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Research Article

Effect of cooking method on fatty acid composition of Oyster (*Crassostrea gigas*)

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ABSTRACT

In the present study the effect of some processing techniques on the fatty acid composition of oyster, a member of bivalves, was investigated. Results showed that, applied processing methods such as smoking, pickling, and different kinds of cooking are recorded to have caused important changes in the fatty acid composition. It was also seen that these changes were occurred from eicosapentaenoic (EPA) (C20:5n-3), and docosahexaenoic (DHA) (C22:6n-3) which are important especially in human health. Results illustrated a decrease in different proportions in the quantity of eicosapentaenoic and docosahexaenoic acids. It seems that, Maximum decrease in the mentioned fatty acids was especially observed in the fried and cooked samples.

Keywords: Cooking method; Oyster; Processing; Seafood.

1. Introduction

Oysters are non-motile marine organisms which are dependent on filtering water through the gills to obtain food. As a consequence of filter-feeding, microorganisms and chemicals, including toxic metals, can be accumulated from the marine environment. Therefore, the quality of oysters is influenced strongly by the environment in which they grow and feed (Bhuiyan, Ratnayake, & Ackman, 1986). Raw and undercooked bivalve mollusks (e.g., clams, oysters, and mussels) represent an important vector of infectious agents and marine biotoxins, largely due to this ability to concentrate pathogens and toxins during filter-feeding (Rippey, 1994). By the way, the consumption of animal foods is of big importance for healthy and balanced nutrition. The effect of composition of nutrients obtained from animal sources such as, meat, milk, eggs, and fish on human health is very big when it comes to consuming of those foods. Moreover, the technological processes to be applied on a product the nutrition value of which is known are going to affect the consumer's preference positively. There are losses in nutritional values due to ignorance in relation to the main elements of preparing, cooking and storage of foods. One of the main components of a food is lipid. An important part of the energy necessary for the body is taken into the body by the means of foods containing lipids. Maintaining a sufficient and balanced nutrition is possible through taking in the foods and energy necessary for the working and life of the body. Nutrients such as, lipid, proteins and carbohydrates undertake this function together (Bhuiyan et al., 1986).

Solid and fluid lipids in diets have many important roles. They are effective energy sources and also have functions such as, being one of the cell membrane components, containing vitamins which dissolve in lipid in their structures, flavoring, satiation, and being the source for essential fatty acids (Pigott & Tucker, 1987). When compared to the other butcher meat varieties and vegetable foods, the lipid that seafood contains shows superior features. Containing unsaturated fatty acids makes the lipid in the seafood more easily absorbed in the lower alimentary canal once taken into the body than

the foods that contain saturated fatty acids. Thus, the condensation of the lipid in veins is prevented. Because of these important characteristics it is possible to be safe from heart and vein diseases (Hearn, Sgoustas, Sgoustas, & Hearn, 1987; Lands, 1985; Pigott & Tucker, 1987). In recent years, much attention has focused on the development of processing methods to reduce microbial load in postharvest oysters and, more specifically, to reduce the levels of *Vibrio vulnificus*. Included in these methods are relaying (Richards, 1988), depuration (Cliver, 1995), freezing (Parker, Maurer, Childers, & Lewis, 1994), use of additives (Birkenhauer & Oliver, 2003; Sun & Oliver, 1994a,b), irradiation (Andrews, Jahncke, & Mallikarjunan, 2003; Hu, Mallikarjunan, Koo, Andrews, & Jahncke, 2005; Mallet, Beghian, & Metclaf, 1991; Novak, Liuzzo, Grodner, & Lovell, 1966), thermo radiation (Ama, Hamby, & Toledo, 1994), and mild heat treatment (Andrews, Park, & Chen, 2000; Cook & Rupple, 1992).

In the present study the effects of different processing methods including pickling, frying, freezing, smoking, cooking on fatty acid composition of Oyster (*Crassostrea gigas*) were investigated.

