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Effect of barley on egg cholesterol of commercial layers

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Abstract

The aim of this trial was to decrease the cholesterol level of egg yolk of commercial layers through inclusion of barley sprouts in daily diets. Forty-two, 54-week-old, commercial laying hens were fed for a 12 weeks laying period on 3 iso-caloric and iso-nitrogenous diets containing 0 (control), 25.5 and 51.1g sprouts/kg. Inclusion of barley sprouts significantly decreased ($P<0.001$) concentrations of plasma cholesterol. Feeding barley sprouts reduced ($P<0.05$) concentrations of total lipids, triglyceride cholesterol and phospholipids in egg yolk compared with the control. It could be concluded that inclusion of barley sprouts in laying hen diets tended to decrease cholesterol in egg yolk.

Keywords: Barley sprouts; cholesterol; egg yolk; commercial layers; plasma

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Introduction

Eggs possess protein of significant biological value and are excellent source of vitamins and minerals, but many people reduce their consumption because they are associated high cholesterol and cardiovascular disease (Zeidler, 2002). Moreover, Butarbutar (2004) mentioned that elevated serum cholesterol in humans has been strongly correlated with consuming greater amounts of cholesterol than normal.

Barley sprouts also called sprouts, a by-product of the brewing industry, consist of the plumule and radicle of barley (McDonald et al., 1995), and also may include some of the malt hulls. Barley sprouts contain 156 g/kg crude fibre and 22 g/kg ether extract, on a dry matter basis, (McDonald et al., 1995). El-Husseiny et al. (1997) found that barley sprouts inclusion in rabbit diets lowered plasma cholesterol. Jonker et al. (2010) showed that barley lowers plasma cholesterol in rats.

Tocopherols (vitamin E) and tocotrienols, grouped as tocols, are a class of lipid-soluble antioxidants (Cavallero et al., 2004). Bonnely et al. (2000) reported that oil of barley sprouts contains 20.6 and 4.2 microgram of alpha-tocopherol and gamma-tocopherol, respectively per gram of dry rootlets. Sahin et al. (2002) reported that supplemental alpha-tocopherol acetate decreased serum cholesterol concentration of laying hens. Cavallero et al. (2004) reported that, the concentration of tocotrienols in barley grain is higher than in most other grains, with a favourable distribution of the most biologically active homologues. Tocotrienols are reported to be capable of reducing serum LDL cholesterol in chickens (Qureshi et al., 1991a). Therefore, the objective of this study was to investigate the effects of inclusion of barley sprouts in laying hen diets on plasma concentrations of cholesterol and on lipid composition of egg yolk.

Materials and Methods

Forty-two, 54-week-old, Lohman laying hens were randomly divided into three equal groups, each of 14 hens (7 experimental units, each consisted of 2 hens housed in one cage). These hen groups were assigned randomly to three experimental diets to evaluate the effects of barley sprouts (BS) inclusion in the diets on plasma concentrations of cholesterol and on lipid composition of egg yolk. Diets were: diet 1 (control)

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contained 0 g BS/kg, while diets 2 and 3 contained 25.5 and 51.1 g BS, respectively/kg diet. Barley sprouts in diets 2 and 3 replaced only parts of both of soybean meal and rice polish of the control diet in order to maintain all diets having all and the same feed ingredients except the tested material (Table 1).

All diets were iso-caloric and iso-nitrogenous, covering the nutritional requirements of laying hens (NRC, 1994). Diets, in mash form, and fresh water were supplied *ad libitum*. Birds were reared at room temperature and were exposed to 18 hrs light/d. Hens were fed the experimental diets for a 12 weeks laying period. The diets were analyzed for proximate composition according to AOAC (1996) methods.

At the end of the experiment, heparinzed blood samples were collected, via wing vein from 4 hens/treatment, chosen at random and plasma was separated by centrifugation and kept frozen at -20^{o}C until analyzed for cholesterol. Plasma cholesterol concentration was determined according to a quantitative-enzymatic-colorimetric method for determination of total cholesterol in serum or plasma (Stein, 1986).

