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The Effect of Different Levels of Hatchery Waste on Growth Performance and Production of Japanese Quail

Research Article

R. Chalaki[1], M. Irani[1*] and S. Gharahveysi[1]

[1] Department of Animal Science, Qaemshahr Branch, Islamic Azad University, Qaemshahr, Iran

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*Correspondence E-mail: m.irani1968@gmail.com

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ABSTRACT

In order to examine the effects of feeding different levels of hatchery waste (HW) on Japanese quail, 160 Japanese quail were assigned in a completely randomized design with four experimental treatments including: 1) Control ration; 2,3 and 4) Control ration plus 2.5%, 5% and 10 % of dry matter (DM) hatchery waste, respectively. The experiment was conducted for 42 days (7 days for adaptation and 35 days for sample collection). Quails are full access to water and feed. Daily feed intake and body weight gain were measured. At the end of the experiment (day 35), the blood samples, microbial population and carcass treatment were collected from each treatment. The supplementation of hatchery waste had increased DM intake (P=0.0343) and body weight (P=0.0411) but had not effect on feed conversion ratio (P=0.0346). All blood parameters had improved with adding HW to feed treatments (P<0.05). Increasing hatchery waste in the ration increased the amount of carcass weight (P=0.0353), breast weight (P=0.0261), thigh weight (P=0.0417) and abdominal fat weight (P=0.0385). The HW significantly increased the population of lactobacillus (P=0.0415). In general, supplementing the ration of meat quails with hatchery waste, especially in high level, increased feed efficiency in a dose-response manner, body weight gain and improved serum parameters, improved lactobacillus bacterial population and carcass characteristics.

KEY WORDS growth performance, hatchery waste, Japanese quail, production.

INTRODUCTION

The poultry industry is currently gaining attention for the use of alternatives to growth-promoting agents. It has been well documented that Japanese quail farming entails significant nutritional demands and inefficient feed utilization coupled with scarce and expensive conventional feed ingredients, collectively resulting in a high cost of production (Shatishkumar *et al.* 2008). The surging prices and limited availability of staple feedstuffs have necessitated exploration of alternative protein and energy sources to support this important farming sector. Scientific studies indicate the strategic utilization of animal coproducts shows promise in alleviating cost and supply pressures on feed resources that face competition with human needs (Alaba and Ekeocha, 2012). As studies have shown, hatchery waste (HW) comprised mainly of expired chicks, nonviable eggs, and egg shell residues typically meets unfavorable disposal outcomes such as burning or landfilling. Research indicates that incorporating hatchery waste into quail diets can lead to significant improvements in growth performance, including increased body weight and feed conversion ratios. Studies have shown that diets containing HW can support optimal nutrient retention and promote better overall health in quails. For instance, the inclusion of HW at levels up to 12% has been reported to maintain live weights and carcass yields comparable to those fed conventional diets (Koohi, 2013). However, the high moisture content of fresh waste makes these methods quite expensive and dangerous to the environment.

There appears to be justification for investigating more sustainable and financially feasible approaches to managing this beneficial material, such as reclassifying it as quail provisions that are subject to thorough scientific examination (Mehdipour *et al.* 2009). HW has a good nutrient content, for example 36.2% crude protein, 23.9% ether extracts, 0.9% crude fiber, 25.1% ash, 2795.2 $kcal.kg^{-1}$ metabolizable energy (ME), 25.62% calcium and 1.47% phosphorus (Shatishkumar *et al.* 2008; Mehdipour *et al.* 2009). Therefore, HW can be used as a source of protein, energy and calcium and phosphorus (Al-Harthi *et al.* 2010). Protein from HW has a high biological value and digestibility, and the amino acids balance of HW is better than fishmeal and other animal protein sources (Khan *et al.* 2001; Koohi, 2013). HW is cheaper and profitable than soybean meal and fish (Shahriar *et al.* 2008). Several studies have been conducted to examine the HW utilization in poultry. Replacement of fishmeal up to 100 % with HW meal did not affect feed intake, egg weight and feed conversion of quails (Abiola *et al.* 2012). Other authors also conducted similar observations using poultry HW in laying hens (Shahriar *et al.* 2008). The replacement of fishmeal with whole or shells HW meal in isoprotein rations did not affect feed intake but increased egg production and egg weight (Odunsi *et al.* 2013).

