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Haematological and Biochemical Responses of West African Dwarf Goats fed Water hyacinth and Cassava peel silage

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Abstract

The dry seasons in the tropics often result in a scarcity of green fodder, which can negatively impact ruminant animal production. As such, the utilization of aquatic plants, which are abundant poses a threat to aquatic organisms and waterways, may be explored as a means of mitigating this shortage. This study aimed to assess the suitability of water hyacinth and its implication on the blood profile of West African Dwarf (WAD) goats. A total of 20 West African Dwarf goats, aged 1-1.5 years and having liveweight of 11 ± 0.42 kg, were fed water hyacinth for a period of 70 days. A five-treatment and four-replicate completely randomized design was employed, in which water hyacinth replaced cassava peels at varying concentrations (0%, 15%, 30%, 45%, and 60%) in the formulated diets, with Panicum maximum and sundried poultry droppings added each at 20% to make complete diets. Significant differences (P<0.05) were noted in the blood profile values of the experimental animals (PCV:24.4-29.73%, RBC:7.75-13.8210^{6}mm^{-1}, WBC: 9.78-13.4810^{3}mm^{-1}) and were within the normal ranges for healthy growing goats. Serum biochemical parameters obtained indicated that total protein (20.02g/L - 42.24g/L), albumin (11.40 – 25.00g/L), globulin (8.62 - 17.24g/L), and creatinine (1.00 - 2.13mg/dL), were significantly (P < 0.05) different across the treatments. WBC and Lymphocytes values obtained were indicative of healthy immune system in the animals. Conclusively, supplementation of the WAD goat's diet with water hyacinth at a 15% inclusion level in cassava peels and poultry dropping silage was tolerable, presented optimal hematological and serum biochemical indices and did not pose any health risk to the experimental animals and was thereby recommended as a suitable feed for goats for optimum production, especially in extended dry seasons.

Keywords: Serum, Water hyacinth, Silage, Blood, Treatment, Health

Réponses hématologiques et biochimiques des chèvres West African Dwarf nourries avec de l'ensilage de jacinthe d'eau et de peau de manioc

Résumé

Les saisons sèches sous les tropiques entraînent souvent une pénurie de fourrage vert, ce qui peut avoir un impact négatif sur la production animale de ruminants. Ainsi, l'utilisation de plantes aquatiques, dont l'abondance constitue une menace pour les organismes aquatiques et les cours d'eau, pourrait être explorée comme moyen d'atténuer cette pénurie. Cette étude visait à évaluer l'adéquation de la jacinthe d'eau et son implication sur le profil sanguin des chèvres West African Dwarf (WAD). Au total, 20 chèvres West African Dwarf, âgées de 1 à 1,5 ans et pesant 11 ± 0,42 kg, ont été nourries avec de la jacinthe d'eau pendant une période

de 70 jours. Un plan complètement randomisé à cinq traitements et quatre répétitions a été utilisé, dans lequel la jacinthe d'eau a remplacé les pelures de manioc à des concentrations variables (0 %, 15 %, 30 %, 45 % et 60 %) dans les régimes alimentaires formulés, avec Panicum maximum et crottes de volailles séchées ajoutées chacune à raison de 20% pour constituer des régimes complets. Des différences significatives (P < 0,05) ont été notées dans les valeurs du profil sanguin des animaux de laboratoire (PCV : 24,4-29,73 %, RBC : 7,75-13,82x10^{6}mm^{-1}, WBC : 9,78-13,48x10^{3}mm^{-1}) et se situaient dans les limites plages normales pour des chèvres en bonne santé. Les paramètres biochimiques sériques obtenus ont indiqué que les protéines totales (20,02 g/L - 42,24 g/L), l'albumine (11,40 – 25,00 g/L), la globuline (8,62 - 17,24 g/L) et la créatinine (1,00 - 2,13 mg/dL) , étaient significativement (P < 0,05) différents selon les traitements. Les valeurs de leucocytes et de lymphocytes obtenues indiquaient un système immunitaire sain chez les animaux. En conclusion, la supplémentation du régime alimentaire de la chèvre WAD avec de la jacinthe d'eau à un niveau d'inclusion de 15 % dans les pelures de manioc et l'ensilage de volaille était tolérable, présentait des indices hématologiques et biochimiques sériques optimaux et ne posait aucun risque pour la santé des animaux de laboratoire et a donc été recommandée comme un aliment adapté aux chèvres pour une production optimale, notamment lors des saisons sèches prolongées.

