WFL Publisher
Science and Technology
Journal of Food, Agriculture & Environment Vol.3 (2) : 130-133 . 2005
www.world-food.net

# Chemical composition, amino acids and functional properties of selected seafoods

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*Received 10 December 2004, accepted 22 March 2005.*

**Abstract**

Proximate, mineral composition and functional properties of selected seafoods *(Parapenaeopsis atlanta*, *Panulirus regius*, *Penaeus duorarum*, *Parapenaeopsis* sp. and *Penaeus kerathurus*) were investigated using standard analytical techniques. Also the amino acid composition of *P. kerathurus* was analyzed. The moisture content, fat and carbohydrate were generally low for all samples. No crude fibre was found except in *P. regius*. The samples had high protein content varying from 42.1 to 81.3%. The samples were found to be good sources of essential minerals such as P, Fe, Mg, K, Na and Ca but Cu, Zn and Mn contents were low. The results of functional properties showed that oil absorption capacity was 130-307%, water absorption capacity 280-404% and gelation capacity 6-10%. The emulsion capacity, foaming capacity and stability were relatively good. The amino acid composition of *P. kerathurus* revealed essential amino acids comparable with that of egg protein.

***Key words:*** Seafoods, functional properties, chemical composition, amino aids.

## Introduction

Seafoods are popular items for non-vegetarians. They vary in shape, size, colour, skin bone and taste. Foods derived from the aquatic environment fall broadly into two major categories, fish and shell fish. Nutritionally, the two groups are not significantly different. There are two groups of shell fish of importance in human food, the mollusca and the anthropoda, while the mollusca consists of bivalves with a 2 piece shells, the anthropods which are of high relevance to human nutrition comprise of lobster, prawn, shrimps, crayfish and crabs.

Seafoods are nutritionally important in the supply of protein, especially the nine essential amino acids[1]. The lipid content of seafoods is primarily in the form of triglycerides or triacyglycerols and is the only major source of highly unsaturated fatty acids with odd numbers of carbon atoms in the chain[2]. Seafooods ingest and accumulate omega–3 fatty acids through the food chain algae and phytoplankton, the primary producers of omega-3 fatty acid. Carbohydrate content in seafoods is known to be very small. Seafoods are best known as sources of fat soluble vitamins, although they can provide significant amounts of some B vitamins and little or no vitamin C. They are better known nutritionally for the dietary minerals they supply [1,2] .

Seafoods serve as excellent food choice for people of all ages. However, there is paucity of information on the functional properties of seafoods which will enhance their usefulness in industrial food formulation or processing. The present study therefore investigates proximate composition, minerals, amino acids and functional properties of selected seafoods.

## Materials and Methods

Five species (*Penaeus kerathurus, Penaeus duorarum*, *Parapenaeopsis* sp., *Parapenaeopsis atlanta, Panulirus regius*) of shrimps (seafoods) were purchased from Makoko market in Adekunle, Ebute-metta and Lagos State of Nigeria. The collected samples were stored in ice in insulated containers. The prawns were thoroughly sorted to eliminate or remove bad ones and then oven-dried, after which they were processed into flour. The flour was stored in a container under favourable conditions to prevent possible deterioration and used for subsequent analyses.

Moisture, crude protein, crude fat and ash were determined according to AOAC[3]. Sodium and potassium were determined using a flame photometer (Corning, UK Model 405). Phosphorus was determined colorimetrically using Spectronic 20 (Gallenkamp, U.K) as described by Pearson [4]. All other minerals were determined using atomic absorption spectrophotometer [4].

Foaming properties, water and oil absorption capacities were determined according to methods described by Sathe et al. [5]. Oil emulsion capacity was determined by the procedure of Inklaar and Fertuin [6], as modified by Adeyeye et al. [7] and oil emulsion stability by the method of Beuchat [8].

Amino acid profiles were determined in *Penaeus kerathurus* using the ion exchange chromatography (IEC). The samples were defatted, hydrolysed, evaporated in a rotatory evaporator and then loaded into the Technicon Sequential Multisample Amino acid Analyser. The full experimental details have been reported by Adeyeye and Afolabi [9].

## Results and Discussion

Table 1 presents the results on moisture, protein, fat, ash, fibre and carbohydrate contents in seafood samples while Table 2 presents the functional properties of selected seafoods. Tables 3, 4 and 5 show the mineral composition of selected seafoods, amino acid content of *Penaeus kerathurus* and analysis of the amino acid and egg scores, respectively. The proximate and functional properties are reported in percentages (g/100 g dry sample); mineral contents are reported in mg/100 g dry sample and the amino acids in mg/g of crude protein. The samples contained low moisture content, which varied from 3.2% in *Penaeus kerathurus* to 4.6% in *Parapenaeopsis* sp. The low value is due to the sample preparation before analyses to preserve its quality. Literature[10] reveals that the moisture content of these fresh seafoods varied between 70-75%.