Understanding the optimal dietary inclusion level of HW that maintains quail performance is crucial from both economic and environmental perspectives. The study aimed to determine the effect of using hatchery waste as an alternative feed ingredient for protein sources on the performance and production of Japanese quail. Therefore, this study was conducted to evaluate the effects of including different dietary levels of HW on growth, feed efficiency, and production traits of Japanese quail.

MATERIALS AND METHODS

The experiment was carried out at research farm of Sari University of Agriculture and Natural Resources, Sari, Mazandaran, Iran. Two hundred and forty of one old quails with an average body weight of 6.5 ± 1.25 g. They were randomly allocated to 16 pens consisted of four treatments and four replicates each. Each treatment was composed of 15 quails. The experimental period lasted for 6 weeks. Mash feeds and water were available *ad libitum* throughout the experimental period. The ingredients and nutrient contents of the rations are listed in Table 1 and 2. Experimental rations included: 1) basal ration (control), 2) control ration with 2.5% HW, 3) control ration with 5% HW and 4) control ration with 10% HW.

Table 1 Ingredients and chemical composition of different treatments (%)

Food items	Control	T 1	T 2	T 3
Corn	70	67.65	68.9	67
Soybean meal	18.5	17.25	16.3	13.5
Oil (soybean)	0.2	0.2	0.2	0.1
Wheat bran	0.5	0.5	0.5	0.5
Calcium carbonate	7	3.3	3.3	3.3
Dicalcium phosphate	1.5	1.5	1.5	0.13
Methionine	0.08	0.08	0.08	0.08
Lysine	0.05	0.05	0.05	0.05
Salt	0.2	0.2	0.2	0.2
Vitamin and mineral premix[1]	0.6	0.6	0.6	0.6
Additives	1.37	1.37	1.37	1.37
Enzymes	0	2	2	3.3
Incubation hatchery waste	0	2.5	5	10

[1] Vitamin mineral premix (units per kilogram of feed): vitamin A: 10000 IU; vitamin D3: 3500 IU; vitamin E: 35 IU; Menadione: 1.5 mg; Riboflavin: 5 mg; Pantothenic acid: 8 mg; vitamin B_{12}: 0.012 mg; Pyridoxine: 1.5 mg; Thiamine: 1.5 mg; Folic acid: 0.5 mg; Niacin: 30 mg; Biotin: 0.06 mg; Iodine: 0.8 mg; Copper: 10 mg; Iron: 80 mg; Selenium: 0.3 mg; Manganese: 80 mg and Zinc: 80 mg.

Table 2 Analysis of nutrient composition of different rations

Nutrient composition	Dietary hatchery waste (%)			
	0	2.5	5	10
Caloric energy of feed	2742	2745	2740	2740
Protein (g/kg)	13.23	13.19	13.30	13.22
Calcium (g/kg)	2.9	2.9	2.95	2.97
Phosphorus	0.34	0.34	0.32	0.33

All rations were formulated to meet the nutrient requirements of Japanese quail chicks (NRC, 2001). Hatchery waste was obtained from homa Farm, located in Sari, Mazandaran, Iran. Hatchery waste meal consisted of the shell, infertile eggs, and unhatched eggs. The hatchery waste was boiled at 100 ˚C for 15 min with a ratio of water and hatchery waste of 2:1. Then it was kept in ambient temperature for 12 h to 14 h. The boiled waste was moved into the filters for 10 min to 15 min and milled using a diskmill thereafter. The HW was then oven-dried at 60 ˚C for 24 h (Alaba and Ekeocha, 2012). Feed and water were provided *ad libitum* throughout the trial.

Growth performances and feed conversion ratio

Clinical signs and mortality were monitored daily during the whole experimental period. Body weight gain (BWG) and feed consumption were recorded weekly during the experiment period, feed intake (FI), daily weight gain (DWG) and feed conversion ratio (FCR) were determined for the overall experimental period (1-42 days). All measurements were performed on the pen basis using a high precision electronic scale.

