# FATTY ACID AND CHOLESTEROL IN EGGS : A REVIEW

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**Abstract.** Elevated serum cholesterol, a major cause of vascular disease, has been strongly correlated with eating greater than normal amounts of cholesterol and saturated fatty acids. The role at omega-3 polyunsaturated fatty acids (PUFA), especially eicosa pentanoic acid (EPA) and decosahexaconic (DHA), has been associated with the prevention of degenerative disease. Breast milk and eggs fulfill the human requirement for DHA, however the DHA level is influenced by lactation levels and the maternal diet. Omega-3 PUFA are derived mainly from fish, eggs, and certain plants. Epidemiological observations, population studies, and basic research indicate the importance of these fatty acids for the membranes of the brain, for the retina in developing infants, and for the possibility of controlling coronary heart disease and other diseases by the ingestion of these fatty acids. Linolenic acid (LNA) enriched eggs may be an excellent source of dietary omega-3 PUFA and an ideal food ingredient for developing infants.

## INTRODUCTION

Since 1980 there has been an increasing public demand for fat and cholesterol modified products; as research continues to provide evidence linking diet and heart disease. Recent recommendations by health professionals to reduce cholesterol intake has resulted in decreased egg product consumption. The egg is considered a highly atherogenic food due to the relatively high yolk cholesterol content. Dietary, genetic, and pharmacological manipulation aimed at reducing the cholesterol content of eggs has resulted in marginal declines in yolk cholesterol levels. The fatty acid composition of the yolk is readily altered by the diet of the chicken. Early investigations indicate a yolk high in polyunsaturated fatty acids (PUFA) and enriched with omega-6 fatty acids can be easily produced with a poultry diet high in polyunsaturated oils, such as sunflower, corn and soybean (Elswyk *et al*, 1977). Laying hens were fed diets containing ground fibers resulting in a cholesterol value of 2.66 mg/100 grams of egg, a 20% reduction from 335 mg/100 grams of egg, and a PUFA value of 8.99 mg/100 grams of egg, a 22% increased from 6.84 mg/100 grams of egg (Butarbutar, 1998).

The relatively high cholesterol content of eggs has contributed to a steady decline in per capita egg consumption. The relationship between dietary cholesterol and heart disease has a profound impact on the public's image of eggs, and has recently received more attention than before from farmers, consumers health professionals and researchers alike. Chicken eggs, enriched with omega-3 fatty acids, tend to reduce plasma and tissue cholesterol levels in animals. Since standard values for food composition are commonly used by dieticians and consumers, accurate information on the cholesterol and fatty acid content of commercially produced eggs is important (Sim *et al*, 1991).

This manuscript will first briefly review the general aspects of the cholesterol and fatty acid, and then discuss the role of the omega-3 PUFA, especially EPA and DHA, associated with the prevention of degenerative diseases and on the reduction of low density lipoprotein (LDL) and high density lipoprotein (HDL) cholesterol. Finally, a global view of the omega-3 fatty acid enriched eggs for the infant food industry will be reviewed, with the aim of providing the potential of the omega-3 fatty acid enriched eggs to modify the fatty acid composition of human milk and to be a natural lipid source and a healthy weaning food for infants.

## THE ESSENTIAL FATTY ACIDS

Linoleic and alpha linolenic acid (ALA) are

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known as essential fatty acids, since they cannot be synthesized by vertebrates, and therefore must be included in the diet. They can, however, be made by plants, and this is their major occurence in our food chain (Andrew, 1993). Once EPA are ingested, they are carried to the liver, where they can be transformed by desaturation and chain elongation enzymes, to longer chain unsaturated fatty acids. Linoleic acid is the precursor of a series of PUFA. These are known as omega-6 PUFA, since linoleic acid is an omega-6 PUFA. ALA is the parent fatty acid for the omega-3 PUFA (Fig 1). Linoleic acid called ALA in order to distinguish it from gamma-linoleic acid (an omega-6 serries fatty acid) found; for example; in the oil from evening primrose seeds.

## THE EFFECT OF FATTY ACID AND CHOLESTEROL ON HEALTH

There have been reports that eggs raise high density lipoprotein (HDL) cholesterol levels, however, there are inconsistent results between the different studies. Most studies report they increase very low density lipoprotein (VLDL) cholesterol and low density lipoprotein (LDL) cholesterol, but HDL cholesterol responses have been varied. Harris (1989) indicated the study design may have contributed to the inconsistent results, since in those studies where saturated fat was held constant. The LDL cholesterol levels were significantly reduced, but only during the last 2 years of the study. These changes are considered beneficial and could lead to a significant reduction in the risk of developing ischemic heart disease (IHD). In another study on the effect of eggs on cholesterol levels, it was shown that DHA-rich eggs decreased LDL cholesterol and EPA-rich eggs decreased HDL-cholesterol levels (Childs *et al*, 1990; Made, 1992). These differences may account for the previously noted inconsistent results for HDL cholesterol with increasing quantities of purified long-chain omega-3 PUFA. More information is needed on the precise physiological roles of EPA and DHA in coronary heart disease.

