THE NATURAL OCCURRENCE AND HEALTH BENEFITS OF POLYUNSATURATED FATTY ACIDS

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ABSTRACT

Various studies have shown that the polyunsaturated fatty acids play an important role in maintaining human health. These fatty acids show preventative effect against certain diseases such as cardiovascular disease, diabetes, cancer and rheumatoid arthritis. Thus, the society should be educated on how to consume healthy diets so that the sufficient amount of polyunsaturated fatty acids is taken in order to maintain a good health. This paper discusses about the natural occurrence of polyunsaturated fatty acids and the scientific explanation of their health effects.

INTRODUCTION

The consumption of diets highly rich in saturated fatty acids have been linked to high blood cholesterol level which is the cause of cardiovascular disease. Nutritionists have been warning of the danger of taking unbalanced diets, which could in turn lead to such diseases. However, not many people are really educated on what are the healthy diets and what are not. Many think that oily foods are harmful to health without knowing what are the contents of the fatty acids in such foods. Cholesterol is being viewed as the 'enemy' to health because this biochemical compound is always being blamed for heart attack and high blood pressure. On the contrary, this compound is produced by the human's own body to regulate certain metabolic functions.

One of the factors that could lead to the low incidence of cardiovascular disease is the regular consumption of fish, which contain high levels of polyunsaturated fatty acids. A study done by Kromhout et. al. in the Netherlands between 1960 and 1980 showed that the death rate from coronary heart disease was lower among those who consumed fish regularly than those who did not eat fish.

With the aid of modern experimental techniques scientists are able to study the metabolic pathway of polyunsaturated fatty acids, which could explain the role of these fatty acids in human health.

THE NATURAL OCCURRENCE AND PROPERTIES OF FATTY ACIDS

The Natural Occurrence of Fatty Acids

Fatty acids are natural organic acids that exist in every living organism. They are mostly found combined with glycerol to form a bigger molecule known as tryglyceride. A tryglyceride molecule consists of one glycerol unit and three units of fatty acids. Tryglycerides form the main component of oils and fats of plants and animals.

Natural fatty acids can be classified into saturated and unsaturated fatty acids. The unsaturated fatty acids can be further classified into monounsaturated and polyunsaturated fatty acids (PUFA). An interesting fact about natural fatty acids is that most of them contain even number of carbon atoms. This is related to the biosynthetic pathway by which the molecules are produced in nature. The symbol ω (omega) is used to describe the structure of common unsaturated fatty acids. The number that follows ω indicates the position of the first double bond encountered from the non-polar end of the molecule. Basically there are three main types of common unsaturated fatty acids: the ω-3, ω-6 and ω-9. The ω-3 fatty acids, like eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are among the most highly unsaturated fatty acids. The fats found in the land animals and plants are mainly composed of saturated or monounsaturated fatty acids (Sikorski et. al. 1990). The aquatic animals and plants are particularly higher in PUFAs. Fishes, especially the coldwater marine fishes are the best sources of ω-3 fatty acids.

Physical Properties of Fatty Acids

The melting point of fatty acids is largely dependent on their degree of unsaturation. Saturated fatty acids have high melting point and many of them are in solid form at room temperature. The unsaturated fatty acids are usually in liquid form at room temperature and the melting point decreases with increasing degree of unsaturation. As for tryglycerides, their melting points depend largely on their main component of fatty acids. Those tryglycerides that are made up mainly of saturated fatty acids form solids at room temperature. This is the characteristic of the fats from mammals. The liquid nature of palm oil is due to the presence of a large amount of oleic acid, which is a monounsaturated fatty acid.

Environmental Factors Affecting the Fatty Acid Content in Organisms

Fatty acids are found in every cell membrane of plants and animals. The composition of these fatty acids in the cell membrane is of significance because it affects the fluidity of the membrane. A high content of low melting point fatty acids will increase the fluidity of the cell membrane. The cell membrane is the place where nutrients and other materials are transported between the internal part of the cell and the surrounding fluid. The effectiveness of this transportation will depend largely on the fluidity and flexibility of the cell membrane. This implies that organisms living at different temperatures need to have different composition of fatty acids in their cell membranes.

Studies have shown that coldwater fishes contain more ω-3 fatty acids than fishes living in warm water (Lovell 1989). Sardine, mackerel and tuna are among the fishes that contain high levels of EPA and DHA. The tropical fishes contain lower level of ω-3 fatty acids than those fishes but are higher in ω-6 fatty acids, particularly the arachidonic acid (AA) that is of lower degree of unsaturation.

