The Effects of Restricted Feeding and Feed Form on Growth, Carcass Characteristics and Days to First Egg of Japanese Quail (*Coturnix coturnix japonica*)*

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ABSTRACT : A study was conducted to determine the effects of restricted feeding and feed form on the growth performance, characteristics of carcass and digestive tract, and days to first egg of Japanese quail (JQ, *Coturnix coturnix japonica*). A total of 240 one-week-old JQ chicks were allocated randomly into 4 experimental groups that consisted of 3 replicates according to a 2×2 factorial arrangement for two feeding methods (*ad libitum*, AF and restricted feeding, RF) and two diet forms (mash, MD and crumble, CD). The JQ chicks were placed in a room with floor battery brooders and fed a commercial starter diet from 7 to 14 d of age. According to the experimental design, four treatments (1: *ad libitum* MD, 2: restricted MD, 3: *ad libitum* CD, and 4: restricted CD) were applied. Feed restriction was applied by 30% reduction of *ad libitum* feed intake for both MD and CD from 15 to 28 d of age. All birds were fed *ad libitum* with treatment diets from 29 d of age until the first laid egg seen (45 d of age). The commercial starter diet, MD and CD were in the same nutrient content (240 g crude protein with 13.4 MJ ME per kg diet). The body weight and overall feed conversion ratio (g feed/g gain) were higher ($p<0.05$) for the AF quails than the RF at 42 d of age. Carcass weights, dressing percentage and percentage yields of breast and back were similar for AF and RF groups at 42 d of age. The RF delayed ($p<0.05$) onset of egg production 2 days compared to the AF. Quail fed with the CD showed higher value ($p<0.05$) for carcass weight and dressing percentage at 42 d of age compared to birds fed with the MD. The interaction effect of feeding method×feed form on any of the studied parameters was not significant. The results suggest that feed restriction as in the present study can achieve a better feed conversion without reduction in carcass weight, and a significant benefit of feeding the crumble diet over the mash diet was obtained in terms of carcass weight in the JQ. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 10 : 1479-1484)***

Key Words : Quail, Growth Performance, Feed Restriction, Diet Form, Sexual Maturity

INTRODUCTION

Commercial poultry have certain behavioural, physiological, and even anatomical traits that may require consideration when manufacturing compound feed. Therefore, it has been recognized for many years that providing feed restricted in quantitative or qualitative (Yu and Robinson, 1992), or in the form of pellets or crumbles (Plavnik et al., 1997) to poultry could enhance the economics of production by improving feed conversion and growth rates.

Several studies have investigated the effect of feed restriction in different age period (Zubair and Leeson, 1994; Sabine et al., 1995; Lee and Leeson, 2001; Hassan et al., 2003; Zulkifli, 2003) or feed form (Hamilton and Proudfoot, 1995a, b; Preston et al., 2000) on the performance of meat birds. Though previous studies revealed that the feed restriction and diet form in poultry are critical for good performance in terms of growth rate and feed efficiency. However, information on the effects of feed restriction at the middle age and diet form combination on growth performance and onset of egg production of poultry, especially quails are scarce. Japanese quail (JQ, *Coturnix coturnix japonica*) that reach sexual maturity rapidly (6 or 7 wk of age) may be less adversely affected by feed restriction than chickens, which require a longer growing period to maturity (Sabine et al., 1995; Hassan et al., 2003). Therefore, the experiment reported herein aimed to determine the effects of restricted feeding from 15 to 28 days of age and feed form on growth, carcass traits and days to first egg of JQ.

