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Evaluation of the possibility of using oligosaccharide-free pea in Japanese quail nutrition

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Abstract: In this paper, evaluation of the effect of processed pea seeds (free of raffinose family oligosaccharides) on the performance traits and the results of reproduction in Japanese quails is presented. A flock of 72 quails was divided into 3 groups consisting of equal numbers of birds (18 females and 6 males). Birds were kept in cages in an environmentally controlled room with a lighting cycle of 17 h of light and 7 h of dark, and they were fed 1 of 3 different diets. Whereas diet 1 served as the control, diet 2 was supplemented with 5% and diet 3 with 10% peas (cultivar Piast) from which oligosaccharides were removed. Feed consumption in the experimental groups was similar and at the same time significantly higher than that in the control group. Significant improvement of feed conversion ratio per 1 egg was found in the group fed with feed mixture containing 5% oligosaccharide-free pea. Lower feed conversion per kilogram of eggs was also observed in both experimental groups fed with pea diet. The use of processed pea (without oligosaccharides) in feed had a favourable effect on laying performance. Better production results were achieved in group 2 fed with feed containing 5% pea in the feed mixture, whereas in group 3 (10% oligosaccharide-free peas) the highest egg weight was found. The other egg quality traits analysed were similar and did not differ significantly irrespective of the type of applied diet. Introduction of oligosaccharide-free pea to quail diet in the amounts of 5% and 10% favourably influenced quail fertilisation rates. Improvement of the hatchability from fertilised eggs was also observed, in particular in the group fed with fodder containing 5% processed pea.

Key words: Nutrition, quail, pea, egg quality, reproduction

Introduction

Pea and sweet lupines are of the greatest importance at present among leguminous plants grown for fodder. Seeds of these plants are characterised by a high content of lysine-rich protein and thus constitute a good complementation of cereal protein in poultry feeding, which, in turn, compensates for a methionine deficiency in legumes (1). However, the possibilities of using legume seeds in poultry feeding are determined not only by their nutritional value but also by the presence of substances with antinutritional character. For this reason, their contribution in the feed ration may differ depending on bird species, age, and type of use.

It was found in a study conducted by Richter et al. (2) that feed mixtures with a pea percentage of up to 20% may be used in the fattening of turkeys, those with 30% pea in broiler chicken production, and

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those with 40% pea in the nutrition of commercial laying hen flocks. According to Fru-Nji et al. (3), feeding with a diet containing up to 50% peas does not negatively affect the laying performance of hens or the quality of eggs, increasing feed consumption in relation to soy-cereal diet by only about 3%.

Utilisation of pea seeds in the feeding of young birds and laying hens producing hatching eggs is considerably limited due to the presence of antinutritional compounds, such as lectins, tannins, and α-galactosides (raffinose family oligosaccharides [RFOs]), which decrease feed intake and feed efficiency, negatively influencing body weight and laying performance (1). They also trigger disturbances in the vascular structure of the ovary, which brings about formation of bloody spots on egg yolk and its decolourisation.

Removal of at least some of the antinutritional compounds or appropriate hydrothermal treatment of pea seeds may yield greater possibilities for using such feed components, especially in the feeding of young birds and those used in reproduction.

Due to development of simple and quick methods for removal of antinutritional factors (alkaloids and α-galactosides) from alkaloid-rich lupine and other legume seeds, possibilities have been created to fully use domestic sources of protein in human and animal nutrition (4,5). Until now, studies on the utilisation of processed products in animal feeding examined lupine seeds only and referred to the effect of debittered lupine seeds on the growth and some meat traits and reproduction in ducks (6,7) as well as the fattening results in pigs (8). The interest in the utilisation of processed products has clearly increased recently. This is related to the finding that RFOs, being the main component of processing waste material, show prebiotic properties (9–11). In this respect, pea seeds have particular importance as a rich source of these sugars. In this paper, evaluation of the effect of processed pea seeds (RFO-free) on the performance traits and the results of reproduction in Japanese quails is presented.

Materials and methods

Pea seeds and their processing

The pea seeds (*Pisum sativum* L.), cultivar Piast, were submitted to extractions according to a previous procedure described by Gulewicz et al. (5). Briefly, 200 g of pea seeds were soaked in 240 mL of distilled water at 4 °C for 8 h. The soaked seeds were then extracted with 400 mL of 48% ethanol (v/v) at 40 °C overnight. After extraction, the supernatant was decanted. The seeds were reextracted with fresh alcohol solutions under the same conditions. After extraction, the pea seeds were dried in a vacuum dryer at 40 °C.

