Bionature, 40(2) 2020 : 1-10 ISSN: 0970-9835 (P), 0974-4282 (O)

EFFECTS OF DIFFERENT FEEDING REGIMES ON TONIC IMMOBILITY, RECTAL TEMPERATURE AND CARCASS CHARACTERISTICS OF COBB BROILERS

GBEMIGA OLADIMEJI ADEYEMO[1], KINGSLEY OMOGIADE IDAHOR[2*] and BUKOLA I. OYEBANJI[1]

[1]Department of Animal Science, Faculty of Agriculture, University of Ibadan, Nigeria.
[2]Department of Animal Science, Nasarawa State University, Keffi, Shabu-Lafia Campus, P.M.B. 135, Lafia, 950101, Nigeria.
Email: koidahor@nsuk.edu.ng

Received: 10 May 2020
Accepted: 13 July 2020
Published: 07 September 2020

Original Research Article

ABSTRACT

In commercial poultry production, profit could be maximized by reducing cost of feeding through feed restriction, which could also reduce abdominal fat accumulation without detrimental effects on the birds' performance. Unfortunately, there are little or no information on performance characteristics of Cobb broilers that is gradually gaining popularity for its dual purpose capability in Nigeria. Hence, the present trial monitored tonic immobility, rectal temperature and carcass characteristics of Cobb broilers placed on different feeding regimes. Results showed that tonic immobility induction was similar across the treatments with values ranging from 1.13 sec (T3) to 1.50 sec (T2). Similar trend was observed in tonic immobility duration that varied between 159.1 and 266.3 sec. Statistical variations (P= .05) were observed in rectal temperature at 3 weeks old, with the lowest value (41.14°C) in control (T1) and highest (41.6°C) in T3. At 6 weeks old, the rectal temperature was similar and ranged from 41.46 – 41.61°C in T2, T3 and T4, respectively, which were significantly higher (P= .05) than 41.34°C recorded in control. At the end of the study, body weight was not statistically different (P= .05) across the treatments but, varied between 860.2 g (T4) and 916 g (T3). Dressing percentage was best (64.97%) in T4, followed by 64.59%, 62.69% and 62.2% in T1, T3 and T2, accordingly. While the abnormal fat was as high as 1.23% in control birds, it was between 0.63 and 0.94% in the treated birds. This probably suggested normal physiological status hence, Cobb broilers may thrive well on feed restriction.

Keywords: Abdominal fat; lean chicken; feed restriction; broiler nutrition.

INTRODUCTION

Poultry birds are kept for human consumption as a veritable source of animal protein. According to Raloff [1], poultry egg and meat are the second most widely consumed food of animal origin in the world. Therefore, meat-type poultry species should have the capability to grow and mature for meat production within a short period of 33 to 60 days. Such meat-type poultry species are commonly referred to as broilers, emanating from rigorous breeding improvement strategies. According to Londok and Rompis [2], broilers are specifically selected for fast growth rate in the poultry industry, to produce strains with high body weight with a short maintenance period. However, broiler meat produced by each strain varies considerably even within breeds, due to different genetic traits and prevailing environmental factors. Feeding is a vital aspect of broiler production, accounting for about 70% of the total cost of production. This in most cases results in high cost of chicken and chicken products,

thus making it unaffordable by many households.

Accordingly to FAO [3], increasing cost of poultry production led to high cost of poultry meat in some regions of the world. Idahor et al. [4] described this phenomenon as a threat to the development of poultry industry, which is an economic giant that is fast asleep in Nigeria. It was stated that whenever this sleeping giant wakes up to assume its giant role in Nigeria, there will be a better national economy, required for quick national growth and development. Thus, suggested feed restriction as a veritable strategy compared to altering the photoperiod and use of chemicals to suppress feed intake. More so, feed restriction could be employed to eliminate problems of fat deposition (particularly accumulated abdominal fat), metabolic disorder, skeletal diseases and mortality [5,6]. Feed restriction is a partial feeding program for animals at a certain age and period in order to reduce the impact of excessive feed consumption. Feed restricted broilers may have high feed efficiency, reduced body fat, increased final body weight and reduced feed costs. Feed restrictions in the short period have the ability to catch up with body weight growth after a period of normal feeding [7,8].

