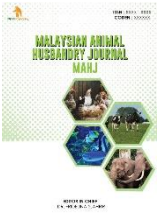
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RESEARCH ARTICLE

EFFECTS OF TUMERIC POWDER TREATED DIETS ON GROWTH, REPRODUCTIVE HORMONE AND SEMEN CHARACTERISTICS OF WEST AFRICAN DWARF BUCKS

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ABSTRACT

Turmeric is a spice with the biologically active substance curcumin which have been reported to have several effects such as anti-inflammatory and antioxidant characteristics. This study evaluated the influence of different levels of Turmeric powder on growth hormones, reproductive hormones and semen quality of male West African dwarf (WAD) goats. Thirty (30) male goats were randomly assigned to five treatments (A, B, C, D and E) in a completely randomized design. The duration of the experiment was eight weeks. They fed diets containing 0, 2, 4, 6 and 8g of turmeric powder per kilogram grower mash which was molded into pellets. Records of weight and blood samples were taken at the beginning and subsequently every two weeks for hormonal assay. Semen samples were obtained every two weeks by electroejaculation for determination of volume, color, concentration, motility and morphology.The General Linear Model procedure of (SAS, 2014) was used for data analysis. Significantly different ($p<0.05$) means were separated using Duncan's Multiple Range Test of the same software. Supplementation with Turmeric powder at 6g/kg feed and 8g/kg feed led to a significantly reduced cholesterol level, low density lipoprotein (LDL). It reduces oxidation of malondialdehyde (MDA) and thiobarbituric reactive substance but significantly increased the high density lipoprotein (HDL). Turmeric had nosignificant effects ($p>0.05$) on the reproductive hormones across all treatments. It significantly ($p<0.05$) increased sperm concentration, motility and morphology with the highest concentration obtained at 8g of turmeric/kg feed, while sperm motility and morphology were high at 2g/kg feed. The semen obtained in all the treatments was whitish grey in colour. In conclusion, Turmeric powder has no improved effects on testosterone,follicle stimulating hormone and luteinizing hormone production at 8g of Turmeric/kg feed but improved sperm concentration, MDA and thiobarbituric reactive substance thereby improve reproductive performance. Although the best dietary level for overall performance was 4g turmeric powder per kilogram diet.

KEYWORDS

Turmeric powder, Semen quality, Hormone, Bucks.

1. INTRODUCTION

In recent time, a lot of attention has been focused on natural plants and its products rather than synthetic drugs for animal improvement (Atanasov et al., 2021). The different plant parts that were once considered of little or no importance are now being studied and developed into drugs with minimal side effects (Salmerón-Manzano et al., 2020). Many wild herbs and spices have been reported to be most effective, relatively non-toxic with substantial scientific documentation attesting to their efficacy in infertility management (Jaradatand Zaid, 2019). The ability to improve fertility of certain plant and its extract has been reported in different studies (Okukpe et al., 2012). *Curcuma longa* (Turmeric) is a tropical rhizome plant which that belongs to the ginger family. It is native to Southern and South-eastern tropical Asia. Curcumindimethoxycurcumin and bis-dimethoxycurcumin 2, 5- xylenolare the yellow bioactive compound that has been isolated from the rhizome (Brewer, 2011 ; Tanvir et al., 2017 ; Boroumand et al., 2018). The compound, curcumin is a natural polyphenol that has widely been known to ameliorate oxidative stress both in humans and animals. Curcumin is capable of scavenging free radicals such as reactive oxygen species (ROS) and reactive nitrogen species (RNS), activating glutathione (GSH), catalase and superoxide dismutase (SOD) in neutralizing free radicals and also inhibiting ROS-generating enzymes for instances lipoxygenase/cyclooxygenase and xanthine hydrogenase/oxidase (Hewlings and Kalman, 2017). It was also revealed in some *in-vivo* studies that turmeric treatment could restore impaired growth performance, physiological alteration, weakened immune system and disrupted antioxidant system in heat-stressed broilers (Akhavan-Salamat and Ghasemi 2016 ; Sadeghi and Moghaddam, 2018). Therefore, it could reduce or substitute the role of synthetic antioxidants that have recently been legislatively restricted (Sugiharto et al., 2019). Also showed that turmeric have anti – inflammatory and antioxidant effects (Igbal et al., 2013). Turmeric is therefore a potential

