https://dx.doi.org/10.4314/ijs.v24i3.6

ANTIOXIDANT EFFECTS OF *Faidherbia albida* LEAF MEAL ON GROWTH PERFORMANCE AND EGG PRODUCTION OF *INSTITUT DE SÉLECTION ANIMALE* (ISA) BROWN LAYER CHICKENS RAISED UNDER SEMI-ARID CONDITIONS

Ibitoye, E. B.[1,*], Olaniyan, A. M.[2], Jimoh, A. A.[1], Ja'afaru, A. I.[3] and Ishola, O. D.[1]

[1]Department of Theriogenology and Animal Production, Faculty of Veterinary Medicine, Usmanu Danfodiyo University Sokoto, Nigeria.

[2]College of Agriculture and Animal Science, Bakura, Zamfara State, Nigeria.

[3]Department of Veterinary Physiology and Biochemistry, Faculty of Veterinary Medicine, Usmanu Danfodiyo University Sokoto, Nigeria.

***Corresponding Author's Email**: eb.ibitoye@gmail.com

(Received: 21st January, 2022; Accepted: 23rd November, 2022)

ABSTRACT

The negative impacts of a hot environment on the growth performance and egg production of layers have been managed using different substances containing antioxidant properties. In this study, the antioxidant potential of *Faidherbia albida* leaf meal (FALM) at ameliorating heat stress in layer chickens was investigated. A total of one hundred and eighty (180) eighteen-week-old brown layers from the *Institut de Sélection Animale* (ISA) were randomly divided into four treatment groups. Four different FALM inclusion levels were incorporated: 0 (control), 5, 10, and 15% as T1, T2, T3, and T4, respectively. Forty-five 18-week-old Point of Lay (POL) chickens were allotted to each of the treatments in three replicates (15 birds per replication). The antioxidant effects of FALM on growth performance, egg production, and hen-day egg production of the chickens were tested. The results showed that birds decreased in body weight and feed intake with increasing levels of FALM. However, birds fed 5% FALM had significant ($P<0.05$) body weight (1.51 kg), decreased feed intake (0.75 kg/bird/week), and better feed conversion efficiency (2.9). Significantly ($P<0.05$) improved egg production and hen-day egg production were recorded in all FALM-treated groups. As a result, *Faidherbia albida* leaf meal at a 5% inclusion level demonstrated antioxidant activities in ISA brown layer chickens under semi-arid conditions.

Keywords: Antioxidants, Egg production, *Faidherbia albida*, ISA Layer chicken, Semi-arid condition.

INTRODUCTION

Heat exposure substantially impacts the health and production of poultry on a global scale. Heat stress (HS) occurs when an animal's ability to discharge heat into its environment is exceeded by the amount it produces. For many years, HS has caused scientists and poultry farmers tremendous concern. Animals with HS often lower their heat production by consuming less feed which affects growth and performance (Akbarian *et al.,* 2016).

It has been known that HS can cause oxidative stress (OS) (Lin *et al.,* 2006). Oxidative stress is defined as the presence of reactive species (RS) that exceeds the antioxidant capacity of animal cells (Halliwell and Whiteman, 2004). Many radicals and metabolic by-products are classified as "reactive oxygen, nitrogen, or chlorine species" and are considered potentially hazardous (Halliwell and Whiteman, 2004). These chemicals have a high degree of reactivity and can alter some macromolecules with biological significance, including proteins, lipids, and nucleic acids (Davies, 1995). HS and OS combine to impair hepatic lipid metabolism, which compromises both broiler and layer performance and well-being (Emami *et al.,* 2021). These phenomena contribute to the development of several metabolic dysfunctions, including cell death, by causing "oxidative stress" and "oxidative damage" (Halliwell and Whiteman, 2004). In addition, OS may alter the redox equilibrium of several cellular redox couples, leading to altered expression of critical enzymes in detoxification, antioxidant defense, and inflammatory responses. The findings of Wang *et al.* (2021) indicated that OS could decrease the laying performance and ovarian function of layers and influence gut microbiota and body metabolites. Moreover, it has been shown that OS plays a role in follicular atresia leading to ovarian aging and reproductive disorders (Devine *et al.,* 2012; Shen *et al.,* 2012).

