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Dietary Intervention Of Vitamin A And Vitamin E On The Performance Of Isa Brown Laying Hens Under Heat Stress In The Humid Tropical Region Of Yandev, Benue State-Nigeria

Nicodemus Terkaa NOMBOR
Department of Animal Health and Production Technology,
School of Agriculture,
Akperan Orshi Polytechnic, Yandev,
P.M.B. 181, Gboko, Benue State-NIGERIA

Abstract
This study was conducted at the Poultry Unit of the Department of Animal Health and Production Technology, Akperan Orshi Polytechnic, Yandev, Benue State – Nigeria to investigate the effects of supplemental Vitamin A (retinol) and Vitamin E (dl- alpha tocopheryl acetate) on performance parameters: hen day production, feed intake, feed conversion ratio, egg weight, haugh unit score, shell thickness, loss in body weight and mortality of Isa brown hens reared under the humid tropical conditions of Yandev, Benue State Nigeria. The study lasted for 24 weeks. A total of 160 twenty-week old Isa Brown pullets at the point of lay (POL) were vent examined and randomly divided into sixteen treatments of five (5) pullets per replicate and two such replicates constituted a treatment of ten (10) birds. Each experimental subject was randomly assigned to a thoroughly cleaned and disinfected cage measuring 49 x 35 x 42cm. Four dietary levels of Vitamin A: 0, 2000, 4000, and 6000IU Kg-1 basal diet were combined with four dietary levels of Vitamin E: 0, 125, 250 and 375mg Kg-1 basal diet in a 4 x 4 factorial arrangement in a Completely Randomized Design. Feed and water were supplied ad libitum. Results obtained indicated that hen day production, feed intake, feed conversion ratio, egg weight, shell thickness, and haugh units were highly significant ($p < 0.01$) among treatments and were better in vitamin treated hens than the controls. Loss in body condition, incidence of cracked eggs and mortality were significantly higher ($p < 0.01$) in the controls than vitamin supplemented birds. The combined effects of the vitamins A and E appear to be better than any of the vitamins used singly. These results hold that these 2- anti-oxidants, Vitamin A and E have synergetic effects, and have some protective roles against heat stress deleterious effects. Thus, dietary supplementation with 400mg Vitamin A plus 250mg Vitamin E per Kg of diet may increase egg production, improve egg quality and is economical in laying hens raised under heat stressed conditions.
Keywords*: laying hens, Isa Brown, Vitamin A, Vitamin E, heat stress, egg production*

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I. Introduction

For poultry to perform its ascribed roles, it is necessary to closely scrutinize the environmental factors that have the capability of frustrating their genetic potentials. Nigeria being a humid tropical country is associated with a myriad of these environmental factors. Sinkalu *et al*. (2008) have listed these environmental stressors as: deprivation of food and water, high ambient temperatures (HAT), relative humidity (RH), high velocity, noise, motion, overcrowding, vibration and mishandling. Among these factors, HAT and RH are the most important meteorological stress factors adversely affecting poultry in general, and laying hens in particular (Ayo *et al*., 2005a; Asli *et al*., 2007; Ayo and Sinkalu, 2007; Ramnath *et al*., 2008).

The zone of thermo neutrality under which the performance of laying hens is not adversely affected by temperature has been identified by Imik *et al*. (2009) as 18- 22^{0}C. Temperatures outside the critical limits of the thermo neutral zone such as those obtained in most humid tropical regions of the World like Nigeria have been reported to constitute heat stress (Holik, 2009; Oguz *et al*., 2010). Under heat stressed conditions, poultry perform sub-optimally owing to a reduction in feed intake. Consequently, egg production drops, small sized eggs are laid, Haugh units, yolk index and other egg quality traits are also adversely affected (Asli *et al*., 2007; Oguz *et al*., 2010). Under these conditions, the survivability of the birds is threatened. With the prospective climate change predisposed by global warming, the magnitude of the low performance may be worsened (Spore, 2008; Nombor and Okeke, 2009).

