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The Effects of Omega-3 and Omega-6 Fatty Acids on Performance, Egg Quality, and Some Blood Parameters of Laying Hens

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Abstract

Polyunsaturated fatty acids (especially omega-3) are beneficial on brain growth, immune system, and preventing of heart attack. In recent years the production of foods with high levels of omega 3 polyunsaturated fatty acids has received special attentions by many companies. One of these foods is hen egg and many researches explained that type and amount of egg yolk fatty acids can be changed by the type and amount of diet fatty acids in laying hens. Also inclusion of polyunsaturated fatty acids in layer hens diet can be reduce cholesterol and triglyceride content in egg yolk and because of it consuming of these eggs humans have an important effect on LDL and HDL contents in humans blood. However, many researches have been done to determine the effects of polyunsaturated fatty acids on the production performance and egg characteristics of laying hens. In conducted experiment major problems were decrease egg production, egg weight, and egg quality. It can be suggested that more studies are needed to be done on effects of polyunsaturated fatty acids on laying performance and egg quality in layers hen.

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Introduction

In the recent study it was explained that consuming of food containing polyunsaturated fatty acids (PUFA) especially omega-3 fatty acids have a benefit effects on human health (Simopoulos, 1999).

Dietary omega-3 fatty acids decrease lipid metabolism (De la cruze *et al*., 2000), induce the LDL cholesterol and increase HDL cholesterol content in blood (Özkan ve Koca, 2006), decrease tissue oxidative stress (Marrugat *et al*., 2003), inhibit the heart attack (Zyriax and Windler, 2000), improve immune system function, have an important role on brain and retinal growth (Lewis, 2000), improve learning and behavior disorders in children (Richardson, 2004), and inhibit the breast cancer (Lewis, 2000) in humans.

According to benefit listed, food industry had a special attention to produce the food in reach with omega fatty acids. Some of these foods are egg and meat that type and amount of these food fatty acids can be changed by ratio fatty acids source and amount. Omega fatty acids mainly founded in fish oil, canola oil, sunflower, and linseed oil that are used in poultry nutrition to provide energy requirement and also, to investigated effects of dietary fatty acids on performance and egg quality (Sadeghi *et al*., 2012; Shahriyar *et al*., 2008; Kahraman *et al*., 2004).

Also in the some studies effects of omega-6 fatty acids on laying performance and egg quality were investigated (Kahraman, 2004; Baucels *et al*., 2000; Tsuzuki *et al*., 2003). The purpose of this study was investigated effects of omega fatty acids in laying hens on performance, egg quality, and some blood parameters.

Effects of dietary fatty acids on Feed intake, body weight and feed conversion ratio

Many studies were conducted about of effects of different source of fatty acids on feed intake, body weight and feed conversion ratio in laying hens. For example in the study was conducted with Kahraman (2004) it was reported that inclusion of 4% fish and sunflower oils and vitamin E and C (100 and 400 ppm) in layer hens' diets does not have effect on feed intake but fed of diet containing 4% fish oil improve the feed conversion ratio and that positive effect is due to omega-3 fatty acids in fish oil. Sadeghi *et al* (2012) reported that feed intake, body weight gain and feed conversion ratio were not changed when 5% fish oil added in broiler's diet. Adding of fish oil as an omega-3 fatty acid source in laying hen's diet cannot change feed intake between experimental groups (Gonzalez-Esquerra and lesson, 2000).

Baucels *et al* (2000) conducted an experimental to investigate of effects of dietary fish, linseed, rape, sunflower, and frozen oil (%0, 25, 50, 75, and 100) on laying hen performance. They reported that adding this oil in laying hens diet cannot change feed intake, feed conversion ratio, and bod weight also they explained that there was not relationship between diet flavors and feed intake. Adding of 5% sunflower, corn, linseed, soybean, fish, and tallow fat in broiler diets cannot change birds feed intake and feed conversion ratio but at the end of experiment that group fed with diet containing 5% tallow oil has a higher body weight (Balevi and Coskun, 2000). Schreiner *et al*. (2004) not founded significant differences in feed intake parameters between experimental groups when the birds fed diets containing different levels of seal blubber oil. It was showen that adding of 2% fish oil in broiler's diet can improve the body weight of broiler at the beginning of experiment and also improve the feed conversion ratio at the end of experiment (Alparslan and Ozdogan, 2006).