MATERIALS AND METHODS

A total of 240 one-week-old JQ chicks were allocated randomly into 4 experimental groups according to a 2×2 factorial arrangement for two feeding methods (*ad libitum*, AF and restricted feeding, RF) and two diet forms (mash, MD and crumble, CD). According to the experimental design, four treatments (1: *ad libitum* MD, 2: restricted MD, 3: *ad libitum* CD, and 4: restricted CD) were applied. The JQ chicks were placed in a room with floor battery brooders and fed a commercial starter diet (240 g crude protein with 13.4 MJ ME per kg diet) from 7 to 14 d of age. Each

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Table 1. Compositions of the experimental diets for both crumble and mash diets

Ingredients	g/kg	Calculated nutrient content per kg experimental diet	
Yellow corn	408.7	Crude protein (g)	239.7
Soybean meal	226.7	Metabolizable energy (MJ)	13.4
Full fat soybean	120	Lysine (g)	18.3
Wheat	100	Methionine (g)	5.1
Sunflower meal	60	Calcium (g)	7.5
Meat and bone meal	30	Available phosphorus (g)	4.8
Fish meal	20		
Vegetable oil	20		
Dicalcium phosphate (DCP)	5.5		
Vitamin and mineral premix [a]	2		
Salt	2.5		
Limestone	2.5		
DL-methionine	1.1		

[a] (per kg diet) vit. A 1,200,000 IU, vit. D_3 160,000 IU, vit. E 1,600 mg, vit. K_3 400 mg, vit.B_1 200 mg, vit. B_2 600 mg, vit. B_6 400 mg, vit. B_{12} 8 mg, vit. C 4,000 mg, Biotin 4 mg, Folic acid 60 mg, Calcium D-pantotenat 800 mg, Choline chloride 80,000 mg, Niacin 2,000 mg, Manganese 8,000 mg, Iron 3,000 mg, Zinc 6,000 mg, Copper 500 mg, Cobalt 50 mg, Iodine 200 mg, Selenium 20 mg.

treatment group consisted of 3 replicates. Each of them included 10 male and 10 female quails resulting a total of 30 male and 30 female quails for each treatment group. The quail chicks were reared in floor pens with wood-shavings (85×75×75 cm) during the 45 days experimental period. The pens were fitted with feeders and winterers. Lighting was provided for 23 h per day throughout the experimental period by 2 fluorescent 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%. Feed restriction was applied by 30% reduction of *ad libitum* feed intake for both MD and CD from 15 to 28 d of age. All birds were fed *ad libitum* with treatment diets from 29 d of age until the first laid egg seen. Therefore, birds were maintained until 45 d of age to obtain first-egg data. Clean and fresh water was accessible at all time. Both MD and CD were in the same nutrient content as presented in Table 1.

Body weight and total feed intake data were determined on 14, 28 and 42 d of age. Quail were individually weighed and mortality was recorded as it occurred. To determine days to first egg, age at the first egg was recorded (Dunnington and Siegel, 1984). Feed conversion ratio (g feed/g gain) was calculated from body weight and feed consumption data. To determine the growth rate of digestive tract and gizzard, and carcass components (breast, back and thighs) of JQ, on 28 and 42 d of age, 4 quails (2 male and 2 female) from each replicate (a total of 12 quails from each treatment) with body weight within 1 standard deviation of the mean treatment weight were slaughtered. Gut was weighed with its content (full gut), while gizzard was weighed after removing its content digesta. Dressing percentage and weights of organs were calculated as a percentage of body weight (g/100 g body weight). For chemical analysis, raw meat from the right breast and thighs was finely minced in a blender. Samples were stored at -20°C until further analysis. Dry matter, protein and fat contents of carcass were determined according to AOAC (1990) methods.

Data were analysed using the GLM procedure (SPSS Inc. 1999). Body weight, feed intake, feed conversion ratio and carcass characteristic were studied by analysis of variance, including the effects of feeding method and feed form and their interaction. When the F-test was significant, least squares means were compared. All percentage data were converted to arcsines prior to analysis. Mortality was analyzed by chi-square.

