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Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

Effect of the diet with common flax (*Linum usitatissimum*) and black cumin seeds (*Nigella sativa*) on quail performance and reproduction

Danuta Szczerbińska*, Zofia Tarasewicz, Marta Sulik, Elżbieta Kopczyńska, Bogusława Pyka

Department of Poultry and Ornamental Bird Breeding, Faculty of Biotechnology and Animal Husbandry, Western Pomeranian University of Technology, Doktora Judyma 20, 71-466 Szczecin, Poland

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Experimental flock, a total of 105 birds, was divided into 5 groups (with three replications), 15 females and 6 males in each. Group I (control) was fed a complete feed mix of standard composition. Feed mix for groups II and III was the control one with 4 and 7% common flax seeds (CFS), whereas that for groups IV and V was the control one with 2 and 5% black cumin seeds (BCS) added, respectively. During the whole study that lasted from week 6 to 40 of quail life, feed intake and egg number and weight, as well as deaths and cullings, were recorded on a daily basis. In the last week of experiment, quality of eggs was evaluated, determining their morphological composition. Egg hatching proceeded at 26, 32 and 38 weeks of quail life. The best egg laying performance (about 86%) was characteristic of the quail groups being fed with 4% CFS or 2% BCS, whereas a significantly lower was that of the control group (82%). No effect of the experimental factors on egg morphological composition was observed, except the eggshell percentage which was significantly lower in the quails receiving 4% CFS in their diet. The highest egg fertilization (95%) was obtained when feeding the quails with feed mix containing 7% CFS. The best hatchability of fertilized eggs (about 90%) was observed in the quail groups receiving feed mix supplemented with 7% CFS and 5% BCS. The results obtained in these quail groups differed from the hatchability of eggs of the control group (81%).

KEY WORDS: quail / nutrition / black cumin / common flax / hatchability

*Corresponding author: danuta.szczerbinska@zut.edu.pl

The ability of female birds to produce a large quantity of eggs of quality which may be intended for hatching and then receive healthy chicks is one of the most important factors determining the profitability of poultry production. Even a small increase in egg fertilization rate and chick hatchability significantly improves the economic performance of a poultry farm. However, a considerable reduction in the egg laying performance and reproduction by the end of egg laying season is still a current problem in all poultry species. Many experiments have been conducted in which different environmental factors have been modified in order to improve chick hatchability. These studies referred, among others, to the effect of artificially generated magnetic field [Lis 2000, Tarasewicz *et al*. 2006, Shafey *et al*, 2011], different egg hue types [Chełmońska *et al*. 2000; Veterany *et al*. 2005], modification of incubation temperature and relative humidity [Horbanczuk *et al*. 1999, Yahav *et al*. 2004], or hatching egg storage time [Haque *et al*. 1996; Fasenko *et al*. 2001, Horbanczuk and Sales 2001]. Nutrition of parental flocks has a direct effect on the health of birds as well as the quality of hatching eggs, shell and content [Wilson 1997, Cooper and Horbanczuk 2004, Mróz *et al*. 2008]. Due to a tendency persisting in recent years to withdraw from using synthetic feed additives in poultry nutrition, studies have been conducted on possibilities to modify feed mixes through introduction of natural components of a different type to them, showing immunostimulating and therapeutic effects or affecting birds' performance. These feed components may include herbs, dry fruits or vegetables, as well as plant extracts. Active substances contained in them, such as flavonoids, fatty acids, vitamins, antioxidants, macro- and microelements, exert components with such properties into poultry diet and may also contribute to the improvement of birds' health status. Introduction of components with such properties into poultry diet may also contribute to the improvement of reproductive capacity of birds, which is of particular importance at the time of egg quality deterioration and the reduction of hatchability at the end of egg laying season. Ogbe *et al*. [2009] showed a favourable effect of bioactive substances of natural origin on the laying performance in hens. Bozkurt *et al*. [2008] found a positive effect of fatty acids contained, among others, in sunflower and fish oils on the egg laying performance, fertilization and hatchability in broiler chickens. Biesiada-Drzazga [2009] observed a considerable improvement of hatching egg quality after application of common flax seeds in feed ration. Similar results were obtained in the experiment with black cumin seeds conducted on layer hens by Akhtar *et al*. [2003].