Eggs were collected for chemical analysis during the last three days of the experimental period. Twelve eggs per each treatment were taken at random, and then were weighted, cracked and their yolks were separated. Then each 4 yolks were pooled and homogenized and considered as one sample i.e., each treatment had three samples of these pooled egg yolks for chemical analysis. These samples of the pooled yolks were freezed and stored at -20^{o}C until the chemical analysis was performed. Egg yolk samples were analyzed for total lipids, total cholesterol, low density lipoprotein (LDL) cholesterol, high density lipoprotein (HDL) cholesterol and phospholipids. Total lipid content of egg yolk was determined gravimetrically after extraction with chloroform: methanol (2:1) according to Folch et al. (1957). The developed colour was read at 410 nm. Cholesterol concentration in egg yolk was determined according to an enzymatic-colorimetric method for the determination of cholesterol in egg (Shen et al., 1982). Low density lipoprotein was determined according to Wieland and Seidel (1983) method while high density lipoprotein cholesterol was determined colorimetrically as described by Eckel (1977). Phospholipids concentration in egg yolk was determined after precipitation of the phospholipids in egg yolk according to the method of Kates (1972) and Kaur et al. (1973).

The effects of dietary treatments were examined using analysis of variance for completely randomized design experiment using SAS (1996), while differences among means were evaluated using Duncan's multiple range test (Duncan, 1955).

Results and Discussion

Plasma lipids

Inclusion of BS in laying hen diets at 25.5 g/kg significantly ($P<0.001$) decreased concentrations of plasma cholesterol compared with the control (Table 2). Such effects could be attributed to fiber and oil contents of BS. The BS used in the present study contained 162 g/kg crude fiber and 21 g/kg ether extract, on a dry matter basis (Table 1). Dandey and Bobraszczyk (2001) reported that barley has one of the highest levels (up to 6%) of β-glucan, a water-soluble polysaccharide, nutritionally classified as soluble dietary fiber, while Sharma and Gujral (2010) reported that barley is an excellent source of β-glucan. It has been hypothesized that upon ingestion, β-glucans increase small intestinal viscosity resulting in reduced bile acid and cholesterol or triglyceride absorption thus lowering plasma cholesterol (Topping, 1991). The liver responds by taking up more LDL-cholesterol from the blood stream thereby lowered the concentration of LDL-cholesterol in the blood. Lopez et al. (1999) reported that soluble dietary fiber has the ability to interact with water, and is almost fully fermented by the large intestine microflora. Short chain fatty acids, which are products of fermentation of soluble fiber in the gut, may inhibit synthesis of cholesterol by the liver, thereby, reducing the concentration of blood cholesterol. Wang et al. (1997) reported that β-glucans are effective polysaccharides for reducing plasma cholesterol concentration in chicks. Moreover, they found that total plasma cholesterol was lower in hamsters fed diets containing barley soluble dietary fiber (SDF) compared to those fed barley diets with SDF being removed or those fed insoluble dietary fiber. Jonker et al. (2010) showed that barley β-glucan lowers plasma cholesterol in rats. Qureshi et al. (1989) reported that the concentration of tocotrienols in the barley grain is high, with a favorable distribution of the most biologically active homologues (**γ-**tocotrienol and**δ-**tocotrienol). Peterson (1994) reported that tocotrienols showed a relevant concentration in the hulls of barley. Bonnely et al. (2000) reported that oil of barley sprouts contains 20.6 and 4.2 microgram of alpha-tocopherol and gamma-tocopherol, respectively, per gram of dry rootlets. Supplemental alpha-tocopherol acetate decreased serum cholesterol concentration of laying hens, (Sahin et al., 2002). Qureshi et al. (1986) found that highly purified tocotrienols from barley oil inhibited the activity of 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase (the rate-limiting enzyme of cholesterol biosynthesis) in rat and avian hepatocytes. Moreover, Qureshi et al. (1991a) found that supplementing chicken diets with brewer's grain, a byproduct of brewing industry, decreased serum total cholesterol and low-density lipoproteins (LDL)-

cholesterol (by 10.8% and 22.7%, respectively) as a result of its content of tocotrienols that act as a cholesterol inhibitor, due to suppressing the enzymatic activity of HMG-CoA reductase and decreasing the enzymatic activity of HMG-CoA synthase. Moreover, Burger et al. (1984) reported a cholesterol-lowering effect of barley oil and barley oil fractions for chicks.