Mots-clés: Sérum, Jacinthe d'eau, Ensilage, Sang, Traitement, Santé

Introduction

Livestock production is a significant means of providing animal protein, income, employment, and foreign exchange globally (Vijayalakshmy *et al.*,2023). It is a source of nutritional security at about 40 percent mark in developed nations and nearly 20 percent in developing ones (FAO, 2023) defining the wellness and development of the people at large. With the growing world population, it is imperative for increased meat production and consumption in order to meet the protein requirements of the Nigerian people (*Bello et al.,* 2022). Due to their hardiness and productivity, goats are a top choice for ruminant production in Nigeria, since they significantly contribute to the agrarian economy. Livestock productivity is directly impacted by nutrition, which in turn depends on the quality and quantity of feed accessible to farm animals all year round.

One important feed material is water hyacinth which is widely invasive and abundant in waterways, streams, ponds and sloughs blocking waterways, disrupting aquatic life and deteriorating water quality constituting environmental and economic menace (Pin *et al.,*2021), yet rich in crude protein. The menace caused by this aquatic plant could be reduced to the barest minimum if exploited as a component of ruminants' diet, especially during dry seasons when pastures diminish in nutrients and could not sufficiently supply all the nutritional needs of the animals. Cassava peels and poultry droppings are agricultural waste products causing disposal concerns for farmers; but could also be harnessed into ruminant diets since cassava peel is a good energy source while poultry droppings are an excellent source of nitrogen (NPN) and minerals; which would consequently lessen the cost of feed and eventual cost of production.

Haematological assessment is a means of evaluating the general health status and physiological state of farm animals (Faraz *et al.,*2023). This measurement is often hinged on observable changes in the various haematological indices and physiological parameters measured. Blood indices of

ruminant animals are usually influenced by nutrition, sex, age, management, stress and diseases (Rakib *et al.,* 2022). The value of given feed and the metabolic status of farm animals might be determined by changes in the components of blood when compared to normal values. By 2050, the demand for livestock products is anticipated to double internationally as nations' living standards are projected to rise (Hoque *et al.,* 2022), therefore sustainable livestock production is of great importance; and this starts from ensuring the good health of the farm animals in order to meet the global sustainable development goals of food availability and zero hunger. However, there is paucity of data on haematological and serum biochemical responses of WAD goats fed fermented water hyacinth-based diets; hence, this study assessed the dietary effects of graded levels of fermented water hyacinth as replacement for cassava peels on the blood profile of WAD goats.

Materials and Methods

Experimental Site

The project was carried out at the Small Ruminant Unit, Teaching and Research Farm, Federal University, Oye-Ekiti. The laboratory analysis was done at the Diagnostic and Nutrition Laboratory of the Department of Animal Production and Health, Federal University Oye-Ekiti, Ekiti-State, Nigeria, located on Longitude E 005◯29.573 and Latitude N 07◯48.308, at elevation of 548.4 meters above the sea levels with an annual rainfall of 1778mm per annum.

Feed Preparation

Fresh water hyacinth was harvested from the river Niger, at Lokoja, Kogi State in Nigeria. The plant roots were cut off and the shoots were further lacerated, and wilted under the shade for 48 hours on polythene sheets. Cassava peels were gathered from a nearby "garri" production factory while fresh poultry droppings were also collected from the Poultry Unit, Teaching and Research Farm, Federal University of Oye-Ekiti, Ekiti-State, Nigeria; both were sundried for six days to reduce moisture before being used for the feed preparation.

Five diets were formulated with four (4) replicates each and the diets were designed to have 12% crude protein. Cassava peels was replaced with water hyacinth at 0, 15, 30, 45, and 60% levels in diets labeled as 0WH, 15WH, 30WH, 45WH, and 60WH, respectively, with 20% *Panicum maximum* and 20% sundried poultry droppings added to make up complete diets making a total mix ration (Table 1). Plastic drums (100L capacity) were used as silos. Ensiling was done by rapid compaction of water hyacinth, cassava peels and poultry droppings in various proportion into large polythene bags placed inside the plastic silos; samples with no water hyacinth was also ensiled as the control. Sealing of the silos was done and the prepared silage samples were left to ferment for 21 days. Immediately after opening the silos, 0.5kg sample of each diet was taken from the bulk by drawing portions from different depths of the silos and mixed up to ensure homogeneity of the sample. The pH values and the physical properties such as moldiness, texture, aroma, colour and moistness of the silage were evaluated with the help of some volunteers. The silage products were then removed from the silos and air dried for 10 days, to reduce moisture content, inhibit further microbial activities and to enhance feed acceptability by the experimental animals.

