Journal of Nutrition & Food Sciences
ISSN: 2155-9600
Soundarapandian et al., J Nutr Food Sci 2015, 5:3
DOI: 10.4172/2155-9600.1000361

Research Article Open Access

Fatty Acid Composition in Long-eyed Swimming Crab *Podophthalmus vigil* (Fabricius)

Soundarapandian P[1]*, Varadharajan D[1], Jaganathan K[1] and Ravichandran S[2]

[1]*Faculty of Marine Sciences, Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai-608 502, Tamil Nadu, India*
[2]*Department of Zoology, Government Arts College, Kumbakonam, Tamil Nadu, India*

Abstract

Three saturated fatty acids were reported in the present study (Palmitic acid, Margaric acid and Stearic acid). All three saturated fatty acids were uniformly shown higher values in females followed by berried females and males. Among three fatty acids, stearic acid contribution was maximum followed by margaric and palmitic acids. Only one monounsaturated fatty acid (Oleic Acid) and two polyunsaturated fatty acids (Omega-6 and Omeg-3 fatty acids) were recorded in *P. vigil*. The linolenic and Alpha linolenic acids were abundant in females followed by berried females and males. The total contributions of unsaturated fatty acids were maximum than saturated fatty acids. From the present study it is confirm that *P. vigil* had rich amount of unsaturated fatty acids which control many heart related diseases. Further, females contain maximum amount of unsaturated fatty acids than males. So, in order of preference, females are standing first that followed by males for consumption.

Keywords: Fatty acids; Saturated; Monounsaturated; Polyunsaturated; *Podophthalmus vigil*

Introduction

In general peoples are eating crabs because of its taste, easy availability and affordability but are often unaware of the health benefits and risks. In recent years lipids have assumed great nutritional significance owing to their protective role against the development of cardiovascular disease and rhecematoid arthritis. Fatty acids are principle components of lipids. The fatty acids of seafood differ from vegetable fatty acids in length: that is vegetable PUFA contains 18 carbon atoms and those of seafood up to 20-22 carbon atoms. A few of these, essential in diet but not biosynthesized in the body are called essential fatty acids (EFA). Crabs have many lipid components which are probably best known but least understood as dietary components for humans. The nature and quality of fatty acids of these crabs vary according to species and habits. Many studies were examined the fatty acid composition of different crustaceans species in different part of the world viz., [1] Dungeness crab *C. magister*, [2] Alaska king crab, [3] queen crab *Chionecetes opilio*, [4] shrimp *Pleoticus muelleri*, [5] deep-water prawn *Pandalus borealis*, [6] wild and farmed prawn, *P. monodon*. [7] Brine shrimp, *Artemia* sp., eyes. [8] Tiger prawn *P. esculentus*, [9] juvenile freshwater prawn *M. rosenbergii,* [10] the prawn, *P. japonicus*, [11] Chinese prawn *P. chinensis*, [12] shrimps. [13] *P. orientalis*, [14] *L. vannamei,* [15] Australian red claw crayfish *Cherax quadricarinatus,* [16] *C. lucifera*, [17] *S. tranquebarica,* [18] *M. idella idella*. The long eyed crab, *Podophthalmus vigil* is used as food for the coastal populations and also fatty acid compositions was not previously studied. So in the present investigation was designed to study the fatty acid composition in the muscles of edible crab *P. vigil.*

