Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Animal Science and Biotechnologies
Open Access

Potentials of Exogenous Melatonin Administration on Growth and Performance of West African Dwarf bucks

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RESEARCH ARTICLE

Abstract

The effect of exogenous melatonin (EM) on growth, physiological and haematological parameters of West African dwarf (WAD) bucks was evaluated in the experiment. Intact selected sixteen WAD bucks were distributed into 4 treatment groups of 0, 3, 6 and 9 mg EM. Bucks were orally dozed with EM 3 times per week for 16 weeks. Blood samples were collected at 0^{th} week, 8^{th} week and 16^{th} week of experiment for evaluation of haematological parameters. Analysis of Variance was carried out and significant means were separated using SAS. Results showed bucks given 6 mg EM had higher average daily weight gain of 31.3 g compared with others. Feed and water intake were similar across treatments, but feed conversion ratio was significantly lower in bucks given 6 mg EM. Values recorded in the morning of data collection days showed pulse and respiratory rates to be significantly different, with bucks given 6 mg of EM having lowest values. 6 mg group was also different for packed cell volume (32.57%), haemoglobin (10.72g/dl), red blood cell (11.38 1012 /L), neutrophil (35.50%) and lymphocyte (64.30%). Therefore, dose of 6 mg/animal EM influences growth performance, physiological and haematological parameters of WAD bucks positively and is therefore recommended for WAD bucks for optimal performance.

Keywords: Exogenous melatonin; performance; West African dwarf goats.

INTRODUCTION

Melatonin – N-acetyl-5methoxytryptamin – a biologically active indole derivative, is a neuro hormone produced by the pineal gland in the brain. An ubiquitously occurring substance found in various foods (milk and milk products, nuts, olive oil, and various fruits) (Binici and Şat, 2021) that affects a vast amount of physiological processes within the body system of a diurnal organism. It activates processes that directly or indirectly dictates the health status of livestock animals. The hormone is released rhythmically depending on the lighting situations (Makowiak et al., 1999). The action of melatonin requires the activity of specific receptors in the brain and peripheral tissues (Vanecek 1998). For instance, the hormone promotes triacylglycerol accumulation via MT_2 receptor during differentiation in bovine intramuscular preadipocytes (Asim, 2020). Melatonin exerts beneficial actions mainly via binding with G-protein-coupled receptors (GPCR), termed MT1 and MT2 (Gao et al., 2022). Therefore, the hormone may act directly or indirectly on many processes affecting the metabolism of the whole

Received: 04 July 2022
Accepted: 03 October 2022
Published: 15 November 2022

DOI:
10.15835/buasvmcn-asb:2022.0005

body. One of the most significant functions of the hormone in livestock is the control of seasonal rhythms. Melatonin has been reported, in many species, to regulate the seasonal cycles of fasting, hibernation, thermoregulation (Vanecek 1998; Skotnicka and Hlynczak, 2001) and reproduction. El-Battawy (2019) reported that melatonin significantly improved sperm motility, reduced dead sperm and improved post-thaw sperm motility. There have been varying reports concerning the effect of the hormone on physiological growth of living organisms. Vriend et al. (1990) observed that melatonin injected in the evening increased concentrations of circulating growth hormone and insulin-like growth factor I (IGF-I) and suppressed insulin-like growth factor 2 receptor (IGF2R)(Minghui et al., 2018). According to Wu et al. (2022) melatonin levels found in blood and milk of Acetylserotonin-O-methyltransferase (ASMT)-overexpressed melatonin-enriched dairy goats successfully generated through the use of pBC1-ASMT expression vector construction and prokaryotic embryo microinjection, were significantly increased with no significant changes detected in the intestinal microbiota patterns in these animals. Also Attanassiou et al. (1986) reported that when melatonin was injected in animals, it exerted an inhibitory effect on growth hormone secretion in rodents. Forsling et al. (1999) reported an increase in circulating growth hormone concentration with higher doses giving similar result which indicates there is probably a maximal dose of melatonin required beyond which there would be no significant change in growth hormone concentration in the body. Growth hormone in mammals is usually secreted during slow wave sleep, however, a direct link between growth hormone and melatonin has been questioned (Jarrett et al., 1990). An animal's environment at any particular time affects the amount of heat exchange between such animal and the environment. Physiological parameters viz-a-viz, pulse rate, respiratory rate and rectal temperature have been identified as an indicator for an organism's adaptability to an environment (Sethi et al., 1994). The range of values such as those reported by Ogebe et al. (1996) has been key in deciding if an animal is in a healthy state or not. Response of individual animals to this standard value is usually affected by fluctuations in the climatic condition of their immediate environment and such changes have a marked impact on the productivity of such animals (Cappa et al., 1991). Exposing farm animals especially males to hot environment will increase respiratory rate and rectal temperature (Spiers et al. 2004 and Avendono- Reyes et al. 2011), temperature of the body surface (Martello et al. 2009) and heart rate (Zahner et al., 2004) which could ultimately affect the breeding ability of such animal. However, Tölü, et al. (2021) reported amelioration of this effect in melatonin treated bucks with positive effects on mating frequency. The haematological profile in goats has also been seen to be generally influenced by several physiological factors (Tambuwal et al., 2002). Significance of such factors has given more insight into the production potentials of domestic farm animals (Opara et al. 2010). Series of studies have been conducted to establish a proper documentation of the haematological indices of indigenous Nigerian goats (Egbe-Nwiyi et al., 2000; Daramola et al., 2005; Addass et al., 2010). The urgent need to improve the production potentials of Nigerian indigenous breeds such as the West African dwarf (WAD) goat, which is readily available in every part of the country, by ensuring improved performance and a balanced haematological profile calls for a novel approach by researchers in bringing forth better practices in animal production. The aim of this study therefore is to determine the effect of oral administration of EM on growing West African dwarf bucks as it affects their growth, performance and haematological profile.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Goat Unit of University Farms, Federal University of Agriculture, Abeokuta, Nigeria between the month of June and December of 2019. The area is situated at latitude 7° 13'N and longitude 3° 26'E (Google Earth, 2019). Its altitude is 76 m above sea level. It is situated in the rain forest of the South-western Nigeria. The mean temperature is between 27 and 28°C. Mean annual rainfall is 1,217.27 mm (Adepitan et al., 2017).