2. Materials and Methods

Fresh Oyster (*C. gigas*) were purchased from a local market in Kuala-lumpur, Malaysia. In order to reflect the initial state of the mussel meat the raw meat was taken out by the means of a spatula. The rest of the mussels were steam-cooked in boiling water at 100 ºC in a sieve for eight minutes. Immediately after steaming the meats, manually separated from shells. After the steaming process the mussels were divided into three lots. The first lot was treated by smoking. The second lot was treated by pickling and the third part was treated by frying. The smoking process was applied by traditional method. Cooked mussel meats was immersed in 2% brine for 1.5 h, and then drained on wire mesh tray. The meats were dipped in sunflower oil and again laid on mesh tray to drain. Preliminary drying was not required. The kiln temperature wasn't able to control as the top of oven was opened to air. The meats were smoked about 50 minutes. The frying process was applied in a deep-fryer for 6 min with sunflower oil at 160 °C. The pickling process was applied by using 3% vinegar, 3% salt and spices. Mussel meats were contained in a jar and covered with spiced vinegar. Each sample was homogenized. Lipids were extracted from the homogenized sample by Bligh and Dyer method (1959). The fatty acids methyl esters derived from the raw, steam cooked, pickled, smoked and fried mussel lipid were analyzed in Agilent 7890 Chromatography. The analysis of the fatty acids methyl ester was realized by the means of 2.5 m x 0.2 mm, 10% DEGS-Chromosorb plated and filled colon FID detector. The temperature of the detector and the injection block was recorded as 250 ºC, and the temperature of the column as 170 ºC. The temperature program was reached 250 ºC through the 2 ºC min^{-1}. increases from 180 ºC to 210 ºC and was remained at that temperature for 30 minutes. The velocity of the carrier gas was recorded as 25 mL min^{-1} N_2, the speed of air as 300 mL min^{-1}, and the speed of H_2 as 30 mL min^{-1}. Peaks were identified by comparing the retention times with those of a mixture of standard methyl esters (Sigma, USA).

3. Results and Discussion

The effects of the various processing methods on the fatty acid composition applied to oysters are illustrated in Table 1. The unsaturated fatty acids of the mussels that were not processed, defined as raw, form 70.5% of the total fatty acid. This ratio varies in all other processed mussels. For example, in fried mussels the ratio was 74.5%, in steam-cooked mussels 74.1%, in smoked mussels 52.3%, and in pickled mussels 61.7%. The 28.5% of the present quantity in the raw mussel, 25.2% of the steam-cooked mussels, 17.6% of the fried mussels, 19.8% of the smoked mussels, and 28.2% of the pickled mussels belongs to the monounsaturated fatty acids. The percentage of the saturated fatty acids in the raw, steam-cooked, fried, pickled, and smoked mussels were in the following order: 25.2%, 19.8%, 27.2%, 36.6%, and 35.2%. In the non-saturated fatty acids that could be found in the processed mussels palmitoleic acid (C16:1) and oleic acid (C18:1) were recorded as the most abundant ones. The level of docosahexaenoic acid (C22:6) that belongs to the class of unsaturated fatty acids was 18.6% in raw mussel, 11.8% in steam-cooked mussel, 14.5% in pickled mussel and 10.8% in smoked mussel. On the contrary, it was remarkable that fried mussel contains a quite low level of docosahexaenoic acid (1.0%) unlike other mussel products. Also, linoleic acid (C 18:2) was more likely to be found more in the samples of steam-cooked (43.0%) and fried mussel (20.2%) when compared with other mussel products. It was detected that linolenic acid (C18:3), a very important component of unsaturated fatty acids, was available in eminently high amounts only in the products, which were processed as fried mussels (33.1%).

