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RESEARCH ARTICLE

Effects of Vitamin E on Stress Resorption, Lipid Profile and Reproductive Performance of Sokoto Red Goats

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Abstract: Vitamin E (α-tocopherol) plays a critical role in animal nutrition as an antioxidant, contributing to anti-inflammatory responses, immune function, and gene expression regulation. This study aimed to determine the optimal dietary level of vitamin E to alleviate the effects of environmental stress in Sokoto Red Goats transported from their native dry savannah belt to the humid derived savanna belt of Nigeria, and to evaluate its effects on physiological stress indicators, serum lipid profile, and reproductive function. Thirty growing Sokoto Red Goats of mixed sexes, aged 12 to 15 months, were used in the experiment. Following a two-week quarantine period during which all animals received long-acting oxytetracycline and ivermectin, they were allotted into five treatment groups (A, B, C, D, and E) with two replicates each, balanced for body weight in a completely randomized design. Dietary vitamin E was supplemented at 0, 3, 6, 9, and 12 g/kg of feed for treatments A through E, respectively. Animals had unrestricted access to feed, forages (Panicum maximum and Pennisetum purpureum), and water for a period of three months. Body weight, respiration rate, pulse rate, and rectal temperature were recorded fortnightly. Blood was collected via jugular venipuncture for serum and hormonal assays. Vitamin E supplementation significantly ($p<0.05$) reduced respiration and pulse rates, with rectal temperature remaining within the normal physiological range for goats. Significant ($p<0.05$) reductions were observed in total cholesterol, low-density lipoprotein (LDL), and triglycerides, while very low-density lipoprotein cholesterol (VLDL) showed a significant increase. Reproductive function was also significantly ($p<0.05$) improved, with elevated oestrogen and testosterone levels, enhanced sperm motility, progressive motility, and acrosome integrity, alongside significant reductions in sperm abnormalities and dead spermatozoa. It was concluded that the inclusion of 6 g vitamin E per kg of feed yielded optimal performance in Sokoto Red Goats under transport and environmental stress conditions.

Keywords: Vitamin, α-tocopherol, Sokoto Red Goats, Lipid Profile, Serum, Hormone, Spermatozoa Conditioning, Anti-Inflammatory Therapy, Risk Factor Modification, Cerebrovascular Disease, Stroke Prevention

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Introduction

One of Nigeria's native goat breeds, the Sokoto red goat, is utilized for milk and meat and is well suited to the arid savannah region. Pneumonia frequently affects its output in the country's humid regions, and climate stress lowers production rates. The attention on the goat breed is motivated by the desire to create a productive and adaptable breed for Nigeria's rainforest zone. The agro-ecological region noted for its trypanosomiasis infection and tsetse fly infestation, which have a detrimental effect on cattle output, corresponds to the rainforest zone. When utilizing local genetic resources to address native demands, it is imperative to employ highly indigenous and well-adapted Sokoto red goats in a suitable breeding plan [1. Finding a remedy to this animal's cold sensitivity was important in order to address certain suspected issues related to it living in a humid environment. This frequently puts the animal at risk for secondary infections, which can lead to dystocia, low birth weight, sluggish growth, a low child survival rate, and an inadequate milk supply [2]. Vitamin E use has been linked to reproduction and is thought to have evolutionary importance for both humans and animals [3,4]. Numerous roles, including lipid transfer, cellular immune control, and antioxidant, have been identified. It lessens the quantity of senescent cells and guards against telomere shortening and deoxyribonucleic acid (DNA) damage caused by H2O2 [5]. Vitamin E combined with other components may lower serum cholesterol, fatty acid levels, and the percentage of peroxide hemolysis in pigs [6]. According to Otomaru et al. [7], it has an impact on the quantity of specific immune cell types in the peripheral blood of nursing Japanese black calves. Additionally, it caused Aohan fine-wool sheep and chicken to have more monounsaturated fatty acids and less saturated fatty acids [8-10]. Although there is literature on the biological functions of vitamin E and its use to prevent disease and enhance animal health and productivity [11-13], its impact on stress resorption, lipid profile, and Sokoto red goat reproductive performance is essential for the genetic preservation of native Nigerian goat breeds in a humid environment.

