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Blood chemistry of West African dwarf goats fed treated maize cob- and maize husk-based diets with mixture of microorganisms

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Abstract

Background: Twenty-four West African Dwarf (WAD) goats with average weight of 6.57 ± 0.56 kg were used in investigating the effect of microbial-treated maize cob and husk diets on blood profile. The goats were assigned to six dietary treatments replicated four times in a completely randomized design. Chopped maize cobs and husks were sterilized for 60 min to eliminate any form of contamination and then inoculated with mixture of 15 ml each of *Lactobacillus delbrueckii* and *Neurospora crassa* and incubated anaerobically for 5 days and then air-dried. The treated maize cob and husk were incorporated in the diets at the rate of 0% (diet), 20% (diet B), 30% (diet C) [maize cob diets], and 0% (diet D), 20% (diet E), 30% (diet F) [maize husk diets], respectively. The animals were acclimatized for two weeks while the experimental period lasted for 56 days. A completely randomized design was adopted.

Results: The results showed that the dietary treatments significantly ($P < 0.05$) influenced the erythrocyte sedimentation rate which ranged from 0.50 to 1.00 mm/hr. Significant ($P < 0.05$) differences were observed in the globulin (28.16 g/dl diet A—59.26 g/dl diet B), aspartate aminotransferase (48.00 u/l diet E—128. 25 u/l diet C) and alanine aminotransferase (8.20 u/l diet A—33.33 u/l diet D). Serum electrolytes values were significantly ($P < 0.05$) influenced by dietary treatments.

Conclusion: Based on the findings of this study, microbial-treated maize cob and husk diets supported erythropoiesis did not induce any liver damage and the serum electrolytes of the animals were improved. Hence, microbial-treated maize cob and husk can be a suitable alternative feed source at 30% incorporation in a complete diet for WAD goats as adverse implications on the health of the animals was not observed.

Keywords: Blood, Serum electrolytes, *Lactobacillus delbrueckii*, Maize cob, Maize husk, *Neurospora crassa*, WAD goats

Background

The dry periods of the year are the major constraining time for ruminants to fully express their potentials and maintain good health status. This situation has become a serious global concern which has necessitated the search for sustainable alternative measures. The use of Agricultural by-products had seemed to be the closest intervention in circumventing this situation. Among such agricultural by-products are maize cob, husk and stover which are obtained during the processing of harvested maize. These feed resources have generally been directed to ruminant production due to their available roughage but are limited by their low protein content. To resolve this problem, fermentation process by bacteria, fungi, and yeast has been applied for increasing the nutrition values of the substrates (Danmek et al. 2014). Also, Sharma and Arora (2011) reported the use of fungal inoculums for the fermentation of agricultural residues in order to improve the nutrition values of substrates. During solid-state fermentation (SSF), the increased nutrition values were due to bioconversion of substrate that had been degraded by fungal enzymes

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(Thana et al. 2019). Maize cob contains 5.22% protein, anti-nutrients, such as saponin (2.09%), tannin (0.03%) and phytate (0.72%) (Ukanwoko and Nwachukwu 2017), cellulose (27.71%) and hemicellulose (38.78%) but also contain a significant amount of lignin (9.4%) (Shinners et al. 2007), calcium (17.19 mg/100 g), potassium (375.25 mg/100 g), sodium (129.19 mg/100 g) (Ababubakar et al. 2016) and antioxidant activity of 0.3–10 µmol/gdw (Nawaz et al. 2018). Maize husk is the leafy outer covering of an ear of maize (corn) as it grows on the plant (Wikipedia 2020). It constitutes 33.15% cellulose, Lignin (4.91%) and hemicellulose of 44.67% (Danmek et al. 2014), total phenolic compounds of 1.62–14.77 g, 1.48–2.05 g flavonoids, 0.45–3.63 g carotenoid and antioxidant activity of 11.85% (Nawaz et al. 2018), potassium (31.14 mg/g), calcium (61.74 mg/g), manganese (0.10 mg/g) (Duru 2020). Physical, enzymatic and chemical treatments are commonly employed in the improvement of agricultural—by products but there is paucity of information on biological treatment of these by-products. *Neurospora crassa* is non-toxic, it is traditionally used for food production in South East Asia, and is considered to be safe for food and technical applications (Perkins and Davis 2000). The filamentous fungal species is commonly found on carbohydrate-rich foodstuffs and residues of sugarcane processing (Kuo et al. 2014). It has the capability to produce and secrete heterologous proteins and all of these features point to a high but so far untapped potential of this fungus for biotechnological applications (Havlik et al. 2017). *Lactobacillus delbrueckii* is a rod shaped, gram positive, and non-motile bacterium. It has the ability to ferment sugar substrates into lactic acid products under anaerobic conditions (Penetrante 2010). It is anaerobic, does not form spores, also non-pathogenic and it is regarded as aciduric or acidophilic since it requires a low pH (around 5.4–4.6) to grow effectively (Prescott et al. 1996).

