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Article

An exploratory study on the effects of rearing system and plumage colour on performance, carcass characteristics and meat quality of local turkeys

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Abstract

In a bid to improve the productive potentials of local turkeys in developing countries, a total of 240 unsexed day-old poults arranged in a 2 × 2 factorial layout into 4 treatments with two rearing systems (indoor and outdoor) and two plumage colours (white and black) were used for this study. Poults were brooded for 4 weeks followed by an acclimatization period of 2 weeks in the two different rearing systems before the commencement of the study which lasted 10 weeks. Each treatment consisting of 60 birds was further sub-divided into six replicates of 10 birds per replicate. Data obtained were subjected to Analysis of Variance in a Completely Randomized Design. Results on performance in the grower phase showed turkeys reared in indoor system recorded significantly (p<0.05) higher weight gain (29.39 vs. 105.19 g/bird/day) and daily feed intake (27.18 vs. 98.11 g/bird/day) compare to turkeys under outdoor system. In addition, weight gain was significantly (p<0.05) higher (29.16 g/bird/day) in turkeys with black plumage than (27.42 g/bird/day) recorded in turkeys with white plumage. However, in the finisher phase turkeys under outdoor system recorded significantly (p<0.05) higher weight gain than turkeys under indoor system. In the finisher phase, interaction effects showed best weight gain and Feed Conversion Ratio (FCR) (39.22 g/bird/day and 4.60) in white-plumaged turkeys reared in outdoor system. Turkeys under outdoor system also had significantly (p<0.05) higher back and spleen percentages. However, proportions of thigh were significantly (p<0.05) higher in turkeys reared indoor. In addition, white-plumaged turkeys recorded significantly (p<0.05) higher (21.07%) cooking loss than 14.58% recorded in turkeys with black plumage. In conclusion, improved weight gain with best FCR at finisher phase as well as highest spleen portion and cooking loss in thigh meat was obtained in white-plumaged turkeys reared in outdoor system.

1 Introduction

In order to provide animal protein in adequate quantity and quality in developing countries, farmers as well as scientists are selecting poultry species with sufficient potentials for domestication and can supplement the availability of essential protein at cheaper cost (Ironkwe *et al.,* 2015). Turkey production plays an important role in this aspect (Amumueller, 2008). Turkeys are excellent foragers that thrive better under arid conditions and tolerate heat when compared with broilers (Yakubu *et al*., 2013). Worldwide, indigenous turkey production is a highly profitable industry with an increased production quantity from 5.1 million ton in 2003 to 5.6 million ton in 2013 (FAOSTAT, 2013). Also, the demand for turkey products is rising globally (Yakubu *et al*., 2013); in fact turkey meat is one of the best options for alternative protein source in the tropics (Asaduzzaman *et al*., 2017). According to Karki (2005), the consumption of turkeys as white meat has increased worldwide and a similar trend also existed in developing countries. However, turkey production has not been fully exploited in developing countries despite its potential over other poultry species.

Turkey (*Meleagris gallopavo*) is well known in the United States of America and Europe, but in developing countries like Nigeria, the rearing of local turkey in traditional production systems serves as an immediate source of meat and income for rural farmers (Okoli *et al.,* 2009; Ekue *et al*., 2002). The traditional village poultry production systems are mainly based on scavenging indigenous poultry found in almost all households in the rural areas. They are characteristically an integral part of the farming systems requiring low-inputs with outputs accessible at household level (Kitalyi, 1998). Although the performances of local poultry are lower than exotic poultry breeds, its hardiness and disease resistance makes it more adaptable to the tropical environment (Padhi, 2016). The importance of local poultry species in the national economy of developing countries and its role for improving the nutritional status and income of many smallholder farmers and landless communities has been very significant (Creevey, 1991; FAO, 1997). Thus, the adoption of improved production systems is essential for the strategic increase in the productivity of local poultry flocks to improve household food security and alleviation of poverty in rural communities (Awuni, 2002; Case *et al*., 2010).