Najib and Alkateb (2004) demonstrated that feed intake and feed conversion ratio in the laying hens were fed diets containing 0, 5, or 10% full fat canola seeds. Celik *et al* (2005) demonstrated that inclusion of soybean, fish and L-Carnitine at hot climate in the broiler diets can change broiler body weight gain.Navidshad (2009) reported that provide of broiler diets with different levels of protein and 4% fish oil does not have any effect on feed intake but it can negative effect on body weight gain.The inclusion of 3% linseed oil in broiler diet did not any effect on broiler's feed intake. (Febal *et al*., 2008).

In the another study which conducted with Ebedi *et al* (2008) it was showed that increasing of polyunsaturated fatty acids in laying hen's diet significantly reduced feed intake of birds. Supplementation of laying hen diets with linseed oil significantly reduce feed intake but improved feed conversion ratio (Raes *et al*, 2002). Adding of 10% linseed in laying hen's diet significantly reduced feed intake. Same of this experiment which was conducted by Celebi and Utlu (2006) it was explained that fed of diets containing 5 or 10% linseed oil can reduce feed intake and improve feed conversion ratio of hens. Also Augusty *et al* (2002) showed that linseed oil in laying hens diet can reduce feed intake and improve of feed conversion ratio. Similarly of this results Crespo and Esteve (2002) demonstrated that in broiler chicken were feed diets containing 5 or 10% linseed oil it was significantly reduced in feed intake and increasing in feed conversion ratio. In the all of these experiment that was showed induced in feed intake. The reason of diet consumption reduction in all the conducted researches on birds is the unpleasant smell of the oxidation of fat sources in the birds' diet.

Effects of dietary fatty acids on laying performance in layer hen

There were many researchers conducted to evaluation of polyunsaturated fatty acids on laying performance of laying hens and results are as fallowing. Schuman *et al* (2000) reported that consuming of diet containing 4% linseed oil significantly reduces egg production of hens and according to these researchers the reduction of egg production is because of the reduction of feed intake of hens. Kahraman *et al* (2004) explained that adding of 2% or 4% sunflower, linseed, and fish oils in layer hens diet does not have a significant effect on daily egg production. In the experiment which was conducted with Grobas *et al* (2001) it was reported that consuming of diet containing 5 or 10% linseed oil does not have a significant effect on egg production in laying hen. Adding of soybean and linseed oil in layer hen's diet cannot change egg production of hens (Silke *et al*., 2008).

Inclusion of 15% linseed oil in layer hen's diet caused significantly induces in egg production parameter (Ansari *et al*., 2006). Van Elswyk (1997) reported that inclusion of different oils in layer hen's diet can be change hen's egg production just at the beginning of their laying cycle.

In the other study was conducted with Yannakopoulos *et al*. (1999) it was show that laying performance was not affected by the different levels (20 or 10%) of dietary linseed oil. Filardi *et al*. (2005) suggested that fed the diet comprising 3.12% canola oil by layer hens does not have any effect on daily egg production. Similarly these result it was explained that there was not any relationship between dietary oil sources and egg production in laying hen (Mazalli *et al*., 2004; Gonzalez-Esquerra and lesson, 2000). Tsuzuki *et al* (2003), showen that adding of different levels of sunflower oil (0, 1.4, 2,8, 4.2, and 5.6%) in layer hens diet cannot any effect on laying performance, Goncuglu and Ergun (2004) in a study investigated that supplementation of laying hens diet with 1, 2, 3, or 4% linseed oil does not have a significant effect on egg production between experimental groups. In most of studies it was shown that in the layer hens fed diet containing 10% linseed egg production did not affected with dietary linseed when compared with other experiment groups (Jiang *et al*., 1991; Novak and Scheideler, 2001).

Effects of dietary fatty acids on Egg quality

The characteristic of egg is identified by egg weight, egg mass, egg width, egg length, egg yolk, egg albumin, egg shell strength, egg shell thickness, Huge Unite, yolk color, and etc. As it is identified these parameters can be affected by dietary integration such as oil sources. And there are many researches in this area. In one of the studies that was conducted by An *et al* (2010) it was demonstrated that adding different levels of vitamin E, 2% fish oils (as a omega-3 polyunsaturated fatty acid) and corn oil in the broiler breeder diets have a significant effect on egg weight, yolk weight, albumin weight and egg shell weight.

