# Effect of sex and tissue on fatty acid composition in the meat of Blue Swimming Crab (*Portunus pelagicus*) from the Persian Gulf, Iran

**Javaheri Baboli M.[1*]; Velayatzadeh M.[2]; Roomiani L.[1]; Khoramabadi A.[1]**

Received: July 2014 Accepted: September 2015

**Abstract**

Fatty acids composition in edible parts of Blue Swimming Crab (*Portunus pelagicus*) caught in the Persian Gulf close to the Bushehr Province were investigated. Among saturated fatty acids (SFA), the 16:0 and 18:0 fatty acids were the most two dominant fatty acids in meat tissues that analyzed. 18:1n-9 and 16:1n-7 were the major fatty acids among the MUFAs of male and female crab. The main PUFAs in lipids of crab meat were 20:5n-3 and 22:6n-3. The n-3 PUFA content was highest in female claw meat (20.26%) and lowest in male meat (11.31%), respectively. The sex and tissue had a significant influence on the EPA, DHA and n-3 HUFA. The highest amounts of DHA and the favorable n-6/n-3 ratio in the meat of blue swimming crab indicate that the claw and breast meat is a very omega-rich edible portion of crab body.

**Keywords:** *Portunus pelagicus*, Fatty acids, Tissue, Sex, Persian Gulf.

1- Department of Fisheries, College of Agricultural Sciences and Natural Resources, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran

2- Young Researchers and Elite Club, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran

* Corresponding author's Email: mehranjavaheri@gmail.com

## Introduction

Crabs are a large group of aquatic invertebrates and due to local food and export of their meat, those are one of the most valuable commercial fisheries products (Latyshev *et al*., 2009). Poturnid crabs and big sea crabs are the most important members of the sea food chain. While they feed on detritus, fish, algae, plants, cephalopods, decapods and annelids, they serve as preys to mammals, birds and fishes (Hall *et al*., 2006). The blue swimmer crab, *P. pelagicus* is a commercially important crab species widely distributed in the coastal and estuarine areas, particularly in the tropical and subtropical regions (Romano and Zeng, 2008). This crab, as an economically important crustacean, has been distributed abundantly until the last few years in the Persian Gulf.

Seafoods are rich sources of n-3 fatty acids, especially eicosa-pentaenoic acid (EPA) and docosa-hexaenoic acid (DHA) (Lombardo *et al*., 2007), which is very important due to the health benefits (Stansby and Hall, 1967; Laakso *et al*., 1990). The n-3 polyunsaturated fatty acids (PUFAs) are rich in fish and shellfish oils that can help to prevent and treat heart disease, cancer, arthritis, high blood pressure and diabetes (Hunter and Robert, 2000; Valfre *et al*., 2003).

It is well known that arachidonic acid, EPA and DHA are the major components of cell membrane phospholipids and are the predominant HUFA for the central nervous system (Innis, 2000). Because human beings have an inadequate ability to biosynthesize these HUFA under conditions of rapid growth or augmented loss, these HUFA are considered conditionally essential fatty acids, especially for fetuses, infants, adolescents, and pregnant or lactating women (Muskiet *et al.*, 2006; Kuley *et al*., 2007).

Seafood products, including crustaceans, may promote human health. Crustaceans contain a large range of PUFAs in their tissues. The fatty acid compositions of different crab species have been reported to be different in various parts of the world (Celik *et al*., 2004; Ramirez *et al*., 2005; Ying *et al*., 2006; Chen *et al*., 2007; Latyshev *et al*., 2009; Barrento *et al*., 2010; Ayas and Ozogul, 2011).

The purpose of the present study was to determine the fatty acids content of claw and breast of male and female in *P. pelagicus*, caught in the north part of the Persian Gulf. Studies on fatty acid composition of fish and shellfish meat consumed in the Persian Gulf are limited, also the aim of this study was to determine the fatty acids value of *P. pelagicus* muscle (claw and breast) to be use as food for humans.

