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Compositional characteristics of green crab (*Carcinus maenas*)

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Abstract

The invasive European green crab (*Carcinus maenus)* was harvested at four sites in Nova Scotia. Crabs were individually weighed and measured for carapace width. A composite of claw and leg meats was sampled from raw green crabs and the meat was subjected to proximate (moisture, protein [N × 6.25], and total lipids), carotenoids, fatty acid distribution, and amino acids composition analyses. In addition, the shell discards were analyzed for their contents of chitin, total lipids, total nitrogen, and total carotenoids. The total protein (N × 6.25) content, lipids, and carotenoids in crab meat, on a dry weight basis (db), were 80.6–83.5, 3.6–4.8%, and 5.1–19.2 mg%, respectively. The shell discards, db, contained 12.6–14.5% of chitin, 2.6–3.11% of total nitrogen, 0.37–0.65% of total lipids, and 4.4–9.3 mg% of total carotenoids. The saturated and $n-3$ fatty acids accounted for 19–20.7% and 37.4–40% of total fatty acids, respectively. The polyunsaturated fatty acids (PUFA) were dominated by eicosapentaenoic acid (EPA: $20:5n-3$) and docosahexaenoic acid (DHA: $22:6n-3$). The ratio of EPA:DHA varied from 1.6 to 2.8. Green crab meat was well balanced in its composition of essential amino acids, except for tryptophan.

Keywords: Green crab; Chemical composition; Proteins; Lipids; Carotenoids; Chitin

1. Introduction

The European green crab, *Carcinus maenas*, has proven to be a very successful invader outside of its natural habitat in the coasts of Eastern Europe (Jamieson, Grosholz, Armstrong, & Elner, 1998), invading South Africa (Le Roux, Branch, & Joska, 1990), Australia (Jamieson et al., 1998), and both the west (Cohen, Carlton, & Fountain, 1995) and east (Glude, 1955) coasts of North America. Attributes that contribute to their success as an invasive species include a very high reproductive output, a planktonic larval phase, tolerance of a wide range of salinity and temperature, and the ability to thrive in densities of several individuals per square meter (Crothers, 1968; Young, Komarow, Deegan, & Garritt, 1999).

Green crab was introduced to the Atlantic coast of North America during the mid-1800s in the Cape Cod area (Glude, 1955). This initial population then expanded northwards and reached Nova Scotia in the early 1950s (Elner, 1981; Glude, 1955; MacPhail, Lord, & Dickie, 1955). Expansion then continued during the next 30 years, both into the Bay of Fundy and in a north-eastern direction along the southern coast of Nova Scotia, in the latter case possibly slowed somewhat by the relatively small number of estuaries and cool summer water temperatures along that shore. It appears that, by the early 1990s, green crabs were established in the southern Gulf of St. Lawrence, where warm summer temperatures and numerous estuaries and bays could be considered optimum habitats for them. It is likely that the green crab will build up to very high numbers in the southern Gulf of St. Lawrence. An

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example of this can be seen in Antigonish Harbour, where green crabs have achieved densities exceeding 1 crab/1 m^2 in less than 10 years after their arrival (Campbell, 2001).

Many studies have examined the ecological impact of invasive green crab populations on pre-invasion flora and fauna (Cohen et al., 1995). Green crabs are very aggressive omnivores (Le Calvez, 1987), and gut content studies have found representatives of many groups, including bivalves (Cohen et al., 1995), snails (Hadlock, 1980), annelids (Gee, Warwick, Davey, & George, 1985), crustaceans (Ropes, 1968), and even algae (Elner, 1981). In particular, though, green crabs tend to have the greatest impact on bivalves (Elner, 1981) and have been associated with collapses of softshell clam (*Mya arenaria*) in New England (Glude, 1955) and severe reductions of the clams *Nutricola tantilla* and *confusa* on the west coast of North America (Grosholz et al., 2000). Despite their relatively small size (maximum carapace width approximately 95 mm) (Grosholz et al., 2000), green crabs use their chelae very effectively to open and consume bivalves and can even open bivalves with relatively thick shells, such as quahaugs (*Mercenaria mercenaria*) and oysters (*Crassostrea virginica*). Given their penchant for shellfish, and their ability to thrive at high densities, the invasive green crabs pose a considerable threat to both wild and aquacultured shellfish in the southern Gulf of St. Lawrence. In addition to shellfish, there is a considerable potential for green crabs to act as competitors or predators for various life history stages of two species of commercially important crustaceans, the rock crab (*Cancer irroratus*) and the American lobster (*Homarus americanus*) (Gillis, MacPherson, & Rattray, 2000). Given the likelihood that green crab may become established in most of the Atlantic provinces, and the potential for considerable impact on aquaculture and crustacean resources, some regional harvest may be implemented in order to control numbers in selected areas of concern. Cost recovery of such an operation would be facilitated by developing uses for components of green crab. The present study represents the first step in exploring the economic potential of the green crab and reports on its proximate, amino acid and fatty acid compositions.

