COMPARATIVE STUDIES OF NUTRIENTS INTAKE AND HAEMATO-BIOCHEMICAL INDICES OF BUCKS FED AT THREE DIFFERENT TIMES OF THE DAY

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ABSTRACT

This study objective was to assess the effect of time of feeding on nutrients intake and haemato-biochemical indices of West African dwarf (WAD) bucks. Fifteen bucks with an initial live-weight of 7.50 ± 0.35 kg aged between 8 – 12 months were grouped into three treatments and five replicates for 115 days. The bucks were fed once daily in the morning, noon or evening either at 06:00, 12:00 or 18:00 hour for 90 days respectively under natural light-dark cycles. The experimental diets were Panicum maximum (Guinea grass) and concentrate diets at 50:50 % DM ratio. Serum glucose in evening fed-bucks was significantly higher (p<0.02) than noon and morning-fed buck. Nitrogen retention also increased from dawn to dusk with the morning-fed bucks (64.31 ± 3.79 %) having significantly lowest (p<0.02) value, while evening-fed bucks had the highest (74.73 ± 1.15 %) nitrogen retention. However, time of feeding did not significantly affect (p>0.05) nutrient digestibility, haematological parameters, total protein, lipid profile, and mineral utilization. Feeding animals in the evening or early hours of the morning may be healthy for livestock in a changing climate.

Keywords: Goat, Chrono management, Nitrogen retention, Nutrient digestibility, Haematological parameters, Serum biochemical, Mineral utilization

INTRODUCTION

Various physiological functions, including the feed-fast cycle, hormone secretion and locomotors activity, exhibit circadian rhythms. This time-dependent regulation is driven by internal circadian clocks. These internal clocks are entrained by not only the light-dependent regulation of the suprachiasmatic nucleus (SCN) but also scheduled feeding and scheduled exercise in an SCN-independent manner (Tahara and Shibata, 2013). Circadian misalignment caused by altered feeding time has been reported in livestock (Nikkhah *et al.*, 2011; Niu and Harvatine, 2018; Salfer and Harvatine, 2020). There are evidences that altering the time of feeding affected feed intake, nutrient digestibility and weight gain in steers and dairy cows (Small *et al.*, 2004). Report in cattle indicated that evening feeding decreased total tract dry matter and NDF digestibility in dairy cows fed during summer (Niu and Harvatine, 2018). Nikkhah *et al.* (2011) showed that dry matter, nitrogen and NDF apparent digestibility coefficient were higher in the evening-fed dairy cow than in the morning-fed cows. Nitrogen excretion via faeces and urine decreased in evening-fed cows compared to the

morning-fed cow (Nikkhah, 2012). Hongyantarachai *et al.* (1989) reported that night grazing or night feeding showed better feed digestibility and utilization than day feeding. Studies on mammals have shown that feeding time can cause alteration in the blood profile of mammals (Hussain and Pan, 2015). Reports have shown that food consumption during the normal rest phase increased body weight and glucose intolerance in mammals even if animals ate the same quantity of diet at both the normal feeding time and the wrong feeding time (Jakubowicz *et al.*, 2013; Bailey *et al.*, 2014; de Goede *et al.*, 2018). Despite the evidence of the influence of time of feeding in other mammals, there is scarcity of information on similar study in goats. Therefore, there is need to investigate the influence of time of nutrient delivery on nutrient digestibility and blood profile of goats in order to access its implication on nutrient efficiency and health before such feeding method is recommended.

MATERIALS AND METHODS

Experimental Animal Preparation: Fifteen (15) West African Dwarf (WAD) bucks with an initial live-weight of 7.50 ± 0.35 kg aged between 8 – 12 months procured from Ikeji-Arakeji and Ikirun towns in Osun State, Nigeria were acclimatized for 3 weeks. Goats were managed in accordance to guide used by Adegbeye *et al.* (2021). All goats were medicated with antibiotics 1ml/10kg body weight (BW) Oxytetracycline LA, 1 ml/10kg BW Tylosin and 1ml/10kg BW Penstrep and treated against ectoparasites and endoparasites using Ivermectin injection at the rate of 1ml/kg BW dosages. All bucks were acclimatized for 4 weeks before the start of the experiment. The bucks were housed individually in a 2 x 1 m^2 pen and allowed free access to water and fed diet (Table 1). During the acclimatization, the goats were fed with forages on a cut and carry basis. Fifteen bucks used for the experiment were grouped into three treatments of five replicates and fed for 90 days. During the experiments, the bucks were raised in an experimental pen with wooden slate and the pen was cleaned every two weeks.