Experiment description

A total of 72 quails (*Coturnix coturnix japonica*), hatched and reared under conventional environmental conditions and husbandry practices at the Department of Poultry and Ornamental Bird Breeding of Western Pomeranian University of Technology in Szczecin, were individually weighed at 6 weeks of age and randomly allocated to 3 experimental groups. Birds were kept in cages in an environmentally controlled room (temperature 20 °C, humidity 60%–65%) with a lighting cycle of 17 h of light and 7 h of dark. Each experimental group consisted of 18 females and 6 males, and was fed 1 of 3 different diets (Table 1). Diets were formulated to be isocaloric and isonitrogenous and were prepared according to the Nutrient Requirement of Poultry (12), and birds were fed ad libitum in mash form with water freely available throughout the experimental period. Whereas diet 1 served as the control, diet 2 was supplemented with 5% and diet 3 with 10% processed pea seeds (RFO-free). Feed consumption, mortality, number of eggs, and egg weight were recorded over a 19-week period until 25 weeks of age. Egg quality characteristics were determined based on 15 eggs randomly sampled from each group at week 19 of the experimental period. Specific gravity was measured by passing eggs through glass buckets containing a graded series of NaCl concentrations ranging from 1.058 to 1.082 in increments of 0.004. Proportions (weight) of albumen, yolk, and shell were determined from eggs after boiling. Albumen and yolk indices were calculated from recorded heights and diameters for these components, whereas yolk colour was evaluated according to the Roche Yolk Colour fan. Albumen and yolk pH was measured with a Sentron 3001 pH-meter. To evaluate reproductive performance, eggs were collected from each group at

Table 1. Composition of diets (%).

Components	Groups		
	1 (control)	2	3
1. Wheat meal	32.00	28.40	26.63
Maize meal	20.0	20.0	18.0
Barley meal	8.0	8.0	8.0
Oligosaccharide-free pea	0	5.0	10.0
2. Extracted soybean meal (46%)	30.4	29.0	27.6
Rapeseed oil	1.5	1.5	1.7
Salt (NaCl)	0.21	0.21	0.21
Limestone	5.25	5.25	5.25
Kemzyme dry	0.1	0.1	0.1
Natuphos 5% layer	0.2	0.2	0.2
DL-methionine	0.11	0.11	0.11
$NaHCO_3$	0.2	0.2	0.2
$CaHPO_4$	1.3	1.3	1.3
Lysine hydrochloride	0.13	0.13	0.09
Lutamix	0.5	0.5	0.5
Chemical composition	1	2	3
Crude protein, g	210.60	210.33	210.35
Metabolisable energy, MJ/kg	11.73	11.70	11.71
Crude fibre, g	37.8	38.9	39.8

23 weeks of age over a 10-day period. After candling and weighing, eggs representing the average weight of each group with a distinct shell pattern were selected to be hatched (80 eggs from each group). Selected eggs were kept in a dark room at about 18 °C. Hatching proceeded in a box-type hatching apparatus, following appropriate procedures, with temperature of 37.8 °C and humidity of 55% until day 15, and temperature of 37.6 °C and humidity of 75% after that stage.

Statistical analysis

Data were subjected to one-way ANOVA. When differences were significant at the 0.05 level, Duncan's post hoc test was used to compare means among treatments.

Results

Daily feed consumption ranged from 26.7 g (control group) to 28.6 g (group 3). Feed consumption in experimental groups was higher by approximately 6%–7% than in the control group, and these differences proved to be statistically significant (Table 2). When analysing feed conversion per production of 1 egg, the worst ratio was observed in group 3 (35.2 g), whereas the best was seen in group 2 (32.9 g). Thus, the effect of feed mixture where oligosaccharide-free pea contribution was 5% may be regarded as favourable.

On the other hand, the largest feed conversion for production of kilogram of eggs was found in the control group (3.05 kg). When compared to the other groups, these differences proved to be significant at $P \leq 0.01$ (Table 2). The parameters under discussion are affected by many factors, including egg production level, feed quality (its composition, nutrient balance, and organoleptic properties), environmental conditions (with temperature playing the decisive part among them), and also the weight of laid eggs in the case of feed consumption per kilogram of eggs.

Table 2. Mean performance characteristics of quails during a 19-week laying period (mean ± standard deviation).