In the other study it was reported that adding of omega-3 fatty acids in layer hen's diet dose not significant effect on egg weight (Eseceli and Kahraman 2003; Hargis *et al*., 1991; Carrillo-Dominguez *et al*., 2005; Bean and Lesson, 2003). Meluzzi *et al*. (2000) also reported similar egg weight in the hens fed on diets with 3% fish oil when compared with other groups. Scheideler and Froning (1996) shown that inclusion of linseed in layer hen's diet significantly increased egg weight but egg shell and albumin present of eggs have not effected by dietary linseed levels. In the some studies it was reported that there was not relationship between dietary omega-3 polyunsaturated fatty acids and egg weight, egg Haugh unit and egg shell thickness (Celebi and Utlu, 2006; Galobart *et al*, 2001). She *et al*. (2012) indicated that adding of8.26, 16.52, and 24.84% sunflower seed meal in laying hens diet does not have any effect on egg quality.

Also in the another studies it was reported that dietary omega-3 poly unsaturated fatty acids cannot any effect on egg shell quality (Bean and Lesson, 2003; Gorbas *et al*., 2001; Raes *et al*., 2002; Filardi *et al*., 2005). Novak and Scheideler (2001) explained that inclusion of linseed in layer hen's diet does not have significant effect on egg mass, wet yolk percent, and albumin percentage. Adding of 4% linseed oil in commercial layer hen's diet does not have any effect on egg weight (Schumann *et al*., 2000). In the study that was conducted with Cherian (2008) it was demonstrated that yolk weight, shell thickness, and yolk color cannot affected by different dietary herbal and fish oil sources. There are some adverse result about the benefit effects of dietary omega-3 fatty acids on egg shell characteristic for example, some researches indicated that dietary fatty acids have a negative effects on egg shell characteristic (Paterson *et al*., 2001; Novak and Scheideler, 2001).

Celebi and Macit (2008) reported that adding of 2% omega-3 and omega-6 fatty acids in layin hens diet cannot effect on egg quality.Inclusion of 0% or 1.5% poultry fat and 0, 4.32 or 8.64% linseed cannot changed egg weight, yolk weight, and shell weight (Basmacıoglu ve ark., 2003).

In the another experiment consumption of diet containing omega-3 fatty acids by laying hens significantly decreased egg weight produced by hens (Beynen, 2004; Sosin *et al*., 2006; Papas *et al*., 2005). Gonzalez-Esquerra and Lesson (2000) reported that in the laying hens consuming of dietary omega-3 fatty acids can cause hypotriglyceridemic and thereby reduce the egg weight also, feeding of high levels of omega-3 fatty acids by birds can effects on estradiol and triglyceride circulating which can change the egg yolk amount (Elswyk, 1997). According this result some researchers indicated that feeding of diets containing high levels of omega-3 fatty acids reduction plasma estradiol levels and causes a decrease in egg weight (Whitehed *et al*., 1993; Scheideler and froning, 1996).

Grobas *et al*. (2001) reported that adding of 5 or 10% for 12 weeks in layer hen's diet does not have any effect on yolk weight and Haugh unit but significantly increased albumin weight of produced egg. In the another study it was shown that there were not any differences in yolk index parameter when the birds fed a diet containing different levels of full fat canola seed (Najib and Al-khateeb, 2004). But in the another studies opposition results expressed, for example Elswky (1997) demonstrated that when the layer hen's diet supplemented with linseed produced egg weight was lower than the control groups and according to this research egg weight loss due to linseed antinutritional factor or changes in circulation estradiol in blood was created.

Synthetic pathways of polyunsaturated fatty acids

Avian and mammals can synthesis saturated fatty acids in there body (Calder, 2001), but cannot synthesis polyunsaturated fatty acids and also cannot convert saturated or monounsaturated fatty acids to polyunsaturated fatty acids and for converting the saturated fatty acids to monounsaturated fatty acids it is needed to elongases and desaturases enzymes (Watkins, 1991; Nakamura *et al*., 2001). In detail in poultries and all avian in the liver desaturase Δ 12 is

in charge of converting oleic acid to linoleic acid and it found only in plants (Calder, 2001). And also desaturase Δ15 is in charge of converting linoleic acid to alfa-linolenic acid and it found only in plants too. It noteworthy to say that linoleic and linolenic acids cannot made by mammals and avian because of this they call essential fatty acids and they must give by diets.

It was reported that by Spercher (2000) when animals received linoleic acids by diet, they can convert small amount of arachidonic acid and also convert small quanty of linolenic fatty acids to longer fatty acids of omeg-3 family such as docosahexaenoic acid in live by the a certain mechanism (Fig 1).

