Growth and Laying Performance of Japanese Quail Fed Graded Levels of Hazelnut Kernel Oil Meal Incorporated into Diets*

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ABSTRACT : Two experiments were conducted to evaluate the effect of substituting different levels of hazelnut kernel oil meal (HKOM) for dehulled soyabean meal (DSBM) in diets for Japanese quail. Five diets in which HKOM was replaced with 0, 25, 50, 75 and 100% of DSBM protein in a growing diet for a 5 week period using 450 Japanese quails of initial age of 1 week and in a layer diet for a 112 days period using 180 Japanese laying quails of initial age of 7 week were examined in experiments 1 and 2, respectively. Hence, treatment groups were: control (0 HKOM), 0.25 HKOM, 0.50 HKOM, 0.75 HKOM and 1HKOM. In the experiment 1, 1 HKOM decreased BWG compared with the 0 HKOM and 0.25 HKOM, while it increased FCR compared with the 0HKOM at day 21 ($p<0.05$). Compared with the other groups, 0.75 HKOM and 1 HKOM decreased BWG ($p<0.01$) at day 28. While the FCR of 1 HKOM was higher ($p<0.01$) than that of 0 HKOM, 0.25 HKOM and 0.50 HKOM, respectively, that of 0.75 HKOM was higher than that of 0 HKOM and 0.25 HKOM diets at day 28. However, at day 42 of age, BWG, FCR and the feed intake (FI) were not affected ($p>0.05$) by inclusion of HKOM. Mortality rate, carcase yield and liver, heart and gizzard weight (% of body weight) were not affected ($p>0.05$) by inclusion of HKOM to the diet. In the experiment 2, egg production was decreased ($p<0.05$) by the 1 HKOM diet compared with the 0.50 HKOM diet. While FCR increased by the 1 HKOM diet compared with the 0.25 HKOM and 0.50 HKOM diets ($p<0.05$). Feed intake for quails fed with the 0 HKOM diet was higher ($p<0.05$) than for quails fed with 0.50 HKOM diet. The egg yolk weight for 0 HKOM diet group was lower ($p<0.05$) than for quails in 1 HKOM diet group. In conclusion, the results indicate that DSBM can be replaced by HKOM in diets for growing and laying Japanese quails. However 50% HKOM has higher laying performance than 100% HKOM in the laying period. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 12 : 1789-1794)***

Key Words : Hazelnut Kernel Oil Meal, Growth and Laying Performance, Japanese Quails

INTRODUCTION

In many countries, different types of feeds are used depending on availability and local conditions. Some of these feeds are not cited in the scientific literature, but are used locally. Also seasonal availability and high cost of conventional feed ingredients are major problems often faced by poultry producers, and consequently the formulation of poultry diets can be a difficult task. Consideration is given to the use of unconventional protein ingredients that are locally available and cheaper than soyabean meal (SBM). Hazelnut kernel oil meal (HKOM) is a candidate in this respect in Turkey.

Hazelnut is primarily grown for human consumption in the Black Sea coastal region in Turkey. Turkey produces about 630,000 tons of hazelnut per year (FAOSTAT, 2001), which is 72% of the total world hazelnut production. Hazelnut kernel oil meal is a by-product of the process used to extract oil from hazelnut kernels, and is a potentially less expensive feed ingredient for poultry. HKOM contains 39 to 43% crude protein depending on the oil extraction process. Although HKOM is high in protein, its utilization in poultry feed as a protein supplement is not great. Hazelnut kernel oil meal contains most essential amino acids in adequate amounts for the substitution of SBM in practical diets with the exception of lysine and methionine (Ocak et al., 1994). Methionine and lysine deficiencies may be overcome, however, by using purified synthetic forms, so the possibility exists that HKOM with amino acid supplements will become competitive with SBM in poultry feeds in Turkey.

The first reports on the use of HKOM in broiler diets were published by Gurocak et al. (1982) and Akkilic et al. (1982). While studies by Akkilic et al. (1982) and Gurocak et al. (1982) have shown that SBM could replace up to 10 to 25% of HKOM in broiler diet, respectively, Ozturk et al. (1997) suggested that HKOM could replace up to 50% of dietary SBM in broiler diets without any adverse effects on performance. However, Sehu et al. (1996) fed growing Japanese quails with various levels of HKOM in isonitrogenous and isocaloric diets, and observed that HKOM could replace up to 20% of SBM. A study in layer by Ozen and Erener (1992) showed that SBM could be replaced totally by HKOM.