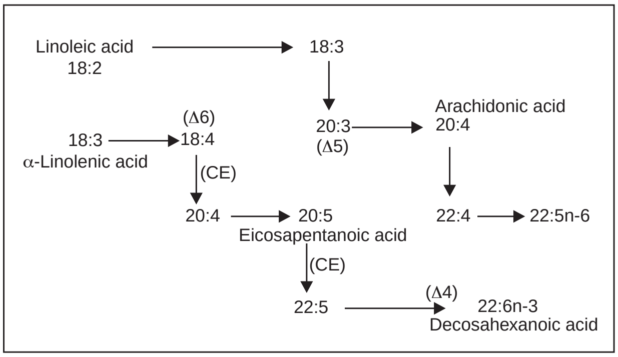


Fig 1–Pathway of metabolism of linoleic and linolenic acid in vertebrata. Desaturation steps are indicated be horizontal arrows (D6 = 6-desaturated, etc) and chain elongation by vertical arrows (Sprecher, 1993), CE = chain elongation.

Thus, there are a number of mechanisms by which omega-3 PUFA from eggs and seafood may exert physiological effects which reduce the risk of cardiovascular disease. There is also evidence that these fatty acids reduce the adhesion of blood cells to the endothelium (Kinsella *et al*, 1990).

## EFFECTS ON PLASMA LIPIDS

Various attempts to reduce the cholesterol content in eggs have met with little success. It has been possible to alter the fatty acid composition of eggs in such a way as to make the altered yolk lipids more acceptable to consumers. By manipulating the diets fed to chicken, we have been able to incorporate omega-3 PUFA into egg yolk lipids and to significantly reduce the omega-6 to omega-3 PUFA ratio from 19:1 to 14:1.

Plasma cholesterol and triglyceride levels can be modified by changing the fatty acids in chicken eggs. In a previous trial (Sim *et al*, 1991), we recruited 23 Mae University students who were asked to consume two omega-3 PUFA enriched eggs daily. We found that plasma total cholesterol levels were virtually unchanged over a 20-day period, and plasma triglycerides were significantly reduced. Plasma cholesterol levels increased and plasma triglycerides are unaffected in those who consumed regular eggs. In another group who consumed three eggs daily for 30 days, plasma total cholesterol and triglyceride levels decreased (Sim *et al*, 1991).

## INFANT FOOD

Omega-3 PUFA accumulates as DHA in the brain lipid of children during the first two years of life, a process essential for normal development and maturation. Omega-3 PUFA intake is via the diet. Fat in infant formulas is generally derived from vegetable oil and, therefore, does not contain DHA. Breast milk levels of DHA are influenced by dietary habits with high levels being found in women who consume marine products. Eggs are an excellent vehicle to provide DHA. Eggs enriched with omega-3 PUFA were obtained by feeding hens a diet containing flax seed. The resulting enriched eggs provided up to 530 mg of omega-3 PUFA, of which 105 mg was DHA. These eggs were fed to lactating women (2 eggs per day). This resulted in a significant increase in the amount of omega-3 PUFA, including DHA, in their breast milk compared with their pretest milk. The omega-6:omega-3 ratio in breast milk was reduced to 3.02 in the enriched eggs consuming group, compared with 6.14 in the control group. Omega-3 PUFA enriched eggs have potential as a healthy weaning food for infants, as well as a natural lipid source for infant formula preparation (Cherian and Sim, 1992).

Eggs are a nutritious food item. The biological value of other foods has been determined using eggs as the reference standard. The discovery that omega-3 PUFA protect against coronary heart disease in fish-consuming Greenland Eskimos spawned much research over the past decade about the various health benefits of dietary omega-3 PUFA from fish and fish oils. DHA, one of the omega-3 PUFA, accumulates in the brain tissue of prenatal and suckling mammals, including humans, where it is essential for normal development and maturation. There are three omega-3 PUFA. One, called linolenic acid (LNA), is found in flax and canola seeds. The other two longer-chain PUFA are named EPA and DHA. LNA-enriched eggs may be an excellent source of dietary omega-3 PUFA for eggs consumers, and may be an ideal food ingredient for the developing infant (Cherian and Sim, 1991). In this context, Sellamayer *et al* (1993) showed that metabolities of arachidonic acid (AA) have an effect on cell growth and mRNA levels. This could mean that AA plays a metabolic and structural role in the developing infant.

## CONCLUSION

Higher levels of omega-3 PUFA in the diet lead to positive benefits for the health of the population. Omega-3 PUFA accumulates in the brain tissues, and is essential for normal development and maturation. EPA and DHA from flax or canola can be converted by animals and humans into the types of fatty acids found in fish oil. Enriched eggs may be an excellent sources of dietary omega-3 PUFA.

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