Nutrient composition of raw and cooked meat of male Southern King Crab (*Lithodes santolla* Molina, 1782)

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ABSTRACT. This study provides information about nutrient composition of adult males of Southern King Crab (*Lithodes santolla)*. Proximate composition of raw and cooked meat (g/100g meat) averaged: moisture= 80.9 and 78.6, protein= 14.6 and 16.3, fat= 0.70 and 0.76, and ash= 2.03 and 2.10, respectively. Arginine, glutamic acid, leucine and aspartic acid (20.4, 9.4, 8.0, and 7.9 g aa/100g protein, respectively) were the major amino acids. The predominant fatty acid was 18:1n-9c (21.8% and 22.1%), followed by 20:5n-3 (17.1% and 21.8%), 16:0 (15.8% and 15.3%) and 22:6n-3 (11.0% and 13.5%). Cooked meat contained more cholesterol (51.0 mg/100g meat) and phospholipids (60.1 mg/100g meat) than raw meat (37.3 and 13.9 mg/100g meat, respectively), with phosphatidylcholine representing over 80% of the total phospholipid content. The main tocopherol was α-tocopherol (raw meat= 1.30 mg/100g meat, cooked meat= 1.14 mg/100g meat). Major mineral contents of raw and cooked meat (mg/100g meat) were: Na= 509 and 594, K= 179 and 203, Ca= 114 and 197, P= 126 and 143, Mg= 34 and 41, Fe= 1.26 and 1.86, Zn= 1.88 and 2.64, respectively. Thus, the nutritional quality of the cooked meat of the Southern King Crab makes it especially adequate for cholesterol-restricted, balanced low-fat meat diets.

KEYWORDS. Southern King Crab, chemical composition, fatty acids, amino acids, minor compounds, phospholipids, minerals, cholesterol.

INTRODUCTION

The Southern King Crab (SKC), *Lithodes santolla* (Molina, 1782), belongs to the family Lithodidae of reptant decapods (Boschi et al., 1992) like the "Alaska king crab" (*Paralithodes camtschatica*). SKC, also called "big sea spider", is a common crab in coastal waters of the southeast Pacific Ocean (Southern Chile), Fueguian Archipelago, and the southwest Atlantic Ocean (Vinuesa et al., 1999).

SKC fishing in the cold sea water of San Jorge Gulf (located between 45 and 47°S, and 65°40'W, in southern Argentinian) is considered an important economic resource in Patagonia, since SKC is prized for its delicious flavour. In 2008, 768.8 tons were landed in Argentina, of which 460.91 tons (5822 US$/t) were exported mainly to the USA and Chile (Secretaría de Agricultura Ganadería Pesca y Alimentación [SAGPyA], 2008). According to local regulations, only male SKCs are allowed to be caught because females carry on the breeding ten months of the year (Vinuesa and Balzi, 2002).

Seafood products, including crustaceans, have nutritional value and they can promote human health. Crustaceans are an excellent source of minerals; they contain a large range of polyunsaturated fatty acids (PUFAs) and high quality proteins in their tissues, among other components. Many authors have investigated proximate, amino acid and fatty acid compositions in crabs from various parts of the world (Adeyeye, 2002; Barrento et al., 2010; Çelik et al., 2004; Chen et al., 2006; Cherif et al., 2008; Gökoðlu and Yerlikaya, 2003; Krzeczkowski et al., 1971; Küçükgülmez et al., 2006; Marques et al., 2010; Naczk et al., 2004; Wu et al., 2010), finding compositional variations among crab

species (Krzynowek et al., 1982; Lauer et al., 1974), seasons (Leu et al., 1981), geographical origin (Aurioles-Gamboa et al., 2004) and processing (Anthony et al., 1983). However, no information is available in the literature about nutrient composition of SKC. There are some studies on cholesterol (Barrento et al., 2010; Krishnamoorthy et al., 1979; Krzynowek et al., 1982; Marques et al., 2010, Wu et al., 2010) and carotenoid contents in crabs (Krzecskowski et al., 1971; Naczk et al., 2004; Sachindra et al., 2005), but there is no reported information on other minor components, such as tocopherols and phospholipids, and on how cooking affects lipid fraction composition.

