Centesimal composition, fatty acids profile and the nutritional quality index of four seafood species from the southern region of Brazil

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ABSTRACT. The objective of this study was to evaluate the centesimal composition, fatty acid profile and the nutritional quality index of four seafood species: pink shrimp (Penaeus brasiliensis), Pacific white shrimp (Litopenaeus vannamei), mussel (Perna perna) and octopus (Octopus vulgaris), that were collected in Santa Catarina, Brazil. The nutritional quality of the lipid fraction was evaluated by the index of thrombogenicity (IT), index of atherogenicity (IA) and the hypocholesterolaemic fatty acids-to-hypercholesterolaemic fatty acids ratio (h/H). All the studied species presented a high protein content (12.88–21.61%) and a low amount of total lipid (0.26–4.07%). The pink shrimp had the most protein and octopus contained the least total lipid. Eicosapentaenoic acid and docosahexaenoic acid were detected in all samples, presenting the highest values in mussel (204.62 and 123.57 mg 100 g−1, respectively). The analysed species presented low IT and IA values and an h/H ratio around 2 or higher, and therefore, they are considered potentially healthy foods. Moreover, the shrimp species can be classified as a source of omega-3s, while the mussels can be categorised as having a high content in these polyunsaturated fatty acids.

Keywords: polyunsaturated fatty acids; omega-3; omega-6; eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

Introduction

In 2013, Brazil's fishery production increased by 66% over the year 2012, from 1.5 Mt to 2.5 Mt. However, the Food and Agriculture Organisation of the United Nations (Food and Agriculture Organisation [FAO], 2004) still regards Brazil as a small global producer, considering the country’s hydrological potential and diversity, with more than 8000 km of coastline.

According to Me’dale, Lefèvre, and Corrèze (2003), fish, shrimp and molluscs occupy an important place in human nutrition. Particularly, these marine foods are a valuable source of high quality protein, minerals, vitamin D, polyunsaturated fatty acids (PUFAs) and essential fatty acids, particularly, omega-3s (n3s), such as α-linolenic acid (18:3n3), eicosapentaenoic acid (EPA, 20:5n3) and docosahexaenoic acid (DHA, 22:6n3). The well-documented health benefits of omega-3s include a reduction of risk factors associated with cardiovascular diseases, hypertension, general...
inflammation, depression, asthma, psoriasis and others (Simopoulos, 2008; Calder & Yagoob, 2009; Hoffmire, Block, Thevenet-Morrison, & Wijngaarden, 2012; Mohamad, Baharuldin, Moklas, Fakurazi, & Muhammad, 2014).

The nutritional quality of lipids can be verified through the omega-6-to-omega-3 (n6/n3) fatty acids ratio and the polyunsaturated-to-saturated fatty acids ratio (PUFAs/SFAs) (Souza, Bentes, Simões, & Fontenelle, 2008). However, Santos-Silva, Bessa, and Santos-Silva (2002) recommend evaluating the nutritional quality of the fatty acid profile based on the functional effects of the fatty acids, such as the hypocholesterolaemic-to-hypercholesterolaemic ratio (h/H), index of atherogenicity (IA) and index of thrombogenicity (IT).

The h/H ratio considers the functional activity of fatty acids in the metabolism of lipoproteins that transport plasma cholesterol, whose type and quantity is related to the higher or lower risk of cardiovascular disease incidence (Santos-Silva et al., 2002).

The IT considers myristic (14:0), palmitic (16:0) and stearic (18:0) as thrombogenic, and PUFAs (omega-6 and omega-3) and monounsaturated fatty acids (MUFAs) as antithrombogenic, with n3 fatty acids providing the greatest effect (Ulbrich & Southgate, 1991). The IA relates pro- and antiatherogenic acids. IT and IA indicate the potential for stimulating platelet aggregation, i.e., the lower the IT and IA values, the greater the antiatherogenic fatty acid content in a given oil/fat and, consequently, the greater the potential of preventing coronary diseases (Turan, Sönmez, & Kaya, 2007).

This study aimed to evaluate the centesimal composition, fatty acid profile and lipid nutritional quality indices of mussel, octopus and two shrimp species collected in Santa Catarina (Brazil).

