Journal of Food Processing & Technology
ISSN: 2157-7110

Guizani and Moujahed, J Food Process Technol 2015, 6:9
DOI: 10.4172/2157-7110.1000487

Research Article Open Access

Seasonal Variation of Chemical and Fatty Acids Composition in Atlantic Mackerel from the Tunisian Northern-East Coast

Guizani SEO* and Moujahed N

National Institute of Agricultural Sciences of Tunisia, 43 Av. Charles Nicolle 1082 Tunis Mahrajene, Tunisia Laboratory of animal and food resources, Tunisia

Abstract

Seasonal variation of chemical and fatty acids composition of Atlantic Mackerel populations from the Northern-East coast of Tunisia were investigated in order to assess the best period for its consumption. Fresh specimens were purchased monthly from Bizerte fishing port located in the north-east coast of Tunisia. It was noted that total lipids and protein contents levels varied significantly (P<0.05) according to the season. The highest protein level was registered in autumn (27.6%), while the lowest was in spring (18.7%). Total fat content decreased significantly (P<0.05) from (11.1%) in spring to (4.5%) in summer. The major fatty acids in each season were 16:0 and18:0 (palmitic and stearic) acids as saturated; 16:1 and 18:1 (palmitoleic and oleic) acids as monounsaturated; and 20:4 (arachidonic acid), 20:5 Eicosapentanoic (EPA), 22:6 Docosahexanoic (DHA)as polyunsaturated. These components varied significantly (P<0.05) during the sampling period.

It was shown that high PUFA values are related to the high n-3 PUFA proportions, mainly represented by EPA and DHA. Docosahexanoic acid was the most abundant (P<0.05) during the study period which highest rate (P>0.05) was observed in autumn (40.1%). It was noted that n-6 PUFA proportions were very low comparatively to those of n-3 PUFA series. The highest level of n-6 PUFA series corresponded to arachidonic acid in autumn (3.9%). The best (n-3)/(n-6) ratio was registered in spring (10.81).

Keywords: Atlantic mackerel; Fatty acids; Lipids; Seasonal variation

Introduction

In many countries fish species are important sources of food in human diet composition. Besides its high level of protein content and its moderate cost, Mackerel species seems to contain substantial amounts of polyunsaturated fatty acids (PUFA) which have benefic effects on human health. These fatty acids are suspected to prevent some diseases such as cardiovascular, rheumatoid, arthritis, mental illness [1,2] and several types of cancer [3,4].

PUFA found in fish oils can be divided into two biochemical families, n-3 and n-6, with different biological effects [5] those of n-3 family mainly represented byeicosapentaenoic acid (EPA, 20:5), docosapentaenoic acid (DPA, 22:5)and docosahexaenoic acid (DHA, 22:6). While those of n-6 family generally present at very low quantity [6] are represented by (arachidonic, 20:4) eicosadienoic (20:2) and linoleic acids (18:2). Moreover, n-3 PUFA series play an important role in the improvement of visual function and in the prevention of atherosclerosis and thrombosis development [7]. Also, studies on newborns indicate that DHA is essential for the normal functional development of the retina and brain, particularly in premature infants [8].

Scomberscombrus is a small pelagic fish species well distributed through the Mediterranean Sea, the Black sea and on the both sides of Atlantic Ocean [9]. Belonging to the Scombridae family, *Scomber scombrus*is characterized by a blue back and silver abdomen, it is one of the most popular fish in Tunisian gastronomy, its annual production was about 196 tones [10]. This species is known for its high fat content and seems to be one of the highest sources of long chain polyunsaturated fatty acids LC-PUFA [11].

In Tunisia, previous studies examined mackerel biometry and biological reproduction, it is characterized by a carnivorous diet and its spawning period was in winter [12]. However, there are few or no available details on biochemical studies of its flesh composition. Moreover, this species is caught during several periods of the year [12] consumer could request data about its seasonal nutritive variation.

The aim of the present study was to evaluate the seasonal variation of chemical and fatty acids composition of Atlantic Mackerel populations from the Northern-East coast of Tunisia in order to determine the most favorable periods for its consumption.