In many parts of Africa, local poultry have been characterized on different grounds; Teketel (1986) characterized them on the basis of plumage colour, for example, Kei (red) or Tikur (black), Tadelle (2003) and Halima *et al*. (2007) both named on the basis of the geographic region of sampling with each local ecotype actually comprising chickens with a wide range of morphologic or genetic diversity. Genetic diversity has been described in chickens using monogenic traits based on different pigmentation and comb types. These different pigmentations can be attributable to melanin which is responsible for the production of varieties of plumage colours in chickens (Dana *et al*., 2010). The presence and level of melanin pigments such as trichochrome is related to feather colour and is considered to be indicative of genetic differences among certain plumage colours (Smyth, 1990). Though the bulk of research work on plumage colour is on chicken, dearth of information still exists on how differences in plumage colour influences performance and carcass components in local poultry.

In addition, plumage colour is second in importance to live weight in affecting market preference for chickens by consumers in developing countries (Dana *et al*., 2010). In certain communities in Africa, plumage colours have cultural and religious functions (Gueye, 1998; Leulseged, 1998). There are specific choices for plumage colours that affect preferences of different geographic markets around the world (Jiang, 1999; Smyth, 1990). Producer, sellers and intermediary traders of chickens attach high market preference to plumage colour and feather distribution (Aklilu, 2007). This clearly suggests that qualitative traits with specific characteristics should be carefully identified and considered for marketability of the local turkeys.

Based on this background, the objective of this research aimed to investigate the effects of rearing system and plumage colour on local turkey performances, carcass components and meat quality.

2 Materials and Methods

2.1 Ethical Statement

This study was performed in accordance with the recommendations of the Animal Ethics Committee guidelines of the Federal University of Agriculture, Abeokuta.

2.2 Experimental Site

The study was carried out at the Poultry Unit of the Directorate of University Farms (DUFARMS), Federal University of Agriculture, Abeokuta (Nigeria).

2.3 Experimental Design

A total of 240 day-old unsexed turkey poults with two different plumage colours (white and black) from local turkey strain were used for this study. Poults were purchased from a reputable hatchery and brooded for 4 weeks. Afterwards, the poults were allotted on weight equalization basis into two different rearing systems (indoor and outdoor) for an acclimatization period of 2 weeks before the commencement of the study which lasted 10 weeks. The indoor pen was constructed with a stocking density of 0.4 m^2 per turkey with wood shavings used as bedding material. However, turkeys in outdoor system had access to runs for foraging with mini-shelters of stocking density of 4 m^2 per replicate. Water and feed were provided *ad libitum* and the composition of experimental diets are presented in Table 1. This study was arranged in a 2×2 factorial layout: the two factors, Factor A (rearing systems) and Factor B (plumage colours) with each taking two levels; Factor A (indoor and outdoor) and Factor B (white and black) resulted in four treatment combinations in total as shown in Table 2. Each treatment group consisting of 60 birds was further sub-divided into six replicates of 10 birds per replicate.

2.4 Zootechnical evaluation

The following growth performance parameters were collected at the grower phase (from 6 to 12 week) and finisher phase (from 12 to 16 week).

Birds in each replicate were weighed individually using a weighing scale (Model: Yongzhou YZ-328+) and the total weight was divided by the number of weighed birds. The initial weights at the beginning of the experiment were recorded while subsequent body weights were recorded on weekly basis.

$$\text{WG (g/bird/day)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{number of weighed birds} \times \text{number of days}}$$

The daily feed intake in each replicate was estimated using the formula below:

$$\text{FI (g/bird/day)} = \frac{\text{Feed supplied} - \text{Left over}}{\text{Number of birds} \times \text{number of days}}$$

The Feed conversion ratio (FCR) of birds in each treatment was determined by calculating the ratio of feed intake to weight gain and thus will be calculated as:

$$\text{FCR} = \frac{\text{Feed intake}}{\text{weight gain}}$$

Table 1: Composition (%) of experimental diets

Ingredient	Grower phase	Finisher phase
Maize	44.00	47.00
Soyabean meal	31.00	20.00
Wheat offal	10.00	25.00
Fish meal (65% Crude Protein)	5.00	1.00
Bone meal	5.60	3.50
Oyster shell	3.00	2.50
Salt (NaCl)	0.45	0.25
DL-Methionine	0.40	0.20
Lysine	0.25	0.25
Premix	0.40	0.30
Total	**100.00**	**100.00**
Calculated Analysis		
Metabolizable energy (MJ/kg)	11.07	10.63
Crude protein (%)	28.00	17.74