Materials and Methods

The male, female and berried females of *P. vigil* were procured from Parangipettai (Lat. 11°21' N; Long. 79° 46' E) landing centres. The carapace of the crabs was opened and the edible parts of muscle tissues were removed with sharp forceps. The samples were oven dried at 70°C for 24 hrs until no more weight reduction was observed. After that the samples were grounded with pestle and mortar. To the 100-200 mg of finely ground tissue samples 1:1 ratio of chloroform: methanol (2 ml) was added and kept for 30 seconds. The residual matter was removed by filtering through Whatman No. 1 filter paper (125 mm). This was washed with 1 ml of chloroform: methonal (2:1 vol.) to remove the inorganic substances from the combined extract by partition and treated with chloroform: methanol: water (8:4:3) where the lower phase evaporated to dryness. The dried matter was subjected in a sealed test tube with 3% Methanolic HCL at 80°C for 18 hrs. To this 2 ml of hexane was added to extract the fatty acid methyl esters (FAME) obtained from methanol phase in Hexane. Top 1 ml of the hexane phase was collected in a micro vial. The residual fraction was dissolved in 10:1 of ethyl acetate and injected 1:1 aliquot into a gas chromatograph (Agilent 6890, 1997) equipped with flame identification detector and column (Hp ULTRA-225 m, 0.2 mm ID) by GC [19]. Triplicate was maintained for each sample.

Statistical analysis

The data was subjected to One-way analysis of variance (ANOVA) and difference between means were determined by Duncan's multiple range tests (P<0.05) using SPSS version 17.0.

Results

Saturated fatty acids

The fatty acid profile from the muscle tissues of the *P. vigil* is presented in Tables 1 and 2. Three saturated fatty acids were reported in the present study (Palmitic acid, Margaric acid and Stearic acid). All three saturated fatty acids were uniformly shown higher values

***Corresponding author:** Soundarapandian P, Faculty of Marine Sciences, Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai-608 502, Tamil Nadu, India, Tel: 04144-243223; Fax: 04144-243553; E-mail: soundsuma@gmail.com

Received November 13, 2014; **Accepted** March 26, 2015; **Published** March 30, 2015

Citation: Soundarapandian P, Varadharajan D, Jaganathan K, Ravichandran S (2015) Fatty Acid Composition in Long-eyed Swimming Crab *Podophthalmus vigil* (Fabricius). J Nutr Food Sci 5: 361. doi:10.4172/2155-9600.1000361

Copyright: © 2015 Soundarapandian P, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

S.No	Fatty acids	Position of the carbon atom	Male	Female	Berried	Total
1	Palmitic acid	C16:0	0.042^c ± 0.26	0.454^a ± 0.12	0.112^b ± 0.41	0.606 ± 0.79
2	Margaric acid	C17:0	0.102^c ± 0.37	0.749^a ± 0.65	0.201^b ± 0.52	1.052 ± 1.54
3	Stearic acid	C18:0	0.275^c ± 0.42	0.589^a ± 0.37	0.302^b ± 0.52	1.166 ± 1.31
Total			0.419^c ± 1.05	1.792^a ± 1.14	0.615^b ± 1.45	2.826 ± 1.51

Different superscripts in a rows are significantly different (P<0.05)

Table 1: Saturated fatty acids (%) in *P. vigil* (Values are mean of three values ± SE).

S.No	Fatty Acids	Position of the carbon atom	Male	Female	Berried	Total
1	Monounsaturated fatty acid Oleic acid	C18:1	0.106^c ± 0.37	0.562^a ± 045	0.210^b ± 0.25	0.878 ± 0.12
2	Poluunsaturated fatty acids Omega-3 fatty acids Alpha Linolenic acid	C18:3	0.986^c ± 0.39	2.89^a ± 0.35	1.078^b ± 0.43	4.954 ± 2.13
3	Omega-6 fatty Acid Linolenic Acid	C18:2	0.564^c ± 0.53	0.946^a ± 0.38	0.757^b ± 0.27	2.267 ± 1.112
Total			1.656 ± 1.29	4.398 ± 1.18	2.045 ± 0.95	8.099 ± 0.12

Different superscripts in a rows are significantly different (P<0.05)

Table 2: Unsaturated fatty acids (%) in *P. vigil* (Values are mean of three values ± SE).

in females followed by berried females and males. The presence of saturated fatty acids in different sexes was statistically significant. Among three fatty acids, stearic acid contribution was maximum followed by margaric and palmitic acids (Table 1).

Monounsaturated fatty acids

Only one monounsaturated fatty acid (Oleic Acid) was reported in *P. vigil* (Table 2). Monounsaturated fatty acid also followed similar trend as saturated fatty acids.