Animals and their management

Intact sixteen WAD bucks of same age and liveweight (7.42±0.29 kg) that have not been used for mating were selected and randomly assigned into four treatment groups (A, B, C and D) in a completely randomized design. There were four animals in each group. Group A was the control group (zero EM), group B received 3 mg EM, group C received 6 mg EM and group D got 9 mg EM. Each group was administered EM 3 times a week (Mondays, Wednesdays and Fridays) in doses of 0, 3, 6, and 9 mg per animal per group. A NatureMade® 3 mg/tablet Melatonin was purchased. Group A receive no tablet. Group B received one tablet (3 mg/animal). Group C received 2 tablets (6 mg/animal) and group D received 3 tablets (9 mg/animal). All tablets were crushed and administered orally (under their tongues). The animals were housed (one animal in each pen and no contact with other animals) in a ventilated pen with slatted floor, equipped with feeding and watering troughs. They were reared intensively and fed a combination of concentrate (composition is shown in Table 1) and chopped *Megathyrsus maximus* (*Panicum maximum)* (composition is shown in Table 2) in a ratio of 50:50 twice daily (08.00 and 16.00). All animals were provided with access to clean fresh water.

Data collection

Live weights of the animals were taken (once per week, every Saturdays before feeding) using electronic scale to monitor weight gain. Daily feed intake was calculated by subtracting quantity leftover from quantity offered in 24 hours. Daily water consumption was also recorded by the difference between quantity given and leftover in 24 hours. Rectal temperature (RT), respiratory rate (RR) and pulse rate (PR) were measured in the morning at 08:00 and afternoon at 14.00 three times per week. Blood samples were collected from each animal at the beginning (0^{th} week), middle (8^{th} week) and end (16^{th} week) of the experiment. Animals were bled between 08:00 and 09:00 on the day of blood collection. Five ml of blood was drawn from each animal through the jugular vein and placed in labelled bottle containing EDTA for haematological analyses. Blood samples were analysed after collection same day in the Department of Animal Physiology Laboratory with Mindray® BC-2800 Vet Auto Hematology Analyzer.

Table 1. Composition of the concentrate

Ingredients	%
Maize	20
Groundnut cake	10
Palm kernel cake	30
Wheat offal	35
Bone meal	2.5
Salt	2.5
Total	100
Calculated nutrients (%)	
Crude protein	17.85
Crude fibre	7.48
Ether extract	4.43
Calcium	1.05
Available phosphorus	0.56
Metabolizable energy (Kcal/Kg)	2257.80

Table 2. Proximate composition of leaf of *Megathyrsus maximus* at Federal University of Agriculture, Abeokuta

Megathyrsus maximus	Composition
Dry matter (per 100 g/dry leaves)	94.71
Crude protein (%)	9.15
Ether extract (%)	6.79
Ash (%)	20.75
Non fibre carbohydrate (%)	15.63

(Jimoh et al., 2015)

Statistical analysis

Data collected were analysed using software (SAS, 2008). Analysis of Variance was carried out and significant means were separated at a level of $P < 0.05$ using Duncan Multiple Range Test in the package.

Statistical model used was: $Y_{ij} = \mu + M_i + \sum_{ij}$,

Y_{ij} = Effect on growth and physiological parameters,

μ = Overall mean,

M_i= the treatment level of EM (I = 0,3,6,9 mg/animal),

$\sum_{ij}$ = Random error.

RESULTS AND DISCUSSIONS

Physiological parameters of WAD bucks administered EM are shown in Table 3. The results showed that rectal temperature was comparable among the treatment groups both in the morning and afternoon. While respiratory rate was similar among treatment groups in the afternoon, animals that received 6 mg melatonin had lower ($P < 0.05$) respiratory rates in the morning. Pulse rate was relatively similar among treatment groups in the morning but animals that received 6 and 9 mg melatonin had lower ($P < 0.05$) pulse rates in the afternoon.

Performance characteristics of WAD bucks administered EM are presented in Table 4. The results showed that average daily weight gain was higher ($P < 0.5$) in animals given 6 mg of melatonin compared to other levels and the control. Total weight gain followed similar pattern. Total weight gain for the duration of the experiment was highest in animals given 6 mg with mean of 3.49 kg while the average daily gain was 31.3 g. Weight gain was lowest in 0 mg bucks with total weight gain of 3.024 kg and average daily weight gain of 27 g.