2. Materials and methods

Green crabs (*C. maenas*) were collected from four sites, Antigonish harbour, Pomquet harbour, Merigomish Bay, and the Little Dover-Canso region (Table 1) using cylindrical traps which were 60 cm in length, 35 cm in width, constructed of a coated 1×1 cm wire mesh. Traps were baited with mackerel and deployed at depths of 1.5–2 m. Soak time was 3 h, after which the traps were hauled and the crabs were placed on crushed ice until euthanized by freezing.

Meat from the body and claw portions was separated manually, combined, homogenized, and then stored at −18 °C until analyzed for moisture, lipid, crude protein, carotenoids, fatty acid, and amino acid compositions.

The moisture content of green crab meat and shell discards was determined by drying the meat at 105 °C until a constant weight was obtained (AOAC, 1980). Crude protein content was calculated by converting the nitrogen content, determined by the Kjeldahl method ($6.25 \times N$) (AOAC, 1980). The total nitrogen content in shell discards and deproteinized shells was determined using the Kjeldahl method (AOAC, 1980). The crude protein content in the shell discard (P) was calculated as: $P = (SD - S) \times 6.25$, where SD is the total nitrogen in shell discards and S is the total nitrogen in deproteinized shells.

The total lipids were isolated from green crab meat and shell discard samples according to the procedure of Bligh and Dyer (1959). One portion of the chloroform extract was evaporated to dryness under vacuum at 40 °C in order to determine the content of fat in the meat and shell discards. The other portion of the extract was concentrated under vacuum and nitrogen at 40 °C to near dryness and then stored at −18 °C until analyzed for carotenoids and fatty acid composition.

The content of the shell in green crab processing discards was determined according to Naczk, Synowiecki, and Sikorski (1981). A sample of 5 g of offal was deproteinized with 5% KOH for 2 h at 100 °C with intermittent mixing. The deproteinized shell was collected on a coarse sintered glass funnel and washed with deionized water to pH 7.0, and then by three portions of 25 ml of acetone, followed by drying to a constant weight at 105 °C. The content of chitin in the deproteinized shell was

Table 1
Yield of meat from green crab from different harvesting sites

Site	Location		Harvest period	Meat yield (weight %)
Site #1	Antigonish Harbour NS, Canada	45°39.90′N61°54.30′W	May 1–10 2001	23.5 ± 3.2
Site #2	Pomquet Harbour NS, Canada	45°38.55′N61°49.25′W	May 1–10 2001	26.7 ± 3.7^{a}
Site #3	Merigomish Harbour NS, Canada	45°38.65′N 61°′25.40′W	July 4 2001	$26.1 \pm 1.4^{a,b}$
Site #4	Little Dover-Canso NS, Canada	45°17.40′N61°02.40′W	July 9–12 2001	27.8 ± 1.6^{b}

Results are mean values from 30 crabs; values within the same column followed by the same superscript are not significantly different ($P > 0.05$).

assayed as described by Naczk et al. (1981). A 0.5–1.0 g portion of deproteinized shell was treated with 20 ml of 5% HCl at room temperature with continuous mixing for 2 h. Crude chitin was collected on a coarse sintered glass funnel and washed with deionized water to pH 7.0 and then by three portions of 25 ml of acetone, followed by drying to a constant weight at 105 °C.