Polyunsaturated fatty acids

Two polyunsaturated fatty acids (Omega-6 and Omega-3 fatty acids) were recorded in *P. vigil*. The linolenic and Alpha linolenic acids were abundant in females followed by berried females and males. The appearance of fatty acids in different sexes was statistically significant (Table 2). The total contributions of unsaturated fatty acids were maximum than saturated fatty acids (Table 3).

Discussion

About 100 fatty acids have been isolated from the lipids of various animals and plants. Basically fatty acids are of two types; saturated fatty acids are those with a single bond between carbon atoms; the unsaturated fatty acids in which more double bonds are present in the carbon chain. Further, the unsaturated fatty acids are divided into mono (MUFA) and polyunsaturated fatty acids (PUFA) based on the number of double bonds present. Lipids of marine origin are rich source of omega-3 (n-3) polyunsaturated fatty acids and they have pronounced hypocholesterolemic effect when supplemented in human diet. The saturated fatty acids are not only a source of body fuel, but are also structural components of cell membranes. Various saturated fatty acids are also associated with proteins and are necessary for their normal function. Saturated fatty acids can be synthesized by the body. When saturated fatty acids are ingested along with fats containing appreciable amounts of unsaturated fatty acids, they are absorbed almost completely by the small intestine. In general, the longer the chain length of the fatty acid, the lower will be the efficiency of absorption. However, unsaturated fatty acids are well absorbed regardless of chain length.

In the present study the values of saturated fatty acids are max in females, (1.792%) than in berried females (0.615%) and males (0.419%). Among three saturated fatty acids recorded (Palmitic acid, Margaric acid and Stearic acid), the amount of stearic acid was maximum. Whereas Perez-Velazquez et al., [16] reported maximum amount of palmitic acid (20.09%) in *C. lucifera.* Similar results were also observed in *M. scabriculum* and *M. idae* by Dinakaran et al. [18,20] respectively. Thompson, et al., [17] also reported maximum amount of palmitic acid in *S. tranquebarica.* Unoxidized stearic acid (9 to 14%) is rapidly de saturated and converted, to the monounsaturated fatty acid, oleic acid [20,21]. For this reason, dietary stearic acid has metabolic effects that are closer to those of oleic acid rather than those of other long-chain saturated fatty acids. The saturated fatty acids, in contrast to *cis* mono- or polyunsaturated fatty acids have a unique property in that they suppress the expression of LDL receptors [22,23]. Through this action, dietary saturated fatty acids raise serum LDL cholesterol concentrations [24]. Saturated fatty acids, like other fatty acids, are generally completely oxidized to carbon dioxide and water.

Although all saturated fatty acids were originally considered to be associated with increased adverse health outcomes, including increased blood cholesterol concentrations, it later became apparent that saturated fatty acids differ in their metabolic effects (e.g., potency in raising blood cholesterol concentrations). Stearic acid (systematic name, octadecanoic acid, CH_3 (CH_2)16COOH) is a long-chain fatty acid consisting of 18 carbon atoms without double bonds. Although it is classified as a saturated fatty acid (SFA), both biochemically and for purposes of nutrition labeling and dietary recommendations, data accumulated during the past 50 years indicate that stearic acid (C18:0) is unique among the SFAs in the food supply [25-27]. In general, stearic acid has been shown to have a neutral effect on total and LDL cholesterol concentrations [27-29]. While palmitic, lauric, and myristic acids increase cholesterol concentrations [30], stearic acid is more similar to oleic acid in its neutral effect [31]. Furthermore, a stearic acid-rich diet has been shown to improve thrombogenic and atherogenic risk factor profiles [32]. However, it is impractical at the current time to make recommendations for saturated fatty acids on the basis of individual fatty acids.