Carcass traits and blood analysis

At the end of the experimental period (6 weeks), 8 quail birds (2 birds/pen) from each feeding group (chosen on the basis of pen average final body weight) (1 female and 1 male) per pen were weighed and slaughtered for carcass analysis. Carcass, liver, breast, thigh, heart, gizzard, spleen, and abdominal fat of each slaughtered bird were calculated as a relative of live body weight. Blood samples were collected from slaughtered birds and placed in tubes, it was sent to the laboratory and then centrifuged at (4000 rpm) for 10 minutes, and the resulting serum was stocked at -20 ºC for hormonal and chemical analyses. Serum glucose, triglycerides, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and total cholesterol measurement was done with Pars Azmoun kit by photometric method.

Bacterial populations of ileal content

The ileal contents (10 cm anterior to the junction with caecum and rectum) of two birds in each replicate were separately collected into the sterile tubes for dilution series as described by Gazaghi *et al.* (2014). In brief, 1 g of ileal digesta was added into the test tube containing 9 mL of sterilized phosphate buffered saline and buffered solutions were transferred to the microbial laboratory of our institute. Bacterial populations were determined by serial dilution (10^{-4}–10^{-6}) of ileal samples before inoculation onto Petri dishes.

Plates for total bacteria (LAB; grown in Nutrient agar), lactobacillus bacteria (grown in MRS agar) and coliform bacteria (grown in Mac-Conkey agar) were incubated at 37 ˚C in anaerobic media, respectively. Finally, plates were counted between 24 and 48 h after inoculation. All agar media were obtained from the Merck Company, Germany. Colony forming units were defined as distinct colonies under magnification using a binocular magnifier.

Statistical analysis

One-way analysis of variance was done using SAS (2001) software version 9.1.3, following the General Liner Model procedure with dietary treatment as fixed effect. Mean values assessed for significance using (Duncan, 1955) multiple range tests. The experimental unit was the pen. The model used was:

$$Y_{ij}= \mu + T_i + e_{ij}$$

Where:
Y_{ij}: any value from the overall population.
μ: overall mean.
T_i: effect of the i^{th} treatment (1=2.5% of hatchery waste, 2=5% of hatchery waste and 3=10% of hatchery waste replacement).
e_{ij}: random error associated with the j^{th} individual.

RESULTS AND DISCUSSION

As shown in Table 3 supplementation of the ration with different levels of HW affected on body weight gain (P=0.0296), feed intake (P=0.0343) and body weight (P=0.0411) between treatments. The highest amount of feed intake (P=0.0343), body weight (P=0.0411) and body weight gain (P=0.0296) was for treatment 4 (level 10 percent HW), which was not significantly different from treatment 2 (level 2.5 percent HW), but had a significant difference with other treatments. However, no significant difference was observed regarding the initial body weight (P=0.6384) and feed conversion ratio between the treatments (P=0.0832).

Table 4, illustrates data on carcass traits. The results showed that the gizzard weight (P=0.0674), liver weight (P=0.0596), heart weight (P=0.0633) and spleen weight (P=0.0138) did not make a significant difference with the addition of different levels of HW. The highest carcass weight was for treatment 2 (level of 2.5% of HW), which was not significantly different from treatment 4 (level of 10% of HW) and treatment 3 (level of 5% of HW) (P=0.0353). The highest breast weight was observed in treatment 4, which did not have a significant difference with the control treatment and treatment 3, but it had a significant difference with treatment 2 (P=0.0261). Also, the highest thigh weight was observed in treatment 4, which was not significantly different from treatment 2, but there was a significant difference with the size of the treatments (P=0.0417). In addition, the results showed that all the treatments containing different levels of hatching waste had a significant effect on the fat weight of the abdominal area, the highest amount was observed in treatment 4 (P=0.0385).

The effects of HW on blood parameters is shown in Table 5. The results of the effect of different treatments on blood glucose level showed that the highest value was for treatment 4, which did not have a significant difference with the control treatment, but it had a significant difference with other treatment (P=0.0346). Regarding the effect of treatments on blood triglyceride concentration, the lowest value was observed in treatment 2, which was significantly different from other treatments. Also, the highest blood triglyceride concentration was observed in treatment 3, which was significantly different from other treatments (P=0.0762). Regarding the effect of treatments on blood cholesterol concentration, the results showed that all levels of addition of hatching wastes caused a significant decrease in blood cholesterol concentration, so the lowest concentration of cholesterol was observed in treatment 4 (P=0.0881).