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substitute for feed antibiotics in livestock diets as result of this biological properties. Different studies to evaluate its effects on the performance of WAD goats (Nayaka et al., 2013 ; Abou-Elkhair et al., 2014). However the results of these studies have been inconsistent keeping in view the medicinal attributes of *Curcuma longa*. Researches have provenbioactive plant substancesto be very effective in animal nutrition as they stimulate appetite and increase feed intake, improve of endogenous digestive enzyme secretion, and activate immune response, antibacterial, antiviral and antioxidant actions (Toghyani et al., 2010 ; Yan et al., 2017). Turmeric has several therapeutic and pharmacologic activities. It has been reported by several authors to have the most important phytopharmacology and therapeutic properties (Djaelani, 2010 ; Sivakumar et al., 2010 ; Sitepu and Marisa, 2019).

Proper nutrition is very important for the health and reproductive performance of animals and the foundation of successful production systems. It also has impact on growth performance and development of reproductive organs. It has been reported that testicular mass and semen characteristics can be influenced by feeding (Okukpe et al., 2024). One of the most common causes of impaired reproductive capacity in terms of semen production and quality is severe under-nutrition (Ferramosca and Zara, 2022). The research revealed that low plane of nutrition suppresses the production of gonadotropins by the pituitary gland and the secondary sex hormones, so that atrophy of the prostrate and the seminal vessels occur thereby affecting semen quality in terms of fluid volume and concentration (Anamthathmakula and Winuthayanon 2020). Thus, the plane of nutrition is pivotal in determining the quality of buck semen. The problem of poor semen quality and low fertility caused by low plane of nutrition can be reduced with high plane of nutrition. Turmericis believed to have a stress modulating effect and contain essential nutrients necessary for reproductive enhancement. According to the analysis of seminal parameters such as semen volume, semen color, sperm concentration, sperm morphology and mass motility is helpful in investigating male infertility, genital infections and pathologies (Akang et al., 2023). This research was done to determine the effect of *Curcuma longa*powdertreated diets on growth hormones, male sex hormones and semen quality in West African dwarf (WAD) bucks.

2. Materials And Methods

2.1 Location of the Study

The feeding trial was conducted from the month of February – May, at the University Teaching and Research farm located (14° N 11° E) in sub-humid tropical environment with an annual rainfall range of 1500-1700 mm and average maximum and minimum temperature readings of 18°C and 25°C respectively. Blood and semen samples were collected at the beginning of the experiment and at every two weeks for hormone assessment in serum and sperm quality parameters respectively.

2.2 Processing of *Curcuma longa*powder for inclusion in concentrate diet

*Curcuma longa*rhizomes were collected in University of Ilorin Teaching and Research farm, the rhizomes were air-dried at a room temperature, cleaned and ground using an electric blender LG^R model.

2.3 Animals and treatments.

Thirty (30) adult male West African Dwarf goats with initial weights of between 10.63 and 12.50kg were divided into five groups, balanced for body weights. The goats were assigned to five dietary groups in a completely randomized design A, B, C, D and E. Goats in each group received a concentrate diet (Table 1) containing 0, 2, 4, 6 and8g *Curcuma longa*/kg feed. The concentrate was fed at 2% equivalent of the body weight in two equal rations (0800 and 1600 hours) daily as supplement to basal *Panicum maximum* hay (9.18% CP). Goats were housed individually in concrete floored pens (1 x 1.5m^2) for 56days, with regular supply of water. The goats were treated against external and internal parasites before the commencement of the feeding trial.

3. Collection Of Samples And Analyses

Body weight measurements were recorded prior to early morning feeding on the first day of the 56-day feeding trial and subsequently at 14-day intervals. The difference between two consecutive measurements was used to estimate body weight gain over the interval period. Semen samples were collected with the use of an electroejaculator into sample bottles on the first day and subsequently every two weeks for semen analysis. Blood samples were collected through the jugular vein from individual goats. Blood collected was put into plain bottles, taken to the laboratory and centrifuged at 1200xg for 20 minutes for serum using Minifuge RF, Heraeus, and Hannover, Germany. Separated serum was stored frozen at -4°C until assayed. Hormone concentrations were measured by using an auto analyzer (Hitachi 747, Boehringer Mannheim, Madrid, Spain) which followed the principles of enzyme linked immunosorbent assay, ELISA kit (Lifespan Biosciences, Inc).