The crude protein varied from 40.7% in *Panulirus regius* to 78.0% in *Parapenaeopsis atlanta.* This is in conformity with the report of Finemann-Kalio[11] that seafoods generally have an appreciable protein quantity, which makes them useful in food formulation. The protein values of all the seafoods except *Panulirus regius* are higher than was obtained for other insects and animal protein such as termites. Percentage ash content was lowest in *P. atlanta* (3.6%) and highest in *P. regius* (20.2%) showing that the latter probably contains more bones. The percentage of fat in the sample varied between 2.4 and 4.7%, the fat content being highest in *P. atlanta*. All the seafoods examined showed very low fat content. The results are in conformity with the report of Adeyeye and Adubiaro[13]. The crude fibre was not detectable in all the samples except *Panulirus regius* with 8.5%. The carbohydrate content in the samples analyzed varied between 0.16% for *P. atlanta* to 9.4% for *P. duorarum*. The values are comparable with the report of Pandit and Magar[15] for *C. lanzara* (3.71%) and *C. latis* (3.06%). This observation indicates that seafoods are not good sources of carbohydrate.

Results of the functional properties of the seafood samples are shown in Table 2. The oil absorption capacity is an important functional property, since oil acts as a flavour retainer and improves the mouth feels of foods[15]. The oil capacity varies between 130% in *Parapenaeopsis* sp. and 30% in *P. duorarum.* These values are higher than those of plant source such as pigeon pea flour[16] (89.75%), wheat flour (84.2%) and soy flour (84.4%)[17], quinoa flour[18] (8.46%) and variegated grasshopper (*Zonocerus variegatus*)[19] (33.3%). Water absorption capacity of the selected seafoods varied between 280% for *P. atlanta* to 400% for *P. duorarum*. These values are higher when compared to some legume flours such as cowpea flour [20] (212-275%). The emulsion capacity of seafood samples varied between 14.6% for *P. kerathurus* to 25.5% for *Parapenaeopsis* sp. The foaming capacity was low and varied from 6% *(Panulirus regius)* to 14% *(P. duorarum)* and foaming stability after 2 hours varied from 2% (*P. atlanta*) to 4% (*P. duorarum*). The least gelation capacity varied from 6% (*P. regius*) to 10% (*P. atlanta*). These are lower than the values observed for oil seed flour (12-18%)[21] and pigeon pea flour (12%)[17]. The solubility of the protein in seafoods is a function of the pH. The lowest protein solubility occurs at the isoelectric point which varied from *P. duorarum* pH 2 to *Parapenaeopsis* sp. pH 4. This is low when compared with the report of Olaofe et al.[19] on *Z. variegatus* with an isoelectric point of pH 5.5; however, the curve follows the similar pattern.

Iron, which plays a major role in the formation of haemoglobin, was highest in *P. regius* (103 mg/100 g) and lowest in *P. duorarum* (20.3 mg/100 g). Since the iron from seafoods is readily absorbed compared with that of legume or cereal, consumption of cereal diet fortified with seafood would therefore contribute significantly to the prevention of anaemia which is widespread in developing countries [22, 23]. The calcium concentration is reasonably distributed among the samples, *P. kerathurus* recorded the highest and *Parapenaeopsis* sp. the lowest value. The present results show that seafoods are good sources of phosphorus with values ranging from 68.2 mg/100g in *P. regius* to 218.3 mg/100 in *Parapenaeopsis* sp. Phosphorus is always found with calcium in the body, both contributing to the blood formation and supportive structure of the body. Low Ca/P ratio facilitates decalcination of calcium in the bone leading to low calcium level in the bones while Ca/P ratio above two helps to increase the absorption of calcium in the small intestine [25], *P. kerathurus* and *P. regius* have Ca/P>1 while others have Ca/P ratio between 5 to 10 indicating that they would serve as good sources of minerals for bone formation. The seafoods samples are good sources of magnesium. Magnesium is required for bone formation and it is also an activator of many enzyme systems which maintain the electrical potential in nerves [24]. Magnesium content varied between 138.8 mg/100g in *Parapenaeopsis* sp. and 216.18 mg/100g in *P. duorarum*.

