
Total neutral amino acid (TNAA)	433.2
Percentage of total non-essential Amino Acid	53.6
Percentage of total essential Amino Acid with Histidine	46.4
Percentage of total essential Amino Acid without Histidine	43.8
Percentage of total Acidic Amino Acid	28.7
Percentage of total Basic Amino Acid	15.1
Percentage of total Neutral Amino Acid	56.2

The isoleucine, leucine, lysine, phenylalanine, valine and methionine values in periwinkle are comparable to that reported by Food Agriculture Organization[12]. This suggests that the meat may meet the minimum daily requirements and contains balanced essential amino acid highly suitable for the fortification of maize food products which are widely used as weaning food for children in most African countries[43].

CONCLUSION

The results show that periwinkle *(Tympanotonus fuscatus var radula)* meat is nutritionally rich in protein and some minerals but low in fat. The functional properties of periwinkle meat are favourably compared with those of westwood larva and fresh crab /fish. Periwinkle meat is highly nutritious and therefore, recommended for consumption especially hypertensive patient whose systolic pressure exceeds 160mm Hg or diastolic pressure exceeds 95mm Hg and for human/baby food formulation due to its high concentration of essential amino acids.

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REFERENCES

1. Buchaan, J. B. Marine molluscs of gold coast of West African. J. West African Sci. Assoc., 7, 1954, 30-45.
2. Okon, B. I.. Utilization of periwinkle Flesh by Broilers feed palm Kernel-based rations. Ph.D. Thesis, University of Ibadan, Nigeria, (1987).
3. APHA,. Procedure for the bacteriological examination of sea water shell fishes. America Public Health Association Washington,DC, USA, 1970.
4. A.O.A.C (Association of Officail Analytical Chemists),. Officail Method of Analysis of the AOAC (W. howrwitz Editor), ,Eighteeth Edition, Washington D.C. 2005.
5. Pearson, D.. Chemical analysis of foods, 6th edition AVI publishers Wet Pot.1976.
6. Sathe,S.K.,,DeshpandeS.S. and Salunkhe,D.K..Functional properties of lupin seed protein.J.FoodSci., 47, 1982, 491-497.
7. Beuchat, L.T.: Functional and electrophoretic characteristics of Succinylated peanut flour. *Protein Journal Agricultural Food Chemistry,*25, 1977, 258-261.
8. Yasumatsu, K., Sawada, K., Moritaka, S. M., Salei M., Toda J., Wada, T., and ISHII, K.: whipping and Emulsifying properties of soybean products. Agriculture Biochem., 361(5), 1972, 719-727.
9. Coffman, C and Garcia, V. V. Functional properties of protein isolate from mung bean flour. J. Food Tech., 12: 1977, 437-484.
10. Spackman, G. H., Stein, E. H. and Moore S.. Automatic recording apparatus for use in the chromatography of amino acids. Analytical Chemistry, 30, 1958, 1191.
11. Babalola, O. O and Akinsoyinu, A. O, Proximate composition and Mineral profile of snail meat from different breeds of land snail in Nigeria. Pakistan Journal of Nutirtion, Vol.8 , 2009, 1842-1844.
12. FAO Amino acid contents of foods and Biological data on protein, FAO Nutritional students; Food and Agriculture Organisation Of United Nations: Rome, pp 285, 1970
13. Awesu, M.O. The Biology and Management of African giant Snail (*Archantina marginata*) Phil. Thesis, University of Ibadan, Nigeria (1980).
14. Odukoya, A. A.. Comparative effect of four different leaves on growth performance of grower snails (*A Marginata*). M. Sc. Thesis, University of Ibadan, Nigeria (1998).
15. Fagbuaro,O., J. A. Oso, J. B., Edward and R. F. Ogunleye. Nutritional status of four species of giant land snail in Nigeria. J. Zhejiang University Sci.,7, 2006, 686-689.
16. Adeyeye, E. I. Determination of the chemical compositions of the nutritionally valuable parts of male and female common West African Fresh Water-Crab. Int. J. Of Food Sci and Nutr. 53, 2002, 189-196.
17. Mayhew S. and Macmillan, A.. Tropical and sub-tropical foods. London: Macmillan. (1988).
18. Olaofe, O. Arogundade, L. A., Adeyeye, E. I. AND Falusi O. M. . Composition and food properties of the variegatus grasshopper (*Z. variegatus*). Trop Sci., 38, 1998, 233 – 237.
