FUDMA Journal of Agriculture and Agricultural Technology
ISSN: 2504-9496
Vol. 10 No. 1, March 2024: Pp. 117-124

https://doi.org/10.33003/jaat.2024.1001.15

EGG QUALITY INDICES OF BLACK HARCO PULLETS FED NUTRACEUTICALS DURING HOT-DRY SEASON IN SOKOTO METROPOLIS

[1]*Jimoh, A. A., [2]Egbewande, O. O., [3]Olorede, B. R., [4]Hassan, W. A., [4]Maigandi, S. A. and [1]Ibitoye, E. B.
[1]Department of Theriogenology and Animal Production, Usmanu Danfodiyo University, Sokoto, Sokoto State, Nigeria.
[2]Department of Animal Production, Ibrahim Badamasi Babangida University, Lapai, Nigeria
[3]College of Agriculture, Ejigbo Campus, Osun State University, Osun State, Nigeria
[4]Department of Animal Science, Usmanu Danfodiyo University, Sokoto, Sokoto State, Nigeria
* Corresponding Author: Tel:+2347035166498, E-mail: aajimoh1@gmail.com
ORCID NUMBER:
JIMOH A. A.: 0000 – 0003 – 4634 - 7598
IBITOYE E. B.: 0000 – 0003 – 3456 - 0009

ABSTRACT

This ninety-day study evaluated egg quality indices of layers fed natural source of vitamins A, C and E to alleviate heat stress during hot-dry season in the Nigerian Sudan-savannah. In a completely randomized design, sixty Black Harco layers of twenty-one weeks old were allotted into six groups of 10 birds each, housed singly per cell on battery cages. The birds were fed six experimental diets; diet 1, T1(BD) was basal diet only, diet 2, 3, 4 and 5 contained 1kg each of synthetic ascorbic acid (AA), baobab pulp meal (BPM), amaranthus leaf meal (ALM) and tiger nut meal (TNM), respectively, while diet 6 designated as (BAT), contained 0.33kg each of BPM, ALM and TNM. Sampled eggs were broken and data obtained were analysed using ANOVA. Egg weight, eggshell surface area, eggshell index, yolk colour and albumen weight differed significantly ($P<0.05$) across the groups, but other external and internal quality parameters were not statistically affected. Hens fed the combined nutraceuticals had the best values in egg weight (53.53 ± 4.06g), eggshell surface area (67.22 ± 5.18), albumen weight (34.83 ± 4.28g), second best in yolk colour (5.57± 0.03), but least value in eggshell index (7.65 ± 0.16). The three nutraceuticals, either singly or in combination played antioxidant roles by improving egg quality. Therefore, amaranthus leaf, baobab pulp and tiger nut meals are recommended as feedstuffs in Black Harco layers' diets to alleviate negative effects of heat on egg quality during hot-dry season in Sokoto metropolis.

Keywords: Black harco, egg quality, nutraceuticals, hot season

INTRODUCTION

Full genetic potentials of birds are always masked by high ambient temperature. Survival rate of such birds is low, and the production efficiency of survived ones is reduced. Heat stress is a major threat to poultry development and is of great economic consequences. Poultry birds at all stages of production are susceptible to heat stress, but older birds face a bigger risk. Heat stress in laying hens reduces feed intake which invariably reduces egg quality. During dry-hot season, heat stress results in small eggs with poor shell quality because high environmental temperature reduces a hen's appetite, and dietary calcium and phosphorus become less available (Lavergne, 2008). Egg being a complete food known naturally (Nuhu *et al*., 2018), its quality must not be compromised. In fact, Bobbo *et al*. (2013) reported that egg quality is a serious concern as it defines the general standard of the internal and external qualities of egg weight, length, width and index, eggshell weight and thickness, albumin height and width, yolk height and index, and Haugh unit, and also the acceptability of eggs by the consumers (Song *et al*., 2000). According to Islam *et al*. (2001), external and internal egg quality traits are significant in poultry breeding, especially for their influence on yield, breeding performance, quality and growth of the chicks. Yenice *et al*. (2016) also reported that the qualities are very important for consumer health and from marketing perspective. The key measure of maintaining egg size and quality during hot-dry season is to prevent hens from becoming over-heated.