Materials and Methods

Location of the Study: The University Teaching and Research Farm served as the experimental location from April through July, when it rained. With an average annual rainfall of 1,250 to 1500 mm and average maximum and minimum temperatures of 19°C and 33°C, respectively, the farm is situated in a sub-humid tropical climate at latitudes 8° 30' and 8° 50' N and longitudes 4° 20' and 4° 35' E of the equator [14]. It is roughly 5,000 hectares in size, 500 kilometers from Abuja, the capital of Nigeria, and 300 kilometers from Lagos, the country's commercial hub.

Experimental Materials: For the experiment, a pharmaceutical business in Nigeria provided vitamin E tablets. Each month, it was well combined and bagged after being pounded into a powder and added to the feed at graded quantities of 2, 4, 6, and 8g of vitamin E per kg of basal feed. Vitamin E was not included in the control diet.

Animal, Housing and Management: The experiment involved thirty Sokoto red goats of mixed sexes that were between 12 and 15 months of age. During the two weeks of quarantine prior to the start of the experiment, they were given long-acting oxytetracycline to treat colds and pneumonia and ivermectin to reduce endoparasites. After being balanced for body weight, the animals were then divided into five treatments (A, B, C, D, and E) with two replicates consisting of three animals each. The design is entirely random. Every day, the animals received 300g of the experimental diet (Table 1) along with free access to water and forage (Panicum maximum and Pennisetumpurpureum). Every day, pens and drinkers were cleaned. Temperature, heartbeat, lipid profile/sex hormone, and sperm quality were assessed using physiological parameters, blood, and semen samples that were taken at the start of the trial and every four nights thereafter. With approval number UERC/ASN/2024/2790, the University of Ilorin Ethical Review Committee's requirements for animal handling and pertinent protocols were followed.

Collection of samples and analyses:

Using a weighing scale, digital thermometer, and flexible stethoscope, body weight was measured every two weeks along with physiological parameters like temperature, pulse rate, and respiration rate. These measurements were made at the left thoracic region at the aortic arch, expressed in beats per minute, and the laryngotracheal region, expressed in movements per minute. Individual goats' jugular veins were used to draw blood samples, which were then placed in simple vials for hormone assays and lipid profiles. Minifuge RF, Heraeus, Hannover, Germany, was used to centrifuge blood in simple bottles at 1200xg for 20 minutes in order to extract serum. Before being tested, separated serum was kept frozen at -4°C. An auto analyzer (Hitachi 747, Boehringer Mannheim, Madrid, Spain) that used the enzyme linked immunosorbent assay (ELISA) kit (Lifespan Biosciences, Inc.) was used to quantify the hormone concentrations.

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Data analysis: The Statistical Analysis Systems software package (2013) was used to analyze the variance of a completely randomized design. Duncan's Multiple Range Test of the same model was used to differentiate treatment mean differences.

Table 1: Composition of the basal diet (Top feed^R)

INGREDIENTS	COMPOSITION (kg)
Maize	50.00
Soybean meal	12.50
Fishmeal	1.00
Wheat offal	11.45
Palm kernel cake	7.00
Corn bran	6.00
Groundnut cake	8.00
Bone meal	2.50
Oyster shell	1.00
Salt	0.30
Vitamin premix	0.25
TOTAL	**100.00**
Crude Protein (%)	18.40
MetabolizableEnergy (Kcal/Kg)	2810.67

Results

Table 2 displays the physiological stress measures of vitamin E-supplemented Sokoto red goats. There were significant differences ($p<0.05$) in body weight, respiration rate, pulse rate, and rectal temperature. The more vitamin E supplements were added to the diets, the lower the pulse and respiration rates were. As the amount of vitamin E in the meals rose, there was a considerable increase in body weight and rectal temperature.

