The effect of a diet supplemented with L-carnitine on egg production in pheasant (*Phasianus colchicus*)

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ABSTRACT: The main aim of the study was to assess the effect of a diet supplemented with L-carnitine on egg weight and laying rate in hens of pheasant (*Phasianus colchicus*). The experiment lasted 14 weeks and was performed with 210 experimental and 210 control laying hens. The birds were kept in cages; one cock and seven hens per cage. Both control and experimental hens were administered the complete feed mixture, with the only difference that the feed mixture administered to experimental hens was supplemented with L-carnitine at a level of 0.01%. During the experimental period, eggs were collected and weight of individual eggs was determined. Control and experimental groups provided 8 039 and 8 499 eggs, respectively. The results showed that L-carnitine increased egg weight ($P < 0.01$) and laying rate. The effect of L-carnitine on egg weight and laying rate manifested itself until weeks 11 and 13, respectively. The average weight of eggs laid during the experimental period was (mean ± SD) 32.22 ± 3.03 g in the control group and 32.51 ± 2.83 g in the experimental group, with the overall laying rate being 44.29% in the control group and 47.30% in the experimental group.

Keywords: common pheasant; egg production; L-carnitine

The word "carnitine" is derived from the Latin word *caro*, which means meat. Carnitine discovered in animal meat in 1905 was originally called vitamin B_T. Since approximately 30% of carnitine is produced in the body, it is not as essential as vitamins and is therefore considered as a vitagene. From a biochemical aspect, L-carnitine is β-hydroxy-γ-N-trimethylaminobutyrate. The chemical structure of carnitine was described in 1927 but as late as in 1955 Friedmann and Fraenkel (1955) found the basic role of carnitine in the beta-oxidation of fat. Its major role is to supply the heart and skeletal muscles with energy released from fat. The major portion of L-carnitine (approximately 90%) occurs in muscles (Harmeyer and Schlumbohm, 1997). Carnitine is formed in all cells of the body and its synthesis requires essential amino acids such as lysine and methionine, and vitamins and minerals such as vitamin C, pyridoxine, niacin, and iron. The pathway of L-carnitine biosynthesis was described by Haeckel et al. (1990). Intensive research into carnitine was performed in the 1970s; only a very small amount of L-carnitine obtained from animal meat was available at that time. In the 1980s, the industrial production of L-carnitine was launched, which allowed significant expansion of research, making it possible to think about the use of L-carnitine in clinical practice. L-carnitine was shown to have beneficial effects on the heart and skeletal muscles and conditions such as disorders of the central nervous system, certain types of male sterility and some disorders in newborns (Borum and Bennett, 1986). Interesting experiments with L-carnitine were reported in pigeons (Borghijs and De Wilde, 1992; Janssens et al., 2000), horses (Chrobok, 2000) and pigs (Böhles et al., 1983).

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Although L-carnitine is synthesised in the body, conditions such as stress, disease, and physical strain may result in L-carnitine deficiency. The main causes of such conditions include increased production performance and fertility, increased physical performance, stress arising due to improper housing, poor air conditioning, etc. Furthermore, the ban on the use of animal-based meal in animal feeding which is the major exogenous source of L-carnitine has resulted in L-carnitine deficiency. This is why efforts are made to supplement plant-based diets in particular with L-carnitine in order to increase the production performance, fertility, physical performance and stress resistance in farm animals. There are only very few scientific publications that deal with the effect of L-carnitine on the reproduction of birds (e.g. Leibetseder, 1995; Rabie et al., 1997; Neuman et al., 2002). The work of Thiemel and Jelínek (2004), who studied the effect of L-carnitine on the hatchability and metabolic profile of breeding hens, can be considered as the major paper dealing with this topic. The authors pointed out to the beneficial effect of L-carnitine on hatchability which increased as a result of increased fertilization of eggs.

The main objective of the present study was to assess the effect of a diet supplemented with L-carnitine on egg production in females of pheasants (*Phasianus colchicus*) during the laying period.

