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EFFECT OF FEED COMPOSITION ON CHOLESTEROL CONTENT OF THE TABLE EGG

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The objective of the experiments presented in this paper was to determine the influence exerted on the cholesterol content of the table egg by the composition of feed, more specifically by its cholesterol and fibre content as well as by some feed components including oats, maize germ meal, green alfalfa, sunflower oil and pork-fat. The experimental feeds were adjusted to different cholesterol concentrations by adding different amounts of crystalline cholesterol (0, 0.5, 1.0, 1.5, and 2.0%, respectively). After feeding the mixed feeds supplemented with different levels of cholesterol, no definite correlation was demonstrated between dietary cholesterol level and the cholesterol content of the blood plasma and egg yolk. The feeding of lard and sunflower oil (each at 5%) caused a significant ($P<0.001$) increase in egg yolk cholesterol concentration (ChCc), with the increase caused by sunflower oil being greater. The addition of 10% oats to the laying mash lowered egg yolk ChCc ($P<0.05$) and raised the ratio of unsaturated fatty acids (C16:1 and C18:2) while decreased that of stearic acid (C18:0) in the egg yolk. A slight elevation of the fibre content of layer diets (0.9% and 2.0%, respectively) slightly reduced egg yolk ChCc. Egg yolk ChCc considerably ($P<0.001$) decreased after the feeding of maize germ meal at an inclusion level of 10%. The feeding of maize germ meal increased ($P<0.05$) the concentration of oleic acid in egg yolk (C18:1) and decreased ($P<0.01$) that of palmitic acid (C16:0). The feeding of alfalfa did not cause significant changes ($P>0.05$) either in ChCc or in total cholesterol content (ChCt) of the egg yolk in these experiments.

Keywords: laying hen, table egg, cholesterol, egg yolk, fatty acids

The egg is an important item in public nutrition, which owes its important nutritional role to the diversity of its possible uses. Based upon the amino acid composition of its protein the egg is considered a protein source of full value. In addition to these favourable properties, it has a substantial cholesterol content

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(GINSBERG et al., 1994). Thus, egg consumption increases the dietary intake of cholesterol, which may serve as a risk factor in the development of cardiovascular diseases (HOLTMEIER, 1991; SCHOLTYSSEK, 1992; SIEBER, 1993; STADELMAN, 1999).

Egg cholesterol content markedly depends on feeding in addition to genetic factors. HARRIS & WILCOX (1963) fed a diet supplemented with 1, 2 or 4% crystalline cholesterol to laying hens and found that the cholesterol content (ChCc) of the layers' blood plasma did not change significantly while that of the egg yolk significantly increased as compared to the pre-feeding values. However, hens fed a diet supplemented with 1 and 4% cholesterol produced eggs having an egg yolk of nearly identical ChCc. DAGHIR and co-workers (1960) studied the influence of dietary fat on serum and egg yolk cholesterol in laying hens, and found that the type of dietary fat had no effect on egg yolk cholesterol content. BARTOV and co-workers (1971) supplemented the diet of laying hens with 20% coconut oil or safflower oil, and found that this supplementation caused a significant but practically negligible rise in egg yolk ChCc. HEBERT and co-workers (1987) carried out experiments to determine whether certain dietary oils or their fatty acid composition influenced the incorporation of cholesterol into the egg yolk. The type (olive oil, safflower oil) and fatty acid composition of the dietary oil exerted no influence on egg yolk weight. Supplementation of the diet with 1% cholesterol increased egg yolk cholesterol content irrespectively of the fatty acid composition.

BEYER and JENSEN (1993) added 10% coarse barley meal to layers' mash with or without 1% cholesterol supplementation. The inclusion of barley had no significant effect on egg yolk ChCc, whereas supplementation of the layer's diet with barley plus 1% cholesterol significantly elevated hepatic and blood plasma ChCc. According to other experimental observations (QURESHI et al., 1980, 1991), the non-starch polysaccharide (NSP) fraction of barley lowers egg yolk ChCc as compared to the feeding of a maize-based mixed feed. The results of these experiments suggest that soluble NSP reduces the chances of interaction between nutrients (fats) and digestive secretions (enzymes, bile salts) by altering the viscosity of the intestinal content. CASTON and LEESON (1990) studied whether linseed meal added to diets of laying hens influenced egg yolk cholesterol content and fatty acid composition. The flax-containing diet exerted a favourable influence on egg yolk fatty acid composition, increasing the ratio of fatty acids belonging to the ω-3 group. The proportion of some ω-6 fatty acids was also found to increase; at the same time, egg yolk ChCc was not affected by dietary flax. SHAFEY and co-workers (1992) studied the effect of dietary wheat, triticale, rye and soybean oil on the production of laying hens and on the cholesterol content as well as fatty acid composition of eggs. Laying hens fed a wheat- and triticale-based diet produced eggs of higher egg yolk weight but lower egg yolk ChCc than those fed a rye-based diet. Triticale-fed laying hens produced eggs of higher egg yolk linoleic acid (C18:2, ω-6) concentration than those fed a rye- or wheat-based diet. Soybean oil was

