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BLOOD PROFILE OF WEST AFRICAN DWARF DOES FED MICROBIAL TREATED BAMBARA NUTSHELL

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ABSTRACT: *A study was conducted using twenty-one (21) West African Dwarf (WAD) goats with an average weight of 10.50± 0.36 kg to evaluate the blood profile of WAD goats fed microbial treated Bambara nutshell diets. The goats were allotted seven dietary treatments with three replicated per treatment in a completely randomized design. The Bambara nutshells underwent sterilization for 15 minutes, were inoculated with 25, 50, and 75ml of Pleurotus pulmonaris and Aspergillus niger, incubated for 7 days, air-dried, and then integrated into the diets, diet A (control), diet B, C, D (25ml, 50ml 75ml Pleurotus pulmonaris) and E, F, G (25ml, 50ml, 75ml Aspergillus niger). Blood was collected from each animal via the jugular vein into bottles containing anticoagulant and without anticoagulant for the measurement of hematological and serum biochemical indices respectively. The study lasted for 63 days. Results showed that the proximate compositions were significantly influenced (p>0.05). Results showed that the blood parameters were significantly (p<0.05) influenced by the diet. Does fed diet C had the highest packed cell volume (35.00 %), hemoglobin (11.97 %) and lymphocytes (47.67%). The serum biochemical parameters also indicated that, total protein (20.09g/l) was highest in diet C. The albumin (4.27g/l) was higher in animals fed diet G, while the serum enzymes alanine aminotransferase (5.40 iu/l) and aspartate aminotransferase (22.83 iu/l) were least in animals fed diet F and G respectively. Conclusively, microbial treatment of Bambara nutshell does not have adverse effects on the goat's health status.*

KEYWORDS: West African Dwarf (WAD) goat, *Pleurotus pulmonaris, Aspergillus niger*, Bambara nutshell, Haematology, Serum biochemical.

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INTRODUCTION

The primary challenge faced by the livestock industry in Nigeria has been ensuring a consistent supply of sustainable animal protein. In the tropics, there is a documented low intake of animal protein, attributed to the elevated costs of livestock products. This rise in costs is primarily driven by the rapid increase in the prices of conventional feed ingredients, as noted by Sobayo *et al*. (2013). During the dry season, feed becomes scarce as most of the grasses are dried up, low in nutritive value and are not suitable for production (Abdurrahaman, 2017). Ibe (2000) reported that animal protein stands as a crucial component in human diets, with consumption patterns varying across countries (Okai *et al*., 2005), and the deficiency in this protein can be addressed through engaging in small ruminant production, such as sheep and goats. Nonetheless, nutrition significantly influences the overall health of a goat flock, as highlighted by Alokan (2008). Given their multifunctional nature, goats possess the capability to effectively utilize forages and agro-industrial by-products as feeds (Aye & Adegun, 2010) and are probably the most efficient converters of plants into muscles because their digestive system can utilize cellulose and fibrous materials and even non-protein nitrogen. Therefore, the prospect of sustaining nations and ensuring their food security in the future hinges on the improved utilization of wastes and agro-industrial byproducts, which are abundantly available and currently not directly consumed by humans (Fajemisin *et al*., 2014; Ogunjemite & Ibhaze, 2020). Among these agro-industrial by-products, the Bambara nutshell shows promise but has yet to be fully employed in ruminant feeding.

The Bambara nutshell, a by-product of the Bambara nut (*Vigna subterranea* (L.) Verdc), comprises 6.7% crude protein, 3.9% ash, 47.6% neutral detergent fiber, and 29.8% acid detergent fiber (Ibrahim *et al*., 2022). Despite its constraints, the Bambara nutshell holds potential for recycling and utilization as a valuable source of lignocellulosic biomass for animals when subjected to fungal treatment. As outlined by Esonu *et al*. (2001), the biochemical components in the blood serve as indicators of the physiological reactions of animals to both internal and external factors, encompassing their diet and nutritional intake. Blood functions as a diagnostic mirror, revealing the health condition of an animal in response to toxins and various environmental conditions. Additionally, it aids in identifying the presence or absence of diseases and assessing the nature and progression of a disease process, be it static, progressive, or regressive (Olafadehan *et al*., 2014). Hence, this study was designed to evaluate the dietary effects of microbial treated Bambara nutshell meal on the blood profiles of West African Dwarf goats.