Gous and Cherry [9] stated that feeding strategies in growing broilers should be aimed at optimizing lean carcass tissue, feed conversion ratio and body weight gain. But success of feed restriction was measured based on complete compensatory growth and the amount of body fat accumulated [10]. Compensatory growth was described as the rapid weight gain usually after a period of reduced nutrients intake. Meanwhile, Osbourn and Wilson [11] earlier demonstrated that compensatory growth in poultry was a period of retardation by early feed restriction. Butzen et al. [12] speculated that feed restriction program, should decrease the initial weight gain to be considered successful but with subsequent full feeding, the broilers must demonstrate compensatory growth rate. Therefore, it is beneficial to underfeed broilers for sometimes as the weight at market age is not affected instead, the carcass composition changes for good. These physiological modifications could result in stressful conditions, leading to poor body conformation, unstable behaviour, diseases, lesions or sudden death in extreme cases.

According to Amer et al. [13], fear is an element of stress measured by the duration of tonic immobility, commonly used as a criterion for evaluating wellbeing and stress levels in poultry birds. Nevertheless, Gudev et al. [14] stated that tonic immobility does not seem to be a reliable marker of fear because of its complex nature and phenomenology. Earlier, Jones [15] described tonic immobility as an unlearned response characterized by a catatonic-like state of reduced responsiveness, to external stimulation elicited by physical restraint in animals. It was stressed that the animal struggles and attempts to escape but, soon adopts an immobilized posture that may persist for few minutes or several hours. It was stated that tonic immobility is characterized by temporary suppression, reduced vocalization, alteration in heart rate, respiration, internal temperature and Parkinsonian-like muscle disorder that may distort carcass accretion. There are several reports on tonic immobility in a wide variety of animal species such as blue crabs, quail, sharks and chickens. In most cases, the animals subjected to this test were placed on their back and gently restrained for a brief period and the longer the animal stays in this immobile state, the more fearful it is [16]. Meanwhile, Fogelholm et al. [17] stated

that the relationship between tonic immobility and anxiety is potentially less straight forward hence it does not often correlate with other basic anxiety measures. Therefore, this study was targeted at evaluating tonic immobility, rectal temperature and carcass quality of Cobb broilers placed on different feeding regimes.

METHODOLOGY

Brief Climatic Description of the Study Site

The experiment was conducted at the Poultry Unit, Teaching and Research Farm, University of Ibadan, located on latitude 07° 20' N and longitude 03° 50' E. It has a hot humid equatorial climate which could be divided into four distinct seasons: early rainy season (April–June), late rainy season (July – September), early dry season (October – December) and late dry season (January – March). The mean total rainfall in Ibadan is 1420.06 mm, falling in approximately 109 days in a year. Ibadan lies completely within the tropical forest zone but close to the boundary between the forest and the derived savanna. The city ranges in elevation from 150 m in the valley area to 275 m above sea level on the major north-south ridge which crosses the central part of the city. The city covers a total area of 3,080 square km with a population of over 3 million people, making it the largest city in Nigeria. The mean maximum temperature is 26.46°C, minimum 21.42°C and relative humidity is 74.55% [18].