Many remedies had been proffered to solving heat stress in poultry. These include the use of well-ventilated pen for birds in the tropics (Lavergne, 2008), reducing the number of birds per cell in cages to avoid over-crowding, and dietary adjustment (WVA, 2005), use of anti-stress agents like vitamin C (Oruseibio and Alu, 2006; Sobayo *et al*., 2008), and use of antioxidants like vitamins A and C (Sinkalu *et al*., 2008). Poultry farmers in the tropics use synthetic anti-stress and antioxidant agents which are expensive. Feeding vitamins through natural and dietary mean rather than from supplements has been recommended. Therefore, using local plant resources classified as nutraceuticals could be better alternative way of reducing heat stress in layers.

Baobab pulp (*Adansonia digitata*) has been reported to be high in vitamin C (Manfredini *et al*., 2002). BOSTID (1984) reported that the leaves of amaranthus are important source of vitamins, especially vitamin A, while Dianne (2006) reported that tiger nut seeds are rich in vitamins E and C. This study therefore, evaluated the effect of Baobab pulp (*Adansonia digitata*) meal, *Amaranthus hybridus* leaf meal and Tiger nut seed (*Cyperus esculentus*) meal, as natural sources of vitamins C, A and E respectively on quality indices of eggs laid by Black Harco pullets during hot-dry season.

MATERIALS AND METHODS

Experimental location

The study was conducted in the poultry house of the Faculty of Agriculture, Usmanu Danfodiyo University, located at the State Veterinary Clinic complex, Aliyu Jodi, Sokoto, during a hot-dry season (April to June). The State is situated between Latitudes 120 -13058'N and Longitudes 408 - 6054'E, and the dry season occurs from March to June (Mamman *et al*., 2000).

Source and processing of experimental materials

Test ingredients were purchased from Sokoto main market. Baobab pulp was separated from the seeds and threads, ground and then sieved with 1mm cheese cloth sieve to obtain the powdery form. Amaranthus leaves were painstakingly detached from the stalks and later air dried for 5 days. Dried tiger nut seeds and other test ingredients were ground and kept in separate polyethylene bag till the time of use. The remaining ingredients were purchased at *Ojuanu* Enterprise in Sokoto.

Experimental diets

Six isonitrogenous and isocaloric diets were formulated and fed to birds in the six groups in such that: Diet 1 contained none of the test ingredients; Diet 2 contained 1% (i.e., 1kg) of ascorbic acid (AA); Diet 3 contained 1% (i.e., 1kg) of baobab pulp meal (BPM); Diet 4 contained 1% (i.e., 1kg) of amaranthus leaf meal (ALM); Diet 5 contained 1% (i.e., 1kg) of tiger nut meal (TNM); and Diet 6 contained 0.99% (i.e., 0.99kg) of the three tested organic nutraceuticals (BAT) at 0.33kg each. These diets were formulated to contain approximately 17% crude protein and 2600 kcal/kg ME as shown in Table 1. The birds in groups 1 (T1), 2 (T2), 3 (T3), 4 (T4), 5 (T5) and 6 (T6) were fed experimental diets 1 (BD), 2 (AA), 3 (BPM), 4 (ALM), 5 (TNM) and 6 (BAT) respectively, and the experiment lasted for 12 weeks.

Table 1: Gross composition of experimental layer diets

Ingredient (%)	Dietary Treatments					
	T1(BD)	**T2(AA)**	**T3(BPM)**	**T4(ALM)**	**T5(TNM)**	**T6(BAT)**
Maize	57.00	57.00	57.00	57.00	57.00	57.00
Groundnut cake (GNC)	19.25	19.25	19.25	19.25	19.25	19.25
Fish meal	1.00	1.00	1.00	1.00	1.00	1.00
Blood meal	1.00	1.00	1.00	1.00	1.00	1.00
Wheat meal	10.00	9.00	9.00	9.00	9.00	9.01
Bone meal	4.00	4.00	4.00	4.00	4.00	4.00
Limestone	7.00	7.00	7.00	7.00	7.00	7.00
Salt	0.30	0.30	0.30	0.30	0.30	0.30
*Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10	0.10
Synthetic ascorbic acid	-	1.00	-	-	-	-
Baobab pulp (Bao)	-	-	1.00	-	-	0.33
Amaranthus leaf (Ama)	-	-	-	1.00	-	0.33
Tiger nut seed (Tig)	-	-	-	-	1.00	0.33
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutrients (%):						
Crude protein	16.66	16.55	16.55	16.55	16.55	16.56
Crude fibre	3.30	3.20	3.20	3.20	3.20	3.21
Ash	2.66	2.59	2.59	2.59	2.59	2.60
Ether extract	4.64	4.59	4.59	4.59	4.59	4.59
Metabolizable E. (kcal/kg)	2626.1	2613.6	2613.6	2613.6	2613.6	2614.8