The aim of the present work is to investigate the chemical composition of SKC caught in San Jorge Gulf, Argentina, comparing raw and cooked crab meat. The study will be focused not only on proximate composition, fatty acids and mineral contents, but also on other minor compounds of nutritional interest, such as tocopherols, cholesterol and phospholipids. The results will allow the updating of the National Food Composition Database, being also of great importance for the local fishing industry.

MATERIALS AND METHODS

Sample Preparation and Cooking

Since only the fishing of male crabs with a carapace length (CL) of more than 110 mm is permitted, two consecutive captures of thirty male SKCs were performed during spring 2005 by fisheries in the south-western Atlantic, San Jorge Gulf (45°S; 67°W), at depths from 2 to 80 m. Each crab was individually weighed, and measured for carapace length. Fifteen crabs from each capture were cooked separately in boiling water for ten minutes, while the others were kept uncooked. Claw, leg and shoulder meat were picked by

hand, and the meat composites from groups of ten crabs of each treatment (cooked and raw meat) were blended to prepare homogenate samples. These six samples were kept in polythene bags and frozen separately (-20°C) until analysis.

Proximate Composition Analyses

Moisture, ash and crude protein contents were determined using the AOAC 950.46, 938.08 and 928.08 methods (AOAC, 2000), respectively. Crude protein content was determined by Kjeldahl method with a conversion factor of 6.25 to convert total nitrogen to crude protein. Total lipids were isolated from raw and cooked meat samples according to Bligh and Dyer's procedure (Bligh and Dyer, 1959). The results were expressed in wet basis as g/100g meat.

Cholesterol

Cholesterol was determined spectrophotometrically by an enzymatic method (Saldanha et al., 2004). Briefly, 2 g samples were saponified with 4 ml of 50% KOH aqueous solution and 6 ml ethyl alcohol (96°). In order to let the samples saponify, the solutions were first maintained at 40°C with shaking until dissolution, and then kept for 10 min at 60°C. Subsequently, 5 ml of water were added and the unsaponifiable fraction was extracted with three portions of 10 ml hexane. Three ml of organic layer were dried under nitrogen stream. The residue was dissolved in 0.5 ml of isopropyl alcohol and subjected to reaction (37ºC, 10 min) after adding 3 ml of reagent composed of 4-aminafenazone, phenol, distilled water and enzymes (97 ml of distilled water, 0.5 ml of 25 mmol/l 4-aminofenazone, 0.5 ml of 55 mmol/l phenol and 2 ml of enzymes (300U/ml lipase, 3 U/ml cholesterol oxidase and 20

U/ml peroxidise)) (Wiener kit, Wiener lab. S.A.I.C., Rosario, Argentina). Ninety minutes after the reaction, cholesterol was determined colorimetrically by measuring the sample absorbance at 499 nm against reagent blank. The cholesterol standard was obtained from Sigma (Sigma Chemical Co., St. Louis, MO). The results were expressed in wet basis as mg/100 g of meat.

Fatty Acids

For fatty acid profile determination, the oil fraction was transmethylated using 10-15% BF_3/MeOH solution (Morrison and Smith, 1964). Fatty acid methyl esters (FAMEs) were analyzed by GLC. The FAMEs were separated on a SP 2560 capillary column [stabilized poly (90% bi cyanopropyl/10% cyanopropylphenyl siloxane)] (length = 100 m, i.d.= 0.25 mm, particle size = 0.2 μm film thickness; Supelco Inc., Bellefonte, PA) using hydrogen as carrier gas. The oven temperature programming was: initial temperature of 140°C, 5 min holding, increasing at 4°C/min to 240°C, and holding for 15 min. FAMEs were identified by comparison with Supelco standards (Supelco 37 Component FAME mix, Supelco Inc., Bellefonte, PA). Quantitative data were calculated using the peak area ratio (% of total fatty acids).

Phospholipids

Quantitative determination of phospholipids (PLs) was carried out by concentration of the oil sample using diol solid phase extraction (SPE) cartridges (J.T.Backer Inc., Philipsburg, NJ) (Carelli et al., 1997) and subsequent analysis by HPLC according to the AOCS official method Ja 7b-91 (AOCS, 1993). A Waters HPLC system with Waters 996