The fatty acid composition of the total lipids, extracted from meat samples according to Bligh and Dyer (1959), was determined as fatty acid methyl esters (FAMEs), by gas chromatography using a Hewlett-Packard, Model 5890 Series II gas chromatograph (Agilent, Palo Alto, CA) equipped with a fused silica capillary column (SUPELCOWAX-10, 0.25 mm diameter, 30 m length, 0.25 μm film thickness; Supelco Canada Ltd., Oakville, ON). The sample was injected into the GC using a Hewlett-Packard 7673 autoinjector (Agilent, Palo Alto, CA). Temperature of the oven was programmed at 220 °C for 10.25 min, followed by ramping to 240 °C at 20 °C/min and kept there for 9 min. Helium at a flow rate of 2 ml/s was used as the carrier gas. The injection port and the flame ionization detector oven temperatures were set at 250 °C. FAMEs were identified by comparing retention times with those of an authentic standard mixture (GLC-461, Nu-Check-Prep, Elysian, MN) or literature values. Methyl heptadecaoneate was used as an internal standard.

The total content of carotenoids in the lipid fraction of the meat and shell discards was determined spectrophotometrically, as described by Saito and Regier (1971), and the concentration of carotenoids in meat samples was calculated using the equation given by Shahidi and Synowiecki (1991).

Crude carotenoid extracts were then separated into individual components (in four replicates) by using preparative thin-layer chromatography (TLC). Silica gel G (20×20 cm, 250 μm, Aldrich Chemical Co. Inc., Milwaukee, WI) plates were spotted with carotenoid extracts dissolved in hexane and then developed using a mixture of acetone–hexane (30:70, v/v) (20). Co-chromatography of authentic carotenoid standards on TLC was performed for tentative identification purposes. The percent distribution of the carotenoids involved each fraction of carotenoids; each one obtained from TLC, was scraped individually from the plate and dissolved in hexane with a few drops of methanol. The absorption of each carotenoid in the hexane solution, diluted to 10 ml, was read on a Diode array spectrophotometer (Agilent, Palo Alto, CA). The absorption maxima for carotenoids involved were in the range of 450–453 nm. The proportion of each identified carotenoid was calculated as the ratio of its volume multiplied by its absorbance to the corresponding values for the crude extract.

The amino acid composition of the green crab meat was determined by hydrolyzing it with 6 N HCl for 24 h at 110 °C (Blackburn, 1968) and then separating the amino acids on a Beckman 121MB amino acid analyzer. Cysteine and methionine were determined as cysteic acid and methionine sulphone, respectively, by performic acid oxidation prior to their digestion in 6 N HCl (Blackburn, 1968). Analysis of tryptophan was carried out by hydrolysis of the sample under vacuum with 3 N mercaptoethane sulphonic acid at 110 °C, as described by Penke, Ferenczi, and Kovacs (1959).

3. Results and discussion

Antigonish, Pomquet, and Merigomish Harbours are relatively small estuaries situated in the southern Gulf of St. Lawrence. Although the freshwater input into these estuaries is modest, they still experience somewhat reduced salinities (ranging from 20 to 30 ppt depending on precipitation) and temperatures a few degrees above outer coastal areas. The sites sampled in these estuaries were characterized by soft bottoms and seagrass (*Zostera marina*) beds. The Little Dover-Canso sites were situated along the northern part of the south shore of Nova Scotia and experience higher salinity (32 ppt) and cooler temperatures than the other three sites. The areas sampled in the Little Dover-Canso areas could be described as rocky intertidal, with hard substrate and seaweeds such as *Fucus vesiculosis* and *Ascophyllum nodosum*.

In this study, only larger sizes of trapped crabs were selected for extraction of meat. The total weight and carapace width of green crabs harvested at four sites were 31.2–102.5 g (on average 60.7 ± 16.9 g) and 54.9–75.6 mm (on average 63.5 ± 4.9 mm), respectively. The mean size of crabs was less than those reported by Skonberg and Perkins (2002), but similar to that reported by Jamieson et al. (1998) for green crab harvested in the west Atlantic. There was a statistically significant (t-test, $P < 0.001$) difference in crab yield among the four harvesting sites. The meat extracted from green crabs varied from 23.5% (site #1) to 27.8% (site #4) of crab weight (Table 1). These values are somewhat lower that those reported by Krzeczkowski and Stone (1974) for snow crabs.

