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**Effects of broiler chicks fed the low crude protein diet supplemented with *Achyranthes Japonica Nakai*
root extract on growth performance and carcass traits**

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ABSTRACT

A total of 360 1-day-old broiler chicks were randomly assigned to 4 treatments with 5 replicate cages and 18 birds per cage for a 35-day trial to investigate the effects of supplementing *Achyranthes Japonica Nakai* (AJN) root extract in low crude protein (CP) diet on growth performance and carcass traits. Experimental diets were divided as standard CP content diet, low CP content (LCP) diet, and LCP diet supplemented with 0.025 or 0.050% AJN root extract. Dietary CP reduction impaired growth performance and carcass traits, while supplementing AJN root extract improved growth performance and carcass traits.

Keywords: crude protein; broiler chick; *Achyranthes Japonica Nakai* root extract; growth performance; carcass traits

INTRODUCTION

In order to reduce the environmental pollution and feed cost of poultry husbandry, a method of reducing crude protein (CP) content in diet was put forward. However, it has been reported that reducing crude protein in diet has negative effects on the performance of birds (Mohammadigheisar and Kim, 2018). Recently, Nuraini et al. (2014) noted that reducing dietary CP content and supplementing antioxidant herbal extract may be an ideal method to alleviate the negative effects of dietary CP content reduction on the performance of broiler chicks.

Santoso et al. (2013) demonstrated that supplementing *Sauropus androgynus* leaves extract in low CP diet inhibited the high-fat growth of broiler chicks induced by feeding low CP diet. Nuraini et al. (2014) reported that the body weight of broiler chicks fed with 17% CP diet supplemented with *Sauropus androgynus* leaves extract was similar to those fed with 19% CP diet. Therefore, supplementing herbal extract with antioxidant properties in low CP diet is beneficial to improve the performance of birds. In this study, the herbal extract with antioxidant activity used was *Achyranthes Japonica Nakai* (AJN) root extract.

Achyranthes is a medicinal plant and belongs to the Amaranthaceae family. Some of the antioxidant phytochemicals and bioactive compounds produced by achyranthes have been shown to exert a range of physiological and biochemical effects. When used in poultry husbandry, Park and Kim (2020) and Sun et al. (2020) reported that supplementing 0.025, 0.050, or 0.100 % AJN root extract in the diet of Ross 308 broiler chicks had positive effects on growth performance and production characteristics.

Therefore, the objective of the present study was to test the hypothesis that supplementing AJN root extract in low CP diet has positive effects on the growth performance and carcass traits, and could alleviate the negative effect of dietary CP reduction on the performance of broiler chicks.

MATERIALS AND METHODS

The Animal Care and Use Committee of Dankook University (Yongin, South Korea) had supervised the procedures of this experiment (DK-1-1949-2).

Animals, housing, and diets

A total of 360 day-old (as hatched) Ross 308 broiler chicks (mean body weight, 43.03 g) were randomly assigned to four diet treatments with five replicate cages per treatment and 18 birds per cage for a 35-day experiment (starter, days 1-7; grower, days 8-21; finisher, days 22-35). The experimental diets include standard CP content (SCP) diet, low CP content (LCP) diet, and LCP diet supplemented with 0.025 or 0.050% AJN root extract. The AJN root extract used in this study was the same as the study of Sun et al. (2020). Dietary CP content in the LCP group was same as the SCP group in days 1-7, but lower than the SCP group in days 8-21 (20.96 vs. 21.50 % CP) and 22-35 (19.50 vs. 20.00 % CP).

The birds were housed in 3-floor battery cages ($1.55 \times 0.75 \times 0.55$ m/cage), in an environmentally controlled room (temperature was started at 32°C and reduced by 2°C every week up to 24°C, and 65 % relative humidity). Fluorescent lamp with an intensity of 10 lx was adjusted for 24 h/d for lighting. Each

cage was equipped with 2 feeders (one feeder on each side) and 2 nipple drinkers to provide feed and water *ad libitum* to birds. Diets were formulated to meet the nutritional requirements recommended by the National Research Council recommendations (Table 1; NRC 1994).

Sampling and measurements

Body weight in each replicate cage was measured on the 1st and 35th day to calculate the body weight gain (BWG). Cage-based feed consumption was daily calculated to measure feed intake (FI). Feed conversion ratio (FCR) was calculated as the ratio of FI to BWG.

At the end of the experimental period, 20 birds (5 birds per replicate) were randomly selected from each treatment (total 80) for slaughter by cervical dislocation. The breast muscle and abdominal fat were removed and weighted to calculate the organ indexes. Organ indexes = Organ weight / Live body weight × 100%.

