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Evaluation of Growth Performance, Meat Quality and Sensory Attributes of the Broiler Fed a Diet supplemented with Curry Leaves (*Murraya koenigii*)

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ABSTRACT An experiment was conducted to evaluate the growth performance and meat quality traits of broilers fed a diet supplemented with dry-ground curry leaves (*Murraya koenigii*). A total of 750 one-day-old broiler chicks (Cobbs 500) were arranged in the experiment with a completely randomized design and allotted to one of five treatments, with T_1−Control and T_2−T_5 curry leaves powder levels (i.e., 0.3%, 0.6%, 0.9% and 1.2%, respectively). The initial body weights, final body weights and daily feed intake were measured over an experimental period of 32 days. At the conclusion of the experiment, the carcass weights and meat quality parameters were measured. The birds fed diets supplemented with curry leaves powder had a higher weight gain (P<0.05; ADG), improved feed conversion ratio (P<0.05; FCR) and lower mortality (P<0.05) rates compared to the birds in the control group. Nonetheless, there was no difference (P>0.05) in feed intake among the dietary treatments. Similarly, supplementation of curry leaves powder had no effect (P>0.05) on the proportions of the carcass, leg meat and drumstick. No differences were (P>0.05) observed in cooking loss or the pH of meat from broilers fed the curry leaves supplemented diet. However, curry leaf supplementation affected (P<0.05) the meat water holding capacity. A sensory evaluation showed higher levels of taste and tenderness in meat from broilers fed with curry leaves powder. In conclusion, our results suggested that curry leaves powder improved the growth performance of broilers, with a lower incidence of mortality and improvement of some meat qualities.

(Key words: broiler, curry leaves, growth performance, meat quality, sensory)

INTRODUCTION

Modern poultry production has been developed efficiently and economically to gain premium and sound chicken meat, eggs and its by-products (Ghazanfari et al., 2015). In this regard, chemical feed additives, antimicrobial growth promoters (AGP), have been induced to improve productivity and quality of meat production animals (Rehman and Munir, 2015). However, residues of these AGP and also antibiotic resistant bacteria due to indiscreet injection of AGP were being threatened human health. In a meanwhile, chicken production industry has long been attempted maximize remaining current events such as antibiotic usage, welfare and even preventing environmental pollutions (Salïh and Güsrbüz, 2015).

As a consequence, the European Union (EU) banned the antibiotic usage to animal feed in 2006, in order to reduce the risk of generating antibiotic resistance in pathogenic microbiota (Liu et al., 2011). Subsequently, many studies have conducted with the direction of alternative feed additives for improving the growth performance of poultry.

Various plant species or derivatives have been received additional attention as possible alternatives to AGP. Recently many studies were conducted with plant materials and their extracts to evaluate possible effects on broiler growth performance as an alternative of AGP source (Ocak et al., 2008, Moorthy et al., 2009, Ali, 2014, Mohamed, 2015).

Curry leaves (*Murraya koenigii*) are tropic aromatic perennial plant, having many nutraceutical properties and rich with carbozole alkaloids. It also displays many biological properties like antioxidant and anti-inflammatory (Priya et al., 2014), which could be one of potential and alternative AGP source for broilers. However, the effect of feeding a diet

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supplemented with curry leaves (*Murraya koenigii*) on growth performance and healthy gut without AGP were scarcely discussed in broilers. Moorthy et al. (2009) have reported that effect of curry leaves powder on the growth performance and carcass characteristics was not significant in broilers at 6 weeks of age. Nevertheless, only 0.2% supplementation level of dried curry leaves powder was examined in this study (Moorthy et al., 2009) along with ginger and pepper.

Therefore, the objective of present study was to evaluate the effects of a diet supplemented with curry leaves powder on the growth performance, mortality rate, carcass characters and meat sensory properties in broilers.

MATERIALS AND METHODS

1. Preparation of Experimental Diets

Mature curry leaves (*Murraya koenigii*) were obtained from mid country wet zone home garden trees to prepare curry leaves powder. Properly washed and cleaned mature curry leaves were sun-dried for 2 days using sun-dryer. Subsequently, dried leaves were ground using grinder (Panasonic Mixer Grinder - MXAC400) to get curry leaves powder. Powder was sieve using stainless steel mesh sieve and stored in air tight containers for avoid contamination and spoilage.