Water salinity also affects the fatty acid composition of the fish. Seawater fishes have higher levels of ω-3 fatty acids compared to freshwater fishes (Leray et. al. 1984). It is believed that a higher fluidity of the membrane is required for the efficient transport of water from the surrounding environment into the cell. This is to counteract the osmosis process where water moves from the less concentrated fluid in the cell to the more concentrated saline water outside the cell.

It was found that the Malaysian freshwater fishes contain low levels of PUFAs (Endinkeau and Tan Kim Kiew 1993). However, in a recent study it was discovered that the local swamp eel contain a significant amount of AA and DHA which are beneficial to human health (Razak et. al. 2001).

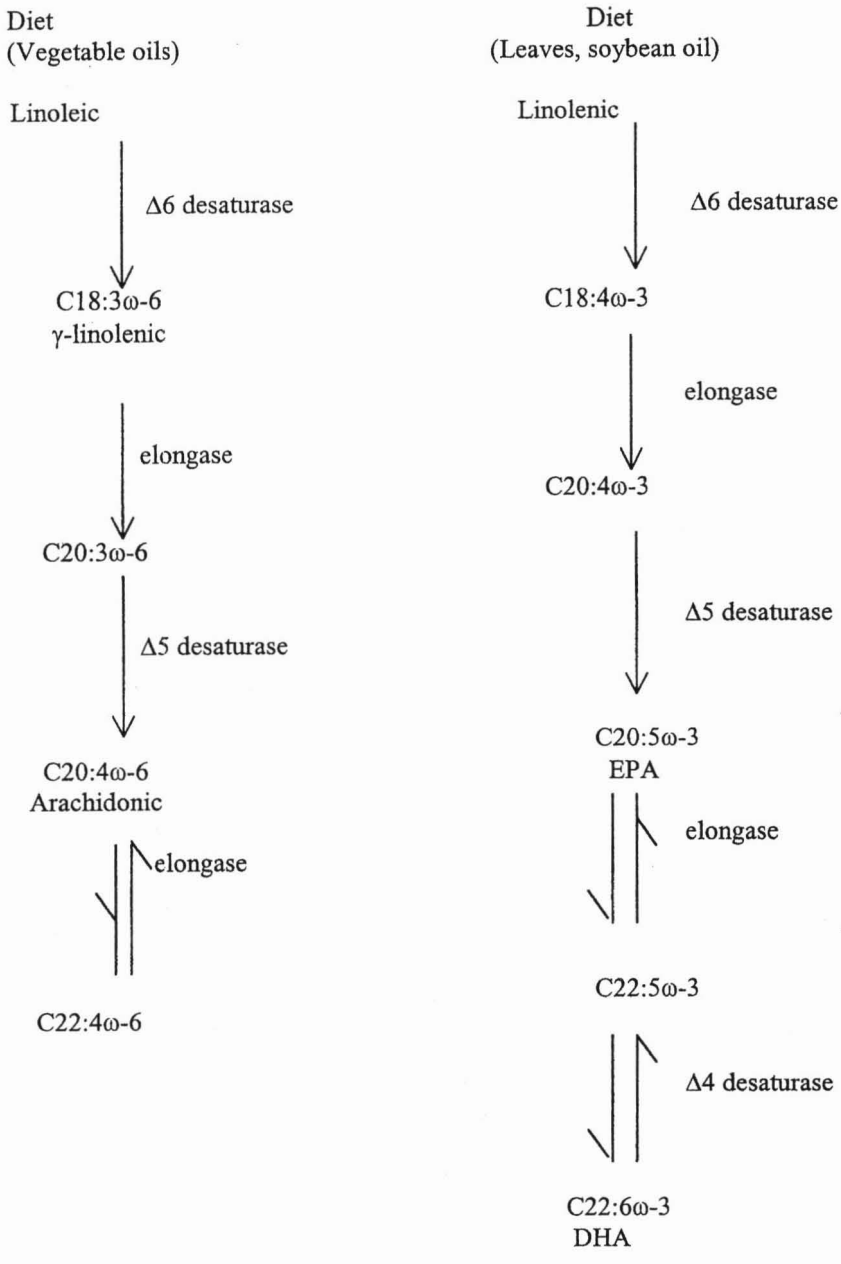
ROLE OF PUFA IN HUMAN HEALTH AND NUTRITION