*Animal Care® Optimix Layer Premix Composition per 1.25kg: Vitamin A, 10,000,000 IU; Vitamin D3, 2,000,000 IU; Vitamin E, 5,000 mg; Vitamin K3, 2,000 mg; Folic Acid, 500 mg; Niacin, 15,000 mg; Calpan, 5,000 mg; Vitamin B1, 1,500 mg; Vitamin B2, 8,000 mg; Vitamin B6, 1,500 mg; Vitamin B12, 10 mg; Biotin, 20 mg; Antioxidant, 125,000 mg, Manganese, 80,000 mg; Zinc, 60,000 mg; Cobalt, 200 mg; Iron, 40,000 mg; Copper, 5,000 mg; Iodine, 1,200 mg; Selenium, 200 mg; Choline chloride, 200,000 mg.

KEY: T1(BD): Treatment 1 for birds fed basal diet only, T2(AA): Treatment 2 for birds fed with diet containing synthetic ascorbic acid, T3(BPM): Treatment 3 for birds fed with diet containing Baobab pulp meal, T4(ALM): Treatment 4 for birds fed with diet containing amaranthus leaf meal, T5(TNM): Treatment 5 for birds fed with diet containing tiger nut meal and T6(BAT): Treatment 6 for birds fed with diet containing mixture of the 3 test nutraceuticals

Experimental birds and management

Sixty Black Harco pullets, at 21 weeks old were used for the study. The birds were housed in battery cage which was demarcated into treatments and replicates. A three-week adjustment period in the cage was observed while the experiment started fully when the birds were 24 weeks of age. The birds were allotted to six treatments of 10 replicates each in a completely randomized design and were housed singly per cell in the battery cage. The birds were managed under same conditions and routine cleaning, feeding, supply of fresh water, packing of the droppings were carried out as at when due, and biosecurity was maintained throughout the experimental period.

Data collection

Egg quality parameters were determined on weekly basis. Six eggs per treatment were randomly selected from eggs laid on the last three days of every experimental week. Thirty-six eggs were assessed weekly for external quality parameters (egg weight, egg width, shell weight, egg shape index, egg length, egg surface and shell thickness), and the internal quality (albumen weight, albumen height, yolk weight, yolk height, yolk diameter, yolk-albumen ratio, yolk index and Haugh Unit). The eggs were weighed with Camry sensitive scale and recorded in grams. The length and width of the eggs were measured using Vernier caliper. The longitudinal distance between the narrow and broad ends of the eggs was measured as the length while the width was taken at the diameter of the widest cross-sectional region. Values obtained from the two parameters were used to calculate the egg shape index according to Akinola and Iyomo (2018).

$$\text{Egg shape index} = \frac{\text{Egg width}}{\text{Egg length}} \times 100$$

The eggs were carefully broken at the middle so as not to rupture the albumen, and the content poured into a clean petri-dish where the yolk was separated from the albumen. Shell weights were taken using the sensitive scale in grams, while shell thickness was measured with micrometer screw gauge graduated at 0.1mm. The measurements were taken at the broad, equatorial and narrow ends of the shell. Yolk and albumen weights were taken using the sensitive scale while yolk height and length, and albumen height and length were measured using Vernier caliper. Eggshell index, egg surface area, egg specific gravity and Haugh unit were calculated using the following formulae:

$$\text{Eggshell index} = \frac{\text{Shell weight}}{\text{Egg surface}} \times 100$$

$$\text{Eggshell surface area} = K \times EW^{2/3}$$

Where: EW = egg weight; K = 4.67 for egg weight less than 60g; K = 4.68 for egg weight between 60 – 70g and 4.69 for egg weight greater than 70g according to Olorede (1998).

$$\text{Egg specific gravity} = \frac{EW}{[0.968(EW-SW) + (0.4921SW)]}$$

Where: EW = egg weight; SW = shell weight according to Sauveur (1988).

$$\text{Haugh unit} = 100\log(H + 7.6 - 1.7W^{0.37})$$

Where: H = observed height of albumen; W = egg weight according to Kul and Seker (2004).

$$\text{Yolk index (\%)} = \frac{\text{Yolk diameter}}{\text{Yolk height}} \times 100$$

according to Ukwu *et al*. (2017)

Statistical analysis

Data generated were subjected to Analysis of Variance (ANOVA), presented in means and standard deviation using the Statistical Analysis System package version 9.4 software (Statistical Analysis System, 2012), and the differences between means were separated using Duncan Multiple Range Test (Duncan, 1955). Means were considered statistically significant at $P<0.05$.