Essential Fatty Acids (EFAs) are necessary fats that humans cannot synthesize, and must be obtained through diet. There are stearic acid (C18:0) is unique among the SFAs in the food supply [27,30]. In

S.No.	Fatty Acids	Total
1	Saturated fatty acids	2.826 ± 1.51
2	Monounsaturated fatty acids	0.878 ± 0.82
3	Polyunsaturated fatty acids	7.22 1 ± 1.56
4	MUFA + PUFA	8.099 ± 0.12

Table 3: Total saturated, mono and polyunsaturated fatty acids (%) in *P. vigil* (Values are mean of three values ± SE).

general, stearic acid has been shown to have a neutral effect on total and LDL cholesterol concentrations [26,27,30]. There are two families of EFAs: Omega-3 and Omega-6. Omega-9 is necessary yet «non-essential» because the body can manufacture a modest amount on its own, provided essential EFAs are present. The number following «Omega-» represents the position of the first double bond, counting from the terminal methyl group on the molecule. Omega-3 fatty acids are derived from Linolenic Acid, Omega-6 from Linoleic Acid, and Omega-9 from Oleic Acid.

Questions have arisen regarding the effects of stearic acid on other risk factors for cardiovascular disease such as thrombosis (blood clot), inflammation, and blood pressure [27]. A heart attack (and stroke) is typically preceded by the formation of a blood clot that blocks the coronary artery. Early studies suggested that stearic acid adversely affects platelet function and blood clotting [26,27]. However, more recent investigations in humans show that diets enriched in stearic acid have a neutral or beneficial effect on thrombotic tendency [27,31,32].

EFAs support the cardiovascular, reproductive, immune, and nervous systems. The human body needs EFAs to manufacture and repair cell membranes, enabling the cells to obtain optimum nutrition and expel harmful waste products. A primary function of EFAs is the production of prostaglandins, which regulate body functions such as heart rate, blood pressure, blood clotting, fertility, conception, and play a role in immune function by regulating inflammation and encouraging the body to fight infection. Essential Fatty Acids are also needed for proper growth in children, particularly for neural development and maturation of sensory systems, with male children having higher needs than females. Fetuses and breast-fed infants also require an adequate supply of EFAs through the mother's dietary intake. EFA deficiency and Omega 6/3 imbalance is linked with serious health conditions, such as heart attacks, cancer, insulin resistance, asthma, lupus, schizophrenia, depression, postpartum depression, accelerated aging, stroke, obesity, diabetes, arthritis, ADHD, and Alzheimer's Disease, among others.

As in saturated fatty acids the total amount of monounsaturated fatty acids are maximum in females (0.526%) than in berried females (0.210%) and males (0.106%). Oleic acid, the major monounsaturated fatty acid in the body, is derived mainly from the diet. Small amounts also come from desaturation of stearic acid. Oleic acid accounts for about 92 percent of dietary monounsaturated fatty acids. Monounsaturated fatty acids, including oleic acid and nervonic acid (24:1*n*-9), are important in membrane structural lipids, particularly nervous tissue myelin. Other monounsaturated fatty acids, such as palmitoleic acid, are present in minor amounts in the diet.

In the presence of Omega-3 fatty acids, the action of prostaglandins on epinephrine is diminished and thus constriction or narrowing of blood vessels is prevented. Saturated fatty acids raise the level of LDL cholesterol whereas the monounsaturated and polyunsaturated fats reduce the LDL cholesterol. Hence dietary intake of omega-3 fatty acids is helpful in pronouncing less inflammatory responses towards bronchial asthma, lupus erythematosus multiple sclerosis, psoriasis and kidney diseases and also inhibit the development of cancer cells.

The total amount of unsaturated fatty acids were more in females when compared to males, it may be due to the storage of lipids for the development of ovaries. Similar results were reported in *M. scabriculum* by Dinakaran et al. [20] and *M. idae* by Dinakaran [18].