Table 2: Effect of vitamin E on Physiological stress parameters of Sokoto Red Goats

Parameters	A (0g E/kg feed)	B (2g E/kg feed)	C (4g E/kg feed)	D (6g E/kg feed)	E (8g E/kg feed)	± SEM
Respiration rate (/Min)	22.54^a	20.96^b	19.58^c	20.04^{bc}	20.50^{bc}	0.25
Pulse rate (/Min)	99.50^a	93.63^b	91.79^c	90.96^c	90.13^c	0.43
Body weight (Kg)	17.29^{ab}	16.31^{ab}	13.31^b	17.64^a	17.27^{ab}	1.05
Rectal temperature (^{O}C)	37.53^b	38.61^a	38.59^a	38.29^{ab}	38.64^a	0.2

$^{a, b, c, d}$ – mean on the same row with different superscripts are significantly different ($p<0.05$). E – Vitamin E, SEM - Standard Error of Mean

The effects of varying vitamin E supplementation amount on the blood lipid profile of Sokoto red goats are displayed in Table 3. Vitamin E supplementation had a substantial impact on T-CHOL (total cholesterol), LDL-C (low density lipoprotein cholesterol), VLDL-C (very low-density lipoprotein cholesterol), and TRIG (triglycerides). However, the introduction of vitamin E in the diets did not significantly influence HDL-C ($p>0.05$). Treatment D (6g vitamin E/kg feed) considerably decreased T-CHOL, whereas the other treatments showed no discernible change. Increased vitamin E intake in the diets resulted in a significant decrease in LDL-C and TRIG. As vitamin E dosage increased, VLDL-C increased considerably.

The effects of varying vitamin E supplement dosages on sperm parameters in Sokoto red goats are displayed in Table 5. Sperm motility, progressive motility (slow/normal), sperm abnormalities (tail to tail/head-to-head attachment), dead spermatozoa, and acrosome integrity were all significantly impacted ($p<0.05$) by vitamin E administration. Vitamin E supplementation had no significant effect ($p>0.05$) on other spermatozoa abnormalities, such as pin head and tangled spermatozoa. Sperm motility and acrosome integrity increased gradually, peaking in treatment D. As vitamin E inclusion in the diets increased, sperm motility decreased. Following the peak level attained in treatment B (2g vitamin E/kg feed), progressive motility (slow/normal), sperm abnormalities (tail to tail/head-to-head attachments), and dead spermatozoa were progressively decreased with further increases in vitamin E supplement.

Table 3: Effects of graded levels of Vitamin E supplementation on serum lipid profile of Sokoto red goats

Parameters, mg/dL	**A (0g E/kg feed)**	**B (2g E/kg feed)**	**C (4g E/kg feed)**	**D (6g E/kg feed)**	**E (8g E/kg feed)**	**± SEM**
T-CHOL	73.87^{a}	72.60^{a}	73.80^{a}	66.20^{b}	74.40^{a}	0.64
HDL-C	49.74	47.28	48.96	49.80	49.50	0.72
LDL-C	25.09^{b}	33.98^{a}	32.69^{a}	25.74^{b}	23.92^{b}	0.67
VLDL-C	17.05^{b}	19.73^{a}	19.73^{a}	20.33^{a}	19.35^{a}	0.69
TRIG	96.39^{a}	85.68^{b}	69.72^{d}	73.71^{c}	84.61^{b}	0.58

$^{a, b, c, d}$ – mean on the same row with different superscripts are significantly different (p<0.05). E – Vitamin E, T-CHOL – Total cholesterol, HDL-C – High density lipoprotein cholesterol, LDL-C – Low density lipoprotein cholesterol, VLDL-C – Very low-density lipoprotein cholesterol, TRIG – Triglycerides, SEM - Standard Error of Mean

Table 4 displays the impact of varying vitamin E supplementation doses on the male sex hormones of Sokoto red goats. Vitamin E administration had a substantial (p<0.05) impact on prolactin, estrogen, luteinizing hormone, and testosterone. The more vitamin E was added to the diets, the higher the levels of estrogen and testosterone. Increased vitamin E intake resulted in a considerable decrease in prolactin and luteinizing hormone.