MATERIALS AND METHODS

Experiment Site: The experiment was carried out at the Sheep and Goat Unit of the Teaching and Research Farm of the Federal University of Technology, Akure, Ondo State, Nigeria. Akure is located on longitude 4.944055o E and 5.82864o E, and latitude 7.491780oN with annual rainfall ranging between 1300 and 1650 mm and annual daily temperature ranging between 270 and 38o C (Daniel, 2015).

Collection and Preparation of Experimental Diets: Bambara nutshell was collected from farmers in Okene in Kogi State. One thousand (1000) grams of sun-dried Bambara nutshell was moistened with one liter of water and was sterilized in the autoclave at a temperature of 121^{o}C for15 minutes to eliminate microbial contamination of the Bambara nut shell. The

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Bambara nutshell was allowed to cool at room temperature (25^{o}c) and was inoculated with 25mls, 50mls and 75mls (*Pleurotus pulmonaris a*nd *aspergillus niger)*. Thereafter, they were sun-dried for some days based on the intensity of the sun. The concentrate was formulated with crushed cassava-peel, wheat offal, urea, palm kernel cake (PKC), microbial treated Bambara nutshell, bone meal, premix and salt were mixed manually. Seven experimental diets with varying levels of microbial treated Bambara nutshell were formulated as shown in Table 1.

Experimental Layout and Animal Management: Twenty-one WAD goats (does) of about 1-1$^{1/2}$ years were bought at open market in Akure and Itaogbolu with average weight of 10.50 ± 0.36 kg, and were randomly assigned to seven dietary treatments of three replicate per treatment in a Completely Randomized Design. Animals were housed in individual pens and offered fresh clean water. Prior to the commencement of the experiment, the WAD goats were vaccinated against PPR disease and treated against ecto-parasites. The goats were given daily ration at 5% of their body weight. The feeding trial lasted for 56 days excluding the 2 weeks of adaptation. All animals were cared for and managed according to the ethical approval and guidelines of NENT (National Ethics Committee for Animal Experimentation) (2016).

Data and Sample Collection: 5ml blood sample was obtained from each goat through jugular vein puncture (Frandson, 1986) at the conclusion of the experiment. These blood samples were collected in sterilized Ethylene Diaminetetra Acetate Acid (EDTA) bottles to prevent coagulation for hematological analysis (Opara *et al*., 2010). The blood samples, placed in EDTA bottles, underwent analysis for parameters such as Packed Cell Volume (PCV), White Blood Cell (WBC), Red Blood Cell (RBC), and Hemoglobin (Hb), following the procedure outlined by Byanet *et al*. (2008). Simultaneously, an additional 5 ml blood sample was collected in bottles without EDTA for the analysis of serum biochemical indices, including Total Protein, Albumin, Triglyceride, Alanine Aminotransferase (ALT), Serum Aspartate Aminotransferase (AST), and Alkaline Phosphatase (ALP), employing the methods described by Cork and Halliwell (2019) and Opara *et al*. (2010). Globulin was determined by calculating the difference between total protein and albumin.

Chemical Composition of Diets

Chemical analyses (proximate, fiber fractions) were carried out on the experimental diets, according to AOAC (Association of Official Analytical Collaboration) (2002), AOAC (2012), Van Soest *et al.* (1991) and Makkar *et al.* (1996) procedures. The fiber fractions measured were Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) and were determined according to Van Soest *et al.* (1991). Hemicellulose was calculated as the difference between NDF and ADF and cellulose as the differences between ADF and ADL. While the metabolizable energy (ME) will be calculated as follows: ME (kcal/kg DM) = (37 × %CP) + (81.8 × %NFE) (Pauzenga, 1985).

Analytical Procedures: All data collected were subjected to One Way Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS, 2017) and the means were separated using Duncan Multiple Range Test of the same statistical package. Significant means were accepted at $P < 0.05$.