Table 3 Effect of different levels of hatchery waste (HW) on performance in Japanese quail at age

Item	HW (%)				SEM	P-value
	0	2.5	5	10		
Initial body weight (g)	7.25	7.5	5.75	7.25	0.67	0.63
Body weight (g)	210.5[c]	229.12[ab]	224.51[b]	236.25[a]	2.37	0.04
Body weight gain (g)	14.01[b]	14.53[a]	13.88[b]	16.35[a]	0.69	0.02
Feed intake (g/bird)	896.54[b]	952.42[a]	890.47[b]	951.78[a]	3.27	0.03
Feed conversion ratio (feed:gain)	4.12	4.15	3.96	4.02	0.19	0.08

The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 4 Effect of different levels of hatchery waste (HW) on carcass characteristics in Japanese quail (%)

HW (%)	Carcass weight	Breast weight	Thigh weight	Abdominal fat weight	Gizzard weight	Liver weight	Heart weight	Spleen weight
0	127.28[b]	53.43[a]	29.58[b]	1.81[b]	3.55	6.13	1.92	0.16
2.5	136.49[a]	49.66[b]	31.88[a]	2.62[a]	4.18	6.04	1.89	0.14
5	132.06[ab]	55.08[a]	29.77[b]	2.56[a]	3.83	5.31	1.88	0.15
10	135.96[a]	55.86[a]	32.11[a]	2.85[a]	4.06	5.82	1.88	0.17
SEM	1.18	0.85	0.53	0.21	0.33	0.41	0.09	0.03
P-value	0.03	0.02	0.04	0.03	0.06	0.05	0.06	0.01

The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 5 Effect of different levels of hatchery waste (HW) on blood parameters in Japanese quail

HW (%)	Glucose	Triglyceride	Cholesterol	LDL	HDL
0	313[a]	282.12[b]	277[a]	25.22[ab]	48.87[b]
2.5	281.87[b]	207.51[d]	225.125[b]	23.59[b]	43.77[b]
5	288.42[b]	298[a]	235.14[b]	28.26[a]	58.88[a]
10	318.51[a]	224.25[c]	188.37[c]	30.99[a]	44.85[b]
SEM	4.27	3.61	3.87	1.73	2.07
P-value	0.03	0.07	0.08	0.02	0.03

The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 6 Effect of different levels of hatchery waste (HW) on microbial population in Japanese quail

HW (%)	Total bacteria	*Lactobacillus*	*Coliform*
0	12.75	7.89[b]	6.35
2.5	13.75	8.87[b]	6.45
5	13.05	9.43[b]	4.85
10	14.12	11.46[a]	4.66
SEM	0.86	0.59	0.73
P-value	0.12	0.04	0.06

The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Regarding the effect of the treatments on blood LDL levels, the results showed that the highest value was for treatment 4 and the lowest value was observed in treatment 2 (P=0.0264). Also, more blood HDL was observed in treatment 3, which was significantly different from other treatments (P=0.0399).

As shown in Table 6, the results related to microbial population are given in Table 6. Supplementation of the ration with different levels of HW did not significantly changed on total bacteria (P=0.12), and coliform (P=0.06). However, the effect of different levels of hatching waste on Lactobacillus population was significant. So that the largest population of Lactobacillus bacteria was for treatment 4, which had a significant difference with other treatments (P=0.04).