Defense mechanisms have been developed within cells to regulate RS synthesis. These comprise both non-enzymatic, low-molecular-weight substances (e.g., vitamin C, GSH, and uric acid) and enzyme-based, high-molecular-weight substances (e.g., superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), and arylesterase). They prevent oxidative damage to cells by limiting the rate and course of oxidation (Akbarian *et al.,* 2016). However, studies have shown that HS frequently raises OS by suppressing the generation of antioxidant enzymes and lowering levels of several reproductive hormones (Davidson *et al.,* 1996; Jana *et al.,* 2010; Tusell *et al.,* 2011). Additionally, the antioxidant capabilities of vitamins A, C, and E have been linked to their functions in the treatment of OS brought on by HS (Ajakaiye *et al.,* 2010). Nevertheless, adulteration of dietary supplements like vitamins C and E is an emerging food safety issue (Rocha *et al.,* 2016). Hence, advocacy for alternative antioxidants is shifting towards natural products due to their safety, availability, and cost-effectiveness. Research on plants that contain bioactive antioxidant components is becoming an area of interest worldwide.

The leaf of *Faidherbia albida* is known to contain quercetin (L-5) and rhamnocitrin (L-4), which have been reported for their strong antioxidant activities (Mohammed *et al.,* 2018). Despite its attendant benefits, studies on the supplementation of *Faidherbia albida* leaf as an antioxidant in laying birds are lacking. This study evaluated the potential of *F. albida* leaf as a substitute antioxidant to minimize the negative effects of OS caused by HS on growth performance and egg production in ISA Brown-layer chickens reared in semi-arid conditions.

MATERIALS AND METHODS

Experimental location

This study was conducted at the Poultry Teaching and Research Farm of the College of Agriculture and Animal Science, Bakura, Zamfara State. The State lies between latitudes 12° 34'-12° 42' N and longitudes 6° 14'-5° 52' E (Dogo *et al.,* 2021). The climate of the area is characterized by a hot, dry season lasting from October to May and a rainy season that usually starts in mid-May and ends in September. Long-term mean annual rainfall ranges from 500 mm to 900 mm, with considerable interannual variations. The annual temperature is 27 °C, with a minimum of 17 °C in December/January and a maximum of 40 °C in April/May (Anonymous, 2013).

Ethical approval

The permission to conduct this study was granted by the Institutional Animal Care and Use Committee (IACUC) of Usmanu Danfodiyo University Sokoto (UDUS) (Reference number UDUS/IACUC/AUP-R05/2020).

Preparation of *Faidherbia albida* leaf meal (FALM)

Faidherbia albida leaves were sourced from Bakura Forest and soaked in boiled water for 2 h. Then the leaves were air-dried under shade and ground to reduce particle size using an electric grinding machine (Capacitor Start Machine, M & T Industries, China) to make *Faidherbia albida* leaf meal (FALM). The FALM were stored at room temperature in airtight, tight bags.

Formulation of the experimental diets

Four isocaloric and isonitrogenous diets were formulated using the Pearson square method at an estimated rate of 125 g feed per hen per day to feed 180 layers for 49 days (Table 1). *Faidherbia albida* leaf meal was included at a certain percentage of the crude protein (CP) of groundnut cake (GNC). Diet 1 had no FALM, while diets 2, 3, and 4 contained 5, 10, and 15% FALM, respectively.

Table 1: Composition of the experimental feed (layers mash).