Blood elements are good pointers of the physiological and health status of individuals and can be used to predict health deviations caused by various factors. Blood functions basically in carrying nutrients, oxygen and waste excretory products to and from various cells and organs of the body (Ogbu and Herbert 2018). Okoruwa and Ikhimioya (2014) also opined that blood is used in assessing the ability of the body to respond to haematological and serum biochemical upset. However, the blood parameters could vary due to factors, such as age, sex, breed, feeding level, diurnal and seasonal variation, physiological status of animals and temperature (Mbassa and Poulsen 2003). The thrust of this study was to evaluate the influence of feeding fungi and bacteria mixture-treated maize cob and husk diets on the blood elements of West African dwarf goats.

Methods

Study site

The experiment was carried out at the small ruminant unit of the Teaching and Research Farm of the Federal University of Technology, Akure, Ondo State, Nigeria. Akure is located on longitude 4.944055°E and 5.82864°E, and latitude 7.491780°N with annual rainfall ranging between 1300 and 1650 mm and annual daily temperature ranging between 27 and 38 °C (Daniel 2015).

Collection and preparation of experimental diets

Maize cobs and husks were collected at various farmlands in Akure, Ondo State, sun-dried for 3 days to reduce the moisture content. The cob was crushed at the feed mill to about 1 mm particle size, while the husk was chopped to smaller size. One kilogram each of maize cob and husk meal, respectively, was moistened with water at ratio 1:1 (w/v). The moistened maize cob and husk were sterilized for 60 min according to the procedure of Aro et al. (2008) to eliminate microbial contamination of the cob and husk thereafter were allowed to cool and were inoculated with mixture of 15 ml each of *N. crassa* and *Lactobacillus delbrueckii.* The microbial-treated maize cobs and husks were fermented for five days. Thereafter, they were sun-dried for some days based on the intensity of the sun and were incorporated into the complete diets at the rate of 0% (diet A), 20% (diet B), 30% (diet C) [maize cob meal diets], and 0% (diet D), 20% (diet E), 30% (diet F) [maize husk diets]. Other ingredients were added to make the complete diets as shown in Table 1.

Experimental layout and animal management

Twenty-four (24) WAD bucks of about 6 to 7 months of average weight of 6.57 kg ± 0.56 were randomly assigned to six dietary treatments of four replicate per treatment in a Completely Randomized Design. The goats weights were balanced for weight and were placed in individual pens. The animals were fed the experimental diets for 56 days excluding the 2 weeks of adaptation at 3% of their body weight alongside *Panicum maximum* serving as the basal diet. All animals were cared for and managed according to the ethical approval and guidelines of NENT (2016).

Data and sample collection

At the end of the 56th day of the trial, three animals from each treatment were randomly selected and 10mls blood sample was collected via the jugular vein (Frandson 1986) and shared into 5mls each in different sterilized specimen bottles containing anti-coagulant for haematological

Table 1 Gross composition of treated maize cob- and maize husk-based diets with mixture of microorganisms

Ingredients	Maize cob			Maize husk		
	A (0%)	B (20%)	C (30%)	D (0%)	E (20%)	F (30%)
Cassava peel	50.00	30.00	20.00	50.00	30.00	20.00
Treated	–	20.00	30.00	–	20.00	30.00
Dry Brewers Grain	11.00	11.00	11.00	11.00	11.00	11.00
Palm kernel cake	24.00	24.00	24.00	24.00	24.00	24.00
Molasses	10.00	10.00	10.00	10.00	10.00	10.00
Salt	3.00	3.00	3.00	3.00	3.00	3.00
Premix	1.00	1.00	1.00	1.00	1.00	1.00
Bone meal	1.00	1.00	1.00	1.00	1.00	1.00
Total	100	100	100	100	100	100

and another without anti-coagulant for serum biochemical evaluations as described by (Olafadehan 2011; Akinrimade and Akinrinde 2012). The collection of blood was done in the morning to avoid excessive bleeding and stress on the goats.