Table 1: Chemical composition of experimental diet (g/100g) fed to WAD bucks

Parameters	Concentrate[a]	Grass
Dry matter	86.96	27.91*
Crude protein	10.70	7.81
Crude fibre	15.73	32.55
Carbohydrate	58.98	4.21
Ether extract	3.46	3.39
Ash	13.82	12.50
Acid detergent lignin	16.12	19.99
Acid detergent fibre	30.07	26.55
Neutral detergent fibre	72.03	63.94
Hemicellulose	41.96	37.39
Cellulose	13.95	6.55
Nitrogen free extract	56.30	43.75
Metabolizable energy	2677.58	2119.03
Minerals (mg/kg)		
Na	91.40	41.20
K	234.00	67.00
Ca	210.50	53.60
Mg	197.00	69.00
P	6.25	5.08

**Dry matter of fresh grass, [a]Vitamin A 8,000,000 IU, vitamin D3 17,000,000 IU, vitamin E 5000 mg, vitamin K3 1500 mg, folic acid 200mg, niacin 1500mg, vitamin B2 3000 mg, vitamin B12 5 mg, vitamin B1 1000mg, vitamin B6 1000mg, iron 25,000 mg, manganese 45,000 mg, copper 3000 mg, zinc 35,000 mg, choline chloride 100,000 mg*

After the 90 days feeding trial period, the bucks were transferred to the metabolic cage individually and the same diet were fed throughout the experiment of 14 days and the faecal and urine samples was collected in the last 7 days of the digestibility trial. Samples (faecal and urine) were taken for feed digestibility studies. They were fed once daily either at 06:00 in the morning, 12:00 at noon or 18:00 hours in the evening under the natural light-dark cycle and the left-over feed was removed at 24 hours.

In Vivo Digestibility Trial: *In vivo* digestibility trial of the WAD bucks was carried out in the metabolic cages. The diets offered were *Panicum maximum* Jacq. and concentrate in a 50:50 w/w ratio. The feeding trial experiment lasted 14 days with 7 days for acclimatization and 7 days for faecal and urine collection. The faecal output for each day was weighed and 10 % was collected from the faeces. Urine samples were collected with the aid of the bottles placed under each cage into which 25 % H_2SO_4 was

added to trap the ammonia (Fajemisin *et al.,* 2012). Ten percent (10 %) of the daily urine output was placed in a stopper plastic bottle and stored for four weeks. At the end of the experiment, faecal and urine samples of each day for 7 days were bulked together, and sub-samples were taken for chemical analysis. This result of the chemical composition of the feed, faecal and the urine samples were used to calculate, the nutrient intake, apparent digestibility, nitrogen balance and mineral balance. Apparent digestibility of diet was calculated as the difference between nutrient intake and excretion in the faeces, expressed as a percentage of nutrient intake (Omotoso *et al*., 2019) thus: Apparent digestibility = Nutrient intake – nutrient in faece/ nutrient intake x 100, and Nitrogen balance/retention = Nitrogen intake – (faecal nitrogen + urinary nitrogen).

Serum Biochemistry and Haematology of WAD Bucks: On the last day of the experiment, 10 ml of blood samples were collected from each goat via the jugular vein puncture using sterile 10 ml hypodermic syringes and needles into Vacutainer tubes (Becton Dickinson, Franklin Lakes, New Jersey, USA). Blood sampling from each animal was performed either in the morning, afternoon or evening depending on the feeding time of each animal by veterinarians to minimize stress. Two ml blood samples were collected in ethylenediaminetetraacetic acid (EDTA) bottles and 8ml in non-EDTA bottles for haematological and serum biochemical assay respectively. Haematological parameters such as packed cell volume (PCV), white blood cell (WBC), white blood cell differential counts, red blood cell (RBC), erythrocyte sedimentation rate (ESR) and haemoglobin (Hb) were carried out according to Dacie and Lewis (2001). Mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH) and mean corpuscular volume (MCV) were calculated from RBC, Hb and PCV values using appropriate formulae by Dacie and Lewis (2001). Albumin was determined using the colorimetric bromocresol green method with Clinichem reagent kit (Doumas *et al*., 1971). Globulin was determined using the immune-nephelometric method with Clinichem reagent kit (Dati *et al*., 1989), while total protein was determined using the Buriet method with Clinichem reagent kit (Gornall *et al*., 1949). Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were carried out using colorimetric method with Sigma-Aldrich assay kit (Sigma-Aldrich, 2017a, b). Serum parameters such as glucose was determined using an oxidase/peroxidase system (Trinder, 1969), urea was determined using colorimetric Urease-Berthelot method with Randox kit (Fawcett and Soctt, 1960), creatinine was determined using Colorimetric Method (Bartels *et al*., 1972), alkaline phosphatase (ALP) was determined using the colorimetric method described in Randox kit (DGKC, 1972) Triglyceride was determined using colorimetric method (Fossati and Prencipe, 1982), cholesterol was determined using the colorimetric method described by Kayamori *et al*. (1999) and lipoproteins (HDL and LDL) were determined using the immunoturbidimetric method of a commercial test kit (Randox Laboratories Limited, United Kingdom). All absorbances were measured using a UV Spectrophotometer (SEAC, Florence, Italy).