Table 2: Experimental Design

Rearing system	Plumage colour	
	White	**Black**
Indoor	White turkeys under indoor system (n =60)	Black turkeys under indoor system (n =60)
Outdoor	White turkeys under outdoor system (n =60)	Black turkeys under outdoor system (n =60)

2.5 Meat Quality

After the 10 week study, two birds per replicate were selected for carcass analysis. Selected birds were fasted for 12 hours before slaughtering by severing the carotid artery and the jugular vein. The birds were allowed to bleed completely followed by removal of feathers and viscera. The weights of the carcasses were recorded and the dressing percentages (DP) were estimated by dividing the dressed weight of carcasses by the live weight (LW) and multiplied by 100. The weight of cut-up parts (breast, back, thigh and drumstick) and organs (heart, spleen, liver, lungs, gizzard and proventriculus) were determined using an electronic scale and the values recorded in grams were expressed as a percentage of the live weight.

Cooking Loss: This was determined by collecting a known amount (20 g) of meat from the breast and thigh regions of carcasses per replicate. Samples were placed in an airtight polythene bag, labelled and immediately cooked in a water bath at 70 $^{\circ}$C for 15 minutes. Thereafter, meat samples were allowed to cool at room temperature and weighed to determine the cooking loss.

$$\text{Cooking Loss (\%)} = \frac{\text{Weight of raw meat} - \text{Weight of cooked meat}}{\text{Weight of raw meat}} \times 100$$

Chilling Loss*:* twenty gram (20 g) of meat from the breast and thigh regions of carcasses from each replicate were placed in an airtight polythene bag; labelled and placed in a refrigerator at 7 °C for 24 hours. Chilling loss was determined as:

$$\text{Chilling Loss (\%)} = \frac{\text{Weight of raw meat} - \text{Weight of chilled meat}}{\text{Weight of raw meat}} \times 100$$

2.6 Statistical analysis

The data obtained were subjected to Analysis of variance (ANOVA) in a Completely Randomized Design. Tukey's test as contained in Minitab® version 17.1.0 software (Minitab Inc., PA, USA) was applied for comparison of means at 5% probability level.

The model of the study was;

$$y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \Sigma_{ijk}$$

Where:

y_{ijk} = Individual Observation

μ = Population Mean

α_i = Main effect of rearing system

β_j = Main effect of plumage colour

$(\alpha\beta)_{ij}$ = Interaction effects between rearing system and plumage colour

Σ_{ijk} = Residual error

3 Results

Table 3 shows the effects of rearing system and plumage colour on growth performance of local turkeys. Weight gain and feed intake measured at the grower phase were significantly ($p<0.05$) affected by rearing system. Turkeys reared in indoor system recorded significantly ($p<0.05$) higher values (29.39 and 105.19 g/bird/day) for weight gain and feed intake than values (27.18 and 98.11 g/bird/day) recorded in turkeys under outdoor system. The effect of plumage colour significantly ($p<0.05$) influenced weight gain measured at the grower phase. Weight gain was significantly ($p<0.05$) higher (29.16 g/bird/day) in turkeys with black plumage colour than (27.42 g/bird/day) recorded in turkeys with white plumage. Weight gain and feed intake measured at the grower phase were significantly ($p<0.05$) influenced by rearing system and plumage colour interaction. Weight gain was significantly ($p<0.05$) higher in statistically similar values (30.10, 28.68 and 29.64 g/bird/day) recorded in white-plumaged turkeys in indoor system, black-plumaged turkeys in indoor system and black-plumaged turkeys reared in outdoor system, respectively and lower (24.73 g/bird/day) in white-plumaged turkeys under outdoor system. Feed intake was significantly ($p<0.05$) highest (107.71 g/bird/day) in white-plumaged turkeys reared indoor and lowest (95.54 g/bird/day) in white-plumaged turkeys reared outdoor.