found to increase egg production, egg weight, egg yolk linoleic acid content and unsaturated to saturated fatty acid ratio, but reduced the oleic acid/linoleic acid (C18:1, ω-9/C18:2, ω-6) ratio. At the same time, ANGELOVICOVA and co-workers (1994) did not find any difference in egg yolk ChCc after substituting triticale for wheat in diets fed to laying hens.

When stressing the importance of linoleic acid in the production of laying hens, mention should be made of the observation of HUSVÉTH (1980) that hepatic lipogenesis increases in states of linoleic acid deficiency, a process which leads to the development of a fattier liver. As the liver serves as the primary site of cholesterol biosynthesis in poultry, these two factors might be related. Among other things, this fact would also justify a more widespread use of fatty acid sources of higher linoleic acid content in the nutrition of laying hens, after the efficacy of the dosage levels used has been elucidated.

As indicated by the publications cited above, the composition of the diet markedly influences the cholesterol content of eggs produced by laying hens. The results available in the literature are, however, rather contradictory. Therefore, the purpose of the work reported here was to determine the correlation between feed composition and cholesterol content of the table egg. Our objective was to study the following factors: (*i*) effect of dietary cholesterol content on blood plasma and egg yolk cholesterol content of laying hens; (*ii*) influence of feeding animal fats and vegetable oils on egg yolk cholesterol content; (*iii*) effect of diets of different fibre compositions and fibre content exceeding the laying hens' requirements on egg yolk cholesterol content; (*iv*) influence of different dietary components (oats, maize germ meal, green alfalfa) on egg yolk cholesterol content and fatty acid composition.

1. Materials and methods

1.1. Experimental animals and management

The experiments were conducted at the Experimental Farm of the Department of Animal Breeding, Georgikon Faculty of Agricultural Sciences of the Pannon Agricultural University, in a laying house having a spacing capacity for 600 hens. A total of six experiments were conducted. In the first experiment 300 Shaver Starcross (Sc.) 579 and 300 Shaver Sc. 288 laying hens were used, while in experiments 2–6 only a Shaver Sc. 579 flock was used. The laying hybrids were kept in three-tier battery cages. Three hens were kept in one cage in all experiments except in Experiment 1 designed to compare diets of different cholesterol content and to monitor blood plasma cholesterol concentrations, in which the laying hens were kept individually.

1.2. Design of the experiments

Experiment 1. To study the effects of different levels of dietary cholesterol, the laying hens' diets were supplemented with different quantities of crystalline cholesterol (manufacturer: Fluka, Buchs, Switzerland). A control diet and four experimental diets supplemented with increasing levels of cholesterol (0.5, 1.0, 1.5 and 2.0%), but otherwise identical with the control diet, were fed. The laying hens were 28 weeks old when feeding of the experimental diets was started. The composition of the control diet is shown in Table 1.

Table 1

Composition and nutrient content of the basic diet used for studying the effects of different levels of cholesterol supplementation

Ingredients	%
Maize	41.78
Wheat	30.50
Extracted soybean meal (grade I)	10.00
Fish meal (64%)	6.00
Meat meal (54%)	3.00
Limestone	7.20
MCP	0.72
Fodder salt	0.30
Standard laying premix 415	0.50
Total	100.00
Nutrient content	
ME (MJ kg^{-1})	11.420
Crude protein (%)	17.420
Crude fat (%)	3.000
Crude fibre (%)	2.510
Cholesterol (%)	0.056
Methionine + cystine (%)	0.640
Lysine (%)	0.820
Linoleic acid (%)	1.140
Ca (%)	3.650
P (%)	0.610

Experiment 2. In this experiment, we studied the effect of feeding fats of different saturation level on egg yolk cholesterol content. The diets fed to laying hens were supplemented with 5% lard and 5% sunflower oil (Table 2), respectively. Each experimental diet was fed to 24 laying hens in 8 battery cages each. Further 24 laying hens in 8 cages received the control diet without fat supplementation.