MATERIAL AND METHODS

An experiment was performed in the facility intended for the rearing of game birds at the University of Pharmaceutical and Veterinary Sciences in Brno, Czech Republic. The experiment included 210 control and 210 experimental hens of the common pheasant (*Phasianus colchicus*). Birds were reared in cages from mid-March. Each cage sized (width × length × height) 85 cm × 200 cm × 70 cm accommodated seven hens

Table 1. Components and nutrients contained in the feed mixture[1]

Components	(%)	Nutrients	(g/kg)
Supplementary premix[2]	0.50	dry matter	887.18
Wheat	34.86	ash	108.91
Maize	25.00	crude protein	166.53
Soybean meal 46%	11.00	fat	3.50
Wheat feed flour	5.00	saccharides	30.69
Biolys 65 (lysine sulphate)	0.10	starch	408.74
DL-methionine 100%	0.13	fibre	38.35
L-threonine	0.02	metabolizable energy[4]	11.28
Monocalcium phosphate	0.95	arginine	9.73
Sodium chloride	0.33	lysine	8.40
Limestone, ground	6.00	methionine	3.77
Extruded full-fat soya (protex)	7.50	sulphur amino acids	6.62
Fodder yeast (vitex Q)	2.50	threonine	6.22
Lactiferm L-400 (probiotic)	0.0003	tryptophan	2.02
Lucerne, dried	5.00	linoleic acid	17.44
Calcium phosphate	1.00	calcium	29.42
Fructooligosaccharides	0.10	phosphorus	5.84
L-carnitine[3]	0.01	magnesium	1.66

[1]information provided by the producer of feed mixture

[2]supplementary premix supplied the following per kg of diet: vitamin A 60 000 IU; α-tocopherol 0.285 mg; vitamin D_3 15 000 IU; subtilisin (3.4.21.62) 3 000 U; xylanase (EU 3.2.1.8.) 9 375 U; phytase (EC 3.1.3.8.) 2 500 FTU; monensin sodium 0.500 mg; Cu 0.090 mg; methionine 0.0185 g

[3]premix containing 50% of L-carnitine; only in the experimental feed mixture

[4]in MJ/kg

and one cock. In order to allow birds to adapt to a new diet before the experiment, all birds were fed *ad libitum* the same commercial complete feed mixture for laying female pheasants (Table 1) for 14 days. When the 14-week experiment started following the 14-day adaptation phase, experimental hens were fed the complete mixture supplemented with L-carnitine at a dose 0.01%, while control hens continued to receive the feed mixture without L-carnitine.

In the course of the experimental period, eggs were collected every day and weighed to the nearest 0.01 g. The average weight of eggs and laying rate (calculated as the percentage of eggs to the number of layers) were evaluated weekly.

The data were processed by mathematical and statistical methods to compare the average values calculated using the *t*-test implemented in the statistical programme Unistat.

RESULTS

The results come out of the set which represents 8 039 eggs in the control group and 8 499 eggs in the experimental group that were laid in the course of the experiment. The average number of laid eggs per layer in the control and in the experimental group was 44 eggs and 48 eggs, respectively, over the 14-week experimental monitoring.

As seen in Table 2, average weekly weight of eggs in the course of the laying period ranged from (mean ± SD) 31.25 ± 3.15 g to 32.79 ± 3.05 g in the control group and average weight of eggs laid in the same group over the whole experimental period was 32.22 ± 3.03 g. Average egg weight in the experimental group, as determined in individual weeks, ranged from 31.64 ± 3.05 g to 32.80 ± 2.94 g and average egg weight in this group over the whole period was 32.51 ± 2.83 g. The lowest average egg weight was found in week 1, when it reached 31.64 ± 3.05 g in the experimental group and 31.25 ± 3.15 g in the control group. The highest egg weight was revealed in week 12 in both the experimental (32.80 ± 2.73 g) and the control group (32.79 ± 3.05 g). It was confirmed that average egg weight of hens receiving the diet supplemented with L-carnitine was significantly ($P < 0.05$) to very significantly higher ($P < 0.01$) from week

Table 2. The effect of the diet supplemented with L-carnitine on egg production in pheasant hens