PUFA as Essential Fatty Acids

In the human body the ω-3 and ω-6 PUFAs are precursors of a class of biochemical compounds required to regulate certain biochemical functions, known as eicosanoids. These two families of PUFA undergo separate metabolic pathways with linoleic acid (C18:2ω-6) and linolenic acid (C18:3ω-3) being the precursors in the ω-6 and ω-3 series respectively, as summarized in Figure 1 (Kinsella 1987). Arachidonic acid (AA, C20:4ω-6) occurs in small quantities in the diet (e.g. meat) but is mainly synthesized in the liver from dietary linoleic acid of vegetable origin. The major sources of dietary linoleic acid are vegetable oils. The precursor in the ω-3 family of PUFA, linolenic acid is present in low concentration in leafy plant tissues and soybean oil. However, large amounts of EPA and DHA are available from fish oils.

Linoleic acid and linolenic acid compete for the same enzymes in the desaturation and elongation reactions. However, the formation of AA from linoleic acid is favoured rather than the formation of EPA and DHA. Even when linolenic acid intake is high, the more efficient metabolism of linoleic acid leads to higher levels of AA in tissues. In addition, age stress and illness can have deleterious effects on ω-3 PUFA biosynthesis (Gill and Valivety 1997). Thus, taking dietary linolenic acid is not a good means of overcoming the EPA and DHA deficiency. These PUFAs should be taken from direct sources such as fish and other seafoods

Figure 1 : Metabolic Pathways of the ω-6 and ω-3 PUFAs



PUFA and Cardiovascular Disease

One of the pathological conditions that lead to cardiovascular disease is arteriosclerosis, the formation of deposits on the arterial wall. Among the factors that contribute to arteriosclerosis is high plasma cholesterol level. It was found that an increase in the ratio of polyunsaturated to saturated fatty acid in the diet results in a drop in the plasma cholesterol level.

Arteriosclerosis is also linked to the imbalance activity of eicosanoids, which are originated from AA and EPA. Arachidonic acid, via the actions of cyclooxygenase and lipoxygenase produces the eicosanoids prostaglandins and leukotrienes respectively. The prostaglandins originated from AA are the precursors of prostacyclin PGI_2 and thromboxane TXA_2 that play important roles in platelet aggregation mechanism. Thromboxane TXA_2 is a proaggregatory agent that stimulates platelet aggregation, a process that induces blood clotting. On the contrary, prostacylin PGI_2 is an antiaggregatory agent that inhibits aggregation of platelets and counteracts the effect of TXA_2. Excessive production of TXA_2 causes platelet aggregation in

the blood vessels, a condition known as thrombosis. The aggregated platelets may form clumps at arterial wall and results in arteriosclerosis (Kinsella 1987)

The presence of EPA has a positive effect in preventing thrombosis. EPA is converted to thromboxane TXA_3 and prostacyclin PGI_3. This could reduce the tendency of blood to clot in blood vessels, since TXA_3 does not aggregate platelets as efficiently as TXA_2 and PGI_3 prevents aggregation about as effectively as PGI_2. Furthermore, EPA competes with AA for cyclooxygenase, and thus reducing the production of TXA_2 (Carroll 1986; Kinsella 1987)

Other Health Benefits of PUFA

There are several mechanisms that enhance tumor growth and one of them is excessive production of prostaglandins particularly PGE2 which is produced from AA via cyclooxygenase. Dietary EPA could reduce the PGE2 production by competing with AA for cyclooxygenase. This also diverts AA into lipoxygenase pathway, producing hydroxy fatty acids and leukotrienes that may enhance immunological cell activity and inhibit tumor cell growth. Thus, consuming a balanced diet of n-3 and n-6 PUFA would reduce the incidence of cancer (Kinsella 1987)

There are evidence that n-3 PUFAs have positive preventive effects against diabetes, multiple sclerosis, psoriasis, inflammation, hypertension and rheumatoid arthritis. It was also found that DHA is an essential component in the brain and retina (Stansby 1990; Jeffrey et. al. 2001). Studies showed that AA and DHA are essential fatty acids for infants. Preterm infants fed with diets deficient in AA showed retarded growth in the first year of life (Carlson *et al*, 1993a). In another study it was observed that DHA-supplemented formula improved the visual acuity of preterm infants through 4 months of age (Carlson et. al. 1993b). AA and DHA are present in human milk but not in non-supplemented infant formula (Guesnet et. al. 1999). Thus, it is recommended that infant formula be supplemented with AA and DHA (Koletzko et. al. 2001).