Statistical analysis

All data were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC, USA) and the replicate cage was used as the experiment unit. Orthogonal contrasts were used to test the effect of treatments: SCP group vs. LCP group or LCP + AJN root extract group, and LCP group vs. LCP + AJN root extract group. Moreover, linear and quadratic effects in response to increasing the supplementation of AJN root extract in the LCP diet were examined by orthogonal contrasts. Variability in the data was expressed as the standard error of means (SEM). Statistical significance was determined at $P < 0.05$.

RESULTS

Body weight gain (BWG) ($P < 0.01$) was lower, while feed conversion ratio (FCR) ($P < 0.05$) was higher, in broiler chicks fed the LCP diet than those fed the SCP diet. There were no statistical differences in

BWG, feed intake (FI), and FCR have observed in broiler chicks fed the LCP diet supplemented with AJN root extract compared with those fed the SCP diet. Moreover, broiler chicks fed the LCP diet supplemented with AJN root extract had higher BWG ($P < 0.01$) and FI ($P < 0.05$), and lower FCR ($P < 0.05$), than those fed the LCP diet. Besides, BWG ($P < 0.01$) was increased linearly, while FCR ($P < 0.05$) was decreased linearly, with the dose of AJN root extract increased in the LCP diet (Table 2).

Relative weight of breast muscle did not differ among all dietary groups. Broiler chicks fed the LCP diet had higher relative weight of abdominal fat ($P < 0.05$) than those fed the SCP diet, while had lower relative weight of abdominal fat ($P < 0.05$) than those fed the LCP diet supplemented with AJN root extract. Moreover, relative weight of abdominal fat ($P < 0.05$) was decreased linearly with increasing of AJN root extract in the LCP diet (Table 3).

DISCUSSION

In this study, the BWG of broiler chicks decreased, while FCR increased, by dietary CP reduction, which was confirmed by Mohammadigheisar and Kim (2018). They noted that dietary CP reduction impaired BWG of broiler chicks, which was associated with the increase of FCR. However, broiler chicks fed the LCP diet supplemented with AJN root extract increased BWG and FI, and decreased FCR, compared with those fed the LCP diet, moreover, the growth performance in broiler chicks fed the LCP diet supplemented with AJN root extract was similar to those fed the SCP diet. Similarly, Nuraini et al. (2014) noted that broiler chicks fed the LCP diet supplemented with antioxidant herbal extract (*Sauropus androgynus* leaves) have similar growth performance to those fed the SCP diet. Park and Kim (2020) and Sun et al. (2020) reported that broiler chicks fed the diet supplemented with 0.025, 0.050, or 0.10 % AJN root extract increased BWG and decreased FCR. Moreover, Long et al. (2020) noted that broiler chicks fed the diet supplemented with antioxidant herbal extract (*Forsythia suspensa*) increased BWG, which was associated with the improvement of FI and the reduction of FCR. Therefore, broiler chicks fed the LCP diet

supplemented with AJN root extract promoted FI and reduced FCR, thereby increasing BWG, and making the growth performance similar to those fed the SCP diet.

As mentioned by Ravangard et al. (2017), the metabolism energy to CP ratio increased by dietary CP content reduction, which will lead to the available energy excess required for protein deposition. The excess energy is used for heat production and/or fat deposition (Swennen et al., 2007). In this study, relative weight of abdominal fat increased in broiler chicks fed the LCP diet compared with those fed the SCP diet, however, relative weight of breast muscle insignificantly affected by dietary CP reduction. Similar studies were reported by Mohammadigheisar and Kim (2018), they noted that dietary CP reduction did not affect relative weight of breast muscle. Therefore, in this study, the reduction of dietary CP did not affect the yield of breast muscle, but damaged carcass traits by increasing relative weight of abdominal fat. While the relative weight of abdominal fat of broiler chicks decreased by the supplementation of AJN root extract in the LCP diet. As mentioned by Latha et al. (2011), the *Achyranthes aspera* could be used as a lipolytic agent, because it can prevent intestinal lipid absorption. Park and Kim (2020) noted that broiler chicks fed the diet supplemented with 0.025, 0.050, or 0.10 % AJN root extract decreased relative weight of abdominal fat but did not affect relative weight of breast muscle. Therefore, supplementing AJN root extract in the LCP diet did not affect the yield of breast meat, while improved carcass traits through reducing relative weight of abdominal fat.

CONCLUSION

The reduction of crude protein (CP) content in the diet caused damage to growth performance and carcass traits, while addition of AJN root extract in low CP diet improved growth performance and carcass traits, which made it similar to broiler chicks fed the standard CP diet. Therefore, supplementation of AJN root extract to low CP diet is a way to alleviate the negative effects on the performance of broiler chicks caused by dietary CP reduction.

Conflict of Interest Statement

The authors confirm that there are no conflicts of interest associated with this publication.