## Materials and methods

### *Sampling*

The crabs, *P. pelagicus*, were caught by dip net from coasts of the Persian Gulf in Bushehr Province (Genaveh Port), in 2012. After catching, they were transferred to the laboratory alive. The mean width and length of carapace were 17.00±0.20 cm and 8.22±0.10 cm for males and 16.30±0.30 cm and 9.10±0.10 cm for females, respectively. The mean weights of male crab and female crab were 285± 13.00 g and 265± 8.50 g, respectively. Meat from breast and claw portions of

crabs was separated by hand and analyzed to determine the fatty acid composition.

*Fatty acids analysis*

Total lipids were extracted by the method of Folch *et al*. (1957) and measured gravimetrically. The formation of FAME was carried out according to the procedure described by Desvilettes *et al*. (1994). The sample was saponified with methanolic sodium hydroxide and the fatty acids were esterified with methanolic sulfuric acid. FAME were analyzed with a 6890 N GC–FID (Agilent Technologies, Wilmington, DE, USA) fitted with a J &W DB-Wax capillary column (30 m, 0.25 mm i.d., 0.25 mm film thickness), a split–splitless injector with Agilent tapered liner (4 mm i.d.) and flame ionization detector. The initial column temperature was maintained at 100ºC for 1 min and then raised at 25ºC/min to 190ºC and held for 10 min and then raised to 220ºC and held for 5 min. Nitrogen was used as carrier and makeup gas, at flow rates of 1.0 and 45 mL/ min, respectively. The injector and detector temperature were held at 250 and 260ºC, respectively. Chemstation software was used for online data collection and processing. Individual FAME was identified by comparison with known standards (Sigma, Chemical Co. St. Louis).

*Nutritional quality*

The propensity of crab's tissue to promote the incidence of coronary heart disease, atherogenic (IA) and thrombogenic (IT) indices were calculated using the Ulbricht and Southgate (1991) equations.

$$IT=\frac{14:0+16:0+18:0}{0.5(MUFA)+0.5(n-6)+3(n-3)+(n-3/n-6)}$$

$$IA=\frac{12:0+4(14:0)+16:0}{(n-6+n-3)PUFA+MUFA}$$

*Statistical analysis*

Statistical analysis of data was carried out with the SPSS 20. A Student's t-test (independent variables) was used to check for significant differences between two means, at 95% level to evaluate the effects of sex on the chemical compositions of blue crab.

**Results**

The results showed that fatty acid profiles were significantly different between claw meat and breast meat of the male and female *P. pelagicus* (Table 1). The highest C14:0, C14:1n-5, C16:0, C16:1n-7, C18:1n-7, C20:4n-6, C22:5n-3, saturation fatty acid (SFA), ratio of EPA to DHA and IT in breast meat of the females were higher than in males ($p$<0.05) (Table 2), but levels of C18:0, C18:1n-9, C18:2n-6cis, C20:0, C18:3n-6, C18:4n-3, C20:3n-6, C20:3n-3, C20:5n-3, C22:5n-6, MUFA, n-6 and IA in breast meat of the males were higher than in females.

The content of total saturated fatty acids, C16:0, C14:0, C14:1n-5, C18:0, C18:1n-7, C22:5n-3, C22:6n-3, DHA/ EPA and IT in male was higher in claw than the breast meat, but levels of C16:1n-7, C18:1n-9, C18:2n-6cis, C20:0, C18:3n-6, C18:4n-3, C22:0, C20:3n-6, C20:3n-3, C20:4n-6, C20:5n-3, C22:5n-6, MUFA, PUFA, n-3, n-6, n-3/n-6 and IA were higher than in the breast meat.