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RESULT

Chemical composition (%) of the experimental diets containing Bambara nut shell treated with *Pleurotus pulmonarius* and *Aspergillus niger*

Table 1: Chemical composition (%) of the experimental diets containing Bambara nut shell treated with *Pleurotus pulmonarius* and *Aspergillus niger*

Parameters	A	B	C	D	E	F	G	±SEM	p-value
Dry matter	94.13^{a}	94.07^{a}	92.33^{b}	93.47^{ab}	92.56^{b}	94.77^{a}	93.41^{ab}	0.30	0.019
Crude protein	19.65	19.19	19.53	19.78	19.20	20.33	19.16	0.26	0.287
Crude fibre	16.76^{cd}	17.93^{c}	21.29^{a}	16.00^{d}	16.43^{d}	19.58^{b}	11.86^{c}	0.47	0.001
Ether extract	14.14^{a}	11.54^{b}	10.60^{b}	10.25^{bc}	12.77^{b}	14.59^{a}	9.52^{d}	0.40	0.001
Ash	9.29^{c}	11.53^{a}	10.55^{b}	10.47^{b}	10.17^{b}	11.75^{a}	11.86^{a}	0.25	0.001
NFE	34.31^{c}	38.69^{b}	30.37^{d}	36.98^{b}	37.99^{b}	37.43^{b}	42.03^{a}	0.52	0.001
NDF	43.00^{b}	41.00^{b}	51.00^{a}	38.00^{bc}	40.00^{bc}	45.00^{ab}	33.00^{c}	1.90	0.003
ADF	34.00^{bc}	38.00^{ab}	44.00^{a}	30.00^{bc}	32.00^{bc}	37.00^{ab}	27.00^{c}	2.14	0.008
ADL	18.50^{b}	18.25^{b}	15.00^{c}	18.50^{b}	20.75^{a}	19.75^{ab}	14.00^{c}	0.56	0.001
Hemicellulose	9.00^{a}	3.00^{b}	7.00^{a}	8.00^{a}	8.00^{a}	8.00^{a}	6.00^{ab}	0.91	0.038
Cellulose	15.50^{b}	19.75^{b}	29.00^{a}	11.50^{b}	11.25^{b}	17.25^{b}	13.00^{b}	2.25	0.003
ME(Kcal/kg)	3061.82^{a}	2596.07^{cd}	2628.59^{cd}	2843.19^{b}	2738.03^{bc}	2505.40^{d}	2858.84^{b}	42.04	0.001

^{abc} = means within the same row with different superscripts are significantly different (P<0.05). ADF= Acid detergent fiber; NDF= Neutral detergent fiber; ADL= Acid detergent lignin; NFE= Nitrogen free extract; ME = Metabolisable energy, A = untreated Bambara shell B = 25 ml *Pleurotus pulmonaris* C = 50 ml *Pleurotus pulmonaris* D = 75 ml *Pleurotus pulmonaris* E = 25 ml *Aspergillus niger* F = 50 ml *Aspergillus niger* G = 75 ml *Aspergillus niger*

The chemical composition of experimental diets containing varying levels of Bambara shell treated with *Aspergillus niger* and *Pleurotus pulmonaris* is shown in Table 1. Most parameters assessed were significantly influenced by the treatment (p<0.05), except for crude protein. Diet F had the highest dry matter content (94.77%), while diet C had the lowest (92.33%). The highest crude protein content was in diet F (20.33%), and the lowest was in diet G (19.16%). Diet C exhibited the highest crude fiber content (21.19%) and the lowest was in diet G (11.86%). The highest ether extract content was in diet A (14.14%), with the lowest in diet F (5.69%). Nitrogen-free extract and ash content were highest in diet G (42.03%, 11.86%) and lowest in diets C and A (30.37%, 9.29%), respectively. Diet C had the highest acid detergent fiber (ADF, 44.00%) and neutral detergent fiber (NDF, 51.00%) values, while diet G had the lowest ADF and NDF values (27.00%, 33.00%). Diet E had the highest acid detergent lignin content (20.75%), and diet G had the lowest (14.00%). The highest cellulose content was found in diet C (29.00%) and the lowest in diet E (11.25%). The highest hemicellulose content was observed in diet A (9.00%) and the lowest in diet G (6.00%).

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Nutrient intake (g/day) of WAD does fed diets containing Bambara nut shell treated with *Pleurotus pulmonarius* and *Aspergillus niger*

Table 2: Nutrient intake (g/day) of WAD does fed diets containing Bambara nut shell treated with *Pleurotus pulmonaris* and *Aspergillus niger*