There has been, to our knowledge, no experiment carried out in laying quails fed with HKOM. The objective of the present study therefore was to evaluate the effect of substituting graded levels of HKOM for DSBM on growth and laying performance of Japanese quails.

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Table 1. Composition of experimental diets

	Experiment 1					Experiment 2				
	HKOM					HKOM				
	0	0.25	0.50	0.75	1	0	0.25	0.50	0.75	1
Maize	58.02	56.00	54.25	51.50	45.00	59.22	56.00	54.10	51.00	48.60
DSBM, 48% CP	34.99	26.25	17.50	8.75	-	28.25	21.02	14.01	7.01	-
HKOM[1]	-	9.79	19.54	29.30	39.07	-	7.82	15.64	23.47	31.28
Fish meal, 66% CP	3.00	3.00	3.00	3.00	3.00	2.00	2.00	2.00	2.00	2.00
Wheat bran	0.67	1.03	1.03	1.70	5.20	0.50	1.63	2.00	3.12	3.87
Soya oil	0.73	1.28	1.78	2.56	4.41	2.17	3.48	4.02	4.92	5.60
Limestone	0.63	0.66	0.65	0.72	0.71	5.08	5.10	5.11	5.18	5.18
Dicalcium phosphate	1.29	1.20	1.17	1.09	0.96	2.08	2.02	1.96	1.90	1.84
Salt (NaCl)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin premix [2]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mineral premix[3]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
L-lysine, 78%	-	0.06	0.30	0.54	0.76	-	0.19	0.38	0.57	0.75
DL-methionine, 99%	0.07	0.13	0.18	0.24	0.29	0.10	0.14	0.18	0.23	0.28
					Composition calculated					
ME, MJ/kg	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56
Crude protein, %	24.00	24.00	24.00	24.00	24.00	20.00	20.00	20.00	20.00	20.00
Lysine, %	1.30	1.30	1.30	1.30	1.30	1.15	1.15	1.15	1.15	1.15
Methionine, %	0.50	0.50	0.50	0.50	0.50	0.45	0.45	0.45	0.45	0.45
Calcium, %	0.80	0.80	0.80	0.80	0.80	2.50	2.50	2.50	2.50	2.50
Available P, %	0.45	0.45	0.45	0.45	0.45	0.55	0.55	0.55	0.55	0.55

[1] Analysis of HKOM (as-fed basis): dry matter, 91.97%; crude protein, 43%; ether extract, 3.01%; crude fiber, 7.84%; ash, 5.98% (all analyzed by Feed Analysis Laboratory, Ondokuz Mayıs University, Agricultural Faculty, Samsun- Turkey); amino acids [(analyzed by The Scientific and Technical Research Council of Turkey (TUBITAK), Marmara Research Center (MRC)- Gebze-Kocaeli-Turkey)]; lysine, 0.99%; methionine, 0.15%; threonine, 0.89%; valine, 1.26%; leucine, 2.77%; isoleucine, 2.82%; cystine, 0.66%; arginine, 4.53%; histidine, 1.07%; glycine, 1.36%; aspartic acid, 4.57%; proline, 0.8%; tyrosine, 0.15%; serine, 1.58%; glutamic acid, 9.38%; alanine, 0.32%.

[2] Vitamin premix provided per kilogram of diet in experiment 1: vitamin A, 10,000 IU; vitamin D_3, 2,500 IU; vitamin E, 10 IU; vitamin K_3, 2 mg; vitamin B_1, 3 mg; vitamin B_2, 5 mg; niacin, 35 mg; Ca-D-pantothenate, 10 mg; vitamin B_6, 5 mg; vitamin B_{12}, 12 mg; folic acid, 0.75 mg; choline chloride, 250 mg. [3] Mineral premix provided per kilogram of diet in experiment 1: manganese, 70 mg; iron, 50 mg; zinc, 30 mg; copper, 10 mg; cobalt, 0.15 mg; iodine, 1.5 mg; selenium, 0.10 mg.