Table 3. Means (SEM) of physiological parameters of WAD bucks after exogenous melatonin administration

Time of day	Exogenous melatonin (mg/animal)				
Morning	**0**	**3**	**6**	**9**	**SEM**
Rectal temperature (°C)	38.70	38.10	38.20	39.00	0.18
Pulse rate (bpm)	107.00^{ab}	105.00^{b}	97.00^{b}	116.00^{a}	2.30
Respiratory rate (bpm)	43.70^{b}	45.60^{a}	41.30^{c}	43.60^{b}	0.47
Afternoon					
Rectal temperature (°C)	40.40	40.60	40.40	40.40	0.22
Pulse rate (bpm)	115.00^{a}	118.00^{a}	100.00^{b}	101.00^{b}	2.90
Respiratory rate (bpm)	49.00	49.00	51.20	50.00	0.80
Average					
Rectal temperature (°C)	39.72	39.85	39.80	39.94	0.11
Pulse rate (bpm)	110.45a	110.97a	99.43b	108.00a	1.95
Respiratory rate (bpm)	46.23	47.40	46.35	46.74	0.76

Note: ^{abc} Means in the same row with different superscripts differ significantly (P < 0.05)

Table 4. Means (SEM) of performance indices following treatment of WAD bucks with exogenous melatonin

Performance parameters/animal	Exogenous melatonin (mg/animal)				
	0	**3**	**6**	**9**	**SEM**
Total weight gained (kg)	3.02^{c}	3.25^{b}	3.49^{a}	3.29^{b}	45.92
Daily weight gained (g)	27.00^{c}	29.00^{b}	31.30^{a}	29.70^{b}	0.41
Total Feed Intake (kg)	44.89	46.66	45.46	45.48	57.61
Daily feed intake (g)	401.00	417.00	406.00	406.00	5.10
Total Water Intake (L)	134.41	128.01	127.54	128.21	23.12
Daily Water Intake (L)	1.20	1.14	1.14	1.15	20.70
Feed Conversion Ratio	14.90^{a}	14.40^{a}	13.00^{b}	13.70^{ab}	0.25

Note: ^{abc} Means in the same row with different superscripts differ significantly (P < 0.05)

The effect of EM on haematological profile in WAD bucks is represented in Table 5. At the beginning of experiment (before the administration of EM) there was no significant (P > 0.05) difference among the various parameters (Packed cell volume - PCV, Haemoglobin - HB, Red blood cell - RBC, Mean corpuscular volume - MCV, Mean Corpuscular Haemoglobin - MCH, Mean corpuscular haemoglobin concentration - MCHC, White blood cell - WBC, Neutrophil - NEU, Lymphocytes - LYM, Eosinophil - EOS, Basophil - BAS, Monocytes – MONO) studied. At the middle of the experiment however, effect of EM administration was significant (P < 0.05) on all parameters measured except eosinophil, basophil and monocyte. Bucks administered 6 mg EM had the highest values for PCV, HB, RBC and WBC (35.10 %, 11.48g/dl, 12.48 x 10^{12} /L and 13.32x 1012 /L, respectively). Bucks administered 0 mg showed highest value for lymphocyte (74%) with 3 and 9 mg groups having the lowest values of 60.08% and 62.08% respectively. Mean values for neutrophil, eosinophil, basophil and monocyte were insignificant for all treatments. Bucks placed on 9 mg of EM had the lowest values for PCV, HB, RBC, MCV, MCH and WBC (23.10%, 7.55 g/dl, 9.03 x 10^{12} /L, 25.93fL, 8.31 pg and 8.85 x 10^{9} /L respectively). The trend observed at the end of the experiment showed that RBC was significantly (P<0.05) higher in animals administered 0, 3 and 6 mg with values of 38.10, 36.00 and 37.10 x 10^{12} /L respectively. WBC was highest in animals administered 0 mg (12.62 x 10^{9} /L) EM with significant differences for other groups, 3, 6 and 9 mg (11.00 x 10^{9} /L, 9.62 x 10^{9} /L and 7.55 x 10^{9} /L respectively). PCV and MCV were highest in animals given 6 mg with mean values of 37.10% and 33.77fL respectively. PCV value was low for animals given 9 mg with value of 29.10%. Mean values for MCV was seen to be highest in 6 mg (33.77fL) and lowest in 3 mg (28.36fL). MCH values were significant with 0 mg having the highest value (10.94 pg) while 9mg animals had the lowest value (9.29 pg). Animals given 0 and 6 mg EM had similar mean values for monocyte (0.25%) with 9 mg showing the highest value (0.75%). Eosinophil values were also significant with 0 and 9 mg having the highest values of 0.75% while animals given 3 and 6 mg showed similar values as well. Values for RBC, MCHC, neutrophil, lymphocyte and basophil were not significant for all the treatments.

Overall, the experiment showed that animals administered 6 mg to be significant for PCV, HB, and RBC with values of 32.57%, 10.72g/dl, 11.38 x 10^{12} /L respectively. Animals administered 9 mg had the lowest values for PCV, HB, MCV and MCH with values of 25.82%, 8.67 g/dl, 26.16 fL and 8.66 pg respectively. The values for MCHC, WBC, eosinophil, basophil and monocyte were insignificant for all treatment levels.