Parameters	A	B	C	D	E	F	G	±SEM	p-value
Dry matter	619.88^{b}	597.29^{b}	642.03^{a}	663.64^{a}	579.10^{b}	613.56^{a}	570.27^{ab}	24.40	0.033
Crude protein	122.53^{a}	114.27^{a}	125.37^{a}	130.44^{a}	112.00^{ab}	124.72^{a}	109.24^{ab}	4.71	0.013
Crude fibre	99.13^{bc}	107.36^{b}	136.67^{a}	111.18^{b}	108.45^{b}	120.00^{ab}	67.56^{d}	4.92	0.001
Ether extract	63.73^{b}	40.38^{c}	68.09^{b}	93.79^{a}	51.76^{c}	34.89^{c}	48.66^{c}	3.86	0.001
Ash	64.87^{a}	68.92^{a}	67.74^{a}	61.60^{a}	60.58^{b}	72.10^{a}	67.67^{a}	3.11	0.011
NFE	229.31^{ab}	230.86^{ab}	194.93^{bc}	227.67^{ab}	212.21^{c}	229.75^{ab}	239.44^{a}	9.53	0.033
NDF	235.39^{bc}	247.47^{bc}	327.36^{a}	285.27^{ab}	220.29^{bc}	276.64^{ab}	187.85^{c}	16.28	0.003
ADF	185.45^{bc}	229.92^{ab}	282.50^{a}	225.58^{ab}	213.82^{ab}	227.41^{ab}	152.96^{c}	16.23	0.004
ADL	114.80^{a}	109.47^{a}	96.22^{ab}	122.82^{a}	107.52^{a}	121.28^{a}	79.84^{b}	7.36	0.024
Hemicellulose	49.93^{a}	17.55^{b}	44.86^{a}	59.70^{a}	48.52^{a}	49.24^{a}	34.89^{ab}	6.65	0.041
Cellulose	70.65^{bc}	120.46^{b}	186.27^{a}	102.76^{bc}	117.84^{bc}	106.13^{bc}	73.13^{bc}	14.38	0.002

^{abc} = means within the same row with different superscripts are significantly different (P<0.05). ADF= Acid detergent fiber; NDF= Neutral detergent fiber; ADL= Acid detergent lignin; NFE= Nitrogen free extract; A = untreated Bambara shell B = 25 ml *Pleurotus pulmonaris* C = 50 ml *Pleurotus pulmonaris* D = 75 ml *Pleurotus pulmonaris* E = 25 ml *Aspergillus niger* F = 50 ml *Aspergillus niger* G = 75 ml *Aspergillus niger*

Table 2 shows that nutrient intake of does fed Bambara shell treated with *Pleurotus pulmonaris* and *Aspergillus niger* at graded levels was significantly (p<0.05) influenced by the treatment. Dry matter intake ranged from 570.27 g/day to 663.63 g/day, with the highest intake in Does fed diet D and the lowest in those fed diet E. Crude protein intake also varied significantly, being highest in diet D (130.44 g/day) and lowest in diet G (109.24 g/day). Crude fibre intake was highest in diet C (136.67 g/day) and lowest in diet G (67.56 g/day). The highest ether extract intake was in diet D (93.79 g/day) and the lowest in diet F (34.89 g/day). Ash intake was highest in diet F (72.10 g/day) and lowest in diet E (60.58 g/day). Nitrogen-free extract intake was highest in diet G (239.44 g/day) and lowest in diet C (194.93 g/day). Neutral detergent fibre intake was highest in diet C (327.36 g/day) and lowest in diet G (187.85 g/day). Acid detergent fibre intake was highest in diet C (282.50 g/day) and lowest in diet A (185.45 g/day). The highest acid detergent lignin intake was in diet D (122.82 g/day) and the lowest in diet G (79.84 g/day). Cellulose intake was highest in diet C (186.27 g/day) and lowest in diet G (73.13 g/day). Hemicellulose intake was highest in diet D (59.70 g/day) and lowest in diet B (17.55 g/day).

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Hematological indices of WAD does fed containing Bambara nut shell treated with *Pleurotus pulmonarius* and *Aspergillus niger*

Table 3: Hematological indices of WAD does fed containing Bambara nut shell treated with *Pleurotus pulmonaris* and *Aspergillus niger*

