Distributional Review and Compositional Characteristics of Ghanaian Shellfish and their Potential Utilization for Chitin Extraction

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ABSTRACT

A review of the distribution of crabs, lobster, shrimps and prawns found in Ghana revealed that crabs, shrimps and prawns are found in most regions of Ghana with abundant quantities in the Greater Accra, Central, Volta, Western and Eastern regions while lobsters are common in the regions along the coast. Compositional characteristics of the unprocessed meats and shells were found to be for Cardiosoma armatum, moisture 80.5%, protein 16.3%, chitin, 25.25%, for Callinectes latimanus, moisture, 86.7%, protein, 11.5%, chitin, 18.3%, for Panulirus regius, moisture, 80.1%, protein, 18.3%, chitin, 17.6%. The prawns Machrobrachium machrobrachion had a moisture of 71.1%, protein, 15.1%, chitin 20.0%, for Machrobrachium vollenhoveni moisture, 69.7%, protein, 17.4%, chitin, 23.7% and for Panaeus notialis , protein, 16.6%, moisture, 76.7%, and chitin, 21.1%. All the types of crustacean meats had a low content of ash and fat, but rich quantities of calcium, iron, copper, and phosphorus were in limited quantities. An important characteristic was the predominance of unsaturated fatty acids.

INTRODUCTION

The term shellfish is used generally to refer to all those invertebrate species that have an external hard shell and include both crustaceans and molluscs. Most of the crustaceans available in Ghana are aquatic species, and these include prawns, shrimps, lobsters and many species of crabs. Several studies have been carried out to investigate the distribution of crabs, lobsters, shrimps and prawns in Ghana and these have shown that most of the named shellfish are found in the southern regions of Ghana. Over the past decade, there has been a progressive increase in the average landings of these shellfishes, but a large proportion of these are exported [1]. Shellfishes are classified under first class protein foods and contain rich quantities of protein, and low amount of fat, which is predominantly unsaturated [2]. The meat also contains high levels of essential minerals, such as calcium and phosphorus and have considerable amounts of other trace minerals and vitamins [3,5,5].

Unfortunately, these compositional data have been obtained on shellfish of temperate waters, and very little information on the compositional characteristics and chitin content of Ghanaian shellfishes are available.

Chitin industry, trade, and research have grown to a large extent in countries like Japan [6], United States of America [7], Italy [8], and Poland [9], but not in Ghana, although shellfish farming and consumption take place to a large extent.

This work was therefore carried out to study the compositional characteristics and chitin content of Ghanaian shellfish and shellfish wastes.

MATERIALS AND METHODS

Source and handling of shellfish.

Fresh, live lobsters, *Panulirus regius* (PR) and fresh, live shrimps, *Panaeus notialis* (PN) were obtained from Gbegbei-sey beach, Accra. Two species of fresh, live crabs, *Cardiosoma armatum* (CA), and *Callinectes latimanus* (CL) were obtained from Community 1 Market, Tema, while two species of fresh, live prawns, *Machrobrachium machrobrachion* (MM) and *Machrobrachium vollenhoveni* (MV), were obtained from the Volta river at Big Ada, Ghana. The shellfishes were transported in frozen form to the laboratory and stored at -20°C in black polythene bags until required. With those samples which were meant for chitin extraction, the meats were separated from the shell and the solid wastes were washed and cleaned by scraping under running tap water, rinsed with deionized water and dried in hot-air oven at

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65°C for 72 hours to obtain a constant weight. The dried shells were then pulverized with a Waring blender and sieved manually to obtain a uniform shell size of 2.0mm. These were stored in black polythene bags at -20°C until required.

Apparatus: Atomic Absorption Spectrophotometer: Perkin-Elmer Model 110B equipped with Flame Ionization Detector was used for the analysis of mineral ions. Air-acetylene flame was employed for the analysis of each mineral with 20mA Narva(GDR) hollow cathode tubes for calcium, copper and iron.

Capillary Gas Chromatography(GC): A Hewlett-Packard Model 5890A gas chromatograph was used.

An HP-20M Hewlett Packard column (60mm x 0.25mm i.d. df. = 0.25μm, bonded polyethylene glycol phase) was connected to a Flame Ionization Detector (FID), and a Hewlett-Packard Model 3390A Integrator was used to determine the peak are. The amount of each component was determined by using an internal standard method. The carrier gas was nitrogen and the GC was operated isothermally at 230°C. Injector port and detector temperatures were 220 and 275°C respectively. Sample injection volumes was 0.3μl.