Chemical and Mineral Analysis: The proximate compositions of feed, faeces and urine samples were analyzed for dry matter (DM) (method ID 930.15), ash (method ID 942.05), nitrogen (N) (Kjeldahl method ID 954.01), ether extract (EE) (method ID 920.39) according to AOAC (1997). The neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analyzed according to Van Soest *et al.* (1991). Hemicellulose was calculated as NDF – ADF, while cellulose was calculated as ADF – ADL. All minerals assay from feed, faeces and urine were carried out using the ash obtained from the chemical analysis. The ashes were diluted with distilled water. Five minerals; sodium (Na), potassium (K), calcium (Ca), magnesium (Mg) and phosphorus (P) were analyzed using the Buck Scientific 210 VGP Atomic Absorption Spectrophotometer (AAS). Metablilzable energy (ME) was calculated according to Pauzenga (1985) = 37 x CP (%) + 81.8 X EE (%) + 35.5

X NFE (%). The minerals were analyzed at different wavelengths such as Na (589.0 nm), K (766.5 nm), Ca (422.7 nm), Mg (285.2 nm) and P (213.6 nm).

Data Analysis: All data collected were subjected to analysis of variance (ANOVA) using SPSS version 23.0 (SPSS, 2015). The differences between treatment means were subjected by Duncan multiple range test of the same statistical package.

RESULTS AND DISCUSSION

Nutrient Intake of WAD Bucks under Different Feeding Regimes: Different feeding time did not significantly affect ($p>0.05$) the dry matter, crude protein, ether extract, crude fibre, ash, nitrogen free extract, acid detergent fibre, neutral detergent fibre, acid detergent fibre, acid detergent lignin, hemicellulose, and cellulose digestibility in WAD bucks (Table 2). However, there was a tendency for the feed intake to increase from dawn to dusk in the animals. This result was in agreement to the study of Schwartzkopf-Genswein *et al.* (2004) and Small *et al.* (2004) who reported improved feed intake in steers fed either in the afternoon or evening. The possible reason for the increased intake may be due to the problem of satiety in evening fed-bucks. Eating at unusual time affects satiety function because satiety is controlled by the circadian clock through expression of leptin; and circadian misalignment via altered feeding time can affect metabolism which might result in increased food intake (Garaulet *et al.,* 2011; Nikkhah *et al.,* 2011).

Nitrogen and Mineral Utilization of WAD Bucks under Different Feeding Regimes: Feeding time had no significant impact ($p>0.05$) on the nitrogen intake, faecal nitrogen output, urine nitrogen output and nitrogen balance in WAD bucks (Table 3). However, the percentage of nitrogen retained by evening-fed bucks (74.73 ± 1.15 %) was higher ($p = 0.02$) than the values observed in the noon (69.38 ± 4.15 %) and morning-fed (64.31 ± 3.79 %) bucks. This pattern showed that evening-fed bucks excrete less nitrogen in their urine compared to morning and noon-fed WAD bucks, while noon-fed bucks excrete the most nitrogen in their faeces and morning-fed bucks excrete the lowest. Notwithstanding, evening-fed bucks retained the highest percentage of nitrogen compared to morning-fed bucks. Time of feeding did not significantly affect ($p>0.05$) mineral intake, faecal and urine mineral output, mineral balance, and percentage mineral retention in WAD bucks (Table 4).

Environmental stewardship is going to be important in the future if sustainable livestock production is to be achieved. This will entail the need to reduce manure excretion of nitrogen due to its contribution to eutrophication. Ruminants do not use nitrogen efficiently, with many of the intake not stored neither are they secreted in saleable production but are mostly excreted with water as urinary nitrogen. Nitrogen that enters the environment may be converted into different forms such as NH_3, NO_3-, N_2O, and organic nitrogen. Therefore, there is need to reduce nitrogen expression in animal manure. Nitrogen retention in evening-fed buck was improved compared to bucks fed in the morning and noon despite the numerically higher nutrient intake. The result of nutrient digestibility in evening-fed bucks was comparable with the results of Robinson *et al.* (1997) and Nikkhah *et al.* (2011) that reported increased nitrogen digestibility in evening-fed dairy cows. Although the reason for increased nitrogen retention is not well known, however, Jeyaraj *et al.* (2012) reported that Krüppel-like factor 15 (Klf15) play an important role in nitrogen homeostasis in mammalian organism and its function can be affected by the time of feeding. It is plausible to suggest that time of feeding improved the function or expression of Klf15 to enhanced nitrogen retention in the body.

Nutrient Digestibility in WAD Bucks under Different Feeding Regimes: The analysed result of the nitrogen digestibility of WAD bucks under different regimes showed significant difference ($p<0.05$) in the percentage nitrogen retention. This may be because of improved nitrogen availability in the rumen for microbial growth (Olorunnisomo, 2010).