There are however, a number of reports which show that under harsh climatic conditions, the use of antioxidants especially Vitamin A (Khan et al., 2023) and vitamin E (dl-α-tocopherol acetate) as dietary supplements in the nutrition of laying hens is beneficial and economical (Panda *et al*., 2008; Holik, 2009; Oguz *et al.,* 2010; Biswas *et al*., 2010). It has been however, reported that beneficial effects of Vitamin A depends largely on the strain of birds, dose, duration of application, experimental design and other environmental factors (El-Ratel et al., 2024).

The climatic conditions of Yandev, Benue State-Nigeria and its environs reflect a typical tropical climate characterized by hot, humid conditions with distinct wet and dry seasons. The average annual temperature range between 29.38 ^{0}C and 44.5 ^{0}C (Wikipedia, 2025). The region receives an average of 135.2 mm of precipitation annually with about 160.01 rainy days (Wikipedia, 2025). The relative humidity (RH) ranges likely between 25% - 80%. These ranges appear to fall outside the zone of thermo neutrality of laying hens which is 18- 22^{0}C as recently defined by EW Nutrition (2025). As such, adverse effects of heat stress are suspected to clasp egg production parameters of laying hens in this region.

Given the above therefore, the general objective of this study was to investigate the effects of dietary Vitamin A and Vitamin E used either singly or in combination on egg production attributes of Is brown hens reared under Yandev humid tropical conditions of Benue State - Nigeria.

II. Materials And Method

Pullet management

A total of 160 twenty-week old Isa Brown pullets at POL were purchased from a reputable hatchery and housed in battery cages at the Poultry Unit of the Department of Animal Health and Production Technology of Akperan Orshi Polytechnic, Yandev, Benue State - Nigeria. The laying house was an open – sided tropical type, fitted with two – tier battery cages with feeders and drinkers. Flat aluminum metal plates were constructed and used to partition the feeding troughs at intervals of ten cages. The idea was to prevent spillover of feeds to neighboring treatments.

The initial body weight of each experimental pullet was recorded and randomly assigned to a cage measuring 49 x 35 x 42 cm. Five of such cages constituted a replicate and two replicates constituted a treatment with ten birds. The birds were initially vent examined to ensure that they were at point of lay before commencing the study. Feeds and water were provided *ad libitum.*

As a general flock prophylactic management strategy, routine vaccinations were regularly administered when due. Wood shavings were spread under the battery cages to absorb moisture and ease the regular removal of poultry droppings from the laying house. The surroundings of the experimental unit were kept as tidy as was possible. No supplemental light was provided during the period of the study. The entire study lasted for 24 weeks.

Experimental design

The study was a 4 x 4 factorial arrangement with sixteen treatments evolving from the combination in a Completely Randomized Design, CRD as described by Akindele (2004). The model employed was:

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

Where,

X_{ij} = Observed value of a dependent variable

μ = Overall mean

α_i = Effect of the i-th level of vitamin A

β_j = Effect of the j-th level of vitamin E

$(\alpha\beta)_{ij}$ = Interactions between i-th level of Vitamin A and the j-th level of vitamin E

ϵ_{ijk} = Residual error associated with the observation.

Four doses of dietary Vitamin A: 0, 2000, 4000 and 6000 IU per kg of the basal diet were combined with four doses of dietary Vitamin E: 0,125,250 and 375 mg per kg of the basal diet. The commercial Vitamin A (3,000 *IU*) was purchased in form of soft gel capsules. These were mixed with appropriate quantity of the basal diet. Similarly, Vitamin E was obtained in form of soft gels. Each soft gel contained 1,000 IU of the vitamin. Suitable number of soft gels were determined and then manually squeezed into appropriate quantity of the basal diet using the conversion (1 IU = 0.667 mg dl- alpha tocopheryl acetate and 1 IU of Vitamin A = 0.3 mcg of retinol) as defined by Askville (2008).The ingredient composition of the basal diet is shown in Table 1.