Management of experimental animals

Twenty young West African Dwarf goats weighing 11 ± 0.42 kg, and aged 1 - 1.5 years were obtained from Otun-Ekiti, a neighboring village in a bid to assess the haematological and biochemical indices of water hyacinth-cassava peels silage. Dentition and information from the goat

owners were used to estimate the age of the animals. The animals were brought in after cleaning and disinfecting the semi-open sheds pen (2m x 3m). The animals were kept in isolation for a total of two weeks at the experiment site in order to monitor any illnesses and enable adaptation. The animals were treated with antibiotics (Oxytetracycline 200LA, 0.6mL/goat) to enhance their immunity against infections during the adaption phase in addition to an ectoparasite treatment using Cypermethrin pour on (0.7mL/goat) and an endoparasite treatment using ivermectin (0.15mL/goat). The *Pestes de petit Ruminate* (PPR) vaccine was later given. The experiment lasted for 70 days. The pens were cleaned every day and the wood shavings used as the beddings were changed fortnightly.

Experimental Methods and Diets

The trial was a completely randomized design (CRD), twenty WAD goats used were randomly assigned based on their initial body weights to five treatments of four replicates. Feed, fresh water and salt lick were provided ad libitum daily in individual pens. Feed offered was weighed and those refused were collected, weighed, and recorded daily before fresh feeds were given in the mornings. The experimental diets were fed at 3% body weight at 0700h and 1600h during the 70-day trial. The feed constituents and experimental diets were dried, ground, bulked, and analyzed for dry matter (residue after drying to constant weight at 100°C), crude protein (Kjeldahl N x 6.25), ether extract or fat extract (dry sample with ether for about 4 hours), ash (residue after ignition at 500°C), and crude fiber (Goering 1970; AOAC. 2010). The varying colour, odour, and moisture level of all the silages were evaluated by a panel of volunteers and were recorded.

Procedure for blood collection and laboratory analysis

After the 70-day trial, the experiment was terminated and blood samples were collected from all the twenty experimental animals, which were bled through the jugular vein early in the morning. Specimens for hematological evaluation were collected into ethylene diamine tetra acetic acid (EDTA)-treated sample bottles to prevent coagulation, labeled and recorded appropriately and then placed in a cooler containing ice cubes before being transported quickly to the laboratory. Haematological indices determined were packed cell volume (PCV), red blood cell (RBC), white blood cell (WBC), hemoglobin (Hb) etc. The packed cell volume (PCV) was carried out using the microhaematocrit while the haemoglobin concentration was carried out using the cyanmethemoglobin method (Cork 2002). The erythrocyte count was estimated by using the haematocytometer using the methods described by (Jain, 1993). Blood samples for serum biochemistry were collected into bottles devoid of EDTA to allow blood clot for easy serum separation, blood tubes were allowed to sit to coagulate at 37 °C for serum separation. The serum samples were then stored frozen at -20C prior to biochemical studies. The serum was thereafter analyzed for total protein, albumin, globulin, creatinine, alanine transaminase (ALT), aspartate aminotransferase (AST), and urea using the method described by Ogunsami (2002).

Chemical Analysis

Feed samples of experimental diets were collected and analyzed for their proximate composition using standard procedures (AOAC) 2010).

Statistical Procedures

The results were presented as the mean value of four replicates per treatments. All data generated were subjected to analysis of variance (ANOVA). Significant differences between means were separated using Duncan's multiple range test (Duncan, 1955) with the aid of SPSS Version 17, IBM SPSS Statistics Computer Software Package (SPSS Inc. 2008); significance was accepted at $P < 0.05$.

