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# Review on the beneficial effects of omega-3 enriched eggs by dietary flaxseed oil supplementation

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**ABSTRACT**

The aim of this review is to convey updated knowledge, for better decision making in preventive and therapeutic health care, as well as in agriculture and food industries. The association of omega -3 polyunsaturated fatty acids (PUFA) with cardiovascular risk was suspected early in Eskimo populations that are known to have a high consumption of fish and fish oil. However, their diet contained almost no vegetable foods. Omega-3 polyunsaturated fatty acids have been studied intensively as nutrients that protect against cardiovascular disease. Awareness of fatty acids beneficial effects seems to have played a role in creating new products labeled high in omega-3. Most of them use ALA (α-linolenic acid), derived from plants. Health effects of omega-3 fatty acids come mostly from EPA (eicosapentaenoic acid) and DHA (docosa-hexaenoic acid). It is not an efficient process for humans to synthesize EPA and DHA from ALA in contrast to laying hens. EPA and DHA Omega-3 enrichment of eggs with ALA rich flaxseed oil is an effective way.

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## Introduction

Adequate and balanced nutrition has a huge impact on the physical health and wellbeing of humans. Protein, carbohydrates and fats provide energy they are required for growth, maintenance and the repair of body tissues,. Vitamins and minerals are also necessary for adequate and balanced nutrition. Dietary bioactive compounds such as vitamins, minerals also PUFA may be used to prevent, and treat diseases and as well as to improve humans health. They may confer some beneficial effects that cannot be obtained from medicines, the need for conventional medications can reduce or eliminate (Stice, 2019)

Linoleic acid (LA) and α-linolenic acid (ALA) are considered essential fatty acids because they cannot be synthesized by humans. Potential health benefits of essential fatty acids (EFAs) reported by recent research and has drawn attention of fatty acids roles ranging from energy source and fuel storage, constituents of membrane lipids, cellular signaling, regulatory effects on molecules, regulation of inflammation (Narce and Niot, 2019)

Omega-3-fatty acids. have been reported to play a role in the prevention and treatment of many chronic diseases which improve the human health in many

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aspects (Trautwein, 2001; Yashodhara et al., 2009).Observation of low incidence of cardiovascular diseases found in the Eskimo population, is remarkable, given that their traditional diet depends heavily on consumption of fish and fish oil almost no vegetable (Das, 2000). It has been generally recognized that Omega-3 PUFA fatty acids provide important health benefits.

Scientific research focuses on omega-3, supplements to improve human health Omega-3, Eicosapentaenoic acid (EPA, 20:5n-3) and Docosahexaenoic acid (DHA, 22:6n-3) are mainly associated with the reduction of cardiovascular diseases. They help in preventing atherosclerosis, diabetes mellitus, neurological disorders mental health diseases, central nervous system, cancer, obesity, immune functions and inflammation (Trikalinos et al., 2012; Stark et al.,2016; De Carvalho and Caramujo, 2018). Unfortunately, the “Western pattern” diet rich in omega-6 and deficient in omega-3. Conventional foods can provide better health benefits, by manipulation of the diet contain omega-3, to boost intake of long chain omega-3 food enrichment is probably the best long-term solution (Molendi-Coste et al.,2011).

**PUFAs, nutrition and health**

Lipids are among main components of food. Fat absorption from mixed micelles occurs throughout the small intestine, by pancreatic enzymes. Fatty acids which must be hydrolyzed before absorption, and the presence of bile salts in mixed micelles greatly enhance the digestion of fatty acids and other fat digestion products (Lichtenstein et al., 2012)

PUFAs are divided into three main classes: omega-3 PUFA, omega-6 PUFA and omega-9 PUFA (Valenzuela et al., 2009; Crupi, 2013). The structure of each PUFA is characterised by an acyl chain with one acid end (-COOH) and one methyl end (-CH3) The structure has at least two double bonds, with “Omega -x” (ω-x, n-x) indicating that the first double bond is found at the X carbon from the methyl end. This means that first carbons double bond position is the main differences among them. PUFA of the same omega class may be converted into another same class PUFA by unsaturation and elongation. PUFAs play important role in maintaining homeostasic conditions (Zárate et al., 2017)

The most biologically important fatty acids are alpha linolenic acid, (ALA 18:3n-3) and linoleic acid (18:2n-6). They are often reffered to as essential fatty acids (EFAs). EFAs cannot be synthesised by humans and other animals and have to be supplied through the diet. EFAs, are required in certain ratio and must be obtained from the diet to ensure good development, growth and optimal health. Various types of unsaturated and saturated fatty acids play important roles in different biological processes like the construction of biological structures such as cell membranes (Kimura et al., 2019). Decreased growth in infants and children, increased susceptibility to infection, poor wound healing scaly dermatitis, alopecia, thrombocytopenia, hyperlipidemia, altered platelet aggregation are clinical signs of EFAs deficiency (Jeppesen et all., 1998; Mogensen, 2017; Szabina, 2019).