The existence of docosahexaenoic acid, the member of unsaturated fatty acids, in seafood was of a very high importance in terms of nutrition. Comparing the effects of processing techniques on EPA and DHA, two of the most important n-3 PUFA, the decreasing rate of DHA (docosahexaenoic acid) were 17.9% (raw mussel), 15.0% (steam-cooked mussel), 1.2% (fried mussel), 13.6% (pickled mussel) and 10.6% (smoked mussel). However, the greatest decrease was detected in fried mussel. The decreasing rate of EPA (eicosapentaenoic acid) were 5.3% (raw mussel), 0.6% (steam-cooked mussel), 0.7% (fried mussel), 2.8% (pickled mussel) and 10.5% (smoked mussel). Mussel has a very high amount of saturated and monounsaturated fatty acids when compared with other bivalve seafood. Orban, Lena, Nevigato, Casini, Marzetti and Caproni (2002) found that the 37-48% of mussel meat's distribution of total fatty acids within a year consists of unsaturated fatty acids, 26-38% of saturated fatty acids, and 16-29% of monounsaturated fatty acids.

Table 1
Fatty acid profile (% of total fatty acids) of untreated and processed oysters (*Crassostrea gigas*)[a].

Fatty acid	Row	Steam-Cooked	Fried	Pickled	Smoked
C4:0	0.01±0.01	0.01±0.01	0.00±0.04	0.02±0.01	0.01±0.02
C6:0	0.07±0.03	0.03±0.05	0.05±0.02	0.05±0.02	0.06±0.20
C8:0	0.12±0.06	0.03±0.07	0.10±0.02	0.22±0.03	0.09±0.01
C10:0	0.28±0.19	0.05±0.08	0.12±0.04	0.38±0.23	0.21±0.03
C12:0	0.35±0.16	0.08±0.04	0.10±0.06	0.44±0.30	0.22±0.12
C14:0	6.24±1.07	1.18±1.08	1.60±0.70	5.40±1.33	7.80±1.01
C16:0	27.4±6.82	5.73±1.05	25.5±3.16	33.5±5.10	22.0±2.28
C16:1	4.87±0.38	2.17±0.90	1.10±0.45	6.40±1.20	2.19±0.68
C18:0	6.85±0.72	2.33±1.16	7.20±1.20	7.12±1.04	3.03±1.16
C18:1	10.3±1.14	18.2±4.32	12.4±1.60	9.55±1.65	11.7±0.88
C18:2n-6	2.39±0.40	28.9±9.16	17.7±3.44	2.88±0.80	8.08±1.14
C18:3n-3	2.64±0.77	5.47±1.12	25.1±4.20	3.01±0.77	10.1±1.06
C20:0	2.46±0.43	0.54±0.02	0.40±0.20	2.11±0.32	1.15±0.42
C20:3n-6	0.26±0.06	0.08±0.13	0.10±0.03	0.21±0.04	0.12±0.08
C20:4n-6	3.32±0.63	1.32±0.55	0.2±0.100	3.15±0.82	1.98±0.30
C20:5n-3	23.1±4.92	7.19±0.93	2.15±0.75	20.55±3.16	17.9±4.18
C22:0	0.01±0.02	0.01±0.01	0.00±0.30	0.01±0.01	0.00±0.01
C22:4n-6	0.02±0.04	0.01±0.02	0.00±0.20	0.03±0.02	0.01±0.01
C22:6n-3	9.43±10.93	2.16±2.02	1.70±0.20	8.18±2.01	5.88±1.68
SFA	43.76±9.29	16.87±2.44	27.2±2.15	45.1±3.31	46.2±4.05
MUFA	15.12±1.26	3.86±0.85	15.5±1.44	16.8±2.1	12.88±3.64
PUFA	41.12±9.27	10.2±1.40	44.2±5.65	33±6.02	46.12±7.16
∑n-3	35.14	14.82	28.95	31.74	33.84
∑n-6	5.99	23.27	18	6.27	10.19
MUFA / SFA	0.35	0.22	0.56	0.37	0.29
PUFA / SFA	0.99	0.60	1.62	0.73	1.00
∑n-6 / ∑n-3 c	0.17	1.57	0.62	0.19	0.30
∑n-3 / ∑n-6 d	5.87	0.63	1.60	5.06	3.32