Material and methods

Sampling

About 3 kg of each of the following species were randomly collected in the city of Itajaí, Santa Catarina State, Brazil: pink shrimp (Penaeus brasiliensis), Pacific white shrimp (Litopenaeus vannamei), octopus (Octopus vulgaris) and brown mussel (Perna perna). The species were sanitised, homogenised in a processor and frozen at -18.0°C, until analysis.

Centesimal composition

The centesimal composition was determined according to the official methods of the Association of Official Analytical Chemists (AOAC, 2016). The moisture content was evaluated by oven drying at 105°C for 4h, and the ash content by incineration in a muffle at 550°C, until constant weight. The protein content was determined by the semi-micro Kjeldahl method, and the total lipid content was performed according to the method described by Bligh and Dyer (1959).

Esterification and transesterification of total lipids

The total fatty acids were methylated as described by Hartman and Lago (1973). Approximately 0.050 g of total lipids were added to a esterification tube, then 500 µL of a standard solution of 1,000 mg mL⁻¹ methyl tricosanoate (23:0) was added as an internal standard in isooctane. The solvent was removed with a flow of gaseous N₂. Next, 4.00 mL of 0.5 mol L⁻¹ methanolic sodium hydroxide was added to the tube, heated at 100°C for 5 min. and, then, cooled to room temperature. Next, 5.0 mL of an esterifying reagent solution (ammonium chloride and sulfuric acid solution in methanol) was added to the tube, which was heated at 100°C for an additional 5 min. After cooling, 5.0 mL of a saturated sodium chloride solution was added with stirring for 30 s. Finally, 2.0 mL of isooctane was added and the mixture stirred for 30 s. The esterified sample was refrigerated until separation of the phases. The supernatant was collected and transferred to a vial for further chromatographic analysis.

Chromatographic conditions

Fatty acid methyl esters (FAME) were separated on a Thermo Trace Ultra gas chromatograph, equipped with a flame ionisation detector and a fused silica 7420 capillary column CP-Select for FAME (100 m × 0.25 mm i.d., 0.25 µm cyanopropyl). The gas flow rates were 1.2 mL min⁻¹ for the carrier gas (H₂), 30 mL min⁻¹ for the auxiliary gas (N₂) and 35 and 350 mL min⁻¹ for H₂ and synthetic air, respectively, to the detector flame. The volume injected was 2.0 µL, using a split of 1:80. The injector and detector temperatures were 240°C. The column temperature was held at 165°C for 7 min., then increased to 185 at 4°C min⁻¹ and held for 3 min. and, finally, heated to 235 at 6°C min⁻¹ and held for 1.67 min., totalling 25 min. of analysis. Retention times and peak areas of the FAME were determined using the ChromQuest™ 5.0 software. Fatty acids were identified by comparing their retention times with Sigma 189-19 standard PUFA mix (USA) of known composition. The absolute quantification of FAME was performed through internal standardisation, and the calculations were done as described by Joseph and Ackman (1992).
Theoretical correction factors were used to determine the concentration values (Visentainer, 2012). The concentration of fatty acids in the samples was calculated in mg 100 g⁻¹ sample, using Equation 1.

\[
Mx = \frac{Ax \times Mp \times Fct \times LT}{Ap \times Ma \times Fcea}
\]  

where: \(Mx\) is the mass of the fatty acid X(mg 100 g⁻¹ of sample), \(Ax\) is the peak area of the fatty acid X, \(Ap\) is the peak area of the internal standard (23:0), \(Mp\) is the mass of the internal standard added to the sample (mg), \(Ma\) is the mass of the sample (g), \(Fct\) is the theoretical correction factor of the flame ionisation detector, \(Fcea\) is the conversion factor of methyl ester to fatty acid, and \(LT\) is the total lipid in the sample.

### Nutritional quality indices of lipids

The IA was calculated by the following Equation 2 (Ulbricht & Southgate, 1991):

\[
IA = \frac{(4 \times 14:0) + 16:0}{MUFAs + n6 + n3}
\]  

The IT was calculated, as shown in Equation 3 (Ulbricht & Southgate, 1991).

\[
IT = \frac{(14:0 + 16:0 + 18:0)}{[(0.5 \times MUFAs) + (0.5 \times n6) + (3 \times n3)+ (\frac{23}{2})]}
\]  

The h/H ratio was determined by the following Equation 4 (Santos-Silva et al., 2002):

\[
18:1n9 + 18:2n6 + 18:3n3 + 20:5n3 + 22:6n3 + 22:5n3

hH = \frac{14:0 + 16:0}{14:0 + 16:0}
\]  

### Statistical analysis

The data were evaluated according to descriptive statistics methods, calculating the mean values and standard deviation for all variables. All analyses were performed in triplicate. The data were submitted to unidirectional analysis of variance (ANOVA), and the means were compared by Tukey’s test. The level of significance was 5% (p < 0.05). Data were processed using the Statistica software, version 10.0.