[2] Vitamin premix provided per kilogram of diet in experiment 2: vitamin A, 10,000 IU; vitamin D_3, 2,500 IU; vitamin E, 20 mg; vitamin K_3, 2.5 mg; vitamin B_1, 2 mg; vitamin B_2, 5 mg; niacin, 30 mg; Ca-D-pantothenate, 8 mg; vitamin B_6, 3.5 mg; vitamin B_{12}, 0.015 mg; folic acid, 1 mg; D-biotin, 0.025 mg; vitamin C, 50 mg; choline chloride, 300 mg. [3] Mineral premix provided per kilogram of diet in experiment 2: manganese, 80 mg; iron, 40 mg; zinc, 60 mg; copper, 5 mg; cobalt, 2 mg; iodine, 2 mg; selenium, 0.15 mg.

MATERIALS AND METHODS

Experiment 1 (Growth study)

The effect of HKOM on growth performance was assessed using a total of four hundred and fifty 7 d old (mixed-sex) Japanese quail chicks. One day old Japanese quail chicks were placed in a room with floor battery brooders and fed a commercial starter diet (240 g crude protein with 13.40 MJ ME per kg diet) until the beginning of the experiment. At 7 days of age, chicks were weighed and divided into five groups of similar weight, with three replicates for each group (90 chicks in each treatment group). The chicks were housed in groups in floor pens with wood-shavings (100 cm×100 cm×50 cm) in a completely randomized plan, and the pens were fitted with feeders and waterers. Lighting was provided for 23 h/d throughout the experimental period by 2 flourescent bulbs. Mean ambient temperature was reduced by 3°C per week from 30 to 24°C and the relative humidity was maintained within a range of 60-70%. All diets were offered *ad libitum.* Clean and fresh water was available at all times. The experiment lasted for five weeks.

The experimental diets consisted of a control group and four levels of HKOM replacing 25, 50, 75 or 100% of DSBM protein, respectively. Hence, treatment groups were: control (0 HKOM), 0.25 HKOM, 0.50 HKOM, 0.75 HKOM and 1 HKOM. Composition of experimental diets and their calculated nutrient levels are presented in Table 1. All diets were formulated according to National Research Council (1994) standards. Growth performance was assessed by measuring feed intake (FI) and body weight (BW) weekly and from these data feed conversion ratio (FCR) and body weight gain (BWG) were calculated. Mortality was recorded daily. At the end of the experiment when quails were 6 weeks age, six quails (three male and three females) for each treatment were slaughtered to determine carcase and edible inner organs (heart, liver, gizzard) weight. Carcase yield and edible inner organs were calculated as a concentration of BW (% of BW).

Table 2. The effects of inclusion of hazelnut kernel oil meal (HKOM) in the diet on body weight gain (BWG), feed intake (FI), feed conversion ratio (FCR), mortality, percentage carcase yield and edible inner organs in Japanese quails (experiment 1)

	0 HKOM	0.25 HKOM	0.50 HKOM	0.75 HKOM	1 HKOM	SEM[1]	Level of significance
BWG, g							
Days 7-14	39.4	38.6	37.9	35.6	35.5	0.69	NS
Days 7-21	71.6 [a]	69.7 [ab]	67.9 [abc]	65.9 [bc]	64.1 [c]	0.94	*
Days 7-28	105.5 [a]	104.7 [a]	105.3 [a]	99.8 [b]	100.2 [b]	0.77	**
Days 7-35	127.1	125.0	127.4	126.0	121.6	0.91	NS
Days 7-42	136.2	133.8	136.6	136.1	131.5	0.89	NS
FI, g/bird							
Days 7-14	88.2	87.6	88.8	88.1	87.9	0.57	NS
Days 7-21	207.1	204.1	208.8	204.1	205.5	0.98	NS
Days 7-28	362.5	363.0	370.1	360.1	366.7	1.74	NS
Days 7-35	544.0	541.1	547.6	541.6	537.7	1.98	NS
Days 7-42	739.5	729.2	742.9	733.4	727.2	3.11	NS
FCR, g feed/g BWG							
Days 7-14	2.25	2.27	2.35	2.48	2.50	0.051	NS
Days 7-21	2.90 [b]	2.94 [ab]	3.08 [ab]	3.11 [ab]	3.21 [a]	0.043	*
Days 7-28	3.44 [c]	3.47 [c]	3.51 [bc]	3.61 [ab]	3.66 [a]	0.027	**
Days 7-35	4.28	4.33	4.30	4.30	4.42	0.029	NS
Days 7-42	5.43	5.45	5.44	5.39	5.53	0.027	NS
Mortality, %	1.11	2.22	3.33	1.11	2.22		NS
Carcass yield, %	71.5	71.5	71.5	70.4	70.1	0.53	NS
Edible inner organs							
Heart, g/100 g BW	1.2	1.1	1.0	1.2	1.2	0.41	NS
Liver, g/100 g BW	2.8	2.2	2.6	2.7	2.3	0.10	NS
Gizzard, g/100 g BW	2.1	2.5	2.3	2.6	2.6	0.07	NS