In the finisher phase, turkeys under outdoor system recorded significantly ($p<0.05$) higher weight gain (36.05 g/bird/day) than (30.99 g/bird/day) recorded in turkeys in the indoor system. However, the effect of plumage colour on all performance parameters measured were not significantly ($p>0.05$) different. In addition, weight gain and feed conversion ratio were significantly ($p<0.05$) influenced at the finisher phase by the interaction between rearing system and plumage colour. Weight gain was significantly ($p<0.05$) higher (39.22 g/bird/day) in white-plumaged turkeys under outdoor system than comparable means (30.05, 31.94 and32.88 g/bird/day) recorded in white-plumaged turkeys reared in indoor system and black-plumaged turkeys under indoor and outdoor systems, respectively. The most excellent FCR value (4.60) was recorded ($p<0.05$) in white-plumaged turkeys reared in outdoor system than 6.16 recorded in black-plumaged turkeys reared in outdoor system.

The effects of rearing system and plumage colour on carcass yield of local turkeys are presented in Table 4. Rearing system significantly ($p<0.05$) influenced back, thigh and spleen percentages. Turkeys under outdoor system had significantly ($p<0.05$) higher (13.24 and 0.21%) back and spleen percentages, respectively than values (11.80 and 0.10%) in turkeys reared in indoor system. However, proportions of thigh were significantly ($p<0.05$) higher (9.81 %) in turkeys reared in indoor and lower (8.53%) in turkeys reared in outdoor. The effect of plumage colour on all carcass traits measured was however not significantly ($p<0.05$) influenced. In addition, thigh and spleen were significantly ($p>0.05$) influenced by rearing system and plumage colour interaction. Comparable means (9.57 and 10.05%) for thigh were recorded in white and black-plumaged turkeys, respectively reared in indoor system which were significantly ($p<0.05$) higher than similar means (8.52 and 8.55%) recorded in white and black-plumaged turkeys, respectively reared in outdoor system. Also, spleen percentage was

significantly (p<0.05) highest (0.25%) in white-plumaged turkeys reared in outdoor system and lowest (0.09%) in white-plumaged turkeys reared in indoor system.

Table 5 shows the effects of rearing system and plumage colour on physical properties of breast and thigh meats from local turkey. Rearing system had no significant (p>0.05) influence on all parameters measured. However, plumage colour effect significantly (p<0.05 affected the percentage cooking loss for thigh meat. White-plumaged turkeys recorded significantly (p<0.05) higher (21.07%) cooking loss than 14.58% recorded in turkeys with black plumage. Furthermore, rearing system and plumage colour interaction influenced cooking loss of breast meat which was significantly (p<0.05) highest (24.29%) in turkeys with white plumage reared in outdoor system and lowest (15.86%) in black turkeys reared in outdoor system.

Table 3: Effects of rearing system and plumage colour on growth performance of local turkeys

		Grower (from 6 to 12 week)				Finisher (from 12 to 16 week)		
	Rearing System	**IW**	**WG**	**FI**	**FCR**	**WG**	**FI**	**FCR**
	Indoor	774.40	29.39^{a}	105.19^{a}	3.63	30.99^{b}	170.25	5.68
	Outdoor	748.21	27.18^{b}	98.11^{b}	3.68	36.05^{a}	177.96	5.38
	SEM	7.69	0.45	1.93	0.11	1.06	6.42	0.24
	P value	0.058	0.003	0.020	0.790	0.004	0.408	0.390
	Plumage colour	**IW**	**WG**	**FI**	**FCR**	**WG**	**FI**	**FCR**
	White	750.60	27.42b	101.62	3.76	34.64	172.79	5.24
	Black	772.02	29.16a	101.68	3.55	32.41	175.42	5.82
	SEM	7.69	0.45	1.93	0.12	1.06	6.42	0.24
	P value	0.066	0.014	0.985	0.217	0.156	0.775	0.106
Rearing System	**Plumage colour**	**IW**	**WG**	**FI**	**FCR**	**WG**	**FI**	**FCR**
Indoor	**White**	757.10	30.10^{a}	107.71^{a}	3.63	30.05^{b}	168.44	5.88^{ab}
	Black	791.70	28.68^{a}	102.67^{ab}	3.64	31.94^{b}	172.06	5.48^{ab}
Outdoor	**White**	744.00	24.73^{b}	95.54^{b}	3.90	39.22^{a}	177.13	4.60^{b}
	Black	752.40	29.64^{a}	100.68^{ab}	3.46	32.88^{b}	178.78	6.16a
	SEM	10.90	0.64	2.73	0.17	1.50	9.08	0.34
	P value	0.246	<0.001	0.041	0.195	0.014	0.915	0.010

