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Effect of Supplementing Spirulina on Live Performance, Carcass Composition and Meat Quality of Japanese Quail

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Abstract

This study was conducted to evaluate the effects of different levels of Spirulina (*Arthrospira platensis*) inclusion in feed on live performance, carcass composition and meat quality of Japanese quails during growing stage to identify the best inclusion range for Japanese quails without affecting the growth and carcass parameters. Three hundred Japanese quails of 15 days of age were used in this experiment, randomly divided into 5 groups with 3 replication comprised of 30 males and 30 females. The quails were fed with a basal diet as a control and 4 levels of Spirulina inclusion diet 1, 2, 4 and 8 %. Diets were fed to birds from 15 days to 35 days of age. Body weight gain (BWG), Feed intake (FI), Feed conversion ratio (FCR) and Mortality rate (MR) were recorded weekly during the experiment. Carcass composition and meat quality tests were done after slaughtering. BWG, FI, FCR and MR were significantly different ($p < 0.05$) in the experiment. Carcass composition was found to be significantly different in the leg percentage ($p < 0.05$). Meat color and meat shear force value were also found to differ significantly ($p < 0.05$) with the Spirulina inclusion diet showing a better result than the control. Therefore, the result of this experiment suggests that diets up to 4 % of Spirulina achieve the best live performance, carcass composition and meat quality.

Keywords: Spirulina, Japanese quails, feed conversion ratio, meat color, shear force value

Introduction

Quail production in Malaysian poultry industries is increasing due to the fact that breeders have started to realize the benefits of growing quails as the consumption rate in poultry meat is expected to increase in the future. Quails have fast growth rates, can be reared in a limited space and there is growing interest from consumers.

The efficiency of feed conversion into meat production has been emphasized by large-scale integrators or small-scale farmers especially with the increasing pressure to purchase good quality raw materials at a reasonable price. One of the most expensive and deficient compounds of feed for livestock is the protein source [1]. In recent years, poultry farmers have experienced a sharp increase in the price of raw ingredients for feed. Commodity prices for materials particularly fishmeal and soya bean, important ingredients in feed, has increased tremendously over the year. Alternative replacements for these raw materials is of prime importance.

Meat quality is defined by a combination of many factors; however, consumers attach a special importance to color and texture [2]. Color is the main aspect that attributes to consumer acceptance of many food products, including poultry meat. Indications that the tenderness, freshness, leanness, healthy and nutritious meat [3] are regarded as important aspect for consumers in determining their choice of

meat [4,5]. The soft and tender taste of poultry meat distinguishes it from beef, mutton, pork and it contributes to the level of preference and consumption of chicken meat. However, no data on quail diet in improving meat color and meat texture has appeared.

Many years ago, *Arthrospira platensis* (henceforth called Spirulina) was used as a partial replacement for soybean meal, fishmeal and groundnut meal in the feed preparation for poultry, cattle, fish and domestic animals [6-8]. Dried Spirulina contains about 60 % of protein content which distinguishes it as a new animal feed [9]. The use of microalgae as a supplement has been recommended to benefit poultry involving growth, survival, feed utilization and carcass quality. Studies have suggested a role for microalgae in broilers for good growth and feed efficacy [10] and eventually resulting in a satisfactory improvement in growing chicken [11]. Spirulina has been cited as containing heavy metals poisoning, but this is very dependent on where the Spirulina is produced. Fortunately, heavy metal toxicity from Spirulina is uncommon with improvement in culturing and harvesting methods, avoiding external contamination. Toxicological studies of the effects of Spirulina consumption on animals have shown no toxic effects and easy digestion [12,13]. Although the use of Spirulina in animal production shows a promising future, the optimal level of Spirulina in an animal diet remains controversial [14]. Based on previous research on Spirulina in a poultry diet [6,15,16], the range of inclusion rate was identified to be from 0.5 to 12.5 %. Nevertheless, and optimum range of Spirulina inclusion has yet to be identified in a quail diet.

Therefore, this study aims to evaluate the effects of different levels of Spirulina inclusion in feed on live performance, carcass composition and meat quality of Japanese quails to further identify the best inclusion range for Japanese quails without affecting the growth and carcass parameters.

Materials and methods

Birds and diets

Spirulina was produced in a tank in a sheltered area and harvested at the Biology Department, Universiti Putra Malaysia. It was cultured with kosaric media [17] under aerated conditions. Spirulina was then oven dried and crushed into powder before formulating into the diet for this experiment. A total of 300 quails were selected based on an average weight of 70 g and were randomly divided into 5 treatments groups, where each treatment consisted of 60 quails, being made up by 30 males and 30 females, divided into 3 replicates. The feeding trial with Spirulina lasted for 21 days, starting from day 15 until day 35 prior to slaughtering. The nutrient composition of feed mixtures and experimental treatments were shown in **Table 1**. The diets were formulated with a corn-soybean meal base without fishmeal. Spirulina was included into diet by substituting the soybean meal content. The control diet and experimental diets with 1, 2, 4 and 8 % of Spirulina were fed ad libitum.