Omega-3 PUFA fatty acids, ALA, EPA and DHA provide important health benefits. Health benefits are related to EPA and DHA, rather than ALA (Trautwein, 2001). EPA and DHA, have anti-oxidative, anti-inflammatory and anti-apoptotic effects (Crupi, 2013). In many studies it is documented that ALA’s biological role is to serve as a substrate for synthesis of EPA and DHA (Burdge, 2004). With a relatively low rate of ALA conversion, these long-chain omega-3 PUFA, EPA and DHA may be considered conditionally essential nutrients.

**Table 1.** Most common omega-3 fatty acids names and abbreviations

| | | |
|---|---|---|
| α-Linolenic acid | ALA | 18:3n-3 |
| Eicosapentaenoic acid | EPA | 20:5n-3 |
| Docosahexaenoic acid | DHA | 22:6n-3 |

EPA and DHA Omega-3 are highly pleiotropic agents, They provide beneficial effects in inflammatory conditions and are important for neurologic and retinal development (Jordan, 2010). In addition they can improve skin and coat health (Rees et al., 2001). EPA is a precursor of many important chemicals in the body, such as prostaglandin-3, thromboxane-3, and leukotriene-5 eicosanoids, among other functions contributes to platelet aggregation and regulation of immune responses, most of sudden cardiac arrests are caused by blood clotting and prostaglandins that interfere with blood clotting. DHA is an important component for the retina, skin, brain and may lower markers of inflammation (Stice, 2019). Increased consumption of EPA and DHA Omega-3 fatty acids are helps in decreasing cholesterol and LDL (low-density lipoproteins) in the blood. Studies of omega-3 PUFA deficiency in rodents have revealed significant impairment on learning and memory (Fedorova et all., 2009).

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**Table 2** Most common omega-6 fatty acids names and abbreviations

| | | |
|---|---|---|
| Linoleic acid | LA | 18:2n-6 |
| Arachidonic acid | AA | 20:4n-6 |

Arachidonic acid (AA) is Omega-6 fatty acid obtained from food or by desaturation and chain elongation from the plant rich essential fatty acid linoleic acid. It is present in the phospholipids of cell membranes, conferring it with fluidity and flexibility and selective permeability to membranes (Brash, 2001). It is abundant in the liver, brain and muscles. Additionally, AA is involved in cellular signaling and is a key inflammatory intermediate. Eicosanoid products, such as Prostaglandin E2 (PGE2) and Leukotriene B4 (LTB4) synthesized from arachidonic acid are more potent mediators of thrombosis and inflammation. AA has a fundamental role in vascular permeability, organelle integrity, neuron functions and brain synaptic plasticity (Tallima and El Ridi, 2018).

Oils are the main source of energy for the poultry diets and have the highest caloric value among all dietary nutrients. Also, oils are need for absorption of fat-soluble vitamins. They increase diet palatability and improve the utilization of the consumed energy. Moreover, the rate of food passage through the gastrointestinal tract can be reduced with subsequent better absorption of all dietary nutrients. (Poorghasemi et al., 2013).

Different oil sources are used as energy sources in the laying hens diets, and these oil sources also affect the lipid profile of eggs (Jia et al., 2008; Cherian, 2015; Huang et al., 2018; Lee et al., 2019). Eggs can be enriched with certain nutrients, and their omega-3 content can be improved by feed supplementation. It has been reported that flaxseed is rich in ALA and effective in omega-3 fatty acid enriched egg (Goyal et al., 2014; Ehr et al., 2017). Hens convert ALA into DHA, DHA content of the eggs increased from 28 to 90 mg/egg when Aymond and Van Elswyk (1995) fed 15% of ground flaxseed to hens.

Current knowledge of metabolism and physiology of EFAs indicates that some traditional ethnic lifestyles develop healthier daily supplies. (Lands, 2016). Nowadays our diets are rich with omega-6 fatty acids which are linked to high consumption of omega-6 PUFA in the diet. It has been described to increase the risk factor of health problems such as obesity, type 2 diabetes and coronary artery diseases (Richardson, 2006). Omega −6/ omega −3 ratio of the diet is one of the major influencing factors for health problems. When omega −6 PUFA intake is rather high relative to n−3 PUFA, that suppresses the ALA conversion rate (the competition for the desaturase enzymes;) causing a decrease in ALA conversion efficiency (Simopoulos, 2016).