Samples of feeds and orts were composited every two weeks, oven dried (60° C) to constant weights and allowed to air-equilibrate before being ground to pass through 1-mm sieve. About 10% of the ground feed and orts samples were preserved for later dry matter and proximate analyses. Preserved feed and faeces subsamples were analyzed for dry Kjeldahl nitrogen, crude fibre, ether extracts and total ash (Van Soest, 1991; AOAC, 2005). Empirical data were subjected to analysis of variance of a completely randomized design experiment using SAS (statistical Analysis software) package, 2015 model. Differences between treatment mean was separated using Duncan`s Multiple Range Test of the same model.

Table 1: Composition of the basal experimental feed

Ingredients, %	A	B	C	D	E
Brewer's Dried Grains (BDG)	50.00	50.00	50.00	50.00	50.00
Wheat offal	16.50	16.50	16.50	16.50	16.50
Palm Kernel Cake (PKC)	20.00	20.00	20.00	20.00	20.00
Corn Bran	8.00	8.00	8.00	8.00	8.00
Oyster Shell	4.75	4.75	4.75	4.75	4.75
Salt	0.50	0.50	0.50	0.50	0.50
Vitamins	0.25	0.25	0.25	0.25	0.25
TOTAL	100.00	100.00	100.00	100.00	100.00
Turmeric powder, g	0.00	2.00	4.00	6.00	8.00
Proximate composition of feed					
Dry matter	92.92	93.90	94.70	92.16	91.14
Crude Protein	17.85	18.47	14.68	14.79	14.87
Crude fibre	22.33	22.11	20.69	21.70	21.30
Crude fat	4.63	4.70	5.76	5.35	5.94
Nitrogen-free extract	30.66	30.07	40.85	33.10	33.05
Ash	17.48	18.05	12.73	16.52	16.98

4. Results

The effects of graded levels of Curcuma longa powder treated diets on some growth and reproductive hormones are shown in Table 2. The dietary supplementation of the diets with curcuma longa (Turmeric) powder had no significant effects ($p>0.05$) on all the growth and reproductive hormones assessed. Although there where numerical differences in values, it showed that Turmeric had little or no effects on growth and reproductive hormones.

Table 2: Effects of Curcuma longa powder treated diets on some growth and reproductive hormone

Parameters	A	B	C	D	E	±SEM
Somatotropin, ng/ml	0.52	0.51	0.53	0.53	0.53	0.02
Gonadotropin, MIU/ml	11.72	11.73	11.70	11.70	11.68	0.18
Thyroid Stimulating Hormone, ng/ml	0.12	0.11	0.10	0.10	0.08	0.01
Thyroxine, µg/dl	6.12	6.11	6.11	6.07	6.09	0.09
Triodothyronine, ng/dl	90.00	89.73	89.06	88.85	88.48	1.85
Testosterone, MIU/ml	3.33	3.35	3.32	3.30	3.27	0.38
FSH, MIU,ml	11.72	11.71	11.67	11.67	11.63	0.58
LH, MIU/ml	13.78	13.77	14.05	14.05	14.14	0.58

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FSH – Follicle Stimulating Hormone, LH – Luteinizing Hormone, SEM – Standard Error of Mean, A – Control (without Tumeric powder), B – 2g Tumeric/kg basal feed, C – 4g Tumeric/kg basal feed, D – 6g Tumeric/kg basal feed, E – 8g Tumeric/ kg basal feed

The oxidative stress indices of West African dwarf bucks fed turmeric powder treated diets are presented in Table 3. Turmeric powder significantly affected ($p<0.05$) the levels of cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL), triglycerides and malondialdehyde. There was significant reduction in the blood levels of cholesterol, HDL, LDL and tryglycerides while malondialdehyde increased with increased levels of turmeric powder.