Potassium and sodium contents ranged between 149.3 mg/100 g in *Parapenaeopsis* sp. and 219.95 mg/100 g in *P. kerathurus* and 113 mg/100 g in *P. regius* to 169 mg/100 g in *P. duorarum*,

**Table 1.** Proximate analyses (%) of selected seafoods.

| Parameter | *Parapenaeopsis atlanta* | *Penaeus kerathurus* | *Panulirus regius* | *Penaeus duorarum* | *Parapenaeopsis sp.* | Mean | S.D | C.V |
|---|---|---|---|---|---|---|---|---|
| Moisture content | 4.02 | 3.2 | 3.4 | 4.3 | 4.6 | 3.9 | 0.59 | 15.13 |
| Dry matter | 95.98 | 96.8 | 96.6 | 95.7 | 95.4 | 96.1 | 0.59 | 0.61 |
| Ash | 13.9 | 12.9 | 37.3 | 15.6 | 21.14 | 02.2 | 10.1 | |
| Fat | 4.7 | 2.48 | 2.69 | 3.24 | 3.56 | 3.33 | 0.88 | 26.43 |
| Crude fibre | ND | ND | 8.5 | ND | ND | - | - | |
| Crude protein | 81.3 | 79.13 | 42.13 | 71.89 | 74.95 | 69.9 | 15.94 | 22.80 |
| Carbohydrate | 0.16 | 5.48 | 9.3 | 9.4 | 0.63 | 4.99 | 4.49 | 89.98 |

ND - Not detectable

**Table 2.** Functional properties of selected seafoods.

| Parameter % | *Parapenaeopsis atlanta* | *Penaus kerathurus* | *Panulirus reguis* | *Penaeus duorarum* | *Parapenaeopsis sp.* | Mean | S.D | C.V |
|---|---|---|---|---|---|---|---|---|
| WAC | 280 | 360 | 370 | 400 | 350 | 352 | 44.4 | 12.4 |
| OAC | 298 | 186 | 149 | 307 | 130 | 180 | 91.6 | 50.9 |
| Foaming capacity (FC) | 10 | 12 | 6 | 14 | 11 | 10.6 | 2.97 | 27.99 |
| Foaming stability (FS) | 2 | 3 | 2 | 4 | 3 | 2.8 | 0.84 | 29.9 |
| Emulsion capacity (EC) | 66 | 82 | 69 | 73 | 70 | 72 | 6.1 | 8.5 |
| Least gelation | 10 | 8 | 6 | 8 | 6 | 7.6 | 1.7 | 2.2 |
| Isoelectric point (IP) | 4 | 4 | 4 | 2 | 5 | 3.8 | 1.1 | 28.8 |

WAC Water absorption capacity; OAC Oil absorption capacity

**Table 3.** Mineral contents of selected seafoods.

| Mineral μg/100g | *Parapenaopsis atlanta* | *Penaus kerathurus* | *Panulirus regius* | *Penaeus duorarum* | *Parapenaeopsis sp.* | Mean | S.D | C.V |
|---|---|---|---|---|---|---|---|---|
| Na | 117 | 116 | 113 | 169 | 114.3 | 125.9 | 24.2 | 19.50 |
| K | 163.3 | 219.95 | 155.8 | 205.2 | 149.3 | 178.71 | 31.79 | 17.8 |
| Na/K | 0.72 | 0.53 | 0.73 | 0.8 | 0.77 | 0.71 | 0.12 | 14.9 |
| Ca | 114.2 | 196.7 | 114.7 | 130.3 | 80.0 | 127.2 | 42.99 | 33.8 |
| P | 136.4 | 156.3 | 68.2 | 142.0 | 218.3 | 143.8 | 53.6 | 37.27 |
| Ca/P | 0.84 | 1.26 | 1.68 | 0.9 | 0.4 | 1.02 | 0.48 | 37.27 |
| Fe | 21.2 | 33.96 | 103.0 | 20.3 | 11.6 | 38.01 | 37.2 | 97.8 |
| Mg | 165 | 208 | 160.4 | 216.98 | 138.8 | 177.8 | 33.3 | 18.7 |
| Cu | 0.2 | 0.8 | 2.0 | 0.7 | 0.4 | 0.82 | 0.70 | 85.5 |
| Zn | 4.9 | 9.5 | 4.2 | 3.4 | 7.9 | 5.98 | 2.60 | 43.6 |
| Mn | 0.9 | 2.1 | 0.6 | 0.4 | 1.9 | 1.02 | 0.66 | 64.8 |