Table 1: Gross and Nutrient Composition of Water hyacinth and Cassava peel silage (g/100g)

Feed Components	Diets				
	0Wh	**15Wh**	**30Wh**	**45Wh**	**60Wh**
Cassava peels	60.00	45.00	30.00	15.00	--
Eichhornia crassipes	--	15.00	30.00	45.00	60.00
Dried Poultry droppings	20.00	20.00	20.00	20.00	20.00
Panicum maximum	20.00	20.00	20.00	20.00	20.00
Total	100	100	100	100	100
Calculated Proximate composition					
Dry matter	94.06	92.24	89.80	86.10	84.00
Crude protein	24.70	24.62	21.84	19.91	17.16
Crude fibre	17.14	19.78	20.19	22.85	23.65
Ether extract	6.95	6.75	6.45	5.79	4.96
Ash	16.52	14.05	11.59	9.70	10.40
Nitrogen free extract	34.69	34.80	39.93	41.75	43.83
Gross Energy(kJ/gDM)	3.80	3.76	3.65	3.20	3.00

0Wh, 15Wh, 30Wh, 45Wh,60Wh Numerals represent the various inclusion levels of Water Hyacinth in the treatment diets at 0, 15, 30, 45 and 60% respectively.

Results and Discussion

The Nutrient Composition of the Experimental Diets

The nutrient composition of the experimental diets was presented in Tables 1. There were observed variations in the values obtained for dry matter, crude protein and crude fiber which may be due to the treatment effects. Remarkable decrease was observed in the crude protein content of the experimental diets with increased water hyacinth from treatments 0WH to 60WH, while the ether extract content of the experimental diets decreased with increasing level of water hyacinth in the diets. Water hyacinth was reported to be high in crude fibre, cellulose and hemicellulose content (Arivendan *et al.,* 2022) and this could account for the observed rise in crude fiber content with increasing levels of water hyacinth inclusion in the experimental diets or treatments. The proximate composition of the experimental feedstuffs showed that all the diets were adequate in nutrients for ruminant animals. Mani, (2018) reported that water hyacinth leaves contains up to 20% crude protein, and can thus be used as ruminant feed; since such diets could enact rumen microorganisms' activities; the high dietary crude protein content of the feeds suggested that the diets were adequate in dietary nitrogen and that when fed to small ruminant animals it is sufficient to support ruminant growth all year round, similar values were observed in feeds fed to ruminants in previous studies by Aye and Tawose (2016).

The gross energy content observed in the treatment diets (3.0 - 3.80 kJ/gDM) were

adequate for the maintenance and growth of growing goats; deficiency evident in decreased production, reproductive failure, increased mortality, and increased susceptibility to diseases and parasites due to inadequate dietary energy (Singh *et al.,*2023) did not occur among the experimental animals. The values reported were influenced by the varying dietary levels of incorporation of water hyacinth in the treatment diets. The ash content (9.70 - 16.52g/100g) of the diets was within the recommended values indicating that the goats were supplied adequate minerals and micronutrients (NRC, 1981). The proximate content of the experimental diets was optimal enough necessary for any globally relished protein sources (Bello *et al.,* 2023).

The high nutritional valued of water hyacinth has increased its suitability as animal feed (Du *et al.*,2020). Yusuf *et al., (*2021) reported that feeding water hyacinth to WAD goats at levels up to 10% improved their growth, blood profile and had no detrimental impact on the animals' health despite the heavy metal concentration in the aquatic plant. Mako (2013) also reported that sun-cured water hyacinth can be fed to growing goats at 30% inclusion level since phenols, saponins, and tannins present are not in hazardous amounts.

The Physical Properties and pH values of the Experimental Diets

The physical properties and pH of the diets were as presented in Table 2 below. The pH values recorded for the diets were acidic as it ranged from 3.62 in 15WH diet to 4.10 in 45WH diet. The low pH values observed in the diets are satisfactory for a good silage, as this agrees with previous reports that well preserved silages usually have low pH values ranging between pH 3.5 and 4.2 (Chavan *et al.,*2022). The absence of harmful microorganisms and safety of the silage were specified by the observed lack of mold, non-sticky texture, appropriate pH, and pleasant scent (Manzoor *et al.,*2021). Fermented feeds such as the experimental diets are reported to have the potentials to maintain intestinal health and homeostasis in gastrointestinal micro flora (Guo *et al.,*2021). The varying colour, odour, and moisture level of the silage might have enhanced the degree of acceptability and palatability of the various treatments. Volatile fatty acids (lactic acid, propionic acid, butyric acid and acetic acid); were produced as by-products of the fermentation process (Wang *et al.,*2022).