Table 1. Gross composition of the broiler starter diet

Ingredients	Quantity (kg)
Maize	55.00
Groundnut cake	33.00
Soybean meal	4.60
Fish meal	0.50
Full fat soya	3.00
Oyster shell	0.50
Di-calcium phosphate	2.50
Di-methionine	0.15
Lysine	0.25
Salt	0.25
Premix	0.25
Total	100.00
Calculated values	
Crude protein (%)	23.11
Metabolisable energy (kcal/kg)	3005.31
Crude fibre (%)	3.82
Calcium (%)	1.02
Ether extract (%)	3.86
Available phosphorus (%)	0.55

Determined proximate composition: Crude protein (24.2%); crude fibre (5%); dry matter (98.5%); ash (5.6%), ether extract (6%); nitrogen free extract (59.3%)

Table 2. Gross composition of the broiler finisher diet

Ingredients	Quantity (kg)
Maize	56.50
Groundnut cake	9.50
Wheat offal	10.00
Fish meal	0.30
Full fat soya	20.00
Oyster shell	1.00
Di-calcium phosphate	1.95
Di-methionine	0.15
Lysine	0.10
Salt	0.25
Premix	0.25
Total	100.00
Calculated values	
Crude protein (%)	19.72
Metabolisable energy (kcal/kg)	3000.39
Crude fibre (%)	3.79
Calcium (%)	1.12
Ether extract (%)	5.51
Available phosphorus (%)	0.45

Determined proximate composition: Crude protein (22%); crude fibre (6%); dry matter (98.5%); ash (4.6%), ether extract (5.5%); nitrogen free extract (61.8%)

Experimental Design and Birds' Management

A total of 192 day-old Cobb broiler chicks were bought from a reputable hatchery in Ibadan, Nigeria. The chicks were randomly assigned to four treatment groups designated as T1 (*ad libitum* feeding), T2 (twice split feeding: morning and evening) T3 (thrice split feeding: morning, afternoon and evening feeding) and T4 (3 hours restricted feeding). Each treatment group was replicated six times and there were eight birds per replicate. The birds were fed according to the experimental feeding regimes of the groups for six weeks and the pens, feeder, water and environment were cleaned, washed and disinfected regularly in order to maintain good hygiene. The experimental starter and finisher diets were offered three weeks each during the study and are presented in Tables 1 and 2, respectively.

Data Collection and Analysis

The proximate analysis of the starter and finisher diets was determined using standard procedures [19]. The birds were weighed weekly using table scale to obtain body weight gain, feed offered were weighed daily to obtain feed intake and the feed conversion ratio was determined by dividing feed intake with body weight value. The rectal temperature was taken by inserting clinical thermometer into the birds'

vents. Tonic immobility test was carried out on day 42 of the experiment by inverting the birds on their right side and restraining until the bird stopped struggling as described by Gudev et al. [14]. At the end of six weeks of feeding trial, five birds per treatment were randomly selected, fasted overnight and sacrificed by severing the jugular vein. The carcasses were dressed according to the procedure of Jones [20] to obtain carcass weight, cut parts and abdominal fat values expressed as percentage of the live weight. All the data collected was analyzed using statistical software procedure of SAS [21] and the mean values were separated using the same software package.

RESULTS

Table 3 shows the tonic immobility and rectal temperature of broilers on different feeding regimes. There were statistical differences (P= .05) in the rectal temperature among the birds across the treatments, whereas tonic immobility induction and duration values did not differ significantly (P= .05). Tonic immobility induction time ranged between 1.13 seconds in birds that were fed thrice split feeding and 1.50 seconds in birds fed twice split feeding. Rectal temperature values at the end of feed restriction varied between 41.1°C and 41.6°C, while at the end of compensatory feeding, it was 41.3 to 41.5°C.

Carcass characteristics of broilers on different feeding regimes are presented in Table 4. There were no statistical variations (P= .05) among all the parameters measured, except breast, wing and abdominal fat weight values. The breast weight value was highest (17%) in birds that were restricted from feeding for 3 hours, followed slightly by those fed thrice split feeding (16.8%), *ad libitum* (16%) and twice split feeding (15%) in that order.

The wing was largest (9.6%) in birds fed twice split feeding slightly followed by birds in *ad libitum* (9.1%), 3 hours restricted feeding (8.7%), while the least value (7.5%) was recorded in birds fed thrice split feeding. Meanwhile, the live body weight value varied between 860 and 916 g, dressing percentage (62.2 and 64.9%), head (3.24 and 3.41 g), drumstick (9.47 and 10.9%) and abdominal fat values were least (0.63%) in birds fed thrice split feeding and highest (1.23%) in *ad libitum* fed birds.