Table 5. Means (SEM) of haematological profile of WAD bucks following administration of administration of exogenous melatonin (beginning, mid and end)

Haematological parameters	Exogenous melatonin (mg/animal)														
	Beginning					Mid					End				
	0	3	6	9	SEM	0	3	6	9	SEM	0	3	6	9	SEM
PCV (%)	28.25	27.75	25.50	25.25	0.84	29.00^{b}	27.10^{b}	35.10^{a}	23.10^{c}	1.18	38.10^{a}	36.00^{a}	37.10^{a}	29.10^{b}	0.98
HB (g/dl)	9.73	9.13	8.65	8.83	0.59	10.00^{ab}	8.90^{ab}	11.48^{a}	7.55^{b}	0.54	12.63^{a}	12.00^{ab}	12.03^{ab}	9.63^{b}	0.48
RBC (10^{12}/L)	9.86	9.23	10.58	10.78	0.42	9.30^{b}	7.00^{b}	12.48^{a}	9.03^{b}	0.63	11.55	12.80	11.10	10.33	0.44
MCV (fL)	29.91	30.03	24.73	24.02	1.50	31.68^{b}	39.93^{a}	28.39^{b}	25.93^{b}	1.65	33.39^{a}	28.36^{b}	33.77^{a}	28.53^{b}	0.94
MCH (pg)	10.32	9.88	8.40	8.37	0.51	10.77^{b}	12.83^{a}	9.19^{c}	8.31^{d}	0.45	10.94^{a}	9.37^{b}	10.85^{a}	9.29^{b}	0.21
MCHC (g/dl)	33.20	33.32	33.84	33.63	0.22	33.04^{a}	33.91^{a}	33.23^{a}	32.45^{a}	0.57	32.91	33.94	33.13	32.72	0.45
WBC (10^{9}/L)	8.03	9.28	9.33	12.25	0.70	11.20^{b}	10.32^{b}	13.32^{a}	8.85^{c}	0.44	12.62^{a}	11.00^{b}	9.62^{c}	7.55^{d}	0.51
NEU (%)	29.50	34.75	39.50	34.75	1.66	26.00^{c}	40.00^{a}	34.00^{b}	37.00^{b}	1.59	31.00	31.00	33.00	28.00	0.96
LYM (%)	68.75	64.25	59.75	65.00	1.53	74.00^{a}	60.08^{b}	66.08^{ab}	62.08^{b}	1.96	68.08	69.00	67.08	70.08	1.43
EOS (%)	0.00	0.25	0.00	0.25	0.09	0.25	0.25	0.25	0.00	0.10	0.75^{a}	0.00^{b}	0.00^{b}	0.75^{a}	0.13
BAS (%)	0.75	0.00	0.25	0.00	0.11	0.25	0.25	0.25	0.25	0.11	0.25	0.25	0.25	0.25	0.11
MONO (%)	0.75	0.75	0.75	0.00	0.16	0.25	0.00	0.25	0.50	0.11	0.25^{ab}	0.00^{b}	0.25^{ab}	0.75^{a}	0.12

Note: ^{abc} Means in the same row with different superscripts differ significantly ($P < 0.05$)

PCV - Packed cell volume, HB – Haemoglobin, RBC – Red blood cell, MCV - Mean corpuscular volume, MCH - Mean Corpuscular Haemoglobin, MCHC - Mean corpuscular haemoglobin concentration, WBC – White blood cell, NEU – Neutrophil, LYM – Lymphocytes, EOS – Eosinophil, BAS - Basophil, MONO - Monocytes