Table 2: Physical Properties and pH of the water hyacinth in Cassava Peels Silage

PARAMETERS	0WH	15WH	30WH	45WH	60WH
pH	3.66	3.62	3.91	4.10	3.75
Mouldiness	No mould	No mould	No mould	No mould	No mould
Odour	Slightly Pungent	Pleasant	Pleasant	Choking	Pungent
Colour	Dark brown	Brown	Greenish	Brownish green	Greenish
Moistness	Slightly moist	Moist	Moist	Moist	Highly moist

0WH, 15WH, 30WH, 45WH, 60WH: Numerals represent the various inclusion levels of Water Hyacinth in the treatment diets at 0, 15, 30, 45 and 60% respectively.

Haematological indices of WAD goats fed the experimental diets.

The haematological indices of the WAD goats after the trial were presented in Table 3. Treatment effects were observed in the heamatological results. Significant ($P<0.05$) differences were observed in the recorded red blood cell counts with values that ranged between 7.75 x $106mm^{-1}$ (60WH) and 13.82 x $106mm^{-1}$ (15WH) in the WAD goats fed the experimental diets. Red blood count indicators aid in the

diagnosis and categorization of anemia. (Rao *et al.,*2022). The observed RBC values indicated that the animals were not susceptible to anemia related disease conditions. Low RBC counts is a sign of blood loss, iron deficiency, bleeding or vitamin deficiencies (Tvedten, 2022). The RBC values observed were similar to baseline value prescribed by (Daramola *et al.,*2005). This suggested that the feed was of high quality, not protein deficient, was digestible, and contained a tolerable level of antinutrients.

Significant ($P<0.05$) differences were observed in the haemoglobin concentration of the blood of experimental animals which were within the range of 8.11 g/dL in 60WH to 13.52 g/dL in 15WH group. The Haemoglobin value decreased with an increased replacement of Water hyacinth across the treatments. Haemoglobin is the red oxygen-carrying pigment in the red blood cells of ruminants (Idowu *et al,* 2022). Haemoglobin values in this study revealed the highest value in animals fed 15WH and the least in 60WH dietary treatments. Similar values were reported by (Al-Bulushi *et al.*,2017) who stated that observed haemoglobin value for different breeds of goats ranged between 6.97 and 10.4g/dL. Jain, (1993) reported that the normal haemoglobin value for small ruminants ranged between 9 -15 × 106cm/µl and this are similar to values observed in this study; thus demonstrating that the experimental diets can support high oxygen carrying capacity in fed goats and are effective for the production of more haemoglobin. The haemoglobin values reported in this study are within the range of values recommended by Daramola *et al.,* (2005).

The packed cell volume (PCV) values observed were significantly ($P < 0.05$) different among the dietary treatments in the range of 24.40% (60WH) and 29.73 (15WH). Increased values were obtained with decreased inclusion of water hyacinth. The packed cell volume value signifies the age, anaemic condition, feed protein status and animal species and health of animals (Agradi *et al.,*2022). The values obtained in this study are similar to the average PCV value range of 28 - 34% observed in a study by (Aye, 2016) and 30% reported by (Jiwuba *et al.,*2023), it has also been reported that high PCV (above 15%) also seen in this study implies that the study animals were not anaemic, but had strong immunity to infections and illnesses with a well-developed immune system (Wetmore, 2022).

The White blood cell counts obtained in this study were significantly ($P < 0.05$) different, ranging from 9.78 (60WH) to 13.48 (0WH) and aligns to the reported normal range of WBC in ruminants (Jain, 1993). The leucocytes are blood cells responsible for fighting against foreign agents within the body system. Stress, digestion, food, parasites, and health influences the number of leucocytes in the blood (Cheng *et al.,*2022). The values obtained for white blood cell count was similar to values reported by Aye and Tawose (2016). The presence of microbial or parasitic illnesses is usually indicated by an unusually high white blood cell count (Teoh, 2022) while abnormal decrease in total leucocytes count could be due to viral, bacterial infections, toxemia; however, this situation was not applicable to this trial. All the values observed were within the normal range of values for goats, and this result ranks with results obtained for West African dwarf goats fed some browse plants and concentrate diets (Oyibo *et al.,* 2020). The erythrocyte sedimentation rate values were not significantly ($P > 0.05$) different across treatments.