Table 2

Composition and nutrient content of diets supplemented with fat

Ingredients	Control diet (%)	Diet supplemented with lard (%)	Diet supplemented with sunflower oil (%)
Maize	41.78	37.00	37.00
Wheat	30.50	30.50	30.50
Lard	–	5.00	–
Sunflower oil	–	–	5.00
Extracted soybean meal (grade I)	10.00	7.00	7.00
Extracted fish meal (64%)	6.00	–	–
Extracted fish meal (70%)	–	5.00	5.00
Meat meal (58%)	3.00	3.00	3.00
Extracted sunflower meal (grade I)	–	4.00	4.00
Limestone	7.2	7.20	7.20
MCP	0.72	0.50	0.50
Fodder salt	0.30	0.30	0.30
Standard laying premix 415	0.50	0.50	0.50
Total	100.00	100.00	100.00
Nutrient content			
Cholesterol (%)	0.056	0.055	0.050
ME (MJ kg^{-1})	11.420	12.560	12.760
Crude protein (%)	17.420	17.600	17.600
Crude fibre (%)	2.510	3.500	3.500
Crude fat (%)	3.000	7.730	7.730
Methionine + cystine (%)	0.640	0.670	0.670
Lysine (%)	0.820	0.800	0.800
Ca (%)	3.650	3.350	3.350
P (%)	0.610	0.710	0.710

Experiment 3. In this experiment, the crude fibre content of the experimental diets was increased by raising the inclusion level of alfalfa meal and extracted sunflower meal. By changing the amounts of the two components, three different crude fibre levels were used: 2.5% (control), 4.3% and 5.3%. The diet of lower crude fibre content was tested with 200 Shaver Sc. 288 and 200 Shaver Sc. 579 laying hens of 54 weeks of age. The composition of the diets is shown in Table 3.

Table 3

Composition and nutrient content of feeds of varying fibre content

Ingredients	Control diet (%)	Experimental diet 1 (%)	Experimental diet 2 (%)
Maize	41.78	41.00	41.00
Wheat	30.50	30.00	24.00
Fish meal (64%)	6.00	–	–
Meat meal (62%)	–	7.00	7.00
Meat meal (54%)	3.00	–	–
Alfalfa meal (grade I)	–	4.00	10.00
Extracted soybean meal (grade I)	10.00	–	–
Extracted sunflower meal (grade I)	–	12.00	12.00
L-lysine	–	0.15	0.15
MCP	0.72	0.80	0.80
Limestone	7.20	4.25	4.25
Standard laying premix 415	0.50	0.50	0.50
Fodder salt	0.30	0.30	0.30
Total	100.00	100.00	100.00
Nutrient content			
ME (MJ kg^{-1})	11.420	11.400	11.280
Crude protein (%)	17.420	17.670	17.310
Crude fibre (%)	2.510	4.260	5.290
Cholesterol (%)	0.056	0.043	0.043
Methionine + cystine (%)	0.640	0.640	0.600
Lysine (%)	0.820	0.800	0.790
Ca (%)	3.650	3.350	3.350
P (%)	0.610	0.710	0.710
Linoleic acid (%)	1.140	1.290	1.290

Experiment 4. In order to study the effect of oats on egg yolk cholesterol content and fatty acid composition, oats were added to the experimental diet at an inclusion level of 10%. The energy and crude protein contents of the control and experimental diets were the same. The composition and calculated nutrient content of the oat-containing and the control diets are shown in Table 4 while their fatty acid composition in Table 5. Each diet was fed to one hundred 39-week-old Shaver Sc. 579 laying hens.