Statistical analysis

Data obtained were analysed using one-way analysis of variance (ANOVA) using statistical analysis software (SAS 2001) and means were separated using the Duncan Multiple Range Test (1955).

Results

The haematological indices of WAD goats fed maize cob- and maize husk-based diets treated with mixture of microorganisms presented in Table 2 showed that there was no significant difference ($P > 0.05$) in the parameters except in the erythrocyte sedimentation rate (ESR). This varied from 0.50 to 1.00 mm/hr with diet D having the highest value. The highest (32.33%) pack cell volume (PCV) was observed in diet F and least (24.00%) in diet D. The red blood cells (RBC) varied from 8.56 (diet D) to $13.06 \times 10^6/mm^3$ (diet F). The white blood cells (WBC) ranged from 2.56 (diet F) to $3.64 \times 10^6/mm^3$ in diet D. The haemoglobin values were also least (8.00 g/dl) in diet E and highest 10.80 g/dl in diet F. The lymphocytes ranged from 59.33 to 62.00%. The neutrophil which is the main defender of the body against infection and antigen ranged from 27 to 30.33% with diet F recording the highest value and diet D the least value. Eosinophils values obtained varied from 2 to 3%. The serum biochemical indices results obtained revealed that there was no significant difference ($P > 0.05$) in total protein, albumin and albumin/globulin ratio while significant differences was observed in other parameters (Table 3). Total protein varied from 65.00 g/l (diet A) to 97.54 g/l (diet E). However, the albumin concentration in husk-based diets had higher values (37.93–48.43 g/dl) than the cob-based

Table 2 Haematological profile of WAD goats fed treated maize cob- and maize husk-based diets with mixture of microorganisms

Parameters (%)	Diets						SEM
	Maize cob			Maize husk			
	A (0%)	B (20%)	C (30%)	D (0%)	E (20%)	F (30%)	
ESR (mm/h)	0.75^{ab}	0.75^{ab}	0.50^{b}	1.00^{b}	0.50^{b}	0.50^{b}	0.06
Pack Cell Volume (%)	27.50	29.00	29.00	24.00	26.67	32.33	1.03
Red Blood Cell ($\times 10^6/mm^3$)	10.26	10.87	11.87	8.56	11.24	13.06	0.53
White Blood Cell ($\times 10^6/mm^3$)	3.14	3.30	2.67	3.64	2.94	2.56	0.15
Haemoglobin (g/100 ml)	9.15	9.65	9.65	8.00	8.90	10.80	0.35
Lymphocytes (%)	60.50	60.50	60.50	62.00	60.67	59.33	0.33
Neutrophil (%)	29.50	28.50	30.00	27.00	29.00	30.33	0.46
Monocytes (%)	7.00	8.00	6.50	7.67	7.67	7.33	0.29
Eosinophil (%)	2.00	2.50	2.00	3.00	2.00	2.33	0.12
Basophil (%	1.00	0.50	1.00	0.00	0.67	0.67	0.13

a, b = means within the same row with different superscripts are significantly ($P < 0.05$) different

Table 3 Biochemical values of WAD goats fed treated maize cob- and maize husk-based diets with mixture of microorganisms

Parameters	Diets						SEM
	Maize cob			Maize husk			
	A (0%)	B (20%)	C (30%)	D (0%)	E (20%)	F (30%)	
Total protein (g/l)	65.00	94.82	79.63	91.63	97.54	88.71	5.52
Albumin (g/l)	36.84	35.56	31.84	48.43	44.62	37.93	6.72
Globulin (g/l)	28.16^{b}	59.26^{a}	47.79^{ab}	43.20^{ab}	52.92^{ab}	50.78^{ab}	2.53
Albumin/globulin ratio	1.31	0.60	0.67	1.12	0.84	0.75	0.10
AST (iu/l)	81.75^{bc}	91.5^{abc}	128.25^{a}	123.52^{ab}	48.00^{c}	84.00^{abc}	8.04
ALT (iu/l)	8.20^{b}	11.8^{b}	10.50^{b}	33.33^{a}	9.60^{b}	14.00^{b}	2.21

a, b, c = means within the same row with different superscripts are significantly ($P < 0.05$) different

diets (31.84–36.84 g/dl). The globulin values ranged from 28.16 (diet A) to 59.26 g/dl (diet B). The serum enzymes values revealed that Aspartate aminotransferase (AST) ranged from 48.00 iu/L (diet E) to 128.25 iu/L in (diet C) while the Alanine aminotransferase (ALT) ranged from 8.20 iu/L (diet A)—33.33 iu/L (diet D). The plasma mineral of goats determined in this study were significantly ($P < 0.05$) influenced by the treatment (Table 4). The potassium serum of the goats ranged from 2.74 (diet D) to 10.46 mg/100 ml (diet B); phosphorus level observed varied from 9.67 mg/100 ml (diet D) to 10.98 mg/100 ml (diet C). The magnesium concentration of the serum of the WAD goats fed experimental diets ranged between 0.16 and 0.81 mg/100 ml.