This study aimed at determination of the effect of common flax and black cumin seeds being used in feed ration on quail performance and reproduction rate at the end of egg laying season.

Material and methods

The study was carried out at the experimental farm of the Department of Poultry and Ornamental Bird Breeding, Western Pomeranian University of Technology in Szczecin.

The research material consisted of Japanese quails (*Coturnix coturnix japonica*) of own hatching and rearing. The birds were kept in groups in cages over the whole experiment, following the recommendations by Rutkowski [2000], *i.e*. temperature 20-22°C, relative humidity 65-75%, and an appropriate lighting cycle (17L:7D).

On day 42 of life, the quails were weighed and divided into 5 groups with three replications, 15 females and 6 males each. The flock set up this way numbered 105 birds in total. Group I (control) received a complete feed mixture of standard composition, being produced from maize, wheat and post-extracted soybean oil meal (Tab. 1).

Table 1. Composition of feed mix

Item	Group				
	I (control)	II	III	IV	V
Feed components (%)					
common flax	0	4.0	7.0	0	0
black cumin	0	0	0	2.0	5.0
maize meal	24.0	5.0	1.0	40.0	47.0
wheat meal	41.14	58.52	60.82	22.71	12.99
soybean oil	0.50	0.50	0.50	0.50	0.50
post-extractive soybean oil meal	26.4	24.0	22.7	26.8	26.5
NaCl	0.21	0.21	0.21	0.21	0.21
monocalcium phosphate	1.25	1.25	1.25	1.25	1.25
limestone	5.10	5.10	5.10	5.10	5.10
DL-Methionine (technically pure)	0.11	0.10	0.10	0.12	0.13
L-Lysine hydrochloride	0.24	0.27	0.27	0.26	0.27
kemzyme X DRY[1]	0.05	0.05	0.05	0.05	0.05
toxfin[2]	0.10	0.10	0.10	0.10	0.10
lutamix DJR[3]	0.50	0.50	0.50	0.50	0.50
sodium hydrogen carbonate	0.20	0.20	0.20	0.20	0.20
natuphos 5% Layer[4]	0.20	0.20	0.20	0.20	0.20
Chemical composition (calculated)					
dry matter (g)	883	885	886	883	884
metabolizable energy (MJ/kg)	11,76	11.92	12.12	11.63	11.72
crude protein (g)	201.00	202.30	202.35	200.35	200.40
crude fibre (g)	35.26	37.30	39.00	35.96	36.73
calcium (g)	25.38	25.43	25.46	25.33	25.28
total phosphorus (g)	8.15	8.23	8.27	8.03	7.89
available phosphorus (g)	5.75	5.78	5.79	5.70	5.64
lysine (g)	11.48	11.51	11.38	11.50	11.33
methionine (g)	4.03	3.92	3.94	4.13	4.16
methionine + cysteine (g)	7.55	7.51	7.55	7.51	7.40

[1]Dry stabilised enzyme preparation containing phytase.
[2]Preparation against mycotoxins.
[3]Vitamin-mineral premix.

Feed mix for groups II and III was supplemented with 4 and 7% common flax seeds (CFS) whereas that for groups IV and V with 2 and 5% black cumin seeds (BCS), respectively. During the whole study lasting to week 40 of quail life, feed consumption and egg number and weight, as well as deaths and cullings were recorded on a daily basis. From the data obtained, basic production indicators were calculated,

i.e. egg laying performance (%), average egg weight (g), average feed intake (g/quail/day) and feed utilization (g per egg). In order to evaluate reproductive capacity of quails, the hatching analysis was performed for eggs with standardized weight in all groups. Hatching eggs were collected at 26, 32 and 38 week of quail life, each time over a 10-day period, and stored in dark room at 18°C and relative humidity 60-65%. When the eggs were collected, they were candled and those unfit for hatching were eliminated (improper shape, bad colour, damaged or dirty shell). On the day of egg setting, the eggs were disinfected with formaldehyde vapours, using 21 cm^3 40% formaldehyde, 17 g $KMnO_4$ and 21 cm^3 water per 1m^3 of disinfection chamber. Egg hatching proceeded in a box-type hatching apparatus, following the technique appropriate for this poultry species. In the last week of the experiment (week 40 of quail life), eggs' quality was evaluated, determining their morphological composition. Out of each quail group, 15 eggs were randomly sampled. They were weighed, boiled, and then relative albumen, yolk and eggshell weights were determined.