[a] All values are means±standard deviations of duplicate data from three independent trials (n =6). SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids

As in other bivalve seafood palmitic acid (C16:0) constitutes the greater part of saturated fatty acids. According to the statement of most researchers; palmitic acid (Karakoltsidis, Zotos, & Constantinides, 1995; Takagi, Itabashi, & Kaneniwa, 1986), which is a member of saturated fatty acids, and palmitoleic acid (Karakoltsidis et al., 1995), a member of monounsaturated fatty acids, are shown as the dominant fatty acids of bivalve seafood. The analyzed mussel meat contains 27.8% saturated, 30.5% monounsaturated and 37.7% unsaturated fatty acids. As similar to the statement of Karakoltsidis et al. (1995) a saturated fatty acid palmitic acid (11.8%) and a monounsaturated palmitoleic acid (12.7%) were found as the chief fatty acids of raw mussel. In addition, the presence of unsaturated fatty acids docosahexaenoic acid (18.6%) and eicosapentaenoic acid (7.8%) in high amounts in raw mussel attracts attention. Takagi et al. (1986) reported that C20:5 and C22:6 fatty acids form nearly the half of bivalve seafood's unsaturated fatty acids. This statement presents a resemblance with the data was obtained in our research results.

The composition of nutrients of seafood is likely to vary uncontrollably because of the eating habits of types, sexual maturity, the geographical structure of the place in which it is caught within a year. This condition may be given as one of the reasons of decreasing in omega-3 and other fatty acids (Karakoltsidis et al., 1995). The study showed that the palmitic acid of processed mussel groups was reduced by steaming least (8.4%), frying (11.1%), smoking (10.4%) most, in order. On contrary to this, that the palmitoleic acid (C16:1) was significant reduced by steaming (2.6%), frying (4.4%) and smoking (5.3%). It was shown that among oleic acid (C18:1) and erucic acid (C22:1) that symbolize monounsaturated fatty acids, oleic acid was found 18.5% in steam-cooked mussel and 10.5% in fried mussel whereas erucic acid was found much less in product groups other than pickled mussel. It was found that linoleic acid (C18:2 3.1%), eicosapentaenoik acid (C20:5 7.8%), docosatetraenoic acid (C22:4 3.6%), docosapentaenoic acid (C22:5 4.1%) and docosahexaenoic acid (C22:6 18.6%); all among unsaturated fatty acids, form the unsaturated fatty acids of raw mussel meat. Whereas, it was found that the increasing rate of linoleic acid (C18:2) by steaming (41.0%), smoking (9.1%), and frying (22.4%). Whereas, it was found that the decreasing rate of C 22:4 fatty acid by steaming (0.8%) and frying (0.2%). Also, the amounts of eicosapentaenoic (C20:5) and docosahexaenoic acids

(C22:6), among unsaturated fatty acids, vary as a result of the processing techniques applied to mussel meat. C20:5 fatty acid was at the level of 7.8 % in raw mussel meat while it was 0.3-0.5% in steam-cooked and fried mussel. Some of these treatments may cause to oxidative reactions in lipids, whereas it may cause the fatty acids with long chains to shatter by means of lipolitic enzymes. Senturk, Baygar, Gokoglu, Kaplan, Senturk (2000) reported that, as a result of the temperature-based process applied in cooking and canning, certain fatty acids of fish shatter and cause to a transformation in themselves, and that on one hand the amounts of fatty acids in fish increase; on the other hand the amounts of others decrease.