Table 4: Effects of graded levels of Vitamin E supplementation on male sex hormones of Sokoto red goats

Parameters	**A (0g E/kg feed)**	**B (2g E/kg feed)**	**C (4g E/kg feed)**	**D (6g E/kg feed)**	**E (8g E/kg feed)**	**± SEM**
Oestrogen, pg/mL	518.38^{d}	530.88^{c}	572.13^{a}	550.87^{b}	563.38^{a}	9.98
LH, IU/mL	271.60^{a}	198.81^{b}	168.61^{d}	184.79^{c}	179.12^{d}	18.40
Testosterone, ng/mL	107.74^{c}	123.67^{b}	141.28^{a}	140.30^{a}	149.25^{a}	7.45
Prolactin, ng/mL	52.88^{c}	181.63^{b}	304.13^{a}	237.88^{a}	69.13^{c}	48.28

$^{a, b, c, d}$ – mean on the same row with different superscripts are significantly different (p<0.05). E – Vitamin E, LH – Luteinizing Hormone, SEM - Standard Error of Mean

Table 5: Effects of graded levels of Vitamin E supplementation on sperm characteristics of Sokoto red goats

Parameters, %	**A (0g E/kg feed)**	**B (2g E/kg feed)**	**C (4g E/kg feed)**	**D (6g E/kg feed)**	**E (8g E/kg feed)**	**± SEM**
Motility	76.00^{c}	35.50^{e}	109.50^{b}	168.00^{a}	66.00^{d}	9.01
Slow	11.00^{c}	23.00^{b}	17.00^{b}	51.50^{a}	10.50^{c}	2.60
Normal	19.00^{b}	17.50^{b}	12.00^{b}	32.00^{a}	16.00^{b}	3.30
Pin head spermatozoa	11.50	4.00	2.50	11.00	8.50	2.80
Tail to Tail attached spermatozoa	7.50^{a}	13.00^{a}	2.50^{b}	0.00^{b}	5.50^{b}	2.30
Tangled abnormality	9.00	9.00	7.50	2.00	10.00	0.36
Head-to-Head attached abnormality	6.50^{c}	21.50^{a}	15.00^{b}	11.50^{b}	3.50^{c}	2.37
Dead spermatozoa	35.00^{a}	41.50^{a}	16.00^{b}	6.00^{c}	37.00^{a}	7.90
Acrosome integrity	72.00^{a}	17.00^{c}	7.00^{d}	67.00^{a}	68.50^{a}	3.01

$^{a, b, c, d}$ – mean on the same row with different superscripts are significantly different (p<0.05). E – Vitamin E, SEM - Standard Error of Mean

Discussion

Extreme heat or cold can kill farm animals, making climate stress one of the most significant elements affecting their metabolism and productivity [15]. The hot, arid savannah regions of Nigeria are ideal for Sokoto red goats. Approximately 70% of Nigeria's sheep and goat populations are concentrated in the dry savannah zone or northern region since they frequently die from pneumonia or the cold when raised in the country's humid southern and sub-humid zones [16,17]. Despite the fact that the majority of these native goats are not seasonal breeds, they frequently show signs of prolonged anoestrus, reduced ovulation rates, anovulation, high embryonic and foetal losses, and poor sperm production due to inadequate nutrition and occasionally environmental factors [18-20]. The distribution and productivity of ruminants in Nigeria are significantly influenced by seasonal and climatic changes [15]. Selection for genetically superior people as parent stock for subsequent generations is typically impeded by non-genetic factors that obscure the true breeding values of the selected individuals [21].

Numerous authors have reported that vitamin E improves animals' immune responses and reduces their susceptibility to common infections, which supports the observed significant effect of vitamin E on the majority of the physiological stress parameters studied [22-24]. Vitamin E incorporation in feed has been linked to improved hatchability, growth rates, and egg production in chicken [25]. In addition, pigs develop faster, experience less stress, and have better-quality meat [26]. The notable rise in body weight supports the findings of Lu et al. [27] that vitamin E administration enhances growth performance. Though it was within the typical range for goats, it also markedly raised the rectal temperature. Given that vitamin E is a potent chain-breaking antioxidant that prevents lipid peroxidation, the rise in rectal temperature may be the consequence of increased cellular activity [2, 28]. Altesman and Cole [29] reported that vitamin E has an antidepressant-like effect by lowering oxidant alterations brought on by stress in a secondary role with antioxidants such glutathione peroxidase and superoxide dismutase. Vitamin E has antioxidant qualities that assist reduce stress, just like vitamin C. The body uses a lot of nutrients when under stress, which leads to oxidative stress and free radicals [30]. This is why animals' development and body weights have been shown to increase. It stops lipid peroxidation, which is its antioxidant mechanism [31].

