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Nutrient composition of green crab (*Carcinus maenus*) leg meat and claw meat

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Abstract

Research is underway in New England to examine the potential for initiating a commercial fishery for the invasive European green crab (*Carcinus maenus*). Information on the nutrient composition is needed to facilitate the processing, utilization, and marketing of value-added green crab products. Green crabs were harvested and individually weighed and measured for carapace width. Claw meat and leg meat samples were picked from steamed crabs, and raw crabs were sampled for claw meat only. Samples were subjected to proximate, mineral (calcium, phosphorus, magnesium, sodium, potassium, aluminium, iron, zinc, copper), cholesterol, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) analyses. Moisture, protein, and total mineral contents of the crab meat averaged 78.7, 17.1, and 2.2 g/100 g, respectively. Leg meat had higher lipid concentrations (1.16 g/100 g) than either steamed (0.62 g/100 g) or raw (0.54 g/100 g) claw meat. Average n-3 fatty acid concentrations ranged from 115 to 336 mg/100 g and 154 to 344 mg/100 g for DHA and EPA, respectively, and were significantly higher in leg meat than in claw meat.

Keywords: Nutrient analyses; Green crab; Proximate composition; Cholesterol; n-3 Fatty acids

1. Introduction

The invasive European green crab (*Carcinus maenas*) has become established as an important predator along much of the Atlantic and Pacific coastlines of the United States (Jamieson, Grosholz, Armstrong, & Elner, 1998; Mathews, McKnight, Avery, & Lee, 1999; Walton, Ruiz, & Starr, 1999). In addition to threatening commercial and recreational mollusk fisheries, this predator also has a negative economic impact on crustacean fisheries through the consumption of juveniles and bait. Green crabs have not previously been targeted by the crab-picking industry, primarily due to their small size and the difficulty of meat removal. However, their abundance, together with their relative ease of capture, make them a potential resource for a new capture fishery.

Research is currently underway to examine the feasibility of developing and marketing various green crab products, including soft shell crab, crab mince, and cocktail claws, for US markets. As a whole, seafood products, including crustacean shellfish, have been lauded for their health promoting characteristics. Polyunsaturated fatty acid (PUFA) content, in particular, has been shown to be beneficial in the reduction of coronary artery disease, rheumatoid arthritis, and respiratory distress in asthmatics (Broughton, Johnson, Pace, Liebman, & Kleppinger, 1997; de Deckere, Korver, Verschuren, & Katan, 1998; Leaf & Weber, 1988; Torres, Mira, Ornelas, & Melim, 2000). Crustacean shellfish are also good sources of various minerals and high quality protein (USDA, 1999). Although the nutritional composition of several commercially harvested species of crab has been partially characterized, shellfish vary widely in their nutrient content (Ackman & McLeod, 1988; King, Childs, Dorsett, Ostrander, & Monsen, 1990; Krzynowek, Wiggin, & Donahue, 1982). Researchers have also reported differences in concentrations of moisture, fat, ash, protein, and various volatile compounds in meats from different body parts of the blue crab, *Callinectes sapidus*, and in the southeast Asian crab, *Charybdis feriatus* (Chung, 1999; Gates & Parker, 1992; Lee, Meyers, & Godber, 1993).

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Table 1
Proximate composition of green crab meats (g/100 g)

	Claw meat (steamed)[a]	Leg meat (steamed)	Claw meat (raw)
Protein	17.7±0.1a	16.9±0.1a	16.8±0.3a
Ash	2.2±0.1a	2.2±0.0a	2.2±0.2a
Fat	0.6±0.2a	1.2±0.2b	0.5±0.1a
Moisture	78.3±0.6a	78.9±0.5a	79.0±0.7a

[a] Each value is the mean of duplicate analyses of three composite samples±S.D. Values in the same row not sharing a letter are significantly different ($P<0.05$), based on one-way analyses of variance.

Fundamental knowledge of chemical composition and nutrient content is needed to facilitate the processing, utilization, and marketing of value-added green crab products for human consumption. This study reports on the proximate analysis and mineral, DHA, EPA, and cholesterol contents of leg meat and claw meat from green crab harvested in the Gulf of Maine.

2. Materials and methods

Forty-two green crabs were harvested from five different sites in the Gulf of Maine in November 2000, and transported live to the laboratory. Each crab was individually weighed, and measured for carapace width using a vernier caliper. Crabs were cooked by steaming for 12 min, and claw meat and leg meat were picked by hand. Uncooked crabs were sampled for claw meat only. Three composite samples of each treatment (steamed claws, steamed legs, raw claws) were prepared by blending the meat from six to eight crabs.