RESULTS

Indices of external egg quality

External egg quality traits during the feeding trials were shown in Table 2. Mean values of egg weight (EW), eggshell surface area (ESA) and eggshell index (ESI) differed significantly ($P<0.05$) among the treatments. For the mean EW, the heaviest value (53.53 ± 4.06g) was obtained in hens fed the combined nutraceuticals {T6 (BAT)}. The mean EWs were non-significantly affected ($P>0.05$) in hens fed only BPM(T3), ALM(T4) and TNM(T5) reflecting 51.39 ± 4.01g, 51.57 ± 4.01g and 50.13 ± 4.02g, respectively. However, it differed significantly ($P<0.05$) in birds fed synthetic AA (T2: 48.33±3.98g). There was also a significant difference ($P<0.05$) in ESA across the groups. However, no significant difference ($P>0.05$) occurred in ESA of eggs from hens under T3(BPM: 65.40 ± 5.16); T4(ALM: 65.56 ± 5.16) and T6(BAT: 67.22 ± 5.18) which were also different from ESA of eggs from hens under T1 (BD: 64.92 ± 5.17) and T5 (TNM: 64.33 ± 5.1). The least mean value (62.77 ± 5.15) was obtained in hens under T2(AA). Eggshell index significantly ($P<0.05$) decreased from 8.36 ± 0.17 in eggs from T3(BPM) to 7.65 ± 0.16 in eggs from T6(BAT). There were no significant ($P>0.05$) differences among mean values of shell thickness, shell weight, egg shape index, egg width, egg length and egg specific gravity. Although, not statistically significant, shell thickness (0.30 ± 0.01mm) and shell weight (5.46 ± 0.17g) were best in hens fed tiger nut (T5) and baobab pulp (T3) meals respectively.

Table 2: External egg characteristics of Black Harco layers fed the test ingredients

Parameters	Dietary Treatments						P value
	T1(BD)	T2(AA)	T3(BPM)	T4(ALM)	T5(TNM)	T6(BAT)	
EW (g)	50.82 ± 4.02 [b]	48.33± 3.98[c]	51.39± 4.01 [b]	51.57± 4.01 [b]	50.13± 4.02 [b]	53.53± 4.06[a]	0.04
EL (mm)	53.43 ± 4.10	56.05 ± 4.12	55.70 ± 4.13	55.25 ± 4.13	52.50 ± 4.09	57.80 ± 4.15	1.12
EWT (mm)	41.68 ± 3.02	43.16 ± 3.03	43.45 ± 3.03	43.10 ± 3.03	40.95 ± 3.01	44.51 ± 3.06	0.86
ST (mm)	0.29 ± 0.01	0.28 ± 0.01	0.29 ± 0.01	0.29 ± 0.01	0.30 ± 0.01	0.26 ± 0.01	0.08
SW (g)	5.36 ± 0.17	5.10 ± 0.16	5.46 ± 0.17	5.10 ± 0.16	5.32 ± 0.16	5.14 ± 0.16	0.09
ESA	64.92 ± 5.17[b]	62.77± 5.15[b]	65.40± 5.16[a]	65.56± 5.16[a]	64.33± 5.17[b]	67.22± 5.18[a]	0.03
ESI	8.26 ± 0.19[b]	8.12 ± 0.17[b]	8.35 ± 0.17[a]	7.78 ± 0.16[c]	8.27 ± 0.17[b]	7.65 ± 0.16[c]	0.01
ESHI	78.01 ± 5.36	77.00 ± 5.34	78.01 ± 5.36	78.01 ± 5.36	78.00 ± 5.36	77.01 ± 5.35	0.08
ESG	1.09 ± 0.00	1.09 ± 0.00	1.09 ± 0.00	1.09 ± 0.00	1.09 ± 0.00	1.08 ± 0.01	0.06