According to Lu et al. [27] and Al-Sowayan and Almarzougi [32], the effective utilization of nutrients in cell membranes, by averting free radical reactions, may explain the observed decrease in total cholesterol, low-density lipoprotein, and triglycerides. Okosun and Adu [33] found that oral vitamin E intake had no discernible impact on a human subject's serum cholesterol profile, which runs counter to the current observation. Additionally, it has been shown to raise serum HDL cholesterol [34] but shield low-density lipoprotein cholesterol from lipid peroxidation [35], which was not the case in this investigation.

Vitamin E was found to have a major impact on male sex hormones, increasing levels of testosterone and oestrogen while decreasing concentrations of prolactin and luteinizing hormone. According to Yin et al. [36], oral vitamin E supplementation reverses the effects of dioxin on testosterone, sperm concentration, and testis structure in rats that have been harmed by the toxin. Vitamin E counteracts the reproductive endocrine toxicity and mitigates the structural alterations in the testicles brought on by polychlorinated biphenyl (Aroclor 1254) and dioxin (2, 3, 7, 8-tetrachlorodibenzo-p-dioxin) [37]. Since vitamin E has been shown to modulate its release from the anterior pituitary in male rats, the increased supplementation may be the cause of the lower levels of prolactin and luteinizing hormone [38]. It has been observed that giving Boer goats an 80 IU daily vitamin E supplement improves their reproductive health by increasing the quantity of epithelium, seminiferous tubule diameter, and Sertoli and Leydig cells [39]. The Leydig cells produce androgen (testosterone), and the Sertoli cells are crucial for both the transit and maintenance of androgens in the testes [4, 40].

Additionally, it was shown that vitamin E treatment significantly increased sperm motility and acrosome integrity while decreasing progressive motility, sperm abnormalities (tail-to-tail and head-to-head attachment), and dead spermatozoa. According to earlier research, vitamin E's ability to stop free radical reactions in cells may improve sperm performance and activity [41, 42, 43, 44]. Its application increases sperm motility and fertilizing capacity in hamster egg penetration, according to in vitro research [4, 45]. Additionally, it was found to be successful in mitigating the detrimental effects of reactive oxygen species (ROS) on sperm concentration and motility in in-vivo experiments [46]. Through the decrease of malondealdehyde (MDA), the byproduct of lipid peroxidation, oral gavage significantly improved sperm motility [47]. An imbalance between the body's capacity to detoxify or repair the damage caused by reactive oxygen species (ROS) and ROS generation results in oxidative stress [5]. According to reports, ROS can harm DNA, proteins, and cell membranes, impairing cellular function and making a person more vulnerable to a number of illnesses [43]. According to reports, vitamin E deficiency alters the structure of spermatozoa, which increases abnormalities, testicular dysfunction, and seminiferous tubule shrinkage [12, 47]. In addition to its antioxidant properties, vitamin E improves the activity of antioxidant enzymes in animals, including glutathione peroxidase and superoxide dismutase (SOD) [3, 48].

Conclusion

Vitamin E (α-tocopherol) is an antioxidant that can be used to improve reproductive function and reduce climate stress in Sokoto red goats in Nigeria. This is because vitamin E normalizes respiration and pulse rates, as well as rectal temperature within the acceptable range in a tropical environment. Additionally, it raised extremely low-density lipoprotein while lowering total cholesterol and triglycerides. By increasing oestrogen and progesterone production, improving sperm motility, acrosome integrity, and reducing sperm abnormalities with improved progressive motility, it also markedly enhanced reproductive function. Animals fed 6g of vitamin E per kilogram of diet performed the best.

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Author Contributions

All authors contributed to the conception and design of this review. The original draft was prepared collectively, with all authors contributing to the writing and reviewing of specific sections. All authors participated in the critical revision and editing of the manuscript for important intellectual content. All authors have read and approved the final version of the manuscript.

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