Table 1. Ingredient composition of the basal diet.

Ingredient	% composition
Maize	25
Soya bean meal	5
Wheat offal	48.1
Groundnut cake	10

Bone meal	3
Limestone	7
Lysine	0.75
Methionine	0.6
Salt	0.3
Layer's premix*	0.25
TOTAL(Kg)	100.00

***The** layer's premix (Bio mix layer, manufactured by Bio-Organics Nutrient Systems Ltd, Lagos, NAFDAC Reg. No. 04-6925) furnished the following amounts of other ingredients per kilogramme of feed: Vitamin A8,500,000 i.u. Vitamin D3 1,500.000 i.u., Vitamin E 10,000 mg, Vitamin K3 1,000 mg, Vitamin B1 1,500 mg, Vitamin B2 4,500 mg, Niacin 15,000 mg, Pantothenic acid 4,500 mg, Vitamin 6 3,000 mg, Vitamin B12 15 mg, Folic acid 600 mg, Biotin H2 500 mg, Choline chloride 175,000 mg, Cobalt 200 mg, Copper 3,ooo mg, Iodine 1,000 mg, Iron 20,000 mg, Manganese 40,000 mg, Selenium 200 mg, Zinc 30,000 mg, antioxidant 1,250 mg.

Table 2. Proximate nutrient composition of the basal diet.

Nutrient	% Composition
Moisture	8.0
Crude protein (CP)	17.6
Ether extract (EE)	3.5
Crude fibre (CF)	6.3
Ash	13.5
Nitrogen free extract (NFE)	45.4
Calcium (Ca)	3.2
Phosphous (P)	0.74
Metabolizable energy (ME) (K Cal Kg^{-1})*	2918.77

* Calculated using Carpenter and Clegg's formula (1956).

Measurement of parameters

Eggs were collected and labeled once a day at 1500 Hours UTC. Weekly summaries were made. Percentage Hen day production was calculated using the following formula:

Hen day production (%) = Average No. of eggs per day x 100%
No. of birds alive

Feed offered and feed refusals were weighed. The difference between the quantity of feed offered and that refused gave the daily feed intake for the previous day as follows:
Average daily feed intake (g) = Feed offered (g) – feed refusals (g)
No. of hens
Feed Conversion Ratio was estimated using the method described by Jabeen *et al*. (2004) as follows:
Feed Conversion Ratio = Quantity of feed consumed
Doz. of eggs produced.

The average egg weight of each individual bird in a given dietary treatment was measured using a G & G electronic Scale (Model J J2000 Y) weekly. The average egg weight was then determined using the formula below:
Average egg weight (g) = Total weight of eggs (g) per treatment
Total number of birds in that treatment

After weighing, the eggs were broken out on a flat plate and the height of the thick albumen determined from the chalazae, at a point midway between the inner and outer edges of the thick white using an Ames Tripod micro-meter as described by Haugh (1937). The Haugh units were simply read from the scale and values recorded in percentages. The shell thickness (mm) was measured by placing a piece of shell without membrane in Ames paper thickness gauge. The values were then read and recorded in millimeters.

Record of cracked eggs involved the discrete numeration of broken or shelless eggs of individual hens. Treatment totals were recorded daily and weekly summaries made.
Percentage mortality rate was calculated using the formula below:
Mortality rate (%) = Total No. of dead birds x 100%
No. of birds originally housed

The initial body weight (Kg) of each of the hens was recorded with the aid of a Way master balance (model 1005K) before assigning them to the various treatments. The average body weight per treatment was then calculated. At the end of the experiment, the average final body weight (Kg) of each experimental hen was also

recorded for each treatment. The difference in body weight measurements was then recorded as the changes in body weight as follows:
Changes in body weight = Average final body weight – Average initial body weight

Meteorological records

Diurnal ambient temperatures were monitored daily using the Minimum and Maximum Thermometer (Zeal model) hung on the wall. Relative humidity records were however, obtained from the Meteorological Unit of Akperan Orshi Polytechnic, Yandev, Benue State-Nigeria.