Measurement, slaughter and carcass sampling

The weekly weight gain of quails and feed intake were taken at the end of each week. The mortality was recorded daily and rectified as mortality rate (MR) per weekly basis. The feed conversion ratio (FCR) was calculated based on the weekly weight gain and weekly feed consumption.

At the end of the period, 24 males and 24 females from each treatment were picked randomly, weighed and slaughtered. The weight of the carcass, breast and legs of each quail was measured separately. The color characteristics were analyzed using fresh *pectoralis major* muscle samples. The color characteristics were recorded as Lightness (L*), redness or red-green scales (a*) and yellowness or yellow blue scales (b*). Meat tenderness was objectively measured by shear force analysis based on the mechanical force required to shear the muscle fibers of a cooked meat sample.

Statistical analysis

The obtained data were subjected to statistical analysis using the General Linear Model (GLM) procedures by statistical software, SPSS and significant differences among the means of treatment were determined by using Duncan multiple range test [18].

Table 1 Nutrient composition of experimental diets.

Ingredient (%)	Treatment [1]				
	A	**B**	**C**	**D**	**E**
Corn	51.55	51.73	51.84	51.52	51.58
Soybean meal	43.39	42.18	40.71	38.94	34.72
Spirulina	0	1.00	2.00	4.00	8.00
Palm oil (refine cooking oil)	2.5	2.51	2.81	2.90	2.99
Limestone	1.54	1.53	1.56	1.54	1.56
Dicalcium phosphate (DCP)	0.33	0.36	0.39	0.41	0.46
Salt	0.25	0.25	0.25	0.25	0.25
Vitamin premix*	0.12	0.12	0.12	0.12	0.12
Mineral premix**	0.12	0.12	0.12	0.12	0.12
L-lysine	0.1	0.1	0.1	0.1	0.1
DL-methionine	0.1	0.1	0.1	0.1	0.1
Total %	100	100	100	100	100
Calculated values					
DM %	89.04	88.59	88.41	89.02	89.07
CP %	24.12	24.15	24.1	24.11	24.15
ME (kcal/kg)	2916	2919	2916	2915	2915
Lys %	1.37	1.36	1.37	1.37	1.36
Met %	0.76	0.77	0.77	0.77	0.76
Ca %	0.82	0.82	0.83	0.83	0.83
Total P %	0.47	0.47	0.48	0.47	0.478
Analyzed values					
CP %	24.05	24.07	24.05	24.04	24.06
ME (kcal/kg)	2928	2932	2926	2930	2932

[1]A-Basal diet-control
B-Diet with soybean substituted by 1 % Spirulina
C-Diet with soybean substituted by 2 % Spirulina
D-Diet with soybean substituted by 4 % Spirulina
E-Diet with soybean substituted by 8 % Spirulina
DM is dry matter, CP is crude protein, ME is metabolism energy, Lys is lysine, Met is methionine, Ca is Calcium, P is phosphorus.

*The vitamin premix provides the following amount per kg of diet: Vitamin A 50.0 MIU, Vitamin D_3 8.0 MIU, Vitamin E 200 g, Vitamin B_2 20.0 g, Vitamin B_6 20.0 g, Vitamin B_{12} 1.0 g, Vitamin K_3 10.0 g, Biotin 0.8 g, Panthothenic acid 80.0 g, Folic acid 10.0 g, Niacin 130.0 g, Anticaking agent 20.0 g and Antioxidant 0.2 g.

**The mineral premix provides the following amounts per kg of diet: Mn 20.0 g, Fe 80.0 g, Zn 80.0 g, Cu 10.0 g, Co 0.2 g, I 0.3 g and Se 0.3 g.

Results and discussion

Body weight gain (BWG), Feed intake (FI), Feed conversion ratio (FCR), bird mortality rate (MR), carcass composition and meat quality of quails are shown in **Tables 2 - 4**.

Table 2 The effect of Spirulina diet on the live performance in quails.

