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EFFECTS OF CHITOSAN ON SELECTED PRODUCTION CHARACTERISTICS AND HATCHING SUCCESS OF THE PHARAOH QUAIL

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ABSTRACT

Chitosan is the simplest form of chitin, found in carapaces of crabs, prawns, and krill. Due to its chemical and physical properties and biological activity, chitosan is widely applied in, i.a., medicine, animal care, and agriculture. Chitosan effects on poultry health and production have been studied to a limited degree only. The present study was thus aimed at elucidating chitosan effects on the utility and reproduction-related characteristics of quail. The experiment involved the quail aged 5 weeks which were divided into two groups, each consisting of 36 females and 12 males. The birds belonging to Group I (control) were fed a standard feed mix for laying quail, while the feed offered to Group II (experimental) was enriched with 5.2 ml chitosan added to 1.2 kg feed. Compared to the control, the experimental quail showed a lower daily feed consumption, lower number of eggs laid, and a higher feed consumption per egg. However, the experimental quail demonstrated a higher survival rate and improved hatching success.

Key words: chitosan, quail, performance, hatchability

INTRODUCTION

Chitosan, the simplest chitin derivative, is a co-polymer of β-(1→4)-2-amine-2-deoxy-D-glucopyranose and β-(1→4)-2-acetamide-2-deoxy-D-glucopyranose or a homopolymer of β-(1→4)-2-amineo-2-deoxy-D-glucopyranose [17]. It is produced as a result of chemical or enzymatic deacetylation involving removal of some or all acetyl groups from acetylamine groups of chitin. Chitin is found in carapaces of crabs, prawns, and krill as well as in squid mantle cartilage remaining after squids have been processed into food products.

Owing to its chemical and physical properties and biological activity, chitosan is widely applied in medicine, animal care, biotechnology, agriculture, and environmental protection as well as in the cosmetics, food, textile, and paper industries [3, 7, 9]. Research of Ramisz et al. [12] on mice demonstrated chitosan to be a strong bacterio- and fungicide. When determining the Minimal Inhibitor Concentration value, the authors quoted found all the bacteria (*E. coli, P. aeruginosa, S. aureus, S. parathypi*) and fungal (*Candida albicans, Trichophyton mentagrophytes, Microsporum canis*) strains used in the study to be chitosan-sensitive. Chitosan effects on the health and utility value of poultry have been studied to a limited extent so far. Noteworthy in this context is the research of Swedish authors who evaluated chitosan effects on body weight growth, feed utilisation, blood serum lipid content, and intestinal bile concentration in hens [13, 14, 15]. Chitosan effects on the blood serum cholesterol level [13] as well as chitosan-hen egg lysozyme relationship [6] were studied as well. Recently, chitosan effects on some morphological characteristics of hen eggs (yolk and egg weight mainly) and albumin content have been assessed [1].

So far, chitosan has not been used as a quail feed additive. Therefore, the present study was aimed at assessing chitosan effects on production characteristics as well as fertilisation and hatching success in quail.

MATERIALS AND METHODS

The study was carried out at an experimental farm of the Department of Utility and Ornamental Bird Breeding, Agricultural University of Szczecin. The study involved the Pharaoh quail basic stock of 96 individuals. The birds were kept in typical pens under controlled microclimatic conditions and were fed as recommended by appropriate standards for the growing quail [11]. At their fifth week of life, the birds were weighed; those quail of body weight close to the stock mean body weight were selected for the experiment. The selected quail were divided into two groups 48 individuals each, each group providing birds for 6 replicates. Each group consisted of 36 females and 12 males. During the 21-week-long experiment, the birds were kept under conditions appropriate for quail raising, with a 17-h-long photoperiod. During the experiment, the Group I quail (control) were fed a full-ration mixed dry feed suitable for adult laying quail (Table 1). Those quail assigned to Group II (experimental) were fed the standard feed enriched with 2% chitosan adipinate added at a concentration of 5.2 ml per 1.2 kg feed (daily feed demand per group). Chitosan was obtained by chemical deacetylation of chitin with 50% sodium hydroxide. The chitosan obtained was in a liquid form, so it was sprayed upon the daily feed ration and mixed thoroughly with it. During the experiment, individual body weight of the quail was determined in week 5 and week 27 of life; the number of eggs laid during 21 weeks was recorded and the egg were weighed. Feed consumption per individual, egg, and 1 kg of eggs was calculated. Quail losses and health problems were monitored. The egg hatching success was followed as well. The eggs for hatching were collected in weeks 23 and 27, for 7 consecutive days. The eggs were candled and weighed; for hatching, eggs weighing 11-12.5 g and having a pronounced shell pattern were selected. The eggs to be hatched were placed in containers and kept in a dark room at about 18ºC. The hatch proceeded in a box-type hatching apparatus, following appropriate procedures; on termination of hatching, fertilisation and hatching success was calculated and the per cent hatch loss was determined. The collected data were analysed statistically using one-way ANOVA and Duncan test.