Polyunsaturated fatty acids are energy sources and also function in the body components of membranes, modulations of gene expression and precursors for Eicosanoids (self-healing agents). Linolenic acid (LA) and Alpha-Linolenic acid (ALA) are the essential polyunsaturated fatty acids and the parent compounds for omega-6 and omega-3 lines respectively In the present study alpha-linolenic acid was reported maximum in females than male crabs. α-Linolenic acid is not synthesized by humans and a lack of it results in adverse clinical symptoms, including neurological abnormalities and poor growth. Therefore, α-linolenic acid is essential in the diet. It is the precursor for synthesis of Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA), which are formed in varying amounts in animal tissues, especially fatty fish, but not in plant cells. EPA is the precursor of *n*-3 eicosanoids, which have been shown to have beneficial effects in preventing coronary heart disease, arrhythmias, and thrombosis [33,34].

Various studies have shown that feeding a diet very low in α-linolenic acid results in reduced brain and retina DHA concentration, which is accompanied by reduced visual function and behavior in learning tasks [35-37]. The omega 3 fatty acids keep skin hydrated to help prevent dry skin and help soothe rough skin. Improve blood flow to the skin and help decrease inflammation. Encourage production of new healthy skin cells. Protect the skin against sun damage. Recent findings from cancer research suggest that omega-3s may be important in discouraging the development or spread of certain cancers especially breast, prostate, and probably colon cancer. They also important in preventing many health problems, including heart disease and rheumatoid and arthritis. They also play a role in improving mood and sharpening memory. Omega-3 deficiencies are linked to decreased memory and mental abilities, tingling sensation of the nerves, poor vision, increased tendency to form blood clots, diminished immune function, increased triglycerides and «bad» cholesterol (LDL) levels, impaired membrane function, hypertension, irregular heartbeat, learning disorders, menopausal discomfort, itchiness on the front of the lower leg(s), and growth retardation in infants, children, and pregnant women.

In the present study omega 6 fatty acid especially linolenic acid was reported maximum in males than females. Linoleic acid cannot be synthesized by humans and a lack of it results in adverse clinical symptoms, including a scaly rash and reduced growth. Therefore, linoleic acid is essential in the diet. Linoleic acid is the precursor to arachidic acid, which is the substrate for eicosanoid production in tissues, is a component of membrane structural lipids, and is also important in cell signaling pathways. Omega -6 fatty acids reduce symptoms of dry, itchy skin and help to keep skin hydrated reduce inflammation associated with some chronic skin disorders. Linoleic Acid is the primary Omega-6 fatty acid. A healthy human with good nutrition will convert linoleic acid into gamma linolenic acid (GLA), which will later by synthesized, with EPA from the Omega-3 group, into eicosanoids. Some Omega-6s improve diabetic neuropathy, rheumatoid arthritis, PMS, skin disorders (e.g. psoriasis and eczema), and aid in cancer treatment.

In fact, all the edible marine fish and shellfish have a lot of qualities which are directly focused on improving the work of the health, the blood flow and which are beneficial for the blood vessels and the blood itself. The most important characteristic of the crabs, for example, is that they contain a high level of the omega 3 fatty acids; and they are thus very useful in the lowering the risk of getting and even curing some heart related diseases. In the present study the total amount of unsaturated fatty acids are more than saturated fatty acids. In general unsaturated fatty acids are not synthesized by human beings so it should be provide along with feed. From the present study it is confirm that *P. vigil* had rich amount of unsaturated fatty acids which control many heart related diseases. Further, females contain maximum amount of unsaturated fatty acids than males. So in order of preference, females standing first that followed by males for consumption. In the present study the fatty acids having carbon atoms above 20 could not be identified by the instrument. So the rest of the fatty acids in the *P. vigil* were not detected. Further detailed study on fatty acid profile using advanced and versatile instrument is suggested.