Commercial feed with maize and soybean meal was used as basal for experiment diet: broiler booster (crude protein 23.3%, metabolizable energy 3,100 kcal/kg), broiler starter (crude protein 21.4%, metabolizable energy 3,000 kcal/kg) and broiler finisher (crude protein 19.9%, metabolizable energy 2,900 kcal/kg) were used as basal diet for respective ages of experiment period (day 1～14: broiler booster, day 15～28: broiler starter, day 29～32: broiler finisher). Five experiment diets were prepared by top dressing basal diet with curry leaves powder presented in Table 1.

2. Experiment Design and Management

A total of seven hundred fifty, one-day-old broiler chicks (Cobbs 500) were used for this study with body weight of 45.0±0.12 g (mean±SEM). At the beginning, birds were divided in to one of five treatment groups (150 birds per group) with three replicate pens per treatment (15 cages with 50 birds per pen). First week birds were reared in the floor brooder.

Table 1. Experimental design for diet treatments

Treatments	Diets
Treatment 1 (T1)	Basal diet[1]
Treatment 2 (T2)	Basal diet + 0.3% curry leaves powder
Treatment 3 (T3)	Basal diet + 0.6% curry leaves powder
Treatment 4 (T4)	Basal diet + 0.9% curry leaves powder
Treatment 5 (T5)	Basal diet + 1.2% curry leaves powder

[1] Basel diet: Day 1～14 - broiler booster feed (crude protein 23.3 %, metabolizable energy 3,100 kcal/kg), Day 15～28 - broiler starter (crude protein 21.4%, metabolizable energy 3,000 kcal/kg), Day 29～32 - broiler finisher (crude protein 19.9%, metabolizable energy 2,900 kcal/kg).

After brooding, each treatment group was moved to growing pens.

Birds were reared in an open-sided house under tropical conditions. Floor pens were used equipped with separate feeder and waterer. *Ad-libitum* access to experimental diets and clean water were facilitated throughout the study period. Lighting was continuous and temperature was maintained 33 ℃ in first three days and gradually decreased to room temperature (25±2℃) until end of the experiment. The birds were vaccinated with ND vaccine on day 7 and Gumboro (Infectious Bursal Disease; IBD) vaccine on days 10, 17 and 23.

3. Growth Performance Evaluation

Body weights were recorded on day 1 and day 32 in each replicates and feed intake was recorded daily. Average daily gain, average daily feed intake and feed conversion (FCR) of birds were calculated. Mortality was recorded for each treatment separately throughout the study.

4. Post-mortem Procedure and Carcass Measurements

At the end of the study period, birds were subjected to feed deprivation for 12 h. Three birds from each treatment (one bird from each replicate with closest median body weight) were selected, recorded the live weights and euthanized via cervical dislocation (Houshmand et al., 2011). Manual evisceration was followed after bleeding.

Slaughtered empty body were dressed and recorded the

carcass weights. Breast, thighs and drumsticks were weighed and expressed as proportion of live weight.

5. Analysis of Meat Quality Parameter

Meat quality parameters were measured according to the methods of Jayasena et al. (2013) and Lakshani et al. (2016). Water holding capacity, pH of meat, and cooking loss were measured. Three replicates samples were analyzed from each treatment separately.

pH values of meat samples were measured using 1 g of minced breast meat. Meat sample was transferred into conical flask and mixed with 9 mL of distilled water. Mixture was homogenized using a vortex mixer (VM-96B, Jeio tech., South Korea). After homogenizing, pH value was measured using pH meter (pH 700, Eutech Instruments, Singapore).

Breast meat sample (2 g) was weighted using analytical balance. Meat sample was wrapped on a round filter paper (No. 4, Whatman Ltd., England). 10 kg of standard weight was applied on the meat sample for 5 min, after then meat sample was weighted and calculated the water holding capacity.

To analysis the cooking loss, 30 g of breast meat sample was packed and seal in polythene bag. It was placed in a water bath at 85℃ for 30 min. Sample was cooled at room temperature (20~25℃) and weighed. Cooking loss was calculated using weight differences.

6. Proximate Analysis

Proximate analysis for curry leaves samples and breast meat samples of each treatment were conducted according to the method of AOAC (1995) as modified by Jayasena et al. (2013) including crude protein, crude fat, crude fiber, moisture and total ash (Table 2).

2 g of samples were dried at 102℃ for 15 h for measure the moisture content. Soxhlet extraction system (TT 12/A, Gerhardt Ltd., Germany) was utilized to measure crude fat contents of samples and crude protein contents were measured using Kjeldahl method (VAPO45, Gerhardt Ltd., Germany). Ash content was measured after ignited the 2 g of samples in a furnace (SX-4-10, China) set at 550℃ for 4 h.