Table 2: Nutrient intake (g/day) of WAD bucks under different feeding time

Parameters	Morning	Noon	Evening
Dry Matter	279.62 ± 23.95[a]	300.57 ± 20.75[b]	307.78 ± 30.48[b]
Crude Protein	25.68 ± 1.98	27.26 ± 1.88	28.10 ± 2.19
Crude Fiber	58.83 ± 2.10	66.33 ± 1.11	66.44 ± 3.07
Ether Extract	9.67 ± 0.71	10.36 ± 0.75	10.67 ± 0.52
Ash	37.80 ± 3.04	40.36 ± 2.01	41.45 ± 3.54
Nitrogen Free Extract	147.52 ± 10.98	156.14 ± 11.24	161.06 ± 17.25
Digestibility (%)			
Dry matter	84.17 ± 2.35	86.00 ± 1.67	82.74 ± 1.33
Crude protein	79.01 ± 3.00	80.15 ± 3.06	82.12 ± 1.60
Ether extract	53.63 ± 9.24	59.77 ± 9.68	52.22 ± 9.62
Crude fibre	76.41 ± 5.09	81.44 ± 2.37	81.55 ± 3.48
Ash	72.96 ± 5.26	76.40 ± 4.63	72.86 ± 3.95
Nitrogen free extract	84.28 ± 2.61	84.79 ± 2.46	80.44 ± 3.65
Acid detergent fibre	69.00 ± 14.42	58.98 ± 6.30	64.12 ± 2.97
Neutral detergent fibre	83.62 ± 3.50	84.57 ± 3.03	83.63 ± 1.24
Acid detergent lignin	64.58 ± 18.65	68.69 ± 11.10	65.75 ± 1.17
Hemicellulose	90.00 ± 4.20	95.85 ± 2.32	92.24 ± 1.58
Cellulose	81.51 ± 12.10	41.37 ± 42.23	63.71 ± 9.35

ab: Means with different letter superscript on a row are significantly different (p<0.05)

Table 3: Nitrogen utilization (g/day) of WAD bucks under different feeding time

Parameters	Morning	Noon	Evening
Nitrogen intake	13.51 ± 2.79	17.82 ± 1.92	18.64 ± 4.83
Faecal Nitrogen	2.80 ± 0.47	3.51 ± 0.44	3.38 ± 1.12
Urine Nitrogen	2.01 ± 0.55	1.89 ± 0.62	1.36 ± 0.24
Nitrogen balance	8.70 ± 1.98	12.42 ± 2.09	13.90 ± 3.50
% Nitrogen retention	64.31 ± 1.78[a]	69.38 ± 1.78[b]	74.73 ± 1.78[c]

abc: Means with different letter superscript on a row are significantly different (p<0.05)

Table 4: Mineral utilization (g/day) of WAD bucks under different feeding time

Minerals	Parameters	Morning	Noon	Evening
Sodium	Intake	0.65 ± 0.01	0.86 ± 0.09	0.90 ± 0.23
	Urine	0.13 ± 0.00	0.11 ± 0.00	0.12 ± 0.00
	Faeces	0.06 ± 0.00	0.07 ± 0.00	0.08 ± 0.00
	Balance	0.46 ± 0.10	0.68 ± 0.06	0.71 ± 0.13
	% Retention	71.02 ± 4.22	78.48 ± 2.85	79.77 ± 7.80
Potassium	Intake	1.8 ± 0.3	2.37 ± 0.26	2.48 ± 0.64
	Urine	0.71 ± 0.60	0.26 ± 0.00	0.49 ± 0.20
	Faeces	0.10 ± 0.00	0.14 ± 0.00	0.12 ± 0.00
	Balance	0.99 ± 0.86	1.96 ± 0.20	1.86 ± 0.20
	% Retention	50.68 ± 39.25	82.92 ± 3.85	77.51 ± 13.43
Calcium	Intake	1.42 ± 0.29	1.87 ± 0.20	1.95 ± 0.50
	Urine	0.41 ± 0.20	0.19 ± 0.00	0.30 ± 0.30
	Faeces	0.05 ± 0.00	0.08 ± 0.00	0.05 ± 0.00
	Balance	0.96 ± 0.47	1.60 ± 0.13	1.60 ± 0.26
	% Retention	65.70 ± 21.31	85.93 ± 3.85	84.28 ± 12.70
Magnesium	Intake	1.45 ± 0.29	1.91 ± 0.20	1.99 ± 0.50
	Urine	0.37 ± 0.20	0.20 ± 0.10	0.27 ± 0.20
	Faeces	0.08 ± 0.00	0.10 ± 0.00	0.10 ± 0.00
	Balance	1.00 ± 0.45	1.61 ± 0.13	1.62 ± 0.25
	% Retention	66.99 ± 21.14	84.41 ± 5.38	82.90 ± 10.77
Phosphorus	Intake	0.032 ± 0.00	0.042 ± 0.00	0.044 ± 0.00
	Urine	0.003 ± 0.00	0.004 ± 0.00	0.002 ± 0.00
	Faeces	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
	Balance	0.02 ± 0.00	0.03 ± 0.00	0.03 ± 0.00
	% Retention	72.57 ± 3.22	74.26 ± 4.02	75.22 ± 4.23

Nutrient digestibility is a major determinant of the faecal and urinary excretion in animals and it affects nutrient content in manure, which impacts on the environment. The nutrients receiving the most attention in recent years as pollutants from animal manure are nitrogen (N) and phosphorus (P). The non-significance of time of feeding on nutrient digestibility has been reported by Niu *et al*. (2014) where morning or evening feeding had no impact on organic matter and NDF digestibility.