Key: a, b, c: Means within a row with no common superscript differ significantly (p<0.05), EW: egg weight, EL: egg length, EWT: egg width, ST: shell thickness, SW: shell weight, ESA: eggshell surface area, ESI: eggshell index, ESHI: egg shape index, ESG: egg specific gravity
KEY: T1(BD): Treatment 1 for birds fed basal diet only, T2(AA): Treatment 2 for birds fed with diet containing synthetic ascorbic acid, T3(BPM): Treatment 3 for birds fed with diet containing baobab pulp meal, T4(ALM): Treatment 4 for birds fed with diet containing amaranthus leaf meal, T5(TNM): Treatment 5 for birds fed with diet containing tiger nut meal and T6(BAT): Treatment 6 for birds fed with diet containing mixture of baobab pulp, amaranthus leaf and tiger nut seed meals

Indices of internal egg quality

Internal egg quality traits of the Black Harco layers are presented in Table 3. There were no significant (P>0.05) differences among treatment means of the internal parameters considered except for yolk colour and albumen weight. Yolk colour of eggs laid by hens under T2(AA: 5.86 ± 0.03) and T6(BAT: 5.57 ± 0.03) differed non-significantly but differed significantly (P<0.05) when compared to those under the control group T1(BD: 5.14 ± 0.03); T3(BPM: 14 ± 0.03); T4(ALM: 5.14 ± 0.03) and T5(TNM: 4.86 ± 0.03). Albumen weights decreased significantly from 34.83 ± 4.28g in T6(BAT) to 30.57 ± 4.26g in T2(AA). Haugh Unit ranged between 65.48% in T6(BAT) to 75.03% in birds fed baobab pulp meal in T3(BPM). Yolk and albumen weights had same pattern where birds in T6(BAT) exhibited the highest values of 13.40 ± 1.14g and 34.83 ± 4.28g, respectively.

Table 3: Internal egg characteristics of Black Harco layers fed test ingredients

Paramete	Dietary Treatments						P value
	T1(BD)	T2(AA)	T3(BPM)	T4(ALM)	T5(TNM)	T6(BAT)	
HU (%)	66.82 ± 5.10	71.02 ± 5.11	75.03 ± 5.12	74.95 ± 5.12	70.19 ± 5.11	65.48 ± 5.10	0.43
YC	5.14 ± 0.03[b]	5.86 ± 0.03[a]	5.14 ± 0.03[b]	5.14 ± 0.03[b]	4.86 ± 0.02[b]	5.57 ± 0.03[a]	0.01
YH (mm)	9.30 ± 0.06	7.25 ± 0.05	7.36 ± 0.05	9.27 ± 0.06	9.65 ± 0.06	8.83 ± 0.06	0.28
YW (g)	12.81 ± 1.16	12.68 ± 1.16	12.95 ± 1.18	12.68 ± 1.16	12.57 ± 1.15	13.40 ± 1.14	0.58
PYW (%)	25.21 ± 1.56	26.24 ± 1.57	25.20 ± 1.56	24.59 ± 1.60	25.07 ± 1.55	25.03 ± 1.55	1.17
YD (mm)	35.92 ± 1.23	37.54 ± 0.96	35.58 ± 1.23	36.56 ± 1.21	36.85 ± 1.21	36.67 ± 1.21	0.09
YI (%)	25.89 ± 3.55	19.31 ± 3.26	20.69 ± 3.27	25.36 ± 3.56	26.19 ± 4.54	24.08 ± 4.49	0.08
AW (g)	32.86 ± 4.27[a]	30.57 ± 4.26[b]	32.81± 4.27[a]	33.78± 4.29[a]	32.36± 4.27[b]	34.83 ± 4.28[a]	0.04
PAW (%)	64.66 ± 1.15	63.25 ± 1.16	63.85 ± 1.16	65.50 ± 1.17	64.55 ± 1.15	65.07 ± 1.17	0.33
AH (mm)	4.33 ± 0.05	4.67 ± 0.06	5.33 ± 0.07	5.33 ± 0.07	4.67 ± 0.06	4.33 ± 0.05	1.34
Y:A	0.39 ± 0.01	0.41 ± 0.01	0.39 ± 0.01	0.38 ± 0.01	0.39 ± 0.01	0.38 ± 0.01	1.98

Key: a, b Means within a row with no common superscript differ significantly ($p<0.05$), HU: Haugh unit, YC: yolk colour, YH: yolk height, YW: yolk weight, PYW: percentage yolk weight, YD: yolk diameter, YI: yolk index, AW: albumen weight, PAW: percentage albumen weight, AH: albumen height, Y:A: yolk-albumen ratio