Table 3: Effects of Curcuma longa powder diets on some oxidative stress indices of West African dwarf bucks

Parameters	A	B	C	D	E	±SEM
Cholesterol, mg/dl	34.72a	35.33a	32.87b	32.00b	30.16c	0.19
HDL, mg/dl	18.84bc	22.50a	20.91ab	19.36bc	17.75c	0.42
LDL, mg/dl	11.63b	13.18a	11.42b	10.77bc	9.94c	0.17
Triglycerides, mg/dl	7.45e	11.06a	9.53b	8.78c	8.04d	0.08
Malondialdehyde, µmol/L	18.44b	27.00a	26.93a	28.74a	26.83a	0.21

a, b, c, d, e – Means with different superscripts along the same row for each parameters are significantly different ($p<0.05$). HDL- High density lipoprotein, LDL- Low density lipoprotein, SEM- Standard Error of Mean, A – Control (without Tumeric powder), B – 2g Tumeric/kg basal feed, C – 4g Tumeric/kg basal feed, D – 6g Tumeric/kg basal feed, E – 8g Tumeric/ kg basal feed

The effects of graded levels of Turmeric powder on semen characteristics of West African dwarf bucks are shown in Table 4. There were significant differences ($p<0.05$) in sperm concentration, motility, morphology and progressive motility, but not in live –to-dead ratio. There were significant ($p<0.05$) increases in sperm motility, concentration and morphology with concomitant increase in Turmericpowder in the animal diets.

Table 4: Effects of graded levels of *Curcuma longa* powder on Semen Characteristics of West African Dwarf Bucks

Parameters	**A**	**B**	**C**	**D**	**E**	**± SEM**
Semen colour	Whitish-grey	Whitish-grey	Whitish-grey	Whitish-grey	Whitish-grey	-
Sperm Concentration, million/ml	92.40^{a}	84.00^{b}	79.00^{b}	82.00^{b}	92.40^{a}	1.60
Sperm motility, %	83.72^{ab}	88.66^{a}	84.27^{ab}	82.98^{b}	86.78^{ab}	1.13
Sperm morphology, %	83.72^{c}	90.72^{a}	87.50^{abc}	85.11^{bc}	89.36^{ab}	1.11
Live to Dead Ratio, %	92.70	94.74	89.77	88.17	93.27	1.57
Progressive motility, %	78.00^{ab}	75.00^{b}	77.00^{ab}	79.00^{a}	76.00^{ab}	0.68
Rapidly sluggish, %	89.00^{d}	106.00^{b}	88.00^{d}	96.00^{c}	117.00^{a}	0.76
Extremely sluggish, %	76.00^{d}	95.00^{a}	79.00^{c}	88.00^{b}	96.00^{a}	0.64

a, b, c, d – Means with different superscripts along the same row for each parameter are significantly different ($p<0.05$).SEM – Standard Error of Mean, A – Control (without Tumeric powder), B – 2g Tumeric/kg basal feed, C – 4g Tumeric/kg basal feed, D – 6g Tumeric/kg basal feed, E – 8g Tumeric/ kg basal feed