Table 4

Composition and nutrient content of the oat-containing and control layer diets

Ingredients	Control diet (%)	Oat-containing diet (%)
Maize	41.78	47.32
Wheat	30.50	13.00
Oats	–	10.00
Extracted soybean meal (grade I)	10.00	10.00
Fish meal (64%)	6.00	6.00
Meat meal (54%)	3.00	5.50
Limestone	7.20	7.00
MCP	0.72	0.38
Fodder salt	0.30	0.30
Standard laying premix 415	0.50	0.50
Total	100.00	100.00
Nutrient content		
ME (MJ kg^{-1})	11.420	11.430
Crude protein (%)	17.420	17.420
Crude fat (%)	3.000	3.580
Crude fibre (%)	2.510	3.160
Cholesterol (%)	0.056	0.072
Methionine + cystine (%)	0.640	0.620
Lysine (%)	0.820	0.850
Linoleic acid (%)	1.140	1.310
Ca (%)	3.650	3.650
P (%)	0.610	0.690

Table 5

Fatty acid composition of the oat-containing and control layer diets

Fatty acid	Control diet (%)	Oat-containing diet (%)
C14:0	1.00	0.61
C16:0	15.33	14.67
C16:1	1.78	1.38
C18:0	2.75	3.97
C18:1	26.96	30.05
C18:2	49.84	46.16
C20:1	0.35	0.07
C18:3	1.71	1.07
Other	0.34	2.05
Total	100.00	100.00

Experiment 5. This experiment was designed to study the effect of feeding maize germ meal on egg yolk fatty acid composition and cholesterol content. Maize germ meal was added to the mixed feed at a level of 10%. The composition of the control and the maize germ meal containing diets is presented in Table 6 while their fatty acid composition in Table 7. Both the diet containing maize germ meal and the control diet were fed to 300 Shaver Sc. 579 laying hens of 55 weeks of age each.

Experiment 6. To study the influence of green forage on egg yolk cholesterol concentration, twelve 65-week-old Shaver Sc. 579 laying hens kept in four battery cages were fed green alfalfa. The green alfalfa was offered to the birds at 2-day intervals, bundled up and fastened above the hens' feeding troughs. The amount of alfalfa consumed by the hens was determined by weighing the leftovers.

1.3. Collection of test samples. Chemical and statistical methods applied in the experiment

The diets containing different levels of cholesterol were fed for three weeks before collection of the eggs to be analysed. Subsequently, a representative sample of 20 eggs per experimental treatment was collected in each experiment. Egg yolk cholesterol content was determined by the method described by BEYER and co-workers (1989). The measurements were performed by gas chromatography in the laboratory of the Department of Chemistry and Microbiology, Georgikon Faculty of Agricultural Science of the Pannon University.

Table 6

Composition and nutrient content of the diet containing maize germ and of the control diet

Ingredients	Control diet (%)	Maize germ containing diet (%)
Maize	42.00	47.70
Wheat	30.50	15.12
Maize germ meal	–	10.00
Extracted soybean meal (grade I)	7.00	10.00
Extracted fish meal (70%)	5.00	–
Extracted sunflower meal (grade I)	4.00	–
Meat meal (58%)	3.00	9.20
MCP	0.50	0.14
Limestone	7.20	7.04
Fodder salt	0.30	0.30
Standard laying premix 415	0.50	0.50
Total	100.00	100.00
Nutrient content		
ME (MJ kg^{-1})	11.460	11.300
Crude protein (%)	17.980	18.000
Crude fibre (%)	2.580	3.000
Crude fat (%)	2.800	4.450
Cholesterol (%)	0.050	0.057
Methionine + cystine (%)	0.720	0.700
Lysine (%)	0.800	0.880
Linoleic acid (%)	1.280	1.800
Ca (%)	3.450	3.500
P (%)	0.700	0.700

To determine the blood plasma cholesterol concentration of laying hens, individual blood samples were taken from the wing vein of a total of 20 laying hens into heparinised test tubes. Cholesterol content of the samples was determined by the method of LOPES-VIRELLA and co-workers (1977). In Experiments 4 and 5, the fatty acid composition of the egg yolk was also determined. The egg yolk was homogenised, then one gram of the homogenised material was assayed for fatty acid composition by gas chromatography as described by HUSVÉTH (1982).

Table 7

Fatty acid composition of the diet containing maize germ and of the control diet

Fatty acid	Control diet (%)	Diet containing maize germ (%)
C14:0	0.38	0.30
C16:0	16.24	14.40
C16:1	1.41	1.23
C18:0	4.27	4.24
C18:1	30.88	31.96
C18:2	43.99	45.67
C18:3	2.00	1.56
C20:0	0.35	0.36
Other	0.48	0.28
Total	100.00	100.00

Data obtained in the experiments were evaluated by analysis of variance. Data processing was done with the help of statistical programs (QUATTRO, 1991 and STATGRAPH, 1991).