Melatonin which is known for its strong antioxidant characteristics helped to increase the growth of the animals. Animals given 6 mg dose of EM performed better in terms of total weight gain compared to other doses. An upward trend of growth was noted from the lowest level of administration until after the 6 mg mark where a sharp decline with respect to weight gain was observed. This variability in effect is similar to what was obtained when the effect of varying levels of EM was compared against WAD buck reproductive performance (Daramola et al., 2007). The same treatment also had the highest feed efficiency and the lowest feed conversion ratio which can be likened to the effect of melatonin in establishing the necessary metabolic balance which is changed during food breakdown from the production of free radicals. Supplementing the body with EM would then help to counteract the negative effect of reactive oxygen species, thereby allowing for better metabolism and use of derived nutritional input. Melatonin has been shown to be involved in the regulation of intake of food and digestion in the gut (Bubenik et al., 1999). Huether et al. (1996) also reported that oral administration of L-tryptophan; an amino acid which is the precursor for melatonin synthesis, caused a rapid and dose-dependent rise in circulating melatonin at a level greater than following intraperitoneal administration. Other antioxidants like Vitamin E which also helps improve growth performance with response being dose-dependent (Lin and Chang, 2006). It was observed that weight gain declined in the treatment group that received a higher dose of melatonin. This suggests that a higher dose such as 9 mg melatonin can produce suppressive effect on the hypothalamus production of growth stimulating factors in the animals. This could have resulted in the establishment of a negative feedback that worked for further decrease in growth hormone levels, which subsequently reduced weight gain. Similarly, Duan et al. (2019) observed that melatonin implantation (2 mg/kg live weight) had no influence on daily weight gain, carcass weight, dressing percentage, loin muscle area, moisture level, crude fat (except for Gluteus muscle) and amino acid content of muscles of cashmere goats. Hot or dry season negatively affect goat performance in Nigeria. The most important signs for change in physiological condition in WAD goats are increased body temperature and respiration rate and this can lead to economic loss. This increased body temperature and respiratory rate are associated with significant reduction in feed intake, adjustment in blood flow and negative changes in endocrine functions that affects productive and reproductive performance of our animals (Eltawill et al., 1990). Respiratory rate, pulse number and rectal temperature are the established parameters that illustrate mechanism of physiological adaptation in livestock. In the present experiment, response of the WAD bucks to EM was not significant for rectal temperature and respiratory rate, but the effect was significant for pulse rate with the control treatment having the highest beats per minutes compared to other animals that received EM. Marlena et al. (2000), reported an inhibitory impact of the pineal gland on both release and synthesis of vasopressin suggesting that melatonin may mediate the effect of the pineal gland on vasopressinergic neuron activity. Administration of melatonin may also exert suppressive effects on sympathetic nervous system (Nishiyama et al., 2001). This would inhibit the fight-or-flight response leading to a lower metabolic and physiological activity in the body. It has been reported that melatonin receptors are present in the vasculature making it possible for the hormone to affect the cardiovascular system (Ekmekcioglu et al., 2003). The hormone has also been shown to increase acetylcholine secretion which then leads to reduction in heart rate (Paredes et al., 1999; Bonnie et al., 2009). The effect of EM in the inhibition of the pulse rate of WAD goat can be deduced to be a factor of the pineal hormone modulating cardiac functions. Variations were observed between the times of day on collection of physiological data in this experiment. The rectal temperature and respiratory rates were lower in the morning and significantly higher in the afternoon. Pulse rate however was not significantly affected by EM. Ambient temperature during the experiment was higher in the afternoon compared to the morning where the average for morning temperature and afternoon were 27.9^{o}C and 30.3^{o}C. The finding is similar to the report of Mormede et al. (2007), that environmental factors, including ambient temperature and humidity influence diurnal rhythm of physiological processes. Also, homoeothermic animals such as sheep and goats, maintain their body heat balance by increasing respiration rate (Sezen et al., 2009). This would account for the changes observed in this study for both rectal temperature and respiratory rate in relation to the time of measurement. When physiological mechanisms of the animals are not able to counteract the effect of unnecessary heat load (Saddiqi et al., 2011) especially during the hot dry season rectal temperature increases. Thus, ambient temperature changes influence the heart rate of farm animals (Sleiman and Saab, 1995). Hormonal interaction with blood parameters is an indicator of the physiological condition of the body. The result showed an upward trend in PCV for the various treatments with a decline at higher melatonin level. A high level of PCV as haematocrit showed an increase in the number of circulating red blood cells or a reduction in circulating plasma volume (Kopp and Hetesa, 2000). Seasonal variations also affect the haematocrit level of animals where high temperature results to loss of body fluids. The quality of food given to animals could as well intervene significantly with haematocrit level, especially during malnutrition (Mbassa and Poulsen, 1991; Lhole et al., 1990). The range of values for packed cell volume, haemoglobin and red blood cell count in the study was similar to those reported by Daramola et al. (2005) within 21.0% - 35.0% for PCV, 7 g/dl – 15 g/dl for haemoglobin and 9.2 x 10^6/ml -13.5 x 10^6/ml for RBC respectively. This is possible because the animals were raised intensively and provided with highly nutritious feed under a healthy condition. Animals placed on higher melatonin level in the treatment experienced a lower level of packed cell volume and haemoglobin compared to other treatments. This shows that physiological activities such as erythropoiesis can be influenced depending on the dosage of EM introduced into an organism (Karimungi et al., 1996). The values derived for mean corpuscular volume and mean corpuscular haemoglobin concentration are dependent upon RBC blood cell, haemoglobin and PCV (Etim et al., 2013). White blood cells are the soldiers of the body and when their numbers increase, it may be due to the increase of the complement in the animal's immune system (Aouaidjia et al., 2014). The range of values observed for neutrophils and lymphocyte for bucks given EM implies normal functioning of the immune system since the range of values were similar to those reported by Daramola et al. (2005) for healthy WAD goats. The lymphocytes form the highest component of the WBC counts. It was higher than the neutrophils as reported by Tambuwal et al. (2002) for goats and other ruminants. But it was noted that the control treatment had the lowest neutrophil and highest lymphocyte compared to other treatments even though it was still within the range described by Daramola et al. (2005) (47% – 82% for lymphocyte and 17% – 52% for neutrophil) for healthy goats. According to Adejinmi et al. (2000) high WBC counts is a result of microbial infection, antigen or parasites. High WBC can also be attributed to elevated level of anti-nutritional factors in the diets ingested by goats (Ahamefule et al., 2005). Neutrophils from post-parturient lactating cows with relatively increased blood concentrations of selenium have greater superoxide production and higher capacity to destroy bacteria than those from cows with relatively low blood concentrations of selenium (Cebra et al., 2003). Injecting antioxidants into cows has been found to increase capacity of neutrophils to destroy bacteria (Gyang et al., 1984). Therefore the case for a lower lymphocyte to neutrophil count in treatments administered melatonin could be attributed to reports of melatonin as a potent antiviral, antibiotic and anti-parasitic molecule (Bagnaresi et al., 2012; Srinivasan et al., 2012). Mean Corpuscular Volume (MCV) is a representation of average red blood cell size, Mean Corpuscular Haemoglobin (MCH) is used to tell the haemoglobin count per blood cell , and Mean Corpuscular haemoglobin Concentration (MCHC) is the amount of haemoglobin relative to the size of the cell (haemoglobin concentration) per red blood cell (Bunn, 2011). These Red Blood Cell (RBC) indices are part of a standard complete blood count test. MCV and MCH mean values for this experiment are greater than the values reported by Obua et al. (2012). Animals given 3 mg EM had the highest value for MCV and MCH. Since haemoglobin is known to be the iron-containing oxygen-transport metalloprotein in the RBC (Maton *et al.,* 1993), higher volume of haemoglobin would impact the oxygen-carrying capacity of the blood positively (Tambuwal et al., 2002).