5. Discussion

Improvement in growth hormone potential of male goats has a great impact on the whole goat breeding industry. Several trials have been conducted to obtain the maximum profit from the male animal via the dietary inclusion of herbal or synthetic supplements. However, in this study dietary supplementation of turmeric powder has no effects on growth hormone of West African dwarf bucks. This observation could be has a result of the inclusion level of the turmeric powder. This findings is consistent with a previous study who reported no significant differences in growth hormones of ram fed dietary levels of papaya powder (Hedia et al., 2019). This result contradicts the findings who reported that high level of Melatonin with eCG improves growth hormones, semen quality and plasma concentrations of melatonin, testosterone gonadotropin and Thyroid stimulating hormone during non-breeding season in Beetal bucks (Abbas et al., 2021). It is noteworthy that livestock production is associated with nutritional and environmental stress, which often compromised health status, reduced immunity and reduced performance of goats. Oxidative stress caused by an imbalance of oxidants and antioxidants is a major stress in intensive goat production (Jimoh, 2022). Antioxidant activity is an important biomarker of physiological, pathological, and nutritional quality of animals. It can be used to demonstrate the effects of nutritional additives in livestock feeds. Turmeric is used as a nutritional supplement in livestock, and the curcumin in turmeric powder is a good antioxidant (Gupta, 2013). Recent studies have evaluated the effect of turmeric powder on blood biochemical parameters and antioxidant capacity of different goat breeds (Gowda et al., 2009 ; Hussein, 2013). However, this research showed that turmeric powder supplementation decreased Cholesterol, and low density lipoprotein (LDL), but increased high density lipoprotein (HDL) at low inclusions. The decrease observed may be due to the presence of vitamin, antioxidant, antibacterial, and anti-inflammatory compounds in turmeric phytogenic compound, which can alleviate the stress load in WAD bucks. Curcuma longa can reduce oxidative stress and control the development of fatty streaks in rabbits (Quiles et al., 2002). Additionally, rabbits fed a diet supplemented with turmeric had reduced lipid peroxides. This results report that 0.05 to 1.0 mg/mL aqueous and ethanol extracts of dried bark of Curcuma longa exhibit anti-superoxide forming activity and are an excellent hepatic enzymatic and non-enzymatic antioxidant (Lin et al., 2003). In addition, it's been reported that administration of turmeric powder (1.66 mg/kg of body weight) to rabbits fed on high fat diet reduces oxidation of erythrocyte, hydroperoxide and thiobarbiutric reactive substance (TBARS) in liver microsomes (Mesa et al., 2003). The level of Triglycerides observed in this study ranged from 7.45 to 11.06 is within the standard range of (6 to 200mg/dL) for goat. This corroborate the work of that turmeric powder stabilizes serum Triglycerides (Lykkesfeldt and Svendsen, 2007). The level of malondialdehyde (MDA) decreased across the treatment, indicating a reduction in oxidative stress and an increase in total antioxidant defense. Generally, turmeric acts as an antioxidant to decrease the harmful effects of free radicals in biological cells (Alexander et al., 2017).

Although the reasons for male infertility are multifaceted, the major cause is hormonal abnormality (Okonofua et al., 2005 ; Chaudhuri et al., 2022). Hormonal abnormality may be caused by the disturbance or suppression of the hypothalamic-pituitary-adrenal axis, which may arise in part from the uncontrolled or excessive use of hormone production inhibitory substances in feed or environmental factors (Chen et al., 2013 ; Sheng et al., 2021). It is known that consumption of the spice is essential for a healthy life due to its anti-oxidative properties (Akharan-Salamat and Ghasemi, 2016 ; Sadeghiand Moghaddam, 2018 ; Gariballa et al., 2021). The result of this research shows the modulating effect and role of turmeric powder in a dose dependant manner.

According tothis study, LH helps to stimulate the leydig cells of the testis to produce testosterone and increase androgen output (Schanbacher, 2011 ; Oduwole, 2021). It is therefore emphasized that LH is the only hormone capable of stimulating testicular steroidogenesis in the absence of the other hormones. According to the report, FSH act on the seminiferous tubules to control spermatogenesis and the growth of androgen dependent accessory reproductive glands as well as support the action of LH on testosterone production (Santi et al., 2020). Turmeric had no effects on testicular steroidogenesis and the seminiferous tubules, and so does not significantly enhance reproductive hormone production at the present level of administration.

The effects of graded levels of *Curcuma longa* on semen quality of West African Dwarf bucks was presented in Table 4. There were significant

($p<0.05$) increases in sperm motility, concentration and morphology with concomitant increase in Turmeric powder in the animal diets.One of the factors that have been reported to affect semen quality is the quality of feed consumed by the animal at a particular time (Ribas-Maynou et al., 2023). This report was corroborated by the significant ($p<0.05$) increases in sperm motility, concentration and morphology with concomitant increase in Turmeric in the animal diets. The result obtained was comparable to the report that administration feed substances or supplement caused significant ($p> 0.05$) increase in sperm concentration, percentage motility, morphology and percentage live sperm produced (Saalu et al., 2013). Although it was inferred that higher dosage of such substances could be deleterious to the testes when administered for a long period. That semen intended to be used for artificial insemination should not have sperm motility less than 60% if high semen quality is required (Silvestre et al., 2004 ; Dcunha et al., 2022). Sperm motility was lowest in the control than any other treatment in this study. The direction of movement of spermatozoa is important in semen evaluation as the percentages of progressive motility have direct effect on fertilizing capacity (Bearden and Fuquay, 1997 ; Bjorndahl, 2010 ; Okukpe, 2024). It could therefore be inferred that Turmericelicitincreased sperm motility which could be due to the flavonoid and ascorbic acid contents of the rhizome. Vitamin C deficient diet is known to reduce sperm motility (Kadir, 2020). According to this study, the semen with less than 80% sperm morphology should not be used for breeding purposes (Tanga et al., 2021). Animals in treatment B (2g Turmeric) had the highest sperm morphology and it can be used for artificial insemination. Semen obtained from other treatments was also of good quality.