2. Results

2.1. Effects of feeding diets of different cholesterol content on blood plasma and egg yolk cholesterol content of laying hens (Experiment 1)

The blood plasma ChCc of laying hens fed diets of different cholesterol content was rather constant. Increasing dietary cholesterol content resulted in a slight elevation of blood plasma cholesterol; however, in the group fed a diet supplemented with 2% cholesterol the blood plasma cholesterol concentration was lower than that found in all the other groups (fed 0.5, 1.0 and 1.5% cholesterol, respectively). Significant differences could not be demonstrated in any of the cases ($P>0.05$). The effect exerted by diets of different cholesterol content on the blood plasma and egg yolk cholesterol content of laying hens is shown in Table 8.

Of the different dietary levels of cholesterol, only the inclusion levels of 1.5% and 2.0% increased egg yolk ChCc. Of these two treatments, only the dietary intake of 1.5% cholesterol resulted in egg yolk cholesterol values significantly ($P<0.001$) different from the control values. In the other cases, the egg yolk ChCc was not significantly different from the control ($P>0.05$).

Table 8

Effect of the cholesterol supplementation of diets on blood plasma and egg yolk cholesterol concentration (ChCc)

Level of cholesterol supplementation	Blood plasma ChCc (mmol l^{-1})	Egg yolk ChCc (mg g^{-1})
0.0%	2.55 ± 0.39	13.33 ± 1.38^{ab}
0.5%	3.32 ± 1.00	17.06 ± 1.47^{b}
1.0%	3.42 ± 1.18	15.53 ± 1.75^{ab}
1.5%	3.50 ± 0.87	12.53 ± 2.56^{ab}
2.0%	2.87 ± 1.00	11.23 ± 1.80^{ab}

Averages having different superscripts are significantly different

2.2. Effect of fat supplementation on egg yolk cholesterol concentration (Experiment 2)

Fat supplementation of the diets exerted a remarkable influence on egg yolk ChCc (Table 9).

In case of both laying hybrids used in the experiments (Shaver Sc. 288, Shaver Sc. 579), the eggs laid by hens fed a diet supplemented with sunflower oil had the highest egg yolk cholesterol concentration. The differences were highly significant ($P<0.001$) as compared to those of the control fed a diet without fat supplementation. Feeding of lard also elevated egg yolk ChCc, although to a lesser extent than that of sunflower oil. That increase, however, was statistically significant ($P<0.001$) only in the case of the Shaver Sc. 579 hybrid.

Table 9

Effect of fat supplementation on egg yolk cholesterol concentration

Fat supplementation	Egg yolk ChCc (mg g^{-1})	
	Shaver Starcross 288	Shaver Starcross 579
Control	11.23 ± 1.19^{ab}	10.40 ± 0.58^{a}
Lard	12.46 ± 2.11^{b}	12.09 ± 0.89^{c}
Sunflower oil	14.49 ± 1.02^{c}	15.70 ± 0.62^{d}

Averages having different superscripts are significantly different

2.3. Effect of diets of different fibre content on egg yolk cholesterol concentration (Experiment 3)

The feeding of a diet of 4.3% crude fibre level lowered egg yolk ChCc but the decrease was not statistically significant ($P>0.05$). As compared to the control, the egg yolk cholesterol concentration of eggs produced by Shaver Sc. 288 and Shaver Sc. 579 laying hens was 0.18 mg g^{-1} and 0.41 mg g^{-1} lower, respectively (Table 10).

The egg yolk cholesterol concentration of eggs laid by the Shaver Sc. 579 flock fed a diet of higher fibre content (5.3%) was 1.3 mg g^{-1} lower as compared to the control (egg yolk ChCc of the control and the experimental group was 11.3±1.4 and 10.0±1.6 mg cholesterol per g of egg yolk, respectively). That difference was only slightly significant ($P<0.1$).

2.4. Effect of feeding oats on egg yolk cholesterol content and fatty acid composition (Experiment 4)

As a result of feeding oats at an inclusion level of 10%, the egg yolk cholesterol concentration of the experimental group was 11.6±1 mg cholesterol per g of egg yolk, as compared to 12.3±1.2 mg measured in eggs of the control group. The difference was statistically significant ($P<0.05$).