Parameter		Treatment				
		A	**B**	**C**	**D**	**E**
BWG (g)	Week 3	69.03±0.64^{c}	71.51±1.53^{c}	75.65±0.20^{a}	74.47±1.70^{ab}	71.90±0.29^{bc}
	Week 4	25.64±1.43^{d}	31.44±2.33^{c}	41.29±1.78^{b}	49.56±0.16^{a}	49.30±0.20^{a}
	Week 5	23.19±0.63^{c}	24.19±2.36^{c}	37.19±3.16^{b}	47.01±4.32^{a}	37.15±0.15^{b}
	Whole period	117.87±1.45^{d}	127.14±6.23^{c}	154.12±4.77^{b}	171.03±6.17^{a}	158.35±0.64^{b}
FI (kg)	Week 3	3.44±0.05^{c}	3.69±0.11^{ab}	3.79±0.03^{a}	3.66±0.02^{b}	3.64±0.02^{b}
	Week 4	1.89±0.03^{e}	2.39±0.03^{d}	3.11±0.03^{c}	3.46±0.01^{b}	3.53±0.02^{a}
	Week 5	2.03±0.02^{d}	2.14±0.02^{c}	3.12±0.02^{b}	3.85±0.02^{a}	3.14±0.01^{b}
	Whole period	7.37±0.05^{e}	8.19±0.03^{d}	10.02±0.02^{c}	10.97±0.04^{a}	10.31±0.01^{b}
FCR	Week 3	2.53±0.01^{b}	2.61±0.02^{a}	2.60±0.01^{a}	2.54±0.02^{b}	2.52±0.01^{b}
	Week 4	4.10±0.01^{a}	4.05±0.03^{b}	3.97±0.01^{c}	3.69±0.02^{d}	3.68±0.02^{d}
	Week 5	5.10±0.01^{a}	4.88±0.02^{b}	4.54±0.01^{c}	4.49±0.01^{d}	4.55±0.01^{c}
	Whole period	3.38±0.01^{a}	3.36±0.00^{b}	3.36±0.00^{b}	3.32±0.00^{c}	3.36±0.01^{b}
MR (%)	Week 3	11.67±2.89^{a}	6.67±2.89^{ab}	3.33±2.89^{b}	3.33±2.89^{b}	3.33±2.89^{b}
	Week 4	1.85±3.20^{ab}	3.51±3.04^{a}	1.67±2.89^{ab}	0±0.00^{b}	0±0.00^{b}
	Week 5	1.85±3.20	0±0.00	0±0.00	0±0.00	0±0.00
	Whole period	5.12±3.10^{a}	3.39±1.98^{ab}	1.67±1.92^{b}	1.11±0.97^{b}	1.11±0.97^{b}

*Means ± SD with different letters in row on each category implies significant differences ($p < 0.05$).

Table 3 The effects of Spirulina diet on carcass, breast and legs percentage (%) of quail's carcass.

Parameters	Treatment				
	A	**B**	**C**	**D**	**E**
Carcass (%)	71.87±3.10	70.83±3.18	71.15±2.45	71.16±2.81	71.02±2.41
Breast (%)	40.44±2.57	39.94±3.18	39.81±3.30	40.76±2.28	41.03±2.44
Legs (%)	32.39±1.53^{a}	32.42±2.54^{a}	31.50±2.16^{c}	31.64±1.47^{b}	30.77±1.69^{c}

*Means ± SD with different letters in row implies significant differences ($p < 0.05$).

Table 4 Mean CIE lightness (L*), red/green axis (a*), yellow/blue axis (b*) colour parameters and shear force value (kg) of breast *pectoralis major* of quails.

Parameters	Treatment				
	A	B	C	D	E
L*	44.88±3.36	46.28±3.38	45.35±2.44	45.67±3.24	45.32±2.18
a*	9.69±1.71^{b}	10.50±1.98^{a}	10.68±1.33^{a}	11.11±1.52^{a}	11.29±1.82^{a}
b*	17.52±1.31^{d}	18.15±1.30^{c}	18.46±1.29^{bc}	18.79±0.93^{ab}	19.11±0.88^{a}
Shear force value (kg)	1.58±0.58^{a}	1.42±0.62^{ab}	1.41±0.60^{ab}	1.39±0.61^{b}	1.29±0.50^{c}

*Means ± SD with different letters in row implies significant differences ($p < 0.05$).

Body Weight gain and Feed Intake

Quails fed with Spirulina treatment displayed better weight gain across the week ($p < 0.05$). The weekly feed intake was recorded proportionally with the body weight obtained in quails. Feed intake increased significantly with the Spirulina treatment compared to the control diet ($p < 0.05$). Feeding of Spirulina gave an optimum performance at 4 % inclusion. Results clearly showed that supplementation exceeding 4 % level demonstrated adverse effects on growth, which is in agreement with previous findings [10]. This is a common phenomenon in animal nutrition that a certain animal has its own optimal dietary requirement. Previous studies have reported that the optimum level of Spirulina substitution on other protein source resulted in satisfactory performance as depressed growth is observed at higher levels of inclusion [6].