photodiode array detector set at 206 nm, a LiChrosorb Si-60 column (length = 25 cm, i.d. = 4 mm, particle size = 5 μm) (Merk, Darmstadt, Germany) and a Millenium 2010 Chromatography Manager (Millipore Corporation) were used. Standards for L-α-phosphatidilethanolamine (PE), L-α-phosphatidylinositol (PI), L-α-phosphatidylcholine (PC) from soybean, L-α-phosphatidylserine (PS), L-α-phosphatidic acid (PA) sodium salt from egg yolk lecithin with purities greater than 98% were obtained from Sigma (Sigma Chemical Co., St. Louis, MO) and used to obtain calibration curves. The phospholipid content, expressed as mg/g oil, was calculated by: PL = 1000 C_{PL} V/M, where C_{PL} represents the phospholipid concentration obtained from the calibration curve in mg/ml, V is the volume in ml of the phospholipid concentrate that constitutes the sample to be injected to the HPLC system, and M is the weight in mg of oil in the SPE cartridge.

Tocopherols

Tocopherol content was determined from the lipid fraction by HPLC using AOCS Ce 8-89 method (AOCS, 1993). A fluorescence detector and a LiChrosorb Si-60 column (length = 25 cm, i.d. = 4 mm, particle size = 5 μm from Merck, Darmstadt, Germany) were used. A standard of α-tocopherol with purity greater than 98% was obtained from Sigma (Sigma Chemical Co., St. Louis, MO) and used as external standard. Results were expressed as mg/kg oil.

Amino Acids

Amino acid analysis was performed by HPLC with pre-column derivatization by AccQ·Tag agent, followed by separation in reverse phase column and then fluorescent

detection. Briefly, 100 mg of homogenized sample was placed in 10 ml ampoules, and 2 ml 6 M HCl was added. Ampoules were vacuum-sealed, and samples were hydrolyzed at 110°C for 24 h (Blackburn, 1978). After that, the hydrolyzate was subjected to derivatization by using AccQ-Fluor (6-aminoquinolil-N-hydroxysuccinimidyl carbamate, Kit from Waters Inc., USA) at 60°C for 10 min. Amino acids were separated by HPLC with a fluorescence detector (excitation wavelength = 250 nm, emission wavelength = 395 nm) and an AccQ-Tag amino acid column Nova-Pack C18 (length = 150 mm, i.d. = 3.9 mm, particle size = 4 μm) from Waters (Waters Corporation, Milford, MA) maintained at 37ºC according to AccQ Tag methods (Waters, MA, USA). The identity and quality of the amino acids were assessed by comparison with the retention times and peak areas of the standard amino acids (Pierce NCI0180, Pierce**,** IL, USA). Tryptophan was determined spectrophotometrically prior to hydrolysis of the sample with papain (Merck, Darmstadt, Germany), extraction of the hydrolyzed protein with a mixture of diluted potassium hydroxide and carbon tetrachloride, and addition of p-dimethylaminobenzaldehyde to an aliquot of the liquid phase containing the hydrolyzed protein (Lombard and de Lange, 1965). The results were expressed as g amino acid/100g protein.

Minerals

For mineral determination, the homogenized samples were digested in $HNO_3/HClO_4$ according to the AOAC method 935.13a (AOAC, 2000). Sodium and potassium were determined by the AOAC method 969.23 (AOAC, 2000) with a flame photometer using NaCl and KCl as standards. Phosphorus was measured colorimetrically with a UV-Vis Metrolab 1700 spectrophotometer, as described by AOCS method Ca 12-55 (AOCS, 1993). Calcium was determined titrimetrically by the APHA 3500-Ca D method

(APHA AWWA WPCF, 1992). Iron, magnesium and zinc were measured by flame atomic absorption spectrophotometry with a GBC 902 atomic absorption spectrometer (GBC Scientific Equipment, Victoria, Australia), according to AOAC 968.08 method (AOAC, 2000). The results were expressed in wet basis as mg/100g meat.

Statistical Analysis

All determinations were carried out in triplicate for raw and cooked meat. In the case of fatty acid analysis, duplicate determinations were performed for each independent sample. Results were expressed as mean value ± standard deviation (SD). The differences were calculated using one-way analysis of variance (ANOVA), and statistically significant differences were reported at $p < 0.05$.

RESULTS AND DISCUSSION

Sample Characteristics

The average weight and carapace length (CL) of the captured male SKCs (n= 60) was 1008 ± 218 g and 126 ± 10 mm, respectively.

Comparing SKC with other crab species, weight and CL were greater in male SKCs than in most other species, but smaller than in the Alaska king crab, whose weight is about 4232 g (Krzeczkowski et al., 1971) and its CL is between 180 and 280 mm.