Statistical analysis

All parameters in the study were analyzed with the POSTHOC mixed models procedure for one way ANOVA using SPSS software version 17.0

III. Results And Discussions

Temperature and relative humidity at the study area

The mean minimum and maximum indoor temperatures ranged between 18.3-25.0 ºC and 27.15-34 ºC respectively. The mean minimum and maximum outdoor temperatures on the other hand fluctuated between 18.2-25.0 and 26.0-32.4 ºC respectively. The RH values however, lied between 53.0 and 88.9%. It was noted that, the ambient temperatures recorded in the present work were well above the zone of thermo neutrality as reported by Imik *et al.* (2009). Consequently, the experimental birds were observed most of the time panting and spreading their wings to dissipate body heat. The effects of supplemental vitamins A and E on the production attributes of Isa Brown pullets in the humid tropical region of Yandev, Benue State- Nigeria are summarized in Table 3.

Table 3. Summary of dietary effects of Vitamins A and E on production attributes of Isa Brown laying hens in the humid tropical region of Yandev, Benue State-Nigeria.

VE levels	0				125				250				375			
VA levels	0	2000	4000	6000	0	2000	4000	6000	0	2000	4000	6000	0	2000	4000	6000
TRT	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16
HDP (%)	42.33 ±1.43^{c}	58.51 ±1.61^{b}	66.16 ±1.82^{ab}	56.38 ±1.56^{bc}	52.31 ±1.32^{bd}	57.14 ±1.37^{bc}	85.45 ±1.15^{a}	76.08 ±1.41^{ab}	63.21 ±1.20^{ab}	64.46 ±1.14^{ab}	67.12 ±1.55^{ab}	61.59 ±1.43^{b}	55.53 ±1.24^{b}	55.95 ±1.30^{ab}	59.23 ±1.55^{ac}	55.57 ±1.39^{abc}
FI(g/bird/d)	65.42 ±0.61^{c}	77.*1*5 ±0.77^{b}	83.29 ±1.54^{ac}	74.55 ±1.15^{bc}	70.10 ±0.81^{bd}	75.33 ±1.33^{bc}	113.15 ±0.56^{a}	100.55 ±1.23^{ab}	84.35 ±1.60^{abc}	89.57 ±1.67^{a}	88.02 ±1.76^{ab}	81.91 ±1.28^{bc}	71.00 ±1.96^{b}	73.51 ±1.65^{b}	69.67 ±1.39^{d}	73.73 ±1.25^{c}
FCR	1.95 ±0.08^{a}	1.62 ±0.05^{b}	1.59 ±0.06^{bc}	1.66 ±0.08^{ab}	1.64 ±0.04^{b}	1.61 ±0.06^{b}	1.59 ±0.02^{bc}	1.60 ±0.04^{b}	1.61 ±0.06^{b}	1.68 ±0.05^{ab}	1.61 ±0.05^{b}	1.63 ±0.04^{b}	1.62 ±0.06^{b}	1.61 ±0.05^{b}	1.44 ±0.04^{c}	1.61 ±0.06^{b}
EWT (g)	54.50 ±1.15^{c}	59.58 ±0.86^{b}	63.55 ±1.25^{ab}	62.19 ±1.20^{ab}	57.63 ±1.01^{bc}	63.23 ±1.48^{ab}	69.11 1.52^{a}	66.02 ±1.00^{ab}	63.15 ±1.03^{a}	63.46 ±0.94^{a}	60.74 ±1.07^{b}	60.57 ±0.90^{b}	64.79 ±1.09^{a}	60.49 ±0.84^{ab}	60.73 ±0.64^{b}	60.42 ±0.84^{b}
SHT(mm)	0.26 ±0.01^{bc}	0.33 ±0.01^{a}	0.34 ±0.00^{a}	0.33 ±0.01	0.34 ±0.00^{a}	0.33 ±0.00^{ab}	0.34 ±0.01^{a}	0.33 ±0.00^{b}	0.32 ±0.01^{b}	0.31 ±0.00^{b}	0.32 ±0.01^{b}	0.32 ±0.01^{c}	0.33 ±0.01^{ab}	0.33 ±0.01^{a}	0.33 ±0.00^{ab}	0.32 ±0.01
CKE (%)	3.94 ±0.58^{a}	1.91 ±0.27^{b}	1.13 ±0.21^{b}	1.35 ±0.25^{b}	1.51 ±0.23^{b}	1.23 ±0.27	0.82 ±0.20	0.99 ±0.20	1.30 ±0.23^{b}	1.19 ±0.24	1.13 ±0.20	1.23 ±0.29	1.48 ±0.31^{b}	1.56 ±0.26	1.45 ±0.20	1.58 ±0.27^{c}
HUS (%)	75.50	84.54	86.05	85.52	80.34	81.99	96.27	88.75	83.80	85.81	86.05	84.93	81.22	81.97	81.86	81.79