Materials and Methods

Fishes sampling and conditioning

The analyzed specimens were collected monthly from the fishery off northern east of Tunisia. A case of Mackerel population was sampled randomly and purchased each month at the hall fish port of Bizerte during the period extending from May 2010 to April 2011. At landing, fishes were transferred in polystyrene boxes containing ice and quickly transported at the laboratory were somato metric measurements were taken; Samples length and weight ranged from 26 cm to 35 cm and 160 g to 310 g. Then fishes were beheaded, washed, filleted, bag packed and frozen at -20°C.

Chemical analysis and fatty acid characterization

Moisture: Moisture content was determined by drying to constant weight in an oven at 105°C (n=6) according to the AOAC, 2000. Results were expressed as percentage of dry weight.

Ash: Ash content was determined after ignition at 550°C (n=6) for 4 h (AOAC, 2000). Results were expressed as percentage of dry weight.

***Corresonding author:** Guizani SEO, National Institute of Agricultural Sciences of Tunisia, 43 Av. Charles Nicolle 1082 Tunis Mahrajene, Tunisia Laboratory of animal and food resources, Tunisia, E-mail: salma.inat@yahoo.fr

Received June 11, 2015; **Accepted** July 03, 2015; **Published** July 10, 2015

Citation: Guizani SEO, Moujahed N (2015) Seasonal Variation of Chemical and Fatty Acids Composition in Atlantic Mackerel from the Tunisian Northern-East Coast. J Food Process Technol 6: 487. doi:10.4172/2157-7110.1000487

Protein: Crude protein (N×6.25) was determined in triplicate by the Kjeldahl method (AOAC, 2000). Results were expressed as percentage of dry weight.

Lipid extraction: Total lipid extraction was carried out by Soxhlet method (AOCS, Ba 3-38) in triplicate using 5 g (dry weight) of flesh powder with 200 ml of petroleum ether for 6 h. The extracted oil was evaporated under vacuum at 65°C using a rotaryevaporator, and then placed in an oven at 45°C for 1 h before being transferred into desiccators and reweighing; results are expressed as a percentage of dry tissue.

Fatty acids analysis

Methyl esters were prepared by direct trans esterification method using 200 µl acetyl chlorides according to Mosers [13]. The extracted lipid was dissolved in 2 ml (methanol/methylene chloride (3:1)); followed by the addition of an internal standard. The mixture was vortexed and heated at 75°C for one hour. After cooling, 4 ml of potassium carbonate (7% W/V), hexane and acetonitrile were added and the mixture was centrifuged for 10 mn; the hexane layer (1 µl) was taken for GC analysis. Fatty acid analysis was performed using a gas chromatograph (HP, 6890), with a split/split less injector and a flame ionization detector. The device includes a 30 m long HP Innowax capillary column with an internal diameter of 250 µm and a 0.25 µm film, the stationary polar phase of the column being polyethylene glycol. Comparison of the retention times of the fatty acids under study and those of standard fatty acid methyl esters (PUFA-3) allowed to identify the different fatty acids contained in mackerel oil extract. Results are expressed as percentage of total fatty acids.

Statistical analysis

For the different biochemical parameters, statistical analysis was performed using analysis of variance according to ANOVA procedure (SAS software, version 9.1). Season effect was analyzed and month sampling in each season was considered as replication. Means were compared using Student Newman and Kull tests and differences were considered significant when P<0.05.

Results

Chemical composition

The chemical composition of *Scomber scombrus* is presented in Table 1. The highest moisture level was obtained in summer (72.25%). Ash proportions ranged from 1.7% in winter to 2.6% in autumn. Moisture and Ash content vary significantly according to the season (P<0.05). Protein content reached in autumn 27.6%, lowest value was obtained in spring 18.7%. Lipid content ranged from 11.1% in spring to 4.5% in summer. Protein and lipids seasonal differences were significantly high (P<0.001).

Fatty acids contents

Fatty acids composition of the analyzed specimens is presented in Table 2. PUFA constitute the majority of the fatty acids pool, followed by saturated (SFA) and monounsaturated fatty acids (MUFA).

Total Saturated fatty acid fraction ranged between 32.35% and 38.22% (Figure 1) with palmitic acid (16:0) as the most important fatty acid, followed by stearic acid (18:0) and myristic acid (14:0) in each season. It is noted that high percentages of (16:0) and (18:0) are obtained in autumn with about 24.97% and 12.01%, however seasonal variation of these components was not statistically significant (p>0.05); whereas (14:0) vary significantly with season (p>0.05); peak is obtained in spring 3.5% and its minimal value was registered in autumn1.24%.