CONCLUSIONS

Exogenous melatonin has a positive impact on weight gain of WAD goats with oral dose of 6 mg/animal, 3 times per week being the most effective. The WAD bucks started showing reduction in weight gain as the dosage of EM increased beyond 6 mg. This places the optimum level of expected EM supplement within the range of 3 – 6 mg. Also this dose of EM administration does not have deleterious effect on the haematological profile of WAD bucks which indicates no health risk whatsoever. Consequently, administration of 6 mg of EM in WAD bucks is both tolerable and beneficial.

Author Contributions: T.J.W. Conceived the project, produced the original draft and the final report; O.I.Y and N.O. Sourced for Funding; I.J.J. and O.A.I. Carried out the investigation and collected data; O.E.O. and J.O.D. Carried out analysis, review and edited the results.

Acknowledgments

The authors are grateful to the Federal University of Agriculture, Abeokuta for providing the animal houses, environment and water.

Conflicts of Interest

The authors declare that there are no conflict of interest in this study.

REFERENCES

1. Addass PA, Midau A, Babale DM. Haemato-biochemical findings of indigenous goats in Mubi, Adamawa State, Nigeria. J Agric Sci., 2010; 6:14-16.
2. Adejinmi JO, Alayande MO, Sadiq NA, Adejinmi OO. Clinical syndrome, haematological and biochemical parameters of goats naturally infested with mange (*Sarcoptes scabie*). Trop Anim Prod Invest. 2000; 3:29-34.
3. Adepitan JO, Falayi EO, Ogunsanwo FO. Confirmation of climate change in Southwestern Nigeria through analysis of rainfall and temperature variations over the region. Cov J Phy Life Sc., 2017; 5 (1), 37-51.
4. Ahamefule FO, Ibeawuchi JA, Ibe SN. Performance of West African Dwarf bucks fed Pigeon pea-cassava peel based diets. J Ani Vet Adv., 2005; 4(12):1010-1015.