Week	Number of laid eggs		Egg weight (g)[1]		Laying rate (%)		
	control	carnitine	control	carnitine	control	carnitine	difference (%)[2]
1	683	746	31.25 ± 3.15^{a}	31.64 ± 3.05^{b}	46.49	50.75	4.26
2	803	868	31.71 ± 2.85^{a}	32.04 ± 2.68^{b}	55.23	59.66	4.43
3	816	829	31.95 ± 2.80^{A}	32.38 ± 2.78^{B}	57.59	60.12	2.53
4	787	820	32.12 ± 2.99^{a}	32.48 ± 2.79^{b}	57.07	62.60	5.53
5	727	790	32.10 ± 3.01^{a}	32.43 ± 2.81^{b}	55.12	63.66	8.54
6	690	767	31.86 ± 2.93^{A}	32.34 ± 2.82^{B}	54.25	62.87	8.62
7	647	667	32.12 ± 2.84^{A}	32.54 ± 2.85^{B}	51.93	56.00	4.07
8	612	631	32.46 ± 2.97^{a}	32.79 ± 2.88^{b}	50.50	53.98	3.48
9	536	621	32.41 ± 2.98^{a}	32.81 ± 3.24^{b}	45.35	54.43	9.08
10	478	493	32.34 ± 3.33^{a}	32.80 ± 2.94^{b}	40.65	43.47	2.82
11	397	409	32.52 ± 3.19	32.66 ± 2.80	33.76	36.10	2.34
12	359	371	32.79 ± 3.05	32.80 ± 2.73	30.63	33.13	2.50
13	287	285	32.76 ± 3.16	32.78 ± 2.95	24.76	25.49	0.73
14	217	202	32.64 ± 3.24	32.58 ± 2.35	18.87	18.28	–0.59
Total	8 039	8 499	32.22 ± 3.03^{A}	32.51 ± 2.83^{B}	44.29	47.30	3.01

^{a,b,A,B}values within rows with different superscripts are significantly different ($P < 0.05$ and $P < 0.01$, respectively)

[1]data are means ± standard deviation (SD)

[2]difference in laying rate between the control and the experimental group within the same week and for the whole experimental period

1 to 10 of laying period, as compared with control hens. Similarly, average egg weight over the whole laying period was significantly ($P < 0.01$) higher in the experimental group (32.51 ± 2.83 g) than that in the control group (32.22 ± 3.03 g).

As seen in Table 2, the lowest laying rate was detected in week 14 of the experiment in the control (18.87%) and experimental (18.28%) group of female pheasants while the highest laying rate was found in the control group in week 3 (57.59%) and in the experimental group in week 5 (63.66%). The trend of increasing laying rate in experimental female pheasants was observed until the end of week 13. Average laying rate over the whole 14-week period was higher in the experimental group (47.30%) than that in the control group (44.29%), i.e. the difference was 3.01%.

DISCUSSION

The present work documents the positive effect of the continuous administration of L-carnitine on egg production in female pheasants in the course of the laying period. The 14-week monitoring which substantially overlapped the laying period characterized by the production of hatching eggs demonstrated the positive effect of L-carnitine on an increase in egg weight and laying rate. Egg weight gradually increased during the laying period until week 12 when the average weight of eggs in both groups was practically the same. Subsequently, egg weight in both groups decreased until week 14 when the monitoring stopped. One important finding is that the eggs laid by female pheasants until week 11 were significantly ($P < 0.05$) or very significantly ($P < 0.01$) heavier, as compared with the control. It may be assumed that heavier eggs will result in heavier chicks at hatching and better growth of chicks in their early postnatal development, as was find out in domestic fowl (O'Neil, 1955; Shanawany, 1987; Pichasov, 1991; Wilson, 1991) and turkey (Moran, 1990).

As with domestic fowl, female pheasants showed an increasing laying rate in the course of the laying period which reached a maximum level in week 3 in the control group and in week 5 in the experimental group over the monitored period. The increased laying rate leads to an increase in the production of eggs per layer, and thus in the increased production of pheasant chickens. On the basis of the results reported by Thiemel and Jelínek (2004), the increased hatchability may result from the enhanced rate of egg fertilization. Since there are no similar studies available in the scientific literature, our results can only be compared with the conclusions published by a number of authors (e.g. Leibetseder, 1995; Rabie et al., 1997; Neuman et al., 2002) who confirmed the beneficial effect of L-carnitine on the reproduction of poultry, which also complies with our findings.

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