Phosphorus analysis: Phosphorus content was determined according to the method of AOAC [10]. 2g of dried and pulverized shells (2.0mm size) was ashed at 600°C for 4 hours. It was then cooled and 40ml of 33% hydrochloric acid and several drops of nitric acid added, and brought to boiling. It was then filtered and aliquots containing 0.5 to 1.5mg phosphorus were measured into 100ml volumetric flasks. 20ml molybdovanate reagent was added. The solution was diluted to volume with water, mixed well and allowed to stand for 10 minutes. Absorbance was read at 400mm against a 5mg standard as blank using a 1cm diameter cuvette with a UV/visible spectrophotometer model LKB Biochrom Ultrospec Plus. Crude fat content was determined by the method of A.O.A.C. [11]. Ash content was determined according to A.O.A.C. [10] method. Crude protein content was determined by a slightly modified A.O.A.C. method [10]. Determination of mineral ions was by the method of A.O.A.C. [10].

Isolation of Chitin: Chitin was extracted from crustacean shells by demineralization and deproteinization procedures developed by Tetteh [12]. The crude chitin was decolorized by the method of Kamasastri and Pabhu [13] and Blumberg et al. [14].

Demineralization: A total of 20g of dried and pulverized shells (2.0mm) was added to 200ml of 2N HCl in a 600ml beaker and stirred with a magnetic stirrer for 5 1/2 hours at room temperature. It was filtered through a 160μm sieve, washed till demineralized shells were free of acid and dried in a hot air oven at 65°C overnight.

Deproteinization: 150ml of 1.7% sodium hydroxide solution was added to the demineralized shells, stirred with a magnetic stirrer at 55°C for 5 1/2 hours and then filtered through 160μm sieve and washed till the deproteinized shells were free of alkali. The residue was dried in a hot air oven at 65°C overnight.

Decolorization of crude chitin: Crude chitin samples were refluxed with absolute acetone for 45 minutes, dried at room temperature for 2 hours and then treated with 70% acetone. Samples were then washed, rinsed with deionized water and then mixed with 0.315% sodium hypochlorite solution (containing 7% available chlorine) for 5 minutes. The residues were then removed by filtration, washed and rinsed with deionized water and dried at 65°C overnight in a hot air oven and weighed.

RESULTS AND DISCUSSION

Distribution and abundance of crustaceans in Ghana.

In Ghana regions along the Atlantic coast have a rich supply of crabs and lobsters. These regions are Greater Accra, Central, Western and Volta Regions. Shrimps and prawns are widely distributed in various regions of Ghana with the exception of the northern part of the country. Table 1 and 2 show the regional distribution of shrimps and prawns in Ghana. Four main Panaeid shrimp species are found in West African waters, namely; *Penaeus kerathurus, Penaeus duorarum, Parapeneopsis atlantica* and *Parapenaeus longrostris* [15, 16]. The predominant species in Ghanaian waters are the Pink shrimp (*Penaeus duorarum*) and tiger shrimp, which is also called caramote prawn (*Parapeneopsis atlantica*) [15, 16]. *Penaeus duorarum* makes up the bulk of landings of commercial shrimpers. An inventory of the freshwater prawns of Ghana showed that large specimens of three species, *Machrobrachium vollenhoveni, Machrobrachium machrobrachion* and *Machrobrachium felicinum* occur in the lower reaches of

Table 1: Regional Distribution of Shrimps In Ghana.

	REGION	HABITAT
Penaeus duororum (Pink shrimp)	Volta, Western, Greater Accra	20-60m over bottoms containing more than 75% fine sediments
Parapeneopsis atlantica (tiger or caramote prawn)	Volta, Western, Greater Accra	Between 10 and 40m depth
Penaeus velutinus	Greater Accra, Central	Found near the shore

Source: [16, 17].

