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A REVIEW OF THE NUTRITIONAL VALUE OF BIVALVE MOLLUSCS AND GASTROPODS

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A review of the nutritional value of bivalve molluscs and gastropods

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ABSTRACT

In the 2010s, world bivalve molluscs production experienced rapid growth, with a mean increasing rate of 277 thousand tonnes per year during this decade. In addition to the high significance of bivalve molluscs consumption at local or regional level, there was also a significant volume of transactions whose share was about 3.1 % of total international exports of fishery products in 2019. Bivalve molluscs and gastropods are highly appreciated in particular for their sensory characteristics (taste and texture). Fat content of bivalve molluscs varies between 0.1 and 3.3 % and protein content ranges between 7.3 and 17.9 % while fat content of gastropods may attain 9.0 % and protein content between 11.2 and 23.2 %. Furthermore, the free amino acids of these molluscs give them unique taste characteristics. This report presents a bibliographic review of worldwide published work on the nutritional value of bivalve molluscs and gastropods in the 2010s.

Keywords: proximate composition, fatty acids, elemental profile, amino acids

Título: Uma revisão bibliográfica do valor nutricional de bivalves e gastrópodes

RESUMO

A produção mundial de bivalves registou, na década de 2010, um rápido crescimento, com uma taxa média de 277 mil toneladas por ano. Além do elevado significado do consumo de bivalves a nível local ou regional, verificou-se também um expressivo volume de transações cujo valor foi cerca de 3.1 % do total das exportações internacionais de produtos da pesca em 2019. Os moluscos bivalves e gastrópodes são muito apreciados devido, em particular, às suas características sensoriais (sabor e textura). Os bivalves apresentam teores de gordura entre 0,1 e 3,3 % e proteína na gama de 7,3 e 17,9 % enquanto os gastrópodes têm teores de gordura que podem atingir 9,0 % e teores de proteína mais elevados entre 11,2 e 23,2 %. Além disso, os aminoácidos livres destes moluscos conferem-lhes características sápidas únicas. Neste relatório apresenta-se uma revisão bibliográfica dos trabalhos publicados a nível mundial sobre o valor nutricional de bivalves e gastrópodes na década de 2010.

Palavras chave: composição química, ácidos gordos, composição mineral, aminoácidos

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Worldwide productions and values

Bivalve molluscs and gastropods as food sources go back more than 10,000 years as observed by the shell middens present in various regions of the world (Stoner, 1997; Jordá *et al*., 2011; Butler *et al.*, 2019). This shellfish group still remains of great importance in several indigenous communities in various areas of the globe such as Australia, Chile, Papua New Guinea, Mozambique, and South Africa (Bird and Bird, 1997; Kyle *et al.*, 1997), but their production has become a fast growing animal-food sector as noted by Sheehan *et al.* (2019). This fast production growth is in line with the increasing demand for bivalve molluscs by consumers which is mainly due to their flavour, tenderness, easy of digestion, together with their nutritional value.

In 2010, the annual bivalve molluscs production reached 14.585 million tonnes where most of this global production (90 %) came from aquaculture. The relative contribution of each bivalve molluscs group for the global production was: 38 % clams, 31 % oysters, 18 % scallops, and 13 % mussels (FAO, 2017). This global production was 17.354 million tonnes in 2019 and the aquaculture production accounted for 91 %. The contribution of clams to the global production decreased to 35 % whereas an increase of oysters percentage (36 %) was recorded and in the case of scallops and mussels, their contributions were 17 % and 12 %, respectively (FAO, 2021). The overwhelming majority of aquaculture production of bivalve molluscs comes from China which represents about 75 % of worldwide bivalve molluscs production. The second most important producer is Republic of Korea, followed by Chile and Japan but their productions are only around 2 % of total production (FAO, 2020). The total estimated value of bivalve molluscs captured in the wild and produced in aquaculture attained USD 30.272 billion in 2019 and almost 90 % came from aquaculture production. In general, bivalve molluscs produced in aquaculture had higher values per tonne than those caught in the wild with the exception of oysters. This is particularly notorious in mussels where the values (USD$/t) of wild caught and aquaculture produced mussels were 950 and 2212, respectively. The highest value/tonne was recorded in aquaculture produced scallops which achieved USD$ 2722/t. In wild caught clams this value (USD$) was 1400/t but in aquaculture produced clams it was 1750/t. In the case of oysters, their value was USD$ 1300/t in wild caught and USD$ 1182/t in aquaculture produced oysters.

Landings and aquaculture production in Portugal

Figures 1A and B show the landings of several groups of bivalve molluscs and gastropod species commercialized in Portugal (INE, 2011-2021). Main species of the cockles group marketed in Portugal is common edible cockle (*Cerastoderma edule*) but occasionally the Norwegian egg cockle (*Laevicardium crassum*) species is also harvested. The clams group includes several species, namely: smooth clam (*Callista chione*), striped venus clam (*Chamelea gallina*), common European bittersweet

(*Glycymeris glycymeris*), grooved carpet shell (*Ruditapes decussates*), Japanese carpet shell (*R. philippinarum*), peppery furrow shell (*Scrobicularia plana*), solid surf clam (*Spisula solida*), pullet carpet shell (*Venerupis corrugate*), and warty venus (*Venus verrucosa*). Other species such as blunt tellin (*Arcopagia crassa*), rayed artemis (*Dosinia exoleta*), and thick-ridged venus (*Venus casina*) are also occasionally harvested. Mussels collected in the Portuguese coast belong to the species common blue mussel (*Mytilus edulis*) and Mediterranean mussel (*M. galloprovincialis*) which are usually marketed together. On the beginning of the 2010's decade, the cockles landings were about 3000 tonnes which raised to 4963 – 5330 tonnes in 2015-2018 but at the end of this decade they fall down to around 3300 tonnes. Clams landings attained a maximum of 1648 tonnes in 2015 but at the end of this decade they were about 1020 tonnes. Concerning mussels, their landings slowly increased from 32 tonnes in 2010 to achieve 845 tonnes in 2017 but in 2020 they only were 31 tonnes.

Truncate donax (*Donax trunculus*) is the main species included in the bean clams group. Razor clams group comprehend species of the genus *Ensis* and also European razor clam (*Solen marginatus*) and bean razor clam (*Pharus legumen*). The oysters marketed in Portugal include the following species: European flat oyster (*Ostrea edulis*), Pacific oyster (*Magallana gigas*) and Portuguese oyster (*M. angulata*). Whelks landed belong to the species: purple dye murex (*Bolinus brandaris*), common whelk (*Buccinum undatum*), trumpet shell (*Charonia lampas*) and banded dye murex (*Murex trunculus*).

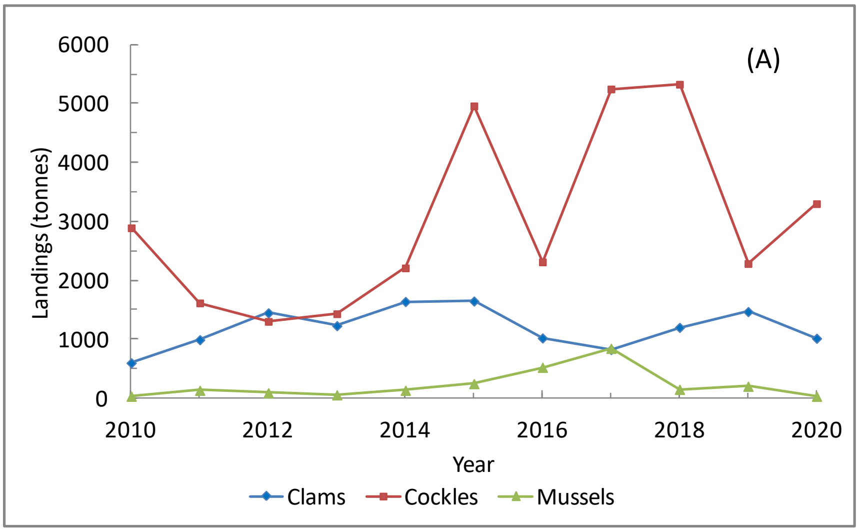


Figure 1A – Landings of clams, cockles and mussels.

Figura 1A – Desembarques de amêijoas, berbigões e mexilhões.

Landings of bean clams shown in figure 1B were around 350 tonnes and 300 tonnes in 2010 and 2019, respectively with a maximum of 378 tonnes in 2012 and a minimum value of 178 tonnes in 2017. However, a sudden increase of bean clams landings occurred in 2020 which attained 811 tonnes. Concerning the razor clams landings, a general increasing trend of landings was registered during this decade. The evolution of oyster landings was uneven during this decade. In 2010 and 2020, oyster landings accounted for 68 and 75 tonnes, respectively with a maximum of 109 tonnes in 2012 and a minimum of 33 tonnes recorded in 2015. The production of whelks was relatively modest, however, a general decrease of their landings was recorded from 51 tonnes in 2010 to 28 tonnes in 2020.

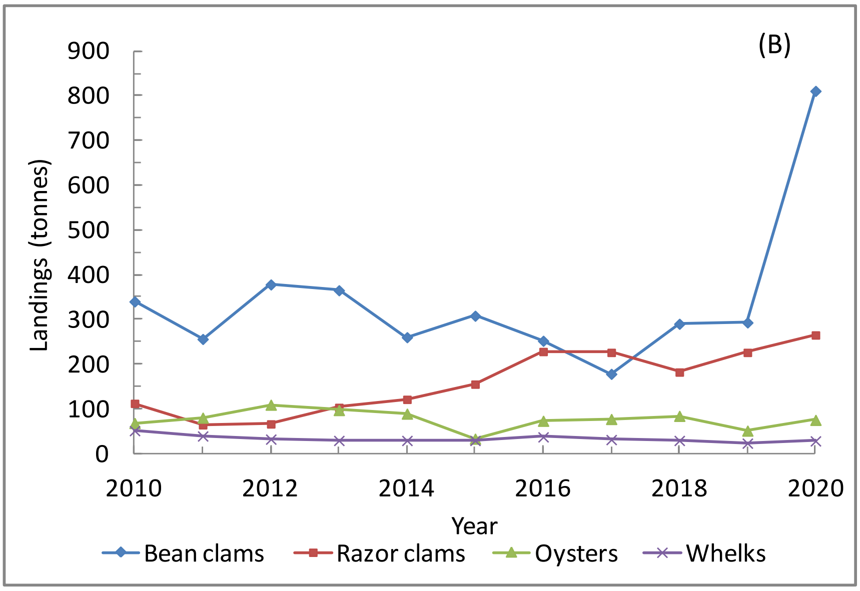


Figure 1B – Landings of bean clams, razor clams, oysters and whelks.

Figura 1B – Desembarques de conquilhas, longueirões, ostras e búzios.

The values (in thousands euros) of bivalve molluscs and gastropods are presented in figures 2A and 2B (INE, 2011-2021). The evolutions of cockles values and their landings were very similar. Concerning prices, an almost linear increase from 0.76 €/kg in 2010 to 0.91 €/kg in 2015 was recorded but in the second half of this decade their evolution was irregular, with a maximum of 1.54 €/kg in 2019.