References

1. Allen WX (1971) Amino acid and fatty acid composition of tissues of the Dungeness crab Cancer magister. J Fish Res Bd Canada 28: 1191-1195.
2. Krzeczkowski RA, Tenney RD, Kelley C (1972) Alaska king crab: fatty acid composition, carotenoid and proximate analysis. J Food Sci 36: 604-606.
3. Addission RF, Ackman RG, Hingle J (1972) Lipid composition of the queen crab Chinoecetes opilio. J Fish Res Bd Canada 29: 407-411.
4. Jeckel WH, Aizpun-de-Moreno JE, Moreno VJ (1989) Biochemical composition, lipid classes and fatty acids in the male reproductive system of the shrimp Pleoticus muelleri Bate. Comp Biochem Physiol B. 93B, 4: 807-811.
5. Hopkins CCE, Sargent JR, Nilssen EM (1990) Total lipid content, and lipid and fatty acid composition of the deep-water prawn Pandalus borealis from Balsfjord, Northern Norway: Growth and feeding relationships. Copenhagen-Denmark-ICES. P. 30.
6. Leary, Matthews AD (1990) Lipid class distribution and fatty acid composition of wild and farmed prawn, Penaeus monodon (Fabricius). Aquacult 89: 65-81.
7. Navarro JC, Bell MV, Amat F, Sargent JR (1992) The fatty acid composition of phospholipids from brine shrimp, Artemia sp., eyes. Comp Biochem Physiol-B 103B: 89-91.
8. Dall W, Chandumpai A, Smith DM (1992) Fatty acid composition of organs and tissues of the tiger prawn Penaeus esculentus during the moulting cycle and during starvation. Mar Biol 113: 45-55.
9. Abramo LR, Sheen, Shyn-Shin (1993) Polyunsaturated fatty acid nutrition in juvenile freshwater prawn Macrobrachium rosenbergii. Aquacult 115: 63-86.
10. Muriana FJG, Ruiz-Gutierrez V, Blaya JA, Bolufer J (1993) Lipid and fatty acid composition of hepatopancreatic brush-border membrane vesicles from the prawn Penaeus japonicus. Thesis submitted to Tokyo University, p. 113.
11. Xu XL, Ji WJ, Castell JD, O'-Dor RK (1993) Essential fatty acid requirements of Chinese prawn (Penaeus chinensis. World Aquaculture '93). Int Conf Torremolinos (Spain) 26-28.
12. Araujo MA, Lawrence A (1993) Fatty acid profiles of muscle and midgut gland from Wild Penaeus californiensis, P. occidentalis, P. Setiferus, P. stylirostris and P. vannamei. J World Aquacult Soc 24: 425-428.
13. Shusen Zhu W, Wang H, Jianying (1993) Nutritional requirements of Penaeus orientalis for linoleic acid and linolenic acid. J Fish China Shuichan Xuebao 17: 1-6.
14. Perez-Velazquez M, Gonzalez-Felix ML, Lawrence AL, Gatlin DM (2003) Changes in lipid class and fatty acid composition of adult male Litopenaeus vannamei (Boone) in response to culture temperature and food deprivation. Aquacult Res 34: 1205-1213.
15. Thompson KR, Muzinic LA, Christian TD, Webster CD, Manomaitis L, et al. (2003) Effect on growth, survival, and fatty acid composition of Australian red claw crayfish cherax quadricarinatus fed practical diets with and without supplemental lecithin and/or cholesterol. J World Aquacult Soc 34: 1-10.
16. Murugesan R, Soundarapandian P, Manivannan K (2008) Effect of unilateral eyestalk ablation on the biochemical changes of edible portunid crab charybdis lucifera (Fabricius). J Fish Aqua Sci 3: 82-86.
17. Manivannan K, Sudhakar M, Murugesan R, Soundrapandian P (2010) Effect of feed on the Biochemical composition of commercially important mud crab Scylla tranquebarica (Fabricius, 1798). Int J Anim Vert Adv 2: 16-20.
18. Dinakaran GK (2010) Mating behavior, Embryonic development, Biochemical composition and mass seed production of edible prawn Macrobrachium idella (Hilgendorf, 1898) Ph.D. Thesis, Annamalai University. pp 1-130.