Ingredients (kg)	FALM inclusion levels (%)			
	0	5	10	15
Maize	57.98	57.98	57.98	57.98
GNC	12.28	10.98	8.76	6.66
FALM	0.00	2.10	4.20	6.30
Soybeans	3.24	3.24	3.24	3.24
Wheat offal	15.00	15.00	15.00	15.00
Blood meal	2.00	2.00	2.00	2.00
Limestone	4.00	4.00	4.00	4.00
Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Methionine	3.00	2.20	2.32	2.32
Lysine	2.00	2.00	2.00	2.00
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Crude protein (%)	16.00	16.02	16.10	15.78
Energy (kcal/kg)	2624.27	2633.26	2622.00	2600.71

Key: FALM = *Faidherbia albida* leaf meal, GNC = groundnut cake, Premix = Minerals and vitamins (Avitech, 2020)

Experimental birds

The experimental birds were 180 eighteen-week-old point-of-lay (POL) brown layer chickens from Zartech Farm in Ibadan, Oyo State, Nigeria. The birds were transported in cages by road to Bakura. They were managed on deep litter at the Poultry Research Farm of the College of Agriculture and Animal Science, Bakura, Zamfara State, Nigeria.

Experimental design and management of experimental animals

FALM inclusion levels of 0 (control), 5, 10, and 15% as treatments 1, 2, 3, and 4, respectively, were included in the layer chicken diet. After 2 weeks of acclimatization, the 180 ISA Brown Layer (IBL) chickens were randomly distributed into four treatment groups at 45 chickens per treatment with three replicates (15 birds per replicate). The FALM-based diets were allotted to each treatment. The birds were fed FALM-based diets and watered *ad libitum* throughout the study. The birds were vaccinated against Newcastle disease, infectious bursa disease, fowl pox, and fowl typhoid, as applicable. The chickens were gradually introduced to experimental diets beginning at 20 weeks of age before data collection began at 28 weeks. The birds started laying eggs at 22 weeks of age, and the egg production was recorded to ascertain the percentage of egg production before data collection.

The feeding trial lasted 7 weeks, from March 23 to May 11, 2020, during which HAT is expected to be common. At the time of the commencement of data collection, the chickens were 28 weeks old and at an approximately sixty percent (60%) production level. The average minimum and maximum daily ambient temperatures and relative humidity of the poultry house were monitored using a digital thermometer and a hygrometer (Model Number: HTC-6, BIOBASE® China), placed in the poultry pen.

Growth performance indices

During the study, initial body weight (at 28 weeks old) and final body weight (at 35 weeks old) were recorded using a kitchen weighing scale. A certain amount of feed was measured and served weekly per replicate, and the leftover feed was subtracted from the feed measured out at the beginning of the week to estimate the feed intake. The feed conversion ratio (FCR) was estimated by dividing the average weight of total eggs produced by the average total feed intake.

Egg production rate and hen-day egg production

Data collection on egg production commenced on the 28th week of age, and the trend of egg production was followed up to the 35th week of age. Hen-day egg production (HDEP) was calculated using the following formula (Huneau-Salaün *et al.,* 2011):

$$HDEP = \frac{\text{Total number of eggs produced per day}}{\text{The total number of hens present on that day}} \times 100\%$$

Data analysis

Data generated from the study were subjected to a one-way analysis of variance (ANOVA). Differences between the mean values were determined using Tukey HSD at a 95% confidence level (P=0.05) with the aid of SPSS version 20.0.

RESULTS

Antioxidant effects of FALM on the growth performance of IBL chickens under semi-arid conditions

The antioxidant effects of FALM on the growth performance of IBL chickens are shown in Table 2. During this study, the temperature ranged from 28.6 °C to 41.9 °C. There was a significant (P<0.05) decrease in the final body weight (FBW) and feed intake (IF) of the chickens, with an increase in the FALM inclusion levels. The FBW differed non-significantly (P>0.05) between the control group (T1: 1.52 ± 0.075 kg) and FALM at 5% (T2: 1.51 ± 0.089 kg), while the rest of the treatments, i.e., FALM at 10% (T3: 1.20 ± 0.069 kg) and 15% (T4: 1.39 ± 0.062 kg), had FBW significantly (P<0.05) below that of the control group. The result showed that feed intake (FI) decreased significantly (P<0.05) with increasing FALM in the diets of IBL chickens. Birds in T4 consumed the least amount of feed (0.72 ± 0.05 kg), while those in the control group consumed the highest amount of feed (0.76 ± 0.01 kg).