KEY: T1(BD): Treatment 1 for birds fed basal diet only, T2(AA): Treatment 2 for birds fed with diet containing synthetic ascorbic acid, T3(BPM): Treatment 3 for birds fed with diet containing baobab pulp meal, T4(ALM): Treatment 4 for birds fed with diet containing amaranthus leaf meal, T5(TNM): Treatment 5 for birds fed with diet containing tiger nut meal and T6(BAT): Treatment 6 for birds fed with diet containing mixture of baobab pulp, amaranthus leaf and tiger nut seed meals

DISCUSSION

From the results of this study, it was observed that among external egg quality traits analysed, EW, ESA and ESI differed significantly across the treatment groups. The values of mean EW and ESA recorded from hens fed the three nutraceuticals combined were the highest. While similar values were recorded in other four groups, the least values were recorded in the hens fed synthetic AA. These observations may be attributed to synergy in antioxidant effects of the vitamins and other micronutrients available in the combined nutraceuticals. The interactions of food-derived micronutrients with one another could have resulted in a better effect than that of the synthetic supplements (AA), as report of an *in vivo* study has established preservation of vitamin C by vitamin E (Tanaka *et al.*, 1997). The findings agreed with the reports of Lin *et al*. (2004), Bawa *et al*. (2011), and Tuleun *et al*. (2013), as it revealed the benefits of micronutrient additives in fruits and vegetable as alternatives to synthetic supplements. In this study, despite feeding 1kg synthetic AA to hens in group T2, the least mean EW and ESA values were recorded. This may suggest overdosing of the synthetic vitamin C. In a study, Metwally and Metwally (2021) fed vitamin C at 260 mg/kg feed (described as overdose) to reduce negative effect of heat stress in Japanese quail, but no positive effect was observed. Vitamins and micronutrients are organic substances present in foods and are needed by animals in small quantity. There are the needs to focus more research on natural sources of vitamins and micronutrients (fruits and vegetables) as alternative in animal diets. According to Ahmed *et al*. (2005), ESI is a measure of eggshell strength based on its crystal size. Lower ESI value indicates presence of larger crystals resulting in weak eggshell. From the result of this study, hens under T3, those fed baobab pulp meal (BPM) laid eggs with highest ESI value, followed by those fed tiger nut meal (TNM) under T5, while the least values were recorded in hens under groups T4 and T6 fed amaranthus leaf meal (ALM) and the combined nutraceuticals (BAT), respectively. This implies that combination of the three nutraceuticals resulted in laying of eggs with poor shell quality, but feeding Baobab pulp meal and tiger nut meal separately led to laying eggs with better eggshell integrity. These findings probably support the report of Manfredini *et al*. (2002) that Baobab pulp is a rich source of organic vitamin C and the report of Dianne (2006) about vitamins E and C pool in tiger nut seeds. It also showed that vitamin A, in amaranthus leaf is not really specific for heat stress amelioration as vitamins C and E.

Among the internal egg quality traits, yolk colour and albumen weight differed significantly. It was observed that the highest value of yolk colour was recorded from hens fed the three nutraceuticals combined. While statically similar values were recorded in the control T1(BD) and two treatment groups fed amaranthus leaf meal T3(ALM) and baobab pulp meal T4(BPM), the least value was recorded in the hens fed tiger nut meal, T5(TNM). The values obtained in this study were lower than the report of Hayat *et al*. (2009), but were better and higher than the report of Dongmo and Fomunyam (2005). The yolk colour values obtained from this study were suitable for home consumption as observed by North (1984), who reported that egg yolk colour in the range of 4 – 8 (in the Roche Colour Fan) were suitable for home consumption while those above 8 were suitable for bakeries. For albumen weight, the mean albumen weight value recorded from hens fed the three nutraceuticals combined was the highest and the least values were recorded in the hens fed synthetic AA (Table 3). The values of albumen weight of eggs of hens under the four other treatment groups were equally better than the yolk weight of hens fed synthetic AA. This indicates the combined nutraceuticals improved albumen weight even than the synthetic AA. Haugh unit values obtained from this study were lower than the reports of Hayat *et al*. (2009), but close to those obtained by Dongmo and Fomunyam (2005). However, it must be noted that the Haugh units obtained from this study were below the cut-off level of 75% set for high quality fresh eggs as reported by Card and Nesheim (1975). This might be attributed to the negative effects of heat on egg quality. Yolk index is a measure of the standing up quality of the yolk (Card and Nesheim, 1975), and that the range for a normal fresh egg is from 0.40 – 0.42. The range obtained for this parameter in this study is slightly lower than the range reported by the authors. Results from this study must have been affected by the climatic condition (hot-dry) prevailing during the experimental period. This agreed with the reports of Demeke (2004) and Bell (2007) that internal egg parameters could be influenced by diet, management system imposed, climatic conditions and the breed of the birds.