7. Sensory Evaluation

Table 2. Proximate composition of curry leaves sample (dry matter basis)[1]

Parameters	Nutrient composition (%)
Moisture content	22.04
Crude protein	6.07
Ash content	9.43
Crude fat	0.96
Crude fiber	3.50
Carbohydrates[2]	58.0

[1] Results are mean with 3 replicates samples.
[2] Calculated based on the determination of the five others.

To evaluate the effect of supplementation of curry leaves powder in broiler feed on meat sensory quality parameters, sensory evaluation was conducted with thirty semi trained panelists. Breast meat samples from each treatment groups were evaluated as outlined by Jayasena et al. (2013) without salt or spice. Five-point hedonic scale (1=dislike very much, 2= dislike slightly, 3=neither like nor dislikes, 4=like slightly, 5= like very much) was used to evaluate the meat samples. The sensory parameters tested were color, appearance, juiciness, taste, odor, and overall acceptability. All the samples were coded with three digit numbers when presented to panelists in order to minimize the bias of panelist during the evaluation.

8. Statistical Analysis

Data were analyzed by ANOVA using the General Linear Models (GLM) procedures of Statistical Analysis System package (SAS Institute Inc., 2008). Pen was considered as the experimental units for growth performance measures. Selected birds and respective meat samples data were pooled to get average for statistical analysis. Differences between means were tested using Duncan multiple range significant difference test when it appropriate ($P<0.05$). The score given by each panelist on each sensory parameters were analyzed using Friedman nonparametric test using MINITAB 16 computer software.

RESULTS AND DISCUSSION

1. Performance of the Bird

The effects of the supplementation of curry leaves powder on the body weight gain, feed intake and feed conversion ratio (FCR) and mortality of broiler chickens are presented in Table 3. The results revealed that, treatments with curry leaves powder improved (P<0.05) body weights, daily weight gain and FCR, and reduced the incidence of mortality compared to the birds fed control diet for 32-days, whereas no effect (P>0.05) was observed in feed intake among curry leaves powder treatments and control. Although, no differences (P>0.05) were observed between each curry leaves powder supplemented treatment for body weights, weight gain, feed intake, FCR and mortality.

A couple of studies reported the improvement of growth performance of broilers fed a diet supplemented with herbal plants and plant derivatives (Ocak et al., 2008; Moorthy et al., 2009). Moorthy et al. (2009) observed enhanced body weight gain in 6-week-old Vencobb broiler fed with curry leaves powder, either in supplement alone or in combination of ginger. This growth enhancement might be resulted from improved nutrient digestibility and antioxidant properties of curry leaves. Additionally, Abor acre broiler chicks fed a diet supplemented with lemon grass (*Cymbopogon citratus*) leaves powder had shown increased growth performance and FCR, and decreased mortality (Mmereole, 2010). These observed enhanced growth performances in chickens might be due to antioxidant properties and essential oils in the herbal plant materials. Indeed, dietary essential oils had influence on growth performance in birds (Cross et al., 2002; Bampidis et al., 2005; Cross et al., 2007), resulted from enhancing digestibility via stimulating digestive enzymes and optimizing the gut microbiota (Gopi et al., 2014). It has been documented that Curry leaves are rich in essential oils such as α-pinene and β-pinene (Rao et al., 2011) and carbazole alkaloids which have radical scavenging activity (Jain et al., 2012). Hence, improved growth performance in the present study may resulted from improved nutrient digestibility and absorption by the mean of stimulating digestive enzyme and enhanced oxidative stability.

Curry leaves powder supplementation to iso-caloric and iso-nitrogenous diets were resulted no deference on feed intake in 6 weeks old Vencobb broilers (Moorthy et al., 2009). Additionally, it was reported broilers regulate energy intake by maintaining feed intake (Leeson et al., 1996). Correspondingly, our presenting data for feed intake observed no difference (P>0.05), when broiler fed diet supplemented with curry leaves with same energy level and nitrogen level from 1 to 32 days of age. Contradictory was reported, supplementation of antioxidant improved feed intake of broiler reared under high ambient temperature (Wang et al., 2008).