Neutrophils, lymphocytes, Monocytes and Basophils values observed were within the normal recommended range reported (Daramola *et al*., 2005). The values of

Eosinophil observed increased with increased replacement level of water hyacinth with values that ranged from 3.00 % in Diet 15WH to 5.09 % in 60WH, and significant (P<0.05) differences were observed across the treatments. Warren *et al.,* (2023) opined that low eosinophil levels is a sign that there were no allergic responses. The eosinophil levels observed in this study were within the normal range (1 – 8%) for healthy goats, which was indicative that the treatment diets used for this study was safe and that the feeding effect was not allergic. Significant (P<0.05) differences were observed in the lymphocyte values that ranged from 55.12% (15WH) to 62.10% in 60WH. Previous studies reported that the normal Lymphocyte values for WAD goats ranged between 60 – 75%, the values obtained in this study were within the range of the baseline values (Tambuwal, 2002). Therefore, the observed values are suggestive of a well-developed immune system in the WAD goats that can proffer their good health.

The neutrophil values ranged from 31.10% in 60WH to 38.11% in 15WH, were significantly (P<0.05) different. The values of basophil obtained increased significantly ($p < 0.05$) with increased replacement level of water hyacinth which ranged from 0.56 in 15WH to 1.31% in 60WH. Values obtained for monocytes were similar ($p > 0.05$) across treatments. Neutrophils, lymphocytes, Eosinophils, Monocytes and Basophils values observed were within the normal range reported by (Daramola *et al.,*2005) which is indicative of strong immunity against bacterial, fungal and viral infections and diseases and the activation of their defense and immune system to infections or toxic substances which is suggestive of a well-developed immune system (Amela, 2022, Hamish, 2023).

Erythrocyte sedimentation rate (ESR) is an important routine test in hematology. The increase in ESR is an indicator of inflammation, as well as pregnancy, anemia, kidney diseases or rheumatoid arthritis. Abnormally increased ESR could be as a result of immune system response to infection, blood disorders, injury, immune system disorders caused by pregnancy, anemia, kidney diseases (Tishkowski, 2022). The values obtained in this study were within the normal range of values for healthy ruminant animals (Daramola *et al,.* 2005). All the experimental animals generally appeared well and alert throughout the experimental period. There was no mortality recorded.

Table 3: Haematology indices of WAD goats fed Water hyacinth and Cassava peel silage.

Treatments/Diets	**1**	**2**	**3**	**4**	**5**	
Levels of WH (%)	**0WH**	**15WH**	**30WH**	**45WH**	**60WH**	**±SEM**
Haematological parameters:						
Packed Cell Volume (%)	29.24^{a}	29.73^{a}	27.14^{b}	26.64^{b}	24.40^{c}	0.29
Red Blood Cell ($\pm10^{6}mm^{-1}$)	13.00^{a}	13.82^{a}	10.12^{b}	9.67^{b}	7.75^{c}	0.23
White Blood Cell ($\pm10^{3}mm^{-1}$)	13.48^{a}	13.24^{a}	12.33^{a}	11.05^{b}	9.78^{c}	0.30
Haemoglobin concentration (g/dl)	12.05^{b}	13.52^{a}	10.63^{c}	9.78^{c}	8.11^{d}	0.21
Erythrocyte sedimentation rate(mm/hr)	1.0	0.5	0.5	1.0	1.0	0.04
Lymphocyte (%)	55.60^{c}	55.12^{c}	58.33^{b}	58.01^{b}	62.10^{a}	0.32
Neutrophils (%)	37.60^{a}	38.11^{a}	35.08^{b}	32.61^{c}	31.10^{d}	0.9
Basophil (%)	0.60	0.56	1.00	1.22	1.31	0.02
Monocytes (%)	2.10	2.00	2.45	3.00	3.66	0.15
Eosinophils (%)	3.14^{d}	3.00^{d}	3.76^{c}	4.5^{b}	5.09^{a}	0.6

(Where Diets A: 0:60, B:15:45, C:30:30, D:45:15, E:60:0 proportion of water hyacinth to cassava peels).
Means with different superscripts along the same rows are significantly different (P<0.05).

Biochemical Parameters of WAD Goats Fed the Experimental diets

Haematological profile provides insight into a feed type and how much nutrients obtainable from it. The results of blood biochemical parameters of the growing experimental animals were presented in Tables 4. The values obtained for serum total protein ranged between 20.02g/l in goats on 60WH to 42.24g/l for those fed 15WH. Total protein is a measure of the protein retained in the body of the animal. (Okoruwa 2019), and it is important in osmotic regulation, immunity, and transport of several substances in the animal body (Jain, 1993). The observed values decreased with increasing inclusion levels of water hyacinth; this may be attributed to the optimal levels of crude protein in the diets and its acceptability to the animals.