The report of the Brazilian College of Animal Reproduction guidelines, showed that goats' semen can display different colors ranging from white to citrine-yellow (CBRA, 1998). All treatments had whitish grey semen color. It shows that the level of Turmeric inclusion in the feed does not have any appreciable effect on semen colour.

In conclusion, the dietary inclusion of Turmeric powder in goat feed is necessary for improved performance in terms of regulating blood lipids and oxidative stress as well as improvement in sperm quality. Although there was no significant effect of turmeric powder diet on growth hormone and reproductive hormone this could be due to the levels added to the basal feed, further study should be done with higher inclusion levels.The best dietary level for improved sperm quality was the 4g turmeric powder to 1kg of basal diet.

REFERENCES

A.O.A.C. 2005. Association of Official Analytical Chemists 20th ed., Pp. 72–73. Washington, DC.

Abbas, M., Khan, M. I.-u.-R., Hameed, N., Rehman, A., Mohsin, I., and Bilal, M. 2021. Melatonin along with eCG improves fresh semen quality and plasma concentrations of melatonin and testosterone during the non-breeding season in Beetal bucks. Small Ruminant Research, 106, 569. https://doi.org/10.1016/j.smallrumres.2021.106569

Abou-Elkhair, R., Ahmed, H. A., and Selim, S. 2014. Effects of black pepper (Piper nigrum), turmeric powder (Curcuma longa) and coriander seeds (Coriandrum sativum) and their combinations as feed additives on growth performance, carcass traits, some blood parameters and humoral immune response of broiler chickens. Asian-Australasian Journal of Animal Sciences, 27(6), Pp. 847–854.

Ahmed-Farid, O. A., Nasr, M., Ahmed, R. F., and Bakeer, R. M. 2017. Beneficial effects of curcumin nano-emulsion on spermatogenesis and reproductive performance in male rats under protein deficient diet model. Journal of Biomedical Science, 24, Pp. 1–14.

Akang, E. N., Opuwari, C. S., Enyioma-Alozie, S., Moungala, L. W., Amatu, T. E., Wada, I., Ogbeche, R. O., Ajayi, O. O., Aderonmu, M. M., Shote, O. B., Akinola, L. A., Ashiru, O. A., and Henkel, R. 2023. Trends in semen parameters of infertile men in South Africa and Nigeria. Scientific Reports, 13(1), 6819. https://doi.org/10.1038/s41598-023-33648-4

Akhavan-Salamat, H., and Ghasemi, H. A. 2016. Alleviation of chronic heat stress in broilers by dietary supplementation of betaine and turmeric rhizome powder. Tropical Animal Health and Production, 48, Pp. 181–188.

Alexander, Y., Yakov, Y., Xiaoyan, X., and Boris, N. 2017. Antioxidant activity of spices and their impact on human health: A review. Antioxidants, 6(70), Pp. 1–18. https://doi.org/10.3390/antiox6030070

Anamthathmakula, P., and Winuthayanon, W. 2020. Mechanism of semen liquefaction and its potential for novel non-hormonal contraception. Biology of Reproduction, 103(2), Pp. 411–426. https://doi.org/10.1093/biolre/ioaa075

Atanasov, A. G., Zotchev, S. B., and Dirsch, V. M. 2021. Natural products in drug discovery: Advances and opportunities. Nature Reviews Drug Discovery, 20, Pp. 200–216. https://doi.org/10.1038/s41573-020-00114-z

Bearden, J., and Fuquay, J. W. 1997. Applied animal reproduction 4th ed., Pp. 158–169. Prentice Hall.

Björndahl, L. 2010. The usefulness and significance of assessing rapidly progressive spermatozoa. Asian Journal of Andrology, 12, Pp. 33–35.

Boroumand, N., Samarghandian, S., and Hashemy, S. I., 2018. Immunomodulatory, anti-inflammatory, and antioxidant effects of curcumin. Journal of Herbal Medicine and Pharmacology, 7, Pp. 211–219.