Proximate Composition

The proximate composition of both raw and cooked SKC meat is shown in Table 1. Regarding moisture and protein, there were significant differences ($P < 0.05$) between raw and cooked meat. After cooking, the moisture content decreased 2.3 g/100 g meat, whereas the protein content increased 1.7 g/100 g meat. In contrast, the fat level was very low (raw: 0.70, cooked: 0.76 g/100 g meat) and statistically similar in both samples.

While the protein, ash and moisture contents of raw and cooked SKC meat presented significant differences, Skonberg and Perkins (2002) reported no significant differences between claw raw, claw steamed and leg steamed meat of green crab (*Carcinus maenus*). Protein, ash and moisture contents of green crab averaged 17.1, 2.2 and 78.7 g/100 g meat, respectively, whereas the fat content of leg meat (1.2 g/100g) was twice the level measured in either steamed or raw claw meat (Skonberg and Perkins, 2002).

When proximate analyses of SKC were compared to those of Alaska king crab (AKC) (US Department of Agriculture Research Service [USDA], 2008), AKC showed higher values of protein (raw: 18.29 g/100 g, cooked: 19.35 g/100 g), appreciable differences in fat content (raw: 0.60 g/100 g, cooked: 1.54 g/100 g), and lower values of moisture (raw: 79.57 g/100 g; cooked: 77.55 g/100 g) and ash content (raw: 1.80 g/100 g, cooked: 1.85 g/100 g).

Cholesterol

The cholesterol content was 37.3 ± 0.1 mg/100 g raw meat and 51.0 ± 0.9 mg/100 g cooked meat. Significant differences in cholesterol levels between raw and cooked meat were found that are not explained by the different moisture content of the treatments. These differences in cholesterol levels may be due to alterations occurring in protein-cholesterol

complexes of tissues after heating. Heating may affect the denaturation of proteins, thereby altering these complexes (Krishnamoorthy et al., 1979), but heating did not affect the total protein values, as it can be observed when they are expressed in dry basis (raw: 76.5 mg/100 g dry meat, cooked: 76.4 mg/100 g dry meat).

Regarding cholesterol level, it was similar to that of the muscle of the Atlantic spider crab (*Maja brachydactyla*, 37.1 mg/100g meat) (Marques et al., 2010) and brown crab (*Cancer pagurus*, 37.0-40.7 mg/100 g meat) (Barrento et al., 2010), but lower than the value in cooked meat of deep-sea red crab (*Geryon quiquedens,* 78.4 mg/100 g meat), rock crab (*Cancer irroratus,* 70.9 mg/100 g meat*)*, Jonah crab (*Cancer borealis*, 78.4 mg/100 g meat) (Krzynowek et al., 1982), green crab (*Carcinus maenus*, steamed claw meat: 57.2 mg/100g meat, raw claw meat: 57.4 mg/100 g meat, steamed leg meat: 64.8 mg/100 g meat) (Skonberg and Perkins, 2002), blue swimmer crab (*Portunus pelagicus*, raw: 79 mg/100 g meat) (Wu et al., 2010) and blue crab (*Callinectes sapidus*, raw: 49 mg/100 g meat) (Krishnamoorthy et al., 1979).

Fatty Acids

Table 2 shows the relative percentages of fatty acids in raw and cooked crab meat. Statistically significant differences were found for most of the fatty acids between raw and cooked SKC meat, except for palmitic (16:0), palmitoleic (16:1) and linoleic (18:2n-6c) fatty acids. The most abundant fatty acid was oleic acid (18:1n9c) (raw: 21.8% and cooked: 22.1%, that represent 153 mg/100 g raw meat and 168 mg/100 g cooked meat), followed by eicosapentaenoic acid (20:5n-3, EPA) (raw: 17.1% and cooked: 21.8%, that represent 120 mg/100 g raw meat and 166 mg/100 g cooked meat), palmitic acid (16:0) (raw: 15.8% and cooked: 15.3%, that represent 111 mg/100 g raw meat and 117 mg/100 g cooked meat), and

docosahexaenoic acid (22:6n-3, DHA) (raw: 11.0% and cooked: 13.5%, that represent 77.4 mg/100 g raw meat and 103 mg/100 g cooked meat).