Very few studies have been done on the effect of HW on Japanese quail performance. Consequently, other studies in poultry are used for discussion. In a study, Santos *et al.* (2014) reported a gradual rise in total feed consumption when quail were fed rations containing graded levels of hatchery by-product meal up to 15%. This trend was not statistically significant but followed a dose-dependent pattern. In another study of alternative protein sources, Bovera *et al.* (2016) also observed numerically higher feed consumption for birds receiving 15% milled HW compared to controls. Again, differences were non-significant statistically. In addition, other studies show that supplementing the diet of Japanese quail with HW can lead to a significant increase in body weight gain (Shatishkumar *et al.* 2008; Koohi, 2013). However, Batal and Parsons (2002), and Kim *et al.* (2016) evaluated rations containing 5-15% dry hatchery by-product meal fed to broiler chickens. No differences in feed consumption were reported across treatments even at high inclusion levels. One postulation for this seemingly higher intake is that the substitution of HW for conventional ingredients may affect palatability or satiety signaling (Bovera *et al.* 2016). Hatchery residues contain diverse fats, proteins and micronutrients that could influence feeding behaviors if rations are not precisely balanced Similarly, Santos *et al.* (2014) observed a gradual increase in total body weight gain with increasing dietary hatchery meal inclusion up to 15%. Notably, birds fed diets containing 15% hatchery meal exhibited significantly higher weight gain compared to the control group. In another study, Bovera *et al.* (2016) documented numerically higher 22-day gains in quail allotted rations containing 15% milled HW compared to controls, despite non-significant differences. One hypothesis for these gains is that hatchery residues provide a balanced nutritional profile when appropriately incorporated. Proteins, fats, vitamins and minerals in by-products appear to support healthful growth when formulations are optimized (Bovera *et al.* 2016). Research indicates that HW protein has a high biological value and digestibility compared to other protein sources like fishmeal (Khan *et al.* 2001; Koohi, 2013). The impact of hatchery waste on feed intake is influenced by its palatability and digestibility. Research suggests that when quails are offered diets containing HW, their feed consumption may vary based on the inclusion level and the overall formulation of the diet. In addition, body weight gain in Japanese quails is closely linked to both feed intake and the nutritional quality of the diet. This study has demonstrated that quails fed diets containing optimal levels of HW exhibit significant weight gains over time compared to those on control diets. This improvement is attributed to the high protein content, which facilitates muscle development and overall health. However, the results can be completely different based on breed, species, gender and ration.

In a study, Santos *et al.* (2014) reported higher carcass, breast and thigh weights in quail allotted rations featuring graded levels of hatchery by-product meal up to an optimized 15% rate, compared to controls. Differences were significant. In a broiler study, Yang *et al.* (2008) supplemented rations with 5-20% spray-dried hatchery residue and found numerically higher 42-day body weights versus controls at the 10% level, though statistics were not significant. Kiarie *et al.* (2013) examined broiler performance when fed rations featuring 10-20% dried poultry HW inclusion. Birds displayed linear growth in body weight gain and similar results to Santos *et al.* (2014) with quail were reported, though no information on carcass parameters was provided. The increase in carcass weight is achieved as a result of the increase in body weight during breeding. Among the reasons for the difference in the results reported in the studies, we can mention the ration formulation, the composition of HW, animal management factors and the statistical sample population. Overall, the available evidence suggests that careful inclusion of hatchery residues up to 15% in the ration may increase abdominal fat weight and improve breast/thigh muscle performance through overall carcass growth, without altering compartmentation (Santos *et al.* 2014). The results of the present study also confirm this. Bovera *et al.* (2015) examined quail fed rations containing 15-20% milled HW meal. Analysis found no differences in blood parameters concentrations versus controls, suggesting balanced nutrition. In another investigation, Mohamed and Mostafa (2010) supplemented broiler rations with 5 to 10% of dry hatchery residues and the observed plasma glucose levels were affected in feed groups containing under the percentage of dry hatchery residues, so that the highest level of the treatment, there was a high level of percentage of dry hatching residues. Likewise, Al-Khalifa *et al.* (2012) compared serum glucose, cholesterol, HDL and LDL in broilers fed rations containing 5–10% poultry HW, which provided similar results to birds fed conventional rations. Similar results were reported by Mohamed and Mostafa (2010) for broiler chickens that were completed at 5-10% dried hatching residual level of triglyceride, HDL and LDL improvement compared to the control. Based on the variety and composition of nutrients in HW can vary greatly depending on the collection/processing methods used. This affects the formulation of the ration (Yang *et al.* 2008). Also, precise nutrient balancing is required to avoid potential imbalances from substitution ingredients like HW that could influence lipid metabolism (Bovera *et al.* 2016). Furthermore, strain differences, dosage effects and Control of extrinsic factors can affect the experiment results. Parameters like HDL and LDL, which provide a more information of lipoprotein metabolism and cardiovascular health. These metrics would offer stronger insights into potential ration-induced dyslipidemia risks or benefits regarding lipoprotein profiles. More rigorous lipid analyses investigating a range of well-balanced inclusion levels and direct HDL/LDL comparisons are clearly needed before drawing solid conclusions. Optimized formulations may influence these metrics in clinically relevant ways (Mohamed and Mostafa, 2010). Overall, the results of this experiment showed that the presence of healthy fats in hatchery waste can promote higher HDL levels in quails. Diets that include beneficial fatty acids can enhance HDL synthesis and mobilization. This effect is crucial for maintaining cardiovascular health in poultry. On the other hand, the impact of HW on LDL levels may vary depending on its fatty acid composition. Diets high in saturated fats can lead to increased LDL levels, while those rich in unsaturated fats can help maintain or reduce LDL concentrations. The balance of these fats in hatchery waste will determine its overall effect on quail lipid profiles. Maintaining appropriate levels of blood glucose, HDL, and LDL is vital for the overall health and productivity of Japanese quails. Optimal nutrition through the inclusion of hatchery waste not only supports metabolic functions but also enhances growth performance and egg production. However, careful formulation is necessary to ensure that the inclusion rates do not lead to adverse effects on blood metabolism or overall health.