When the data were collected and passed into Statistica 7.1 PL computer software, one-way analysis of variance and Duncan's multiple range test were performed.

Results and discussion

Introduction of experimental components into quail diet did not significantly affect the weight of quail eggs. It was similar in all quail groups analysed and amounted to about 12 g (Tab. 2). Similar results, though on chickens, were reported by Bölükbaşi *et al*. [2009] who did not find any differences in the egg weight in laying hens receiving different amounts of black cumin oil in their diet (1, 2 or 3 ml/kg feed). In the present study, the highest egg laying performance (about 86%) was obtained in group II being fed with feed mix supplemented with 4% CFS and group IV being fed with feed mix supplemented with 2% BCS. The lowest laying performance occurred in the control group (82%). Differences between these groups were significant. Comparable results were obtained by Augustyn *et al*. [2006] and Basmacioglu *et al*. [2003] who showed an increase (by 4% on average) in the egg laying performance in hens in the groups

Table 2. Quail production traits (means ±SD)

Group	Egg weight (g)	Egg laying performance (%)	Feed intake (g/day)	Feed utilization (g/egg)	Deaths and cullings (n)
I (control)	12.00^{a}±0.21	82.57^{a}±9.54	40.29^{a}±4.38	49.89±8.23	0
II (4% common flax)	11.93^{a}±0.19	86.14^{b}±6.88	41.04^{a}±4.32	48.65±9.78	1
III (7% common flax)	11.97^{a}±0.21	84.44ab±8.37	41.56^{a}±4.16	49.64±7.13	0
IV (2% black cumin)	11.96±0.26	86.22^{b}±6.31	42.60±4.26	48.87±11.14	0
V (5% black cumin)	12.00^{a}±0.31	83.79^{ab}±9.31	38.23^{b}±4.90	48.28±8.71	

^{ab}Within columns means bearing different superscripts differ significantly at P≤0.05.

fed with CFS as compared to the control. Satisfactory results were also reported by Sari *et al*. [2002] who while feeding hens with a feed supplemented with 5, 10 and 15% CFS obtained a higher egg laying performance (87, 91 and 88% respectively), with 84% in the control group. On the other hand, Hayat *et al*. [2009] did not find any significant effect of the application of feed supplemented with 10% CFS on hen egg laying performance. It was found that the diet of hens with 1, 2 or 3% BCS induced a significant increase in their egg laying performance [Aydin *et al*. 2008]. Also Akhtar *et al*. [2003] observed that BCS included into the diet of hens (1.5%) increased their egg production from 59 to 77%. Different results were reported by El-Bagir *et al*. [2006]. They showed a decrease in egg production by 9-16% in the groups being fed with a feed supplemented with 1 or 3% BCS. The authors suggested that a smaller egg production could have been induced by a substantial decrease in the cholesterol level in egg yolk.

Daily feed consumption was significantly smaller (38.2 g) in the quail group receiving feed mixture supplemented with 5% BCS when compared to other experimental groups. Shewita *et al*. [2011] observed the lowest feed consumption in the chickens being fed with a diet supplemented with 4 g/kg BCS in relation to the groups fed with a diet with higher percentage of that component (6, 8, and 10 g/kg). On the other hand, Çetin *et al*. [2008] reported a linearly decreasing feed consumption together with an increasing percentage of BCS extract in the feed ration of partridges. Results of the study by Augustyn *et al*. [2006] indicate that administration of 5% CFS in diet does not affect significantly the feed consumption, whereas Sari *et al*. [2002] show its significant decrease in the groups receiving that component.

The lowest feed consumption, as compared to the control group, was found after introduction of 4% CFS or 5% BCS into feed mixture. The results obtained in the present study correspond with those of Augustyn *et al.* [2006] and Sari *et al*. [2002] in which smaller feed consumption was reported in the experimental groups receiving feed with 5, 10 and 15% CFS.