Total monounsaturated fatty acids mainly represented by (16:1) and (18:1) increasing in winter 16.58% (Figure 1). The most important MUFA corresponds to (18:1) reaching in winter 13.81%; whereas (16:1) high percentage is obtained in spring 4.13%. These two components (16:1 and 18:1) vary significantly with seasons (p<0.05) in fact it is noted that their minimal values were obtained respectively in autumn 2.63% and 7.09%.

Polyunsaturated fatty acids content constitute the biggest part in Mackerel lipid. It was noted that high PUFA levels are related to n-3 PUFA family mainly represented by EPA (20:5) and DHA (22:6) increasing respectively in spring 7.8% and in autumn 40.10%, and which seasonal variation was statistically significant (p<0.05); however minimal values were obtained in autumn 4.54% and 35.66%.

The high proportion of n-6 PUFA series is linked to that of arachidonic acid (20:4) increasing in autumn (3.91%) and the eicosadienoic acid (20:2) maximum rate was obtained in spring (0.34%). Seasonal variation of these two components was statistically significant (P<0.05). The highest n-3/n-6 ratio is observed in spring (10.81).

Discussion

Proximate composition

Proximate composition of mackerel flesh was investigated; results showed that moisture contentsin studied samples were the highest when lipid was the lowest leading to deduce an inverse relation between thesetwo components. This finding is in agreement with Orban et al.[14] study on *Boops boops* from the Southern Adriatic coast of Italy. Ash content range is between 1.70 - 2.68%. These values were close to those found on *Sardina pilichardus* by Caponio et al. [15]. Moisture and ash contents seasonal variation was statistically significant (p<0, 05) as observed on other studied fish species by Kacem et al. [16].

Scomber scombrus protein and lipid contents vary significantly (P<0.01) according to the seasons, this trend is in accordance with Orban et al. [14] study on horse mackerel from the Southern Adriatic coast of Italy; moreover, according to Wallace [17], mackerel fat fillets content vary with season with a maximum level ranging from 25 to 30% in December and a minimum of around 5% in May when the fish spawns.

The observed seasonal variations in mackerel flesh composition may be explained by the impact of some environmental parameters such as temperature, salinity and fluctuations in food availability and fish life cycle. In addition, during the reproductive periods, lipids and proteins are mobilized from muscles and transferred to the gonads [18] influencing fish nutritional value and particularly flesh lipid composition.

Fatty acids

Our results show that palmitic acid 16:0 is the predominant fatty acid in SFA family [19-21]; in fact, palmitic acid is the key metabolite in fish species [22] its rate seemed to be constant through the sampling

Parameters	Autumn	Winter	Spring	Summer	P-value
Moisture (%)	71.1 ± 0.8^{b}	70.15 ± 0.7^{b}	71,6 ± 0.9^{b}	72.25 ± 2.8^{a}	0.04
Ash (%)	2.6±0.9^{a}	1.70±0.3^{b}	1.8±0.2^{b}	2.05±0.7^{a}	0.01
Protein (%)	27.6±1.82^{b}	20.6±2.23^{a}	18.7±1.09^{b}	22.7±1.53^{a}	0.001
Lipid (%)	6.5±0.51^{c}	6±0.22^{b}	11.1±1.51^{a}	4.5±0.80^{d}	0.001

Means with the same letter in the raw are not significantly different.

Table 1: Proximate composition of studied samples.