Parameters	A	B	C	D	E	F	G	Reference	±SEM	P-value
ESR (mm/hr)	0.93[a]	0.91[a]	0.73[b]	0.73[b]	0.70[b]	0.70[b]	0.71[b]	0.5-15mm/hr	1.52	0.00
PCV (%)	28.00[b]	29.67[ab]	35.00[a]	29.33[ab]	33.00[ab]	28.33[b]	31.00[b]	25.6-36.8 %	1.49	0.01
RBC ($x10^6\mu l$)	5.63	4.57	5.17	5.23	6.87	3.97	4.57	8.0 – 18.0 ($x10^6ul$)	0.85	0.50
WBC ($x10^3\mu l$)	10.73	8.90	9.70	10.67	6.77	7.90	7.27	3.7 – 14 ($x10^3ul$)	1.54	0.50
Haemoglobin (%)	9.30[b]	9.80[b]	11.97[a]	10.07[b]	11.20[ab]	9.73[b]	10.33[ab]	9.2 – 14.2(g/dl)	0.51	0.06
Lymphocytes (%)	45.10[b]	45.09[b]	47.67[a]	34.67[c]	32.67[c]	45.00[b]	28.67[d]	45.6-70.4 (%)	6.68	0.04
Monocytes (%)	0.33[b]	0.65[ab]	0.32[b]	0.25[c]	0.14[d]	1.33[a]	0.21[c]	0.6-2.44 (%)	0.30	0.02
Neutrophils (%)	54.67[c]	56.00[c]	51.00[d]	64.67[b]	63.67[bc]	51.67[d]	74.67[a]	28.3-50.6(%)	6.18	0.01
Eosinophil (%)	2.00[a]	1.33[ab]	1.00[d]	1.09[bc]	1.10[bc]	2.00[a]	1.33[ab]	1.42-4.54(%)	0.01	0.03
Basophils (%)	1.00	1.32	1.28	1.21	1.20	1.23	1.20	0.00-0.20 (%)	0.21	0.68
MCV (m^3)	5.38	6.64	6.77	5.88	5.09	7.96	10.11	15.7-20.1 (fl)	1.61	0.70
MCH (pg)	1.79	2.20	2.30	2.01	1.73	2.73	3.37	5.33-7.68 (pg)	0.55	0.70
MCHC (%)	33.22	33.03	34.21	34.29	34.07	34.32	33.33	29.5-44 (%)	0.81	0.80

[abc]= means significant ($p<0.05$) difference between rows; PCV = Packed cell volume; WBC = White blood cell, RBC = Red blood cell, MCV=Mean corpuscular volume, MCH= Mean corpuscular haemoglobin, MCHC= Mean corpuscular haemoglobin concentration, ESR= erythrocyte sedimentation rate.; A = untreated Bambara shell B = 25 ml *Pleurotus pulmonaris* C = 50 ml *Pleurotus pulmonaris* D = 75 ml *Pleurotus pulmonaris* E = 25 ml *Aspergillus niger* F = 50 ml *Aspergillus niger* G = 75 ml *Aspergillus niger.*

Table 3 show the haematological characteristics of does fed experimental diets, revealing significant (P<0.05) influences on most indices except for MCV, MCH, MCHC, RBC, and WBC. ESR values were highest in does fed diet A (0.93 mm/hr) and lowest in diets E and F (0.70 mm/hr). PCV values ranged from 28.00% (diet A) to 35.00% (diet C). RBC count ranged from 3.97 x 10^6 µl (diet F) to 6.87 x 10^6 µl (diet E). WBC count varied from 6.77 x 10^3 µl to 10.73 x 10^3 µl, with diet E showing the least and diet A the highest count. Hb content ranged from 9.30 g/dl to 11.97 g/dl, with diet A having the lowest and diet C the highest. Lymphocytes ranged from 28.67% to 47.67%, lowest in diet G and highest in diet C. Neutrophils ranged from 51.00% to 74.67%, lowest in diet C and highest in diet G. Monocytes ranged from 0.14% (diet E) to 1.33% (diet F). Eosinophils ranged from 1.00% (diet C) to 2.00% (diets A and F). Basophils were lowest in diet A (1.00%) and highest in diet B (1.32%). MCV and MCH were higher in diet A (10.11 m^3 and 3.37 pg respectively) compared to diet E (5.09 m^3 and 1.73 pg respectively). MCHC ranged from 33.03% to 34.32%, with diet F having the highest and diet B the lowest values.