Discussion

Haematological profile of WAD goats fed treated maize cob- and maize husk-based diets with mixture of microorganisms

The erythrocyte sedimentation rate (ESR) values suggest that the maize husk and cob in combination with other ingredients did not have any allergic effect on the health status of the goats. The pack cell volume (PCV) is the total percentage of the blood that constitute the red blood cells. Values obtained in this study showed that all the PCV concentrations of the goats fed the experimental diets were within the recommended value of 21–37% reported for healthy goats and sheep (Daramola et al. 2005; Plumb 1999; Kalio et al. 2014). Pack cell volume value below normal range could be an indication of anaemia and poor quality of protein in the diet (Radostis et al. 1994). However, the result of this study revealed that the values obtained could be a result of the high crude protein content of the diets (Radostis et al. 1994). The red blood cells (RBC) are responsible for the transport of oxygen from the lungs to body cells (Ibhaze and Fajemisin 2017). The values obtained in this study were within the range of $9.9–18.7 \times 10^{6}mm^{3}$ reported by Taiwo and Ogunsanmi (2003) as normal count for goats, however, were higher than $6.67–7.73 \times 10^{6}mm^{3}$ reported by Oloche et al. (2014) but comparable to the range of $10.00–18.81 \times 10^{6}mm^{3}$ reported by Ibhaze (2015) who fed fermented maize cob-based diets to WAD goats. The white blood cells are indicators to immune response to foreign bodies in the organism (Ibhaze and Fajemisin 2017). The values obtained which are within the normal range for healthy goats suggests that the animals did not experience any stress to have triggered the body's immune system to produce more white blood cells for defence. Haemoglobin is the iron-containing oxygen-transporting protein in the red blood cells. The shortage of haemoglobin in the red blood cells lowers

Table 4 Serum electrolytes of WAD goats fed treated maize cob- and husk-based diets with mixture of microorganisms

Parameters (mg/100 ml)	Diets						SEM
	Maize cob			Maize husk			
	A (0%)	B (20%)	C (30%)	D (0%)	E (20%)	F (30%)	
Calcium	0.29^{bc}	0.45^{b}	0.31^{bc}	0.23^{c}	0.33^{bc}	0.70^{a}	0.01
Magnesium	0.24^{d}	0.16^{b}	0.81^{a}	0.16^{b}	0.17^{bc}	0.23^{a}	0.01
Potassium	7.62^{ab}	10.46^{a}	9.15^{a}	2.74^{c}	7.08^{ab}	9.17^{a}	0.71
Phosphorus	9.78^{ab}	10.95^{a}	10.98^{a}	9.67^{ab}	9.79^{ab}	10.57^{a}	0.41

a, b = means within the same row with different superscripts are significantly ($P < 0.05$) different

the blood oxygen-carrying capacity that could lead to anaemic condition in the individual. The results obtained here is lower than 11.4 g/dl reported by Tambuwal et al. (2002) for Red Sokoto goats but was within the range 8–12 g/100 ml opined by Plumb (1999) for healthy goats. This suggests that the goats had adequate blood pigment for proper transportation of oxygen, thereby preventing microcytic hypochromic anaemia caused by iron deficiency (Olafadehan 2011). The lymphocytes are involved in protection of the body from viral infections. High levels are an indication of an active viral infection and a low value suggests an exhausted immune system (Plumb 1999). It was observed that the husk-based diets values reduced as the inclusion level increased while that of the cob-based diets did not vary. This could mean that goats fed maize cob diets had a stable immune system and they did not experience any form of active infection that could have elevated the lymphocytes concentration. The lower levels observed in maize husk diets suggests a depressed immune system which could predispose the animals to viral infection. The neutrophil which is the main defender of the body against infection and antigen showed that there was no incidence of neutrophilia which could occur when the animal is under stress or neutropenia which could occur with very severe infections. Eosinophils are used by the body to protect against allergic reactions and parasites and that low level of eosinophils indicates no allergic reactions (Plumb 1999). The result showed that the eosinophils values were within the normal range (1–8%) for goats as reported by Plumb (1999). This low count indicates a normal condition of the goats.