RESULTS AND DISCUSSION

The effects of feed restriction on growth parameters are given in Table 2. The interaction effect of feeding method× feed form on any of the studied parameters was found no significant. Feed restriction caused a reduction in body weight gain during the period of feed restriction. Therefore, body weight of the RF was lower than that of the AF both on 28 d (27.7%; $p<0.01$) and 42 d of age (5.6%; $p<0.05$). While overall body weight gain of the AF from 15 to 28 d of age was greater (56.1 vs. 20.1 g; $p<0.01$), from 29 to 42 d of age it was lower (55.7 vs. 81.1 g; $p<0.01$) than that of the RF. These results show that the feed restricted JQ from 15 to 28 d of age were unsuccessful to make compensatory growth. An increase in body weight gain of the RF birds during re-feeding period confirms the results of Susbilla et al. (1994) who showed growth rates of restricted broilers during that period (12 to 39 d of age) were higher than that of the full fed birds. During the restriction period, feed consumption of the RF quails was 67% ($p<0.01$) of that of the AF birds. The total feed consumption of the RF group was 12% less ($p<0.01$) than that of the full fed birds on 42 d of age (Table 2). From 15 to 28 d of age, the RF increased feed conversion ratio ($p<0.01$), while it decreased ($p<0.01$) from 29 to 42 d of age and thus, overall feed conversion ratio was higher ($p<0.05$) for the AF group than the RF group on 42 d of age. During the restriction period, the

Table 2. The body weight (BW), feed consumption (FC), feed conversion ratio (FCR) days to first egg and first egg weight of Japanese Quails (*Coturnix c. japonica*) subjected to feed restriction from 15 to 28 days of age and fed on mash and crumble diet

		Feeding methods		Feed form		SEM	Main effects	
	Age, d	*Ad libitum*	Restricted	Mash	Crumble		Method	Form
BW (g)	14	74.0	73.9	74.0	73.9	0.64	NS	NS
	28	130.7	94.5	111.7	113.4	1.13	**	NS
	42	186.4	176.0	179.7	182.9	1.51	*	NS
FC (g)	14-28	237.5	159.4	195.9	200.9	1.99	**	NS
	28-42	434.8	421.2	427.5	428.6	3.76	NS	NS
	14-42	672.3	580.6	623.4	629.5	4.15	*	NS
FCR (g feed/g gain)	14-28	4.25	7.91	5.76	6.15	0.425	**	NS
	28-42	7.81	5.18	6.39	6.50	0.206	**	NS
	14-42	5.98	5.69	5.89	5.78	0.055	*	NS
Days to first egg		42.0	44.0	42.6	42.9	0.62	*	NS
First egg weight		8.8	8.9	8.7	9.1	1.20	NS	NS

SEM: standard error of the mean. NS: p>0.05, * p<0.05, ** p<0.01.

Table 3. The slaughter yield (g) and cut-up parts (g or cm/100 g body weight) of Japanese quail (*Coturnix c. japonica*) subjected to feed restriction from 15 to 28 days of age and fed on mash and crumble diet

	Feeding methods		Feed form		SEM	Main effects	
	Ad libitum	Restricted	Mash	Crumble		Method	Form
28 d of age							
Carcass weight	95.7	63.7	78.4	81.2	0.35	**	NS
Dressing percentage	70.7	66.2	68.6	68.4	0.34	**	NS
Breast weight	27.7	24.3	25.9	26.3	0.27	**	NS
Back weight	16.2	14.9	15.8	15.6	0.21	**	NS
Thighs weight	16.4	15.6	16.1	16.0	0.16	*	NS
Empty gizzard weight	2.8	3.5	3.4	3.0	0.11	**	*
Full gut weight	9.0	10.9	9.9	9.9	0.28	**	NS
Full gut length	49.7	63.2	54.6	58.3	0.74	**	NS
42 d of age							
Carcass weight	130.6	128.7	124.9	134.5	2.44	NS	*
Dressing percentage	69.6	71.8	69.1	72.3	0.83	NS	*
Breast weight	27.5	28.4	27.4	28.6	0.32	NS	NS
Back weight	18.0	16.9	16.8	18.1	0.40	NS	NS
Thighs weight	14.9	16.5	15.4	15.9	0.26	**	NS
Empty gizzard weight	2.1	2.5	2.4	2.2	0.07	*	NS
Full gut weight	9.3	9.5	9.7	9.6	0.23	NS	NS
Full gut length	39.4	40.3	41.0	38.8	0.69	NS	NS

SEM: standard error of the mean. NS: p>0.05, * p<0.05, ** p<0.01.

restricted birds had very high feed conversion ratio, which could be due to a high % of the feed being used for maintenance (Hassan et al., 2003). However, during re-feeding period the control group had very low feed conversion. This can be explained by the fact that quail is notorious for high feed wastage (Wang et al., 2003).