Nutrients	Autumn	Winter	Spring	Summer	P-value
Saturated fattya cids (SFA)					
C14:0	1.24±0.52^{a}	1.57±1.03^{a}	3.5±2.55^{b}	1.79±0.54^{a}	**0.04**
C16:0	24.97±6.15^{a}	20.94±5.61^{a}	21.76±1.31^{a}	22.67±3.28^{a}	**0.11**
C18:0	12.01±3.03^{a}	9.84±2.15^{a}	7.85±3.14^{a}	9.69±0.92^{a}	**0.07**
Mono unsaturated fatty acids (MUFA)					
C16:1	2.63±0.77^{a}	2.77±1.39^{a}	4.13±1.16^{b}	2.69±0.69^{a}	**0.001**
C18:1	7.09±3.92^{b}	13.81±6.60^{a}	12.23±3.73^{a}	11.93±4.21^{a}	**0.01**
Poly unsaturated fatty acids : n-6 series					
C18:2n-6	1.34±0.40^{a}	1.26±0.31^{a}	1.46±0.51^{a}	1.42±0.23^{a}	**0.02**
C18:3 n-6	0.15±0.10^{a}	0.12±0.05^{a}	0.10±0.03^{a}	0.19±0.09^{a}	**0.53**
C20:2n-6	0.15±0.06^{a}	0.26±0.04^{a}	0.34±0.13^{a}	0.17±0.16^{a}	**0.03**
C20:4n-6	3.91±0.57^{a}	2.81±0.79^{b}	2.37±0.79^{b}	2.72±0.70^{b}	**0.004**
Poly unsaturated fatty acids : n-3 series					
C18:3 n-3	0.29±0.05^{c}	0.50±0.18^{a}	0.73±0.38^{b}	0.47±0.17^{a}	**0.001**
C20:3n-3	0.35±0.17^{a}	0.51±0.29^{a}	0.26±0.14^{b}	0.38±0.05^{a}	**0.02**
C20:5n-3	4.57±0.91^{a}	5.79±0.77^{a}	7.80±0.97^{b}	6.08±1.10^{b}	**0.001**
C22:5n-3	1.05±0.23^{a}	1.63±0.68^{a}	1.75±0.42^{a}	1.46±0.24^{a}	**0.009**
C22:6n-3	40.10±7.93^{b}	38±8.91^{b}	35.66±4.45^{a}	38.28±5.8^{b}	**0.04**
PUFA/SFA	1.36	1.56	1.52	1.49	
ω3/ ω6	8.36	10.40	10.81	10.37	

Means (n = 6) with the same letter in the raw are not significantly different (p>0.05).

Table 2: Fatty acids composition of Atlantic mackerel samples (% TFA).

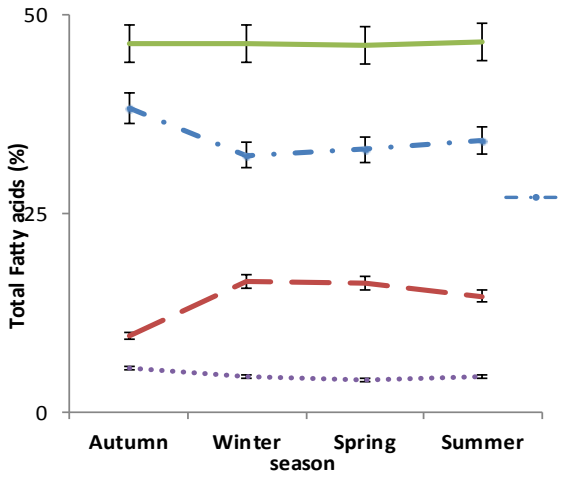

Figure 1: Seasonal variations of total SFA, MUFA, n-3PUFA, n-6 PUFA.

period and which seasonal variation was not statistically significant (p>0.05) leading to deduce that this compound is not influenced by diet and environmental condition variations.

Total MUFA mainly represented by oleic (18:1) and palmitoleic (16:1) acids varied significantly (P<0.05) with fishing season increasing in winter 16.5% which is in accordance with Soriguer et al.[23] finding on Atlantic mackerel from the south of Spain. Moreover, high MUFA level is an indicator of high degree of carnivory as signaled by Dalsgaard et al. [24], in addition the analyzed specimens diet composition show that this fish species is typically carnivorous feeding essentially by small fish species as (*Sardina pilchardus*, *Engraulis encrasicolus*) crustacean mainly represented by (mysidacea and euphosiacea) and mollusks as (*Sepia officinalis*, *Loligo vulgaris*, *Octopus vulgaris*) personal unpublished.

Comparatively with SFA and MUFA, PUFA constitute the highest proportion in mackerel extracted lipid as indicated by Ozogul et al. [25]. Moreover, n-3 PUFA family was dominant comparatively with n-6 series present at very low quantity [6]. Also, it was noted that highest total PUFA level was obtained in autumn 52% and the lowest in spring 50.5% (Figure 1). These high percentages are linked to n-3 PUFA mainly represented by EPA and DHA, where the latter is present at an abundant amount during the study period ranging from 35.7% in spring to 40.2% in autumn which is in accordance with Ozogul et al. [25] finding in Mackerel mussels from Turkey(35.2%).