**Table 1: Fatty acid composition in breast and claw meats of *Portunus pelagicus* (percent of total fatty acids).**

| Fatty acid | Male claw | Female claw | Male breast | Female breast |
|---|---|---|---|---|
| **C14:0** | 3.99±0.05$^{b}$ | 2.16±0.03$^{a}$ | 2.66±0.66$^{a}$ | 4.32±0.16$^{b}$ |
| **C16:0** | 32.31±0.64$^{a}$ | 21.1±0.18$^{b}$ | 22.65±0.15$^{c}$ | 28.05±0.29$^{d}$ |
| **C18:0** | 11.25±0.07$^{a}$ | 15.98±0.13$^{b}$ | 10.69±0.18$^{c}$ | 10±0.13$^{d}$ |
| **C20:0** | 0.18±0.05$^{a}$ | 0.67±0.01$^{b}$ | 0.51±0.02$^{c}$ | 0.16±0.00$^{a}$ |
| **C22:0** | 0.15±0.00$^{a}$ | 0.37±0.02$^{b}$ | 0.16±0.01$^{a}$ | 0.18±0.01$^{a}$ |
| **SFA** | 47.89±0.67$^{a}$ | 40.29±0.36$^{b}$ | 36.01±0.32$^{c}$ | 42.73±0.45$^{d}$ |
| **C14:1n5** | 0.49±0.00$^{b}$ | 0.26±0.00$^{a}$ | 0.26±0.00$^{a}$ | 0.42±0.01$^{c}$ |
| **C16:1n7** | 7.65±1.15$^{a}$ | 6.54±0.06$^{a}$ | 7.76±0.09$^{a}$ | 12.05±0.08$^{b}$ |
| **C18:1n7** | 2.46±0.04$^{a}$ | 2.42±0.05$^{ab}$ | 1.87±0.05$^{c}$ | 2.26±0.05$^{b}$ |
| **C18:1n9** | 15.51±0.24$^{a}$ | 13.62±0.11$^{b}$ | 21.08±0.19$^{c}$ | 14.88±0.32$^{a}$ |
| **MUFA** | 26.13±1.36$^{a}$ | 22.85±0.21$^{a}$ | 30.98±0.30$^{b}$ | 29.62±0.37$^{b}$ |
| **C18:2n6cis** | 2.46±0.03$^{a}$ | 2.52±0.04$^{a}$ | 2.78±0.05$^{b}$ | 2.26±0.05$^{c}$ |
| **C18:3n6** | 0.27±0.00$^{a}$ | 0.22±0.03$^{a}$ | 0.59±0.02$^{b}$ | 0.29±0.02$^{b}$ |
| **C18:3n3** | 0.57±0.01$^{a}$ | 0.45±0.00$^{a}$ | 0.57±0.01$^{a}$ | 3.14±2.42$^{a}$ |
| **C18:4n3** | 0.13±0.00$^{a}$ | 0.16±0.01$^{ab}$ | 0.34±0.02$^{c}$ | 0.22±0.01$^{b}$ |
| **C20:3n6** | 0.28±0.01$^{a}$ | 0.63±0.01$^{a}$ | 0.33±0.04$^{b}$ | 0.15±0.00$^{a}$ |
| **C20:4n6** | 0.08±0.05$^{a}$ | 0.57±0.00$^{b}$ | 0.12±0.05$^{a}$ | 0.46±0.04$^{c}$ |
| **C20:3n3** | 0.48±0.00$^{a}$ | 0.46±0.00$^{b}$ | 0.62±0.01$^{a}$ | 0.44±0.02$^{b}$ |
| **C20:5n3 (EPA)** | 5.47±0.07$^{a}$ | 7.22±0.06$^{c}$ | 6.25±0.15$^{b}$ | 5.99±0.1$^{b}$ |
| **C22:5n6** | 0.23±0.00$^{ab}$ | 0.19±0.00$^{a}$ | 0.33±0.03$^{c}$ | 0.29±0.02$^{bc}$ |
| **C22:5n3** | 0.37±0.00$^{a}$ | 0.00±0.00$^{b}$ | 0.06±0.00$^{c}$ | 0.17±0.00$^{d}$ |
| **C22:6n3 (DHA)** | 8.01±0.18$^{a}$ | 11.96±0.10$^{b}$ | 7.27±0.10$^{a}$ | 8.49±0.43$^{a}$ |
| **PUFA** | 18.39±0.27$^{a}$ | 24.41±0.22$^{b}$ | 19.31±0.26$^{a}$ | 21.94±2.18$^{ab}$ |
| **n-3** | 11.31±3.93$^{a}$ | 20.26±0.17$^{b}$ | 15.14±0.21$^{ab}$ | 18.47±2.12$^{ab}$ |
| **n-6** | 3.34±0.03$^{a}$ | 4.15±0.04$^{b}$ | 4.17±0.07$^{b}$ | 3.47±0.11$^{a}$ |
| **n-3/n-6** | 3.35±1.15$^{a}$ | 4.87±0.01$^{a}$ | 3.62±0.05$^{a}$ | 5.31±0.54$^{a}$ |
| **DHA/EPA** | 1.46±0.02$^{a}$ | 1.65±0.01$^{b}$ | 1.16±0.00$^{c}$ | 1.41±0.08$^{a}$ |
| **IT** | 1.07±0.33$^{a}$ | 0.49±0.00$^{b}$ | 0.53±0.00$^{a}$ | 0.55±0.04$^{b}$ |
| **IA** | 1.48±0.12$^{a}$ | 0.96±0.00$^{a}$ | 0.82±0.00$^{a}$ | 1.07±0.03$^{a}$ |