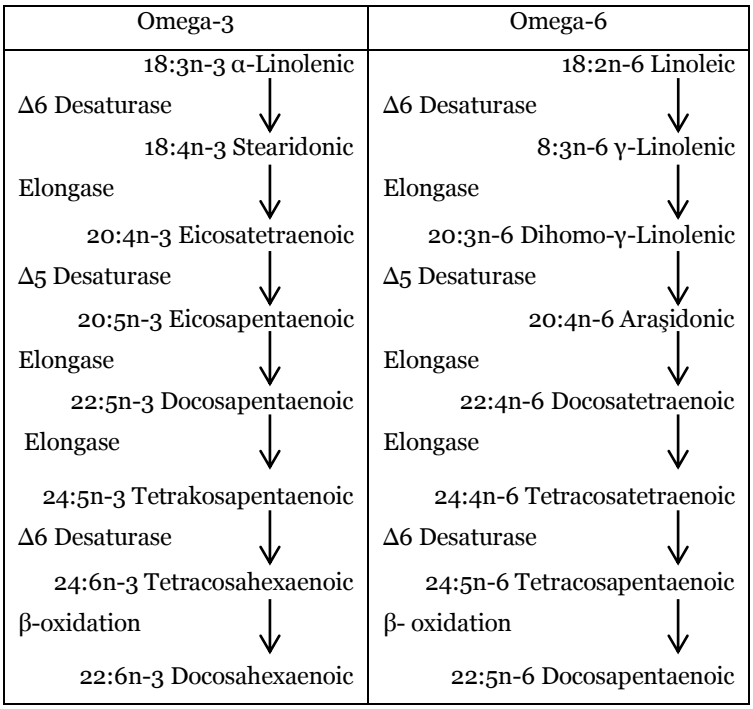

Fig. 1. Synthetic pathways of polyunsaturated fatty acids.

Synthesis of yolk by laying hen

In the mature hens at the laying period dietary fat digested by lipase action and triglycerides convert to monoglycerides and free fatty acids and absorbed in the small intestine and secreted into the portal vein as portomicrons (Speake *et al*., 1998a). Portomicrons are absorbed by the liver and food fatty acids may be selectively oxidized or they incorporated into very low density lipoproteins (VLDL) and synthesized fatty acids from glucose (Applegate, 2002). VLDL is large and contains a lot of apoproteins and dietary fatty acids elongation and desaturation may occur prior to incorporation into the VLDL. Triglycerides of VLDL after inters in capillaries peripheral tissues hydrolyses by lipase enzyme (the turning of VLDL to LDL) and create free fatty acids to provide muscle energy or convert back to triglycerides and stored in the adipose tissue (Speake *et al*., 1998a).

In the laying hens at the laying period secreting a lot of estrogen hormone cause an increase the rate of lipid synthesis from dietary carbohydrate (Applegate, 2002) also, in this phase VLDL is resistant to lipase enzyme and is not used by adipose tissue and muscles but it transported to the maturing oocyte which VLDL has a most of yolk precursors and other yolk lipids are phospholipids, cholesteryl ester, cholesterol, and free fatty acids (Vierra and Morgan, 1999).

Effects of dietary fatty acids on cholesterol and triglyceride levels in blood and egg yolk

It's well documented those dietary fatty acids profiles can be change the serum lipoproteins level, blood composition, plasma lipoprotein and liver metabolism (Hermier and Dillon, 1992; Donaldson, 1979).

Mori *et al.* (1999) reported that dietary polyunsaturated fatty acids in laying hens significantly decreased the plasma cholesterol concentration. According this result Celebi and Utlu (2006) demonstrated that serum VLDL and low density lipoprotein (LDL), serum triglycerides and cholesterol in layer hens significantly decreased when the hens fed a diet containing 4% linseed oil but blood HDL level was higher that the control group. Febal *et al.* (2008) in a conducted study observed that omega-3 fatty acids sources in diet can induce the total cholesterol and LDL-cholesterol but it cannot change blood HDL levels. Also in the one of study on the broiler chicken it was reported that dietary omega-3 fatty acids can improve the total cholesterol and plasma VLDL (Crespo and Esteve-Garcia, 2003). Inclusion of 0, 5, 10 or 15% linseed in layer hen's diet does not have any effect on plasma cholesterol (Ansari *et al.*, 2006). It was reported that consuming of omega-3 fatty acids in laying hens induced plasma triglycerides (Crespo and Esteve-Garcia, 2003).