Table 1. Composition of feed mix offered to adult quail

Component	Percentage
Feed component	
Ground wheat	30.00
Ground triticale	20.00
Ground barley	11.67
Post-extraction soybean oilmeal 46%	19.20
Post-extraction rapeseed oilmeal 35.5%	5.00
Meat meal 55%	5.00
Poultry fat	2.00
Rapeseed oil	1.60
Fodder salt	0.20
Fodder chalk	3.20
Calcium biphosphate	0.70
Premix (EWOS)	1.20
Lysine	0.20
Methionine	0.03
Chemical composition (%)	
Dry matter	86.01
Crude protein	20.83
Raw fibre	3.01
Metabolic energy MJ·kg^{-1}	11.71

RESULTS AND DISCUSSION

When entering maturity, the quail showed a uniform body weight. Chitosan added to the feed offered the adult bird had no significant effect on body weight of females at the terminal part of the experiment; it did, however, contributed to a body weight reduction in males. The Group II male body weight was lower than that of the control by 22.3g (Table 2). Similar results with respect to chicken were reported by Razdan et al. [15]. They found a significantly lower body weight increments in those chickens fed chitosan-enriched feed, compared to the control. Chitosan, however, was found to reduce to blood serum cholesterol level and to reduce fat digestibility by 8 - 26%.

During the 21 weeks of observations, the higher egg production was typical of the Group I (control) quail, 139 eggs being an average output of a laying quail (Table 2). The value was significantly higher than that obtained in Group II (120.5 eggs). Laying intensity over the period analysed ranged from 82.0% (Group II) to 94.5% (Group I). The number of eggs laid by a quail during a week was by about 1 egg lower in the experimental group, compared to the control. The still lower weekly laying output in quail was found by Michalska and Korzyńska-Nowak [8] whose study focused on the initial laying phase. The adverse effect of chitosan on laying characteristics in hens was reported by Hirono et al. [4] who added chitosan in a daily dose of 3.6 to 4.2 g·kg^{-1} body weight. Fuentes et al. [2], too, demonstrated a relationship between chitosan dose and laying characteristics in hen and found chitosan to affect the egg laying capacity when applied at doses exceeding 3%. Those authors as well as Nogueira et al. [10] suggested chitosan to have a hypolipidaemic potential.

Table 2. Production characteristics

Item	Group I		Group II	
	x	SD	x	SD
Body weight in week 5 of life (g)				
males	176.6 a	2.58	175.0 a	4.47
females	214.3 a	9.89	213.0 a	8.16
Body weight in week 27 of life (g)				
males	196.5 b	4.85	174.2 a	9.99
(%)	100.00	11.01	88.60	25.00
females	224.0 a	0.94	229.7 a	0.43
(%)	100.00	9.40	102.50	10.30
Egg laying until week 27 of life				
No. of eggs per female				
weekly	6.6 a	8.90	5.7 b	7.60
total	139.0 a	0.87	120.5 b	0.69
(%)	94.5 a	12.3	82.0 b	14.0
egg weight (g)	11.8	1.18	12.1	1.98
Shell thickness (μm)	209.0	4.78	215.1	5.21
Food uptake ($g \cdot day^{-1} \cdot ind.^{-1}$)	29.7 a	0.42	27.9 b	0.51
Food consumption ($g \cdot egg^{-1}$)	31.40		34.00	
(%)	100.00		108.30	
[kg per 1 kg eggs]	2.79		2.99	
(%)	100.00		107.20	
[g per g egg]	2.65		2.85	
(%)	100.00		100.70	
Deaths and health-related losses %	6.2		2.1	

a, b- means in rows marked with different letters differ significantly ($p<0.05$).

