Oceanological and Hydrobiological Studies
International Journal of Oceanography and Hydrobiology

Volume 41, Issue 2

ISSN 1730-413X
eISSN 1897-3191

(57–64)
2012

VERSITA

DOI: 10.2478/s13545-012-0017-z
Original research paper

Received: *October 09, 2011*
Accepted: *January 24, 2012*

Composition of fatty acids and sterols composition in brown shrimp *Crangon crangon* and herring *Clupea harengus membras* from the Baltic Sea

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Key words: Lipid composition, essential fatty acids, sterols, herring, *Clupea harengus membras,* shrimp, *Crangon crangon*

Abstract

The composition and the content of lipids, fatty acids and sterols during spawning (spring) in different tissues of herring *Clupea harengus membras* were compared with quantities of lipid compounds in abdomen muscle of brown shrimp *Crangon crangon*. The largest quantity of fatty acids in lipids (93.7%), was observed in fish muscle. The liver was characterized by a higher content and variety of sterols (about 4.6 times more than in fish muscle), and in fish sperm, additional fatty acids were identified and the highest amount of EPA and DHA (22% and 34% of fatty acids, respectively) was recorded. The brown shrimp, despite its small size, contained significantly more lipids than the Baltic herring per g of tissues. Fatty acids were at the same level (83% of the total lipids in shrimp muscle and 93.7% in fish muscle), but the amount of sterols was significantly higher in the muscle of shrimp (5.50 ±0.31 mg g^{-1}, 17% of total sterols, n=10) than in fish muscle (1.33 ±0.04 mg g^{-1}, 6.3% of total lipids, n=6). And thus, shrimp is a good source of food for higher trophic levels, and in consequence – a good source of PUFAs for humans. With these results we prove that shrimp and herring play an important role in the supply of EFAs, which has great pharmaceutical and medical benefits.

INTRODUCTION

In each period of the life cycle significant changes occur in the chemical composition and the content of fish tissues. One of the reasons is sexual maturation and the lack of feeding in this period. Major changes are always noted in lipid content and composition of fatty acids (Huynh et al. 2007).

There are a few subspecies of herring, and different ecosystems, various locations and food are the reason of different composition of their fatty acids (Gladyshev et al. 2007, Morais et al. 2007). The Baltic herring (*Clupea harengus membras*) is a subspecies of Atlantic herring and belongs to pelagic fish. Together with the Pacific herring, they have an enormous economic importance and are a major target of catches in marine fishing (Jensen et al. 2007). In 2010, an increase in the intake of herring among the Polish population amounted to 13.26 kg live weight/per capita, simultaneously with the biomass caught of 12200 tonnes, where a few years ago this intake and catching was much smaller (Seremak-Bulge 2010).

The second examined marine species is *Crangon crangon*. The brown shrimp inhabit the sandy or muddy bottoms of shallow coastal waters down to 130 m (Holthuis 1980). They are common in the Eastern Atlantic, Atlantic coast of Morocco, in the Mediterranean and Black Seas, as well as in the North Sea (Holthuis 1980). The shrimp are caught on a large scale (40 322 tons per year in the North

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Atlantic and 113 tons per year in the Mediterranean Sea in 2005) (FAO 2008). *C. crangon* is a precious marine resource of fisheries in the North Sea and the benefits amounted to 50-70 million Euro in 2004 (Revill and Holst 2004).

These two marine species from the Baltic Sea - are probably rich in biologically highly valuable peptides, proteins, minerals, trace metals, vitamins, flavor components, natural antioxidants and unsaturated fatty acids, like other fish and shrimp (Heu et al. 2003, Elvevoll et al. 2006). Moreover, as pointed out by many researchers, the main and the only source of PUFAs n-3 essential for humans are fish and seafood (Osman et al. 2001, Gladyshev et al. 2007). Therefore, marine species are a valuable and relatively cheap source of many food ingredients of high biological activity and value. In regard to medical and dietary benefits, fatty acids and sterols of fish and seafood are the main subject in chemical, biological and food researches over the last few decades (Jabeen and Chaudhry 2011). Many authors described the connection between a diet rich in polyunsaturated fatty acids from sea fish with greater benefit for sick and healthy people (Logan 2004, Varney et al. 2009).