5. Aouaidjia N, Cherif A. Ilhem O. Variation of biological markers under hot and cold seasons in goats. Adv Environ Biol. 2014; 8(21), 289-295.
6. Asim F. Role of melatonin in beef animals. Farmer Reformer, a Soc of Crop and Ani Prod. 2020, 5: (3); 5-6
7. Attanassiou A, Bombelli M, Kuzmanovic D, Gupta D. The pineal; influence on growth hormone secretion. Neuro Lets. 1986; 8, 275-282.
8. Avendono-Reyes L, Hernandez-Rivera JA, Alvaraze-Valenzuela FD, Macias-Cruz U, Diaz-Molinar R, Correa-Calderon A, Robinson PH, Fadel JG. Physiological and productive responses of multiparous lactating Holstein cows exposed to short-term cooling during severe summer conditions in an arid region of Mexico. Int J Biomet. 2011; doi: 1007/s00484-011-0510-x.
9. Bagnaresi P, Nakabashi M, Thomas AP, Reiter RJ, Garcia CR. The role of melatonin in parasite biology. Mol Biochem Parasitol. 2012; 181:1-6.
10. Binici HI, Şat IG. Melatonin and Melatonin-Rich Foods. J Inst Sc Tech. 2021; 11(3): 2062-2068. DOI: 10.21597/jist.906094.
11. Bonnie K, Krithika K, Elizabeth M, Larissa S, Rebecca K. Effects of melatonin and ethanol on the heart rate of Daphnia magna (water flea). Impulse: The Prem. J Undergrad Publi Neuro. 2009; 1-8.
12. Bubenik GA, Hacker RR, Brown GM, Bartos L Melatonin concentrations in the luminal fluid, mucosa, and muscularis of the bovine and porcine gastrointestinal tract. J Pin Res. 1999; 26:56-63.
13. Bunn HF. Approach to the anaemias. In: Goldman, L., Schaffer, A. I. eds. Cecil Medicine. 24th ed. Philadelphia, Pa: Saunders Elsevier, 2011; 161.
14. Cappa V, Calamari L, Vazhapilly P, Frazzi E. Effect of high temperature on production and quality of milk. Proceedings of the International Symposium on Animal Husbandry in Warm Climates, 25-27, EAAP. 1991; Pub. No, 55: 93-97.
15. Cebra CK, Heidel JR, Crisman RO. The relationship between endogenous cortisol, blood micronutrients, and neutrophil function in postpartum Holstein cows. J Vet Int Med; 2003; 17:902-907.
16. Daramola JO, Adeloye AA, Fatoba TA, Soladoye AO. Aematological and biochemical parameters for West African Dwarf goats. Live Res Rur Dev. 2005; 17: 8. Retrieved from: http://www.cipav.org.co/lrrd/lrrd 17/8/dara17095.htm.
17. Daramola JO, Adeloye AA, Fatoba TA, Soladoye AO. Induction of puberty in West African Dwarf buck-kids with exogenous melatonin. Live Res Rur Dev. 2007; 19: 9.
18. Egbe-Nwiyi TN, Nwosu SC, Salami HA. Haematological values of apparently healthy sheep and goats as influenced by age and sex in arid zones of Nigeria. Afr J Biomed Res. 2000; 3: 109-115.
19. Ekmekcioglu C, Thalhammer T, Humpeler S, Mehrabi MR, Glogar HD, Hölzenbein T, Markovic O, Leibetseder VJ, StraussBlasche G, Marktl W. The melatonin receptor subtype MT2 is present in the human cardiovascular system. J Pin Res. 2003; 35:40-4.
20. El-Battawy KA. Preservation of goat semen at 5°C with emphasis on its freezability and the impact of melatonin. Int J Vet Sci Res. 2019; 5(2): 035-038. DOI: ttp://dx.doi.org/10.17352/ijvsr.000039
21. Eltawill A, Narendran R. Ewe productivity in four breed of sheep in Saudi Arabia. World Rev Anim Prod. 1990; 25: 93.
22. Etim NN, Enyenihi GE, Williams ME, Udo MD, Offiong EEA. Haematological parameters: indicators of the physiological status of farm animals. Brit J Sc. 2013; 33(1):10.
23. Forsling ML, Wheeler MJ, Williams AJ. The effect of melatonin administration on pituitary hormone secretion in man. Blackwell Science Ltd. Clin Endo., 1999; 51, 637-642.
24. Gao, Y, Zhao S, Zhang Y, Zhang Q. Melatonin receptors: a key mediator in animal reproduction. Vet Sci. 2022, 9, 309. https://doi.org/10.3390/vetsci9070309
25. Google Earth. Retrieved from https://www.google.earth_2019.
26. Gyang EO, Stevens JB, Olson WG. Effects of selenium - vitamin E injection on bovine polymorphonucleated leukocytes phagocytosis and killing of Staphylococcus aureus. Am J Vet Res. 1984; 45: 175-177.
27. Huether G. Melatonin as an anti-ageing drug: between facts and fantasy. Geronto. 1996; 538: 1-9.
28. Jarrett DB, Greenhouse JB, Miewald JM, Fedorka IV, Kupfer DJ. A re-examination of the relationship between growth hormone secretion and slow wave sleep using delta wave analysis. Bio Psych. 1990; 27, 497-509.
29. Jimoh SO, Olanite JA, Mustapha SO, Oladepo O, Amisu AA, Sotimehin OA. 1st Biennial Conference: Society for Grassland Research and Development in Nigeria. Dec. 6-9, 2015; Federal Univ. of Agric. Abeokuta, Nigeria: pp. 83-85.