19. Kashiwagi T, Meyer Rochow VB, Nishimura K, Eguchi F (1997) Analysis of fatty acids by GCJ. Comp Physiol B167: 1-8.
20. Dinakaran GK, Soundarapandian P, Chandra SK (2009) Proximate composition of edible palaemonid prawn Macrobrachium idae. Cur Res J Biol Sci 1: 78-82.
21. Emken EA (1994) Metabolism of dietary stearic acid relative to other fatty acids in human subjects. Am J Clin Nutr 60: 1023S-1028S.
22. Rhee SK, Kayani AJ, Ciszek A, Brenna JT (1997) Desaturation and interconversion of dietary stearic and palmitic acids in human plasma and lipoproteins. Am J Clin Nutr 65: 451-458.
23. Spady DK, Woollett LA, Dietschy JM (1993) Regulation of plasma LDL-cholesterol levels by dietary cholesterol and fatty acids. Annu Rev Nutr 13: 355-381.
24. Mustad VA, Etherton TD, Cooper AD, Mastro AM, Pearson TA, et al. (1997) Reducing saturated fat intake is associated with increased levels of LDL receptors on mononuclear cells in healthy men and women. J Lipid Res 38: 459-468.
25. Celik K, Tureli C, Celik M, Yanar Y, Erdem U, et al., (2004) Fatty acid composition of the blue crab (Callinectus sapidus Rathbun, 1896) in the north eastern Mediterrean. Food Chem 88: 271-273.
26. Haumann BF (1998) Stearic acid: a 'different' saturated fatty acid. INFORM (American Oil Chemists' Society) 9: 202-208.
27. Kris-Etherton PM, Griel AE, Psota TL, Gebauer SK, Zhang J, et al. (2005) Dietary stearic acid and risk of cardiovascular disease: intake, sources, digestion, and absorption. Lipids 40: 1193-1200.
28. Hegsted DM, McGandy RB, Myers ML, Stare FJ (1965) Quantitative effects of dietary fat on serum cholesterol in man. Am J Clin Nutr 17: 281-295.
29. Grundy SM (1994) Influence of stearic acid on cholesterol metabolism relative to other long-chain fatty acids. Am J Clin Nutr 60: 986S-990S.
30. Mensink RP, Temme EH, Hornstra G (1994) Dietary saturated and trans fatty acids and lipoprotein metabolism. Ann Med 26: 461-464.
31. Kris-Etherton PM, Derr J, Mitchell DC, Mustad VA, Russell ME, et al. (1993) The role of fatty acid saturation on plasma lipids, lipoproteins, and apolipoproteins: I. Effects of whole food diets high in cocoa butter, olive oil, soybean oil, dairy butter, and milk chocolate on the plasma lipids of young men. Metabolism 42: 121-129.
32. Kelly FD, Sinclair AJ, Mann NJ, Turner AH, Abedin L, et al. (2001) A stearic acid-rich diet improves thrombogenic and atherogenic risk factor profiles in healthy males. Eur J Clin Nutr 55: 88-96.
33. Judd JT, Baer DJ, Clevidence BA, Kris-Etherton P, Muesing RA, et al. (2002) Dietary cis and trans monounsaturated and saturated FA and plasma lipids and lipoproteins in men. Lipids 37: 123-131.
34. Kinsella JE, Lokesh B, Stone RA (1990) Dietary n-3 polyunsaturated fatty acids and amelioration of cardiovascular disease: possible mechanisms. Am J Clin Nutr 52: 1-28.
35. Benolken RM, Anderson RE, Wheeler TG (1973) Membrane fatty acids associated with the electrical response in visual excitation. Science 182: 1253-1254.
36. Wheeler TG, Benolken RM, Anderson RE (1975) Visual membranes: specificity of fatty acid precursors for the electrical response to illumination. Science 188: 1312-1314.
37. Bourre JM, Francois M, Youyou A, Dumont O, Piciotti M, et al., (1989) The effects of dietary a-linolenic acid on the composition of nerve membranes, enzymatic activity, amplitude of electrophysiological parameters, resistance to poisons and performance of learning tasks in rats. J Nutr 119: 18800-1892.