Studies have been focused on improving foods omega-3 from animal origin. Various supplementation have been used to improve egg omega-3 fatty acid concentration Moran et al. (2018) who reported heterotrophic microalgae significantly increased egg EPA and DHA concentrations, Ehr et al. (2017) used flaxseed and flaxseed oil for omega-3 enrichment, Eseceli and Kahraman (2013) observed Egg yolk omega-3 levels were found higher in fish oil supplemented group. Poultry products have become the primary source of PUFAs and eggs are very important source of animal protein in the human diet. When the feedstuff is enriched with omega-3 fatty acid, the omega-3 fatty acid content of the eggs increases. (Barroeta, 2007; Gürbüz et al., 2012). Flax seed oil (one of the richest sources of ALA) is a good alternative source of omega fatty acid for poultry diets, Approximately half of its total fatty acid contents being ALA. It has been reported that control group eggs contain 173 mg/50 g egg, total omega-3 fatty acid. By adding 15% dietary flaxseed, the fatty acid content of eggs increases to between 358 mg and 458 mg/50 g. As flaxseed oil % is increased the total omega-3 fatty acid concentration increased linearly (Ehr et al., 2017)

Dietary intervention with omega-3 is not only used for improving the health and productivity of birds, but also important for our health-consciousness. Because the society prefers properly balanced diets to minimize adverse health issues. It is possible to improve egg composition to provide better protection against Omega-3 PUFA deficiency related diseases/ disorders (Simopoulos, 2008).

PUFA's effects are dependent on the ratio of omega-3 and omega-6. There is a close interaction between omega-3 and omega-6 fatty acids which is about 1:10 in modern dietary habits but its recommended ratio is 1:4 (Petrovic, and Arsic, 2016). Some studies offer even lower ratios. Products labeled high in omega-3 use ALA that is derived from plants, such as flaxseed, which may not have EPA and DHA (Barringer et al., 2015).

To produce poultry products with health benefits for the consumer, birds are fed with a diet supplemented with omega-3 fatty acids. By doing so, not only the cholesterol content of eggs is decreases (Sihvo et al., 2014) but also the EPA and DHA omega-3 fatty acids content of eggs is increases. It has been reported that the beneficial effects of omega-3 fatty acids on health mostly comes from EPA and DHA. ALA from flax and other vegetarian sources needs to be converted to EPA and DHA (Crupi, 2013). If α-linolenic acid (ALA; C18:3) is present in laying hens diets, EPA and DHA can be synthesized from ALA during metabolic processes (Ebeid et al., 2008; Yalçın and Unal, 2010). ALA Omega-3 is better converted to EPA and DHA by laying hens. However, the conversion of ALA into EPA in humans is limited, and further transformation to DHA is even lower caused by competition for the enzymes Δ-6-desaturase which also acts on linoleic acid (18:2n−6, LA); (Trautwein, 2001; Burdge, 2004). Therefore, most of these long chain PUFAs must be obtained directly from the diet (Brenna, 2002; Cherian, 2008;). It is a good strategy to increase eggs omega-3 long chain polyunsaturated fatty acids (LC-PUFA) with flaxseed, It provides an excellent source of ALA, that makes up about 53% of its total fatty acid contents (Surai and Sparks, 2001; Huang et al., 2018;).

Omega-3 fatty acids from fish and fish oils can protect against coronary heart disease (CHD), Fish and fish products are good sources of Omega-3 but only 20% of the world population consumes 250 mg/d of seafood. Countries like Japan, South Korea and Scandinavia traditionally reliant on fishing and hunting tended to have moderate to high blood levels of EPA+DHA. Also reported that in"Western pattern" diets, adapted countries of North America (Canada and USA), Central and South America (Guatemala and Brazil) and Europe (Ireland, UK, Italy, Greece, Serbia and Turkey) blood levels of EPA+DHA are very low (Micha et al., 2010; Stark et al.,2016).

## Conclusion

After Dr. Sinclair (1956), who proposed that deficiency of fatty acids may be attributed to a CHD, evidence regarding positive effects of omega-3 fatty acids in Cardiovascular Health and Disease has been accumulating. Previous studies shows that diet can influence eggs fatty acid composition (Keum et al.,2018; Fraeye et al., 2012). Eggs are very important source of protein for human diet and without any religious or cultural restriction they are consumed worldwide. Omega-3 enrichment of eggs with flaxseed oil may be a good strategy for most people to consume sufficient quantities of EPA and DHA, omega-3 that could reduce chronic disease and protect against CHD, which is still the most common cause of death in the western countries. Egg producers must be aware that eggs enriched with value-added ALA, EPA and DHA, not only researchers but also the public are increasingly interested prevention of CHD. In market, the choice of "omega-3 enriched eggs" by consumers is very popular, omega-3 rich eggs containing low levels of cholesterol are more valuable than ordinary commercial eggs (Shakeel et al., 2010). More attention is paid to the concentration of omega-3 fatty acid in yolk. Information on the effect of flaxseed oil on immune system is relatively limited and needs to be investigated in future trials.

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