[1] SEM: standard error of the mean. [a, b, c] Means in the same row with different superscripts are significantly different * ($p<0.05$); **($p<0.01$).

Experiment 2 (Layer study)

One hundred and eighty Japanese quails, selected from 450 quails used in the experiment 1, at 7 weeks of age and 50% of an average egg production were allocated to five dietary treatments. Experimental treatments were randomly assigned to a total of 15 cages in a completely randomized plan with one replicate for each treatment at each tier cage (36 quails per treatment). Hazelnut kernel oil meal was incorporated into a standard laying diet for Japanese quails at 0, 25, 50, 75 and 100% of DSBM protein, respectively. Treatment groups in this experiment were control (0 HKOM), 0.25 HKOM, 0.50 HKOM, 0.75 HKOM and 1 HKOM. All diets were isonitrogenous and isocaloric (Table 1). The experiment was conducted in a three-tier cage system, with 12 quails in each cage (120 cm×50 cm×50 cm). The cages were placed in ventilated (naturally and mechanically) and illuminated (artificially and naturally through windows) on cement–flooring. Lighting was provided for 16 h/d (from 8:00 to 24:00 h) throughout the laying period. Feed and water were supplied for *ad libitum* consumption.

Quails were weighed at the beginning and at the end of the experiment to determine body weight change. The study lasted 16 weeks. Egg production (EP) was recorded daily and FI and FCR were calculated for every 28 d. All eggs produced during the last 3 d of every week were saved, and weight per replicate was recorded. Egg quality was estimated by measuring length, width, shape index (width/lenght), shell weight, shell thickness, albumen weight and yolk weight. Shell samples from the top, the middle and the bottom of eggs were measured for thickness using a micrometer, and the mean value of the 3 replicates was used for statistical analysis. Yolk color was measured by the Roche yolk color fan. Mortality was recorded daily.

Metabolizable energy, crude protein lysine, methionine, calcium and available phosphorus of diets were calculated from content of the feed ingredients (NRC, 1994).

Statistical analysis

Growth and laying performance data and egg quality parameters were analyzed using the GLM procedure of SPSS (release 10.0). Differences among treatment means were determined using Duncan's Multiple Range Test. Percentage data were subjected to arcsine transformation before statistical analysis and untransformed means were presented.

RESULTS

Experiment 1 (Growth study)

The growth performance of the quails is shown in Table 2. While 1 HKOM diet decreased BWG of quails compared with the quails in 0 HKOM and 0.25 HKOM diets, it increased FCR compared with the 0 HKOM diet at day 21

Table 3. The effect of inclusion of hazelnut kernel oil meal (HKOM) in the diet on laying performance and egg quality in Japanese quails (experiment 2)