### Results and discussion

#### Centesimal composition

As shown in Table 1, the centesimal composition differed between the species (Table 1). In general, moisture was the major component, followed by crude protein.

<table>
<thead>
<tr>
<th>%</th>
<th>Pink shrimp</th>
<th>Pacific shrimp</th>
<th>Octopus</th>
<th>Mussel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>74.67±0.08</td>
<td>78.96±3.36</td>
<td>85.63±2.28</td>
<td>74.74±0.49</td>
</tr>
<tr>
<td>Protein</td>
<td>21.64±0.24</td>
<td>18.40±0.45</td>
<td>12.88±0.57</td>
<td>18.42±0.46</td>
</tr>
<tr>
<td>Total Lipid</td>
<td>0.65±0.02</td>
<td>0.71±0.03</td>
<td>0.26±0.01</td>
<td>4.07±0.12</td>
</tr>
<tr>
<td>Ash</td>
<td>2.01±0.03</td>
<td>1.20±0.06</td>
<td>0.80±0.01</td>
<td>1.52±0.13</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>1.07±0.35</td>
<td>0.74±0.08</td>
<td>0.42±0.41</td>
<td>1.24±0.33</td>
</tr>
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</table>

Data represent the mean ± standard deviation of the samples (analysed in triplicate). Different letters on the same line indicate significantly different values (p < 0.05).

The Pink shrimp presented the highest protein content of all studied species. The pacific white shrimp and mussel also presented protein content higher than 18%. Seafood is a source of proteins of high biological value (Germano & Germano, 2008), has all the essential amino acids and has high content of lysine, an amino acid initiator of the digestive process. The digestibility is high, above 95%, due to the minimal amount of connective tissue (Oetterer, Regitano-D’arce, & Spoto, 2006). Regarding the total lipids content, mussel showed the highest value (4.07%), being categorised as semi-fat according to Ackman (1989) (4-8% of fat). The other species can be considered as lean, since they showed total lipids content lesser than 2% (Ackman, 1989). The consumption of these seafood species in a regular diet, especially when replacing others animal protein sources, shows advantages given the lower relative content of lipids, allowing them to be used in diets with restriction of lipids and cholesterol (Rosa, Pereira, & Nunes, 2004).

According to Table 1, the total lipids of the *Penaeus brasilensis* and *Litopenaeus vannamei* shrimps were 0.65 and 0.71%, respectively. These values are close to those found by other researchers, such as Bragagnolo and Rodriguez-Amaya (1997), who reported 0.8–1.1% of total lipid in pink shrimp (*P. brasilensis* in natura). Similarly, Moura and Tenuta-Filho (2002) found 1.0–1.4% total lipids in native Brazilian shrimp. The moisture contents for *L. vannamei* (78.96%) and *P. brasilensis* (74.67%) are comparable to those verified by Sriket et al. (2007), of 78%. The *P. brasilensis* and *L. vannamei* presented significantly different protein contents (p < 0.05), however, the values were consistent with that found in *L. vannamei* by Sriket et al. (2007), of 18.8%.

The moisture (74.74%) and ash (1.52%) contents detected in *P. perna* mussel species were lower than those found by Furlan, Galvão, Salan, and Oetterer (2007) and Cordeiro, Lopes,
Oetterer, Porto, and Galvão (2007), of 83.8 and 85% for moisture and 1.8 and 3.8% for ash, respectively. Conversely, the crude protein (18.42%) and total lipids (4.07%) were higher than those verified by these same previous studies, which reported a corresponding 9.1 and 7.2% for protein and 1.1 and 1.1% for lipids, respectively. Such difference may be associated with removal of the shell, a common pre-baking process, or opening of the shells by cutting the adductor muscle. Both procedures decrease the moisture content and increase the crude protein and total lipid values.