Means± SD (n= 3) followed by different letters within a row significantly different ($p< 0.05$).

**Table 2: Summary of two-way ANOVA results on the effects of sex and tissue on fatty acid compositions of *Portunus pelagicus.***

| Fatty acid | Sex | | Tissue | | Interaction | |
|---|---|---|---|---|---|---|
| | **F value** | ***p*** | **F value** | ***p*** | **F value** | ***p*** |
| **EPA** | 76.938 | 0.001 | 7.440 | 0.026 | 140.011 | 0.001 |
| **DHA** | 107.212 | 0.001 | 71.051 | 0.001 | 29.971 | 0.001 |
| **SFA** | 0.772 | 0.405 | 86.901 | 0.001 | 199.922 | 0.001 |
| **MUFA** | 10.013 | 0.013 | 62.922 | 0.001 | 1.711 | 0.227 |
| **PUFA** | 15.084 | 0.005 | 0.487 | 0.505 | 2.307 | 0.167 |
| **n-3 PUFA** | 7.508 | 0.025 | 0.208 | 0.660 | 1.567 | 0.246 |
| **n-6 PUFA** | 0.450 | 0.521 | 0.877 | 0.276 | 100.297 | 0.001 |
| **n3/n6** | 6.258 | 0.037 | 0.305 | 0.596 | 0.017 | 0.898 |

Also C14:0, C14:1n-5, C16:0, C16:1n-7, C18:1n-9, C18:3n-3, C18:3n-6, C18:4n-3, C22:5n-6, C22:5n-3, SFA, MUFA, n-3/n-6 and IT in females were higher in the breast than the claw meat, but content of C18:0, C18:1n-7, C18:2n-6cis, C20:0, C22:0, C20:3n-6, C20:3n-3, C20:4n-6, C20:5n-3, PUFA, n-3, n-6, C22:6n-3, DHA/ EPA and IA was higher in the claw than the breast meat (Table 1).

The total n-6 fatty acids were in the range of 3.34% and 4.17% in the claw meat and breast meat, respectively. Also the total n-3 fatty acids were in the range of 11.31% and 20.26%. The content of arachidonic acid (20:4n-6) was highest in the female claw, 0.57% and lowest in the male claw, 0.08%.

The total EPA (C20:5n-3) contents averaged 5.47%, 7.22%, 6.25% and 5.99% for male claw, female claw, male breast, female breast and DHA (C20:6n-3) contents averaged 8.01%, 11.96%, 7.27 and 8.49% for male claw, female claw, male breast, female breast, respectively.

The fatty acid composition of *P. pelagicus* was found to be 36.01- 47.89% for SFA, 22.85- 30.98% for MUFA, 18.39- 24.41% for PUFA. Among, the IA was 1.48%, 0.96%, 0.82% and 1.07% for male claw, female claw, male breast, female breast and IT was 1.07%, 0.49%, 0.53% and 0.55% for male claw, female claw, male breast, female breast, respectively (Table 1).