Haematology and Serum Biochemicals of WAD Bucks under Different Feeding Regimes: The different time of feeding had no significant impact ($p>0.05$) on haematological parameters of the WAD bucks (Table 5). Blood glucose in evening fed-bucks was higher ($P = 0.02$) than morning fed does, while the serum glucose in noon fed bucks was similar to the other feeding time (Table 6). However, the feeding time did not affect ($p>0.05$) serum protein, albumin, globulin, transaminase, aspartate transaminase, alanine phosphatase, triglycerides, cholesterol, high-density lipoprotein and low-density lipoprotein in WAD bucks. Changes in plasma glucose indicate either changes in the rate of gluconeogenesis or rate of plasma glucose clearance, as the ruminant absorbs little glucose (Rottman *et al*., 2014). Blood glucose in evening fed-bucks were higher than morning fed-bucks. Blood glucose concentration obtained in this present study was in the range reported by Yusuf *et al*. (2012) and Babale *et al*. (2019) in evening fed-bucks. Blood glucose is a marker of energy status, and low blood glucose is an indication of utilization of previous meal and indicates lower energy availability in the body (Ciampolini *et al.,* 2010; Gletsu-Miller and McCrory, 2014). Thus, high blood glucose suggests low utilization of previous meal and implies increased energy availability in the body. The SCN regulates whole body insulin sensitivity and glucose tolerance (Stenvers *et al.,* 2019) and misalignment caused by feeding at wrong times of the day will affect insulin sensitivity. Glucose sensitivity is very high in the morning/active phase and the sensitivity increases as the day progresses to evening/inactive phase in a diurnal animal. So, as the bucks were receiving feed at the inactive period of the day, the tissues responsible for insulin mediated glucose uptake especially the muscle - a major site for insulin-mediated glucose uptake increasingly becomes insensitive to insulin resulting in lower blood glucose uptake by muscle cells leading to reduced cell entry of glucose and increased availability of blood glucose (Nikkhah, 2012; Kalsbeek *et al.,* 2014). Glucose intolerance has been observed to occur concurrently with increased melatonin secretion in diurnal animal (Van Cauter *et al.,* 1998). This imply that in morning fed-bucks, the cells were sensitive to insulin leading to higher uptake of available serum glucose, however, at night the insulin insensitivity reduces the rate of glucose clearance. Other serum parameters like protein, albumin and cholesterol were similar to the report of Okonkwo *et al.* (2010), Yusuf *et al.* (2012) and Babale *et al.* (2019). The activities of ALT and AST reflect the integrity of hepatocytes and are often used as indicators of liver injuries/infarction. This is because, when liver damages occur, there is leakage of some of these organ specific enzymes beyond the concentration expected in the blood. Although these enzymes are available in the blood at a level, undue increases could suggest a liver damage especially with ALT enzyme. Our AST and ALT level are lower than those reported by Okpanachi *et al.* (2019), Ogunbosoye *et al*. (2018) and Ibhaze *et al.* (2021). In this result, the AST and ALT levels are within the physiological range expected in healthy West African Dwarf goats, and thus, the goats could be adjudged healthy.

Conclusions: Blood glucose in evening-fed bucks was higher than bucks in other feeding regime. This suggests slow clearance of glucose from the blood. The study showed that efficient nitrogen retention increases from dawn to dusk. This suggests that the time of feeding influences the level of glucose circulation and nitrogen retention. There was no significant difference in the haematological parameters observed in all the feeding regimes, however, those fed in the evening had better PCV, WBC and RBC.

Table 5: Haematological profile of WAD bucks under different feeding time

Parameters	Morning	Noon	Evening
Erythrocyte sedimentation rate (min/hr)	0.40 ± 0.17	0.67 ± 0.29	0.50 ± 0.00
Packed cell volume (%)	25.67 ± 1.16	25.33 ± 2.08	26.00 ± 1.73
Red blood cell (x10^6/mm^3)	9.98 ± 1.14	9.84 ± 2.27	9.99 ± 1.37
White blood cell (x 10^3/mm^3)	2.65 ± 0.09	2.75 ± 0.12	2.61 ± 0.16
Haemoglobin (g/dl)	8.53 ± 0.40	8.43 ± 0.74	8.63 ± 0.58
Mean corpuscular haemoglobin (pg)	8.59 ± 0.65	8.80 ± 1.47	8.69 ± 0.66
Mean corpuscular volume (fl)	25.85 ± 2.01	26.45 ± 4.65	26.18 ± 1.99
Mean corpuscular haemoglobin concentration (%)	33.24 ± 0.08	33.28 ± 0.21	33.21 ± 0.00
Lymphocyte (%)	61.33 ± 1.16	61.67 ± 2.08	61.33 ± 1.16
Neutrophils (%)	26.33 ± 2.52	25.00 ± 1.73	27.00 ± 1.73
Monocytes (%)	8.00 ± 1.00	8.33 ± 1.16	7.67 ± 1.53
Eosinophils (%)	3.67 ± 1.16	4.00 ± 1.00	3.33 ± 0.58
Basophils (%)	0.67 ± 0.58	1.00 ± 0.00	0.67 ±0.58