	0 HKOM	0.25 HKOM	0.50 HKOM	0.75 HKOM	1 HKOM	SEM[1]	Level of significance
Production performance, 8-20 weeks of age							
Initial body weight, g/bird	181.4	183.4	187.8	180.1	171.6	2.26	NS
Body weight changes, g/bird/112 days	43.2	41.1	40.8	37.7	54.8	2.86	NS
Feed intake, FI; g/bird/112 days	3,308.8 [a]	3,235.6 [ab]	3,191.2 [b]	3,220.6 [ab]	3,263.3 [ab]	15.65	*
Feed conversion ratio, feed: egg	3.13 [ab]	2.94 [b]	2.92 [b]	3.08 [ab]	3.33 [a]	0.05	*
Egg production, %	88.30 [ab]	87.38 [ab]	89.72 [a]	83.87 [ab]	78.90 [b]	1.52	*
Egg weight, g	11.5	11.9	11.5	11.6	12.0	0.09	NS
Egg quality							
Egg shell weight, g/egg	0.91	0.97	0.94	0.91	0.97	0.10	NS
Egg albumen weight, g/egg	6.92	7.15	6.79	6.95	7.11	0.06	NS
Egg yolk weight, g/egg	3.67 [b]	3.81 [ab]	3.78 [ab]	3.70 [ab]	3.95 [a]	0.04	*
Egg width, cm	2.56	2.59	2.56	2.58	2.60	0.01	NS
Egg length, cm	3.18	3.22	3.18	3.18	3.24	0.01	NS
Shape index, width/length; %	80.47	80.70	80.54	80.76	80.14	0.22	NS
Egg shell thickness, μm	186.2	191.2	189.8	187.4	188.3	1.53	NS
Yolk colour[2]	8.2	8.3	8.4	9.0	9.1	0.14	NS

[1] SEM: standard error of the mean. [2] Roche yolk colour fan. [a, b, c] Means in the same row with different superscripts are significantly different * ($p<0.05$).

($p<0.05$). Compared with the other groups, 0.75 HKOM and 1 HKOM diets decreased BWG ($p<0.01$) at day 28. While the FCR of 1 HKOM diet was higher ($p<0.01$) than that of 0 HKOM, 0.25 HKOM and 0.50 HKOM diets, respectively, that of 0.75 HKOM diet was higher than that of 0 HKOM and 0.25 HKOM at day 28. However, at 42 days of age, BWG, FCR and FI were not affected ($p>0.05$) by the addition of any level of HKOM. During the experimental period, FI was not affected ($p>0.05$) by inclusion of HKOM at different levels. The mortality rate, carcase yield and liver, heart and gizzard weight (% of BW) were not affected ($p>0.05$) by the inclusion of HKOM in the diet.

Experiment 2 (Layer study)

Laying performance and egg quality data are presented in Table 3. Egg production was decreased ($p<0.05$) by the 1 HKOM diet compared with the 0.50 HKOM diet. Feed conversion ratio increased by the 1 HKOM diet compared with the 0.25 HKOM and 0.50 HKOM diets. Feed intake for quails fed the 0 HKOM diet was higher ($p<0.05$) than for quails fed the 0.50 HKOM diet. Egg quality measurements were not different ($p>0.05$) between 0 HKOM and all the other HKOM diets except for egg yolk weight, which was lower ($p<0.05$) for 0 HKOM diet than for quails fed the 1 HKOM diet. There were no differences between treatment groups in terms of mortality (data are not shown). All the birds showed positive growth.

DISCUSSION

The results of the experiment 1 indicated that DSBM could be replaced totally by HKOM in growing diets for Japanese quails. Replacement of DSBM with HKOM at a level of 75 or 100% resulted in a decrease in BWG and an increase in FCR at 21 and 28 d of age. Akkilic et al. (1982), Gurocak et al. (1982) and Ozturk et al. (1997) observed adverse effect on BWG and FCR of broiler chickens with more than 10, 25 and 50 levels of HKOM, respectively, and Sehu et al. (1996) observed adverse effect on the same criteria of Japanese quails with 20% level of HKOM. In general, by-products from the human industry vary widely in nutritional composition. In this particular case, the nutritional composition of the HKOM used in our trial differ from the sample used in previous studies (Akkilic et al., 1982; Sehu et al., 1996). Crude protein and ether extract contents of the HKOM in this study were 10% higher and 20% lower in the studies of Akkilic et al. (1982) and Sehu et al. (1996), respectively. Discrepancies between the studies may also be attributed to differences in the level of vegetable oil content of the diets. For instance, Sehu et al.(1996) used 4.50% and 4.89% vegetable oil in their experimental diets tested in quail, while Akkilic et al. (1982) and Gurocak et al. (1982) did not add vegetable oil, and Ozturk et al. (1997) supplemented their experimental diets with 2.50% and 3.63% vegetable oil in the broilers. However, in experiment of the present study dietary contentration of vegetable oil in the 0 HKOM and 1 HKOM diets were 0.73% and 4.41%, respectively. Mateos and Sell (1980) and Sell and Owings (1981) suggested that the extra caloric effect of fats on ME might be due to a favorable interaction between supplementation of fats and fats inherent in other diet components, and to a beneficial influence of supplemental fats on energy utilization from certain nonlipid dietary components.