Table 2: Regional Distribution of Prawns In Ghana

SPECIES	REGION	HABITAT
Machrobrachium machrobrachion	Greater Accra, Western, Eastern	Shallow habitats with deeper portions away from rivers margins
Machrobrachium felicinum	Greater Accra Western, Volta, Brong Ahafo.	Shallow habitats with deeper portions away from the margins of river
Machrobrachium vollenhoveni	Greater Accra, Eastern, Western, Volta, Brong-Ahafo	Shallow habitats with deeper portions away from margins of river
Palaemon paucidens	Ashanti	Shallow habitats with deeper portions away from margins of river

Source: [15, 16]

Table 3: Regional Distribution of Lobsters In Ghana

SPECIES	REGION
Panulirus regius	Greater Accra, Western, Central and Volta
Scyllarides herklotsi	Greater Accra and Western.
Stereomastus sculpta	Greater Accra
Scyllarus carpati	Greater Accra
Scyllarides latus	Greater Accra

Source: [19, 20, 32]

rivers in the south and in a number of freshwater ponds, reservoirs and lakes in the coastal savanna[17]. M. vollenhoveni is the dominant and largest species.

Table 3 shows the regional distribution of lobsters in Ghana. The only species of commercial importance is Panulirus regius. These lobsters appear to be the highest chitin producers of the marine benthic communities [18]. The relative abundance of shrimps, prawns, lobsters and crabs in the various regions of Ghana is shown in Fig.1. which shows that, in Ghana shellfishes are more abundant in the southern areas and decrease as one approaches the north.

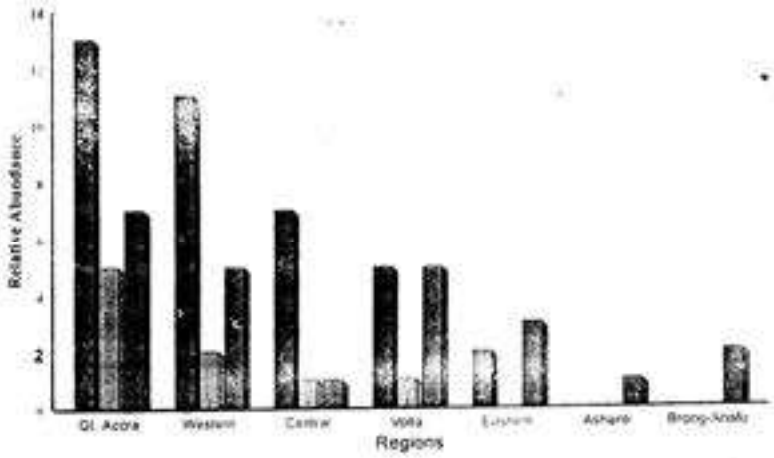

Figure 1 : Relative Abundance of Crustaceans Found in Ghana

Table 4: Regional Distribution of Crabs In Ghana

SPECIES	LOCATIONS (Region)
Ocypoda africana (sand crab)	Greater Accra, Western, Central and Volta
Callinectes gladiator (Benedict)	Greater Accra, Western, Volta and Central
Calinectes latimanus (Rathbun)	Greater Accra, Western
Cardiosoma armatum (Herklots)	Greater Accra, Western, Central and Volta
Potamon potamonautes (River crab)	Eastern Region
Panopeus parvulus	Western

Source: [19, 21]

Several species of crabs have been identified in Ghana. [19, 20, 21]. A good many of them are of no commercial importance. The crabs of commercial significance in Ghana are presented in Table 4. Fig.1 which shows the relative abundance of crabs in Ghana, indicating that crabs dominate the total landings of crustaceans and are more abundant in the southern part of the country.

Catch of Crabs, Lobsters, Prawns and Shrimps

The total landings of crabs and lobsters in Ghana for the period 1981-1990 (Table 5) shows a wide variation in catch from year to year but a steady increase in total landings for shrimps and prawns over the same period.

Compositional characteristics of crustacean meat.

Moisture, protein, crude fat, and ash contents of Ghanaian crustaceans were determined. All the crabs and lobsters had a moisture content of about 80% while the prawns and shrimp had a lower moisture content of about 70% (Table 6). Eyeson and Ankrah [22], Charley [5], and Rechcigl Jnr. [23] also observed a moisture content of between 70 - 80% for the Blue crab, *Callinectes sapidus*, the Northern lobster, and the spiny lobster, *Panulirus argus*. The crabs, lobsters, shrimps and prawns all had a high protein content of between the 18% (Table 6). A higher protein content of 17 - 21%

Table 5: Total landings of crabs, lobsters, shrimps and prawns (1981-1990)

Year	Quantity (metric tonnes)		
	Crabs	Lobsters	Shrimps/Prawns
1981	5.0	168.0	489.9
1982	9.4	176.0	339.2
1983	31.0	128.3	331.7
1984	9.6	203.8	216.5
1985	21.8	133.2	508.0
1986	4.8	554.5	552.0
1987	239.1	753.5	1,602.0
1988	237.1	172.8	1,177.0
1989	36.8	173.3	1,509.0
1990	322.0	122.2	2,637.0

Source:[33,34].