The *O. vulgaris* showed different values of centesimal than those reported by Vaz-Pires, Seixas, and Barbosa (2004) and Mendes, Silva, Anacleto, and Cardoso (2011). Vaz-Pires et al. (2004), when working with octopus stored on ice, found moisture contents (79.80%), crude protein (16.30%), ash (1.86%) and total lipids (0.56%) lower than those found in the current study. Conversely, Mendes et al. (2011), analysing the samples under the same conditions, found results higher than those reported in Table 1.

**Table 2. Fatty acids composition of pink shrimp, Pacific white shrimp, octopus and mussel expressed as a percentage and as mg 100 g⁻¹.**

<table>
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<td>Table 2 shows the fatty acids profile of the studied species. The results are expressed in percentage of the relative area for the comparison to other authors and as mg of fatty acids per 100 g of sample, to inform about the nutritional properties of the four types of seafood evaluated. Studies suggest that diets rich in saturated fatty acids are not healthy, the recommendation of fat consumption for the maintenance of good health is the reduction in the consumption of saturated fatty acids and consumption of mono and polyunsaturated fatty acids (Costa &amp; Borém, 2003). Typically, fish species have a low content of saturated fatty acids in comparison to unsaturated fatty acids (Simopoulos, 1997). Similar results were observed in the fatty acids profile of the four species studied (Table 2). The saturated fatty acids (SFA) content ranged from 21.16–36.98%, whereas monounsaturated fatty acids (MUFA) varied between 21.90 and 22.92% and polyunsaturated fatty acids (PUFA) ranged from 23.26 – 44.02%.</td>
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AA: arachidonic acid; DHA: docosahexaenoic acid; EPA: eicosapentaenoic acid; MUFA: monounsaturated fatty acids; n3: omega-3; n6: omega-6; PUFA: polyunsaturated fatty acids. n5: saturated fatty acids. Data represent the mean ± standard deviation of the samples (analysed in triplicate). Values (%) in the same row, followed by the same letters, do not differ from each other (p > 0.05). Values (mg 100 g⁻¹) on the same line, followed by the same Greek letters, do not differ from each other (p < 0.05).
The lower content of SFA compared to unsaturated fatty (MUFA + PUFA) acids is beneficial, since the SFAs are directly related to increase in coronary disease as reported by Hu et al. (1999), and the high intake of myristic (14:0), palmitic (16:0), and lauric acid (12:0), increase cholesterol synthesis and support the retainment of low density lipoproteins - LDL (Mensink, Zock, Kester, & Katan 2003).

Heptadecenoic acid (17:1n9) was the main MUFA among three of the four species studied, presenting a variation between 21.90 and 22.92%. In general, high concentrations of MUFA are important because they have antithrombogenic and antiatherogenic functions, helping to prevent cardiovascular diseases (Ulbrich & Southgate, 1991). The oleic acid (18:1n-9) was the most plentiful MUFA in Pink Shrimp and the second in the other species. This fatty acid is used as primary source of metabolizable energy during fast growing (Lira et al., 2005).

The most abundant PUFA were mainly of the n3 type. Marine animals accumulate these compounds, mainly EPA and DHA, through the trophic chain, with algae and phytoplankton being the primary producers (Nunes, Bandarra, & Batista, 2003; Turan et al., 2007). In relation to the percentage, EPA was the most abundant omega-3s in Pink Shrimp, Pacific white shrimp and mussel followed by DHA, while octopus had a higher DHA content than EPA. Normally, the DHA composition is related to the predatory activity (crustaceans, molluscs and larvae for example), indicating that the octopus has a predominantly carnivorous feeding, and the EPA composition is related more to the consumption of plankton (Bandarra, Batista, Nunes, & Empis, 2001). Literature studies show that omega-3 fatty acids are capable of improve cardiac hemodynamic factors, such as blood pressure, left ventricular diastolic filling, heart rate and endothelial function (Adkins & Kelley, 2010).

The ANVISA Resolution n° 54 of 12 November 2012 regulates the supplementary nutritional information on food labels. This law indicates that to be considered as a source of omega-3, the food must contain at least 40 mg of EPA + DHA in 100 g. Furthermore, to be considered high in omega-3, the food must contain at least 80 mg of EPA + DHA in 100 g. Thus, through this study, it was verified that Pink Shrimp and Pacific White Shrimp, can be considered sources of omega-3 (78.25 and 45.72 mg 100 g⁻¹, respectively), whereas the mussel can be regarded as a food with high omega-3 content (328.19 mg 100 g⁻¹).