The health status of quails during this experiment did not create objections, as negative health indicators were of accidental nature (Tab. 2). Small losses observed in group II and V were induced by self-mutilation of quails between cage bars and therefore were not related to any experimental factor.

No significant effect of the experimental factors on relative albumen and yolk weight was found. In the group being fed with feed mix supplemented with 4% CFS, a significantly smaller percentage of eggshell in egg morphological composition was recorded but only in relation to the control group (Tab. 3). Results of the experiment carried out by Sari *et al*. [2002] indicate a significant decrease in the yolk weight of the eggs of hens receiving CFS in a diet, contrary to the report by Hayat *et al*. [2009] who found that feed supplemented with CFS did not affect the egg morphological composition significantly. Introduction of CFS and CBS into quails' diet favourably affected their reproduction results (Tab. 4). Fertilization rate in the experimental groups ranged from 86.6 to 95,5% and was significantly higher when compared to

Table 3. Morphological composition of quail eggs (means±SD)

Group	Yolk (%)	Egg white (%)	Eggshell (%)
I (control)	29.0^{a}±1.99	60.1^{a}±1.46	10.9^{a}±1.08
II (4% common flax)	29.9^{a}±1.60	60.0^{a}±1.76	10.0^{b}±0.67
III (7% common flax)	29.7^{a}±2.01	59.6^{a}±2.78	10.7^{ab}±1.07
IV (2% black cumin)	29.2^{a}±1.71	60.4^{a}±1.9	10.4^{ab}±0.83
V (5% black cumin)	30.4^{a}±1.97	59.2^{a}±1.75	10.3^{ab}±0.6

^{ab}Within columns means bearing different superscripts differ significantly at P≤0.05.

Table 4. Quail reproduction traits. Results of three settings (from 26th, the 32nd and the 38th week of quail life, means ±SD)

Group	Set eggs (n)	Indicator (%)		
		fertilization rate	hatchability rate of set eggs	hatchability rate of fertilized eggs
I (control)	180	82.78±2.35	67.22±3.47	81.21^{a}±5.80
II (4% common flax)	164	92.19±3.18	80.28±7.95	86.96^{ab}±4.51
III (7% common flax)	179	95.56±2.11	86.09±10.00	89.91^{b}±5.96
IV (2% black cumin)	180	92.78±1.89	80.55±2.54	86.86^{ab}±3.56
V (5% black cumin)	180	86.67±2.01	78.34±10.41	90.11^{b}±5.96

^{ab}Within columns means bearing different superscripts differ significantly at P≤0.05.

that of the control (82.7%). The best hatchability of fertilized eggs (about 90%) was obseved in the quail groups receiving feed mix supplemented with 7% CFS and 5% BCS. The results obtained in these groups significantly differ from the hatchability in the control birds (81%). Quail reproduction rates in the present study differed slightly from those reported by Hazim *et al*. [2010]. In the latter, quails being fed with feed mix suplemented with 3% common flax oil were characterized by better hatchability of set and fertilized eggs (83% and 94%, respectively), as well as by higher fertilization rate (87%), when compared to the control group.

It can be supposed that very good reproductive results of the quails receiving BCS and CFS in the diet could have been induced by a high percentage of phytoestrogens [Caston *et al*. 1994, Cetin *et al*. 2008]. Souza *et al*. [2008] showed that linseed contains much of lignans and isoflavones which play an important role in reproduction control together with fatty acids. According to Dalton [2000], a decreased ratio of omega-6 to omega-3 fatty acids in the diet of quails receiving feed supplemented with CFS had a significant effect on increased egg production, higher fertilization rate and better hatchability.

The performed study shows that the best egg laying performance was a characteristic of the quail groups being fed with feed mixture supplemented with 4% common flax seeds and 2% black cumin seeds. At the same time, no effect of the

experimental variation factors on egg morphological composition was observed, except the eggshell percentage which was significantly lower in the quail group receiving 4% CFS in their diet. The obtained results indicate a favourable effect of the plant components being evaluated on quail reproduction. The highest fertilization rates were obtained in the quail group being fed with the diet containing 7% common flax seeds. Significantly higher hatchability rates of fertilized eggs were found when the experimental components, *i.e*. common flax and black cumin seeds, were used in a higher percentage (7% and 5 %) of feed mixes.

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