Brewer, M. S. 2011. Natural antioxidants: Sources, compounds, mechanisms of action, and applications. Comprehensive Reviews in Food Science and Food Safety, 10, Pp. 221–247.

CBRA. 1998. Manual parameter examination of animal semen 2nd ed., Pp. 49.

Chaudhuri, G. R., Das, A., and Kesh, S. B. 2022. Obesity and male infertility: Multifaceted reproductive disruption. Middle East Fertility Society Journal, 27, 8. https://doi.org/10.1186/s43043-022-00099-2

Chen, Y., Zhang, Z., Lin, Y., Lin, H., Li, M., Nie, P., Chen, L., Qiu, J., Lu, Y., Chen, L., Xu, B., Lin, W., Zhang, J., Du, H., Liang, J., and Zhang, Z. 2013.

Dcunha, R., Hussein, R. S., Ananda, H., et al., 2022. Current insights and latest updates in sperm motility. Reproductive Sciences, 29, Pp. 7–25. https://doi.org/10.1007/s43032-020-00408-y

Djaelani, M. A. 2010. Spermatozoa concentration of mice after turmeric rhizome supplementation. Physiological Anatomy, 18(2), Pp. 56–63.

Ferramosca, A., and Zara, V. 2022. Diet and male fertility. International Journal of Molecular Sciences, 23(5), 2542. https://doi.org/10.3390/ijms23052542

Gariballa, S., Al-Bluwi, G. S., and Yasin, J. 2021. Increased fruit and vegetable consumption mitigates oxidative damage. Nutrients, 15(7), 1638. https://doi.org/10.3390/nu15071638

Gowda, N. K., Ledoux, D. R., Rottinghaus, G. E., Bermudez, A. J., and Chen, Y. C. 2009. Antioxidant efficacy of curcuminoids. British Journal of Nutrition, 102, Pp. 1629–1634.

Gupta, S. C., Patchva, S., and Aggarwal, B. B. 2013. Therapeutic roles of curcumin. AAPS Journal, 15(1), Pp. 195–218.

Hedia, M., El-Belely, M., Ismail, S., and El-Maaty, A. M. A. 2019. Monthly changes in testicular blood flow in rams. Theriogenology, 123, Pp. 68–73.

Hewlings, S. J., and Kalman, D. S.m., 2017. Curcumin: A review of its effects on human health. Foods, 6(92).

Hussein, S. N. 2013. Effect of turmeric powder on broilers. Journal of Advanced Biomedical and Pathobiological Research, 3, Pp. 25–32.

Iqbal, M., Sharma, S. D., Okazaki, Y., Fujisawa, M., and Okada, S., 2003. Curcumin supplementation in mice. Pharmacology & Toxicology, 92, 33–38.

Jaradat, N., and Zaid, A. N. 2019. Herbal remedies for infertility. BMC Complementary and Alternative Medicine, 19, 194. https://doi.org/10.1186/s12906-019-2617-2

Jimoh, O. 2022. Oxidative stress in animals. Nigerian Journal of Animal Production, 49, Pp. 67–76.

Kadir, R. E., Ibrahim, A., Ibrahim, B. A., et al., 2020. Bitter leaf improves sperm quality. International Journal of Reproduction & Biomedicine, 18(3), Pp. 215–226.

Lin, C. C., Wu, S. J., Chang, C. H., and Ng, L. T. 2003. Antioxidant activity of Cinnamomum cassia. Phytotherapy Research, 17, Pp. 726–730.

Lykkesfeldt, J., and Svendsen, O. 2007. Oxidative stress in farm animals. Veterinary Journal, 173, Pp. 502–511.

Mesa, M. D., Aguilera, C. M., Ramírez-Tortosa, C. L., et al., 2003. Turmeric extract and membrane oxidation. Nutrition, 19, Pp. 800–804.

Nayaka, H. B. S., Umakantha, B., Ruban, S. W., Murthy, H., and Narayanaswamy, H. D. 2013. Neem, turmeric and vitamin E in broilers. Emirates Journal of Food and Agriculture, 25, Pp. 483–487.

Oduwole, O. O., Huhtaniemi, I. T., and Misrahi, M. 2021. Roles of LH, FSH and testosterone. International Journal of Molecular Sciences, 22(23), 12735.