The fatty acid profile of SKC lipids was dominated by polyunsaturated fatty acids (PUFAs) (raw: 38.8%, cooked: 45.7%). PUFAs are beneficial for human health, since their intake would lower the risk of developing cardiovascular diseases. Among PUFAs, the essential fatty acids 20:5n-3 (EPA) and 22:6n-3 (DHA) were the most abundant, followed by another essential fatty acid, C20:4n-6 (ARA). EPA+DHA content represented 28.1 and 35.3% of fatty acids in raw and cooked SKC meat, respectively. These values were lower than those reported for steamed green crab (60%) (Skonberg and Perkins, 2002), higher than those reported for cooked blue crab (16.52%) (Çelik et al., 2004), and similar to those for cooked Alaska King Crab (30-48%) (Krzeczkowski et al., 1971; USDA, 2008), Atlantic spider crab muscle (34.6%) (Marques et al., 2010), blue swimmer crab (27.8%) (Wu et al., 2010) and raw brown crab muscle (32.8%) (Barrento et al., 2010). The Food and Agriculture Organization of the United Nations and the World Health Organization (FAO/WHO) have recommended a dietary n-3 PUFA to n-6 PUFA ratio of at least 0.1-0.2, considering higher ratios more beneficial to human health (FAO/WHO, 1994). The n-3 to n-6 ratio (raw: 3.26%, cooked: 3.60%) for SKC was similar to both that for blue crab breast meat (3.18%) (Çelik et al., 2004) and for brown crab muscle (3.76%) (Barrento et al., 2010). Dyerberg (1986) noted that an increase in ratio of n-3/n-6 PUFAs increases the availability of n-3 PUFAs, which are beneficial for human health.

In Table 2 it can be also observed that the PUFA content in cooked meat (45.7%) was higher than in raw meat (38.8%) due mainly to the higher amounts of ARA, EPA and DHA in the cooked sample. These differences in the fatty acid composition between raw and cooked SKC meat cannot be explained by the different amount of moisture between

samples, since the total fat contents were similar (Table 1), although the fatty acid profiles were different. These differences may be attributed to the higher extractability of phospholipids together with the oil when the meat was cooked. PUFAs are mainly located in sn-2 position of glyceric compounds. Thus, the composition of phospholipid fatty acids generally differs from that of triacylglicerol fatty acids. In studies performed for a number of marine species, EPA and DHA were preferentially esterified at sn-2 position in the phospholipid molecule (Padley et al., 1994). The higher amount of phospholipids determined in cooked meat (shown in the following section) accounts for the relative increase of PUFAs in cooked SKC.

Phospholipids

Table 3 shows the phospholipids profile and contents in raw and cooked meat. Phosphatidylcholine (PC) represented 80% of the phospholipid fraction in raw and cooked meat, being also present phosphatidylethanolamine (PE), phosphatidylinositol (PI), phosphatidylserine (PS) and phosphatidic acids (PA). Phospholipids in SKC had a higher percentage of PC but a lower percentage of PE and PS than those reported in marine crabs (*Cyclograpsus punctatus*, PC: 57%, PS: 5%, and PE: 22%) (de Koning, 1970). In addition, significant differences in the total phospholipid content of SKC were found between raw and cooked meat, indicating a higher extractability of phospholipids when the crab was cooked. Phospholipids, like cholesterol, are constituents of the cell membranes, which consist in a phospholipid bilayer interweaved with cholesterol and proteins. Therefore, it is possible that in a similar way to cholesterol, the denaturation of proteins could explain this fact.

Tocopherol

Table 3 also presents tocopherol contents in raw and cooked meat. The oil fraction presented a high total tocopherol content (raw= 1883 mg/kg oil, cooked= 1494 mg/kg oil), which was constituted by α-tocopherol (raw: 96.4%, cooked: 98.9%) and γ-tocopherol. Tocopherols have demonstrated antioxidant properties; they can scavenge oxygen radicals and stop free-radical chain reactions during oxidative processes. α-Tocopherol, which is known as Vitamin E, is the most effective isomer *in vivo*; however, γ-tocopherol is a stronger antioxidant *in vitro* (Madhavi et al., 1996). After cooking, total amount of tocopherols decreased, suggesting that tocopherols had probably taken part in oxidative reactions protecting the oil from oxidative deterioration. Tocopherol values in SKC represented 7.4-8.4% of the dietary tocopherol intake (Dietary References Intakes, 2000).