The arachidonic acid (AA, 20:4n-6) was prevalent in the n-6 family in all studied species. The mussel showed the highest concentration (30.85 mg 100 g⁻¹), followed by pink shrimp (15.41 mg 100 g⁻¹). This fatty acid is derived from the desaturation/elongation of linoleic acid (18:2n-6) and is the major component of membrane lipids (phospholipids), acting as an eicosanoid precursor (Wang et al., 2006).

SFAs (31.31%) and PUFA (31.05%) found in O. vulgaris were similar to those presented by Vasconcelos and Zapata (2010), ranging from 25.13-30.76 and 23-31.43%, respectively. However, the level of MUFAs (37.64%) was higher than that reported by the same authors (7.50–14.99%). In the current study, O. vulgaris presented a significant amount (7.42%) of AA (20:4n6). Likewise, Miliou, Fintikaki, Tzitzinakis, Triantaphyllos, and Verriopoulos (2006) and Navarro and Villaneuva (2003) found octopus containing 2.4–9.6 and 2.8–5.6% AA, respectively.

The results obtained for P. perna mussel, indicated a predominance of palmitic (16:0; 23.21%), heptadecenoic (17:1n9; 21.90%), EPA (20:5n3; 9.32%), palmitoleic (16:1n7; 9.15%) and DHA (22:6n3; 5.63%) fatty acids. The high n3 values are favorable, considering that these fatty acids are important in the prevention of cardiovascular diseases. Moreover, according to the Agência Nacional de Vigilância Sanitária (ANVISA, 2012), the values of EPA + DHA obtained (328.19 mg 100 g⁻¹) indicate that this species has a high omega-3 content (> 80 mg 100 g⁻¹). Lira et al. (2004) studied various mollusc species from the Northeast coast of Maceió in Alagoas, Brazil. These authors reported that the predominant fatty acids in Mytella falkata mussel and stout razor clam (Tagelus plebeius) were palmitic (16:0), palmitoleic (16:1n7), oleic (18:1n9), DHA (22:6n3) and EPA (20:5n3). The values are similar to those found in this study for P. perna mussel.

Evaluating the results of table 2, in both shrimp species, the predominant SFA was the palmitic, followed by stearic. The high percentages of palmitic acid (16:0; 14.9%) found in this study were also observed by Bragagnolo and Rodriguez-Amaya (1997) in pink shrimp and Pacific white shrimp.

PUFA values were 44.02% for pink shrimp and 22.39% for Pacific white shrimp. Moura et al. (2002) observed 41% PUFA in refrigerated commercial samples of pink shrimp (P. brasiliensis and P. paulensis), while Bragagnolo and Rodriguez-Amaya (1997) reported 45%, in average. Pink shrimp presented high levels of EPA (20:5n3; 16.39%) and DHA (22:6n3; 15.33%).
Simopoulos (2006), the ideal nutritional value of different species. Goodstine According to Pigott and Tucker (1990), the linked to suppression of inflammation in patients cancer patients, and a ratio between 2.0 to 3.0 is a reduction of rectal cell proliferation in colorectal Furthermore, an reduction in death from coronary heart disease. Data represent the mean ± standard deviation of the samples (analysed in triplicate). In the same row, the values with different letters are significantly different (p < 0.05). Table 3. Nutritional quality indices for pink shrimp, Pacific white shrimp, octopus and mussel.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pink shrimp</th>
<th>Pacific white shrimp</th>
<th>Octopus</th>
<th>Mussel</th>
</tr>
</thead>
<tbody>
<tr>
<td>n6/n3</td>
<td>0.27±0.01</td>
<td>0.81±0.02</td>
<td>0.64±0.05</td>
<td>0.26±0.01</td>
</tr>
<tr>
<td>n3/n6</td>
<td>3.76±0.04</td>
<td>1.24±0.03</td>
<td>1.57±0.04</td>
<td>3.82±0.18</td>
</tr>
<tr>
<td>PUFAs/SFAs</td>
<td>1.39±0.04</td>
<td>1.06±0.09</td>
<td>0.99±0.06</td>
<td>0.53±0.04</td>
</tr>
<tr>
<td>IA</td>
<td>0.27±0.02</td>
<td>0.19±0.03</td>
<td>0.32±0.04</td>
<td>0.64±0.06</td>
</tr>
<tr>
<td>IT</td>
<td>0.21±0.01</td>
<td>0.26±0.04</td>
<td>0.33±0.04</td>
<td>0.40±0.04</td>
</tr>
<tr>
<td>h/H</td>
<td>3.10±0.24</td>
<td>2.15±0.09</td>
<td>1.39±0.16</td>
<td>0.86±0.07</td>
</tr>
</tbody>
</table>