But the role of fatty acids in organisms of fish and seafood is equally important. They are the main source of energy for many metabolic processes. These acids are responsible for the development of gonads, they are transferred to ovaries, and are components of eggs during the reproduction (Cordier et al. 2002, Huynh 2007). Moreover, the polyunsaturated fatty acid, 22:6n-3, is necessary for the survival and growth of marine species (Cordier et al. 2002, Saito et al. 2002), as well as it is the major component of the neural tissues (Copeman and Parrish 2004). Arachidonic acid (20:4, AA), which belongs to PUFA omega-6, is a precursor of eicosanoids (leucotrienes, prostaglandins, thromboxanes). 20:4 is responsible for the growth and development of larval fish, however a high value of AA can have a negative influence on larval pigmentation. Fatty acid 20:5n-3 produces eicosanoids with lower biological activity (Copeman et al. 2002) and is a substrate for platelet anti-aggregatory factors (Osman et al. 2001).

The aim of this study was to determine the lipid content and fatty acids and sterols composition during the spawning period in different major tissues of herring - in muscle, liver and sperm. Another representative of the fauna of the Baltic Sea is *C. crangon*. The brown shrimp, as the seafood, should be characterized by a high content of PUFA. We prove that both our native species are rich in EFAs. EFAs have the preventive and therapeutic benefits. We mention the composition of sterols, which are also of great importance at the time of reproduction, together with PUFA.

MATERIALS AND METHODS

Samples collection

The studied marine species, Baltic herring *C. harengus membras* and brown shrimp *C. crangon*, were caught in the Gulf of Gdansk (Poland) in spring 2011 (May and April, respectively). The fresh species were put in ice immediately after collection and were transported to the laboratory on the same day. Muscles, livers and sperm from herring were dissected and frozen at -80°C in glass tubes. A similar procedure was follow with muscle from brown shrimp. Tissues were weighed (muscle mass of fish and shrimp: 2328.9 mg and 1732.8 mg, respectively and liver and sperm mass of fish: 1397.4 mg and 2241.8 mg, respectively). Before homogenization of lipids, water was removed from the examined tissues by lyophilization. The examined tissues were obtained from 10 stages of *C. crangon* and 6 stages of *C. harengus membras*. To determine the variability of the results, they were compared with Student's *t*-test: significant at $p<0.05$.

Chemicals and reagents

Methanol, chloroform, dichloromethane (all HPLC grade) and ethanol (99.8%) were obtained from Chempur (Piekary Śląskie, Poland) and NaCl (0.9%) from Fresenius-Kabi (Kutno, Poland). Sodium hydrate (pills) was purchased from POCH S.A. (Gliwice, Poland) and BSTFA + TMCS (99:1) was supplied by Supelco (Bellefonte, USA). Nonadecanoic acid and stigmasterol were internal standards and were obtained from Sigma-Aldrich (Poznań, Poland).

Extraction and analysis of lipids

Lipids were extracted using Folch's method (1957) which included homogenization in chloroform/methanol (2:1 v/v). After the extraction of lipids from herring tissues and shrimp muscle, trimethylsilyl esters of fatty acids were prepared for GC-MS analysis. They were silylated by treatment

with 50 µl of 1% bis (trimethylsilyl) acetamide and 99% chlorotrimethylsilane (Sigma Aldrich), and were heated at 1 h at 100°C. After derivatization, they were evaporated to dryness under a stream of nitrogen and resuspended in 150 µl of dichloromethane. To avoid destruction of derivatives, sterols and fatty acids were immediately analyzed by GC-MS after derivatization.

GC-MS analysis

Sterols and fatty acids were identified qualitatively and quantitatively using Hewlett Packard GC MS 5890 (Finnigan Mat). The column was a HP-5 silica capillary, 30 m in length, 0.25 mm i.d. and 0.25 µm film thickness (Agilent). The oven temperature of 60°C was increased to 300°C at 40°C min^{-1}. The injector temperature was 300°C, the carrier gas was helium and the pressure was constant at 10 psi. The injection volume was 1 µl and the total running time was 80 minutes.