^{ab} Means on the same column having different superscript are significantly different at 5% probability level
IW—initial weight (g); WG—weight gain (g/bird/day); FI—daily feed intake (g/bird/day); FCR – Feed conversion ratio

Table 4: Effects of rearing system and plumage colour on carcass characteristics of local turkeys

				Cut-up parts[1]				Organs[1]					
	Rearing System	**LW (g)**	**DP (%)**	**Breast**	**Back**	**Thigh**	**Drumstick**	**Heart**	**Spleen**	**Liver**	**Lungs**	**Gizzard**	**Proventriculus**
	Indoor	2835.00	74.89	18.72	11.80^{b}	9.81^{a}	9.98	0.45	0.10^{b}	1.55	0.52	2.82	0.33
	Outdoor	2678.80	74.89	17.82	13.24^{a}	8.53^{b}	9.84	0.44	0.21^{a}	1.69	0.49	2.54	0.30
	SEM	67.40	1.16	0.44	0.39	0.18	0.18	0.02	0.03	0.05	0.02	0.12	0.02
	P value	0.121	0.999	0.165	0.019	<0.001	0.596	0.631	0.013	0.068	0.235	0.124	0.319
	Plumage colour	**LW (g)**	**DP (%)**	**Breast**	**Back**	**Thigh**	**Drumstick**	**Heart**	**Spleen**	**Liver**	**Lungs**	**Gizzard**	**Proventriculus**
	White	2746.10	73.69	18.28	12.26	9.05	9.82	0.43	0.17	1.58	0.50	2.54	0.31
	Black	2767.70	76.08	18.26	12.77	9.30	10.00	0.46	0.14	1.65	0.51	2.82	0.31
	SEM	67.40	1.16	0.44	0.39	0.18	0.18	0.02	0.03	0.05	0.02	0.13	0.02
	P value	0.824	0.163	0.978	0.366	0.333	0.488	0.324	0.342	0.358	0.841	0.134	0.801
Rearing System	**Plumage colour**	**LW (g)**	**DP (%)**	**Breast**	**Back**	**Thigh**	**Drumstick**	**Heart**	**Spleen**	**Liver**	**Lungs**	**Gizzard**	**Proventriculus**
Indoor	**White**	2857.00	72.84	18.51	11.78	9.57^{a}	9.86	0.44	0.09^{b}	1.46	0.50	2.56	0.30
	Black	2813.00	76.93	18.92	11.81	10.05^{a}	10.09	0.49	0.11^{ab}	1.63	0.53	3.08	0.36
Outdoor	**White**	2635.20	74.54	18.04	12.74	8.52^{b}	9.77	0.42	0.25^{a}	1.71	0.50	2.52	0.33
	Black	2722.30	75.24	17.60	13.73	8.55^{b}	9.91	0.46	0.16^{ab}	1.67	0.48	2.55	0.27
	SEM	95.30	1.64	0.62	0.55	0.25	0.25	0.03	0.04	0.07	0.03	0.18	0.03
	P value	0.501	0.317	0.496	0.393	0.397	0.865	0.906	0.171	0.151	0.287	0.168	0.051

^{abc} Means on the same column having different superscript are significantly different at 5% probability level
$^{1:}$ values are expressed as percentages of the live weight
LW-Live weight (g); DP-Dressing percentage (%)

Table 5: Effects of rearing system and plumage colour on physical properties of breast and thigh meats from local turkeys

		Breast		Thigh	
	Rearing System	**Cooking loss (%)**	**Chilling loss (%)**	**Cooking loss (%)**	**Chilling loss (%)**
	Indoor	20.34	2.70	18.16	3.36
	Outdoor	20.08	5.10	17.49	3.18
	SEM	1.44	2.00	1.85	0.88
	P value	0.898	0.410	0.803	0.889
	Plumage colour	**Cooking loss (%)**	**Chilling loss (%)**	**Cooking loss (%)**	**Chilling loss (%)**
	White	21.62	5.34	21.07^{a}	3.10
	Black	18.80	2.47	14.58^{b}	3.43
	SEM	1.44	2.00	1.85	0.88
	P value	0.185	0.326	0.025	0.791
Rearing System	**Plumage colour**	**Cooking loss (%)**	**Chilling loss (%)**	**Cooking loss (%)**	**Chilling loss (%)**
Indoor	**White**	18.95^{ab}	3.29	21.13	3.09
	Black	21.73^{ab}	2.12	15.18	3.62
Outdoor	**White**	24.29^{a}	7.39	21.01	3.11
	Black	15.86^{b}	2.81	13.97	3.25
	SEM	2.04	2.84	2.62	1.25
	P value	0.014	0.555	0.839	0.876

^{ab} Means on the same column having different superscript are significantly different at 5% probability level.