The values of clams (Fig. 2A) presented two maximums in 2012 and 2019, the latter being more pronounced due to the higher prices of these bivalve molluscs at the end of the decade. In fact, between 2010 and 2014, there was a decrease in prices from €3.77/kg to €1.71/kg, respectively. However, from 2015 onwards, there was a gradual increase reaching €2.63/kg in 2020. Concerning bean clams, the value of these shellfish in the period 2010-2019 ranged from €604 thousand in 2017 and €1074 thousand in 2012. However, the value increased significantly to €2,289 thousand in 2020 due to the exceptionally high volume of landings in that year. Prices were relatively stable between 2010 and 2014, ranging between €2.76 and €2.72/kg, respectively. However, they then started to rise, reaching 3.41 €/kg in 2019, with a small decrease to 2.82 €/kg in 2020. The value of razor clams increased steadily throughout the decade, following the same trend as their landings. Prices have also increased, ranging from 2.65 €/kg in 2010 to 3.89 €/kg in 2018, followed by a slight decrease to 3.77 €/kg by 2020.

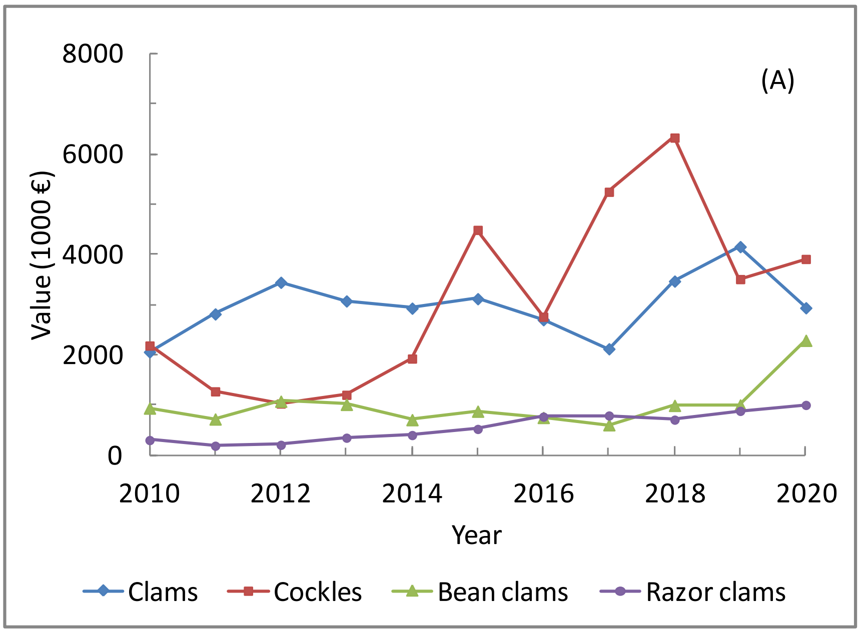


Figure 2A – Values (in euros) of clams, cockles, bean clams and razor clams.

Figura 2A – Evolução dos valores dos desembarques (em euros) de amêijoas, berbigões, conquilhas e longueirões.

As shown in figure 2B, a decrease in the value of whelks was recorded until 2013, but after that, the average value was around €200,000. Gastropods were the most valued shellfish group with an average price of 6.21 €/kg in this decade. Oysters values varied between €33,000 in 2015 and €87,000 in 2012. The lowest and highest landings of this bivalve in this decade were also recorded in these dates. Oysters prices were generally relatively low and reached their highest value (1.06 €/kg) in 2020. In the evolution of mussels values over this period, the high rise from €44,000 in 2013 to €349,000 in 2017 stands out. Landings in this period increased from 55,000 to 845,000 tonnes and in 2017 the price reached the lowest value (0.41 €/kg).

The global aquaculture production of bivalve molluscs recorded in 2010 was 3851 tonnes and reached 6682 tonnes in 2020, with a maximum of 9368 tonnes in 2019 (INE, 2011-2021). In this period there was a 30 % increase in bivalve production in a first phase between 2010 and 2014, followed by a decrease to 4765 tonnes in 2016, but by 2019 this production had almost doubled. In the global production of bivalve molluscs are included: clams (cockles, carpet shell clams, and razor clams), Portuguese and Japanese oysters, and mussels. The productions of these shellfish groups are shown in figure 3. Carpet shell clams accounted for more than 90 % of clams production, except in 2014 when it dropped to 84 %, while the cockles contribution was generally below 10 %. Japanese oyster was the predominant species but the available statistical data do not allow knowing the percentages of the different oyster species produced. A general increase in mussel production occurred in this decade mainly as a result of investments in infrastructures.

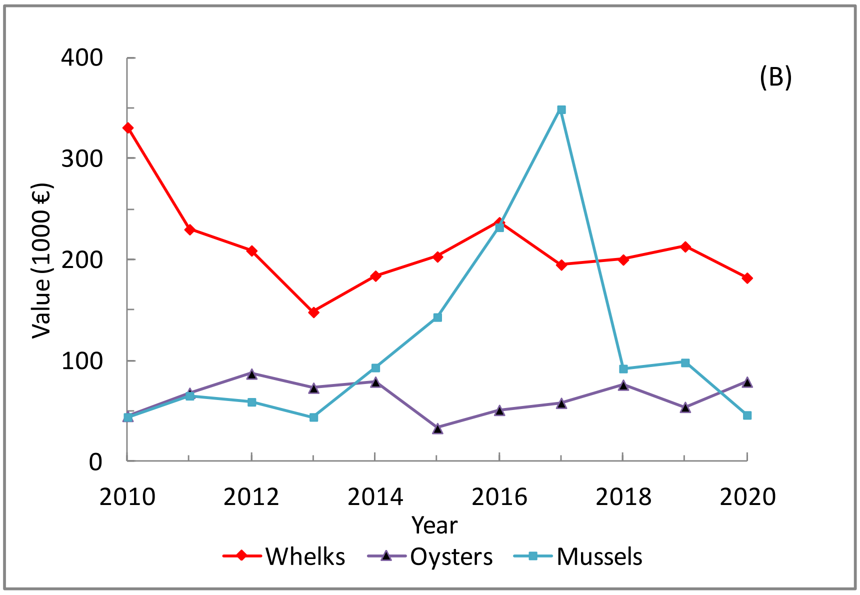


Figure 2B – Evolution of whelks, oysters, and mussels values (in euros).

Figura 2B – Evolução dos valores (em euros) de búzios, ostras e mexilhões.

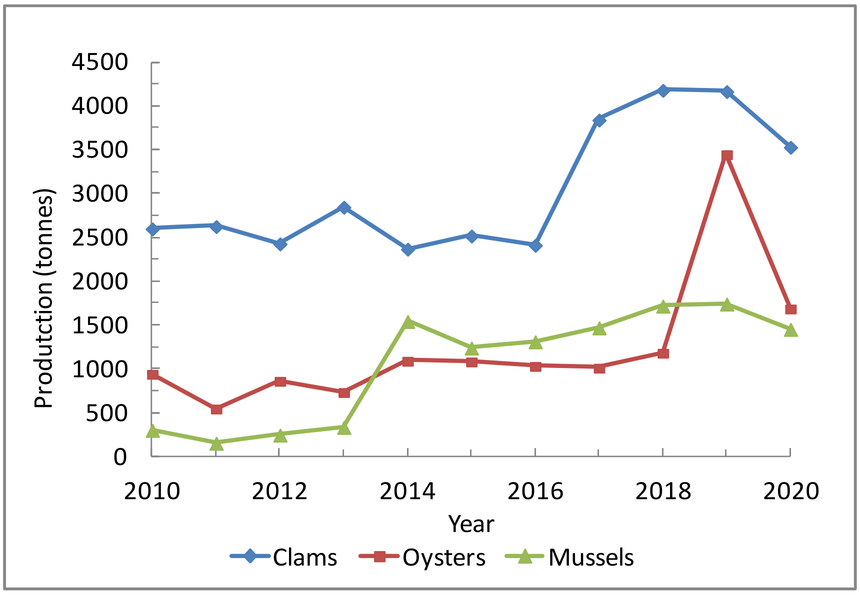


Figure 3 – Evolution of clams, oysters and mussels aquaculture productions.

Figura 3 – Evolução das produções de aquacultura de amêijoas, ostras e mexilhões.

The evolution of values of the three shellfish groups is presented in figure 4. The value of clams was €22.326 million in 2010 and attained €43.494 million in 2018. The values did not show a defined trend between 2010 and 2015, but from 2015 onwards there has been a steady increase as a result of the increasing of production and price which reached 11.14 €/kg in 2018. Oyster values showed a general tendency to increase over the period 2010 and 2018 and the mean price was 1.86 €/kg. Regarding mussels, their values were relatively stable and low until 2013, but then increased reaching a maximum of €2.423 million in 2017. The decreases recorded in 2016 and 2018 were mainly due to the low prices achieved in these two years which were 0.78 and 0.77 €/kg, respectively.

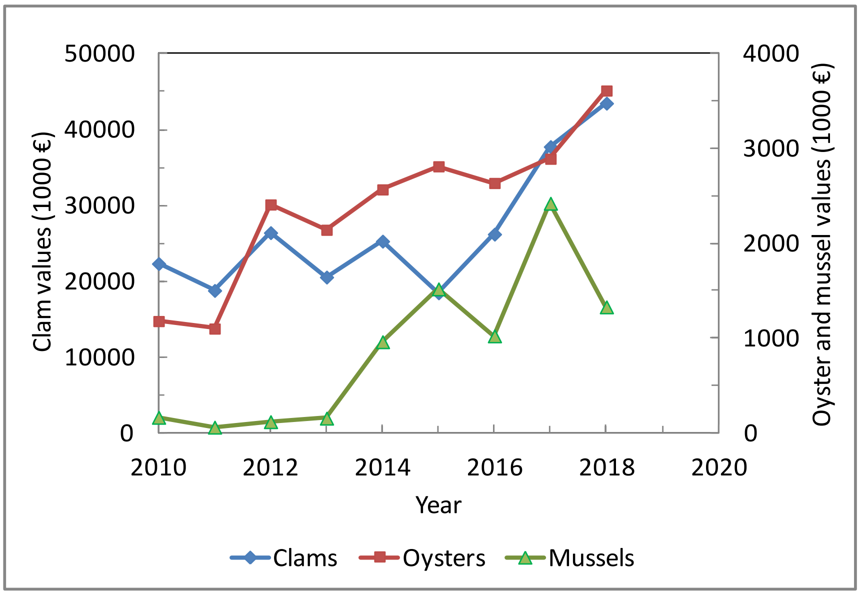


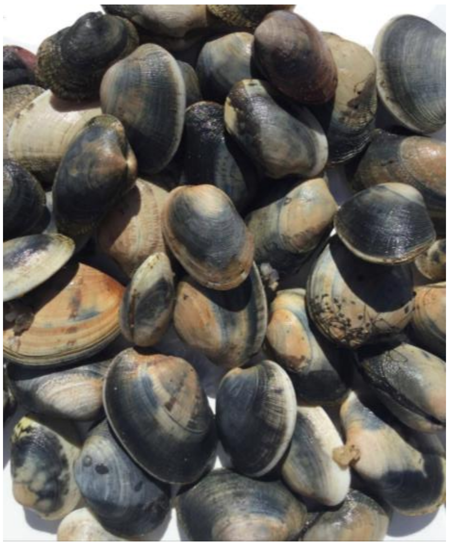
Figure 4 – Evolution of clam, oyster and mussel values (in euros).