The results reported here for body weight and feed efficiency disagree with the previous observations in quail (Sabine et al., 1995; Hassan et al., 2003). However, in many feed restriction studies, similar observations have been reported for body weight and feed efficiency of broiler (Palo et al., 1995; Mazzuco et al., 1999; Lippens et al., 2000; Mazzuco et al., 2000). In the present study, inability of quails to achieve compensatory growth may be attributed to the quail strain and severity, timing and duration of feed restriction (Yu and Robinson, 1992; Zubair and Leeson, 1999). On the other hand, Deaton (1995) showed that feed restricted broilers (feed restricted to 60 and 75% of normal), with a significant weight reduction as much as or greater than 17 or 18% on 14 d of age, were unable to equate the weight of the full fed control group by 41 d of age. However, Hassan et al. (2003) showed that feed restricted JQ (feed restricted to 70% of normal), with a 16% weight reduction on 35 d of age, were able to attain the weight of the full fed control group by 42 d of age. The body weight reduction (27.7%) of the RF quail on 28 d of age in the present study is greater than previously reported (Deaton, 1995; Hassan et al., 2003).

Carcass weights, dressing percentage and percentage yields of breast and back were higher (p<0.01) for the AF group than the RF group on 28 d of age but not on 42 d of age (Table 3). The relative thighs weight of the RF group

Table 4. The Dry matter, protein and fat contents (%) of carcass from Japanese quail (*Coturnix c. japonica*) subjected to feed restriction from 15 to 28 d of age and fed a mash or crumble feed

	Feeding methods		Feed form		SEM	Main effects	
	Ad libitum	Restricted	Mash	Crumble		Method	Form diet
28 d of age							
Dry matter	24.29	23.34	24.43	24.20	0.187	*	NS
Protein	20.76	20.36	20.15	21.02	0.196	NS	*
Fat	2.31	1.76	2.12	1.95	0.166	NS	NS
42 d of age							
Dry matter	27.33	26.77	26.71	27.40	0.221	NS	NS
Protein	20.37	20.00	20.10	19.91	0.093	*	NS
Fat	5.70	5.82	5.29	6.20	0.270	NS	*

SEM: standard error of the mean. NS: p>0.05, * p<0.05, ** p<0.01.

was lower (p<0.05) than that of the AF on 28 d of age, while it was higher (p<0.01) on 42 d of age. On 28 d of age, the relative weight of empty gizzard and full gut, and relative length of full gut was lower (p<0.05) for the AF quails compared to the RF birds. Susbilla et al. (1994) also noted that relative weight of digestive tract of restricted broilers at the end of restricted period was higher than that of the control group. Although gut development was nearly normal even under very low nutritional status (Picard et al., 1999), the relative weight of empty gizzard was greater (p<0.05) for the RF quails than the AF birds on 42 d old (Table 3). Increased relative weight of supply organs may be adaptation to feed restriction. Adaptation to feed restriction includes increased capacity and slower evacuation of the gastrointestinal tract to increase the supply of nutrients during the periods of feed deprivation (Nir et al., 1996).

The results with respect to slaughter yield and cut-up parts show that carcass components responded more quickly to realimentation than the whole body. Uncompleted body weight recovery when comparing full fed quails with restricted birds without any concomitant reduction in the carcass weight and dressing percentage may be attributed to the relative weight and length of full gut, because the increased weight of the empty digestive tract may have contributed to the ability of chickens to achieve compensatory growth (Susbillah et al., 1994). Thus, compensatory growth of visceral organ tissue can be account for a small percentage of the overall tissue weight gain in the compensating animals. The majority of the gain is a result of an increased muscle mass, the most saleable portion of the animal carcass. No reduction in the carcass weight and dressing percentage of restricted birds was observed (Table 3).