	±2.10^{b}	±1.02^{ab}	±1.18^{ab}	±0.90^{ab}	±1.72^{ac}	±1.35^{bc}	±0.47^{a}	±0.68^{ab}	±0.89^{a}	±1.07^{a}	±1.07^{b}	±0.85^{b}	±1.48^{a}	±1.43^{b}	±1.01^{c}	±1.38^{c}
LBWT (g)	525.0±7^{a}	370.0±56.6bc	342.3±53.0bc	412.3±52.6^{b}	483.3±57.5^{a}	400.0±63.7^{b}	385.7±61.8	407.1±48.5^{b}	442.8±41.5^{ab}	300.0±39.2^{bc}	292.3±54.8^{c}	328.5±42.4^{bc}	400.0±55.4^{b}	400.0±55.4^{b}	292.8±62.9^{c}	389.2±49.2^{b}
MRT (%)	2.92	2.08	0.83	0.83	1.25	0.42	0.42	0.42	0.42	0.83	0.83	0.42	0.83	0.83	0.42	0.42

a,b,c,d- Row means with different superscripts are statistically significant at P < 0.01 or P < 0.05.
KEY: VE-Vitamin E; VC-Vitamin C; TRT- Treatments; HDP-Hen day production; FI- Feed intake ; FCR- Feed conversion ratio; EWT- Egg weight ; SHT- Shell thickness ; CRE- Cracked eggs; HUS- Haugh unit score; LBWT- Loss in body weight ; MRT-Mortality.

Hen day production

The differences in the percentage hen day production of dietary treatments were highly significant ($p < 0.01$). The least percentage hen day production (42.33 ± 1.43%) was recorded in T_1 while the highest percentage hen day production (85.45±1.15%) was recorded in T_7 followed by T_8 with (76.08 ± 1.41%). Generally, vitamin treated birds were better than ($p < 0.01$) the controls statistically. The result of the present work is consistent with the study of Smith (2010) who reported beneficial effects of supplementing increasing levels of vitamins E (10, 125, 250, 375 and 500mg kg-1) to laying hens experiencing heat stress. The drop in hen day production in the control group could probably be attributed to the prevailing high ambient temperatures during period of the study which ensued inadequate nutrient consumption necessary for egg production (Slaghter and Waldroup, 1990; Hosseini *et al*; 2009).

Similarly, Gan et al. (2020) and El-Ratel (2024) reported beneficial effects of using Vitmin A in the diets of laying hens corroborating the studies of Guo (2021) who reported that dietary addition of 4 000 IU/kg vitamin A maintained the hen-day egg production and eggshell thickness. The present investigation also corroborates the finding of Ciftci *et al*. (2005) who reported that supplemental vitamin E at 125 mg/kg diet in laying hens improved egg production significantly, contrary to Bartov *et al*. (1991) who indicated no improvement in egg production in laying hens under similar conditions. It is also on record that Vitamin A can improve the overall integrity and functioning of reproductive tract resulting into increased egg weight especially in heat stressed laying hens (Elsherif , 2017).