Table 3. Tonic immobility and rectal temperature of Cobb broilers on different feeding regimes

Parameters	Treatments				
	T1	T2	T3	T4	SEM
Tonic immobility					
Induction (seconds)	1.25	1.50	1.13	1.38	0.09
Duration (seconds)	229.0	266.3	159.1	179.5	35.54
Rectal temperature (°C)					
End of feed restriction (3rd week)	41.14^{c}	41.46^{b}	41.61^{a}	41.50^{ab}	0.03
End of compensatory feeding (6th week)	41.34^{b}	41.51^{a}	41.53^{a}	41.47^{a}	0.02

a,b,c: Means with different superscript in the same row are significantly different (P= .05);
SEM: Standard error of means; T1 – ad libitum feeding; T2 – morning and evening (twice split feeding); T3 – morning, afternoon and evening (thrice split feeding); T4 – 3 hours restricted feeding

Table 4. Carcass characteristics of Cobb broilers on different feeding regimes

Parameters	Treatments				
	T1	T2	T3	T4	SEM
Live weight (g/bird)	900.80	871.80	916.00	860.20	20.62
Feed intake (kg/bird)	1.29	1.25	1.21	1.21	0.27
FCR	1.94	2.09	2.15	2.16	0.49
Weight gain (kg/bird)	0.089	0.093	0.092	0.093	0.06
Bled weight (%)	96.30	96.05	95.85	95.65	0.16
Dressing percentage (%)	64.59	62.20	62.69	64.97	0.81
Head (%)	3.35	3.43	3.24	3.41	0.07
Neck (%)	6.01	6.20	5.98	5.80	0.28
Breast (%)	16.03^{ab}	15.09^{b}	16.82^{ab}	17.03^{a}	0.32
Back (%)	13.95	13.87	13.58	13.06	0.20
Wing (%)	9.12^{ab}	9.55^{a}	7.50^{b}	8.68^{ab}	0.33
Drumstick (%)	10.90	9.85	9.47	10.06	0.24
Shank (%)	5.54	4.74	4.90	5.18	0.16
Abdominal fat (%)	1.23^{a}	0.94^{b}	0.63^{c}	0.69^{c}	0.06

a,b,c: Means with different superscript in the same row are significantly different (P= .05); SEM: Standard error of means; FCR: Feed conversion ratio; T1 – ad libitum feeding; T2 – morning and evening (twice split feeding); T3 – morning, afternoon and evening (thrice split feeding); T4 – 3 hours restricted feeding

DISCUSSION

Energy values of both the starter and finisher diets used in this study were similar to 3,000 kcal/kg, while the determined protein values were within 16 – 24% recommended for broiler chickens [22]. This probably suggested that the experimental feeds provided the required nutrients for the experimental birds' physiological growth and development. Tonic immobility induction time was similar to a range of 1.2 – 1.6 seconds reported in meat type chickens subjected to tonic immobility by placing them on their back in a U-shaped cradle. Similarly, the tonic immobility duration values were close to a range of 214 – 408 seconds recorded in that study [23]. Also, the values recorded in the present study were within 1.5 – 2.3 seconds and 100 – 350 seconds reported as tonic induction time and duration, respectively in broilers restrained on their side [24]. This possibly indicated that the birds' physiological integrity in the present study was perhaps not compromised by the feed restriction strategy.

However, this observation was at variance with the report of Gudev et al. [14], who observed tonic induction values within 590 – 600 seconds which was much higher than the recorded values in the present study. It was stated in that study that adrenal response of extremely fearful birds, did not differ in less fearful birds when the tonic immobility duration was measured in female Label chickens at 51 days old. The differences observed could be due to the strain, age and nature of tonic immobility induction techniques adopted in the studies. This observation strengthened the belief that fear probably underlies tonic immobility in domestic fowls [25,26,27] and the observed scenario probably expressed no deleterious consequences on the Cobb broilers welfare

and performance. Therefore, different feeding regimes may not induce stress, fearfulness and as such there may be little or no adrenal response due to the feed restricted periods in the Cobb broilers. Meanwhile, Erhard et al. [28] reported reactive and proactive individuals to tonic immobility in poultry species.