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Serum biochemistry of WAD does fed diets containing Bambara nut shell treated with *Pleurotus pulmonarius* and *Aspergillus niger*

Table 4: Serum biochemistry of WAD does fed diets containing Bambara nut shell treated with *Pleurotus pulmonaris* and *Aspergillus niger*

Parameters	A	B	C	D	E	F	G	Reference	±SEM	P-value
Protein	17.57^{ab}	16.32^{b}	20.09^{a}	17.45^{ab}	19.43^{ab}	19.22^{ab}	19.07^{ab}	5.90-7.80 (g/dl)	0.77	0.01
Albumin	4.01^{a}	4.04^{a}	3.43^{b}	4.10^{a}	3.87^{ab}	3.85^{ab}	4.27^{a}	2.45-4.35(g/dl)	0.10	0.03
Globulin	13.56^{bc}	12.28^{c}	16.66^{a}	13.35^{ab}	15.56^{ab}	15.37^{ab}	14.80^{b}	14.80-28.50 (g/dl)	0.86	0.02
A:G	0.30	0.33	0.21	0.31	0.26	0.25	0.29	-	0.03	0.12
AST	23.13^{b}	27.87^{b}	48.50^{a}	33.67^{b}	31.33^{b}	27.33^{b}	22.83^{b}	12-122 (IU/liter)	2.49	0.00
ALT	11.10	11.23	10.77	8.47	8.93	5.40	7.40	0.5-47(IU/liter)	1.62	0.26
ALP	45.59^{c}	48.34^{bc}	58.62^{a}	50.58^{bc}	53.73^{ab}	45.63^{bc}	44.52^{c}	45.0-125(IU/liter)	0.89	0.00

^{abc} =Means in rows with different superscript indicates significant difference (p<0.05); AST = Aspartate aminotransferase, A:G = Albumin globulin ratio; ALT= Alanine aminotransferase, ALP=Alkaline phosphatase. A = untreated Bambara shell B = 25 ml *Pleurotus pulmonaris* C = 50 ml *Pleurotus pulmonaris* D = 75 ml *Pleurotus pulmonaris* E = 25 ml *Aspergillus niger* F = 50 ml *Aspergillus niger* G = 75 ml *Aspergillus niger*

The analysis of blood chemistry, detailed in Table 4, revealed a significant influence ($p < 0.05$) of the dietary treatments on most parameters, except for Alanine aminotransferase (ALT). Total protein levels were highest in does fed diet C (20.09 mg/dl) and lowest in those fed diet B (16.32 mg/dl). Interestingly, albumin levels were highest in does fed diet G (4.27 mg/dl) but lowest in those fed diet C (3.43 mg/dl). Similarly, the highest globulin level (16.66 mg/dl) was observed in does fed diet C, while the lowest (12.28 mg/dl) was found in does fed diet B. Examining liver enzymes, ALT values ranged from 5.40 u/l (diet F) to 11.23 u/l (diet B), while Aspartate aminotransferase (AST) levels ranged from 22.83 u/l (diet G) to 48.50 u/l (diet C). Alkaline Phosphatase (ALP) levels were highest in does fed diet C (58.62 u/l) and lowest in those fed diet G (44.52 u/l).

DISCUSSION

Chemical composition (%) of the experimental diets containing Bambara nut shell treated with *Pleurotus pulmonarius* and *Aspergillus niger*

The dry matter (DM) content varied across the diets, with Diet F having the highest value (94.77 ± 0.13%) and Diet C containing the least (92.33 ± 0.21%). The high DM content observed in the diets can be attributed to the inherent dryness of the feedstuffs and the values reported in this study align with the findings of 94.55% reported by Olagunju *et al*. (2013) for fungus (*Lachnocladium spp*.) fermented corncobs and Mohammed and Mhya (2021) for Bambara groundnut varieties grown in Northeastern Nigeria.

All diets exceeded the recommended minimum crude protein (CP) level of 7% for ruminant animals (McDonald *et al*., 2002). Notably, Diet F displayed the highest CP content (20.33 ± 0.10%) similar to those recorded (19.73 - 28.88%) by Fajemisin *et al*. (2018) and this can be possibly attributable to an increase in fungal biomass, as suggested by de Vries *et al*. (2007). The trend observed for crude fiber content showed a gradual increase from Diet A (16.76 ± 0.27%) to Diet C (21.29 ± 0.08%). This rise can be attributed to the fungi's ability to secrete

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hydrolyzing and oxidizing enzymes, facilitating the breakdown of complex compounds into usable forms, as reported by Akinyele *et al*. (2017). The ash content values (ranging from 9.29 ± 0.30% to 11.86 ± 0.06%) favorably compared to those reported in other studies (11.29 – 19.84%) by Omotoso *et al*. (2019). Neutral detergent fiber (NDF) content varied between diets, with Diet C having the lowest amount (51.00 ± 0.58%) and Diet G containing the highest (33.00 ± 0.58%). This variation might be linked to the lignocellulose content of the respective diets. These values favorably compare to the findings of Belewu *et al*. (2003).