Samples were homogenized and subjected to moisture, ash, and Kjeldahl nitrogen analyses using AOAC (1998) methods 950.46, 938.08, and 928.08, respectively. Crude lipid was determined by the acid hydrolysis method (AOAC #922.06). Ashed samples were dissolved in 2 ml of concentrated acid ($HCl:HNO_3$; 1:1), then diluted with distilled water (Shearer, 1984). The diluted mixture was analysed for calcium, phosphorus, magnesium, sodium, potassium, aluminium, iron, zinc, and copper content with an ICP spectrophotometer (Jarrell-Ash AtomComp).

Crude lipid for EPA and DHA analyses was extracted by homogenizing a 10 g sample in 50 ml of chloroform:methanol (2:1) solution (Folch, Lees, & Stanley, 1957). The extracted lipid was transesterified for fatty acid analysis by adding 5.5 ml of boron trifluoride (14% in methanol; Sigma Chemical) and 0.5 ml dimethoxypropane (Sigma Chemical) per 100 mg of fat, then heating at 60 °C for 10 min (Morrison & Smith, 1964). The fatty acid methyl esters in the upper layer were separated and quantified by injecting 1 μl (40:1 split ratio) into a gas chromatograph (Hewlett Packard Model 5890 series II) equipped with an AED detector (Hewlett Packard Model 5921A). The column used was a Hewlett Packard FFAP (20 m length×0.32 mm i.d., 0.52 μm film thickness). The analyses were performed isothermally at 200 °C using helium (2 ml/min) as a carrier gas. Injector and detector temperatures were each maintained at 250 °C. The signal was monitored in the carbon mode at 496 nm, using oxygen as a reagent gas. DHA and EPA were identified by comparison with retention times of authentic fatty acid methyl ester standards.

Cholesterol determinations were carried out using a direct saponification method (Kovacs, Anderson, & Ackman, 1979). Unsaponifiables were extracted with hexane, and analysed by gas chromatography. The GC system and operating parameters were identical to those used for DHA and EPA analysis with the following exceptions. The column was a J&W Associates DB-17 (15 m length×0.32 i.d., 0.25 μm film thickness). The injector and detector temperatures were set at 300 °C and the oven temperature was ramped to from 235 to 275 °C at a rate of 2 °C per min.

All chemical analyses were run in duplicate. Data were subjected to one-way analysis of variance using the Systat 7.0 (SPSS) software program. Differences between treatment means were detected by the Tukey test (Zar, 1998).

3. Results and discussion

There were no significant differences in crab weight and size among the three groups. Average weight and carapace width were 124.6±23.3 g and 79.7±3.9 mm, respectively. Average carapace width was larger than the modal population size carapace width (60 mm) for green crab in the west Atlantic region reported by Jamieson et al. (1998), and was due to the harvesting method employed. In this study, traps were used that selected for larger sized animals.

Protein, ash, and moisture contents of the crab meat averaged 17.1, 2.2, and 78.7 g/100 g, respectively (Table 1). These values are similar to those for Dungeness crab (*Cancer magister*), reported as 17.8, 2.6, and 77.6 g/100 g, for protein, ash, and moisture, respectively

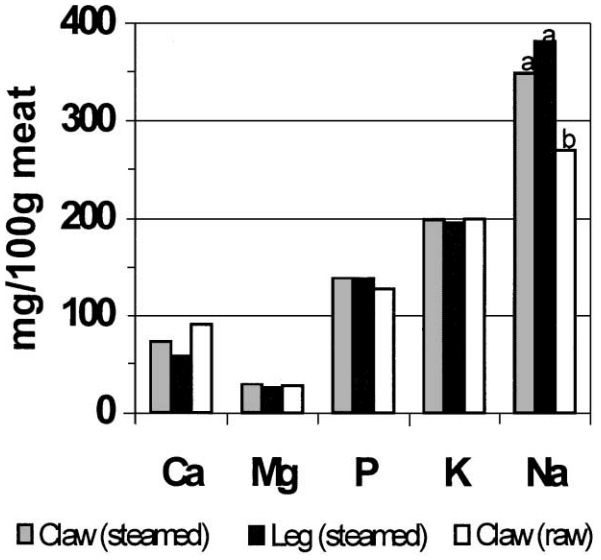

Fig. 1. Selected macromineral concentrations (mg/100 g) in green crab meats. Each value is the mean of duplicate analyses of three composite samples. Values in the same cluster not sharing a superscript are significantly different ($P<0.05$), based on one-way analyses of variance. Lack of superscript within a cluster indicates no significant difference ($P>0.05$) among treatments.