Birds fed 5 and 10% FALM yielded heavier eggs (261.98 ± 33.02 g and 261.48 ± 19.04 g, respectively) than those fed the control diet (236.76 ± 23.30 g) and 15% FALM (236.63 ± 13.41 g). However, it was not statistically significant (P>0.05). Also, the inclusion of FALM at different levels did not affect (P>0.05) the FCR across all the treatment groups.

Table 2: Mean (± SD) Antioxidant effects of FALM on growth performance of IBL raised under semi-condition chickens.

Parameter	FALM Inclusion levels (%)				P-value
	0	5	10	15	
IBW (kg/bird)	1.67 ± 0.064	1.72 ± 0.062	1.72 ± 0.054	1.73 ± 0.031	0.238
FBW (kg/bird)	1.52 ± 0.075^{a}	1.51 ± 0.089^{ab}	1.20 ± 0.069^{c}	1.39 ± 0.062^{b}	0.043
FI (kg/bird/week)	0.76 ± 0.01^{a}	0.75 ± 0.01^{b}	0.74 ± 0.04^{c}	0.72 ± 0.05^{d}	0.000
WTEP(g/bird/week)	236.76±23.30	261.98±33.02	261.48±19.04	236.63±13.41	0.069
FCR	3.24 ± 0.37	2.90 ± 0.38	2.85 ± 0.20	3.04 ± 0.17	0.090

Means within the same row with different superscripts $^{a, b, c, d}$ are significantly different (P<0.05). Key: SD = standard deviation, IBL = ISA Brown Layers, = FALM = *Faidherbia albida* leaf meal, IBW = initial body weight, FBW = final body weight, FI = feed intake, WTEP = weight of total egg produced, and FCR = feed conversion ratio.

Effects of FALM on egg production and hen-day egg production (HDEP) of IBL

The mean daily egg production (DEP) of the IBL chickens is presented in Table 3. Birds treated with a 5% FALM-based diet had better DEP, followed by those fed a 10% FALM-based diet. The lowest DEP was recorded in layers fed the control diet, with the highest concentration of FALM (15%). There was a significant difference (P<0.05) between the DEP in birds fed 5 and 10% FALM compared to those fed the control diet and the 15% FALM-based diet.

The hen-day egg production of ISA layer birds under semi-arid conditions is shown in Table 3. The mean HDEP of experimental IBL was observed to be significantly (P<0.05) affected and followed the same trend as DEP. It was significantly (P<0.05) highest in T2 (77.35 ± 3.050), closely followed by T3 (72.51 ± 3.234), while it was significantly ($P<0.05$) lowest in the control group (T1) (65.09 ± 1.672) and T4 (66.60 ± 1.185). The mean HDEP obtained for birds in T3 was significantly ($P<0.05$) higher than those in T1 and T4, but significantly lower when compared with those in T2.

Table 3: Mean (± SD) antioxidant effects of FALM on daily egg production and hen-day egg production of IBL semi-condition condition.

Parameter	FALM inclusion levels (%)				P-value
	0	5	10	15	
DEP (group/day)	19.53 ± 0.50 [c]	23.20 ± 0.92 [a]	21.75 ± 0.97 [b]	19.98 ± 0.36 [c]	0.022
HDEP (%)	65.09± 1.672[c]	77.35± 3.050[a]	72.51 ± 3.234 [b]	66.60± 1.185[c]	0.006

Means within the same row with different superscripts [a, b, c] are significantly different ($p<0.05$).
Key: SD = standard deviation, IBL = ISA Brown Layers, FALM = *Faidherbia albida* leaf meal, DEP = daily egg production

DISCUSSION

The daily feed intake observed in this study is in agreement with previous reports that extreme ambient temperature induces decreased feed intake in chickens (Attia *et al.,* 2009; Wasti *et al.,* 2020). This could be due to a response to thermostatic theory or the control of voluntary feed intake, in which animals eat to keep warm and when the ambient temperature is high. Also, they reduce feed to avoid causing a rise in body temperature due to metabolic heat. Consequently, this might explain the decreased final body weight observed in this study.