Our study revealed lower acid detergent fiber (ADF) and lignin values compared to those reported by Belewu and Fagbcmi (2007) in their investigation using Aspergillus-treated cassava waste-based diets. This finding aligns with the observation by Belewu *et al*. (2003) that fermentation, particularly with fungi possessing cellulase enzymes capable of degrading lignocellulose, generally reduces or breaks down cellulose bonds within crude fiber content of crop residues. The nitrogen-free extract (NFE) values (30.37 ± 0.19% – 42.03 ± 0.37%) were consistent with the results reported by Omotoso *et al*. (2019) in their study on West African dwarf goats fed molasses-treated rice husk.

Interestingly, the diets containing *Aspergillus niger*-treated Bambara nutshell exhibited higher ash content. This observation may be attributed to the enzymatic activities of *A. niger*, potentially causing the release of minerals bound within the plant material, thereby increasing the overall ash content in the treated diets.

Nutrient intake (g/day) of WAD Does fed diets containing Bambara nut shell treated with *Pleurotus pulmonarius* and *Aspergillus niger*

The dry matter intake (DMI) observed in this study (Table 3) was significantly influenced ($p<0.05$) by the microbial-treated Bambara nutshell. This effect can be attributed to the protein quality, palatability, and acceptability of the experimental diets. This finding aligns with Ahamefule *et al*. (2006), who reported that higher crude protein (CP) levels stimulate DMI. It also agrees with Ventura *et al*. (1975), who found that nutrient intake increases as DMI and CP concentration improve. However, the average voluntary DMI values of the goats exceeded the 3.5% of body weight recommended for small ruminants by McDonald *et al*. (2002).

Interestingly, this finding diverged from Fajemisin *et al*. (2018), who found no significant effect of *P. pulmonarius-treated* cocoa bean shell meal on DMI in WAD goats. Notably, CP intake varied across diets, with some diets meeting or exceeding the recommended minimum of 41.50 g/day for goats (NRC, 1981). The CP intake reported in this study was higher than the 76.26 – 83.2 g/day reported by Ahamefule *et al*. (2006) for WAD bucks fed a pigeon pea-cassava peel-based diet. These values were also higher compared to some previous studies, including those by Fajemisin *et al*. (2018), but closely matched the findings of Belewu *et al*. (2003), who evaluated West African dwarf goats fed graded levels of Aspergillus-treated rice husk.

The noticeable increase in both CP and DMI can be attributed to the significant degradation of the Bambara nutshell facilitated by fungal treatment, enhancing nutrient availability. The ether extract (EE) intake was highest in goats fed Diet D (93.79 ± 1.32 g/day), likely due to the higher fat/oil concentration in the diet. Maia *et al*. (2012) reported an increase in EE intake in sheep fed oils. EE represents the fat portion of the diet and serves as a source of energy for goats, suggesting more energy is available for metabolic processes. This higher EE intake did not show any deleterious effect on the animals.

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Additionally, goats showed increased consumption of crude fiber and ether extract, likely due to the specific nutritional composition of the diets. Furthermore, intake values for acid detergent fiber, lignin, cellulose, and hemicellulose surpassed those reported by Belewu and Yahaya (2008), potentially due to the improved CP quality resulting from the fungal treatment.

Hematological indices of WAD does fed containing Bambara nut shell treated with *Pleurotus pulmonarius* and *Aspergillus niger*

Evaluating the blood parameters of animals is a valuable tool for diagnosing pathological stresses, nutritional disorders, and environmental influences (Etim *et al*., 2014). The erythrocyte sedimentation rate (ESR) values obtained for the diets were comparable, suggesting that the diets did not induce acute general infections. Packed Cell Volume (PCV) serves as an indicator of toxicity in feed samples (Ahamefule, 2005), and a decrease in PCV concentration indicates potentially harmful factors (Anya *et al*., 2018). PCV is crucial for transporting oxygen and nutrients in the blood (Etim, 2015), and low PCV levels suggest inadequate dietary protein quality and possible anemia (Ademola, 2015). In this study, the observed PCV values imply good-quality dietary protein.