The rectal temperature of the birds was somewhat higher than 40.7°C reported in broiler strains [24,29,30], but lower than 43.0°C reported elsewhere [31,32,33]. Meanwhile, the rectal temperature value was within 41.46 – 41.71°C reported in layer strains fed different levels of dietary acetyl salicylic acid [34]. This conformity probably suggested that the broiler birds in the present study were probably not stressed by the feed restriction regimes. While the body weight value of the broiler birds was far less than 2.1 to 2.4 kg reported by Idahor et al. [4], when different strains of broilers were placed on feed restriction, it was similar to body weight of 874.6 to 891.5 g reported by Yakubu et al. [35]. The observed differences could be adduced to environmental, physiological, genetic influences, age at slaughter and the nature of treatments the birds were subjected to.

Feed intake, weight gain and feed conversion ratio values were less than 2.51 to 2.92 kg, 1.09 to 1.13 kg and 2.33 to 2.6 in that order reported by Adeyemo et al. [36], when biscuit waste was fed to broilers. The disparities could be largely due to bird strain, age and partly as a result of the feed restriction. The abdominal fat was tremendously reduced in the treated birds compared to the birds in control group, suggesting that feed restriction may be a sure way to achieve lean chicken production for healthy human consumption. This was probably as a result of metabolic pathways involved in providing nutrients for the cells to function even during adverse conditions in animals. This observation partially conformed to Tulung et al. [37], who reported that duration of feeding up to 16 days, reduced carcass and abdominal fat weight but had no deleterious effects on serum cholesterol levels, weight of organs and digestive organs. The head, neck, breast, wing and drumstick values were similar to the observation of Adeyemo and Akanmu [38], when neem leaves were fed to broilers and all the values were within the ranges given for healthy broilers [39,40]. Consequently, different feeding regimes may not affect carcass characteristics in Cobb broilers.

CONCLUSION

Different feeding regimes apparently did not induce outrageous tonic immobility and rectal temperature in Cobb broiler strain during the trial, thus feed restriction may not induce fear or increase body temperature in broilers. The carcass characteristics of the treated broilers were probably not physiologically distorted during the study period. Yet, the abdominal fat was drastically reduced and the dressing percentage, drumstick and body weight values were seemingly not affected by the feeding regimes. Consequently, feed restriction strategy may be adopted to produce Cobb broiler strain lean meat which is required for healthy human living.