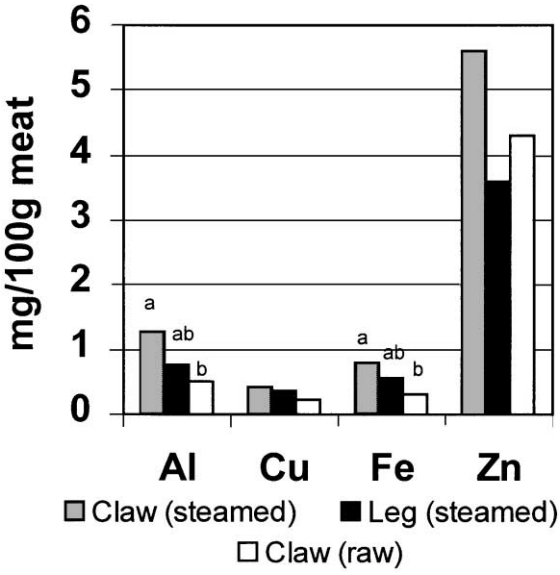

Fig. 2. Selected micromineral concentrations (mg/100 g) in green crab meats. Each value is the mean of duplicate analyses of three composite samples. Values in the same cluster not sharing a superscript are significantly different ($P<0.05$) based on one-way analyses of variance. Lack of superscript within a cluster indicates no significant difference ($P>0.05$) among treatments.

Table 2
Cholesterol and selected n-3 fatty acids in green crab meats (mg/100 g)

	Claw meat (steamed)[a]	Leg meat (steamed)	Claw meat (raw)
Cholesterol	57.2±4.9a	64.8±3.4a	57.4±3.6a
EPA (20:5n3)	198±70.6a	344±54.7b	154±20.3a
DHA (22:6n3)	158±53.2a	336±65.5b	115±14.7a

[a] Each value is the mean of duplicate analyses of three composite samples±S.D. Values in the same row not sharing a letter are significantly different ($P<0.05$), based on one-way analyses of variance.

(King et al., 1990), and are somewhat higher in protein than values reported for blue crab composite (15.6 g/100 g) and claw mince (13.9 g/100 g) samples (Lee et al., 1993). Fat content of leg meat (1.2 g/100 g) was twice the level measured in either steamed or raw claw meat. This agrees with observations by Gates and Parker (1992), who reported significantly higher fat content in leg meat than claw meat (0.12 g/100 g) of blue crab. Krzynowek et al. (1982) reported average fat contents of 1.1, 1.2, and 0.9 g/100 g for Jonah (*Cancer borealis*), Rock (*Cancer irroratus*), and Red crab (*Geryon quinquedens*) harvested in the northwest Atlantic region. However, it is not clear which portions of the crab body were evaluated.

Cholesterol concentrations in leg meat and claw meat ranged from 57.2 to 64.8 mg/100 g (Table 2). These values are lower than those reported for Dungeness crab (69–76 mg/100 g), Rock crab (70.9 mg/100 g) and Jonah crab (78.4 mg/100 g) (Ackman & McLeod, 1988; King et al., 1990), and may reflect differences between the *Cancer* and *Carcinus* genuses. Significant differences were observed in EPA and DHA contents between groups. Steamed leg meat had significantly higher concentrations of both polyunsaturated fatty acids than either the steamed or raw claw meat (Table 2). The total EPA and DHA contents averaged 0.35 g/100 g and 0.68 g/100 g, respectively, for steamed claw meat and leg meat, which corresponded to approximately 60% of the total lipid. The total EPA and DHA value for steamed claw meat is similar to data reported by Ackman and McLeod (1988) for Jonah crab (0.38 g/100 g) and Rock crab 0.42 g/100 g).

No significant differences in macromineral content were observed between claw meat and leg meat samples (Fig. 1). Calcium, magnesium, phosphorus, and potassium concentrations in the crab meat averaged 74, 28, 135, and 198 mg/100 g, respectively. Steamed claw meat and leg meat samples had significantly higher sodium concentrations than the samples of raw claw meat. All macromineral data fell within the range reported by King et al. (1990) and the USDA (1999) for Dungeness crab meat, with the exception of calcium, which was slightly higher in the green crab samples (≈74 mg/100 g).

Steamed claw meat samples had the highest concentrations of microminerals among the three groups (Fig. 2). The significantly higher aluminium and iron concentrations noted in the steamed versus raw claw meats were most likely due to contact with the steaming apparatus during cooking. Zinc and copper concentrations averaged 4.5 and 0.34 mg/100 g, similar to the ranges of 2.8–5.5 and 0.3–0.7 mg/100 g for zinc and copper, respectively, reported for Dungeness crab (King et al., 1990; USDA, 1999).