In comparison with other fish species DHA in mackerel mussels are close to those of *Boops boops* captured in March from the Southern Adriatic coast of Italy in Orban et al. [14] finding (31.18%), whereas it is much higher than those of Horse mackerel in the same study. DHA in our study is higher than *Scomber scombrus* value from Marmara Sea (25.2%), but it is close to *Merangius merlangus* value (40.5%) from the Black Sea in Tanakol et al. [26] finding. In this study DHA high values may be explained by the impact of many factors influencing Mackerel flesh composition essentially *n-3* PUFA series as:location, environmental parameters, and food availability with a large variety of prey items such as fish (*Engraulis encrasicolus, Sardina pilchardus*….); crustacean (mysidacea and euphosiace)and mollusks present respectively with 67%, 20.17%, 12% of frequency of occurrence (F%) (El Oudiani unpublished).

Regarding n-6 PUFA, high values are linked to arachidonic acid (20:4) reaching in autumn (3.91%), the obtained results are close to Tanakol et al. [26] finding on mackerel from Marmara sea (2.8%),and *Merangiu smerlangus* from the Black Sea(3.5%). The n-3/n-6 PUFA ratio is an essential element of human nutritional evaluation and an indicator of the lipid quality [14]. Its high level was obtained in spring 10.81 which is in agreement with Ozogul et al. [25] finding on mackerel from Turkey. Indeed, the n-3 PUFA are known to decrease the rate of triacylglycerols, cholesterol, mainly low density lipoproteins in the human serum, and to inhibit the aggregation of blood platelets and the damage of blood vessels [27-29]. In addition, they are suggested to play a role in the prevention of some cancers [30].

In human diet, seafood products are the most important significant source of n-3 PUFA, that's why dietary guidelines recommend more and more their consumption. The period from May to November where *n-3* PUFA values range from (36% to 46%) is considered as the most important for mackerel consumption due to the optimum n-3 PUFA level; although the consumption of this fish is recommended throughout the year. However, from nutritional point of view *Scomber scombrus* is classified among the fatty fish species. The present data shows that its flesh composition is characterized by a high protein and lipid contents and an important n-3 PUFA level mainly DHA.

Conclusion

This study dealing with seasonal variation of the mackerel flesh composition is very important and may provide some useful information in the production of higher value-added products such as oil extraction in view of commercial exploitation.

These variations are essentially due to the impact of many factors such as sex, size, age, reproduction, water temperature, degree of pollution, nutritional condition, geographical location, species genetic differences, processing, storage, and distribution which could affect the quality of the value-added product. The advantage of oil from mackerel flesh is its higher level of EPA and DHA. These applications include essentially the production of nutraceutical foods with high level of PUFAs that could potentially decrease cholesterol levels and prevent heart diseases.