In contrast Svedova *et al.* (2008), explained supplementation of layer hen's diet with 3% linseed oil significantly increased plasma triglyceride level. Agdamshahriyar *et al.* (2007) reported that adding of 4% canola and tallow oil and 0, 75, and 150mg/kg vitamin E in broiler breeder's diet have not any effect on egg cholesterol and triglycerides content. Al-khalifa *et al.* (2012) shown that inclusion of dietary omega-3 fatty acids in broiler's diet have a significant effect on plasma fatty acids composition. It was reported that broiler's blood triglyceride, cholesterol, and LDL contents unaffected by dietary fatty acids composition but it was significantly differences in blood HDL content (Alparsalan and Ozdogan, 2006).

Kamran azad *et al.* (2009) indicated that inclusion of flaxseed, canola seed, and tallow with different levels in broiler's diet does not have a significant effect on total cholesterol and triglyceride content. It was reported that adding of different levels of flax seed, sawdust, and fish oil in laying hen's diet have a significant effect on egg yolk cholesterol content but it cannot changed triglyceride and HDL content in egg yolk (Basmacioglu *et al.*, 2003).

Adding of 4% fish, sunflower, flaxseed and mixture oils in layer hen's diet have significant effects on serum triglyceride, total cholesterol, HDL, LDL, and VLDL levels (Celebi and Utlu, 2006). In the some study it was) reported that dietary fatty acids increased plasma LDL and VLDL in layer hens (Grundy,1989, Nestel *et al*, 1984) and also result Harris (1989) demonstrated diets containing omega-3 fatty acids reduce triglyceride levels. In te some study it was reported that dietary polyunsaturated fatty acids cannot effect egg yolk cholesterol contents (Ceylan *et al.*, 2011; Cobos *et al.*, 1995) but inconstant of this result Atakisi *et al.* (2009) reported that supplementation of diets with fish oil significantly induced egg cholesterol contents.

Effects of dietary fatty acids on egg yolk fatty acids composition

Ahmad *et al.* (2010) indicated that adding of 0, 2, 3, and 4% canola oil in laying hen's diet significantly increased omega-3 fatty acids content in egg yolk. It was reported that layer hen's diet containing high levels of alfa-linolenic acid can increased yolk fatty acids content (Ahn, *et al.*, 1995). In another study it was explained that broiler dark and withe meats fatty acids composition effected by different levels of dietary canola and fish meals, seeds, and oils (Ajuyah *et al*, 1999).

Adding of different levels of flaxseed, rapeseed, chia seed, chia meal, flaxseed oil, and chia oil in laying hen's diet significantly effected yolk fatty acids composition (Antruejo *et al.* 2011). Azad *et al.* (2009) indicated that inclusion of flaxseed, canola seed, and tallow with different levels in broiler's diet has a significant effect on meat polyunsaturated, omega-3, and omega-6 fatty acids composition. In the other study it was reported that adding of different levels of sunflower seed meal in layer hen's diet have a significant effect on egg fatty acids composition (Shi *et al.*, 2012) Basmacioglu *et al.* (2003) reported that adding of different levels of flax seed, sawdust, and fish oil in laying hen's diet significantly effected yolk fatty acids composition.

It was reported that in the laying hens egg yolk fatty acids composition significantly effected when the bird fed diets containing different levels of linseed oil, rapeseed oil, sunflower oil, and tallow (Baucells *et al*., 2000). In the study with Cachaldora *et al.* (2006) it was reported that adding of different levels and different spice of fish oil in layer hen's diet have a significantly effect on egg yolk fatty acids composition. Ceylan *et al.* (2011) reported that yolk fatty acids composition in egg produced with laying hen affected by dietary polyunsaturated fatty acids composition. It was reported that in the laying hens egg yolk fatty acids composition (PUFA) significantly increased when their diets containing 3% sunflower and linseed oils (Mazalli *et al.* 2004). Souza *et al.* (2008) indicated that supplementation of diets with linseed oil increased the unsaturated fatty acid content in egg yolk. It was reported that diets containing different levels of conjugated linoleic acid and fish oil can affect egg yolk fatty acids profile (Cherian, 2007). King *et al* (2012) reported that adding of fish, sunflower, and tallow oils in layer hen's diet have a significant effect on egg fatty acids profil.

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