Amino Acids

With respect to amino acid analysis, variation coefficients were lower than 11%, and no significant differences were found between the amino acid composition of raw and cooked meat expressed as g/100g protein. The SKC protein contained high amounts (g/100 g protein) of arginine (20.4), followed by glutamic acid (9.42), leucine (8.01), aspartic acid (7.90), glycine (6.05), phenylalanine (5.60), lysine (5.20), serine (4.85), alanine (4.69), tyrosine (4.22), proline (4.20), valine (4.18), isoleucine (3.60), histidine (3.36), methionine (3.04), threonine (2.81), cysteine (1.41) and tryptophan (1.06), in decreasing order.

Table 4 shows the essential amino acid score of SKC calculated with respect to the reference amino acid pattern for children (3-10 years) (World Health Organization/Food and Agriculture Organization of the United Nations/United Nations University

(WHO/FAO/UNU), 2002). All the amino acid scores were over 100, indicating that the proteins from SKC were well-balanced in the essential amino acid compositions.

In addition, no changes in amino acid composition were detected between raw and cooked SKC meat. Comparing SKC with AKC, both species have high quality proteins since the essential amino acid scores were over 100.

Minerals

The mineral levels of crab meat are shown in Table 5. Sodium was the predominant element among the analyzed minerals. Significant differences in macro mineral (sodium, potassium, calcium and phosphorus) and micro mineral contents (magnesium, iron and zinc) were observed between raw and cooked meat, being appreciable the higher amounts of Ca in cooked meat with respect to raw meat.

The level of macro and micro minerals in the intake of SKC represented 14-24% of the recommended daily dietary allowances for adults (Dietary References Intakes, 1997; Dietary References Intakes, 2001). In contrast to the mineral contents of AKC (Na: 836 and 1,072; K: 204 and 262; P: 219 and 280; Ca: 46 and 59; Mg: 49 and 63; Fe: 0.59 and 0.76; and Zn: 5.95 and 7.62, expressed in mg/100 g meat for raw and cooked meat, respectively; USDA, 2008), SKC contained lower amounts of macro and micro minerals, but it had considerable higher amounts of Ca.

CONCLUSIONS

This study showed that cooked meat of SKC from the San Jorge Gulf in Argentina has high protein content with well-balanced essential amino acid composition. In contrast, it has low fat and cholesterol contents. The fatty acid fraction is of high quality due to its high content of n-3 polyunsaturated fatty acid rich in EPA and DHA, of proven beneficial effect on human health. Cooking did not affect the amino acids composition. SKC is also a good source of minerals, tocopherols and phospholipids. Finally, the data obtained in this study are important for the fishing industry in the south Atlantic coasts, by improving the current knowledge about the nutrient composition of the southern king crab.

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TABLE 1. Proximate composition (g/100g meat) in raw and cooked meat of southern king crab.

Lithodes santolla	Moisture (g/100 g)	Protein (g/100g)	Fat (g/100g)	Ash (g/100g)
Raw meat	80.9 ± 0.6^{a}	14.6 ± 0.3^{a}	0.70 ± 0.03^{a}	2.03 ± 0.01^{a}
Cooked meat	78.6 ± 0.1^{b}	16.3 ± 0.3^{b}	0.76 ± 0.04^{a}	2.10 ± 0.06^{a}

Data are mean values $\pm$ standard errors, n=3.

Within the same column, values with different letters are significantly different ($p < 0.05$).

TABLE 2. Fatty acid composition (%) of raw and cooked southern king crab meat.

Fatty Acid	Raw meat (%)	Cooked meat (%)
Saturated Fatty Acids (SFA)		
14:0	0.47 ± 0.02[a]	0.37 ± 0.04[b]
15:0	0.49 ± 0.04[a]	0.38 ± 0.04[b]
16:0	15.8 ± 0.97[a]	15.3 ± 0.54[a]
17:0	0.84 ± 0.07[a]	1.10 ± 0.10[b]
18:0	5.77 ± 0.29[a]	4.77 ± 0.30[b]
20:0	0.10 ± 0.01	nd
22:0	0.17 ± 0.02	nd
24:0	0.08 ± 0.01	nd
Monounsaturated Fatty Acid (MUFA)		
16:1	4.52 ± 0.32[a]	4.08 ± 0.34[a]
17:1	1.66 ± 0.18	nd
18:1n-9t	0.82 ± 0.05[a]	0.42 ± 0.04[b]