C22:6 fatty acid, among the unsaturated fatty acids of mussel, was at the minimum level in fried mussel (1.0%). It was possible that the decreasing rate of docosahexaenoic acid in fried mussel to take place as a result of the fatty acid composition of sunflower oil used in the process of frying, docosahexaenoic acid may have shattered and turned into fatty acids with shorter chains. Therefore, the choice of the lipid used in the process of frying was very important. Kayahan (1981) puts forward that the usage of sunflower oil, which has a more unsaturated structure in proportion to oil, should not be preferred in frying as it causes to the formation of oxide-acid. Some researchers reported that the process of frying has a very important effect on the fatty acid composition of some fish types (Asiedu, Julshamn, & Lie, 1991; Candela, Astisaran, & Bello, 1997; Gall, Otwell, Koburger, & Appledorf, 1983; Mustafa & Medeiros, 1985). In the light of their statements; the process of fried mussel was shown as an important source of C20:5 and C22:6 fatty acids (Pigott & Tucker, 1987; Rawls, 1981) that play a significant role in reducing the risk of heart diseases. As a result of pickling of the mussels an increase in the palmitic acid in saturated fatty acids, and in palmitoleic acid in monounsaturated fatty acids were recorded. This state was the indicator of the effect of the vinegar and salt used for pickling had on the fish meat enzymes. The ripening by the means of pickling is a very complicated physiochemical process. Ripening does not occur either with only vinegar or with only salt's effect. Salt and vinegar affect the present protein and lipid in the fish together with the enzymes the fish contain. With the decomposing of the protein and lipid at a certain level, nice and aromatically scented products are produced. (Varlik, Gokoglu, & Gun, 1993) When generally evaluated, it was thought that pickling did not affect the monounsaturated and polyunsaturated fatty acid compositions and that it was only a negative effect on the decrease in docosahexaenoic acid related to the lipid hydrolyzing and thus benefices for the nice and aromatic scented flavor. However, a significant increase in palmitoleic acid (14.7%) was found after pickling. Generally, it was found that an increase in the amount of the polyunsaturated fatty acids by cooking. Both in fried and steam-cooked mussels the glycerides were decomposed during the temperature based process and thus may lead to the decomposing of the fatty acid composition. Medina, Aubourg and Martin (1993) informed that the DHA, the essential source of the polyunsaturated fatty acids, can go through changes with the lipolitic enzymes on high temperatures. When mussels were smoked there was a change in the fatty acid composition on the contrary to what some researchers claim. (Asiedu et al., 1991; Bhuiyan et al., 1986) This change was observed at saturated fatty acids such as pentadecanoic acid (C15:0) and oleic acids (C18:1), monounsaturated fatty acids such as palmitoleic acid (C16:1) and erucic/cis-13-docosenoic acid (C 22:1), polyunsaturated fatty acids such as C20:5, C22:5 and C22:6 especially. Beltran and Moral (1991) reported that the changes occurring during the smoking of sardine fish may be related to the balance between lipolysis and protein lipid and autoxidation. The same researchers found that the decrease in the PUFAs was caused by the oxidative phenomenon created by the exposure of the fish to atmospheric oxygen and the temperatures reached during the smoking process. An increase in the C18:2, C18:3 and C 22:5 polyunsaturated fatty acids was found in the smoked mussels; whereas, in the other fatty acids were found a decrease. These increase and decreases may have come out due to the temperature reached during the smoking process.

4. Conclusion

It seems that, steam-cooking, smoking, frying process gives rise to amount of the polyunsaturated fatty acid level than the pickling process. However, the right choice for consumption is to choose the technique that would best preserve the nutrition values of a food. When looked from this point of view, being the process that has a negative effect on the fatty acids, which are important for health, most effectively, frying should be the lastly preferred process for the mussels to be consumed. Pickling can provide both a presentation of a product with different aroma and taste on the mussel meat to the consumers and pickled mussel has a good fatty acid composition and thus may take its place among the products a consumer would prefer. Smoking process may be negatively effect on the fatty acid composition of the mussel. This change occurs especially in the polyunsaturated fatty acids as increase in some or as decrease in the others of these fatty acids.

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