Simopoulos (2008) reported that a diet with an n6/n3 ratio of up to 4.0 is associated with a 70% reduction in death from coronary heart disease. Furthermore, an n6/n3 ratio of 2.5 is associated with a reduction of rectal cell proliferation in colorectal cancer patients, and a ratio between 2.0 to 3.0 is linked to suppression of inflammation in patients with rheumatoid arthritis (Simopoulos, 2008). According to Pigott and Tucker (1990), the n3/n6 ratio is a useful indicator for comparing the nutritional value of different species. Goodstone et al. (2003) confirmed that an increased n3/n6 ratio in the diet might reduce the risk of breast cancer, particularly in premenopausal women. According to Simopoulos (2006), the ideal n3/n6 ratio present in the diet should be equal to or greater than 1. All species studied herein had an n3/n6 ratio (1.24–3.82) and the n6/n3 ratio (0.26–0.81) was less than 4.0. Therefore, these species can be considered sources of good quality lipids.

Foods with a PUFAs/SFAs ratio below 0.45 have been considered undesirable in the diet because of their potential in inducing blood cholesterol increase (Departament of Health and Social Security, 1994). In all species studied, this ratio was higher than 0.45. In the mussel, the PUFAs/SFAs ratio was 0.63, which was close to the values described in three mollusc species (0.61 on average) studied by Lira et al. (2004). The pink shrimp and Pacific white shrimp presented a PUFAs/SFAs ratio of 1.39 and 1.06, respectively, in line with the advice provided by the Department of Health and Social Security (1994). In several other shrimp species, the PUFAs/SFAs ratio ranged from 1.2–1.5 (Moura et al., 2002; Bragagnolo & Rodriguez-Amaya, 1997).

The indexes of atherogenicity and thrombogenicity and the relation between hypocholesterolemic and hypercholesterolemic fatty acids are used to evaluate the food nutritional value according to each fatty acid. There is no recommended value considered more favorable to human health (Sousa Bentes, Souza, Simões, & Mendoça, 2009). According to Table 3 both shrimp species showed the lowest values of IA and IT, respectively (0.27 and 0.21 Pink Shrimp) and (0.19 and 0.26 Pacific White Shrimp), whereas octopus (0.32 and 0.33) and mussel (0.64 and 0.40) showed higher values. All studied species are considered to potentially prevent diseases, since its IA and IT values were lower than one (<1), indicating that the influence of monounsaturated fatty acids and polyunsaturated fatty acids are higher than the influence of saturated fatty acids.

Hypcholesterolemic fatty acids act to reduce LDL (low density lipoprotein), thereby, preventing cardiovascular disease. Saturated fatty acids, which are part of the hypercholesterolemic group, increase blood cholesterol levels by reducing the activity of LDL cholesterol receptor, thus reducing LDL clearance in the bloodstream. There is no recommended value in literature for the index h/H for fish products, the value 2.0 assigned to meat products is considered as a reference (Santos-Silva et al., 2002). From a nutritional perspective, h/H values >2.0 correspond to products with a desirable fatty acid composition, considering they are composed, for the most part, of hypcholesterolaemic fatty acids and, consequently, reduce the risk of cardiovascular disease.

Hence, the shrimp offered the best consumption options. Moreover, pink shrimp and Pacific white shrimp presented h/H > 2.0, showing a better nutritional quality of the composition of fatty acids.
Conclusion

All the studied species presented a high protein content and low total lipid. Moreover, all the species contained MUFA + PUFA > SFA, with DHÅ and EPA, as the main PUFAs. The mussel can be considered as a high omega-3 content, while both shrimp species can be classified as a source of omega-3. The indices of nutritional quality indicated that all studied species have the potential to improve health, highlighting both shrimp species, Penaeus brasiliensis and Litopenaeus vannamei.

Acknowledgements

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References


de colesterol e perfil de ácidos graxos da carne de búfalo (Bubalis bubalis) da cidade de São Luiz do Quitandinha-AL. *Instituto Adolfo Lutz*, 64(1), 31-38.


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