Feed intake

Feed Intake was significantly increased ($P<0.01$) in vitamin treated pullets. The highest feed intake (113.l5±0.56g /bird/day) was recorded in T_7 followed by T_8 with (100.55±1.23g/bird/day). The experimental birds used as control consumed the lowest feed/bird/day which was 65.42±0.61g. The average hen according to Oluyemi and Roberts (1979) is expected to consume 112g feed/day. However, under hot climates birds do not attain this consumption (Smith and Oliver, 1972) due to reduced feed intake. Consequently, laying hens under heat stressed conditions eat less feed as temperature increased and decreased feed consumption drastically at temperatures above 33 ^{0}C (NRC, 1994; Wasti et. al., 2020).

In the present study, it is suspected that the high ambient temperature recorded may have drastically lowered feed intake. This probably must have explained why the reduced feed intake had more pronounced effects ($P<0.01$) on the controls than the vitamin treated birds (Table 3). The poor feed intake observed in the control group in this study supports previous workers (Gous and Morris, 2005; Smith, 2006) who reported reduced feed intake in laying hens reared under hot climatic conditions.

Previous workers too have recommended the inclusions of vitamins A and E as possible anti- stress agents (Kucuk *et al*., 2003; Biswas *et al*., 2010; Wang et al., 2022).

Feed conversion ratio (FCR), Shell thickness and Haugh unit score

Other parameters such as feed conversation ratio, average egg weight, shell thickness and haugh unit score were highly significant ($P<0.01$) in vitamin treated birds than the controls. These findings are in line with those of Puthpongsiriporn *et al*. (2001), Alkan *et al*. (2008), Smith (2010), McDowell and Ward (2010) who reported similar results.

Cracked eggs

The highest number of cracked eggs (3.94±0.58%) was recorded in T_1 (control group) while T_7 had the lowest number (0.82±0.20%) agreeing with the findings of Arslan *et al*.(2001),Sobayo *et al.* (2008) and McDowell and Ward (2010) who reported that ethoxiquine, vitamins A, C and E have ameliorative effects of improving egg quality traits of hens under heat stress.

Average body weight

The highest average body weight loss (525.00±75.00g/bird) and mortality (2.97%) were observed in the controls (T_1) compared to the vitamin treated birds. Treatment differences were highly significant (P<0.01). In the present study it appears that in the advent of pathogenic attack, the immune system of untreated birds become overwhelmed leading to high mortality as was observed in the controls. Vitamins A and E appear to reduce mortality in treated birds whether used singly or in combination by 30 – 85% (Bhuiyan, et al., 2004; Hastak and Pelletier, 2023). The combined effects of the two vitamins appear to have more impact in reducing mortality than when any of the vitamins was applied singly (Table 3). This result is in conformity with reports of Mori *et al*. (2003) who investigated the combined effect of the two antioxidants vitamins A and E on egg yolk retinol and alpha tocopherol levels concluded that mortality was significantly decreased (P<0.05) in supplemented birds. Biswas et al. (2010) also reported a positive dietary effect of vitamins A and E on the performance of poultry by increasing resistance to disease and stress (Abd El-Hack et al., 2019). That probably explains why the untreated group (T_1) was worse heat by pathogenic organisms during the experimental period. Under similar conditions, many investigators have reported positive synergistic effect of vitamins A and E in enhancing immune response by modifying corticosteroid synthesis in adrenal glands (Franchnini *et al*., 1991; Meydani and Blumberg, 1993, Khan 2023).

Economic analysis of production

Considering the economics of producing a kilogram of egg, the total cost of production was, thus, extracted from the revenue generated for a given treatment to obtain the net income/dozen eggs (Table 4).

Table 4. Net income/dozen eggs (₦).