RESULTS

Content of lipids and fatty acids composition

Table 1 presents a comparison of total lipids, fatty acids and sterols content of herring and shrimp. The total lipid content in muscle was 21.13 ±0.04 mg g^{-1} (dry mass) and was very close to the value from liver tissues. Significant differences occurred in the quantity of fatty acids and sterols. Significantly higher amounts of fatty acids were reported in fish muscle than in fish liver, while the content of sterols in the liver was about 4.6 times higher than the sterols content in the muscle tissue of herring. The lowest amount of fatty acids was recorded in the sperm. In the sperm, however, the contribution of sterols in relation to fatty acids was the highest compared with all the analyzed fish tissues (Table 1).

Table 1 shows the content of lipid, fatty acids and sterols of brown shrimp. The content of lipids was higher than in the tissues of fish. The muscle lipid content was 32.28 ±1.83 mg g^{-1} (dry mass). The value of fatty acids of shrimp was also higher than in fish muscle, similarly to sterols content - in shrimp muscle this group was about 4 times higher than sterols in fish muscle.

The fatty acids composition among all fractions, which one could have in their structure of acidic components, (as triacylglycerols, free fatty acids and acidic fragments of polar lipids/phospholipids) have been included in one group - Fatty Acids.

Table 1

Total mass of tissue (mg dry mass), total mass of lipid, fatty acids and sterols in muscle of *Crangon crangon* and in muscle, liver and sperm of *Clupea harengus membras* (mg g^{-1} dry mass), n- number of individuals.

	C. crangon	*C. harengus membras*		
	Muscle (n=10)	Muscle (n=6)	Liver (n=6)	Sperm (n=6)
Total mass of tissue	953.0 ±53.94	1280.9 ±36.60	697.7 ±21.80	1227.8 ±35.10
Total lipid	32.28 ±1.83	21.13 ±0.6	20.78 ±0.65	10.93 ±0.31
Fatty acids	26.78 ±1.16	19.80 ±0.56	14.6 ±0.46	7.40 ±0.21
Sterols	5.50 ±0.31	1.33 ±0.04	6.18 ±0.19	3.56 ±0.10

Table 2 presents an entire identified profile of fatty acids in tissues of herring and muscle of shrimp. Only 19 components of fatty acids were identified in fish tissues (Table 2). It was 8 components in SFA, 6 MUFA and 5 components in PUFA. In the group of saturated fatty acids (SFA) they were as follows: acids 14:0, 15:0, 16:0, 17:0, 18:0 (presence in all analyzed tissues), 20:0 (presence only in liver tissues), 22:0 (identified in fish muscle and liver) and 24:0 (only muscle tissue). In all analyzed tissues acid 16:0 predominated with the quantity of 5.40 mg g^{-1} in muscle, 5.26 mg g^{-1} in liver and 1.13 mg g^{-1} in semen. The next subclass of fatty acids consisted of monounsaturated fatty acids, and acids 16:1, 17:1, 18:1, 20:1, 22:1 and 24:1 were recorded. Acid 18:1 dominated in all samples: muscle 1.70 mg g^{-1}, liver 2.79 mg g^{-1} and semen 0.88 mg g^{-1}. Semen was the poorest sample, only 13 FA was identified. Fatty acid 18:2n-6, which belongs to polyunsaturated fatty acids omega-6, was recorded only in sperm and in a very small amount (0.20 mg g^{-1}). Other polyunsaturated acids: 20:5n-3, 20:4n-6 and 22:6n-3, 22:5n-3, were present in all tissues. 22:6n-6 dominated in muscle (4.93 mg g^{-1}), liver (2.17 mg g^{-1}) and sperm (2.50 mg g^{-1}). The second most popular acid was 20:5n-3. Generally, the content of PUFA (10.3 mg g^{-1} in muscle, 4.6 mg g^{-1} in sperm) was higher than the content of SFA and MUFA in fish muscle and sperm. SFA predominated in liver (6.8 mg g^{-1}).

The highest ratio PUFA/SFA was in fish sperm and was almost 3:1 (Table 2). The second highest ratio was found in muscle (1:1). In liver tissues, the ratio PUFA/SFA was below 1:1. The muscle tissue of *C. harengus membras* had the highest ratio n-3/n-6 (37:1). The ratio in other tissues was as follows: liver 32:1 and sperm 10.5:1 (Table 2).