Figura 4 – Evolução dos valores (em euros) de amêijoas, ostras e mexilhões produzidos em aquacultura.

Nutritional value of bivalve molluscs

Clams

The striped venus clam is a popular foodstuff especially consumed in Italy, Spain, and France. The seasonal variation of the nutritional value of this clam from the southern coast of the Marmara Sea (Turkey) was followed by Arik Colakoglu *et al.* (2011). The samples were seasonally harvested at five stations for one year and analyzed to determine meat yield, proximate composition and elemental profile. The meat yield ranged from 20.24 % and 29.94 % and the lowest yield was recorded in summer which is the reproduction season of striped venus clam in the Marmara Sea. The mean proximate composition and the ranges of variation of some elements are shown in Tables 1 and 5, respectively. Fat content depended on the reproduction cycle and it was in the range 2.13-3.13 %, where the minimum value was recorded after summer. Some striped venus clams samples had relatively high levels of Fe, Cu, Zn and Mn due to household and industrial wastes (Cu) and also the location of the sampling sites close to a shipyard (Fe) or an iron-steel plant (Mn and Zn).



Pullet carpet shell (*V. corrugate*). (Photo kindly provided by Dr. Helena Silva).

Amêijoa-macha (*V. corrugate*). (Fotografia amavelmente cedida pela Dr. Helena Silva).

The Pacific geoduck clam (*Panopea abrupta*) has an average whole weight of 1.2 kg and it is a high-value foodstuff in Japan and China. The chemical characterization of the mantle and siphon of this clam harvested in Southeast Alaska was reported by Oliveira *et al.* (2011). As can be seen in Table 1, mantle and siphon present significant differences. Mantle was fatter and had higher carbohydrate content than siphon, which had slightly higher protein content. The differences in proximate composition between these tissues are closely related to their different functions in the live animal. These tissues also present significant differences in their levels of fatty acids. Siphon was richer in monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), and docosahexaenoic acid (DHA) than mantle (Table 3). Palmitic acid (16:0) was the main saturated fatty acid (SFA) in both tissues (12.10 % in mantle and 10.91 % in siphon) and *cis*-vaccenic acid (18:1 n-7) the main MUFA (4.43 % in mantle and 3.55 % in siphon). The high percentage of PUFA, especially DHA, has been related to the low environmental temperature in which this clam resides. The presence of long-chain omega-3 fatty acids in the lipid bilayers of cell membranes would provide the ability to sustain the membrane fluidity at low temperatures. It is also noticeable the high n-3/n-6 ratio in both tissues. The mineral composition differences between the mantle and the siphon are related to the different functions of these tissues in the live clam (Table 5). The molar Na:K ratio was 0.67 and 0.63 in the mantle and siphon, respectively. The higher potassium content in siphon tissue is related to the involvement of K^+ ions in the biochemical process of muscle contraction. According to Swanepoel *et al.* (2016) and Vasara *et al.* (2017) a molar Na:K ratio intake between 1.0 and 2.0 may lower cardiovascular disease risk in adults. As shown in Table 5, mantle and siphon are both good sources of P and excellent sources of Se. Mantle is also good source of Mg and excellent source of Cu and Zn.

The seasonal variations of the proximate composition of the high-value grooved carpet shell clam harvested in Ria Formosa, Portugal, were investigated by Aníbal *et al*. (2011). The data shown in Table 1 are the average of results obtained monthly during one sampling year. The clams showed higher nutritional value on the beginning of summer (June) when the protein content peaks (8.66 %) as well as percentage of meat yield (meat wet weight x 100/total wet weight) and condition index (meat dry weight x 100/shell dry weight) attained their maximum values.

Nurnadia *et al.* (2011) studied the proximate composition of blood cockles (*Anadara granosa*) harvested in the West Coast of Peninsular Malaysia aiming to make available the nutritional value of several seafood products. The proximate composition of this bivalve presented in Table 1 evidences its relatively high protein content. The elemental profile of these cockles reported by Nurnadia *et al.* (2013) and presented in Table 5 shows that they are excellent source of Mg and Fe and good source of Cu. On the other hand, these cockles had a very high molar Na:K ratio (15.64).

Chen *et al.* (2012) evaluated the proximate composition (Table 1) and the amino acid profile of the Asiatic hard clam (*Meretrix meretrix*) and paphia (*Paphia papilionacea*) collected from the Beibu Gulf, China. The percentage of each constituent in the two bivalves was not significantly different. Total amino acid contents (g 100 g^{-1}) in fresh meat were 7.45 for clam and 7.62 for paphia. Glutamic acid (Glu) was the main amino acid in both species accounting for 1.17 and 1.33 g 100 g^{-1}, for clam and paphia, respectively. The essential amino acids (EAAs) of clam and paphia (g 100 g^{-1}) were 2.76 and 3.10, respectively and the non-essential amino acids (NEAAs) of clam and paphia (g 100 g^{-1}) were 4.68 and 5.34, respectively. It is also relevant to mention the high levels (g 100 g^{-1}) of free amino acids (FAA) – 1.13 in clam and 1.75 in paphia – which are generally related to the specific flavours of bivalve molluscs.

The proximate composition (Table 1) of the edible portions (foot, f, mantle, m, and viscera, v) of poker chip venus (*Meretrix lusoria*) harvested from the coast of Andaman Sea, Thailand, was evaluated by Karnjanapratum *et al.* (2013). Amongst all the portions, foot had the lowest moisture content but the highest protein content. On the contrary, mantle had the highest moisture content and the lowest protein content. It is also noticeable the high fat content of the viscera and the high carbohydrate content in the foot. Cholesterol content was in the range of 0.07–0.21 % where the highest level was determined in the viscera and the lowest in the foot. The fatty acid composition presented in Table 3 shows that in all three portions PUFAs were the major group, followed by SFAs and MUFAs. Palmitic and oleic (18:1 *cis* n-9) acids were the main SFA and MUFA, respectively in the three edible portions. All portions contained high content of EAAs (g 100 g^{-1} wet weight) between 2.97 in the mantle and 3.98 in the foot. Leucine (Leu) and lysine (Lys) were the predominant amino acids and their lowest and highest levels (g 100 g^{-1} wet weight) were determined in the mantle (0.58 Leu and 0.57 Lys) and in foot (0.83 Leu and 0.84 Lys), respectively. Total NEAAs ranged from 5.03 and 7.01 g 100 g^{-1} wet weight in mantle and foot, respectively. The range of variation of several elements is shown in Table 5. In general, the viscera and mantle had higher contents of Na, K, Ca, and Mg than the foot and mantle is good source of mg and Ca. On the other hand, viscera showed much higher content of microelements than the other two portions and all portions are excellent sources of Fe. The molar Na:K ratio - 0.92, 2.83, and 1.99 in the foot, mantle, and viscera, respectively – also evidences the different proportions of Na and K in these portions.

The study by Olmedo *et al.* (2013) evaluated the level of four essential elements (Zn, Cu, Mn, and Se) in several fresh and canned bivalve molluscs from different origins and consumed in Andalusia, Spain. The level of these elements (median in mg kg^{-1}) was the following: fresh clam (*Venus gallina*) – 6.303 Zn, 0.661 Cu, 0.665 Mn, and 0.090 Se; canned clam (*Protothaca thaca*) – 6.057 Zn, 2.350 Cu, 1.880 Mn, and 0.155 Se; canned cockle (*Cerastoderma edule*) – 9.527 Zn, 1.481 Cu, 2.153 Mn, and 0.034 Se. It is worth mentioning that the canned clam is excellent source of Cu and Se and fresh clam and canned cockle are good sources of Se and Cu, respectively.

The seasonal variation of nutritional value of granular ark (*Tegillarca grabosa*) from South Korea was followed by Nguyen *et al.* (2017). The samples were collected in different seasons and analyzed after harvesting, washing and sorting, and before marketing. The average proximate and fatty acid compositions of marketed granular ark samples collected in January, April, and November are presented in Tables 1 and 3. The decreasing order of abundance of the three fatty acid groups was: PUFAs > SFAs > MUFAs where palmitic acid was the main SFA (average 13.0 %) and 16-docosenoic acid (22:1 n-6) the major MUFA (average 4.3 %) followed by oleic acid (average 3.4 %). The maximum of eicosapentaenoic acid (EPA) content occurred in April (17.3 %) and the highest DHA content took place in January and November. The FAA composition of granular ark collected in the three seasons and production steps showed that Glu, glycine (Gly), taurine (Tau), and alanine (Ala) were the predominant amino acids. The average content (mg 100 g^{-1}) of these FAAs determined in the marketed samples from the three seasons were: 814.4 for Glu, 496.9 for Gly, 463.4 for Tau, and 335.6 for Ala. Table 5 shows the average elemental profile of these granular ark samples which are good sources of P, Mg, and Zn and excellent sources of Fe and Cu and their mean molar Na:K ratio is 2.09.

Tabakaeva *et al.* (2018) studied the nutritional composition of inflated ark (*Anadara broughtonii*) and sunray surf clam (*Mactra chinensis*) collected in Sea of Japan. The muscle, mantle and adductor of the edible portion of both clams were separately analyzed and their proximate composition is presented in Table 1. These authors used the conversion factor 5.8 for the determination of total crude protein. The water content in the various parts of these bivalve molluscs decreased in the following order: mantle > adductor > muscle. In the case of protein content the decreasing order in both bivalve molluscs was: muscle>adductor>mantle. However, mantle was richest in carbohydrates, followed by adductor and muscle. The three parts of inflated ark had higher protein and fat than their counterparts of sunray surf clam. Table 5 shows the mineral profile of the three parts of both species. As shown in this table, the inflated ark muscle had the highest content of all elements, with the exception of Mn. The decreasing order of macroelements content was the following: muscle > adductor > mantle, while this order of microelements content was: muscle > mantle > adductor. In the case of sunray surf clam, muscle was the richest in K, Cu, Zn, and Mn, while the highest levels of Na and Ca were determined in the adductor and mantle had the highest content of Mg and Fe. Moreover, the average content of the majority of elements was higher in inflated ark than in sunray surf clam. In inflated ark the molar Na:K ratio was between 1.36 in the muscle and 2.17 in the mantle while in sunray surf clam this ratio varied from 0.97 in the muscle and 1.58 in the mantle. In the adductor, this ratio was 1.55 in inflated ark and 1.45 in sunray surf clam. The edible parts of both bivalve molluscs presented high levels of Gly, Glu, aspartic acid (Asp), Ala, Leu, Lys and arginine (Arg).

Oysters

Nurnadia *et al.* (2011) studied the proximate composition of oysters (*Ostrea* spp.) harvested in the West Coast of Peninsular Malaysia in the frame of a project to provide information on the nutritional value of 24 marine fish and shellfish species. Table 1 shows the proximate composition of these oysters' species and it is to stress their relatively high protein and carbohydrate contents. The elemental profile of these oysters (Table 5) reported by Nurnadia *et al.* (2013) evidences their high content of Mg, Fe, and Cu but it is also noticeable their very high molar Na:K ratio (19.90).