The dry matter content of carcass on 28 d of age and protein content of carcass on 42 d of age were lower (p<0.05) for the RF quails than the AF birds (Table 4). Feed restriction did not affect the carcass fat content in JQ, but decreased the protein content. No significant differences in carcass fat content between restricted and full fed birds has been reported (Lippens et al., 2001); however, others (Donaldson, 1990; Deaton, 1995) have reported reduced carcass fat content of restricted broilers compared to full fed birds. These may be due to low rates of protein turnover, depending on fat content of carcass and ageing of birds (Dibner and Ivey, 1990; Donaldson, 1990).

Feed restriction delayed (p<0.05) the onset of egg production 2 days without affecting the first egg weight compared to *ad libitum* fed JQ pullets (Table 2). However, due to their early age of sexual maturity, quail may also exhibit an accelerated growth following early feed restriction in order to obtain the minimum body weight required for sexual maturity (Hassan et al., 2003). The results with respect to first egg weight confirm previous reports (Sabine et al., 1995; Hassan et al., 2003) that early feed restriction did not affect first egg weight in quail. In the present study, reduced body weight of restricted quail might have delayed onset of egg production, because body weight and body fat of birds are important factors as the primary determinant for onset of lay (Dunnington and Siegel, 1984; Brody et al., 1984; Kwakkel et al., 1995). A lack of nutrients during the growing period might also delay the initiation of egg production (Kwakkel et al., 1995). In fact, feed restriction may affect negatively the chicks' attainment of body mass and the achievement of female sexual maturity in two lines of JQ (Van der Ziel et al., 2001). In practice, delayed the onset of egg production may play a role in maintaining of peak production and reduction of prolapse problems (Kwakkel et al., 1995). Indeed, Hassan et al. (2003) suggested that feed could be restricted to 85 or 70% of *ad libitum* feed consumption from 14 to 35 d of age without detrimentally affecting egg production and reproductive parameters of JQ from 42 to 91 d of age. However, Kirikci et al. (2004) reported that live weight of pheasant hens is not an important factor to obtain high egg production in pheasants.

Means for body weight, feed consumption and feed conversion ratio at 28 and 42 d of age and for days to the first egg, indicate that there are no significant differences between diet forms (Table 2). Pelleted diets increase carcass yield (Jensen, 2000) and decrease the relative gizzard weight compared with mash feed (Plavnick et al., 1997). In the present study, quail fed with the CD showed higher value for carcass weight ($p<0.05$) and dressing percentage ($p<0.05$) on 42 d of age, and lower value for empty gizzard weight on 28 d of age. The protein content of quail carcass was lower for the MD than the CD (Table 4). It is also known that the anatomy of the digestive system is affected by feed particle size (Nir et al., 1995), which could impact nutrient absorption (Choi et al., 1986).

Diets fed to broiler chickens usually are in pellet or crumble form due to the positive effects on growth rate (Douglas et al., 1990; Nir et al., 1994; Hamilton and Proudfoot, 1995b; Wahlström et al., 1999; Preston et al., 2000) and efficiency of gain (Plavnik et al., 1997) compared with mash diet. These may be a result of better nutrient availability (Douglas et al., 1990; Wahlström et al., 1999; Kilburn and Edwards, 2001) and an increase in daily nutrient intakes (Hamilton and Proudfoot, 1995a). However, no differences in body weights and feed efficiency between quails fed with the MD and CD groups were observed (Table 2). This can be due to probably cereals used in the feed mixture and differences in nutrient flow and absorption depending on avian strain and species, which may be different in relative size of the gut (Wahlström et al., 1999). No significant differences in mortality between feeding methods (1.67 and 5.00% for the AL and RF) or diet forms (3.00 and 5.00% for the MD and CD) were observed.

In conclusion, the results suggest that feed restriction as in the present study can achieve a better feed conversion without reduction in carcass weight, and a significant benefit of feeding the crumble diet over the mash diet were obtained in terms of carcass weight in the JQ. Further research is required to determine the role of the delayed initiation of egg production in maintaining peak production and reduction of prolapse problems if the restricted quails were used for the egg production, and final body weight according to the desired carcass weight, taking into account the differences between the diet and quail price in markets.

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