**Discussion**

The meat of *P. pelagicus* has a similar fatty acid profile to that of the other marine crabs, including *Cancer magister* (Allen, 1971), snow crab, *Chionoecetes opilio* (Krzecekowski and Stone, 1974), swimming crab, *Portunus trituberculatus* (Su *et al.*, 1996), green crab, *Carcinus maenas* (Naczk *et al*., 2004), mud crab (Tan *et al*., 2000), and blue crab, *Callinectes sapidus* (Kuley *et al*., 2007). However, the meat of blue swimmer crab appeared to have higher ARA levels than the *C. magister* (Allen, 1971), *C. opilio* (Krzecekowski and Stone, 1974), *P. trituberculatus* (Su *et al*., 1996), and *C. maenas* (Naczk *et al*., 2004).

In this study, SFA, MUFA and PUFA in *P. pelagicus* were 36.01- 47.89%, 22.85-30.98%, 18.39-24.41%. Wu *et al*. (2010) reported that SFA, MUFA and PUFA in *P. pelagicus* in Beibu Gulf, near the northwest coast of Hainan Island were 25.40- 36.30%, 23.40- 32.40% and 19.10-42.10%. Also Naczk *et al*. (2004) reported that the levels of SFA, MUFA and PUFA in *C. maenus* were 18.10- 20.70 %, 24.20-25.70 % and 47.10- 50.50 %. Other researchers have also reported similarities in concentrations of SFA, MUFA and PUFA in *C. sapidus* in the Mersian Bay which were 22.59-25.20 %, 26.18- 30.05 % and 38.41- 43.41 % (Ayas and Ozogul, 2011) and in Sea of Japan and the Okhotsk Sea, SFA, MUFA and PUFA in *Paralithodes camtschaticus*, *Paralithodes platypus*, *C. opilio*, *Chionoecetes angulatus* and *Chionoecetes japonicas* were 13.70- 20.30 %, 24.60- 49.90 % and 27.40- 56.00 %, respectively (Latyshev *et al*., 2009).

The main dominant SFAs were palmitic (16:0) and stearic (18:0) acids in male and female *P. pelagicus*. Levels of C22:0 and C20:0 were lower than C14:0, C16:0 and C18:0. King *et al*. (1990) reported a

slightly higher than 16:0 (13.40 %) and lower 18:0 (4.46 %) and 18:1 (13.08 %) contents in the total lipids of *C. magister*. Wu *et al*. (2010) reported the amounts of SFA in male and female as 16:0 (13.1 and 13.00 %), 18:0 (9.15 and 9.95 %) and 14:0 (0.68 and 1.03 %) in *P. pelagicus* from Beibu Gulf. Other studies have also reported similarities in concentrations of fatty acids in male and female of *C. sapidus* in the Mersian Bay as 16:0 (13.62 and 14.23%), 18:0 (6.42 and 6.99%) and 14:0 (0.78 and 0.83%), C20:0 (0.72 and 0.84 %) and C22:0 (0.00 and 0.08) (Ayas and Ozogul, 2011).

Oleic acid (18:1) was the dominant MUFA. Oleic acid (13.62-21.08 %) was the major MUFA in all *P. pelagicus* meats, followed by palmitoleic acid (6.54-12.05 %) and octadecenic acid (1.87-2.46 %). Wu *et al*. (2010) reported oleic acid (13.2-13.8 %), palmitoleic acid (4.83-7.88 %) and octadecenic acid (1.48- 1.83 %) in *P. pelagicus* from Beibu Gulf. Naczk *et al*. (2004) reported oleic acid (10.3-13.1%), palmitoleic acid (3.63-4.61%) and octadecenic acid (3.53-4.66%) in *C. maenus*. Kuley *et al*. (2007) determined that the amounts of oleic acid and palmitoleic acid in *C. sapidus* changed between 3.40-17.10 % and 3.00-3.30 %, respectively. Other researchers have also reported similarities in concentrations of fatty acids of *C. sapidus* caught from Mersian Bay which were oleic acid (14.66-14.75%), palmitoleic acid (6.09- 8.65 %) and octadecenic acid (4.28- 4.38 %) (Ayas and Ozogul, 2011).