Chen *et al.* (2012) evaluated the proximate composition (Table 1) and the amino acid profile of suminoe oyster (*Crassostrea rivularis*) collected from the Beibu Gulf, China. Protein content was relatively low but falls in variation range of this constituent (5.11-9.72) in several oyster species as reported in FAO (2016). Total amino acids content in fresh meat was 7.62 g 100 g^{-1}, Glu was the main amino acid (1.19 g 100 g^{-1}) followed by Asp (0.80 g 100 g^{-1}). The EAAs and NEAAs of oyster (g 100 g^{-1}) was 2.96 and 4.65, respectively. Typically, suminoe oyster had high FAA content (1.21 g 100 g^{-1}) and Gly (0.14), Ala (0.11) and Glu (0.09) were the major FAA. The former two FAA are known for their sweet taste and the latter for the UMAMI taste.

Mangrove oysters (*C. rhizophorae*) cultivated in Alagoas, Brazil, were collected in the summer and winter periods in order to evaluate the influence of season on their nutritional value (Lira *et al.*, 2013). The oysters collected in the winter had significantly higher protein content than those from summer but lower carbohydrate content (Table 1). The order of abundance of fatty acids in mangrove oysters from both seasons was SFAs > PUFAs > MUFAs (Table 3). However, oysters collected in the winter had higher level of n-3 fatty acids. Palmitic acid was the major fatty acid accounting for 655.3 and 607.5 mg 100 g^{-1} in the summer and winter collected oysters, respectively. Oleic acid was the main

MUFA (97.4 and 56.7 mg 100 g^{-1} in the summer and winter collected oysters). The cholesterol levels, in mg 100 g^{-1}, were 49.0 and 54.4 in summer and winter oysters, respectively.

Japanese oyster (*M. gigas*). (Photo kindly provided by Dr. Helena Silva).
Ostra-japonesa (M. gigas). (Fotografia amavelmente cedida pela Dr. Helena Silva).

The nutritional value of culture Indian backwater oyster (*C. madrasensis*) harvested in the Ernakulam of Kerala (India) was determined by Asha *et al.* (2014). The relatively high fat content (Table 1) is the most relevant feature of the proximate composition of this oyster and the carbohydrate content may be considered a median value taking into consideration the level of this constituent in the bivalves presented in Table 1. The fatty acid composition presented in Table 3 shows that PUFA was the main fatty acid group where EPA was the major fatty acid. Arachidic acid (20:0) was the main SFA (91.60 mg 100 g^{-1}) and palmitoleic acid (16:1 n-7) the dominant MUFA (28.00 mg 100 g^{-1}) followed by 15-docosenoic acid (22:1 n-7) (22.60 mg 100 g^{-1}). This oyster had a relatively high cholesterol content (106 mg 100 g^{-1}) which, according to the authors, is compensated by the presence of high taurine content (243 mg 100 g^{-1}). The hypocholesterolemic effect of taurine has been reported by several authors although the results from the oral supplementation of this amino acid to human are ambiguous (Eilertsen *et al*., 2012). The levels of total EAAs and NEAAs were 5.13 and 4.229 g 100 g^{-1}, respectively. High contents (g 100 g^{-1}) of Lys (1.35), threonine (1.16), histidine (0.73), and Asp (1.11) are noteworthy.

The study by Mohanty *et al.* (2014) on the protein and amino acid composition of important food fishes consumed in India included the Indian backwater oyster. These authors reported a protein content of 16.8 % for this oyster species. The main amino acids (mg 100 g^{-1}) were Leu (218) and Lys (185) and the total EAAs and NEAAs contents (g 100 g^{-1}) were 0.96 and 1.81, respectively. The proximate composition (Table 1) and fatty acids profile (Table 3) of this species were determined in another study by Mohanty *et al.* (2016a). These authors obtained considerably higher protein content but slightly lower fat content for Indian backwater oyster compared to the results reported by Asha *et al.* (2014). The decreasing order of abundance was SFAs > PUFAs > MUFAs where palmitic acid was the major fatty acid (26.8 %) and oleic acid (9.9 %) the main MUFA. Within PUFAs, it is to mention the relatively high percentage of n-6 fatty acids (10.5 %) mainly due to the levels of linoleic acid (18:2 n-6) (3.2 %) and arachidonic acid (20: 4 n-6, ARA) (2.4 %). The elemental profile of Indian backwater oyster is shown in Table 5 as reported by Mohanty *et al.* (2016b). This bivalve is particularly rich in Mn and it is a good source of P and an excellent source of Ca, Fe, and Se. It is also noticeable its low molar Na:K ratio (0.72). The levels of vitamins A, D, E, and K (μg 100 g^{-1}) in Indian oyster were 1.38, 11.29, 134.2, and 1.2, respectively.

Scallops

Smooth scallop (*Flexopecten glaber*) collected in the Aegean Sea was analyzed by Özden and Erkan (2011) and its proximate composition and elemental profile are shown in Tables 1 and 5, respectively. This study showed this scallop had relatively low protein content but it was a good source of P and Ca and an excellent source of Mg, Fe, and Se. The molar Na:K ratio is 2.07. This bivalve had relatively high amino acids content (19.80 g 100 g^{-1}) and the total EAAs and NEAAs were 9.03 and 10.77 g 100 g^{-1}, respectively.

Scallop (*Aequipecten opercularis*) shells. (Photo kindly provided by Dr. Helena Silva and species identification by Dr. Miguel Gaspar).

Conchas de vieiras (*Aequipecten opercularis*). (Fotografia amavelmente cedida pela Dr. Helena Silva e identificação da espécie pelo Dr. Miguel Gaspar).

The lion's paw scallop (*Nodipecten subnodosus*) is one of the most important fishery resources of the Mexico's Baja California Peninsula. Jiménez-Ruiz *et al.* (2012) evaluated the proximate composition of the adductor muscle (Table 1) of these scallops harvested in Bahia Tortugas. Adductor muscle of lion's paw scallop had very low fat content and high protein content and contained high level of carbohydrates like most pectinids.

A study on the composition of the adductor muscle from different scallop products available in the German market was made by Manthey-Karl *et al.* (2015). Table 1 shows the average proximate composition of fresh and frozen great Atlantic scallops (*Pecten maximus*) from France and Norway and frozen Atlantic sea scallops (*Placopecten magellanicus*). The higher protein and carbohydrate contents of fresh great Atlantic scallop in comparison with frozen samples are the main features to stress. The fatty acid profile of all scallop samples (Table 3) evidences the high percentage of PUFA, EPA and DHA and n-3/n-6 ratio. Palmitic (average 17.9 %) and vaccenic (average 3.6 %) acids were the main SFA and MUFA, respectively. Table 5 presents the elemental composition of fresh and frozen great Atlantic and frozen Atlantic sea scallops. The higher sodium content in frozen scallops results from additives such as monosodium citrate and sodium triphosphate, usually used to prevent lipid oxidation or improve water retention. It is worth noting the differences of the molar Na:K ratio in the fresh and frozen great Atlantic scallop (0.43 and 1.08) and Atlantic sea scallop (1.63). The average total free amino acids (FAAs) of fresh great Atlantic scallop were 2.72 and 2.96 g 100 g^{-1} in the Norwegian and French samples, respectively. In frozen great Atlantic and Atlantic sea scallops, total FAAs were 1.37 and 1.76 g 100 g^{-1}, respectively. The most frequent FAAs in fresh great Atlantic scallops (mg 100 g^{-1}) were: Ala 59; Arg 242; Gly 1440; and Tau 887 in Norwegian samples. The level of these FFAs in French samples was: Ala 117; Arg 310; Gly 1460; and Tau 953. In frozen samples of great Atlantic and Atlantic sea scallops, the level of these FAAs was respectively: Ala 53 and 75; Arg 156 and 249; Gly 693 and 688; and Tau 395 and 681.

Mussels

Ersoy and Şereflişan (2010) analyzed the chemical composition and fatty acid profile of two freshwater mussels species: common mussel (*Unio terminalis*) and black river mussel (*Potamida littoralis*) collected in the South Eastern Mediterranean region of Turkey. The proximate composition (Table 1) of these species was similar but common mussel was richer in PUFA, EPA, and DHA than black river mussel (Table 3). In both species, the main SFA, MUFA, and PUFA were palmitic, palmitoleic and EPA, respectively.

In the study by Olmedo *et al.* (2013) the levels of Zn, Cu, Mn, and Se in fresh blue mussel (*Mytilus edulis*) and canned Mediterranean mussel (*M. galloprovincialis*) from different origins and consumed in Andalusia, Spain, were determined. The levels of these elements (median in mg kg^{-1}) were the following: 14.173 Zn, 0.491 Cu, 0.647 Mn, and 0.160 Se in the fresh product and 22.723 Zn, 1.700 Cu, 0.926 Mn, and 0.141 Se in the canned mussel. Both fresh and canned mussels are excellent sources of Se and in addition, canned mussels are also good sources of Zn and Cu.

Samples of the freshwater mussel *Lamellidens marginalis* collected from ponds in West Bengal, India, were analyzed by Haldar *et al.* (2014). This freshwater mussel had moderate protein content and high carbohydrate content as shown in Table 1. Total SFAs was the main fatty acids group (Table 3) where arachidic acid (18.9 %) was the predominant. Within MUFAs, palmitoleic acid (16:1 n-7) accounted for 22.18 % and the other MUFAs were residual, whereas EPA and DHA represented only 3.43 % and 9.55 %, respectively.

The fatty acid profile and fat soluble vitamins (A, D_3, and E) of Mediterranean mussel collected in the Black Sea were determined by Merdzhanova *et al.* (2014). The fat content of this mussel was 2.49 g 100 g^{-1} and the decreasing abundance of the three fatty acids groups followed the order SFAs > PUFAs > MUFAs (Table 3). Palmitic (29.04 %) and palmitoleic (18.25 %) acids were the main SFA and MUFA, respectively. The major PUFA was DHA, followed by ARA (5.56 %) and EPA. The levels (μg 100 g^{-1}) of vitamins A, D3 and E were 99.7, 14.8, and 1688.9, respectively. Taking into account the Adequate Intake (AI) of 15 μg day^{-1} for vitamin D and 11 mg day^{-1} for vitamin E for adult males and the Population Reference Index of 650 μg day^{-1} for adult males and 490 μg day^{-1} for adult females of vitamin A reported in EFSA (2017), the consumption of 100 g of raw Mediterranean mussel contributes to 98.7 % of vitamin D, 15.4 % of vitamin E and 15.3 % and 20.3 % of vitamin A for males and females, respectively.

Mediterranean mussel. (Photo kindly provided by Dr. Helena Silva).
Mexilhão. (Fotografia amavelmente cedida pela Dr. Helena Silva).