Table 2 shows also a profile of fatty acids from shrimp muscle. The PUFA/SFA ratio was very

Table 2

Total mass of tissue (mg dry mass), total mass of lipid, fatty acids and sterols in muscle of *Crangon crangon* and in muscle, liver and sperm of *Clupea harengus membras* (mg g^{-1} dry mass), n- number of individuals.

	C. crangon	*C. harengus membras*		
Fatty acids	Muscle (n=10)	Muscle (n=6)	Liver (n=6)	Sperm (n=6)
12:0	0.19 ±0.01	--	--	--
13:0	0.02 ±0.00	--	--	--
14:0	0.70 ±0.04	0.70 ±0.02	0.32 ±0.01	0.12 ±0.003
15:0	0.21 ±0.01	0.10 ±0.00	0.11 ±0.00	0.02 ±0.0
16:0	7.41 ±0.44	5.40 ±0.16	5.26 ±0.21	1.13 ±0.03
17:0	0.26 ±0.02	0.06 ±0.00	0.21 ±0.01	--
18:0	1.38 ±0.08	0.50 ±0.02	0.75 ±0.03	0.42 ±0.01
20:0	0.11 ±0.01	--	0.06 ±0.00	--
22:0	0.08 ±0.00	0.03 ±0.00	0.09 ±0.00	--
24:0	0.08 ±0.00	0.06 ±0.0	--	--
SFA	**10.44 ±0.48**	**6.85 ±0.20**	**6.80 ±0.27**	**1.69 ±0.05**
15:1	0.03 ±0.00			
16:1	1.59 ±0.01	0.60 ±0.02	0.11 ±0.00	0.10 ±0.003
17:1	0.45 ±0.03	0.06 ±0.00	0.32 ±0.01	--
18:1	3.49 ±0.21	1.70 ±0.05	2.79 ±0.11	0.88 ±0.02
20:1	0.33 ±0.02	0.90 ±0.03	0.64 ±0.03	0.11 ±0.003
22:1	0.08 ±0.00	2.00 ±0.06	0.21 ±0.01	0.01 ±0.0
24:1	0.05 ±0.00	0.06 ±0.00	0.06 ±0.00	--
MUFA	**6.02 ±0.26**	**5.32 ±0.18**	**4.13 ±0.19**	**1.10 ±0.02**
18:2n-6	--	--	--	0.20 ±0.006
20:2n-6	0.40 ±0.02			
20:4n-6	0.26 ±0.02	0.20 ±0.01	0.11 ±0.00	0.20 ±0.01
20:5n-3	7.41 ±0.44	2.20 ±0.07	1.18 ±0.05	1.61 ±0.05
22:5n-3	0.29 ±0.02	0.30 ±0.01	0.21 ±0.01	0.10 ±0.003
22:6n-3	1.96 ±0.12	4.93 ±0.15	2.17 ±0.09	2.50 ±0.08
PUFA	**10.32 ±0.52**	**7.63 ±0.24**	**3.67 ±0.16**	**4.61 ±0.14**
PUFA/SFA	1.00 ±0.05	1.11 ±0.03	0.54 ±0.02	2.73 ±0.08
Σn-3	9.66 ±0.49	7.43 ±0.23	3.56 ±0.15	4.21 ±0.13
DHA/EPA	0.26 ±0.01	2.24 ±0.07	1.84 ±0.08	1.55 ±0.05
EPA/AA	28.50 ±1.69	11.00 ±0.35	10.73 ±0.45	8.05 ±0.25
Σn-3/n-6	14.64 ±0.74	37.15 ±1.00	32.36 ±1.4	10.52 ±0.35
ΣFA	**26.78 ±1.16**	**19.80 ±0.56**	**14.6 ±0.46**	**7.4 ±0.18**

similar in fish and shrimp muscle (1:1), but n-3/n-6 ratio in fish muscle was 2.5 times higher than in shrimp. That implied that higher levels of PUFA n-3 were recorded in Baltic herring, but on the other hand, only one PUFA n-6 (20:4n-6) was recorded in fish muscle, additionally in lower content than in shrimp muscle (Table 2). Nevertheless, the content of individual groups of fatty acids in muscle of *C. crangon* ranged from 10.44 ±0.48 mg g^{-1} (SFA), 6.02 ±0.26 mg g^{-1} (MUFA) to 10.32 ±0.52 mg g^{-1} (PUFA). In fish muscle, these values ranged from 6.85 ±0.20 mg g^{-1} (SFA), 5.32 ±0.18 mg g^{-1} (MUFA) to 7.63 ±0.24 mg g^{-1} (PUFA) (Table 2).