Kuley *et al.* (2007) also reported the values of oleic acid in crab meat were similar to our study, while these values were different for palmitoleic acid. Among SFAs, the 16:0 and 18:0 fatty acids were the two most dominant fatty acids. This is consistent with the *C. maenas* (Naczk *et al.,* 2004), *P. camtschaticus*, *P. platypus*, *C. opilio*, *C. angulatus* , *C. japonicus* (Latyshev *et al*., 2009), *Cancer pagurus* (Barrento *et al*., 2010), and *P. pelagicus* (Wu *et al*., 2010).

In the present study SFA content was higher than MUFA and PUFA in all tissues. The results are similar to the results of Chaiyawat *et al*., (2008) for *P. pelagicus*. Profile of fatty acids in *Eriocheir sinensis* seem dominated by MUFAs (Chen *et al*., 2007). However, several studies demonstrated that PUFA is the most important group of fatty acids in crab meat (Celik *et al*., 2004; Latyshev *et al.,* 2009; Wu *et al*., 2010). All crab tissues contained arachidonic acid (C20:4), which is a precursor for prostaglandin and thromboxane biosynthesis (Pompeia *et al*., 2002). Arachidonic acid (C20:4) can facilitate the blood clotting process and attach to endothelial cells during wound healing (Rahman *et al*., 1995).

The male crabs had higher 22:6n-3 fatty acid content than the females in meat of *P. pelagicus* (Wu *et al*., 2010). While in present study, female crabs had higher 22:6n-3 than males in claw and breast meat. The higher EPA values in muscle of *C. pagurus* may be related to its physiological function as an important structural component of cell membranes (Barrento *et al*., 2010). PUFA plays a vital role in alleviating cardiovascular disease, type-2 diabetes, inflammatory ailments and autoimmune disorders. EPA and DHA have extremely useful properties for the

prevention of human coronary artery disease (Chow, 2007).

Total percentage of n-3 PUFA ranged 11.31-20.26 % which was higher than the n-6 (3.34-4.17 %). The n-3 PUFA content was highest in female claw meat (20.26 %) and lowest in male claw meat (11.31 %), while n-6 PUFA content was highest in female claw meat (4.17 %) and lowest in male breast meat (3.34 %). The main PUFAs in lipids of crab meat were 20:5n-3 and 22:6n-3. These values were similar to those given by Latyshev *et al*. (2009) for five species of commercial crabs and for total lipids in muscles of *P. pelagicus* (Wu *et al*., 2010).

Nutritionists believe that the ratio of n-6/ n-3 should be 0.10-0.20 %, and higher ratios (>0.2) are more useful for human health (FAO/ WHO, 1994). An increase in human dietary n-3/ n-6 fatty acid ratio is essential in the diet to help prevent coronary heart disease by reducing plasma lipids and to reduce cancer risk (Kinsella *et al*., 1990). The ratios of n-3 PUFA to n-6 PUFA of the edible parts of *P. pelagicus* ranged from 3.35 to 5.31 %. The result of Wu *et al*. (2010) supported our results (2.55-2.64 %) for *P. pelagicus* meat although much higher values that were observed by present study. The high amounts of DHA and favorable n-6/ n-3 ratio in the meat of *P. pelagicus* indicate that the claw and breast meats are very omega rich edible portions of the crab's body. In the present study, the IA value between claw and breast meat of *P. pelagicus* was not significantly different, while the IT value in female claw and breast than that of male claw and breast was significantly different ($p$<0.05). IA and IT take the interactions among different fatty acids into account, allowing an integrated assessment of dietary lipid on human coronary health (Ulbricht and Southgate, 1991). Higher values of IT and IA (>1.0) are detrimental to human health (Bobe *et al.*, 2004). The present results have shown that female meat had higher amounts of omega 3, DHA and EPA fatty acids than the male meat. Having n-3/ n-6 value and IT, IA index indicate that swimming crab is a healthy food.