The proximate composition of raw green crab meat is shown in Table 2. Crude protein ($N \times 6.25$) and total lipid contents of crab meat, on a dry weight basis, were 80.6–83.5% and 3.6–4.8 %, respectively. These values are in good agreement with those published by Skonberg and Perkins (2002) for meat obtained from green crabs harvested in the Gulf of Maine as well as those reported by King, Dorset, and Monsen (1990) for Dungeness crab and Gökoŏlu and Yerlikaya (2003) for blue crab (*Callinectes sapidus*), but somewhat lower than those reported by Lauer, Murray, Anderson, and Guptill (1974) for Atlantic Queen crab (*Chionoecetes opilio*).

Table 2
Proximate chemical composition of green crab meat[A] from different harvesting sites

Location	Moisture (%)	Protein[B] (N × 6.25)	Total lipids[B]	Total carotenoids[C]
Site #1	82.3 ± 0.5^{a}	83.5 ± 0.7^{a}	4.8 ± 0.2^{a}	19.2 ± 0.3
Site #2	$82.5 \pm 0.1^{a,b}$	80.9 ± 0.5^{b}	3.8 ± 0.1	18.6 ± 0.3
Site #3	$83.3 \pm 0.8^{a,b}$	80.6 ± 1.0^{b}	4.6 ± 0.2^{a}	8.9 ± 0.2
Site #4	79.1 ± 0.4	82.3 ± 0.9^{a}	3.6 ± 0.1	5.1 ± 0.1

[A] Results are mean values of four replicates ± SD; for site specifications see Table 1; values within the same column followed by the same superscript are not significantly different ($P > 0.05$).
[B] Expressed as % on a dry weight basis.
[C] Expressed as mg% on a dry weight basis.

Table 3
Proximate composition of shell discards from green crab[A] from different harvesting sites

Location[A]	Total lipids[B]	Total nitrogen[B]	Shell[B]	Total carotenoids[C]	Chitin[B]	Crude protein [N × 6.25]
Site #1	0.37 ± 0.02^{a}	2.60 ± 0.04^{a}	83.4 ± 1.7^{a}	9.3 ± 0.3^{a}	14.1 ± 0.3^{a}	5.00 ± 0.20
Site #2	0.38 ± 0.03^{a}	2.62 ± 0.07^{a}	$84.9 \pm 2.0^{a,b}$	9.0 ± 0.2^{a}	$14.5 \pm 0.5^{a,b}$	7.06 ± 0.38
Site #3	0.48 ± 0.04	3.11 ± 0.06	$82.4 \pm 4.9^{a-c}$	4.4 ± 0.2	12.6 ± 0.4^{c}	6.00 ± 0.28
Site #4	0.65 ± 0.08	2.84 ± 0.01	$82.7 \pm 1.3^{a-c}$	5.1 ± 0.2	$13.3 \pm 1.1^{a-c}$	4.31 ± 0.16

[A] Results are mean values of four replicates ± SD; for site specification see Table 1; values within the same column followed by the same superscript are not significantly different ($P > 0.05$).
[B] Expressed as % on a dry weight basis.
[C] Expressed as mg% on a dry weight basis.

The proximate composition of green crab processing discards is summarized in Table 3. The content of crude proteins in green crab discards was 3–4 times lower than that reported by Shahidi and Synowiecki (1991) for different parts of snow crab (*C. opilio*) shell discards. These differences may originate from the method of processing of crabs. In this study, the shell discards were separated from raw crab, while those examined by Shahidi and Synowiecki (1991) were obtained from processing of cooked snow crab. Green crab offal from different collection sites contained from 82.4% to 84.9% of shell on a dry weight basis. The content of chitin in the green crab shells varied from 12.6% to 14.5% on a dry weight basis. Similar values were reported by Muzzarelli (1977) and Johnson and Peniston (1982, Chap. 19) who found that crab shell contained from 13% to 15% of chitin, on a dry weight basis. On the other hand, a somewhat higher content of chitin in crab shells was detected by Shahidi and Synowiecki (1991). These authors related the higher level of chitin to the smaller amount of residual meat in the shell offal.