CONCLUSION

Inclusion of amaranthus leaf, baobab pulp and tiger nut meals, either separate or in combination, had positive effects on internal and external traits of eggs from experimental hens studied in Sokoto, the Sudan Savannah part of Nigeria. Anti-stress and antioxidant properties of these nutraceuticals played important roles in maintenance of egg quality during the hot-dry season. It is therefore recommended that the test ingredients be included at 1% when used separately or 0.33% each in combination in poultry diets in Sokoto Metropolis to combat heat stress among laying hens.

ACKNOWLEDGEMENT

The authors thank and appreciate Prof. H.M. Tukur who made available the poultry facilities at Aliyu Jodi, Sokoto, to be used for the research.

CONFLICTS OF INTEREST

The authors declare that there were no competing interests.

REFERENCES

Ahmed, A.M.H., Rodriguez-Navarro, A.B., Vidal, M.L., Gautron, J., Garcia-Ruiz, J.M., & Nys, Y. (2005). Changes in eggshell mechanical properties, crystallographic texture and in matrix proteins induced by moult in hens. *British Poultry Science,* 46, 268–279.

Akinola, L.A.F., & Iyomo, E. (2018). Egg quality analysis and performance of laying hens fed different levels of calcium. *Nigerian Journal of Animal Production*, 45(1), 172-182. http\\www.njap.org.ng.

Bawa, G.S., Lombin, L.H., Karsin, P., Musa, U., Payi, E., & Shamaki, D. (2011). Responses of Japanese quails to varying dietary protein levels in the tropics. *Nigerian Journal of Animal Production*, 38(1), 43-54.

Bell, D. (2007). Eggshell quality: Its impact on production, processing and marketing economics. All Tech. Inc, 98(22), 243-265.

Bobbo, A.G., Baba, S.S. & Yahaya, M.S. (2013). Egg quality characteristics of three phenotypes of local chickens in Adamawa State. *Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 4(2), 13-21.

BOSTID (1984). Board on Science and Technology for International Development. Amaranth: Modern Prospects for an Ancient Crop, Pp. 74, Accessed on 6/30/2008 from: www.appropedia.org/amaranth

Card, L.E. & Nesheim, M.C. (1975). *Poultry Production*. 11th Edition, Lea and Febiger, Philadelphia, USA.

Demeke, S. (2004). Egg production and performance of local white leghorn hens under intensive and rural household conditions in Ethiopia. *Livestock Research for Rural Development*, 16(2). http://www.lrrd.org/lrrd16/2/deme1602.htm

Dianne, M. (2006). Tiger nuts. *Journal of National Vegetable Society*. Retrieved from: www.\tigernut\Tiger Nuts I.htm on 5/14/2008.

Dongmo, T. & Fomunyam, R.T. (2005). Effects of feeding different levels of rumen contents and palm oil vitamins on egg production and quality. *Bulletin of Animal Health and Production,* 53(1), 69-75, DOI: 10.4314/bahpa.v53i1.32691

Duncan, D.B. (1955). Multiple Range and Multiple F Tests. *Biometrics*, 11, 1 – 42.

Hayat, Z., Cherian, G., Pasha, T.N., Khattak, F.M. & Jabbar, M.A. (2009). Effect of feeding flax and two types of antioxidants on egg production, egg quality and lipid composition of eggs. *Journal of Applied Poultry Research*, 18, 541-551, https://doi.org/10.3382/japr.2009-00008

Islam, M.A., Bulbuli, S.M., Seeland, G. & Islam, A.B. (2001). Egg quality in different chicken genotypes in summer and winter. *Pakistan Journal of Biological Science*, 4, 1411-1414. DOI: 10.3923/pjbs.2001.1411.1414

Kul, S. & Seker, I. (2004). Phenotypic correlation between some external and internal egg quality traits in the Japanese quail (Coturanix coturnix japonica). *International Journal of Poultry Science*, 3(6), 400-405. DOI: 10.3923/ijps.2004.400.405

Lavergne, T. (2008). Advice on reducing heat stress in poultry. LSU Ag Center, Louisiana, Retrieved from: http://www.bae.lsu.edu/en/cropslivestock/livestock/anima l health/poultry/Advice on 3/25/2008

Lin, Y.F., Chang, S.J. & Hsu, A.L. (2004). Effects of supplemental vitamin E during the laying period on the reproductive performance of Taiwan nature chickens. *British Journal of Poultry Science*, 45(6), 807-814.