The significantly lower feed consumed in FALM-treated groups was not expected in this study, as the processing of FALM should have reduced the level of anti-nutritional factor tannin in the *F. albida* leaf. Although feed intakes were significantly lower in the FALM-treated groups when compared to the control group, nevertheless, they converted the feed more efficiently than the control group. This might have been due to the antioxidant activity of FALM in the diet. Furthermore, the mean feed conversion ratio showed no significant difference among the experimental diets. This is because fibrous feed reduces the availability of nutrients to birds, so the egg weight of birds in the high feed intake treatment did not affect the conversion ratio.

The detrimental effects of heat stress and consequently oxidative stress on performance and egg production have been documented (Star *et al.,* 2008; Mack *et al.,* 2013). This is the first report on the effect of *F. albida* on the egg production of IBL chickens. From the outcome of the egg production study of the experimental laying hens, it showed that the inclusion of FALM at 5 and 10% levels improved ($P<0.05$) egg production and ameliorated the reduction in egg laying, a usual occurrence in semi-arid environments as observed in the control group (T1: 0% FALM). This improvement in egg production may be attributed to the enhanced ability of birds in these groups (T2 and T3) to utilize and effectively convert the feed they consumed, as reflected by the best FCR of 2.9 and 2.85 for T2 and T3, respectively, as against the FCR > 3 recorded in T1 and T4. Similarly, this might be due to the antioxidant potential of *F. albida,* attributed to the presence of some phenolic compounds (Mohammed *et al.,* 2018).

In conclusion, the inclusion of *Faidherbia albida* leaf meal (FALM) contributed to ameliorating some negative effects of oxidative stress induced by heat stress in the experimental chickens. *Faidherbia albida* leaf meal (FALM), especially at 5%, ameliorated oxidative stress and consequently improved body weight and egg production. It could be recommended that *Faidherbia albida* leaf meal (FALM) be included as a potential antioxidant in the diet of ISA brown layer chickens up to a 5% level to mitigate oxidative stress in semi-arid zones.

REFERENCES

Ajakaiye, J.J., Ayo, J.O. and Ojo, S.A. 2010. Effects of heat stress on some blood parameters and egg production of Shika Brown layer chickens transported by road. *Biological Research*, 43: 183–189.

Akbarian, A., Michiels, J., Degroote, J., Majdeddin, M., Golian, A. and de Smet, S. 2016. Association between heat stress and oxidative stress in poultry; mitochondrial dysfunction and dietary interventions with phytochemicals. *Journal of Animal Science and Biotechnology*, 7: 1–14. doi.org/10.1186/s40104-016-0097-5

Anonymous. 2013. *Zamfara State physical setting, people, population, and settlement*. Available: www.onlinenigeria.com/Links/Zam Farastateadv.Asp?Blurb=393.

Attia, Y.A., Hassan, R.A. and Qota, E.M.A. 2009. Recovery from adverse effects of heat stress on slow-growing chicks in the tropics 1: Effect of ascorbic acid and different levels of betaine. *Tropical Animal Health and Production*, 41: 807–818. doi.org/10.1007/s11250-008-9256-9

Davidson, J.F., Whytet, B., Bissingertt, P.H. and Schiestl, R.H. 1996. Oxidative stress is involved in heat-induced cell death in *Saccharomyces cerevisiae*. *Proceedings of the National Academy of Sciences (PNAS), USA*, 93: 5116–5121.

Davies, K.J.A. 1995. Oxidative stress: the paradox aerobic life. *Biochemical Society Symposia*, 61: 1–3.