Item	Groups		
	1 (control)	2	3
Daily feed consumption/quail, g	$26.69^{A} \pm 1.25$	$28.33^{B} \pm 0.85$	$28.65^{B} \pm 0.57$
Feed conversion/egg, g	$34.24^{a} \pm 2.36$	$32.93^{b} \pm 2.00$	$35.16^{a} \pm 2.33$
Feed conversion/kg eggs, kg	$3.05^{A} \pm 0.15$	$2.88^{B} \pm 0.16$	$2.88^{B} \pm 0.12$
Egg yield, %	$78.21^{A} \pm 4.99$	$86.28^{B} \pm 4.60$	$81.78^{A} \pm 4.66$
Number of eggs per layer (in relation to average), %	$104.0^{A} \pm 0.35$	$112.5^{B} \pm 0.39$	$108.4^{AB} \pm 0.33$
Egg weight, g	$11.22^{A} \pm 0.16$	$11.30^{A} \pm 0.09$	$12.01^{B} \pm 0.08$

$^{A, B}$: means within a row not followed by the same letter differ significantly at $P \leq 0.01$.
$^{a, b}$: means within a row not followed by the same letter differ significantly at $P \leq 0.05$.

In groups 2 and 3, higher egg yield as well as larger egg weight were observed, which explains the more favourable feed conversion ratios in these groups.

Based on the obtained results, it is possible to state that addition of oligosaccharide-free pea had a favourable effect on laying performance, with the best results (86.28%) being obtained in group 2 with 5% pea contribution in feed mixture (Table 2). The lowest laying rate (78.21%) was obtained in the control group, and a slightly higher rate was seen in group 3 (81.78%). For groups 1 and 2, these differences proved to be statistically significant at $P \leq 0.01$, whereas for groups 2 and 3, they were significant at $P \leq 0.05$.

In the control group as well as in group 2, egg weight was very similar and amounted to 11.2 g and 11.3 g respectively (Table 2). The highest significantly different egg weight was observed in group 3 (12.0 g).

Observations related to hatchability analysis were preceded by evaluation of the quality of eggs from birds of the experimental flock. Despite the larger weight of eggs in quails fed with diet containing pea, no significant differences were observed in the case of the other egg quality traits under analysis or their morphological composition in relation to the control group (Tables 3 and 4). The feeding of birds with diet containing pea did not worsen eggshell quality, the determinant of which in this study was egg specific gravity, eggshell thickness, and its relative weight. The analysed parameters had similar values irrespective of the type of diet. Moreover, it was found that introduction of pea to feed mixtures did not negatively affect the structure of yolk and thick albumen or the relative weight of these egg components, being most important from the nutritional point of view. No significant changes in yolk colour were observed either depending on the diet applied.

Quail survival rate during the experimental period was high: 100%, 87.5%, and 95.8% in groups 1, 2, and 3, respectively. Small losses observed in the experimental groups were caused by quails jamming between cage rods, thus not being related to the experimental factor.

The feeding of quails with diet containing oligosaccharide-free pea favourably influenced the quail fertilisation rate since it was higher by 6%–9% in experimental groups when compared to the control group (Table 5). The best hatchability from fertilised eggs (94.7%) was characteristic of the birds of group 2 receiving feed mixture with 5% pea contribution. The value of this index in the control group and group 3 amounted to 84.0% and 91.9%, respectively.

Discussion

The obtained value of the daily feed consumption was similar to values presented in the literature referring to quail performance traits (13,14). In the available literature, there is no information on possibilities of using pea in the feeding of birds used in reproduction. On the other hand, results from studies carried

Table 3. Quality indices for fresh eggs (n = 15 in each group) of 25-week-old layers (mean ± standard deviation).

Trait	Groups		
	1 (control)	2	3
Egg weight, g	11.04[a] ± 0.53	11.37[b] ± 0.35	11.56[b] ± 0.39
Specific gravity, g/cm^3	1.062 ± 0.001	1.070 ± 0.003	1.070 ± 0.003
Eggshell thickness, mm	0.28 ± 0.04	0.23 ± 0.03	0.28 ± 0.03
Albumen index	0.12 ± 0.01	0.11 ± 0.02	0.12 ± 0.02
Albumen pH	8.56 ± 0.19	9.20 ± 0.08	8.58 ± 0.11
Yolk index	0.47 ± 0.02	0.45 ± 0.03	0.46 ± 0.04
Yolk pH	5.45 ± 0.5	5.36 ± 0.48	5.45 ± 0.5
Yolk colour	6.14 ± 0.24	6.47 ± 0.12	6.04 ± 0.13

[a, b]: means within a row not followed by the same letter differ significantly at $P \leq 0.05$.

out in commercial hen flocks showed that even a high contribution of this feed component in bird diet neither negatively affected their production traits nor improved their laying performance (15). According to Fru-Nji et al. (3), introduction of pea to hen diet in the amount of 10% to 50% did not bring about differences in egg yield, egg weight, or feed consumption, but with its maximum contribution in feed mixture a significant increase in daily feed consumption was observed in relation to the control group.