## References

**Allen, W.V., 1971.** Amino acid and fatty acid composition of tissues of the Dungeness crabs, *Cancer magister*. *Journal Fisheries Research Board of Canada*, 28 (**8**), 1191-1195.

**Ayas, D. and Ozogul, Y., 2011.** The chemical composition of carapace meat of sexually mature blue crab (*Callinectes sapidus*) in the Mersin Bay. *Journal of Fisheries Science*, 5(**3**), 262-269.

**Barrento, S., Marques, A., Teixeira, B., Mendes, R., Bandarra, N., Vaz-Pires, P. and Nunes, M.L., 2010.** Chemical composition, cholesterol, fatty acid and amino acid in two populations of brown crab *Cancer pagurus*: Ecological and human health implications. *Journal of Food Composition and Analysis*, 23(**7**), 716-725.

**Bobe, G., Zimmerman, S., Hammond, F.G., Freeman, G., Lindberg, G.L. and Betiz, D.C., 2004.** Texture of butters made from milks differing in indices of atherogenicity. Animal Industry Report, AS Leaflet R, Iowa State University.

**Celik, M., Tureli, C., Celik, M., Yanar, Y., Erdem, U. and Kucukgulmez, A., 2004.** Fatty acid composition of the blue crab (*Callinectes sapidus*) in the north eastern Mediterranean. *Food Chemistry*, 88, 271-273.

**Chaiyawat, M., Eungrasmee, I. and Raksakulthai, N., 2008.** Quality characteristics of blue swimming Crab (*Portunus pelagicus*) meat feed *Gracilaria edulis* (Gmelin) Silva. *Kasetsart Journal*, 42, 522-530.

**Chen, D., Zhang, M. and Shrestha, S., 2007.** Compositional characteristics and nutritional quality of Chinese mitten crab (*Eriocheir sinensis*). *Food Chemistry*, 103(**4**), 1343-1349.

**Chow, C.K., 2007.** Fatty acids in foods and their health implications, 3rd edition. Boca Raton, FL: CRC Press, 1296 P.

**Desvilettes, C., Bourdier, G. and Breton, J.C., 1994.** Lipid class and fatty acid composition of planktivorous larval pike (*Esox lucius*) living in a natural pond. *Aquatic Living Resources*, 7, 67-77.

**FAO/ WHO. 1994.** Fats and oils in human nutrition. Report of a Joint FAO/ WHO Expert Consultation, 19 to 26 October 1993, Rome, pp. 168.

**Folch, J.M., Less, M. and Sloane-Stanley, G.H., 1957.** A simple method for the isolation and purification of total lipids from animal tissues. *Journal of Biological Chemistry*, 226, 497-509.

**Hall, D., Lee, S.Y. and Meziane, T., 2006.** Fatty acids as trophic tracer in an experimental estuarine food chain: Tracer transfer. *Journal of Experimental Marine Biology and Ecology*, 336, 42-53.

**Hunter, B.J. and Robert, D.C.K., 2000.** Potential impact of the fat composition of farmed fish on human health. *Nutrition Research*, 20(**7**), 1047-1058.

**Innis, S.M., 2000.** The role of dietary n-6 and n-3 fatty acids in the developing brain. *Developmental Neuroscience*, 22, 474-480.

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

**Kinsella, J.E., Lokesh, B. and Stone, R.A., 1990.** Dietary n-3 polyunsaturated fatty acids and amelioration of cardiovascular disease: Possible mechanism. *American Journal of Clinical Nutrition*, 52, 1-28.

**Krzecekowski, R.A. and Stone, F.E., 1974.** Amino acid, fatty acid and proximate composition of snow crab (*Chionoecetes bairdi*). *Journal of Food Science*, 39(**2**), 386-388.