Biochemical values of WAD goats fed treated maize cob- and maize husk-based diets with mixture of microorganisms

The serum total protein obtained was higher than 44 g/l observed in Red Sokoto goat (Tambuwal et al. 2002); this variation might be due to breed of animal, environmental condition, and concentration of protein in diet (Kalio et al. 2014). The serum total protein content however is within the normal range (64 to 78%) in a healthy goat (Tambuwal et al. 2002). This implied that the test diets had adequate supply of protein, because total serum protein is an indicator of protein quality of feed. Albumin helps to hasten blood clot during injury, thereby reducing loss of blood. The values obtained are slightly higher than the normal range of 24–44 g/l in a healthy goat as reported by (Tambuwal et al. 2002). The globulin values were compared to the normal range (34.40 g/dl to 55.70 g/dl) in a healthy goat (Kaneko 1989). These values reflect the quality of protein in the diets, because the indices examined are pointers of high protein quality. The serum enzymes values obtained were lower than the range 76.95–138 iu/l for AST and 23.09–95.28 iu/l for ALT in WAD goats fed pulverized biofibre wastes-based diets as reported by Ibhaze and Fajemisin (2017). However, values of AST and ALT obtained in this study fell within the normal ranges of 43–132 iu/l and 7–24 iu/l, respectively (Sirois 1995). The AST values were higher than the findings 21.02–43.78 iu/l of Oloche et al. (2019) for Kano brown goats fed Gmelina arborea leaves and supplemented with diets containing water soaked sweet orange (Citrus sinensis) peels, while the ALT values obtained in this study were also higher than the range 10.10–12.98 iu/l also reported by Oloche et al. (2019). Increased ALT values are a sign of liver disease, because it's a liver-specific hepatocellular enzyme that is used to assess liver damage (Mahgoub et al. 2008). These results indicated that the test diets did not interfere with the levels of these enzymes to pre-dispose the animals to any form of liver dysfunction or damage.

Serum electrolytes of WAD goats fed treated maize cob- and maize husk-based diets with mixture of microorganisms

Minerals play an important role in growth, health and reproduction functions of livestock (Gonul et al. 2009) and have been recognized as potent nutrients and deficiency can impair utilization of other nutrients (Szefer and Nriagu 2007) and their performance. The serum potassium level was slightly lower in the WAD goats but did not differ from the values reported for Red Sokoto goat (Tambuwal et al. 2002); however these values were comparable to the range 4–8 mg/100 ml for goats and sheep (NRC 2007). This implies that the diets were adequately furnished with the required potassium for goats. The phosphorus concentration was higher than 4.52–6.06 mg/100 ml reported by Yatoo et al. (2013). The magnesium concentration of the serum of the WAD goats fed experimental diets ranged between 0.16 and 0.24 mg/100 ml and these values were lower than the average value of (1.97 mg/100 ml) reported by Kalio et al. (2014). The NRC (2007) for small ruminants reported blood magnesium values of 1.8 to 3.5 mg/dl. Magnesium is closely associated with calcium and phosphorus and 70% of the total magnesium in the body is embedded in the bone.

Conclusion

The results obtained in this study showed that treating maize cob and husks with mixture of microorganisms (*Neurospora crassa* and *Lactobacillus delbrueckii*) can enhance the nutrient composition of the diets with a resultant improvement in erythropoiesis and effective regulation of the serum proteins and enzymes which enhanced the healthy status of the goats. Microbial

(*Neurospora crassa* and *Lactobacillus delbrueckii)*-treated maize cob and husk can be incorporated at 30% in WAD goats diets for improved packed cell volume, immunity of animals against infection. The mineral concentration findings implied that maintenance and production was not compromised to make the goats susceptible to metabolic diseases.

Abbreviations

WAD: West African dwarf goats; ESR: Erythrocyte sedimentation rate; PKC: Palm kernel cake; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; RBC: Red blood cell; WBC: White blood cell; NRC: National Research Council.

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Authors' contributions

ANF designed the study. All authors managed the activities of the experiment and interpreted the data collectively. ANF, GAI and GEO prepared the proposal of the study. GEO prepared the first draft of the manuscript. GAI reviewed the first draft and prepared the second draft. All authors have read and approved the manuscript.

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Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

All the authors agreed to publish the article.

Competing interests

The authors declare that they have no competing interests.

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