AUTHORS' CONTRIBUTIONS

Author GOA conceived designed and supervised the experiment. Author KOI consulted the literature and prepared the manuscript while author BIO collected the data, analyzed and interpreted the data. All authors read and approved the final manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Raloff J. Food for thought: Global food trends; 2003. (Accessed March 2019) Available at: https://www.sciencenews.org/blog/food-thought/global-food-trends
2. Londok JMR, Rompis JEG. The effect of early feed restriction on the commercial pieces of two broiler chicken strains. IOP Conf. Ser.: Earth Environ. Sci. 2020;411:012029.
3. FAO. Poultry production system. Food and Agricultural Organization FAO, Health Paper. 2004;19:102-103.
4. Idahor KO, Yakubu A, Egahi JO, Gwaza DS, Ahmadu GB, Thani AP. Growth performance, carcass characteristics and cost benefits of four broiler strains on restricted feeding regimen in North Central Nigeria. J. Anim. Sci. Adv. 2013;3(9):449-456.
5. Ozkan S, Plavnik I, Yahav S. Effects of early feed restriction on performance and ascites development in broiler chickens subsequently raised at low ambient temperature. J. Appl. Poult. Res. 2006;15:9-19.
6. Saleh EA, Watkins SE, Waldroup AL, Waldroup PW. Effects of early feed restriction on live performance and carcass composition of male broilers grown for further processing. J. Appl. Poult. Res. 2005;14:87–93.
7. Fondevila G, Archs JL, Camara L, de Juan AF, Mateos GG. The length of the feed restriction period affects eating behaviour, growth performance and the development of the proximal part of the gastrointestinal tract of young broilers. Poultry Science. 2020;99:1010–1018. DOI:https://doi.org/10.1016/j.psj.2019.10.011
8. Shafiei A, Khavarinezhad S, Javandel F, Nosrati M, Seidavi A, Diarra SS. Effects of duration of early feed withdrawal and re-feeding on growth, carcass traits, plasma constituents and intestinal microflora of broiler chickens. Journal of Applied Animal Research. 2018;46(1):1358–1362. DOI:https://doi.org/10.1080/09712119.2018.1509004
9. Gous RM, Cherry P. Effects of body weight at and lighting regimen and growth curve to, 20 weeks on laying performance in broiler breeders. Brit. Poult. Sci. 2004;45:445–452.
10. Hassanabadi A, Moghaddam H. Effect of early feed restriction on performance characteristics and serum thyroxin of broiler chickens. Int'l J. Poult. Sci. 2006;5(12):1156-1159.
11. Osbourn DF, Wilson PN. Effects of different patterns of allocation of a restricted quantity of food upon the growth and development of cockerels. J. Agric. Sci. 1960;54:278-289.
12. Butzen FM, Ribeiro AML, Vieira MM, Kessler AM, Dadalt JC, Della MP. Early feed restriction in broilers. I– Performance, body fraction weights and meat quality. J. Appl. Poult. Res. 2013;22:251–259. DOI:http://dx.doi.org/10.3382/japr.2012-00639
13. Amer SA, Omar AE, Mohamed WAM, Gharib HSA, El-Eraky WA. Impact of betaine supplementation on the growth performance, tonic immobility and some blood chemistry of broiler chickens fed normal and low energy diets during natural summer stress.

Zagazig Veterinary Journal. 2018;46(1):37–50.
DOI: 10.5281/zenodo.1232385
14. Gudev D, Moneva P, Popova-Ralcheva S, Sredkova V. Tonic immobility and adrenal response in chickens fed supplemental tryptophan. Bulg. J. Agric. Sci. 2011;17(4):560-566.
15. Jones RB. The tonic immobility reaction of the domestic fowl: A review. World's Poult. Sci. J. 1986;42(1):82-96.
DOI: 10.1079/WPS19860008
16. Vegger JB, Brüel A, Dahlgaard AF, Thomsen JS. Alterations in gene expression precede sarcopenia and osteopenia in botulinum toxin immobilized mice. J. Musculoskelet. Neuronal Interact. 2016;16:355–368.
17. Fogelholm J, Inkabi S, Höglund A, Abbey-Lee R, Johnsson M, Jensen P, Henriksen R, Wright D. Genetical genomics of tonic immobility in the chicken. Genes. 2019;10:341.
DOI:10.3390/genes10050341.www.mdpi.com/journal/genes
18. Wikipedia. Ibadan location in Nigeria; 2019.
(Accessed March 2020)
Available:https://en.wikipedia.org/w/index.php?title=Ibadan&oldid=941308619
19. AOAC. Official methods of analysis. Vol. 18th Ed. Association of Official Analytical Chemists, Arlington, VA, USA; 2002.
20. Jones RB. A standard method of dissection of poultry for carcass analysis. Technical Bulletin No. 222, West Scotland; 1984.
21. SAS. Statistical analysis systems. SAS User's Guide: Statistics software. Cary, NC, SAS Institute; 2007.
22. Olomu JM. Monogastric animal nutrition, principles and practice. 2nd Edn. Jachem Publication, Benin City, Nigeria; 2011.
23. Ghareeb K, Bohm J. Fear behaviour, ease of capture and performance traits of growing meat type chickens. Int'l J. Poult. Sci. 2008;7(12):1185-1189.
24. Yildirim M, Taskin A. The effects of environmental enrichment on some physiological and behavioural parameters of broiler chicks. Braz. J. Poult. Sci. 2017;19(2):355-362.
25. Gallup G. G. Jr., Creekmore HS, Hill WE. Shock-enhanced immobility reactions in chickens: Support for the fear hypothesis. Psychol. Rec. 1970;20:243-245.
26. Gallup G. G. Jr., Nash RF, Doneyan NH, McClure MK. The immobility response: A predator-induced reaction in chickens. Psychol. Res. 1971;21:513-519.
27. Gallup GG, Rosen TS, Brown CW. Effect of conditioned fear on tonic immobility in domestic chickens. J Comp Physiol. Psychol. 1972;78:22-25.
28. Erhard HW, Mendl M, Christiansen SB. Individual differences in tonic immobility may reflect behavioural strategies. Appl. Anim. Behav. Sci. 1999;64:31-46.
29. Eleroglu H, Yildirim A, Duman M, Sekeroglu A. The welfare of slow growing broiler genotypes reared in organic system. Emir. J. Food and Agric. 2015;27(5):454-459.
30. Xie J, Tang L, Lu L, Zhang L, Lin X, Liu HC, Odle J, Luo X. Effects of acute and chronic heat stress on plasma metabolites, hormones and oxidant status in restrictedly fed broiler breeders. Poult. Sci. 2015;94:1635-1644.
31. Isidahomen CE, Jidda AA, Olatunji EA. Heat tolerant traits among local