Feed conversion ratio

The FCR in quails with 4 % Spirulina (3.32) was also better ($p < 0.05$) than other treatment groups including the control group with a recorded FCR of 3.38. Supplementation exceeding 4 % is beyond what the quail can take physiologically or biologically manifested in a slower growth. Feed consumption was significantly greater in the quails fed on Spirulina and paralleled to body weight increment. Results showed a marked improvement in FCR in quails fed on Spirulina. The Spirulina diet led to improved efficiency of feed utilization [10,19]. A tremendous feed consumption with better feed efficiency was manifested towards positive growth by healthy quails fed on Spirulina. These results are in agreement with the findings of previous studies, that the addition of Spirulina to the diet improved the feed conversion of poultry [10,15,19].

Mortality rate

Spirulina inclusion into diet showed a significant reduction in the MR in quails ($p < 0.05$) during the trial period. The MR in the beginning of trial during the transition of the starter diet to the control diet and treatment diet were higher. Multifactorial conditions including stress, feather pecking and attacking each other during competition for feed [20] caused injuries and resulted in mortality. The MR was greatly reduced when quails were fed on Spirulina at 2 % and above ($p < 0.05$). The control group reported a total mortality of 5.12 %, diet with 2 % of Spirulina inclusion recorded 1.67 % and when the Spirulina inclusion was increased to 4 and 8 %, it was 1.11 %. Spirulina is thought to improve the immune system; with little inclusion of Spirulina in the poultry diet found to significantly enhancing defense systems for increased microbial killing, antigen processing and greater T-cell activity, reducing stress and improving total health condition [21]. Poultry receiving dietary Spirulina showed better health than the unsupplemented group indicating the enhancement of disease resistance with increased dietary Spirulina levels in poultry.

Carcass composition

Japanese quail is a species with carcass dressing percentage at 65 - 73 %. Generally the percentage of breast and legs represent the relative proportion of the weight to the dressing yield. In fact, quails showed allometry growth at slaughtering age, therefore the dressing yields and the breast showed no significance ($p > 0.05$) of being affected by the diet. Results were found to be similar to the value reported by [22]. Quails fed on 4 % Spirulina diet yield the heaviest meat portion especially in the breast and leg meat. A significant difference in legs percentage was partly accounted for by leaner muscle and the improvement of fat content, partly attributed to the total lipid reduction fed by Spirulina [23,24], besides from the combination of high specification nutrient in Spirulina together with positive feed efficiency and nutrient utilization in lean meat conversion. Nevertheless, different levels of Spirulina inclusion in the feed did not affect the dressing meat yield percentage as long as all the treatments were isocaloric and isonitrogenous [16].

Meat color

The effects of dietary treatment levels on the color in breast muscles were found significantly ($p < 0.05$), contribute to higher redness (a*) and yellowness (b*) when level of Spirulina was increased ($p < 0.05$), although the lightness (L*) in the meat was not significant ($p > 0.05$). Treatment groups with 4 and 8 % of Spirulina produced higher a* (11.11 and 11.29 respectively) when compared to the control group (9.69) and b* (18.79 and 19.11 respectively) when compared to the control group (17.52). Feed with Spirulina, rich in beta-carotene and zeaxanthin, can significantly improve meat coloration. No significant difference in Lightness (L*) of the *pectoralis major muscle* from chicken fed a diet of various proportions of Spirulina [16]. Redness (a*) of breast muscle increased with introduction of any level of Spirulina, where redness of the fillet increased until 8 % of Spirulina [16]. On the other hand, Yellowness (b*) of the *pectoralis major muscle* increased in a linear fashion with increasing Spirulina content in the diet [16]. Based on these results, dietary Spirulina influenced both redness and yellowness in quail meat. This suggests that dietary Spirulina affects the colour characteristics and may be reflected in the accumulation of pigment within meat, possibly by incorporation of beta-carotene and zeaxanthin [16].

Meat texture

The toughness of the meat was reduced with inclusion of Spirulina in the diet ($p < 0.05$). Diets with Spirulina improved meat tenderness. The meat quality was found to be higher mainly due to the lower drip loss and cooking loss in quails fed on Spirulina. The meat texture was affected by a few factors such as water holding capacity, intramuscular fat, actomyosin complex and also quality of collagen [25]. Nevertheless, quails were slaughtered at marketing age when collagen normally did not constitute a texture problem [25].

Conclusions

The results of the experiment conclude that different inclusion levels of Spirulina significantly affected the quail's live performance in term of FCR and MR. Meat quality was also affected by the Spirulina inclusion in the diets. However, the range for optimum inclusion of Spirulina was observed to have a positive effect on the quails growth and carcass quality. Inclusion of Spirulina up to 4 % of total diet is recommended considering the vast improvement in meat yield and body health condition.

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