Hemoglobin (Hb) and PCV were higher in animals fed microbial-treated Bambara nut haulms compared to those fed the control diet. High hemoglobin levels are beneficial as they improve oxygen-carrying capacity (Daramola *et al*., 2005). The Hb and PCV values, ranging from 9.30 g/dl to 11.97 g/dl and 28.00% to 35.00%, respectively, fall within the normal ranges (7 g/dl – 15 g/dl and 21% – 35%) reported by Daramola *et al*. (2005), indicating that the goats are not anemic. The presence of microbes may have affected the anti-nutritional factors of Bambara nut haulms. Total white blood cell (TWBC) counts were within the normal range (6.8 x10^3/ml – 20.1 x10^3/ml for goats (Daramola *et al*., 2005), indicating that the diets were safe for the goats. An abnormally high white blood cell count suggests infection (Drees *et al*., 2012), which was not observed in the experimental does. However, the red blood cell count was below the normal range (9.2 x10^6/ml – 13.5 x10^6/ml) reported by Daramola *et al*. (2005), suggesting anemia and high parasitic burden.

Lymphocyte values fell within the range of 47-82%, as reported by Daramola *et al*. (2005), Tambuwal *et al*. (2002), and Anya *et al*. (2018), indicating adequate protection against infections. Neutrophil, basophil, and monocyte values were within the recommended ranges for healthy goats (Tambuwal *et al*., 2002). Eosinophil values, within the normal range of 1-8% (Plumb, 2009; Fadiyimu *et al*., 2010), indicated no allergic reactions from the diets. Furthermore, the recorded values for MCV, MCH, and MCHC were consistent with those reported for goats by Plumb (1999).

Serum biochemistry of WAD does fed diets containing Bambara nut shell treated with *Pleurotus pulmonaris* and *Aspergillus niger*

The trial observed serum total protein levels ranging from 16.32 to 20.09 g/l significantly influenced ($p<0.05$) by the treatment. These values were higher than the normal range of 6.3 to 8.5 g/100ml reported for WAD goats (Daramola *et al*., 2005). Diet C showed the highest serum total protein levels (20.09 g/l), aligning with findings by Opara *et al*. (2010) and Ileyemi (2017). Elevated total protein values suggest the diet contains sufficient crude protein, indicating quality protein in the experimental diet (Aletor *et al*., 1998). Albumin levels, which help accelerate blood clotting during injuries, fell within the normal range of 2.8 to 4.3 g/100ml

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for healthy goats (Daramola *et al*., 2005). The elevated albumin levels observed suggest an enhanced blood clotting ability, reducing the risk of hemorrhage (Paar *et al*., 2017).

Globulin concentrations ranged from 12.28 g/L to 16.66 g/L, consistent with the 1.6 - 16 g/L range reported for WAD goats (Daramola *et al*., 2005). This indicates that microbial-treated Bambara nutshell can enhance immunity in goats, providing better defense against infections. No mortality was recorded during the experimental period, highlighting the beneficial effects on immunity (Fulks *et al*., 2014). No significant differences were observed. A low A:G ratio can indicate liver problems or inflammation. Aspartate aminotransferase (AST) values fell within the normal range (12 IU/L – 38 IU/L) reported by Daramola *et al*. (2005), while alkaline phosphatase (ALP) values were higher than those reported by the same authors. Variations could be due to differences in feed collection, blood sample handling, genetic factors, environmental conditions, sex, and age of the animals (Omotoso *et al*., 2019).

Alanine aminotransferase (ALT) values showed no significant influence ($p>0.05$) from the dietary treatment but were within the normal range reported for WAD sheep and goats by Daramola *et al*. (2005) and Ileyemi (2017). These values also compared favorably with those reported by Omotoso and Fajemisin (2020), indicating no evidence of liver or cellular dysfunction. The ALT values observed align with the normal range (0-30 U/L) reported by Ileyemi (2017) for ruminants and the range (2-22 U/L) reported by Daramola *et al*. (2005) for healthy goats.

CONCLUSION

From the study it can be concluded that Bambara nut shells treated with *Pleurotus pulmonarius* might lead to increased total protein, potentially indicating improved health. Bambara nut shells treated with *Aspergillus niger*, on the other hand, showed lower levels of liver enzymes in some groups, hinting at a possible protective effect. However, some conflicting results, such as decreased albumin in the *Pleurotus pulmonarius* group, warrant further investigation. Overall, this study provides a starting point for exploring the potential benefits of these fungi for goat health, but more research is needed to determine optimal dosages and long-term effects.

COMPETING INTERESTS

Authors have declared that no competing interest exists.

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