Egg yolk lipids

Inclusion of barley sprouts in laying hen diets at 51.1 g/kg diet tended to decrease ($P<0.05$) concentrations of total lipids, cholesterol and phospholipids in egg yolk (Table 3). Such decrease could be attributed to the high fiber content of barley sprouts [162 g crude fiber/kg DM, Table (1)]. Hargis (1988) reported that dietary fiber affects cholesterol metabolism of laying hens by decreasing absorption of cholesterol, binding with bile salts in the intestinal tract, shortening intestinal transit time and increasing fecal sterol excretion. Qureshi et al. (1984) reported that laying hens fed barley produced eggs with less cholesterol than eggs produced from corn-fed hens which is in agreement with the present findings. Lipids are synthesized in the liver of a laying hen and transported to the ovary by lipoproteins. Lipoproteins serve as precursors of egg yolk lipid, and plasma very low-density lipoproteins (VLDL) are the major components of egg yolk (Chapman, 1980). Cholesterol is largely synthesized in the liver and like lipids,

Table 1: Feed ingredients and nutrients composition of the experimental diets

	BS (g/Kg diet)		
Ingredients (g/Kg)	0 (control)	25.5	51.1
Yellow maize	570	570	570
Soybean meal (44% CP)	180	167/8	155/5
Barley sprouts	0/00	25/5	51/1
Rice polish	100	86/7	73/4
Fish meal	50	50	50
Bone meal	21/5	21/5	21/5
Limestone	70	70	70
Vitamin-Mineral premix	2/5	2/5	2/5
Sodium Chloride	5	5	5
Methionisne	1	1	1
Nutrient Composition			
Crude protein (g/Kg)	176/1	177	177/9
Crude fiber (g/Kg)	30	33/8	38/9
Ether extract (g/Kg)	43/1	46/7	49/3
ME (MJ/Kg)	11/63	11/60	11/58

Table 2: Plasma cholesterol concentration[1] of laying hens fed diets included barley sprouts (BS) at different levels

Item	BS (g/Kg diet)		
	0 (control)	25.5	51.1
Cholesterol (mg/dL)	127.3±11.95[a]	56.3±5.17[b]	84.3±8.18[ab]

Means±SEM; n= 4

Table 3: Lipids composition (units/100 g yolk)[1] of laying hens fed diets included barley sprouts (BS) at different levels

	BS (g/Kg diet)		
Item	0 (control)	25.5	51.1
Total lipids (mg/dL)	130.00±0.58[a]	123.0±0.35[ab]	114.4±0.23[b]
Triglyceride (mg/dL)	77.5±0.38[a]	71.7±0.14[ab]	67.4±0.15[b]
Cholesterol (mg/dL)	115.0±0.05[a]	108.0±0.02[ab]	101.0±0.3[b]
LDL[1] (mg/dL)	116.0±0.006[b]	150.0±0.005[a]	140.0±0.003[ab]
HDL[2] (mg/dL)	70.00±0.00	71.00±0.00	67.00±0.00
Phospholipids (mg/dL)	103±0.09[a]	87.0±0.08[ab]	69.0±0.04[b]

Means±SEM; n= 3. [1]LDL: Low density lipoprotein.[2]HDL: High density lipoprotein. The means within the same row that have at least one common letter, do not have significant difference ($P>0.05$).

transported to the growing follicles primarily in the VLDL (McDonald and Shafey, 1989). Moreover, Gallaher et al. (1993) reported that thecholesterol-lowering effect of soluble fiber in hamsters was due to the reduction of VLDL cholesterol. Accordingly, the lowering effect of barley sprouts on cholesterol and lipids concentrations of egg yolk, in the present study is more likely a secondary consequence arising from its lowering effects on cholesterol in plasma (Table 2).

Conclusion

It could be concluded that inclusion of barley sprouts in laying hen diets decreased cholesterol concentrations in egg yolk.

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