No effect of chitosan addition to feed on egg weight could be detected; the eggs of both groups had similar weights of 12.1 and 11.8 g in the experimental and control groups, respectively (Table 2). In their study on hens, Davis et al. [1] obtained different results: eggs produced by the hens fed chitosan-enriched food weighed less and had a smaller yolk, compared to the control, the observations focusing on the early phase of laying. This study showed no statistically significant differences between egg shells in the two groups, although there were slight differences in egg shell thickness between the groups: eggs laid by the experimental quail had somewhat thicker shells (Table 2).

The experimental quail showed a significantly lower feed uptake per individual and per day. Feed consumption in Group II was 27.9 g, by 1.8 g less than in the control (Table 2). Hirono et al. [4] found a lower food uptake in the group of hens fed chitosan-enriched feed, too. Food consumption per egg proved unfavourable in Group II as it was by 2.6 g higher, compared with the control; the result was a direct outcome of a lower number of eggs obtained in the experimental group. Somewhat lower between-groups differences were observed in feed consumption per 1 g and 1 kg of eggs. The two characteristics were higher in Group II by as little as about 6 and 7%, respectively, compared with Group I. The lower differences in feed consumption per egg weight unit in the experimental group resulted from a higher individual egg weight. It should be, however, stressed that feed consumption per 1 g of eggs found in the two groups in this study did not deviate from the results reported by Yaman et al. [18] who used a feed of metabolic energy content of 11.63 $MJ \cdot kg^{-1}$, i.e., similar to that used in this study.

Quail mortality rate in the period of study was lower in Group II and amounted to 2.1% , i.e., an equivalent of an about 0.4 % monthly loss (Table 2). Thus the loss was less than a half of that considered as mortality standard in hens. Lower monthly losses in quail keeping were arrived at by Tarasewicz [16] in a group offered a probiotic (oligosaccharides) at a dose of 12 $g \cdot kg^{-1}$ feed. A positive effect of chitosan on the bird health was reported by

Razdan et al. [15]. On the other hand, results obtained by Davis et al. [1] are not as unequivocal because no differences in mortality rate between the control and chitosan-treated chickens were detected. Due to a higher susceptibility of poultry to infection-, invasion-, and environmental effects-related diseases resulting from intensification of breeding, it is necessary to look for factors improving birds' resistance to disease.

Table 3. Fertilisation and hatching success

Hatch sequence	Group	Fertilisation (%)	Dead embryos (%)	Unhatched chicks (%)	Impaired chicks (%)	Hatching rate	
						incubated eggs (%)	fertilised eggs (%)
First	I	100.0	5.8	13.0	1.4	79.7	79.7
	II	95.7	2.2	10.8	2.2	80.6	85.4
Second	I	97.3	5.3	9.3	6.7	76.0	78.1
	II	94.6	4.1	10.8	1.4	78.4	82.9
Mean of two incubations	I	98.6	5.5	11.2	4.5	77.8	78.9
Mean of two incubations	II	95.2	3.1	10.8	1.8	79.5	84.1

The health of laying hens affects embryogenesis in a major way. Even 15-20% of embryos obtained from healthy laying females may succumb to natural selection during incubation. Hatching success, in turn, is one of the most important factors for breeding farm economic performance, for which reason it is fully appropriate to look for factors improving poultry health state. As demonstrated by this study, chitosan may be one of such factors. The Group II quails had a higher hatching success, both in relation to the number of incubated eggs and the number of fertilised ones, 79.5 and 84.1%, respectively (Table 3). The values obtained in the control were by 5.2% lower in relation to the number of fertilised eggs. The lower results in the control resulted from a higher percentage of dead embryos (2.4%) and impaired and weak hatchlings (2.7%). As already mentioned, effects of chitosan as a food additive in breeding quail have not been studied before, for which reason no literature data with which to compare the present results could be found. It should be, however, mentioned that the results obtained in both groups were better than those reported by Kraszewska-Domańska [5] with respect to eggs kept for a week. The results obtained in this study demonstrated positive effects of chitosan on the hatching success; however, repeating the experiment is desirable for a fully convincing interpretation.

CONCLUSIONS

1. Feed enrichment with chitosan resulted in reduced daily food uptake, reduced egg production, and increased feed consumption per egg laid.
2. No chitosan effects on the resultant body weight of breeding quail was found.
3. The chitosan-treated quail showed a doubled survival rate and increased egg hatching success.

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