The decrease in BWG and increase in FCR at 21 and 28 day with HKOM at a level of 75 or 100% could be attributed to differences in crude fiber, vegetable oil, threonine and anti-nutritive factors of the diets. Dietary crude fiber increased with the addition of HKOM and wheat bran (Table 1), but the diets were isocaloric beacause of the addition of soya oil. Nevertheless, the changes in physical characteristics of such high fiber diets might account for the observed effects on BWG and FCR. For example, high fiber diets are known to increase the rate of feed passage through the gastrointestinal tract (Connell, 1981), and might cause a lowering of actual dietary ME values. High dietary fiber level may also increase sloughing of intestinal epithelial cells, causing an increase in secretion of the mucosa into the intestine and increased losses of endogenous amino acids (Parsons et al., 1983). Diets in present study were prepared by balancing lysine and methionine content. However calculations showed that threonine content of diets was different. Threonine content of growing diets was calculated as 0.95%, 0.87%, 0.78%, 0.69% and 0.59%, respectively. Because threonine is not commercially available in Turkey, synthetic threonine was not added into the diets in present study. Tannins are known to inhibit feed intake and physiological performance of animals. The antinutritional activities of tannins may involve in impaired nutrient utilisation, retarded growth, inhibition of enzymic activity and consequently reduced performance of animals (Mahmood et al., 1997). The work of Sehu et al. (1996) indicated that the content of tannin of HKOM was 5.9 ppm. However, at 42 days of age, BWG, FCR and the FI were not affected by inclusion of HKOM. The older quails were better able to perform with HKOM, which may be explained by the fact amino acid requirements decrease with age (NRC, 1994). In addition to having lowered amino acid requirements, the older chicks may also be better able to digest the HKOM. Thus, decreases in BWG during 14-28 days might have been compensated by all these reasons.

The results of experiment 2 indicate that DSBM can be replaced by HKOM in diets for laying Japanese quails. However 0.50 HKOM diet have higher laying performance than 1 HKOM diet. The results regarding laying performance are in agreement with those in laying hens reported by Ozen and Erener (1992). Depressed EP and increased FCR for quails fed 1 HKOM might be attributed to the amino acid content, especially threonine. Threonine requirement of poultry may vary because of dietary amino acid levels (Ishibashi et al., 1998). Methionine and lysine were also added into the diets in experiment 2, but not threonine, which may result in different dietary amino acid levels of treatment groups. In the present study the threonine content of the 0.50 HKOM diet was 0.14% higher than that of the 1 HKOM diet.

Egg quality did not differ among dietary treatment groups except 1 HKOM diet in which egg yolk weight was increased as compared with 0 HKOM diet. Egg quality measurements are in agreement with the observations of Ozen and Erener (1992) who also reported that HKOM diet did not affect egg quality in laying hens. The increased egg yolk weight in 1 HKOM diet in present study could be attributed to the level of dietary fat and egg weight. In order to keep all diets isocaloric it was necessary to increase the level of fat with the increasing level of HKOM in the diet. In present study, the heaviest egg was obtained from 1 HKOM diet group which was supplemented with soya oil. Grobas et al. (2001) reported that the largest eggs were obtained with the soya oil and linseed oil supplemented diets.

In conclusion, the results of the present study indicated that DSBM could be replaced totally by HKOM in growing and laying diets for Japanese quails, although the numericall values did not favor HKOM expect to 0.50 HKOM. HKOM supplementation to the diet at a level of 50% substitution for DSBM protein increased laying performance compared with 1 HKOM diet. However, results obtained from growing period indicated that HKOM in diet for Japanese quail can not be used over 50% from 14 to 28 d. Because more than 50% of HKOM has adverse effect on BWG and FCR, the use of HKOM in the period of 14 to 28 d should receive special attention. On the other hand, continued investigations of nutritional value of HKOM are needed, and in particular, more information is needed about amino acid availability, and content of anti-nutritional factors.

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