Table 6: Serum parameter of WAD bucks under different feeding time

Parameters	Morning	Afternoon	Evening
Glucose (mg/dl)	44.10 ± 13.68^a	59.74 ± 3.55^{ab}	72.56 ± 0.44^c
Total Protein (mg/dl)	37.58 ± 15.67	35.65 ± 20.42	41.06 ± 15.22
Albumin (mg/dl)	11.40 ± 0.43	11.41 ± 0.51	11.71 ± 0.09
Globulin (mg/dl)	26.18 ± 15.81	24.24 ± 19.89	29.34 ± 15.29
Alanine aminotransaminase (U/L)	7.67 ± 1.92	8.27 ± 1.79	7.33 ± 0.50
Aspartate aminotransaminase (U/L)	17.17 ± 2.47	22.33 ± 6.79	14.50 ± 5.50
Alkaline phosphatase (U/L)	114.08 ± 26.52	122.36 ± 24.74	109.48 ± 6.95
Creatinine (mg/dl)	28.65 ± 6.62	41.38 ± 22.63	50.30 ± 43.74
Urea (mg/dl)	33.07 ± 22.66	34.32 ± 5.41	37.39 ± 3.36
Triglycerides (mg/dl)	31.03 ± 20.41	26.51 ± 15.29	31.03 ± 10.08
Cholesterol (mg/dl)	101.82 ± 47.46	82.24 ± 24.44	63.15 ± 13.22
High density lipoprotein (mg/dl)	68.98 ± 23.92	79.85 ± 49.59	59.13 ± 49.39
Low density lipoprotein (mg/dl)	26.63 ± 27.86	16.25 ± 21.85	20.37 ± 27.95

abc: means with different letter superscript on a row are significantly different ($p<0.05$)

The AST levels in evening fed-bucks implied no liver infarction/impairment. Based on the findings of this present study, it could be recommended that feeding in the evening is a good feeding management strategy to enhance goats' productivity without compromising the health of the animals.

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REFERENCES

ADEGBEYE, M. J., FAJEMISIN, A. N., ARO, S. O., OMOTOSO, O. B., TOYE, C., ADERIBIGBE, A. M., ELGHANDOUR, M. M. M. Y. and SALEM, A. Z. M. (2021). Impact of varied time of feeding on the lactation and growth performance of West African Dwarf goat. *Tropical Animal Health and Production*, 53: 495. https://doi.org/10.1007/s11250-021-02946-2

AOAC (1997). *Official Methods of Analysis*. 16th Edition, Association of Official Analytical Chemists, Washington, DC, USA.

BABALE, D. M., MILLAM, J. J. and GWORGWOR, Z. (2019). Blood profile and carcass characteristics of WAD goats fed groundnut haulms and cowpea husk supplemented with brewers dried grains. *EC Veterinary Science*, 4(4): 216 – 221.

BAILEY, S. M., UDOH, U. S. and YOUNG, M. E. (2014). Circadian regulation of metabolism. *Journal of Endocrinology,* 222(2): R75 – R96.

BARTELS, H., BÖHMER, M. and HEIERLI, C. (1972). Serum creatinine determination without protein precipitation. *Clinica Chimica Acta,* 37: 193 – 197.

CIAMPOLINI, M., LOVELL-SMITH, D. and SIFONE, M. (2010). Sustained self-regulation of energy intake. Loss of weight in overweight subjects. Maintenance of weight in normal-weight subjects. *Nutrition and Metabolism*, 7: 4. https://doi.org/10.1186/1743-7075-7-4

DACIE, J. V. and LEWIS, S. M. (2001). *Practical Haematology*. 9th Edition, Churchill Livingstone, London.

DATI, F., LAMMERS, M., ADAM, A., SONDAG, D. and STIENEN, L. (1989). Reference values for 18 plasma proteins on the Behring nephelometer system. *Journal of Laboratory Medicine*, 13(3): 87 – 90.

DE GOEDE, P., SEN, S., OOSTERMAN, J. E., FOPPEN, E., JANSEN, R., LA FLEUR, S. E., CHALLET, E. and KALSBEEK, A. (2018). Differential effects of diet composition and timing of feeding behaviour on rat brown adipose tissue and skeletal muscle peripheral clocks. *Neurobiology of Sleep and Circadian Rhythms*, 4: 24 – 33.

DGKC (1972). Optimized standard colorimetric method: serum alkaline phosphatase determination. *Journal of Clinical Chemistry and Clinical Biochemistry*. 10: 182.

DOUMAS, B. T., WATSON, W. A. and BIGGS, H. G. (1971). Albumin standards and the measurement of serum albumin with bromcresol green. *Clinica Chimica Acta*, 31(1): 87 – 96.

FAJEMISIN, A. N., OMOTOSHO, O. B., FADIYIMU, A. A. and SHUAIBU, Y. A. (2012). Nutrient intake and utilization by West African dwarf goat fed cassava peels substituted with *Cajanus cajan* hay. Pages 636 – 639. *In: Agricultural Transformation Strategies and Policies for Livestock Development in Nigeria. ASAN-NIAS Proceedings of the 17th Annual Conference held at the International Conference Centre, Abuja,* September 9th – 13th 2012.