Content and composition of sterols

The total sterols content in Baltic herring tissues was between 1.33 mg g^{-1} (muscle), 3.56 mg g^{-1} (sperm) and 6.18 mg g^{-1} (liver) (Table 3). Cholesterol was the major sterol in all tissues. It was present in the range from 1.33 mg g^{-1} in muscle, 3.56 mg g^{-1} in sperm to 5.74 mg g^{-1} in liver (Table 3). In the muscle of herring, cholesterol was the only oneidentified sterol. In sperm, the second recorded sterol was norcholestadienol with the value of 0.04 mg g^{-1}. The liver revealed a wealth of sterols. 9 sterols were recorded in this tissue, the second predominant was 22-dehydrocholesterol (0.12 mg g^{-1}) and norcholestadienol with the amount of 0.07 mg g^{-1}. The value of other sterols ranged from 0.05 to 0.03 mg g^{-1}. The content of sterols in shrimp muscle was 5.50 mg g^{-1}, and also cholesterol predominated (5.30 mg g^{-1}). Campesterol was the second dominant sterol and its value amounted to 0.06 mg g^{-1}. Values for other five sterols ranged from 0.02 mg g^{-1} to 0.05 mg g^{-1}. The content of cholesterol in shrimp muscle was 4 times higher than in fish muscle.

DISCUSSION

In Poland, consumption of fish and fish products is very low. Polish people consume on average 9 kg/capita/year, but it is recommended to eat fish twice a week (Pieniak et al. 2008). The daily demand for PUFAs is 1-1.5 g (up to 2 g/male) and in the North American intake of EPA and DHA is about 130 mg per day (10-15% recommended) (Logan 2004). The Baltic Sea abounds in many species of fish. However, are Baltic fish sufficiently rich in essential unsaturated omega-3 and omega-6? And what about the smaller organisms (*C. crangon*), which are the food for flatfish, shore crabs, seals, various waders, seagulls and auks (Jung 2008)? The composition and content of lipids depends on different conditions, such as diet (Cahu et al. 2004), salinity and temperature of marine water (Cordier et al. 2002). These factors are correlated with the life cycle of marine species (Cordier et al. 2002) and the condition of maturity (Huynh et al. 2007). Season changes are responsible for changes of lipids in various tissues (Cordier et al. 2002). During the

Table 3

Sterols composition of *Crangon crangon* and *Clupea harengus membras* from Baltic Sea, analyzed by GC-MS method (dry mass mg g^{-1}), n- number of individuals.

Sterols		*C. crangon*	*C. harengus membras*		
common name	systematic name	Muscle (n=10)	Muscle (n=6)	Liver (n=6)	Sperm (n=6)
cholesta-3,5,7-triene	cholesta-3,5,7-triene	--	--	0.04 ±0.001	--
cholesta-3,5-diene	cholesta-3,5-diene	--	--	0.04 ±0.001	--
24-nordehydrocholesterol	24-norcholesta-5,22*E*-lien-3*β*-ol	0.02 ±0.001	--	0.07 ±0.002	0.04 ±0.001
22-dehydroholesterol	cholesta-5,22*E*-dien-3*β*-ol	--	--	0.12 ±0.004	--
cholesterol	cholest-5-en-3*β*-ol	5.30 ±0.300	1.33 ±0.04	5.74 ±0.180	3.52 ±0.09
desmosterol	cholesta-5,24-dien-3β-ol	--	--	0.03 ±0.001	--
brassicasterol	24-methylenecholest-5-en-3*β*-ol	0.03 ±0.001			
24-methylenecholesterol	24-methycholesta-5,24(28)-dien-3*β*-ol	0.02 ±0.001	--	0.04 ±0.001	--
campestanol	24-methyl-5α-cholestan-3*β*-ol	0.05 ±0.002	--	0.05 ±0.002	--
campesterol	24-methylcholest-5-en-3*β*-ol	0.06 ±0.003	--	0.05 ±0.002	--
β-sitosterol	24-ethylcholest-5-en-3*β*-ol	0.02 ±0.001			
	Σ Sterols	**5.50 ±0.31**	**1.33 ±0.04**	**6.18 ±0.19**	**3.56 ±0.10**