18:1n-9c	21.8 ± 0.33[a]	22.1 ± 0.78[b]
20:1n-9	0.35 ± 0.03[a]	0.24 ± 0.02[b]
Polyunsaturated Fatty Acid (PUFA)		
18:2n-6c	1.36 ± 0.03[a]	1.25 ± 0.11[a]
18:2n-6t	2.22 ± 0.06	nd
18:3n-6	0.12 ± 0.01[a]	0.10 ± 0.01[b]
18:3n-3	1.42 ± 0.10[a]	0.44 ± 0.04[b]
20:2n-6	0.45 ± 0.05[a]	0.39 ± 0.04[a]
20:3n-6	0.09 ± 0.01	nd
20:3n-3	0.13 ± 0.01	nd
20:4n-6	4.74 ± 0.19[a]	8.14 ± 0.09[b]
22:2n-6	0.15 ± 0.01[a]	0.11 ± 0.01[b]
20:5n-3	17.1 ± 0.9[a]	21.8 ± 0.5[b]
22:6n-3	11.0 ± 0.7[a]	13.5 ± 0.5[b]
Σ SFA	23.7	21.9
Σ MUFA	29.1	26.8
Σ PUFA	38.8	45.7

Σ MUFA+ Σ PUFA	70.0	72.5
Unknown	8.41	5.60
Σ n-3	29.7	36.0
Σ n-6	9.13	9.99
Σ n-3/ Σ n-6	3.26	3.60

Mean values of duplicate analyses of three independent samples are accompanied by their standard deviation.

Values with different letters in the same row are significantly different ($p < 0.05$), nd: not detected.

TABLE 3. Phospholipid and tocopherol contents in raw and cooked southern king crab meat.

Compound	Raw meat	Cooked meat
Phospholipids		
PE (%)	8.69	13.84
PA (%)	6.54	nd
PI (%)	2.59	4.54
PS (%)	2.09	0.93
PC (%)	80.09	80.69
Total (mg/g oil)	19.8 ± 1.23^{a}	79.0 ± 4.22^{b}
Total (mg/100 g meat)	13.91 ± 0.93^{a}	60.08 ± 3.21^{b}
Tocopherols		
α (%)	96.42	98.06
γ (%)	3.58	1.94
Total (mg/kg oil)	1883 ± 66^{a}	1494 ± 64^{b}
Total (mg/100 g meat)	1.30 ± 0.05^{a}	1.14 ± 0.05^{b}

Data are mean values ± standard errors, n=3.

Within the same row, values with different letters are significantly different ($p < 0.05$).

PE: phosphatidylethanolamine, PA: phosphatidic acid, PI: phosphatidylinositol, PS: phosphatidylserine, PC: phosphatidylcholine, nd: not detected.

TABLE 4. Reference amino acid pattern for children (3-10 years) and amino acids score of southern king crab meat and Alaska king crab meat.

Amino acid	Reference[a]	Southern King Crab		Alaska King Crab[b]	
		Content	Score[c]	Content	Score[c]
	(mg/g protein)	(mg/g protein)		(mg/g protein)	
Histidine	16	33.6	210	20.3	127
Isoleucine	31	36.0	116	48.5	156
Leucine	61	80.1	131	79.4	130
Lysine	48	52.0	108	87.0	181
Cysteine + Methionine	24	44.5	185	39.4	164
Phenylalanine + Tyrosine	41	98.2	239	75.5	184
Threonine	25	28.1	112	40.5	162
Tryptophan	6.6	10.6	161	13.9	211
Valine	40	41.8	105	47.1	118

[a] Reference amino acid pattern for children (3-10 years) (/WHO/FAO/UNU, 2002).

[b] USDA, 2008.

[c] Score= (sample amino acid/ reference amino acid)* 100.

TABLE 5. Minerals composition of southern king crab (mg/100 g meat).

Meat status	Na	K	Ca	P	Mg	Fe	Zn
Raw	509 ± 3[a]	179 ± 2[a]	114 ± 3[a]	126 ± 0.45[a]	34.3 ± 0.5[a]	1.26 ± 0.74[a]	1.88 ± 1.42[a]
Cooked	594 ± 6[b]	203 ± 4[b]	197 ± 1[b]	143 ± 0.21[b]	41.3 ± 1.0[b]	1.86 ± 0.30[b]	2.64 ± 0.85[b]

Data are mean values ± standard errors, n=3.

Within the same column, values with different letters are significantly different ($p < 0.05$).