Bongiorno *et al.* (2015) studied the seasonal nutritional quality of Mediterranean mussels cultured in a long-line system in the Gulf of Trieste, Italy. Mussel samples of commercial size were monthly collected during one year for determination of proximate composition and fatty acids, amino acids and mineral profiles. The average proximate composition is shown in Table 1. The highest protein (11.6 %) and fat (2.2 %) contents were obtained in summer and the minimum values (7.5 % protein and 1.0 % fat) during winter. The concentration ranges (mg 100 g^{-1}) of the three fatty acids groups were: 126-368 SFAs, 89.6-208 MUFAs, and 306-657 PUFAs. The range of the n-3/n-6 ratio was 5.35-11.74 and the concentration ranges (mg 100 g^{-1}) of EPA and DHA were 59.8-129 and 169-256, respectively. The maximum of total fatty acids, EPA and DHA was recorded in July and the minimum of MUFAs in January and SFAs, PUFAs, EPA, and DHA in March. Palmitic acid was the main SFA and its content ranged from 66.8 and 220 mg 100 g^{-1}. Within MUFAs, the most abundant was *cis*-11-eicosenoic acid (20:1 n-11) (16.1-34.4 mg 100 g^{-1}) followed by *cis*-11-docosenoic acid (22:1 n-11) (16.2-32.2 mg 100 g^{-1}). The total amino acids (TAA) range was 5.52-7.66 g 100 g^{-1} where the minimum was recorded in December and the maximum in May. The average mineral profile is shown in Table 5. The levels of these elements presented wide range of seasonal variations and the range of the molar Na:K ratio varied from 1.81 in May and 17.84 in November.

The proximate composition and mineral profile of soft tissues (foot, mantle, and gills) of duck mussel (*Anodonta anatina*) from Chashma Lake, River Indus Pakistan, were analyzed (Sohail *et al.*, 2016). Foot was the best nutritive portion due to its high protein and fat contents (Table 1). It is also to highlight its low ash content. The mineral profile of the three tissues is shown in the Table 5 and the great differences between them are evident. It is quite notorious the very high levels of P, Ca, Zn and Mn in mantle and particularly in gills compared to those in foot. The molar Na:K ratio in foot, mantle and gills were 3.19, 10.90, and 4.52, respectively. Duck mussel may be considered excellent source of P, Ca, Cu, and Zn.

The proximate composition and fatty acids profile of green mussel (*Perna viridis*) purchased in landing centers of India was studied by Mohanty *et al.* (2016a). As shown in Table 1, green mussel presented a typical protein content of this group of bivalve molluscs. Several mussel species reported in FAO (2016) presented protein content in the range of 8.25-13.5 %. The decreasing order of fatty acids abundance was SFAs > PUFAs > MUFAs (Table 3) and palmitic acid was the most abundant (24.6 %), followed by oleic acid (15.4 %), EPA, and DHA. The elemental profile of green mussel determined by Mohanty *et al.* (2016b) showed that this bivalve is good source of Zn and excellent source of K, P, Mg, Fe, and Se as shown in Table 5. The molar Na:K ratio was 2.34. The levels of total EAAs and NEAAs in green mussel were 0.11 and 0.10 g 100 g^{-1}, respectively, as reported by Mohanty *et al.* (2014). The levels (μg 100 g^{-1}) of fat soluble vitamins in green mussel were: 2.85 vitamin A, 10.1 vitamin D, 67.1 vitamin E, and 2.2 vitamin K (Mohanty *et al.*, 2016b). According to reference values of AI and PRI for fat soluble vitamins above mentioned and the AI 70 μg day^{-1} for vitamin K (EFSA, 2017), the consumption of 100 g of raw green mussel contributes to 67.3 % of vitamin D. However, the contribution to the other vitamins is very modest.

Nutritional value of gastropods

Ekin *et al.* (2010) studied the fatty acid profile seasonal variations of the freshwater snail (*Melanopsis praemorsa*) collected in southeast Anatolia (Turkey). The Table 4 shows the average percentage of the three fatty acids groups, EPA, and n-3/n-6 ratio during the four seasons. However, the DHA percentage was only detected in autumn in both neutral and total body lipids. The highest level of SFAs was recorded in summer snails and the lowest in the winter snails which also had the highest MUFA content. Snails collected in the autumn showed the highest PUFA (39.98 %) and EPA (6.96 %) contents. Within PUFAs, linoleic acid was generally the predominant followed by EPA and linolenic acid (18:3 n-3). The n-3/n-6 ratio varied from 0.51 in the summer snails and 1.05 in the spring snails.

The fatty acid composition of the edible snail, coronate moon turban (*Lunella coronata*) collected from Shaikh Embrahin Island, Bahrain, was analyzed by Freije and Awadh (2010). As shown in Table 4, the decreasing order of the three fatty acid groups was SFAs > PUFAs > MUFAs with a residual level of DHA. Palmitic acid was the most abundant SFA (38.5 %) and palmitoleic the main MUFA (8.45 %). Linolenic acid (18.4 %) was the predominant PUFA but the percentages of linoleic acid (7.44) and ARA (6.52) were also significant. According to the authors, the lower concentration of PUFAs in relation to SFAs was due to environmental factors (warm water and high salinity) and food availability.

Trumpet shell (*C. lampas*). (Photo kindly provided by Dr. Helena Lourenço).
Buzina (*C. lampas*). (Fotografia amavelmente cedida pela Dr.ª Helena Lourenço)

The proximate composition of purple whelk (*Rapana venosa*) from the Black Sea is shown in Table 2 (Özden and Erkan, 2011). The high protein content of this whelk species was noteworthy. The elemental profile of this whelk is shown in Table 6. Purple whelk was a good source of P and excellent source of Mg, Fe, and Se as well as a low molar Na:K ratio (0.62). Concerning the amino acid content of purple whelk, it should be mentioned the levels (g 100 g^{-1}) of phenylalanine (Phe) (1.48) and Lys (1.00) within EAAs and proline (Pro) (3.26), Glu (1.78) and Arg (1.21) within NEAAs. Total of EAAs and NEAAs accounted for 5.55 and 10.35 g 100 g^{-1}, respectively.

Merdzhanova *et al.* (2014) evaluated the fatty acid profile and fat soluble vitamins of purple whelk also collected in the Bulgarian Black Sea coast. The fat content of this whelk was 0.55 % and its fatty acid percentages are presented in Table 4. The decreasing order of the three fatty acids groups is PUFAs > SFAs > MUFAs. Palmitic acid (24.21 %), oleic acid (7.21 %), and EPA were the main SFA, MUFA, and PUFA, respectively. Linoleic acid (11.82 %) was the second most abundant PUFA. The levels (µg 100 g^{-1}) of vitamins A, D_3, and E were 0.60, 3.90, and 925.4, respectively. Taking into account the EFSA (2017) reference values for these vitamins, the contribution of 100 g purple whelk consumption to vitamin D was 26 % but only 8.4 % to vitamin E and less than 1 % to vitamin A.

The seasonal variations in the proximate composition and fatty acids profile of purple whelk harvested in Bulgarian coast of Black Sea was also studied by Popova *et al.* (2017). This study took place between June and October and the average proximate composition is shown in Table 2. The meat yield (meat content (g)x100/live weight (g)) varied between 20.08 % in October and 25.52 % in July but its maximum protein content (24.09 %) was recorded in October. Similarly to proximate composition, significant seasonal changes of the lipid profile were observed and in Table 4 are presented the average percentages of the three fatty acids groups, EPA, DHA, and n-3/n-6 ratio. SFAs range was 36.33 and 45.17 % and palmitic acid (17.58-23.23 %) the main SFA followed by stearic acid (18:0) (12.28-15.30 %). In the MUFAs group, with a variation between 4.28 and 6.14 %, oleic acid (1.10-3.55 %) was the predominant. The variation range of PUFAs was 50.23-58.48 % and ARA showed the highest average percentage (15.66-17.59 %). Within PUFAs, it is to mention the relatively high level of docosapentaenoic acid (22:5 n-3, DPA) ranging from 13.73 to 14.30 %.

The nutritional value of meat and viscera from purple whelk collected in China was also characterized by Luo *et al.* (2017). The proximate composition shown in Table 2 put into evidence the higher protein and fat contents of visceral mass. It is also worth noting the similarity between the proximate composition obtained by these authors and that mentioned by Popova *et al.* (2017). Total EAAs and NEAAs (g 100 g^{-1}) in the purple whelk meat were 5.32 and 9.53, respectively. The levels of three most abundant amino acids - Leu, Lys and Val - were 1.25, 1.05, and 0.71, respectively. Edible tissues (meat and visceral mass) were valuable sources of EAAs, with the exception of methionine and cysteine. Moreover, meat purple whelk was rich in taurine (0.81 g 100^{-1}).

The meat (m) and hepatopancreas (h) of banded-dye murex (*Hexaplex trunculus*) harvested in Tunisian coast presents the proximate composition shown in Table 2 (Zarai *et al.*, 2011). As can be seen, both portions had high protein and fat contents. PUFAs were the major group followed by SFAs in both portions (Table 4). The main PUFAs in meat lipids were eicosatetraenoic acid (20:4n-3) and ARA with 11.92 % and 11.59 %, respectively. On the other hand, linoleic acid (8.88 %) was predominant in the hepatopancreas. In meat the levels of EAAs and NEAAs were 5.81 and 5.91 g 100 g^{-1}, respectively and in hepatopancreas they were 3.34 (EAAs) and 3.20 (NEAAs) g 100 g^{-1}. Lysine (1.32 g 100 g^{-1}) was the most abundant amino acid in meat and Gly (0.72 g 100 g^{-1}) in hepatopancreas. As shown in Table 6, the hepatopancreas are good source of P and both portions are excellent sources of Mg, Ca, Fe, Cu, and Zn. The molar Na:K ratio was 0.62 and 1.48 in meat and hepatopancreas, respectively.

The sea snail, spotted babylon (*Babylonia areolata*), reared in Malaysia and analyzed by Noordin *et al.* (2014), presents the proximate composition shown in Table 2, where it is noticeable its high protein content. The fatty acid composition (Table 4) shows that SFAs was the major group where palmitic acid represented about 50 % of total SFAs. Within MUFAs, oleic acid was the most abundant (9.85 %) followed by nervonic acid (24:1) (3.41 %). Linolenic acid was the major PUFA (6.71 %) followed by ARA (3.74 %) and DHA was not detected. The levels of total EAAs and NEAAs were 7.31 and 14.08 g 100 g^{-1}, respectively. Within EAAs, Leu (1.53 g 100 g^{-1}) and Lys (1.32 g 100 g^{-1}) were the most abundant and Glu (3.01 g 100 g^{-1}), Gly (2.28 g 100 g^{-1}), and Asp (2.25 g 100 g^{-1}) were the major NEAAs. The elemental profile of spotted Babylon in Table 6 shows this gastropod is good source of P and Fe and excellent source of Cu and Zn, with a molar Na:K ratio of 0.81.

The nutritional value of Captain Cook snails (*Cookia sulcata*) collected from Te Oka Bay (New Zealand) was studied by Mason *et al.* (2014). Snails were divided into two groups based on the entire snail weight: small (≤ 60 g whole animal weight) and large (> 60 g whole animal weight). As shown in Table 2, fat content of these snails was very low but smaller snails had higher fat content as well as ash content than large snails. The decreasing order of abundance of the three fatty acids groups in the snails of both sizes is SFAs > PUFAs > MUFAs as shown in Table 4. Palmitic acid (27.3 % in small snails and 22.6 % in large ones) was the main SFA and oleic acid the main MUFA (8.8 % in small snails and 8.0 % in large snails). The most abundant PUFAs were ARA (11.1 % in small snails and 11.7 % in large snails), followed by DPA (8.4 % in small snails and 7.6 % in large snails) and EPA. The average cholesterol content was 132 mg 100 g^{-1} which was not affected by the snail size. α-Tocopherol was the only isoform of vitamin E identified in Captain Cook snails at 2.16 and 3.71 mg 100 g^{-1} for the small and large snails, respectively. EAAs and NEAAs contents (g 100 g^{-1}) of small snails were 5.31 and 13.24, respectively. In the case of large snails, the total EAAs accounted for 5.92 g 100 g^{-1} and total NEAAs was 12.94 g 100 g^{-1}. The three major EAAs (g 100 g^{-1}) in small snails were tryptophan (1.27), Lys (1.20), and Leu (1.10), but in large snails the reverse order, 1.28 Leu, 1.13 Lys, and 1.05 triptophan, was obtained. High levels of taurine were measured in small and large snails, 1.93 and 1.84 g 100 g^{-1}, respectively. The elemental profile of small and large snails is presented in Table 6. Sulfur was the prevalent element in small (600 mg 100 g^{-1}) and large snails (550 mg 100 g^{-1}) and the Na:K ratio was 2.26 and 2.18 for small and large snails, respectively. Small and large snails are excellent sources of Mg, Fe, Cu, and Zn and small snails good sources of Ca.