In the yolk of eggs laid by hens fed the oat-supplemented diet the proportions of palmitoleic acid (C16:1) and linoleic acid (C18:2) significantly increased ($P<0.01$ and $P<0.05$, respectively). At the same time, the level of stearic acid (C18:0) was significantly lower in the experimental group ($P<0.01$). The effect exerted by feeding oats on egg yolk fatty acid composition is shown in Table 11.

Table 10

Effect of feeding diets of varying fibre content (4.26%) and fibre composition on egg yolk cholesterol concentration

Group	Egg yolk ChCc (mg g^{-1})	
	Shaver Starcross 288	Shaver Starcross 579
Control	13.42 ± 0.82^{b}	12.57 ± 1.04^{ab}
Experimental	13.24 ± 0.97^{b}	12.16 ± 0.76^{a}

Averages having different superscripts are significantly different

Table 11

Effect of feeding oats on egg yolk fatty acid composition

Fatty acid	Control	Experimental [c]
C14:0	0.32 ± 0.05[a]	0.30 ± 0.03[a]
C16:0	29.16 ± 1.21[a]	28.38 ± 0.49[a]
C16:1	4.32 ± 0.44[a]	4.83 ± 0.42[b]
C18:0	7.14 ± 0.81[a]	6.15 ± 0.51[b]
C18:1	47.00 ± 2.00[a]	45.57 ± 1.47[b]
C18:2	1.96 ± 1.66[a]	14.56 ± 0.75[b]

[c]: Fatty acid composition of the yolk of eggs produced by laying hens fed an oat-containing diet
Averages having different superscripts are significantly different

2.5. Effect of feeding maize germ meal on egg yolk cholesterol concentration and fatty acid composition (Experiment 5)

The feeding of maize germ meal markedly lowered the cholesterol concentration of the egg yolk, which was 12.7±1.4 mg cholesterol per g of egg yolk in the control group and 9.7±0.7 mg g^{-1} in the experimental group. The difference was highly significant ($P<0.001$).

In this experiment, a significant difference ($P<0.05$) was observed in egg yolk fatty acid composition as regards the proportion of oleic acid (C18:1). The level of palmitic acid (C16:0) was also higher in the control group (Table 12). Linoleic acid could be detected in the egg yolk in only a few cases, and even in those cases only from the yolk of eggs produced by laying hens fed the diet containing maize germ meal.

Table 12

Effect of feeding maize germ meal on egg yolk fatty acid composition

Fatty acid	Control	Experimental [c]
C14:0	0.42 ± 0.10[a]	0.36 ± 0.07[a]
C16:0	30.13 ± 1.40[a]	27.40 ± 1.19[b]
C16:1	4.37 ± 0.76[a]	4.00 ± 0.49[a]
C18:0	9.01 ± 1.03[a]	9.05 ± 1.38[a]
C18:1	39.62 ± 2.03[a]	43.01 ± 1.80[b]
C18:2	16.28 ± 1.17[a]	15.62 ± 0.86[a]

[c]: Fatty acid composition of the yolk of eggs produced by laying hens fed a diet containing maize germ meal
Averages having different superscripts are significantly different

2.6. Effect of feeding green alfalfa on egg yolk cholesterol concentration

The feeding of green alfalfa did not have a significant effect on egg yolk cholesterol concentration. The cholesterol content of the egg yolk was 11.7 mg g^{-1} both in the control and the experimental groups.

3. Discussion

The results of this study indicate that the dietary intake of cholesterol did not exert a marked influence on blood plasma cholesterol concentration in laying hens. This apparent contradiction can probably be explained by the fact that in birds the mechanism of cholesterol biosynthesis and excretion is very well regulated. Birds respond to a cholesterol load of dietary origin by increased excretion. At the same time, the decrease found in blood plasma and egg yolk cholesterol concentration of laying hens fed a diet supplemented with 2% cholesterol are difficult to explain. One possible explanation is that cholesterol intake exceeding a certain level induces a drastic decrease of endogenous cholesterol synthesis in the laying hen. The absorption of cholesterol taken up with the feed is greatly influenced by the quality and quantity of dietary fat (MARCH & BIELY, 1959; CHUNG et al., 1965; SIM & BRAGG, 1977). Unsaturated fatty acids facilitate the absorption of cholesterol and thus elevate egg yolk ChCc (WEISS et al., 1967a, b; BARTOV et al., 1971; LALL & SLINGER, 1973).