Herbal feed additives and essential oils are known to affect immune functions of birds via stimulating nonspecific immune system (Rahimi et al. 2011; Dhama et al., 2014; Zeng et al., 2015). Curry leaves have also shown anti-oxidative activity, immunomodulatory activity, hepatoprotective activity and anti-inflammatory activity (Jain et al., 2012). Dietary antioxidants supplement suggested as efficient way to reduce heat stresses and improve growth performances in broilers (Wang et al., 2008). Hence, the supplementation of curry leaves powder in this study might reduce broiler oxidative stress, enhanced oxidative stability via reduce oxidative free radicals and balance in antioxidant status. Consequently, it resulted a low incident of mortality in curry leave powder supplemented groups compared to control (Table 3).

2. Carcass Measurements

To evaluate carcass characteristics, percentages of carcass, breast meat, leg meat and drumstick were measured as a proportion of live body weight at 32 days of age (Table 4). There were no effects (P>0.05) of the supplementation of curry leaves powder on the proportions of carcass, leg meat and drumstick (Table 4). Our results were with the agreement of previous work by Moorthy et al. (2009) who reported no effect of dietary curry leaves powder on carcass measurements of 6-week-old Vencobb broilers. Also, several studies have suggested that no influence of dietary herbal essential oils on the carcass yield in poultry (Denli et al., 2004; Bozkurt et al., 2012; Symeon et al., 2014). However, our study showed the supplementation of curry leaves enhanced breast meat proportion of the broilers (P<0.05) comparatively to control group at the age of 32 days (Table 4). The highest yield of breast muscle was observed in the treatment 3 (T3; 0.6% curry leaves powder). Although carcass yield was not statistically significant among the curry leave supplemented treatments.

3. Meat Quality

Table 3. Effects of the supplementation of curry leaves powder on the body weight gain, daily feed intake, feed conversion ratio and mortality of broiler chickens from 1 to 32 days of age[1,2]

Treatment	BW (g)	ADG (g)	ADFI (g)	FCR	Mortality (%)
Basal diet (T1)	1,696.60[b]	51.56[b]	83.84	1.63[a]	7.33[a]
BD + 0.3% CLP (T2)	1,826.60[a]	56.04[a]	82.90	1.48[b]	3.33[b]
BD + 0.6% CLP (T3)	1,850.10[a]	56.14[a]	82.50	1.47[b]	1.33[b]
BD + 0.9% CLP (T4)	1,836.60[a]	56.25[a]	82.06	1.46[b]	2.00[b]
BD + 1.2% CLP (T5)	1,823.30[a]	55.10[a]	82.81	1.50[b]	1.33[b]
SEM[3]	0.016	0.018	0.019	0.017	1.192

[1] Results are mean with 3 replicates per treatment.
[2] BW: body weight at the age of 32 days, ADG: average daily gain, ADFI: average daily feed intake, FCR: feed conversion ratio, CLS: curry leaves powder.
[3] Standard error of mean.
[a,b] Mean values in the same column with different superscript are significantly different (P<0.05).

Table 4. Effects of the supplementation of curry leaves powder on the carcass parameters of broiler chickens[1,2]

Treatment	Carcass (%)	Breast meat (%)	Leg meat (%)	Drumstick (%)
Basal diet (T1)	72.41	20.87[b]	5.98	4.34
BD + 0.3% CLP (T2)	73.11	22.41[ab]	6.16	4.19
BD + 0.6% CLP (T3)	73.66	23.14[a]	6.33	4.52
BD + 0.9% CLP (T4)	73.85	21.78[ab]	5.97	4.23
BD + 1.2% CLP (T5)	72.53	22.11[ab]	5.94	4.38
SEM[3]	0.620	0.659	0.304	0.253

[1] Results are mean with 3 replicates per treatment.
[2] Percentages as proportion of live body weight at the age of 32 days, CLP: curry leaves powder.
[3] Standard error of mean.
[a,b] Mean values in the same column with different superscript are significantly different (P<0.05).

Table 5. Effects of the supplementation of curry leaves powder on the cooking loss, water holding capacity and pH of broiler chicken meat[1,2]

Treatment	Cooking loss	WHC	pH
Basal diet (T1)	13.28	73.55[ab]	5.87
BD + 0.3% CLP (T2)	15.31	70.21[b]	6.03
BD + 0.6% CLP (T3)	15.58	74.90[a]	5.70
BD + 0.9% CLP (T4)	13.33	74.14[ab]	5.80
BD + 1.2% CLP (T5)	13.55	71.64[ab]	5.77
SEM[3]	0.460	1.230	0.100

[1] Results are mean with 3 replicates per treatment.
[2] WHC: water holding capacity, CLP: curry leaves powder.
[3] Standard error of mean.
[a,b] Mean values in the same column with different superscript are significantly different (P<0.05).