spring, an organism accumulates nutrients, fatty acids and PUFAs for later use for reproduction and development. Almost 40% of the body fat is used by fish for the development of ovaries and eggs for reproduction purposes (Huynh et al. 2007).

The highest content of lipids in the Baltic herring is recorded in the feeding season and drops in winter and the spawning season (Usydus et al. 2011). The month of May, when the Baltic herring was caught, is within the spawning season, when fish do not take any food, and all the energy reserves and fat are spend for the process of reproduction, thus the content of lipids in this period is the lowest. This value is estimated at 2% (Aro et al. 2000), which corresponds with our results from May (spawning season), where the amount of lipids in muscle accounted for 2.1% of the total lipids, and 2.1% in liver (Table 1). More importantly, the content and composition of fatty acids depends on the water temperature (Cordier et al. 2002). Fatty acid composition in various tissues differed, particularly in sperm, and it was probably caused by the use of fatty acids in the reproductive cycle of fish (Huynh et al. 2007). The two most important, unsaturated fatty acids, EPA and DHA, were reported in the largest quantities among all identified PUFA. According to many authors (Gladyshev 2007, Usydus et al. 2011), acid DHA significantly exceeded the EPA value. Baltic herring had DHA levels from 15% (liver) to 34% of fatty acids (sperm), and the value of EPA ranged from 8% (liver) to 22% of fatty acids (sperm) (Table 2). Sperm, as the most important factor used in the process of reproduction, should have the highest indication of the EPA and DHA value. DHA dominates among all the acids in sperm of most animals, for example, in rainbow trout (Lahnsteiner et al. 2009). In birds, PUFA n-6 dominates (Meunpol et al. 2005). In the examined tissues of *C. harengus membras*: muscle, liver and sperm, the largest amount of DHA and EPA was observed in sperm of fish, and FA n-6 (18:2 and 20:4) prevailed also among all identified tissues. However, many factors affect the quality of a FA set in sperm, they include changes in the environment, such as, water quality, pollution, global warming or diseases (Meunpol et al. 2005). Higher percentage of PUFA in fish sperm confirms very high amounts of fatty acids EPA + DHA, which are found in herring roe (Morija et al. 2007). But the excess of EPA in relation to acid DHA causes poorer brain development (Copeman et al. 2002). The ratio of DHA / EPA from the diet of fish is about 2:1 (Sargent et al. 1999). This data correspond with our studies. DHA / EPA in muscle, liver and sperm of herring was 2.24, 1.84 and 1.55, respectively (Table 2). According to Cahu et al. (2004) and Jensen et al. (2007), the amount of EPA identified in fish caught in May is the highest amount of acid during the year. However, not only DHA and EPA acids dominated in the fatty acid profile. Saturated fatty acids 16:0 ranged from 15% in sperm and 27% in muscle, to 36% of fatty acids in liver. Similar values between 12-27% in Pacific herring *Clupea harengus pallasi* were noted by Huynh (2007). Higher values of 16:0 in herring muscle and liver, compared with values recorded by other authors, may result from a different season of researches (Copeman and Parrish 2004) and a higher content of phytoplankton in the diet from where the acid comes

(Saito et al. 2002). Fish during spawning were rich in monounsaturated fatty acids, such as 18:1, 20:1 and 22: 1 (Table 2). The liver contains almost 19% of total fatty acids of 18:1, which was also reported by Huynh (2007) and as suggested by other authors, this acid is accumulated from zooplankton (Copeman and Parrish 2004). Parameters of fatty acids depend on the age, gender, metabolism, season and environmental factors, which may interfere with the previous guidelines (Nielson et al. 2005, Jensen et al. 2007). However, researchers consider that higher amounts of PUFA are observed in muscles of wild fish compared with farmed fish (Cordier et al. 2002, Cahu et al. 2004). A small amount of fatty acids may depend on different stages of herring and a diet poor in PUFA n-3, because then the fatty acid composition and the content change (Copeman et al. 2002). The study period (spawning) contributes to a significantly reduced content of lipids and their representation in tissues of herring. Nevertheless, *C. harengus membras* is a good source of EPA and DHA (Jensen et al. 2007). Additionally, we noted a higher ratio of n-3/n-6, likewise Jensen et al. (2007). The authors emphasize that it is 50 times higher than recommended, which can explaine our higher results.