Debnath *et al.* (2016) assessed the proximate (Table 2) and mineral (Table 6) compositions of four freshwater snails – *Brotia costula*, *Filopaludina bengalensis* (common banded pond snail), *Idiopoma dissimilis* and *Pila globosa* (apple snail) – collected from ponds, paddy fields and wetlands in Tripura, North-East India. The highest protein and fat contents and the lowest ash and carbohydrate contents were recorded in apple snail. *Brotia costula*, common banded pond snail, and *I. dissimilis* are good sources of Ca but apple snail is excellent source of this mineral. Common banded pond snail, *I. dissimilis*, and apple snail are good sources of Zn and all snails are excellent sources of Fe and Cu.

Tang *et al.* (2016) compared the proximate composition, amino acid and fatty acid profiles of cultured and wild whelks (*Brunneifusus ternatanus*) from Hainan Province (China). The cultured whelks contained higher levels of fat and ash than wild whelks (Table 2) but both cultured and wild whelks had high protein content. Stearic acid was the main SFA (19.27 % in cultured whelk and 18.86 % in wild whelk) and within MUFAs, oleic acid predominated (10.81 %) in cultured whelk but elaidic acid (18:1 *trans* n-9) was the most abundant (7.89 %) in wild whelk. The percentage of EPA was similar in cultured and wild whelks but the former whelks had lower DHA level than their wild counterparts (Table 4). The relatively low n-3/n-6 ratios were due to the presence of high percentages of ARA in cultured (18.57) and wild whelks (22.69). It was also noticeable the relatively high level of docosapentaenoic acid (22:5n-3, DPA) in cultured (11.21 %) and wild (8.71 %) whelks. The levels (g 100 g^{-1}) of EAAs and NEAAs in the foot muscle of cultured whelk were 7.76 and 16.28, respectively and in wild whelk these levels were 6.03 and 13.08, respectively. There were no statistically significant differences in the overall amino acids composition between the cultured and wild whelks. The decreasing order of abundance of the three major EAAs was Leu > Lys > Val, both in the cultured and wild whelks. The levels of taurine (g 100 g^{-1}) in cultured and wild whelks were 0.40 and 0.46, respectively.

Military turban (*Turbo militaris*), lightning turban (*Lunella undulate*) and twisted necklace (*L. torquata*) collected in northern New South Wales, Australia were studied to compare their proximate composition, fatty acid profile and mineral content of foot tissue (Lah *et al.*, 2017). The proximate composition of these whelks (Table 2) shows that twisted necklace had the highest fat content while the lowest protein content was recorded in the military turban. Table 4 presents the percentages of three fatty acids groups of these turban snails. Palmitic acid (> 21 %) was the most abundant in all species. Oleic acid was the main MUFA in the three turban snails and their percentages were in range 7.89-8.41. Amongst PUFA, DPA was the major fatty acid (> 13 %) and it is also noticeable the high percentage of ARA reaching 16.01 % in lightning turban. The elemental profile of these turban snails is shown in Table 6. Sulfur was the main element achieving the highest concentration (1232 mg 100 g^{-1}) in lightning turban and the lowest in military turban (837 mg 100 g^{-1}). Lightning turban had the lowest molar Na:K ratio (1.37) and military turban the highest (2.48). These turban snails are generally good or excellent sources of P, Mg, Ca, Fe, Cu, Zn, and Se as shown in Table 6.

In order to compare the nutritional value of long sea snail (*Hinia reticulata*), considered to have no commercial value, with common sea snail (*Nassarius mutabilis*) collected from the middle Adriatic Sea, Felici *et al.* (2020) analyzed samples of both species to determine their proximate composition, fatty acid and mineral profiles. The meat weight of common sea snail (1.38 g) was considerably higher in respect to long sea snail (0.97 g) and the meat yield of the former snail (48.59 %) was almost the double of the long snail. The proximate composition of these snails (Table 2) is the mean values obtained in samples collected in March and November. The composition of both species was very similar without remarkable seasonal and species differences. The average percentages of the three fatty acids groups of both species are shown in Table 4. The main difference of fatty acids profile between these two species was the higher level of n-6PUFAs (8.13 % in long sea snail) than in common sea snail (4.64 %) which was due to the prevalence of ARA (6.92 %) in the long snail. The average concentration of elements (Table 6) was similar in both snail species which are excellent sources of Se and good sources of Mg, Fe, and Zn, except long sea snail that is excellent source of Fe.

The proximate composition of strawberry conch (*Strombus luhuanus*) and spider conch (*Lambis lambis*) collected from Suli and Waisarisa waters (Indonesia) was determined by Leiwakabessy and Lewerissa (2017) as shown in Table 2. In general, both conch species from Suli tended to have higher moisture, protein, and fat contents compared to conchs collected in Waisarisa. The total EAAs and NEAAs (g 100 g^{-1}) of strawberry conch from Waisarisa were 5.67 and 9.69, respectively while these contents in Suli samples were 3.91 and 6.53 g 100 g^{-1} for total EAAs and NEAAs, repectively. In the case of spider conch from Waisarisa, total EAAs and NEAAs were 6.29 and 15.93 g 100 g^{-1}, respectively. The samples of this species collected in Suli presented 6.29 and 8.88 g 100 g^{-1} for total EAAs and NEAAs, respectively. Total EAAs of strawberry conch from Waisarisa was higher than that of its counterpart from Suli but they had very close EAAs/NEAAs ratio (0.60). On the other hand, spider conch from Waisarisa and Suli had similar total content of EAAs but the EAAs/NEAAs ratio in Waisarisa spider conch was slightly lower (0.65) than that recorded in samples from Suli (0.71).

Latuihamallo *et al.* (2015) studied the effect of three different culture conditions (floating cage, longline, and laboratory) on the chemical composition of abalone (*Haliotis squamata*). The average proximate composition is shown in Table 2. The high protein and low fat content are the main aspects to be highlighted in the proximate composition of this abalone species. The percentage ranges of the main constituents were: 67.53-69.07 % moisture, 19.46-28.63 % protein, 0.16-0.20 % fat, 6.76-7.53 % ash, and 4.29-5.05 crude fiber. The range of variation (as percentage of fresh muscle) of fatty acids was: 9.07-10.15 (SFAs), 3.19-4.54 (MUFAs), and 2.70-3.63 (PUFAs). The lowest level of PUFAs was recorded in abalone produced in longline system but it had the highest EPA content (1.22 mg 100 g^{-1}). Only a residual level of DHA (0.14 mg 100 g^{-1}) was detected in abalones produced in the laboratory experiment. The levels of amino acids (g 100 g^{-1}) of abalone produced in different conditions were the following: floating cage (9.53 EAAs and 7.31 NEAAs), longline (8.24 EAAs and 6.38 NEAAs), and laboratory (11.02 EAAs and 9.40 NEAAs).

Summing up

The contents of the main constituents of bivalve molluscs edible fraction show the following ranges of variation: 75.18-84.91 % moisture; 7.34-18.80 % protein; 0.11-3.15 % fat; and 1.01-3.08 % ash. In the case of gastropods, their protein, fat and ash contents attain higher percentages than in bivalve molluscs and their variation ranges are: 11.18-23.75 % protein; 0.18-8.46 % fat; and 0.93-7.21 % ash. On the other hand, lower moisture contents are recorded in gastropods (64.94-78.00 %). In the majority of bivalve molluscs, the decreasing percentage of the three fatty acid groups is PUFAs>SFAs>MUFAs whereas in the majority of gastropods the order is: SFAs>PUFAs>MUFAs. All bivalve molluscs have n-3/n-6 ratio values higher than one and its variation range is: 1.40-18.20. This ratio is below one in a few gastropods species and varies from 0.64 to 4.98. All species of bivalve molluscs and gastropods where Se was determined are excellent sources of this element. Many bivalve molluscs species are good or excellent sources of Mg and Ca. All gastropods species are excellent sources of Fe and many of them are good or excellent sources of Mg, Ca, Cu, and Zn.

The reproductive cycle of bivalves is one of the main factors that influence their proximate composition. They generally accumulate and utilize protein, lipids and carbohydrates and attain high condition index before the spawning period. After this period, a general decrease of these constituent levels is observed.

Factors used for converting the percentage of fatty acid to fatty acid in mg 100 g^{-1} edible portion

In order to convert the percentage of fatty acid to fatty acid in mg 100 g^{-1} edible portion (EP) the following equation was used:

Total fatty acid (mg 100 g^{-1} EP) = % fatty acid x XFA x F x 10

where XFA is the conversion factor and F the total lipid content (g 100 g^{-1} EP).

XFA was calculated using the formula for molluscs (Weihrauch *et al.*, 1977):

XFA (g g^{-1}) = 0.956 - 0.296/total lipid content.

For molluscs with total lipid content lower than 0.55 g 100 g^{-1} EP, XFA = 0.417 was used according to Nowak *et al.* (2014).

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Table 1 - Proximate chemical composition of bivalve molluscs (g 100 g^{-1}).

Tabela 1 – Composição química aproximada de moluscos bivalves (g 100 g^{-1}).