**Kuley, E., Ozogul, F., Ozogul, Y. and Olgunoglu, A.I., 2007.** Comparison of fatty acid and proximate compositions of the body and claw of male and female blue crabs (*Callinectes sapidus*) from different regions of the Mediterranean coast. *International Journal of Food Science and Nutrition*, 59, 573-580.

**Laakso, P., Christie, W.W. and Petterson, J., 1990.** Analysis of north Atlantic and Baltic fish oil triacylglycerols by high-performance

liquid chromatography with a silver ion column. *Lipids*, 25 (**2**), 284-291.

**Latyshev, N.A., Kasyanov, S.P., Kharlamenko, V.I. and Svetashev, V.I., 2009.** Lipids and of fatty acids of edible crabs of the north-western Pacific. *Food Chemistry*, 116, 657-661.

**Lombardo, B.L., Hein, G. and Chicco, A., 2007.** Metabolic syndrome: Effects of n-3 PUFA on a model of dyslipidemia, insulin resistance and adiposity. *Lipids*, 42, 427-437.

**Muskiet, F.A.J., Van Goor, S.A., Kuipers, R.S., Velzing-Aarts, F.V., Smit, E.N., Bouwstra, H., Dijck-Brouwer, D.A.J., Boersma, E.R. and Hadders-Algra, M., 2006.** Long-chain polyunsaturated fatty acids in maternal and infant nutrition. *Prostaglandins, Leukotrienes and Essential Fatty Acids*, 75, 135-144.

**Naczk, M., Williams, J., Brennan, K., Liyanapathirana, C. and Shahidi, F., 2004.** Compositional characteristics of green crab (*Carcinus maenas*). *Food Chemistry*, 88, 429-434.

**Pompeia, C., Freitas, J.S., Kimj, S., Zyngier, S.B. and Curi R., 2002.** Arachidonic acid cytotoxicity in leukocytes: Implications of oxidative stress and eicosanoid synthesis. *Biology of the Cell*, 94 (**4**), 251-265.

**Rahman, A.S., The, S.H., Osman, H. and Daud, N.M., 1995.** Fatty acid composition of some Malaysian freshwater fish. *Food Chemistry*, 54, 45-49.

**Ramirez, M.R., Morcuende, D., Estevez, M. and Cava Lopez, R., 2005.** Fatty acid profiles of intramuscular fat from pork loin chops fried in different culinary fats following refrigerated storage. *Food Chemistry*, 92, 159-167.

**Romano, N. and Zeng, C., 2008.** Blue swimmer crabs, emerging species in Asia. *Global Aquaculture Advocate*, 11 (**3**), 34-36.

**Stansby, M.E. and Hall, A.S., 1967.** Chemical composition of commercially important fish of United States. *United State Fish and Wildlife Service*, 3 (**4**), 29.

**Su, X.R., Li, T.W., Oyang, F. and Li, P., 1996.** Study on the nutritive compositions of *Portunus trituberculatus*. *Acta Nutrimenta Sinica, 18* (**3**), 342-346. (In Chinese, with English abstract).

**Tan, D.F., Wu, G.X., Lin, Y.X. and Qiu, W.F., 2000.** Analysis of nutritional composition of *Scylla serrata*. *Journal of Fujian Normal University National Science*, 16 (**4**), 79-84. (In Chinese, with English abstract).

**Ulbricht, T.L.V. and Southgate, D.A.T., 1991.** Coronary heart disease: seven dietary factors. *Lancet*, 338, 985-992.

**Valfre, F., Caprino, F. and Turchini, G.M., 2003.** The health benefit of seafood. *Veterinary Research Communications*, 27 (**1**), 507-512.

**Wu, X., Zhou, B., Cheng, Y., Zeng, C., Wang, C. and Feng, L., 2010.** Comparison of gender differences in biochemical composition and nutritional value of various edible parts of the blue swimmer crab. *Journal of Food Composition and Analysis*, 23, 154-159.

**Ying, X., Yang, W. and Zhang, Y., 2006.** Comparative studies on fatty acid composition of the ovaries and hepatopancreas at different physiological stages of the Chinese mitten crab. *Aquaculture*, 256, 617-623.