4 Discussion

This study revealed that growing turkeys under indoor system recorded significant higher weight gain and feed intake than turkeys reared outdoor. This is consistent with earlier reports by Wang *et al.* (2009) and Dou *et al.* (2009) who reported lower growth rate in growing birds in outdoor system than those in the intensive system. Similarly, Li *et al.* (2017) recorded significant changes in body weights and feed intakes of growing chickens reared on different housing system. However, rearing system had no influence on feed conversion ratio of growing turkeys in this present study. This contradicted

previous studies (Hoop and Rippinger, 1997; Permin *et al*., 1999; Zhao *et al.,* 2014) indicating lower feed conversion for birds with outdoor access. This variation could be attributed to differences in poultry species reared, age of birds as well as welfare condition of rearing system between past and present studies. In addition, black-plumaged growing turkeys had higher weight gain than turkeys with white plumages. This agrees with reports of studies like Yildiz and Kesici (1997), Petek *et al*. (2004), Minvielle *et al*. (2005) and Yilmaz and Çağlayan (2008) indicating that white-feathered birds had less body weight than birds with wild breeds with different feather colours.

Contrary to the results obtained in the grower phase, weight gain obtained in the finisher phase was greater in turkeys reared in outdoor system than birds in indoor system. Result is in line with the findings of Batkowska *et al*. (2015) who observed higher weights in finisher broilers reared in extensive system than those reared in intensive system. Santos *et al*. (2005) also reported higher weight gain in birds reared in semi-confined system than those in confined system. However, Fortomaris *et al.* (2007) and Sogunle *et al.* (2016) had contrary opinions; the authors respectively observed no significant differences in weights of poultry species monitored at the finisher phase in different housing systems. This variation could be attributed to differences in size and type of housing system in these studies. Moreover, the effect of plumage colour had no impact on the growth performance of turkeys monitored at the finisher phase. This contradicted earlier reports by Tarhyel *et al*. (2012), who observed significant differences in live weight of quails with different feather colours. Inci *et al*. (2015) also revealed feather colour variations affected feed intake and feed conversion ratios of Japanese quails at the end of fattening period.

According to this study, rearing system had no impact on live weights and dressing percentages of local turkeys. Wang *et al*. (2009), Chen *et al*. (2013), Batkowska *et al*. (2015) and Sogunle *et al*. (2016) had reported similar findings. On the contrary, the reports of Castellini *et al*. (2002) and Feddes *et al*. (2002) revealed birds managed on outdoor houses had significantly higher dressing percentages compared to birds in indoor houses because of increased motor activity. However, back, thigh and spleen portions of turkeys reared in different rearing systems were significantly different in this study. This is in agreement with the findings of Aline (2015) who observed significant differences in cut-up parts of broilers reared in indoor and free-range houses. Similarly, Li *et al*. (2017) observed differences in leg muscle yield in different production system. In addition, it was observed in this study that plumage colour had no effect on carcass characteristics of turkeys, which however contradicted the reports of Inci *et al*. (2015) who observed significant variations in carcass weight, carcass yield, and carcass parts of

quails with different feather colour. This variation could be attributed to differences in genotype and species of birds in both studies.

Furthermore, rearing system had no influence on cooking and chilling losses of turkey meat in this study. Similar findings on the influence of housing system were also reported by Tong *et al.* (2015); the authors observed no differences in the physical qualities of meat from local chicken except meat colour. In addition, this study found significant differences in cooking loss of turkey thigh meat as influenced by plumage colour effect but literatures relating to this are limited.

5 Conclusion

From the findings of this study, improved weight gain with best feed conversion ratio at finisher phase as well as highest spleen and cooking loss in thigh meat was obtained in white-plumaged turkeys reared in outdoor system.

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