Common name	Scientific name	Moisture	Protein	Fat	Carbohydrate	Ash	Source
Clams							
Striped venus	*Chamelea gallina*	83.50	10.11	2.76	-	1.61	Arik Colakoglu *et al.* (2011)
Geoduck clam (mantle)	*Panopea abrupta*	74.82	14.32	2.5	6.92	1.37	Oliveira *et al.* (2011)
Geoduck clam (siphon)		80.37	15.29	0.73	2.19	1.42	
Carpet shell clam	*Ruditapes decussatus*	84.91	7.34	0.83	1.23	3.08	Aníbal *et al*. (2011)
Blood cockle	*Anadara granosa*	78.94	15.99	1.93	1.51	1.63	Nurnadia *et al.* (2011)
Asiatic hard clam	*Meretrix meretrix*	78.33	10.67	2.99	-	1.68	Chen *et al.* (2012)
Paphia	*Paphia papilionacea*	82.07	10.19	2.64	-	1.72	Chen *et al.* (2012)
Poker chip venus (f)	*Meretrix lusoria*	76.23	12.75	1.58	7.89	1.23	Karnjanapratum *et al.* (2013)
Poker chip venus (m)		84.22	9.09	3.53	1.20	1.94	
Poker chip venus (v)		80.89	9.61	6.58	0.32	2.58	
Granular ark	*Tegillarca grabosa*	78.8	12.3	1.6	4.4	2.0	Nguyen *et al.* (2017)
Inflated ark (mu)	*Anadara broughtonii*	78.55	16.50	1.12	2.67	1.16	Tabakaeva *et al.* (2018)
Inflated ark (ma)		80.70	13.14	0.87	4.23	1.06	
Inflated ark (ad)		78.94	15.82	1.37	2.92	0.95	
Sunray surf clam (mu)	*Mactra chinensis*	80.16	14.55	0.53	2.87	1.89	Tabakaeva *et al.* (2018)
Sunray surf clam (ma)		82.32	12.20	0.43	3.60	1.45	
Sunray surf clam (ad)		81.35	13.13	0.73	3.18	1.61	
Oysters							
Oyster	*Ostrea* spp.	77.73	13.31	1.24	6.45	1.27	Nurnadia *et al.* (2011)
Suminoe oyster	*Crassostrea rivularis*	78.49	8.60	1.67	-	1.57	Chen *et al.* (2012)
Mangrove oyster (summer)	*C. rhizophorae*	82.5	11.0	2.7	2.0	1.7	Lira *et al.* (2013)
Mangrove oyster (winter)		82.8	13.0	2.5	0.6	1.5	
Indian backwater oyster	*C. madrasensis*	82.64	9.41	3.25	3.2	1.01	Asha *et al.* (2014)

Table 1 (cont.)

Common name	Scientific name	Moisture	Protein	Fat	Carbohydrate	Ash	Source
Indian backwater oyster	*C. madrasensis*	80.1	16.8	2.7	-	1.3	Mohanty *et al.* (2016a)
Scallops							
Smooth scallop	*Flexopecten glaber*	84.04	11.79	0.84	-	2.15	Özden and Erkan (2011)
Lion’s paw scallop	*Nodipecten subnodosus*	75.18	17.88	0.11	7.08	1.40	Jiménez-Ruiz *et al.* (2012)
Great Atlantic scallop (fresh)	*Pecten maximus*	76.6	18.8	1.0	4.5	1.4	Manthey-Karl *et al.* (2015)
Great Atlantic scallop (frozen)		81.2	14.1	0.8	3.5	1.4	
Atlantic sea scallop (frozen)	*Placopecten magellanicus*	80.5	15.0	0.6	2.9	1.7	Manthey-Karl *et al.* (2015)
Mussels							
Common mussel	*Unio terminalis*	80.36	11.87	2.55	-	1.68	Ersoy and Şereflişan (2010)
Black river mussel	*Potamida littoralis*	81.69	11.97	1.05	-	1.61	Ersoy and Şereflişan (2010)
Freshwater mussel	*Lamellidens marginalis*	80.03	8.30	1.02	8.01	2.63	Haldar *et al.* (2014)
Mediterranean mussel	*M. galloprovincialis*	82.95	9.84	2.33	-	2.96	Bongiorno *et al.* (2015)
Duck mussel (f)	*Anodonta anatina*	78.22	15.90	1.19	4.23	0.46	Sohail *et al.* (2016)
Duck mussel (m)	*A. anatina*	75.12	10.78	0.27	8.54	5.29	
Duck mussel (g)	*A. anatina*	78.96	6.44	0.53	6.55	7.51	
Green mussel	*Perna viridis*	83.5	11.0	1.7	-	1.4	Mohanty *et al.* (2016a)

ad – adductor; f – foot; g – gills; m, mu – muscle; ma - mantle; v -viscera

Table 2 – Proximate chemical composition of gastropods (g 100 g^{-1}).

Tabela 2 – Composição química aproximada de gastrópodes (g 100 g^{-1}).

Common name	Scientific name	Moisture	Protein	Fat	Carbohydrate	Ash	Source
Purple whelk	*Rapana venosa*	65.78	21.08	2.54	8.64	1.96	Özden and Erkan (2011)
Purple whelk	*R. venosa*	73.61	21.45	0.67	-	2.32	Popova *et al.* (2017)
Purple whelk (m)	*R. venosa*	70.75	19.15	0.62	-	1.72	Luo *et al.* (2017)
Purple whelk (v)		61.46	24.01	5.44	-	1.71	
Banded dye-murex (m)	*Hexaplex trunculus*	67.05	15.75	9.00	-	4.99	Zarai *et al.* (2011)
Banded dye-murex (h)		51.06	22.75	15.75	-	4.10	
Spotted babylon	*Babylonia areolata*	67.1	22.4	2.7	2.4	5.4	Noordin *et al.* (2014)
Captain Cook snail (S)	*Cookia sulcata*	77.7	17.5	1.0	-	2.0	Mason *et al.* (2014)
Captain Cook snail (L)		78.0	17.6	0.7	-	1.8	
Freshwater snail	*Brotia costula*	69.86	12.91	0.82	9.12	7.28	Debnath *et al.* (2016)
Common banded pond snail	*Filopaludina bengalensis*	65.80	13.14	0.96	11.97	8.11	Debnath *et al.* (2016)
Freshwater snail	*Idiopoma dissimilis*	67.73	11.18	0.99	11.96	8.15	Debnath *et al.* (2016)
Apple snail	*Pila globosa*	73.80	15.59	1.15	5.62	3.82	Debnath *et al.* (2016)
Whelk (wild)	*Brunneifusus ternatanus*	71.64	22.57	3.09	-	0.93	Tang *et al.* (2016)
Whelk (cultured)		64.94	22.74	4.48	-	1.25	
Military turban	*Turbo militaris*	73.08	16.19	5.57	3.02	2.14	Lah *et al.* (2017)
Lightning turban	*Lunella undulata*	70.83	18.49	5.20	3.51	1.97	Lah *et al.* (2017)
Twisted necklace	*L. torquata*	68.50	18.03	8.46	2.92	2.10	Lah *et al.* (2017)
Long sea snail	*Hinia reticulata*	76.25	22.02	1.53	-	1.72	Felici *et al.* (2020)
Common sea snail	*Nassarius mutabilis*	73.73	21.24	1.79	-	1.71	Felici *et al.* (2020)
Strawberry conch (Su)	*Strombus luhuanus*	73.42	17.94	1.41	4.58	2.65	Leiwakabessy and Lewerissa (2017)
Strawberry conch (Wa)		72.52	17.45	1.25	4.21	4.57	

Table 2 (cont.)

Common name	Scientific name	Moisture	Protein	Fat	Carbohydrate	Ash	Source
Spider conch (Su)	*Lambis lambis*	77.90	16.97	1.29	2.16	1.68	Leiwakabessy and Lewerissa (2017)
Spider conch (Wa)		77.20	15.52	1.23	3.21	2.84	
Abalone	*Haliotis squamata*	68.41	23.25	0.18	4.51	7.21	Latuihamallo *et al.* (2015)

h – hepatopancreas; m – meat; v – viscera; L – large; S – small; Su – Suli; Wa - Waisarisa

Table 3 – Total content of SFAs, MUFAs, PUFAs, EPA, and DHA as percentage of total fatty acids and in mg 100 g^{-1} (in brackets) of several bivalve molluscs species.

Tabela 3 - Teores de SFA, MUFA, PUFA, EPA e DHA expressos em percentagem do total de ácidos gordos e em mg 100 g^{-1} (entre parêntesis) de várias espécies de bivalves.

Common name	SFA	MUFA	PUFA	EPA	DHA	n-3/n-6	Source
Clams							
Geoduck clam (m)	25.39 (531.7)	17.40 (364.4)	51.03 (1068.6)	25.16 (526.9)	17.36 (363.5)	13.3	Oliveira *et al.* (2011)
Geoduck clam (s)	24.38 (98.0)	18.16 (73.0)	51.82 (208.3)	20.26 (81.4)	21.46 (86.2)	11.0	
Poker chip venus (f)	30.46 (369.9)	21.92 (266.2)	47.62 (578.3)	5.54 (67.3)	16.47 (200.0)	1.36	Karnjanapratum *et al.* (2013)
Poker chip venus (m)	28.39 (874.0)	22.43 (690.5)	49.18 (1514.1)	4.75 (146.2)	14.95 (460.3)	0.99	
Poker chip venus (v)	33.58 (2012.9)	19.58 (1173.7)	46.84 (2807.8)	7.11 (426.2)	13.33 (799.1)	1.58	
Granular ark	25.8 (318.3)	24.8 (305.9)	49.3 (608.2)	14.8 (182.6)	10.2 (125.8)	4.4	Nguyen *et al.* (2017)
Oysters							
Mangrove oyster (summer)	(920.9)	(233.8)	(605.7)	(196.6)	(196.6)	6.13	Lira *et al.* (2013)
Mangrove oyster (winter)	(876.6)	(152.3)	(740.3)	(178.9)	(357.7)	7.71	
Indian backwater oyster	(188.10)	(80.12)	(261.58)	(112.0)	(91.6)	4.66	Asha *et al.*(2014)
Indian backwater oyster	47.1 (1076.3)	23.8 (543.9)	28.8 (658.1)	7.3 (166.8)	7.4 (169.1)	1.7	Mohanty *et al.* (2016a)

Table 3 (cont.)

Common name	SFA	MUFA	PUFA	EPA	DHA	n-3/n-6	Source
Scallops							
Great Atlantic scallop (fresh)	29.6 (195.4)	7.1 (46.9)	52.8 (348.5)	19.0 (125.4)	26.1 (172.3)	10.8	Manthey-Karl *et al.* (2015)
Great Atlantic scallop (frozen)	29.3 (137.4)	7.4 (34.7)	47.8 (224.1)	14.8 (69.4)	26.1 (122.4)	15.2	
Atlantic sea scallop (frozen)	27.8 (77.2)	9.4 (26.1)	47.0 (130.5)	20.3 (56.4)	21.3 (59.1)	18.2	Manthey-Karl *et al.* (2015)
Mussels							
Common mussel	32.13 (688.2)	19.60 (419.8)	37.08 (794.2)	12.00 (257.0)	7.12 (152.5)	1.54	Ersoy and Şereflişan (2010)
Black river mussel	30.21 (213.8)	22.84 (161.7)	32.41 (229.4)	8.90 (63.0)	5.87 (41.5)	1.40	Ersoy and Şereflişan (2010)
Freshwater mussel	49.43 (335.7)	22.18 (150.6)	28.62 (194.4)	3.43 (23.3)	9.55 (64.9)	-	Haldar *et al.* (2014)
Mediterranean mussel	41.91 (809.5)	25.49 (492.3)	32.60 (629.7)	3.35 (64.7)	15.25 (294.6)	2.00	Merdzhanova *et al.* (2014)
Green mussel	34.9 (463.9)	23.4 (311.0)	28.6 (380.2)	10.2 (135.6)	9.5 (126.3)	5.3	Mohanty *et al.* (2016a)

f – foot; m – mantle; s – siphon; v – viscera.

Table 4 – Total content of SFAs, MUFAs, PUFAs, EPA, and DHA as percentage of total fatty acids and in mg 100 g^{-1} (in brackets) of several gastropods species.

Tabela 4 - Teores de SFA, MUFA, PUFA, EPA e DHA expressos em percentagem do total de ácidos gordos e em mg 100 g^{-1} (entre parêntesis) de várias espécies de gastrópodes.