The fatty acid distribution in total lipids of the green crab meat is shown in Table 4. The main saturated fatty acids were palmitic (16:0) and stearic (18:0) acids, while oleic acid (18:1) was the dominant monounsaturated fatty acid. King et al. (1990) reported a somewhat higher 16:0 (13.4%) and lower 18:0 (4.46%) and 18:1 (13.08%) contents in the total lipids of Dungeness crab (*Cancer magister*). The fatty acid profile of green crab lipids was dominated by polyunsaturated fatty acids (PUFA), which comprised 47.1% (site #1) to 50.5% (site #4) of the total lipids. These values are lower than

Table 4
Fatty acid composition of the total lipids on green crab meat[a] from different harvesting sites

Fatty acid	Site #1	Site #2	Site #3	Site #4
14:0	0.45	0.45	0.36	0.29
15:0	0.94	0.68	0.59	0.54
16:0	9.80	9.97	11.7	9.17
17:0	1.59	1.27	1.12	1.09
18:0	6.31	6.05	6.30	6.32
20:0	0.66	0.56	0.61	0.61
$16:1n-7$	4.56	4.61	4.01	3.63
17:1	2.29	1.79	1.09	1.61
$18:1n-13$	0.45	0.44	0.27	0.70
$18:1n-9$	10.3	11.5	11.9	13.1
$18:1n-7$	4.47	4.66	4.43	3.53
$20:1n-11$	0.52	0.42	0.60	0.62
$20:1n-9$	0.82	0.79	0.64	0.68
$20:1n-7$	0.44	0.30	0.34	0.44
$20:1n-5$	0.25	0.18	0.34	0.12
$22:1n-9$	0.78	0.69	0.65	0.62
$22:1n-7$	0.29	0.27	ND	ND
$18:2n-6$	0.72	0.76	0.78	1.37
$20:2n-6$	1.05	1.10	1.11	2.45
$18:3n-3$	0.31	0.30	0.27	0.45
$20:4n-6$	6.04	5.96	7.81	7.78
$22:4n-6$	0.51	0.42	0.46	0.56
$20:5n-3$	24.6	25.1	22.3	26.5
$22:5n-6$	0.22	0.17	0.15	ND
$22:5n-3$	1.88	2.79	1.44	1.95
$22:6n-3$	11.8	11.9	13.4	9.38
Others	7.94	6.96	7.43	6.41
Saturated	19.8	19.0	20.7	18.1
Monounsaturated	25.2	25.7	24.2	25.1
Polyunsaturated	47.1	48.4	47.7	50.5
$n-3$	38.6	40.0	37.4	38.2

[a] Results are mean values of duplicate injection of two samples. SDs from means did not exceed 2% of absolute values. For site specification see Table 1. ND, not detected.

those reported by King et al. (1990) for Dungeness crab. The dominant PUFA were EPA ($20:5n-3$) and DHA ($22:6n-3$) and the ratio of EPA to DHA varied from 1.6 in site #3 to 2.8 in site #4 with an average of 2.1. These values are similar to those reported by Krzeczkowski and Stone (1974) for snow crab, King et al. (1990) for Dungeness crab, and Ackman and McLeod (1988) for Jonah, Queen, and Rock crabs, but much higher than values reported by Skonberg and Perkins (2002) for green crab caught in the Gulf of Maine. The observed difference in the EPA to DHA ratios in this study compared to those reported by Skonberg and Perkins (2002) may be due to the existing differences in the diet of crab at the harvesting sites. Moreover, Styrishave and Andersen (2000) reported the influence of factors such as season, sex, and intermoult duration on the fatty acid profiles in the hepatopancreas of the green crab (*C. maenas*) inhabiting the Isefjord, Denmark. The $n-3$ fatty acids accounted for 38.2–40% of the total and 75.7–82.6% of all PUFA. Styrishave, Petersen, and Andersen (2000) also found that PUFA were the predominant fatty acids found in gills and muscles of green crab (*C. maenas*). The total contents of $n-3$ fatty acids were somewhat lower than those reported in the literature for Dungeness crab (King et al., 1990). On the other hand, values from this study are in the range of those published by Spinelli, Lehman, and Wieg (1974) for red crab, who demonstrated that the content of $n-3$ fatty acids was affected by both the season and place of catch.

The content of carotenoid pigments in green crab meat ranged from 5.1 (site #4) to 19.2 (site #1) mg/100 g on a dry weight basis (Table 2), while in crab discards it varied from 4.4 (site #3) to over 9.0 mg/100 g (site #1 and #2) (Table 3). These values are similar to those reported by Shahidi and Synowiecki (1991) for snow crab discards. Variations in the amount of carotenoids may originate from the existing differences in the amounts of dietary pigments and living conditions at the harvesting site. It should also be noted that green crabs from sites #1 and #2 were collected in May, while those from sites #3 and #4 were harvested in June. Composition of carotenoids in green crab meat is summarized in Table 5. Astaxanthin diester was the major carotenoid present, while astaxanthin monoester and β-carotene were present in smaller amounts. In addition, three minor carotenoids, namely free astaxanthin, canthaxanthin, and lutein were also identified in green crab meat.