Mamman, A.B., Oyebanji, J.O. & Petters, S.W. (Eds.) (2000). Nigeria: *A People United, A Future Assured (Survey of States).* Vol. 2, Gabumo Publishing Co. Ltd. Calabar, Nigeria.

Manfredini, S., Vertuani, S., Braccioli, E. & Buzzoni, V. (2002). Antioxidant capacity of *Adansonia digitata* fruit pulp and leaves. *Acta Phytotherapeutica*, 2, 2-7

Metwally, M.M. & Metwally, M.A. (2021). Efficacy of overdosing of vitamin c supplementation on growth performance, Europe Production Efficiency Factor (EPEF), carcass traits and some blood constituents of Japanese quail, *Egyptian Journal of Nutrition and Feeds*, 24(2), 273-285

North, M.O. (1984). *Commercial Chicken Production Manual*. The Avi Publishing House Co. Inc. Westpod Connectical, USA.

Nuhu, B.T., Adelanwa, M.A., Hassan, M.R. & Duru, S. (2018). Egg quality parameters and blood biochemical profile of six strains of poultry under extensive management system in Nigerian savanna. *Nigerian Journal of Animal Science*, 20(1), 72-80. www.animalscienceassociation.org.ng

Olorede, B.R. (1998). Sheabutter cake as an unconventional feed ingredient in the diets of broilers and egg-type pullet. Ph.D. Thesis, Department of Animal Science, University of Ibadan.

Oruseibio, S.M. & Alu, E.U. (2006). Responses of broiler birds to supplementation of synthetic ascorbic acid – vitamin C. *Nigerian Poultry Science Journal*, 4, 12-15.

SAS, (2002). Statistical Analysis System, Computer Software, Version 9: Statistical SAS Institute Inc. Cary, Northern Carolina 27513, USA.

Sauveur, B, (1988). Reproduction des volailles et prodrection d'oeufs, INRA paris. Pp. 385-391.

Sinkalu, V.A., Ayo, J.O., Adelaiye, A.B. & Hambolu, J.O. (2008). Diurnal fluctuation in rectal temperature of Black Harco pullets administered vitamins A and C during hot-dry season. Proceedings of 33rd Annual Conference of Nigerian Society of Animal Production. March 16-19, pp. 78-81.

Sobayo, R.A., Oguntona, E.B., Osinowo, O.A., Eruvbetine, D., Bamgbose, A.M., Adeyemi, O.A., Olomola, A., Oso, A.O. & Usman, J.M. (2008). Effects of synthetic ascorbic acid supplementation on the performance of growing pullets. *Nigerian Journal of Animal Production*, 35(2), 186-194.

Song, K.T., Choi, S.H. & Oh, H.R. (2000). A comparison of egg quality of pheasant, chukar, quail and guinea fowl. *Asian-Australian Journal of Animal*

Science, 13(7), 986-990. DOI:10.5713/ajas.2000.986

Tanaka, K., Hashimoto, T., Tokumaru, S., Iguchi, H. & Kojo, S. (1997): Interactions between vitamin C and vitamin E are observed in tissues of inherently scorbutic rats. *Journal of Nutrition,* 127, 2060–2064.

Tuleun, C.D., Adenkola, A.Y. & Yenle, F.G. (2013). Performance and erythrocyte osmotic membrane stability of laying Japanese quails (Coturnix coturnix japonica) fed dietary protein levels in a Hot-Humid Tropics. *Agriculture and Biology Journal of North America*, 4(1), 6-13. doi:10.5251/abjna.2013.4.1.6.13

Ukwu, H.O., Ezihe, C.O., Asaa, S.K. & Anyogo, M.E. (2017). Effect of egg weight on external and internal egg quality traits of Isa Brown egg layer chickens in Nigeria. *Journal of Animal Science and Veterinary Medicine*, 2, 126-132, ISSN: 2536-7099. https://doi.org/10.31248/JASVM2017.051

WVA (2005). World Veterinary Association. Save poultry industry by heat stress management. Accessed from: www.vetscite.org/publish/issues/2005-04 on 5/8/2008.

Yenice, G., Kaynar, O., Heriturk, M., Hira, F. & Hayirli, A. (2016). Quality of eggs in different production system. *Czech Journal of Food Science*, 34(4), 370-376. doi: 10.17221/33/2016-CJFS