Researchers dealing with the cholesterol problem have long been trying to elucidate the effect of high-energy dietary components of different fatty acid composition on the deposition of cholesterol in the egg yolk. After feeding layer diets containing fats of animal and vegetable origin, DAGHIR and co-workers (1960) found no differences in egg yolk ChCc. The number of publications claiming the opposite, i.e. that egg yolk ChCc can be increased by supplementing the diet with certain fat sources, is higher. Primarily those fats can be expected to exert such an effect which contain high proportion unsaturated fatty acids (WEISS et al., 1967b; SIM & BRAGG, 1977; HARGIS, 1988; HEBERT, 1991; WESTERMANN, 1991).

From the results of our studies on this subject it can be established that of all the different approaches tested by us, the use of different fat sources exerted the most marked effect on egg cholesterol content. The highest egg yolk ChCc was measured in Shaver Sc. 288 and 579 laying hybrids fed a diet containing sunflower oil. Lard had a less pronounced effect in that respect. Hence, our experimental observations suggest that unsaturated fatty acids are more potent in increasing the excretion of cholesterol via the egg in the laying hen.

TURK and BARNETT (1972) found that alfalfa meal mixed to maize- and soybean-based diets caused the greatest decrease in egg yolk cholesterol concentration. MENGE

and co-workers (1974) increased dietary crude fibre content by the addition of cellulose. This resulted in elevated egg yolk ChCc accompanied by a decrease in egg production. NAKUE and co-workers (1980) reported that the addition of 10% alfalfa meal to the diet of laying hens did not cause a significant change in egg yolk ChCc.

In the present experiments, the feeding of a diet of moderately elevated crude fibre content (4.3%) to Shaver Sc. 288 and Shaver Sc. 579 hybrids caused no appreciable change in egg yolk ChCc as compared to the control. For both hybrids, egg yolk total cholesterol (ChCt) content was almost the same in the experimental and in the control groups. At the same time, an even higher dietary fibre level (5.3%) already had a depressive effect on the level of egg production, and decreased both mean egg weight and mean egg yolk weight. This decrease in mean egg yolk weight was accompanied by a decline of egg yolk cholesterol concentration. In the experimental group fed 5.3% crude fibre, the decrease in egg yolk weight was so large that it caused a significant difference ($P<0.001$) in egg yolk ChCt content despite the non-significant difference in ChCt. All this suggests that an elevated level of dietary crude fibre lowers the cholesterol content of the egg yolk.

Our experimental observations regarding the use of oats support and complete the results obtained by FARREL (1994), according to which the feeding of rye lowered egg yolk cholesterol content. In our experiment, oats resulted in a somewhat greater (about 15%) decrease in egg yolk cholesterol concentration. Oats and rye presumably exert this effect through their antinutritive substance content, primarily through the non-starch polysaccharide (NSP) fraction, thus decreasing the digestibility of dietary nutrients including fats. When fed at higher levels, however, these feed components already depress egg production.

Maize germ meal strongly decreased egg yolk cholesterol content. As the two types of diets used in the experiment differed in their fat and linoleic acid content the most, the result obtained can probably be attributed to that difference. Namely, if the proportion of unsaturated fatty acids is higher within the total fatty acids, on exceeding a certain level this may inhibit micelle formation and fat digestion in the small intestine. This may be accompanied by an increase in the proportion of bile acids excreted via the faeces, which loss can no longer be compensated for by endogenous biosynthesis. Upon absorption, unsaturated fatty acids may inhibit endogenous fatty acid synthesis and, as acetyl-CoA is a common precursor of both endogenous fatty acid and cholesterol biosynthesis, they may also reduce the biosynthesis of cholesterol.

The feeding of green alfalfa did not appreciably affect egg yolk cholesterol concentration in this experiment. In this respect, only those reported works can serve as a basis for comparison which used green alfalfa feeding in order to study the effect of fibre. These papers point out that alfalfa meal is more potent in lowering egg yolk cholesterol content than is cellulose (TURK & BARNETT, 1972). At the same time,

NAKUE and co-workers (1980) did not observe significant differences when feeding alfalfa meal of varying saponin content to laying hens. This latter finding is supported also by our own results, since we could not detect any change in egg yolk cholesterol concentration after feeding green alfalfa.

By the series of experiments reported in this paper we have determined the effects of changing certain dietary components on the cholesterol concentration and fatty acid composition of the eggs produced. Further research is needed, however, to get a closer insight into avian lipid metabolism and to determine the influence of non-conventional laying hen diets on the most important production parameters.

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