Ohshiro, I., Kuroyanagi, M., and Keno, M. 1990. Constituents of Curcuma longa. Chemical and Pharmaceutical Bulletin, 38(7), 2020–2022.

Okonofua, F., Menakaya, U., Onemu, S. O., Omo-Aghoja, L. O., and Bergstrom, S. 2005. Risk factors for male infertility in Nigeria. Asian Journal of Andrology, 7, Pp. 351–361.

Okukpe, K. M. 2024. Effects of hMG on dwarf does. Cameroon Journal of Experimental Biology, 18(2), Pp. 91–97.

Okukpe, K. M., Adeloye, A. A., Adeyemi, K. D., et al., 2012. Effects of extender types on ram semen. Asian Journal of Animal Sciences, 6(5), Pp. 249–255.

Okukpe, K. M., Alli, O. I., Olayinka, O. A., et al., 2024. Role of Vernonia amygdalina on spermatogenesis. Current Scientia, 27(2), Pp. 37–45.

Quiles, J. L., Mesa, M. D., Ramírez-Tortosa, C. L., et al., 2002. Curcuma longa reduces oxidative stress in rabbits. Arteriosclerosis, Thrombosis, and Vascular Biology, 22, Pp. 1225–1231.

Ribas-Maynou, J., Barranco, I., and Salas-Huetos, A. 2023. Sperm quality and fertility. Animals, 13(4), 604.

Saalu, L. C., Akunna, G. G., and Ajayi, J. O. 2013. Bitter leaf and testicular function. American Journal of Biochemistry and Molecular Biology, 3, Pp. 314–321.

Sadeghi, A. A., and Moghaddam, M. 2018. Turmeric, cinnamon, ginger and garlic in broiler heat stress. Iranian Journal of Applied Animal Science, 8, Pp. 125–130.

Salmerón-Manzano, E., Garrido-Cardenas, J. A., and Manzano-Agugliaro, F. 2020. Research trends on medicinal plants. International Journal of Environmental Research and Public Health, 17(10), 3376.

Santi, D., Crépieux, P., Reiter, E., et al., 2020. FSH action on spermatogenesis. Journal of Clinical Medicine, 9(4), 1014.

SAS Institute. 2015. JMP/STAT guide to personal computers (Version 11.0.0). SAS Institute.

Schanbacher, B. D. 2011. LH secretion and bovine testis development. Journal of Endocrinology, 88, 393.

Sheng, J. A., Bales, N. J., Myers, S. A., et al., 2020. HPA axis development. Frontiers in Behavioral Neuroscience, 14, Article 601939.

Silvestre, M. A., Salvador, I., and Sanchez, J. P. 2004. Female stimulus and semen collection in goats. Journal of Animal Science, 82, Pp. 1641–1645.

Sitepu, S. A., & Marisa, J. 2019. Membrane integrity of spermatozoa with additives. IOP Conference Series: Earth and Environmental Science, 327, 012027.

Sivakumar, A. V., Singh, G., and Varshney, V. P. 2010. Antioxidants during heat stress in goats. Asian-Australasian Journal of Animal Sciences, 23(11), Pp. 1462–1468.

Sugiharto, S., Yudiarti, T., Isroli, I., et al., 2019. Fermented feed as antioxidants. Agriculturae Conspectus Scientificus, 84, Pp. 313–318.

Tanga, B. M., Qamar, A. Y., Raza, S., et al., 2021. Semen evaluation advancements. Animal Bioscience, 34(8), Pp. 1253–1270.

Tanvir, E. M., Hossen, M. S., Hossain, M. F., et al., 2017. Antioxidant properties of turmeric varieties. Journal of Food Quality, 2017, Article 8471785.

Toghyani, M., Gheisari, A. A., Ghalamkari, G., and Mohammadrezaei, M. 2010. Black seed and peppermint in broilers. Livestock Science, 129, Pp. 173–178.

Van Soest, P. J., Robertson, J. B., and Lewis, B. A. 1991. Dietary fiber methods. Journal of Dairy Science, 74(10), Pp. 3583–3597.

Yan, W., Kanno, C., Oshima, E., et al., 2017. Turmeric supplementation improves rooster sperm. Animal Reproduction Science, 185, Pp. 195–204.