Obtained egg weights in the control group and in group 2 were consistent with reference literature data for Japanese quails (13,16,17). In the case of group 3, egg weight was even higher than in a study carried out on heavier quails of the Pharaoh breed with egg weights ranging from 11.03 g to 11.36 g (9,18).

The lack of data concerning quality indices for fresh eggs, egg weight, and percentage of egg components in boiled eggs of quails in the available literature referring to quails fed with diet containing oligosaccharide-free pea does not allow for comparison of the obtained results. Some references can be made by taking into consideration other poultry species, but only in the case of commercial flocks and allowing for peas not exposed to modification of their chemical composition. Ivusic et al. (15) reported that pea contribution in

Table 4. Egg weight and percentage of egg components in boiled eggs (n = 15 in each group) of 25-week-old layers (mean ± standard deviation).

Trait	Groups		
	1 (control)	2	3
Egg weight, g	11.34[a] ± 0.53	11.53[b] ± 0.35	11.81[b] ± 0.39
Yolk, g %	3.55[a] ± 0.21	3.57[a] ± 0.26	3.64[b] ± 0.23
	31.2 ± 1.8	31.1 ± 1.99	30.8 ± 1.97
Albumen, g %	6.67[a] ± 0.32	6.78[a] ± 0.25	7.02[b] ± 0.45
	58.8 ± 1.3	58.9 ± 2.0	59.4 ± 2.2
Eggshell, g%	1.11 ± 0.13	1.13 ± 0.04	1.15 ± 0.11
	9.8 ± 0.5	9.8 ± 0.48	9.7 ± 0.97

[a, b]: means within a row not followed by the same letter differ significantly at $P \leq 0.05$.

Table 5. Reproductive performance of quails.

Item	Groups		
	1 (control)	2	3
Number of set eggs	80	80	80
Fertilised eggs, %	86.2	95.0	92.5
Dead embryos, %	10.0	2.5	6.2
Crippled chicks, %	3.7	2.5	1.2
Hatchability of set eggs, %	72.5	90.0	85.0
Hatchability of fertilised eggs, %	84.0	94.7	91.9

feed mixtures for hens not lower than 59% induced eggshell thinning and yolk colour deterioration. On the other hand, Fru-Nji et al. (3) showed that the feeding of hens with diet containing 10% to 50% pea did not negatively affect eggshell breaking strength or egg percentage, nor did it worsen the quality of egg content expressed by yolk and albumen indices and relative weights and yolk colour.

Hatchability of fertilised eggs did not differ significantly from the results obtained by Szczerbińska et al. (19), who evaluated reproductive performance of quails under standard feeding. In the aforesaid study, the best hatchability from fertilised eggs was characteristic of birds at 22 and 36 weeks of age, i.e. 81% and 86%, respectively. In the case of reproductive hens fed with a low-tannin pea diet (in the amount of 6% to 42% of ration), an impairment in hatchability was observed, but only in groups receiving feed with higher pea content (20).

It seems that improvement of reproductive indicators could have been connected with better digestibility of pea seeds due to removal of oligosaccharides as well as with the chemical processing itself related to this process (5). Oligosaccharides do not undergo enzymatic digestion because appropriate enzymes are missing, but they are fermented by gastrointestinal tract bacteria. This induces formation of large amounts of gases and in consequence symptoms of flatulence and deterioration in energy efficiency and other feed components (1). Therefore, it is possible to assume that assimilability of nutrients from feed increased due to isolation of oligosaccharides, which positively affected laying performance and egg weight as well as reproductive indicators in quails. Nasr et al. (21) showed that ration digestibility, particularly availability of critical amino acids, significantly affects fertilisation and hatchability indices in hens.

The amino acid profile also changed in pea seeds after isolation of oligosaccharides, which is confirmed by the results of a study carried out on this material at the Department of Animal Nutrition of the Western Pomeranian University of Technology in Szczecin (unpublished data). In that study, a larger quantity of amino acids was obtained, by 17%, in pea after extraction of oligosaccharides, including about 5% more exogenous amino acids, mainly lysine, methionine, and tryptophan.

Feed consumption in the experimental groups was similar and at the same time significantly higher than that in the control group. Significant improvement of feed conversion ratio per 1 egg was found in the group fed with feed mixture containing 5% oligosaccharide-free pea. Lower feed conversion per kilogram of eggs was also observed in both experimental groups fed with pea diet.

The use of processed pea (without oligosaccharides) in feed had a favourable effect on laying performance. Better production results were achieved when the pea contribution in feed mixture was 5%.

Introduction of oligosaccharide-free pea to quail diet in the amount of 5% and 10% favourably influenced quail fertilisation rates. Improvement of the hatchability from fertilised eggs was also observed, in particular in the group fed with feed containing 5% processed pea.

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