FAWCETT, J. and SCOTT, J. (1960). A rapid and precise method for the determination of urea. *Journal of Clinical Pathology*, 13(2): 156 – 159.

FOSSATI, P. and PRENCIPE, L. (1982). Serum triglycerides determined colorimetrically with an enzyme that produces hydrogen peroxide. *Clinical Chemistry*, 28(10): 2077 – 2080.

GARAULET, M., ORDOVÁS, J. M., GÓMEZ-ABELLÁN, P., MARTÍNEZ, J. A. and MADRID, J. A. (2011). An approximation to the temporal order in endogenous circadian rhythms of genes implicated in human adipose tissue metabolism. *Journal of Cellular Physiology*, 226(8): 2075 – 2080.

GLETSU-MILLER, N. and MCCRORY, M. A. (2014). Modifying eating behaviour: novel approaches for reducing body weight, preventing weight regain, and reducing chronic disease risk. *Advances in Nutrition*, 5(6): 789 – 791.

GORNALL, A. G., BARDAWILL, C. J. and DAVID, M. M. (1949). Determination of serum proteins by means of the biuret reaction. *Journal of Biological Chemistry*, 177(2): 751 – 766.

HONGYANTARACHAI, S., NITHICHAI, G., WONGSUWAN, N., PRASANPANICH, S., SIWICHAI, S., PRATUMSUWAN, S., TASAPANON, T. and WATKIN, B. R. (1989). The effects of grazing versus indoor feeding during the day on milk production in Thailand. *Tropical Grasslands*, 23: 8 – 14.

HUSSAIN, M. M. and PAN, X. (2015). Circadian regulation of macronutrient absorption. *Journal of Biological Rhythms*, 30(6): 459 – 469.

IBHAZE, G. A., OGUNJEMITE, G. E. and FAJEMISIN, A. N. (2021). Blood chemistry of West African dwarf goats fed treated maize cob- and maize husk-based diets with mixture of microorganisms. *Bulletin of Animal Health and Production in Africa*, 45: 63. https://doi.org/10.1186/s42269-021-00519-9

JAKUBOWICZ, D., BARNEA, M., WAINSTEIN, J. and FROY, O. (2013). High caloric intake at breakfast vs. dinner differentially influences weight loss of

overweight and obese women. *Obesity*, 21(12): 2504 – 2512.

JEYARAJ, D., SCHEER, F. A., RIPPERGER, J. A., HALDAR, S. M., LU, Y., PROSDOCIMO, D. A., EAPEN, S. J., EAPEN, B. L., CUI, Y., MAHABELESHWAR, G. H. and LEE, H. G. (2012). Klf15 orchestrates circadian nitrogen homeostasis. *Cell Metabolism*, 15(3): 311 – 323.

KALSBEEK, A., LA FLEUR, S. and FLIERS, E. (2014). Circadian control of glucose metabolism. *Molecular Metabolism*, 3(4): 372 – 383.

KAYAMORI, Y., HATSUYAMA, H., TSUJIOKA, T., NASU, M. and KATAYAMA, Y. (1999). Endpoint colorimetric method for assaying total cholesterol in serum with cholesterol dehydrogenase. *Clinical Chemistry*, 45(12): 2158 – 2163.

MCCOMB, R. B., BOWERS, G. N. and POSEN, S. (1979). *Alkaline Phosphatase*. Plenum Press, New York.

NIKKHAH, A. (2012). Timing of feed presentation entrains periprandial rhythms of energy metabolism indicators in once-daily fed lactating cows. *Biological Rhythm Research*, 43(6): 651 – 661.

NIKKHAH, A., FUREDI, C. J., KENNEDY, A. D., SCOTT, S. L., WITTENBERG, K. M., CROW, G. H. and PLAIZIER, J. C. (2011). Morning vs. evening feed delivery for lactating dairy cows. *Canadian Journal of Animal Science*, 91(1): 113 – 122.

NIU, M. and HARVATINE, K. J. (2018). The effects of morning compared with evening feed delivery in lactating dairy cows during the summer. *Journal Dairy Science,* 101(1): 396 – 400.

NIU, M., YING, Y., BARTELL, P. A. and HARVATINE, K. J. (2014). The effects of feeding time on milk production, total-tract digestibility, and daily rhythms of feeding behaviour and plasma metabolites and hormones in dairy cows. *Journal of Dairy Science,* 97(12): 7764 – 7776.

OGUNBOSOYE, D. O., AKINFEMI, A. and AJAYI, D. A. (2018). Blood profiles of West African dwarf (WAD) growing bucks fed varying levels of shea nut cake based rations in Nigeria. *Cogent Food and Agriculture*, 4(1): 1474620. https://doi.org/10.1080/23311932.2018.1474620

OKONKWO, J. C., OMEJE, I. S., OKONKWO, I. F. and UMEGHALU, I. C. E. (2010). Effects of breed, sex, and source within breed on the blood bilirubin, cholesterol, and glucose concentrations of Nigerian goats. *Pakistan Journal of Nutrition,* 9(2): 120 – 124.