Common name	SFA	MUFA	PUFA	EPA	DHA	n-3/n-6	Source
Freshwater snail (*Melanopsis praemorsa*)	43.65	25.21	31.33	4.24	2.02	0.78	Ekin *et al.* (2010)
Coronate moon turban (*Lunella coronata*)	49.25	9.60	40.92	7.81	0.23	1.92	Freije and Awadh (2010)
Marine snail (m)	33.44 (2778.2)	9.84 (817.5)	58.37 (4849.4)	5.73 (476.0)	8.84 (734.4)	1.68	Zarai *et al.* (2011)
Marine snail (h)	34.81 (5138.3)	17.05 (2516.8)	48.17 (7110.4)	7.76 (1145.5)	7.86 (1160.2)	1.37	
Purple whelk	38.06	14.56	47.38	12.33	8.53	1.35	Merdzhanova *et al.* (2014)
Purple whelk	39.85 (137.3)	5.21 (17.9)	54.84 (188.9)	10.30 (35.5)	11.44 (39.4)	2.04	Popova *et al.* (2017)
Spotted babylon	30.56 (698.4)	23.19 (529.9)	23.21 (530.4)	2.56 (58.5)	-	1.17	Noordin *et al.* (2014)
Captain Cook snails (S)	46.6 (307.6)	14.9 (98.3)	32.3 (213.2)	4.9 (32.3)	0.6 (4.0)	1.1	Mason *et al.* (2014)
Captain Cook snails (L)	42.2 (157.5)	10.8 (40.3)	36.3 (135.5)	6.0 (22.4)	0.6 (2.2)	1.0	
Whelks (w)	22.75 (604.7)	20.64 (548.6)	55.41 (1472.8)	6.41 (170.4)	6.01 (159.7)	0.64	Tang *et al.* (2016)
Whelks (c)	26.54 (1058.1)	21.51 (857.6)	53.83 (2146.1)	7.28 (290.2)	1.87 (74.6)	0.84	
Military turban	39.83 (2003.0)	15.05 (756.9)	45.12 (2269.0)	3.70 (186.1)	0.37 (18.6)	1.09	Lah *et al.* (2017)

Table 4 (cont.)

Common name	SFA	MUFA	PUFA	EPA	DHA	n-3/n-6	Source
Lightning turban	39.95 (1867.7)	14.83 (693.3)	45.22 (2114.1)	4.63 (216.5)	0.53 (24.8)	1.15	Lah *et al.* (2017)
Twisted necklace	48.95 (3814.1)	14.45 (1125.9)	36.60 (2851.8)	5.29 (412.2)	0.80 (62.3)	1.36	Lah *et al.* (2017)
Long sea snail	46.43 (541.7)	20.17 (235.3)	29.96 (349.5)	12.89 (150.4)	5.00 (58.3)	2.86	Felici *et al.* (2020)
Common sea snail	47.11 (666.7)	22.69 (321.1)	27.77 (393.0)	13.86 (196.2)	5.45 (77.1)	4.98	Felici *et al.* (2020)

c - cultured; h - hepatopancreas; m - meat; w – wild; L – large; S – small.

Table 5 – Elemental profile (mg 100 g^{-1} or μg 100 g^{-1}) of bivalve molluscs.
Tabela 5 - Perfil mineral de várias espécies de bivalves (mg 100 g^{-1} ou μg 100 g^{-1}).

	Na	K	P	Mg	Ca	Fe	Cu	Zn	Mn	I	Se	Source
Clams												
Striped venus	-	-	-	-	-	0.25-11.42	0.07-0.53	1.31-7.78	0.03-0.59	-	-	Arik Colakoglu *et al.* (2011)
Geoduck clam (m)	99.8	251.8	*201.4*	*50.4*	25.2	1.8	**0.2**	**6.7**	<0.1	-	**70.5***	Oliveira *et al.* (2011)
Geoduck clam (s)	118.0	314.1	*137.4*	39.3	19.6	1.0	0.02	0.57	<0.1		**17.7***	
Poker chip venus (f)	107.27	197.97	-	36.37	39.85	**3.78**	0.074	*2.13*	-	-	-	Karnjanapratum *et al.* (2013)
Poker chip venus (m)	259.70	155.64	-	*57.87*	*149.20*	**8.26**	0.070	0.91	-	-	-	
Poker chip venus (v)	234.23	199.21	-	*51.04*	95.35	**27.61**	*0.125*	*2.03*	-	-	-	
Cockle	113.89	12.35	-	**1450.50**	41.32	**6.21**	*0.13*	0.82	0.21	-	-	Nurnadia *et al.* (2013)
Granular ark	279.0	226.9	*138.1*	*80.7*	107.7	**7.9**	**0.2**	*2.6*	1.0	-	-	Nguyen *et al.* (2017)
Inflated ark (mu)	327.5	408.6	-	**108.8**	**332.5**	10.39*	0.10*	4.32*	2.06*	-	-	Tabakaeva *et al.* (2018)
Inflated ark (ma)	268.8	210.0	-	**87.5**	114.7	8.24*	0.07*	4.10*	2.17*	-	-	
Inflated ark (ad)	284.9	311.3	-	**88.3**	*166.5*	5.55*	0.04*	3.90*	1.66*	-	-	
Sunray surf clam (mu)	259.3	454.9	-	*78.4*	*187.7*	7.93*	0.05*	3.49*	2.36*	-	-	Tabakaeva *et al.* (2018)
Sunray surf clam (ma)	200.5	215.0	-	**92.8**	*142.0*	8.92*	0.04*	2.66*	1.54*	-	-	
Sunray surf clam (ad)	277.9	324.9	-	*72.3*	*199.0*	6.66*	0.03*	3.34*	1.93*	-	-	
Oysters												
Oyster	115.23	9.82	-	**1534.80**	48.02	**3.95**	**1.26**	1.47	0.18	-	**-**	Nurnadia *et al.* (2013)
Indian backwater oyster	166.3	390.4	*145*	nd	**422**	**3.7**	nd	0.43	3.9	-	**30***	Mohanty *et al.* (2016b)
Scallops												
Smooth scallop	439.6	360.9	*223.4*	**88.4**	*171.7*	**15.7**	-	-	-	0.20	**327.6***	Özden and Erkan (2011)
Great Atlantic scallop (fresh)	100.5	400.6	-	34.6	65.5	-	-	1.4	-	-	**30***	Manthey-Karl *et al.* (2015)
Great Atlantic scallop (frozen)	145.8	229.8	-	26.8	45.0	-	-	1.7	-	-	**20***	

Table 5 (cont.)

	Na	K	P	Mg	Ca	Fe	Cu	Zn	Mn	I	Se	Source
Atlantic sea scallop (frozen)	279.7	290.2	-	32.2	38.8	-	-	1.0	-	-	**20***	Manthey-Karl *et al.* (2015)
Mussels												
Mediterranean mussel	162.4	40.8	4.9	13.8	4.9	1.19	0.05	0.53	0.07	-	**60***	Bongiorno *et al*. (2015)
Duck mussel (f)	114.8	61.0	**271.1**	-	*215.8*	-	**1.6**	**8.5**	4.7	-	-	Sohail *et al.* (2016)
Duck mussel (m)	270.6	42.1	**692.1**	-	**4683.8**	-	**3.0**	**21.2**	720.7	-	-	
Duck mussel (g)	226.1	84.9	**4710.0**	-	**17769.8**	-	**2.9**	**22.2**	2351.9	-	-	
Green mussel	1810.2	**1310.9**	**522.6**	**251**	nd	**6.3**	**0.2**	*2.59*	0.6	-	**40***	Mohanty *et al*. (2016b)
DV	-	4700	1250	420	1300	18	0.9	15	-	-	55	

* Values in μg 100 g^{-1}; nd – not detected; f – foot; g – gills; m – mantle; s – siphon; v – viscera. DV - daily value in mg 100 g^{-1} except Se (μg 100 g^{-1}). Daily values are based on the Available Dietary Guidelines from the USDA National Nutritional Database as reported by Wright *et al.* (2018). A “good” nutritional source contributes 10-19 % of the DV whereas the contribution of an “excellent” source is 20 % or higher of the DV. Values in italics are “good sources” and values in bold are “excellent sources”.

Table 6 – Elemental profile (mg 100 g^{-1} or μg 100 g^{-1} for Se) of gastropods.

Tabela 6 - Perfil mineral de várias espécies de gastrópodes (mg 100 g^{-1} ou μg 100 g^{-1} no caso do Se).

	Na	K	P	Mg	Ca	Fe	Cu	Zn	Mn	I	Se	Source
Purple whelk	132.2	362.0	*192.2*	**276.8**	125.6	**4.66**	-	-	-	0.14	**776.2**	Özden and Erkan (2011)
Marine snail (m)	196.10	224.80	95.20	**178.70**	**674.40**	**8.10**	**3.10**	**112.80**	0.69	-	-	Zarai *et al.* (2011)
Marine snail (h)	27.8	235.60	*162.90*	**119.70**	**860.00**	**17.80**	**15.03**	**225.20**	1.06	-	-	
Spotted babylon	107.5	225.5	*132.9*	27.5	26.7	*2.82*	**0.95**	**3.35**	0.06	-	-	Noordin *et al.* (2014)
Captain Cook snails (S)	400	300	110	**330**	*140*	**5.81**	**0.64**	**3.22**	0.13	-	-	Mason et al. (2014)
Captain Cook snails (L)	410	280	90	**310**	70	**7.41**	**0.78**	**3.82**	0.12	-	-	
Freshwater snail	-	161.80	116.87	17.93	*236.07*	**5.07**	**0.73**	1.47	3.13	-	-	Debnath *et al.* (2016)
Common banded pond snail	-	143.80	93.53	21.43	*227.13*	**4.81**	**0.69**	*1.57*	3.17	-	-	Debnath *et al.* (2016)
Freshwater snail	-	118.20	55.39	13.37	*142.50*	**4.03**	**0.41**	*2.07*	4.27	-	-	Debnath *et al.* (2016)
Apple snail	-	182.28	121.17	18.50	**312.50**	**6.86**	**0.84**	*2.17*	5.33	-	-	Debnath *et al.* (2016)
Military turban	400	273	122	*77*	61	*1.93*	**0.22**	1.22	0.05	-	**177**	Lah *et al.* (2017)
Lightning turban	270	333	*164*	*65*	44	**4.11**	0.06	*1.52*	0.05	-	**144**	Lah *et al.* (2017)
Twisted necklace	301	305	*153*	*69*	*239*	*3.24*	*0.11*	1.40	0.05	-	**177**	Lah *et al.* (2017)
Long sea snail	-	310	-	*54*	33	**4.4**		*1.5*	-	-	**35**	Felici *et al.* (2020)
Common sea snail	-	290	-	*51*	32	*3.1*		*1.7*	-	-	**24**	Felici *et al.* (2020)
DV	-	4700	1250	420	1300	18	0.9	15	-	-	55	

h – hepatopancreas; m – meat. S - small; L - large; DV – daily value. DV - daily value in mg 100 g^{-1} except Se (μg 100 g^{-1}). Daily values are based on the Available Dietary Guidelines from the USDA National Nutritional Database as reported by Wright *et al.* (2018). A “good” nutritional source contributes 10-19 % of the DV whereas the contribution of an “excellent” source is 20 % or higher of the DV. Values in italics are “good sources” and values in bold are “excellent sources”.

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