A similar combination of sterols, which was identified in Baltic herring was noted by Souchet and Laplante in mackerel and herring (2007). Cholesterol was the major sterol , which, depending on the tissue, ranged from 93% of the total sterols (liver) and 98.9% (sperm) to 100% (muscle). Sterols, such as campesterol and campestanol, belonging to phytosterols, were derived from phytoplankton, while other identified sterols could come from zooplankton (Copeman and Parrish 2004, Souchet and Laplante 2007). According to other authors, these data confirmed that cholesterol is the main sterol in fish. The high levels of cholesterol in tissues were also reported for other marine species (Kanazawa 2001, Bragagnolo and Rodriguez-Amaya 2001, Saito et al. 2002, Copeman and Parrish 2004, Souchet and Laplante 2007). The composition of the sterol fraction is affected by the time of the year when the material is collected, depth of the sea, geographical location (Bragagnolo and Rodriguez-Amaya 2001) and dietary sources (Kanazawa 2001).

Most of the studied papers indicate that DHA acid dominated in fish species and EPA predominated in shrimp (crustaceans) (Copeman and Parrish 2004). What about the fatty acids profile in the Baltic marine species? Crustaceans belonging to the zooplankton are a very good source of fatty PUFA n-3 for fish (Saito et al. 2002). However, there is no information on the composition and the content of fatty acids and sterols in the muscle of shrimp from the South Baltic region. Szaniawska (1991) quotes the lipid content, which in *C. crangon* in the Gulf of Gdansk amounts to 5.3 ±2.5% of dry mass. It appears from our data that the amount of EPA in the muscle tissue of shrimp is almost 4 times higher than in herring muscle. On the other hand, the amount of DHA in muscle of shrimp is 2 times lower than in fish muscle, as reported by other authors (Saito et al. 2002). Smaller organisms are the main food source for *C. crangon* (Luttikhuizen et al. 2008), while the fish have an additional food source in the form of larger crustaceans and they balance the level of DHA to a large extent (Saito et al. 2002). The excess of acid 16:0 in muscle of brown shrimp (7.41 mg g^{-1}), and *C. harengus membras* (5.40 mg g^{-1}) is the original source of phytoplankton. The other saturated acids, as 14:0, 18:0, also come from phytoplankton (Brown 2002). The highest quantity of FA, which corresponds to EPA, explains the diet of *C. crangon,* rich in smaller crustaceans, bivalves and fish (Luttikhuizen et al. 2008). Accordingly, the highest amount in our study period was noted for PUFA n-3. A high level of cholesterol is required for the biosynthesis of sex and molting hormones (Kanazawa 2001), as well as for the formation of cell membranes and intercellular structures in crustaceans (Le Nechet et al. 2007). Cholesterol is also an intermediate in the biosynthesis of ecdysteroids (Hopkins 2009). Crustaceans do not have the capacity for biosynthesis of sterols and incorporate them from food. None of the 16 known sterols is synthesized, so all sterols come from dietary sources (Kanazawa 2001). According to Bragagnolo and Rodriguez-Amaya (2001), very high cholesterol content in shrimp is balanced by the reduced mass of the total lipids and a predominance of polyunsaturated fatty acids, especially n-3.

CONCLUSIONS

1. *Crangon crangon* is a good source of omega-3, omega-6 and sterols. At the same time, it contains higher amounts of PUFA than fish, so it is perfect food for them during the feeding season.
2. High content of EPA and DHA in herring *C. harengus membras*, and low-fat herring is perfect for consumption.

ACKNOWLEDGEMENTS

Financial support was provided by the Polish Ministry of Research and Higher Education under grant DS 8110-4-0085-1.

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