OKPANACHI, U., OKPANACHI, G. A. C., KAYE, J., AGU, C. I. and ODAH, E. O. (2019). Haematological profile and serum biochemistry of West African dwarf goats fed sun-dried yellow cashew pulp based diets. *Journal of Applied Sciences*, 19(4): 319 – 324.

OLORUNNISOMO, O. A. (2010). Nutritive value of conserved maize, amaranth, or maize-amaranth mixture as dry season fodder for growing West African dwarf sheep. *Livestock Research for Rural Development,* 22: 191. http://www.lrrd.org/lrrd22/10/olor22191.htm

OMOTOSO, O. B., ARILEKOLASI, T. A. and FAJEMISIN, A. N. (2019). Study on mineral, antinutrient and blood parameters of goats fed molasses treated rice husk. *Journal of Food, Nutrition and Agriculture*, 2(1): 10 – 19.

PAUZENGA, U. (1985). Feeding parent stock. *Zootecnica International*, 17: 22 – 24.

ROBINSON, P. H., GILL, M. and KENNELLY, J. J. (1997). Influence of time of feeding a protein meal on ruminal fermentation and fore stomach digestion in dairy cows. *Journal of Dairy Science*, 80(7): 1366 – 1373.

ROTTMAN, L. W., YING, Y., ZHOU, K., BARTELL, P. A. and HARVATINE, K. J. (2014). The daily rhythm of milk synthesis is dependent on the timing of feed intake in dairy cows. *Physiological Reports*, 2(6): e12049. https://doi.org/10.14814/phy2.12049

SALFER, I. J. and HARVATINE, K. J. (2020). Night-restricted feeding of dairy cows modifies daily rhythms of feed intake,

milk synthesis and plasma metabolites compared to day-restricted feeding. *British Journal of Nutrition,* 123(8): 849 – 858.

SCHWARTZKOPF-GENSWEIN, K. S., BEAUCHEMIN, K. A., MCALLISTER, T. A., GIBB, D. J., STREETER, M. and KENNEDY, A. D. (2004). Effect of feed delivery fluctuations and feeding time on ruminal acidosis, growth performance, and feeding behavior of feedlot cattle. *Journal of Animal Science*, 82(11): 3357 – 3365.

SIGMA-ALDRICH (2017a). *Alanine Aminotransferase Activity Assay Kit. Catalog Number MAK052, Technical Bulletin.* Sigma-Aldrich, St. Louis, USA. https://www.sigmaaldrich.com/deepweb/assets /sigmaaldrich/product/documents/731/802/mak052bul.pdf

SIGMA-ALDRICH (2017b). *Aspartate Aminotransferase (AST) Activity Assay Kit. Catalog Number MAK055, Technical Bulletin.* Sigma-Aldrich, St. Louis, USA. https://www.sigmaaldrich.com/deepweb/assets/sigmaaldrich/product/documents/911/845/mak055bul.pdf

SMALL, J. A., KENNEDY, A. D., VEIRA, D. M., MCCAUGHEY, W. P. and WARD, D. R. (2004). Time of feeding and growth promotant effects on the winter growth performance and carcass traits of steers. *Canadian Journal of Animal Science*, 84(1): 133 – 144.

SPSS (2015). *IBM SPSS Scientist Statistics for Windows, Version 23.0.* IBM SPSS Corporation, Armonk, New York, USA.

STENVERS, D. J., SCHEER, F. A., SCHRAUWEN, P., LA FLEUR, S. E. and KALSBEEK, A. (2019). Circadian clocks and insulin resistance. *Nature Reviews Endocrinology*, 15(2): 75 – 89.

TAHARA, Y. and SHIBATA, S. (2013). Chronobiology and nutrition. *Neuroscience,* 253: 78 – 88.

TRINDER, P. (1969). Determination of blood glucose using an oxidase-peroxidase system with a non-carcinogenic chromogen. *Journal of Clinical Pathology*, 22(2): 158 – 161.

VAN CAUTER, E., MORENO-REYES, R., AKSEKI, E., L'HERMITE-BALÉRIAUX, M., HIRSCHFELD, U., LEPROULT, R. and COPINSCHI, G. (1998). Rapid phase advance of the 24-h melatonin profile in response to afternoon dark exposure. *American Journal of Physiology-Endocrinology and Metabolism*, 275(1): E48 – E54.

VAN SOEST, P. V., ROBERTSON, J. B. and LEWIS, B. (1991). Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, 74(10): 3583 – 3597.

YUSUF, A. O., OYEBANJI, O. A., YUSUF, D. A., EKUNSEITAN, K. A., ADELEYE, O. S., SOWANDE, O. S. and FASAE, O. A. (2012). Blood profile of West African dwarf goats fed *Panicum maximum* supplemented with *Newbouldia laevis* leaves. *Bulletin of Animal Health and Production in Africa*, 60(4): 481 – 490.