The broiler industry concerns meat quality as it effects further processing and profitability (Mellsop and Wilkinson, 2005; Cobanoglu et al., 2014). Therefore, the parameters of meat quality were examined to identify the effect of supplementation of curry leaves powder on broiler diets. In this study, no difference (P>0.05) was observed in cooking loss and pH of meat from broilers fed with curry leaves powder (Table 5). Contradictory, meat water holding capacity was effected (P<0.05) in broilers fed with curry leaves powder. The highest (P<0.05) water holding capacity was observed in treatment 3 (T3; 0.6% curry leaves powder) (Table 5). Previously, many studies demonstrated that there was no effect of herbal growth promoters or essential oil mix on cooking loss and pH of broiler meat (Kim et al., 2009; Herawati and Marjuki, 2011; Elmali et al., 2014; Symeon et al., 2014). In agreement, supplementation of curry leaves powder in diets have no effects on meat quality parameters in the present study.

4. Proximate Composition

The proximate composition of chicken breast meat is presented in Table 6. There were no differences (P>0.05) on moisture, protein, ash and fat contents of curry leave supplemented treatments compared with birds fed with a control diet (Table 6). Similarly, it was reported supplementation of herbal growth promoters on broiler feed, resulted no influence on the contents of moisture and lipid in chicken meat (Gardzielewska et al. 2003; Kim et al., 2009; Onibi et al., 2009).

5. Sensory Evaluation of Meat

Sensory parameters are important that make purchase decision of meat products (Liu et al., 2007; Font-i-Furnols and Guerrero, 2014). As shown in Table 7, there were no significantly differences (P>0.05) in the appearance, odor, color, juiciness and overall acceptability of broiler meat among groups. Nonetheless, panelists' preference for taste and tenderness were higher (P<0.05) in the meat from treatment 3 (T3; 0.6% curry leaves powder) (Table 7). This outcome is probably associated with water holding capacity observed in Table 4. Although there was no statistically difference in odor and color among treatments, still higher levels expressed in meat from T3 (Table 7).

Table 6. Effects of dietary curry leaves powder on the proximate composition of chicken breast meat[1,2]

Treatments	Moisture (%)	Protein (%)	Ash (%)	Fat (%)
Basal diet (T1)	61.15	26.73	1.27	4.82
BD + 0.3% CLP (T2)	60.80	25.13	1.18	4.66
BD + 0.6% CLP (T3)	63.09	24.43	1.30	4.85
BD + 0.9% CLP (T4)	62.40	25.23	1.19	4.52
BD + 1.2% CLP (T5)	59.69	23.92	1.23	5.03
SEM[3]	1.320	1.040	0.030	0.180

[1] Results are mean with 3 replicates per treatment.
[2] CLP: curry leaves powder.
[3] Standard error of mean.

6. Conclusion

The supplementation of curry leaves powder on broilers diet significantly improved the growth performance, while reduced the incidence of mortality. Although this supplementation did not alter the parameters of carcass, meat quality and proximate composition, higher levels of taste and tenderness in sensory evaluation showed in the meat from broilers fed a diet supplemented with curry leaves powder. Consequently, dietary curry leaves might be a potential as an alternative growth promoter, resulting in production of high quality and safe meat to fulfill consumer needs.

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Table 7. Effects of the curry leaves powder on sensory characters of chicken meat[1,2]

Treatment	Appearance	Taste	Oder	Color	Juiciness	Tenderness	Overall acceptability
Basal diet (T1)	3.67	3.87^{ab}	3.77	3.73	3.60	3.73^{b}	3.73
BD + 0.3% CLP (T2)	3.97	3.87^{ab}	3.87	3.83	4.00	3.73^{b}	3.90
BD + 0.6% CLP (T3)	3.83	3.97^{a}	4.20	3.97	4.00	4.27^{a}	3.77
BD + 0.9% CLP (T4)	4.10	3.50^{b}	4.07	3.80	3.83	3.80^{b}	3.57
BD + 1.2% CLP (T5)	3.77	3.90^{ab}	4.00	3.70	3.70	3.80^{b}	3.73
SEM[3]	0.068	0.060	0.087	0.071	0.073	0.067	0.080

[1] Results are mean with 30 replicates per treatment.
[2] CLP: curry leaves powder.
[3] Standard error of mean.
[a,b] Mean values in the same column with different superscript are significantly different (P<0.05).

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