Table 6: Proximate composition of crustaceans

Component	CA	CL	PR	MM	MV	PN
Moisture	80.5	86.7	80.1	71.1	69.7	76.2
Protein: meat	16.3	11.5	18.3	15.4	17.4	16.6
shell	15.1	21.6	26.0	46.2	34.4	48.8
Fat	0.7	0.4	0.3	1.5	2.3	0.8
Ash: meat	1.8	1.7	1.9	4.3	3.9	3.9
shell	41.2	40.1	48.9	2.8	21.2	21.7
Chitin	25.25	18.4	17.6	20.0	23.7	21.1

was reported for some Penaeus and Pandalus species [22, 24]. Crustaceans have a high quality protein and contain the essential amino acids, leucine, isoleucine, lysine, methionine, valine, threonine, tryptophan, phenylalanine and histidine [25, 26, 27, 28]. A low ash content of the meat of about 2% were observed for crabs and lobsters, and about 4% for shrimps and prawns (Table 6). On the other hand, the shells of shrimps and prawns had a higher ash content of about 21%, while that of the crabs and lobsters were 40 - 49%.

Chitin content of the shells of all crustaceans was very high, 17 -25% (Table 6). Teitch [12] reported chitin contents of 28.8% for the blue crab, and 23.2% for the northern lobster. These variations observed may be due to factors such as geographical location, seasonal variations, age, sex, and size of the crustacean [2].

Variation in mineral content

Crustaceans appear to be very good source of minerals, especially, calcium. Callinectes latimanus appeared to have the highest calcium content of 821mg/100g, and Panulirus regius having the lowest calcium content of 21mg/100g, though it had a relatively high phosphorus content of 147mg-/100g, (Table 7). Shrimps and prawns appear to be a poor source of phosphorus. Crustaceans are however a poor source of the micronutrient, iron and copper (Table 7).

Fat and fatty acid composition

Crude fat content of six crustaceans were found to be quite low of about 0.3 - 2.3%. The low fat

Table 7: Mineral composition of crustaceans mg/100g

Crustacean	Calcium	Iron	Copper	Phosphorus
MM	683 ± 23.3	0.93 ± 1.21	0.13 ± 0.08	0.28 ± 0.03
MV	680 ± 23.8	0.19 ± 0.09	0.51 ± 0.05	0.33 ± 0.03
PN	135 ± 14.2	0.43 ± 0.05	0.18 ± 0.01	0.39 ± 0.04
CL	821 ± 30.0	0.50 ± 0.03	0.82 ± 0.06	114 ± 8.0
CA	124 ± 14.0	1.31 ± 0.02	1.24 ± 0.20	201 ± 10.2
PR	21 ± 1.6	0.60 ± 0.07	0.39 ± 0.13	137 ± 10.6

Table 8: Fatty acid composition of crustaceans

Crustaceans name	12:0	14:0	16:0	18:0	18:1	18:2	18:3
CL	0.5	0.0	0.4	0.0	13.3	0.0	0.0
CA	0.9	4.1	2.3	1.5	0.2	0.0	0.2
PR	0.4	0.0	0.0	3.2	0.0	0.0	0.4
MM	7.8	2.4	0.9	16.8	18.7	5.2	6.4
MV	2.0	1.7	8.5	2.2	0.3	2.2	4.8
PN	0.0	0.8	11.6	18.6	0.1	0.1	1.3

content of the meat of crustaceans make the protein quality rich [25]. Their oils were extracted and analyzed by gas chromatography. Table 8 shows fatty acid composition obtained from gas chromatographic analysis by direct injection of fatty acid methyl esters (FAME) of the crustaceans. It was found that, the crustaceans contained rich quantities of unsaturated fatty acids. These unsaturated fatty acids are thought to be responsible for the beneficial effects of fish oils in health [29, 30]. These influence health by altering the synthesis of prostaglandins, that are produced in the body. They are required for the development of the foetal brain [31] and other physiological roles in the body.

CONCLUSION

While crustaceans are good food source for many people, due to their rich quantities of protein, essential minerals, and unsaturated fatty acids of the omega-3 types, the solid wastes which are thrown away, may be used to produce useful quantities of chitin. Consolidation of a chitin industry in Ghana would lead the way toward proper waste disposal techniques of the shellfish industry.

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