Table 5
Distribution of carotenoids in green crab meat (% of total)[a] from different harvesting sites

Carotenoid	R_f	Site #1[a]	Site #2	Site #3	Site #4
Astaxanthin diester	0.74	69	64	67	58
Astaxanthin monoester	0.41	13	17	15	18
Astaxanthin	0.25	<3	<3	<3	<3
β-Carotene	0.79	5	8	8	12
Lutein	0.23	<2	<2	<2	<2
Cantaxanthin	0.39	<3	<3	<3	<3

[a] Results are mean values of two replicates. For site specifications see Table 1.

The amino acid composition of green crab meat is summarized in Table 6. Results indicate that proteins from green crab meat are well-balanced in their essential amino acid compositions, except for tryptophan, which was present in low amounts. These values are similar to those reported by Spinelli et al. (1974) for proteins from

Table 6
Amino acid composition of proteins from meat fraction of green crab (mg per g protein)[a] from different harvesting sites

Amino acid	Site #1	Site #2	Site #3	Site #4
Alanine	65.7 ± 0.2	54.2 ± 0.1	57.4 ± 0.3	59.0 ± 0.4
Aspartic acid	100 ± 0.1	95.1 ± 0.2	113 ± 0.2	100 ± 0.1
Arginine	86.3 ± 0.2	84.8 ± 0.2	77.3 ± 0.5	92.3 ± 0.7
Cysteine	28.4 ± 0.1	23.9 ± 0.2	25.9 ± 0.4	24.7 ± 0.5
Glutamic acid	147 ± 1.2	143 ± 1.4	149 ± 2.7	152 ± 2.2
Glycine	67.5 ± 0.4	55.6 ± 0.6	77.7 ± 0.4	72.4 ± 0.7
Histidine	23.8 ± 0.3	22.3 ± 0.4	24.5 ± 0.5	24.0 ± 0.5
Isoleucine	47.1 ± 0.2	42.2 ± 0.3	46.9 ± 0.3	46.5 ± 0.4
Leucine	76.3 ± 0.3	71.6 ± 0.2	76.6 ± 0.7	76.4 ± 0.3
Lysine	80.6 ± 0.6	150 ± 2.2	79.7 ± 0.5	80.8 ± 0.4
Methionine	34.5 ± 0.5	33.9 ± 0.3	25.1 ± 0.4	33.6 ± 0.5
Phenylalanine	40.2 ± 0.4	36.5 ± 0.3	39.8 ± 0.3	32.3 ± 0.6
Proline	42.9 ± 0.3	39.3 ± 0.4	43.6 ± 0.2	47.5 ± 0.4
Serine	41.2 ± 0.1	39.4 ± 0.3	41.6 ± 0.4	39.7 ± 0.3
Threonine	45.4 ± 0.2	43.5 ± 0.2	45.6 ± 0.3	44.4 ± 0.4
Tryptophan	10.2 ± 0.1	10.4 ± 0.1	9.8 ± 0.05	9.3 ± 0.01
Tyrosine	34.8 ± 0.3	34.2 ± 0.4	34.9 ± 0.3	35.2 ± 0.1
Valine	47.9 ± 0.2	41.8 ± 0.3	46.3 ± 0.2	46.3 ± 0.5

[a] Results are mean value of three replicates ± SD. For site specifications see Table 1.

whole red crab pulp, Krzeczkowski and Stone (1974) for proteins from whole snow crab meat, and Shahidi and Synowiecki (1991) for proteins removed from processing discards of snow crab.The most abundant amino acid in green crab meat samples from sites #1, 3, and 4 was glutamic acid (>140 mg/g of protein), followed by aspartic acid, arginine, lysine, and leucine, in a decreasing order. On the other hand, glutamic acid and lysine were the most abundant (>140 mg/g of protein) amino acids in green crab meat from site #2,followed by aspartic acid, arginine, and leucine.

In conclusion, green crab provides a nutritious source of meat and useful by-products for possible commercial exploitation. However, the small size of the green crab and a low yield of meat may dictate the economy of the process.

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