**Table 4.** Amino acid composition of *P. kerathurus* (mg/g) crude protein.

| Amino acid | *P. kerathurus* (mg/g) | Suggested level (mg/g)* | Amino acid score |
|---|---|---|---|
| Lysine | 65.5 | 55 | 1.19 |
| Histidine | 22.0 | | |
| Arginine | 92.6 | | |
| Aspartic acid | 73.2 | | |
| Threomine | 50.9 | 40 | 1.27 |
| Serine | 25.5 | | |
| Glutamic acid | 143.9 | | |
| Proline | 36.6 | | |
| Glycine | 81.0 | | |
| Alanine | 44.0 | | |
| Cystine | 10.6 | 35 | 1.25 |
| Methionine | 33.0 | | |
| Valine | 48.7 | 50 | 0.97 |
| Isoleucine | 57.0 | 40 | 1.43 |
| Leucine | 80.4 | 70 | 1.15 |
| Tyrosine | 47.9 | 60 | 1.63 |
| Phenylalanine | 50.1 | | |

* Source FAO/WHO (1991)

**Table 5.** Analysis of essential and non-essential amino acids of *P. kerathurus* (mg/g crude protein).

| Amino acid | *P. kerathurus* | % |
|---|---|---|
| Total amino acid | 1972.9 | - |
| Total non-essential amino acid (TNEAA) | 472.7 | 48.6 |
| Total essential amino acid (TEAA) with histidine | 500.2 | 51.4 |
| TEAA without histidine | 478.2 | 49.2 |
| Total neutral amino acid (TNAA) | 576.1 | 59.2 |
| Total acidic amino acid (TAAA) | 217.1 | 22.3 |
| Total basic amino acid (TBAA) | 180.1 | 18.5 |

respectively. The ratio of sodium to potassium in the body is of great concern for prevention of high blood pressure. Na/K ratio less than one is recommended. The Na/K ratio for the seafood samples under consideration though less than one; hence most of the samples would probably reduce high blood pressure disease. Foods that have low sodium and high potassium values include most fruits, vegetables and low sodium cereals [25], which can be consumed with the animal protein. Copper, zinc and manganese are the minerals with the lowest values. Copper content varied from 0.2 mg/100 g in *P. atlanta* to 2.0 mg/100 g in *P. regius,* zinc from 3.4 mg/100 g (*P. duorarum*) to 9.5 mg/100 g (P. *kerathurus*) and manganese from 0.4 mg/100 g in *Penaeus duorarum* to 2.1 mg/100 g in *P. kerathurus*. Copper has the lowest occurrence when compared to all the other elements. The present study reveals that seafoods can be good sources of mineral supplement in our diet.

Table 4 presents the result of the amino acid analysis of *P. kerathurus*. It is observed that glutamic and aspartic acids are the most abundant amino acids and make up to 217 mg/g on an average basis with a percentage of 22.3%. Similar observation has been reported by Olaofe and Akintayo[26]. The total essential amino acid (TEAA) in the sample is 500.2 mg/g (51.4%) and 478.2 mg/g (49.2%) with and without histidine, respectively. These are comparable with values obtained from selected oil seeds (melon seed, pumpkin seed and gourd seed), which ranged between 33.3 and 53.6% [21]. Therefore seafoods can be considered as good diets that can provide the required essential amino acids. The amino acid composition shows that total, neutral, acidic and basic amino acids are 59.2, 22.3 and 18.5% respectively, indicating that the protein is probably acidic in nature. This lends credence to the isoelectric point in the acidic range (pH 2.0-4.0).

The present results are compared with the amino acid requirement pattern as recommended by FAO/WHO[27]. The amino acid content of the selected seafoods is high, except phenylalanine, which is close to the recommended value. The results of amino acid score revealed that the essential amino acid scores are greater than one, except valine with a value of 0.97 mg/g. The implication is that seafood is slightly deficient in valine; this means that the seafoods can meet the essential amino acid requirements for school children. It would also meet the amino acids requirements for adults since the amino acid composition that meets the requirements of a child would meet the requirements of an adult [28, 29]. It can also be suitable for fortification of maize food products which are deficient in lysine and commonly used as weaning foods for children in most developing countries[30].

## Conclusions

The present study indicates that seafoods can be classified as high source of protein with nutritionally valuable minerals and complete essential amino acids. It also reveals the suitability of diets from seafoods for hypertensive people since Na/K is less than one and that phosphorus absorption would be enhanced and decalcination of bone would be reduced since the Ca/P ratio lies between 0.5 and 1.0. The results of the functional properties revealed that the selected seafoods would be excellent ingredients for various industrial applications (food formulation/supplement). The high quality protein of *P. kerathurus* shows its reliability as a good source of amino acids for school children and adults.

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