Devine, P.J., Perreault, S.D. and Luderer, U. 2012. Roles of reactive oxygen species and antioxidants in ovarian toxicity. *Biology of Reproduction*, 86: 1–10. doi.org/10.1095/biolreprod.111.095224

Dogo, A.A., Dikko, A.U., Audu, M., Shamaki, S.B. and Zubyr, M.T. 2021. Status of soil micronutrients in paddy soils of Zamfara State, Northwestern Nigeria. *Proceedings of the 45th Conference of Soil Science Society of Nigeria*, 480–485. doi.org/10.36266/colsssn.2021.4523

Emami, N.K., Jung, U., Voy, B. and Dridi, S. 2021. Radical response: Effects of heat stress-induced oxidative stress on lipid metabolism in the avian liver. *Antioxidants,* 10: 1–15. doi.org/10.3390/antiox10010035

Halliwell, B. and Whiteman, M. 2004. Measuring reactive species and oxidative damage in vivo and in cell culture: How should you do it and what do the results mean? *British Journal of Pharmacology,* 142: 231–255. doi.org/10.1038/sj.bjp.0705776

Huneau-Salaün, A., Guinebretière, M., Taktak, A., Huonnic, D. and Michel, V. 2011. Furnished cages for laying hens: Study of the effects of group size and litter provision on laying location, zootechnical performance, and egg quality. *Animal*, 5: 911–917. doi.org/10.1017/S1751731110002582

Jana, K., Samanta, P.K. and Kumar De, D. 2010. Nicotine diminishes testicular gametogenesis, steroidogenesis, and steroidogenic acute regulatory protein expression in adult albino rats: Possible influence on pituitary gonadotropins and alteration of testicular antioxidant status. *Toxicological Sciences*, 116: 647–659. doi.org/10.1093/toxsci/kfq149

Lin, H., Decuypere, E. and Buyse, J. 2006. Acute heat stress induces oxidative stress in broiler chickens. *Comparative Biochemistry and Physiology - A Molecular and Integrative Physiology*, 144: 11–17. doi.org/10.1016/j.cbpa.2006.01.032

Mack, L.A., Felver-Gant, J.N., Dennis, R.L. and Cheng, H.W. 2013. Genetic variations alter production and behavioral responses following heat stress in 2 strains of laying hens. *Poultry Science*, 92: 285–294. doi.org/10.3382/ps.2012-02589

Mohammed, M.M., Ali, A.A., Desoky, E.K. and Gobraeil, L.G. 2018. Compounds isolation and in-vitro antioxidant activity evaluation of *Faidherbia albida* (Del.) A. Chev. Leaves ethanolic extract. *Journal of Pharmacognosy and Phytochemistry*, 7: 471–475.

Rocha, T., Amaral, J.S. and Oliveira, M.B.P.P. 2016. Adulteration of Dietary Supplements by the Illegal Addition of Synthetic Drugs: A Review. *Comprehensive Reviews in Food Science and Food Safety*, 15: 43–62. doi.org/10.1111/1541-4337.12173

Shen, M., Lin, F., Zhang, J., Tang, Y., Chen, W.K. and Liu, H. 2012. Involvement of the upregulated FoxO1 expression in follicular granulosa cell apoptosis induced by oxidative stress. *Journal of Biological Chemistry*, 287: 25727–25740. doi.org/10.1074/jbc.M112.349902

Star, L., Decuypere, E., Parmentier, H.K. and Kemp, B. 2008. Effect of Single or Combined Climatic and Hygienic Stress in Four Layer Lines: 2. Endocrine and Oxidative Stress Responses. *Poultry Science*, 87: 1031–1038. doi.org/10.3382/ps.2007-00143

Tusell, L., David, I., Bodin, L., Legarra, A., Rafel, O., López-Bejar, M. and Piles, M. 2011. Using the product threshold model for estimating separately the effect of temperature on male and female fertility. *Journal of Animal Science*, 89: 3983–3995. doi.org/10.2527/jas.2011-3924

Wang, J., Jia, R., Gong, H., Celi, P., Zhuo, Y., Ding, X., Bai, S., Zeng, Q., Yin, H., Xu, S., Liu, J., Mao, X. and Zhang, K. 2021. The effect of oxidative stress on the chicken ovary: Involvement of microbiota and melatonin interventions. *Antioxidants*, 10: 1–21. doi.org/10.3390/antiox10091422

Wasti, S., Sah, N. and Mishra, B. 2020. Impact of heat stress on poultry health and performances, and potential mitigation strategies. *Animals*, 10: 1–19. doi.org/10.3390/ani10081266