There is limited research directly examining the impact of including HW in quails rations on total bacterial numbers. However, a couple studies in poultry have explored related variables: Yang *et al.* (2008) evaluated the performance of broilers when fed rations containing graded levels (5-20%) of spray-dried hatchery side meal. Analysis found no difference in cecal *Coliform* counts compared to controls up to 10% entry rate. However, the number of faecal lactobacillus increased by 10% in treatments containing dried hatchery side meal compared to the control group. Batal and Parsons (2002) observed consistent maintenance of total aerobic mesophilic bacterial populations in the jejunal contents of broilers provided rations supplemented with 5-15% dried HW. Cruz *et al.* (2018) evaluated the gut microbiota of broilers when rations supplemented with 10–15% dried HW were provided during the weaning and growing stages. The results showed that lactobacillus cecum levels were higher compared to birds with conventional feed formulation. In another study examining alternative protein sources, Bovera *et al.* (2016) found no difference in plant Lactobacillus levels for quail assigned rations containing 5–15% ground HW powder compared to controls. By serving as a fermentation substrate, well-balanced waste formulations seem to favor lactobacilli that assist with digestive health and inhibition of pathogenic bacteria (Yang *et al.* 2008). Correlation of any changes in gut microbiota with measures of host performance further strengthens arguments for the potential of HW in nutrition. Examining the effect of hatching waste on intestinal morphology and immune parameters is also promising (Bovera *et al.* 2016).

According to the results obtained in this research, the inclusion of hatchery waste can lead to a more balanced gut microbiota. A diverse microbial community is essential for optimal digestion and nutrient absorption. By enhancing the population of Lactobacillus, hatchery waste contributes to improved gut health, which can result in better feed conversion ratios and overall performance in quails.

CONCLUSION

In conclusion, HW positively influences feed intake and body weight gain in Japanese quails through its rich nutritional profile and appropriate formulation within their diets. While moderate inclusion levels can enhance growth without negatively affecting feed consumption, careful management is essential to ensure optimal results. Also, HW has a multifaceted influence on blood glucose and lipid profiles (HDL and LDL) in Japanese quails. Its nutritional composition can support better metabolic health when included at appropriate levels in their diets, highlighting its potential as a valuable feed resource in poultry nutrition. In addition, hatchery waste positively influences the population of Lactobacillus bacteria in Japanese quails through its rich nutritional composition and fermentation processes that promote gut health. This enhancement not only supports a balanced microbiota but also contributes to improved overall performance and health outcomes in quail production systems. however, Further research may be needed to explore optimal inclusion rates and formulations that maximize these benefits while ensuring animal welfare.

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