References

1. Ruxton CH, Calder PC, Reed SC, Simpson MJ (2005) The impact of long chain n-3 polyunsaturated fatty acids on human health. Nut Res Rev 18: 113-129.
2. Song C, Zhao S (2007) Omega-3 fatty acid eicosapentaenoic acid. A new treatment for psychiatric and neurodegenerative diseases: A review of clinical investigations. Exp Opin Inv Dru 16: 1627-1638.
3. Chen YQ, Edwards IJ, Kridel SJ, Thornburg T, Berquin IM (2007) Dietary fat-gene interaction in cancer. Can Meta Rev 26: 535-551.
4. Calviello G, Serini S, Piccioni E (2007) N-3 polyunsaturated fatty acids and the prevention of colorectal cancer: molecular mechanisms involved. Curr Medi Chem 14: 3059-3069.
5. James MJ, Cleland LG, Gibson RA (2000) Dietary polyunsaturated fatty acids and inflammatory mediator production. American Journal of Clinical Nutrition 71: 343-348.
6. Sargent JR (1997) Fish oils and human diet. Brit J Nut 78: S5 -13.
7. Calder PC (2003) New evidence in support of the cardiovascular benefits of long-chain n-3 fatty acids. Ital Heart J 4: 427-429.
8. Connor WE (2000) Importance of n-3 fatty acids in health and disease. Ame J Clin Nutr 71: 171S-175S.
9. MacKay KT (1967) An ecological study of *mackerel Scomberscombrus* (Linnaeus), in the coastal waters of Canada. Can Fish Res Board Tech Rep.
10. Tunisian general direction of fishing and aquaculture (TGDFA), statistics of the year 2013.
11. Ackman RG (1990) Seafood lipids and fatty acids. Food Rev Int 6: 617-646.
12. Hattour A (2000) Contribution à l'étude des poissons pélagiques des eaux tunisiennes. Thèse de Doctorat d'Etat de la Faculté des Sciences de Tunis.
13. Moser HW, Moser AB (1991) Measurement of very long fatty acids in plasma. Techniques in diagnostic human biochemical genetics: A Laboratory Manual. Willey-Liss, Inc: 177-191.
14. Orban E, Dilena G, Nevigato T, Masci M, Casini I, et al. (2011) Proximate unsaponifiable lipid and fatty acid composition of bogue (*Boops boops*) and *horse mackerel* (*Trachurus trachurus*) from the Italian trawl fishery. J Food Comp Anal 24: 1110-1116.
15. Caponio F, Lestingi A, Summo CMT, Bilancia MT, Laudadio V (2004) Chemical characteristics and lipid fraction quality of sardines (*Sardina pilchardus* W.): Influence of sex and length. J Appl Icht 20: 530-535.
16. Kacem M, Sellami M, Kammoun W, Frikha F, Miled N, et al. (2011) Seasonal variations in proximate and fatty acid composition of Viscera of *Sardinella aurita*, *Sarpasalpa*, and *Sepia officinalis* from Tunisia:J Aqua Food Prod Techn 20:233-246.
17. Wallace PD (1991) Seasonal variations in fat content of mackerel (*Scomber scombrus* L.) caught in the English Channel. Fish Res Techn Rep.
18. Love RM (1997) Biochemical dynamics and the quality of fresh and frozen fish. Fish Proc Techn 1-31.
19. Osman H, Suriah AR, Law EC (2001) Fatty acid composition and cholesterol content of selected marine fish in Malaysian waters. Food Chem 73: 55-60.
20. Aidos I, Van Der Padt A, Luten JB, Boom RM (2002) Seasonal changes in crude and lipid composition of herring fillets, by-products, and respective produced oils. J Agric Food Chem 16: 4589-4599.
21. Passi S, Cataudella S, Marco DP, Simone DF, Rastrelli L (2002) Fatty acid composition and antioxidant levels in muscle tissue of different Mediterranean marine species of fish and shellfish. J Agr Food Chem 50: 7314-7322.
22. Andrade AD, Rubira AF, Matsushita M, Souza NE (1997) Omega-3 fatty acids in baked freshwater fish from South Brazil. Arch Latinoam Nutr 47: 73-76.
23. Soriguer F, Serna S, Valverde E, Hernando J, Martin-Reyes HA, et al. (1997) Lipid, protein and calorie content of different Atlantic and Mediterranean fish, shellfish and molluscs commonly eaten in the south of Spain. Eur J Epi 13: 451-463.
24. Dalsgaard J, St John M, Kattner G, Muller-Navarra D, Hagen W (2003) Fatty acid trophic markers in the pelagic marine environment. Adv Mar Biol 46: 225-340.
25. Özogul Y, Özogul F, Alagoz S (2007) Fatty acid profiles and fat contents of commercially important seawater and freshwater fish species of Turkey: A comparative study. Food Chem 103: 217-223.
26. Tanakol R, Yazıcı Z, Sener E, Sencer E (1999) Fatty acid composition of 19 species of fish from the Black Sea and the Marmara Sea. Lipids 34: 291-297.
27. Kromhout D, Bosschieter EB, Coulander de Lezenne C (1985) The inverse relation between fish consumption and 20-year mortality from coronary heart disease. New Eng J Med 312: 1205-1209.
28. Herold PM, Kinsella JE (1986) Fish oil consumption and decreased risk of cardiovascular disease: A comparison of findings from animal and human feeding trials. Am J Clin Nutr 43: 566-598.
29. Simopoulos AP (1991) Omega-3 fatty acids in health and disease and in growth and development. Ame J Clin Nutr 54: 438-463.
30. Larsson SC, Kumlin M, Ingelman-Sundberg M, Wolk A (2004) Dietary long-chain n-3 fatty acids for the prevention of cancer: A review of potential mechanisms. Am J Clin Nutr 79: 935-945.