CONCLUSION

A regular intake of the polyunsaturated fatty acids is required in order to maintain a good health. Thus, fish or other seafood should be taken regularly so as to minimize the risk of chronic diseases such as heart disease, diabetes and cancer. If fish cannot be taken then fish oil could be the alternative. Infants should be breast-fed since the mother's milk contains the essential AA and DHA, which is required for their physical, mental and visual growth. The supplementation of these fatty acids in infant formula could help to overcome the deficiency of these acids in infants that cannot be breast-fed.

REFERENCES

Kromhout, D., Bosschieter, E.B. and Coulander, C. de L. (1985). *The Inverse Relation between Fish Consumption and 20-Year Mortality from Coronary Heart Disease.* New Engl. J. Med. 312, 1205-1209.

Sikorski, Z.E., Kolakowska, A. and Pan, B.S. (1990). *The Nutritive Composition of the Major Groups of Marine Food Organisms.* In Sikorski, Z.E. (ed.) Seafood: Resources, Nutritional Composition and Preservation. Florida : CRC press Inc. pp 29-54.

Lovell, T. (1989). *Nutrition and Feeding of Fish.* New York : Van Nostrand Reinhold.

Leray, C., Chapelle, S., Duportail, G. and Florentz, A. (1984). *Changes in Fluidity and 22:6(n-3) Content in Phospholipids of Trout Intestinal Brush-Border Membrane as Related to Environmental Salinity.* Biochim. Biophys. Acta. 778, 233-238.

Endinkeau, K. and Kiew, T.K. (1993). *Profile of Fatty Acid Contents in Malaysian Freshwater Fish.* Pertanika J. Trop. Agric. Sci. 16(3), 215-221.

Razak, Z.K.A., Basri, M., Dzulkefly, K., Razak, C.N.A. and Salleh, A.B. (2001). *Extraction and Characterization of Fish Oil from Monopterus albus. Malays.* J. Anal. Sci. 7(1), 217-220.

Kinsella, J.E. (1987). *Seafoods and Fish Oils in Human Health and Disease.* New York : Marcel Dekker Inc.

Gill, I. and Valivety, R. (1997). *Polyunsaturated Fatty Acids, Part 1: Occurrence, Biological Activities and Applications.* Trends Biotechnol. 15, 401-409.

Caroll, K.K. (1986). *Biological Effects of Fish Oils in Relation to Chronic Diseases.* Lipids. 21(12), 731-732.

Stansby, M.E. (1990). *Fish oils in Nutrition.* New York : Van Nostrand Reinhold.

Jeffrey, B.G., Weisingerb, H.S., Neuringer, M. and Mitcheli D.C. (2001). *The Role of Docosahexaenoic Acid in Retinal Function.* Lipids. 36(9), 859-871.

Carlson, S.E., Werkman, S.H., Peeples, J.M., Cooke, R.J. and Tolley, E.A. (1993a). *Arachidonic Acid Status Correlates with First Year Growth in Preterm Infants.* Proc. Natl. Acad. Sci. 90, 1073-1077.

Carlson, S.E., Werkman, S.H., Rhodes, P.G. and Tolley, E.A. (1993b). *Visual-acuity Development in Healthy Preterm Infants: Effect of Marine -Oil Supplementation.* Am. J. Clin. Nutr. 58, 35-42.

Guesnet, P., Pugo-Gunsam, P., Maurage, C., Pinault, M., Giraudeau, B., Alessandri, J., Durand, G., Antoine, J. and Couet, C. (1999). *Blood Lipid Concentrations of Docosahexaenoic and Arachidonic Acids at Birth Determine their Relative Postnatal Changes in Term Infants Fed Breast Milk or Formula.* Am. J. Clin. Nutr. 70(2), 292-298.

Koletzko, B., Agostoni, C., Carlson, S.E., Clandinin, T., Hornstra, G., Neuringer, M., Uauy, R., Yamashiro, Y. and Willatts, P. (2001*). Long Chain Polyunsaturated Fatty Acids (LC-PUFA) and Perinatal Development.* Acta Paediatrica. 90(4), 460-464.