and exotic chickens in Southern Nigerian. IOSR J. Agric. Vet. Sci. 2012;1(6):31-36.
32. Justin E. Heat stress in poultry: Solving the problem. 2004;28. (Accessed June 2019). Available at: www.gov.uk/.../69373/pb10543-heat-stress-050330.pdf
33. Medeiros CM. Ajuste de modelos e determinação de índice térmico ambiental de produtividade para frangos de corte. Tese apresentada à Universidade Federal de Viçosa, Como parte das exigências do Programa de PósGraduação em Engenharia Agrícola para obtenção do título de "Doctor Scientiae". 2001;125.
34. Aro SO, Osho IB, Awoneye OO. Comparison of rectal and axillary temperatures of Isa brown and Harco black layers fed different levels of dietary acetylsalicylic acid. Anim. Res. Int'l. 2017;14(1):2691-2696.
35. Yakubu A, Idahor KO, Usman EA, Jonathan LF, Musa-Azara IS. Effect of feed restriction on growth performance, body conformation, carcass characteristics and cost-benefit in broiler chickens. Wayamba J Anim Sci. 2013;2:P704-P713. ISSN: 2012-578X.
36. Adeyemo GO, Oni OR, Longe OG. Effect of dietary biscuit waste on performance and carcass characteristics of broilers. Food Sci. Qual. Manage.; 2013. ISSN: 2224-6088 (Paper) ISSN 2225-0557. Available at: www.iiste.org
37. Tooling B, Londok JJMR, Regard MN. The effect of length of feeding and level of crude fibre carcass quality and serum cholesterol of broiler chicken. Proceeding the 4th International Seminar, Manado: Sam Ratulangi University; 2015.
38. Adeyemo GO, Akanmu AM. Effects of neem (*Azadirachta indica*) and pawpaw (*Carica papaya*) leaves supplementation on performance and carcass characteristics of broilers. Int'l J. Curr. Res. 2012;4(12):268-271.
39. Benyi K, Acheampong-Boateng O, Norris D, Ligaraba TJ. Response of Ross 308 and Hubbard broiler chickens to feed removal for different durations during the day. Trop. Anim. Health and Prod. 2010;42:1421-1426.
40. Zhan XA, Wang M, Ren H, Zhao RQ, Li JX, Tan ZL. Effect of early feed restriction on metabolic programming and compensatory growth in broiler chickens. Poult. Sci. 2007;86:654-660.