Mean ± SE

Vitamin level (IU/ kg diet)		Vitamin E				
		0	125	250	375	OVERALL MEAN
Vitamin A	0	560.50±32.12^{d}	921.77±30.66^{bc}	1166.09±29.34^{ab}	923.60±30.64^{bc}	892.99±21.83**
	2,000	930.64±39.12^{bc}	045.73±31.21^{bc}	1176.40±27.41^{ab}	971.21±33.11^{bc}	1030.99±17.71**
	4,000	1221.48±36.86^{ab}	1627.11±28.68^{a}	1218.76±34.00^{ab}	1079±85±33.27^{b}	1286.80±22.20**
	6,000	1029.23±37.15^{b}	1418.68±33.54^{ab}	1117.84±34.16^{b}	1 004.52±34.03^{b}	1142.56±20.96**
OVERALL MEAN		935.46±16.49**	1253.32±16.49**	1169.77±16.49	994.80±16.49**	1088.34±11.60

a,b,c,d- Row means with different superscripts are highly significant at P < 0.01.

The controls recorded the lowest net income/dozen eggs of ₦ 560.50±32.12 which was highly significant (P < 0.01) from values obtained from treated birds. The highest net income/dozen eggs (₦ 1,627.09±28.69) observed in T7 was similar (P>0.05) to values of ₦ 1,221.48±36.86, ₦ 1,418.68±33.54, ₦ 1,166.09±29.34, ₦ 1,176.40±27.41, and ₦ 1,218.76±34.00 recorded for T3, T8, T9, T10, and T11 respectively but differed highly significantly (P < 0.01) from the other treatments.

In the poultry industry, feeding alone accounts for 70-80% of the total cost of production (Madubuike and Obidimma, 2009). The ultimate goal of any producer is profit maximization (Arene, 1998; Koutsoyiannis, 1981; Tyokever, 2007). Given the poor performance of poultry generally and laying hens in particular under humid tropical situations as is associated with Nigeria in general and Yandev in particular, maximizing profit is a strenuous exercise and a mirage. The ameliorative roles of antioxidant vitamins especially Vitamins A and E as shown in the present work have not only improved egg production but the net income is high in treated birds.

It is therefore reasoned that, corresponding increase in egg production due to vitamin treatment in layer's diet justify the cost of production and returns were higher compared to when the diet was not supplemented. This result is in agreement with previous reports by Gous and Morris (2005), Sahin *et al.* (2001), and Whitehead and Mitchell (2010) who demonstrated that supplementing layers diet under heat stress with Vitamins A and E, gave maximum economic benefits.

In terms of the economic considerations of production, therefore, even though supplementing laying hens diet with Vitamins A and E relatively increased the cost of production but the overall economic benefits accruing at the end of the production venture significantly outweighed (p<0.01) that of the un-supplemented birds (Table 4).

IV. Conclusion

Laying hens exposed to heat stress in the humid tropical conditions of Yandev, Benue State-Nigeria respond favourably to supplemental vitamin A and vitamin E especially when used as a combination. But if vitamin A is to be used as a single supplement, then dietary level of inclusion of up to 4000 *IU* kg-1 diet is beneficial and improve production under heat stressed conditions. On the other hand if vitamin E is to be used under similar conditions, then the dietary levels of inclusion should not exceed 250mgkg-1 feed for optimum performance and better economic gains. It should be borne in mind that, vitamin E is a relatively expensive vitamin, so routine supplementation of laying hen diets with 250mg vitamin E/kg might not be economical. Feeding lower concentrations, whilst not giving the highest production response, could be cost effective.

Based on results of the present study, supplementing vitamins A and E (4,000 IU + 125mg dl-∝-tocopheryl acetate) per kg of feed gives the best performance. Such a combination of these vitamin supplements can offer a potential protective managements practice in preventing heat stress-related losses in performance of laying hens. This work therefore, upholds that effects of the two anti-oxidants: vitamin A and vitamin E acting in synergy are additive, immunomodulatory, anti-parasitic and economical.

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