19. Bukola, C., Adebayo, T. Abiodun, A. O, Adeniyi, A. O and Damilola, O. A, Bacteriological and proximate Analysis of periwinkles from two different creeks in Nigeria. World Appl. Sci. J. 1 (2):2006, 87-91.
20. 20. Asp N. George. Dietary carbohydrates: Classification by chemistry and physiology, Food Chem. 7(1), 1996, 9 – 14.
21. Ogungbenle,H.N..Nutritional Evaluation of quinoa flour.Int.J.Sc.&Nutr., 54(2), 2003, 153 – 158.
22. Okaraonye, C. C. AND Ikewuchi, J. C.. Nutritional potential of Oryctes rhinoceros larva Pak. J. Nutr., 8(1), 2009, 35 – 38.
23. Bright, S. O..Prospects and problems Associated with snail Farming. Heritage printers Nig. Ltd., Lagos (1996).
24. Adeyeye, E. I., Akinyugha, N. J., Fesobi, M. E., Tenabe, V. O.: Determination of some metals in *Clarias garipinus, Cyprinus capio and Oreochromis nitoticus* fishes in a polyculture fresh water pond and their environments. Aquaculture, 147, 1996, 205 – 214.
25. Adeyeye E. I. Waste yield, proximate and mineral composition of three different types of land snail found in Nigeria. Int. J, Food Sci. Nutr., 2,47: 1996, 111-116.
26. Adeyeye, E. I.: Determination of major elements in *Illisha africana* fish, associated water and soil sediments from some fresh water ponds. Bang. J. Sci. and Ind. Res., 31, 1996b, 171 – 184.
27. Fox, B. A. and Cameron, A. G. Food science and chemical approach Hodder and Stoughton Educational, London, UK, 1980.
28. Adeyeye, E. I. The heavy metal distribution in illisha Africana fish organs and tissues 11.Zinc,Copper.Iron.and Cobalt. Pak.J.Sci.& Ind.Res., 36, 1993, 333-337.
29. LI. TING-KAI and Vallee BL. The biochemical and nutritional role of trace elements in introduction to Nutrition, ed. H. Fleck, New York, Macmillian, 1973, 204-237.
30. FAO/WHO. FAO Nutrition meetings report series no. 52. WHO technical Repot series No 522, energy and protein requirements report of a joint FAO/WHO Ad. Hoc. Expert committee (1985).
31. Omotoso O. T. Nutritional quality, functional properties and anti-nutient compositions of the larva of *Cirina forda* (West Wood). J. Zhejiang University Science, 8. 2006, 51-55.
32. Abugoch I., Barrios J. and Gaurda A. Proximal chemical Composition and Funcitional Properties of Fresh Meat of Crab Claws (*Homalaspis plana*).Arch Latinoam Nutr., 309-314, 1996.
33. Oshodi, A. A and Ekperigin, M. M functional properties of pigeon pea *(Cajanus Cajan*) Flour Chem., 34; 1989, 187-191.
34. Oshodi, A. A., Ipinmoroti K. O. and Adeyeye E. I Functional proterites of some verceteis of African yam bean. (*Sphenostylis Sternocarpa*) flour. Int. J Food Sci. Nutri 48, 1997, 243-250.
35. Ogungbenle, H. N. Oshodi, N. A., M. O. Oladimeji, Effect of salts on the functional properties of bean seed flour. Int. J. Fd. Sci.Nutr., 53, 2002, 5 – 14.
36. Kinsella, J. E. Functional properties of protein in foods A survey critical review food science nutrition, Vol. 1, No 3, 1976.
37. Lin, M. J. Y., Humbert E. S. and Sosutski F. O. Certain functional properties of sunflower meal products. J. Food Sci., 39, 1974, 368 - 370.
38. Olaofe, O., Umar, Y. O. AND Adediran, G. O. The effect of rematocides on the nutritive value and functional properties of cowpea seeds. Food Chem., 46, 1993, 337 – 341.
39. Akubor, P. I. and Chukwu, J. K, Proximate Composition and selected functional properties of fermented and unfermented African oil bean (*Pentaclethra macrophylla*) seed flour plant foods for human Nutr. 54, 1999, 227-238.
40. Kinsella, J. E, Scrinivasan, D. and Bruce, G. Physical, Chemical and functional properties of oil seed protein with emphasis on soy protein in new protein food, eds. AM Alt schul and HL Wilcks, Vol 5, 1985, 107.
41. Altschul A. M. and Wilcks H. L. New protein foods food science and technology. Academic press, Orlando, Florida, 1985.
42. Fagbemi, T. N. & Oshodi, A. A. Chemical composition and functional properties of full fat fluted pumpkin seed flour. Nig. Food. J., 9, 1991, 26 – 32.
43. Akinrele, I. A. and Edward, C. A. An assessment of the Nutritive value of a maize soya mixture, as a weaning food in Nigeria. Br. J. Nutri., 26. 1971, 177-185.

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