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Table 1. Ingredients and calculated chemical composition of diets, (% as fed)

Items	Starter (days 1-7)	Grower (days 8-21)		Finisher (days 22-35)	
	SCP	SCP	LCP	SCP	LCP
Ingredients (%)					
Corn	43.63	47.45	48.83	53.78	55.09
Soybean meal	35.08	31.28	29.83	28.18	26.80
Corn gluten meal	13.00	13.00	13.00	10.00	10.00
Wheat bran	3.00	3.00	3.00	3.00	3.00
Soy oil	1.76	1.74	1.75	1.51	1.51
Dicalcium phosphate	1.81	1.81	1.85	1.81	1.85
Limestone	0.94	0.94	0.91	0.94	0.92
Salt	0.36	0.36	0.36	0.36	0.36
Methionine (99%)	0.19	0.19	0.19	0.19	0.19
Lysine	0.03	0.03	0.08	0.03	0.08
Mineral mix ¹	0.10	0.10	0.10	0.10	0.10
Vitamin mix ²	0.10	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00	100.00
Calculated value					
Crude protein, %	23.00	21.50	20.96	20.00	19.50
Ca, %	1.10	1.08	1.08	1.07	1.07
Total P, %	0.83	0.82	0.82	0.79	0.79
Available P, %	0.54	0.53	0.53	0.52	0.52
Lys, %	1.26	1.15	1.15	1.06	1.06
Met, %	0.54	0.52	0.52	0.50	0.50
Metabolism energy, kcal/kg	3200	3200	3200	3200	3200
Crude fat, %	4.45	4.51	4.54	4.32	4.35
Crude fiber, %	3.55	3.48	3.46	3.30	3.27
Crude ash, %	6.76	6.57	6.51	6.30	6.25

Abbreviations: SCP, standard crude protein content; LCP, low crude protein content

¹ Provided per kg of complete diet: 37.5 mg Zn (as ZnSO₄); 37.5 mg Mn (as MnO₂); 37.5 mg Fe (as FeSO₄·7H₂O); 3.75 mg Cu (as CuSO₄·5H₂O); 0.83 mg I (as KI); and 0.23 mg Se (as Na₂SeO₃·5H₂O).

² Provided per kg of complete diet: 15,000 IU of vitamin A, 3,750 IU of vitamin D₃, 37.5 IU of vitamin E, 2.55 mg of vitamin K₃, 3 mg of Thiamin, 7.5 mg of Riboflavin, 4.5 mg of vitamin B₆, 24 ug of vitamin B₁₂, 51 mg of Niacin, 1.5 mg of Folic acid, 0.2 mg of Biotin, and 13.5 mg of Ca-Pantothenate.

Table 2. Effects of broiler chicks fed the low crude protein diet supplemented with *Achyranthes Japonica Nakai* (AJN) root extract on growth performance

	BWG, g/d/bird	FI, g/d/bird	FCR
SCP	1790.44	3044.00	1.70
LCP	1668.12	3003.42	1.80
LCP + 0.025% AJN root extract	1762.81	3077.42	1.75
LCP + 0.050% AJN root extract	1796.53	3091.45	1.72
LCP + AJN root extract ¹	1779.67	3084.44	1.73
SEM	20.079	25.849	0.024
SCP vs. LCP	0.001	0.283	0.010
SCP vs. LCP + AJN root extract	0.667	0.220	0.295
LCP vs. LCP + AJN root extract	<.001	0.021	0.036
SEM	16.336	29.096	0.024
Linear	<.001	0.054	0.038
Quadratic	0.154	0.417	0.618

Abbreviations: BWG, body weight gain; FI, feed intake; FCR, feed conversion ratio; SCP, standard crude protein content; LCP, low crude protein content; SEM, standard error of the mean.

¹The mean value of LCP + 0.025% AJN root extract and LCP + 0.050% AJN root extract

Table 3. Effects of broiler chicks fed the low crude protein diet supplemented with *Achyranthes Japonica Nakai* (AJN) root extract on carcass traits

	Breast muscle, %	Abdominal fat, %
SCP	17.98	1.24
LCP	15.74	1.61
LCP + 0.025% AJN root extract	16.77	1.44
LCP + 0.050% AJN root extract	17.52	1.14
LCP + AJN root extract ¹	17.14	1.29
SEM	1.062	0.106
SCP vs. LCP	0.155	0.023
SCP vs. LCP + AJN root extract	0.529	0.694
LCP vs. LCP + AJN root extract	0.297	0.024
SEM	1.004	0.113
Linear	0.234	0.011
Quadratic	0.912	0.628

Abbreviations: SCP, standard crude protein content; LCP, low crude protein content; SEM, standard error of the mean.

¹The mean value of LCP + 0.025% AJN root extract and LCP + 0.050% AJN root extract