Significant differences were observed in total fat, EPA, and DHA contents of green crab leg meat and claw meat. Processing did not affect nutrient composition of the samples, with the exception of increased aluminium and iron contents observed in the steamed claw meat samples. The samples were all low in fat, and provided a good source of zinc, copper, and n-3 fatty acids. The nutrient composition values obtained were similar to those reported for other commercially harvested crab species, with the exception of cholesterol, which was lower in green crab.

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References

Ackman, R. G., & McLeod, C. (1988). Total lipids and nutritionally important fatty acids of some Nova Scotia fish and shellfish food products. *Canadian Institute of Food Science and Technology Journal*, *21*(4), 390–398.

AOAC. (1998). *Official methods of analysis* (16th ed.). Arlington, VA: Association of Official Analytical Chemists.

Broughton, K. S., Johnson, C. S., Pace, B. K., Liebman, M., & Kleppinger, K. M. (1997). Reduced asthma symptoms with n-3 fatty acid ingestion are related to 5-series leukotriene production. *American Journal of Clinical Nutrition*, *65*, 1011–1017.

Chung, H. Y. (1999). Volatile components in crabmeats of *Charybdis feriatus*. *Journal of Agricultural and Food Chemistry*, *47*, 2280–2287.

de Deckere, E. A. M., Korver, O., Verschuren, P. M., & Katan, M. B. (1998). Health aspects of fish and n-3 polyunsaturated fatty acids from plant and marine origin. *European Journal of Clinical Nutrition*, *52*, 749–753.

Folch, J., Lees, M., & Stanley, S. (1957). A simple method for the isolation and purification of total lipides from animal tissues. *Journal of Biological Chemistry*, *226*, 497–509.

Gates, K. W., & Parker, A. H. (1992). Characterization of minced meat extracted from Blue crab picking plant by-products. *Journal of Food Science*, *57*(2), 267–270, 292.

Jamieson, G. S., Grosholz, E. D., Armstrong, D. A., & Elner, R. W. (1998). Potential ecological implications from the introduction of the European green crab, *Carcinus maenas* (Linneaus), to British Columbia, Canada, and Washington, USA. *Journal of Natural History*, *32*, 1587–1598.

King, I., Childs, M. T., Dorsett, C., Ostrander, J. G., & Monsen, E. R. (1990). Shellfish: proximate composition, minerals, fatty acids, and sterols. *Journal of the American Dietetic Association*, *90*, 677–685.

Kovacs, M. I. P., Anderson, W. E., & Ackman, R. G. (1979). A simple method for the determination of cholesterol and some plant sterols in fishery-based food products. *Journal of Food Science*, *44*, 1299–1301 1305.

Krzynowek, J., Wiggin, K., & Donahue, P. (1982). Cholesterol and fatty acid content in three species of crab found in the northwest Atlantic. *Journal of Food Science*, *47*, 1025–1026.

Leaf, A., & Weber, P. C. (1988). Cardiovascular effects of n-3 fatty acids. *New England Journal of Medicine*, *318*, 549–555.

Lee, E., Meyers, S. P., & Godber, J. S. (1993). Minced meat crabcake from Blue crab processing by-products—development and sensory evaluation. *Journal of Food Science*, *58*(1), 99–103.

Mathews, L. M., McKnight, A. E., Avery, R., & Lee, K. T. (1999). Incidence of autonomy in New England populations of green crabs, *Carcinus maenas*, and an examination of the effect of claw autonomy on diet. *Journal of Crustacean Biology*, *19*, 713–719.

Morrison, W. R., & Smith, L. M. (1964). Preparation of fatty acid methyl esters and dimethyacetals from lipid with boron fluoride-methanol. *Journal of Lipid Research*, *5*, 600–608.

Shearer, K. D. (1984). Changes in elemental composition of hatchery-reared rainbow trout, *Salmo gairdneri*, associated with growth and reproduction. *Canadian Journal of Fisheries and Aquatic Sciences*, *41*, 1592–1600.

Torres, I. C., Mira, L., Ornelas, C. P., & Melim, A. (2000). Study of the effects of dietary fish intake on serum lipids and lipoproteins in two populations with different dietary habits. *British Journal of Nutrition*, *83*, 371–379.

US Department of Agriculture, Agricultural Research Service. (1999). *USDA nutrient database for standard reference*, Release 13. Nutrient Data Laboratory Home Page. Available: http://www.nal.usda.gov/fnic/foodcomp

Walton, W. C., Ruiz, G. M., & Starr, B. A. (1999). Mitigating predation by the European green crab, *Carcinus maenus*, upon publicly maricultured quahogs, *Mercenaria mercenaria*. *Journal of Shellfish Research*, *18*, 305.

Zar, J. H. (1998). *Biostatistical analysis* (4th ed.). Englewood Cliffs, NJ: Prentice Hall.