30. Karimungi MG. Influence of melatonin on blood morphology in male albino mice. Ind J Exp Biol. 1996; 34,758-63.
31. Kopp R, Hetesa J. Changes of Haematological studies in adolescent breeding cocks. Acta Vet Brno., 2000; 69:189-194.
32. Lhole KU, Veter W, Seifert H. Haematological findings in African Dwarf goats of Tanzania and breeds raised in Denmark. Vet Res. 1990; 16:221-29.
33. Lin YF, Chang SJ. Effect of vitamin E on growth performance and immune response of breeder chickens. Asian-Aust J Ani Sc. 2006; 19(6): 884-891.
34. Makowiak P, Bejma E, Przybylska-Darul K. Acute melatonin action on insulin and thyroid hormone blood levels and carbohydrate metabolism in rat. Roczniki Akademii Rolniczej, Poznañ 1999; 51:169-174.
35. Marlena J, Ewa B, Ryszard D. Melatonin and the synthesis of vasopressin in pinealectomized male rats. Exp Bio. Med (Maywood) 2000; 225(3):207-210.
36. Martello LS, Savastano H Jr, Silva, SL Balieiro JCC. Alternative body sites for heat stress measurement in milking cows under tropical conditions and their relationship to thermal discomfort of animals. Int J Biomet. 2009; 54. 647-652.
37. Maton A, Jean H, Charles W, McLaughlin SJ, Maryanna QW, David L, Wright JD. Human biology and health. Englewood Cliffs, New Jersey, USA: Prentice Hall. 1993
38. Mbassa GK, Poulsen JS. Profiles of some clinical chemical reference values in Danish and racai dairy goats (Capra hurcus) of different parity-I: Electrolytes and enzymes. Comp Biochim Physio B. 1991; 100(2):413-422.
39. Minghui Y, Jingli T, Hao W, Lu Z, Yujun Y, Lixi L, Tianqi Z, Hao F, Xudai C, Haoran D, Guoshi L. Responses of transgenic melatonin-enriched goats on lps stimulation and the proteogenomic profiles of their PBMCs. Int J Mol Sci. 2018; 19: 2406-2422; doi:10.3390/ijms19082406.
40. Mormède P, Andanson S, Aupérin B, Beerda B, Guémené D, Malmkvist J, Manteca, X, Manteuffel G, Prunet P, Van Reenen C, Richard S, Veissier I. Exploration of the hypothalamic-pituitary-adrenal function as a tool to evaluate animal welfare. Physiol Behav. 2007; 92(3):317-339.
41. Nishiyama K, Yasue H, Moriyama Y, Tsunoda R, Ogawa H, Yoshimura M, Kugiyama K. Acute effects of melatonin administration on cardiovascular autonomic regulation in healthy men. Ame Hea J., 2001; 141(5):E9.
42. Obua BE, Amaechi N, Osodeke, S. Comparative evaluation of haematological profile of West African Dwarf and Red Sokoto goats reared in humid South-eastern Nigeria. International J. Agric. and Rur. Dev., 2012; 15 (3):1190-1197.
43. Ogebe PO, Ogunmodede BK, McDowell, LR. Behavioural and physiological responses of Nigerian Dwarf goats to seasonal changes of the humid tropics. Small Rum Res. 1996; 22(3):213-217.
44. Opara MN, Udevi N, Okoli IC. Haematological parameters and blood chemistry of apparently healthy West African Dwarf (WAD) goats in Owerri, South-Eastern Nigeria. N Yo Sc J. 2010; 3 (8): 68-72.
45. Paredes D, Rada P, Bonilla E, Gonzalez LE, Parada M, Hernandez L. Melatonin acts on the nucleus accumbens to increase acetylcholine release and modify the motor activity pattern of rats. Bra Res. 2010; 850:14-20.
46. SAS institute, SAS/STAT Guide for Personal Computers 2008; (8th ed) Cary, N.C. SAS Insitute.
47. Saddiqi HA, Nisa M, Mukhtar N, Shahzad MA, Jabbar A, Sarwar M, Documentation of physiological parameters and blood profile in newly born Kajli lambs. Asian-Australasian J Ani Sc. 2011; 24:912-918.
48. Sethi RK, Bharadwaj A, Chopra SC. Effect of heat stress on buffaloes under different shelter strategies. Ind J Ani Sc. 1994:64: pp. 1282-1285.
49. Sezen O, Hasan O, Okan G. Thermo-physiological responses and some growth parameters in kids during the first 45 days under mediterranean climate conditions in Turkey. J Ani Vet Adv. 2009; 8 (6):1237-1241.
50. Skotnicka E, Hłynczak A. Melatonin and its possible role in regulation of water and electrolyte metabolism. Medycyna Wet. 2001; 57:299-303.
51. Sleiman FT, Abi-Saab S. Influence of environment on respiration, heart rate and body temperature of filial crosses compared to local Awassi sheep. Small Rum Res. 1995;16:49-53.
52. Spiers DE, Spain JN, Sampson JD, Rhoads RP. Use of physiological parameters to predict milk yield and feed intake in heat stressed dairy cows. J Therm Biol. 2004; 29:759-764.
53. Srinivasan V, Mohamed M, Kato H. Melatonin in bacterial and viral infections with Focus on sepsis: a review. Recent Pat Endo Metab Imm Dru Discov. 2012; 6: 30-39.

54. Tao Duan, Ziyuan Wu, Huan Zhang, Ying Liu, Yan Li, Wei Zhang. Effects of melatonin implantation on carcass characteristics, meat quality and tissue levels of melatonin and prolactin in Inner Mongolian Cashmere goats. J Ani Sc Biotech. 2019; 10:70-78 https://doi.org/10.1186/s40104-019-0377-y.
55. Tambuwal FM, Agale BM, Bangana A. Haematological and biochemical values of apparently healthy Red Sokoto goats.Proc.27th Annual Conference Nigerian Society of Animal Production (NSAP) 17-21 March, 2002; FUTA, Akure, Nigeria. pp. 50-53.
56. Tölü C, Yazgan N, Akbağ HI. Mating behaviour and hormone profile in melatonin treated goat bucks. J Ani Sc. Prod. (JASP). 2021; 4(2):153-163. DOI: 10.51970/jasp.1019391.
57. Vanecek I. Cellular mechanism of melatonin action. Physio. Rev. 1998; 78: 687-721.
58. Vriend J, Sheppard MS, Borer KT. Melatonin increases growth hormone and insulin-like growth factor I (IGF-I) levels in male Syrian hamsters via hypothalamic neurotransmitters. Gro Dev Ag. 1990; 54: 165-171.
59. Wu H, Xudai C, Shengyu G, Guangdong L, Yujun Y, Haixin W, Jinlong Z, Xiaosheng Z, Tuan Y, Yunxiang L, Zhengxing L, Lu Z, Guoshi L. The improved milk quality and enhanced anti-inflammatory effect in Acetylserotonin-O-methyltransferase (ASMT) overexpressed goats: an association with the elevated endogenous melatonin production. Molecules. 2022; 27: 572-588 https://doi.org/10.3390/molecules27020572.
60. Zahner M, Schrader L, Hauser R, Keck M, Langhans W, Wechsler B. The influence of climatic conditions on physiological and behavioural parameters in dairy cows kept in open stables. Anim Sci. 2004; 78:139-147.