Albumin values (11.40 - 25.00g/l) were significantly (P < 0.0.05) different. Albumin is a water-soluble protein found in blood that account for about 55-60% of plasma proteins (Mittal, Gandhi, and Roy 2022; Ban *et al.,*2022). In the evaluation of liver function, the albumin index is often assessed. The primary function of albumin in blood is to transport fatty acids, drugs, thyroid hormones, and steroids, metabolites, and other substances under osmotic pressure (Dewangan 2020). Values observed in this study were similar to values reported by Ogunbosoye *et al*., (2018) and Washaya *et al., (*2019). Due to a reduced supply of amino acids to the liver and other nutritional deficits, particularly iron and zinc, animals can have low serum albumin levels leading to poor protein utilization (Gounden *et al.,*2023). Such low albumin levels were not observed in the experimental animals, indicating that there is no incidence of liver impairment in the experimental animals.

The serum globulin was calculated as the difference between serum total protein and serum albumin (Busher 2021). Globulin values obtained in this study significantly varied from 8.62g/L for goats on 60WH to 17.24g/l for those on 15WH diet. Serum globulins play an important role in liver function, blood clotting, and fighting infection. Globulin is often indicative of the liver functioning in animals (Brown 2016). Globulin concentration in tested animals were within the normal range indicating that the study animals were in optimum physiological state during the study (Age *et al.,* 2022). Creatinine values obtained (1.00mg/dl - 2.13mg/dL) were similar (P > 0.05) across treatments. . The serum glucose values were significantly (P<0.05) different across the treatments. Cholesterol analysis indicated significant differences (P < 0.05) Ranging from 0.61mg/dl (15WH) to 1.03mg/dl (60WH).

Aspartate aminotransferase was highest (70.06 IU/L) in goats fed Diet 60WH and least (57.09 IU/L) in goats fed Diet with 15WH. Goats placed on Diet with 60WH had the highest alkaline phosphatase levels (24.38 IU/L), while the least value (9.67 IU/L) was recorded in goats fed 0WH. The alanine transferase increased with increased replacement of water hyacinth with the highest value observed in goats fed with 60WH (64.50 IU/L), while the least value was observed in goats fed 0WH (49.03 IU/L). Some of the major enzymes produced by the liver include: Alkaline phosphatase (ALP), Alanine transaminase (ALT), and Aspartate transaminase (AST) which are important indicators of liver functionality. The values observed in the test animals were within the recommended range, demonstrating that the study diets had no deleterious impact on the liver. A high level of ALT released into the blood may be a sign of liver damage, cancer, or other diseases and this was not the case in the studied animals.

Values recorded for all the cholesterol indices were within the recommended limits for healthy goats, cholesterol

evaluation is useful in diagnosing hepatic damage in domestic animals, the observed blood cholesterol values were within the normal range for healthy goats, therefore, the animals had optimum liver function and were not at risk of hormonal imbalance or any heart disease (Khan and Elahi, 2020). The cholesterol concentration of the blood serum of the experimental animals were comparable to the standard values reported by Daramola *et al.,* (2005) which indicates that feeding the experimental diets was not detrimental to the health of the consumers which made the goat meat healthy and suitable for human consumption. Values obtained were similar to values observed by Omotoso *et al.,* (2017) when *Panicum maximum* was replaced with untreated cocoa pod husk meal in WAD goats.

One of the basis for evaluating dietary protein, kidney health and renal disorders is the urea index; Blood Urea nitrogen values observed in this study were within the normal range proffered by previous studies suggestive of optimum kidney function, proper blood waste disposal and adequacy and utilization of protein in the diet (Marina, 2022). Values observed in the urea concentration were within the recommended range and are similar to the range reported by (Ban *et al.,*2022). The urea value obtained was within reported range of 8 - 20 mg/dL (Banerje 2007) and 4.00 to 20.00mg/dl (Okoruwa 2017) in matured goats. Normal range of blood urea results in the efficacy of nitrogen utilization, urea recycling, nitrogen conservation, due to optimal nitrogen retention as observed in the experimental animals (MacPherson *et al.,*2022). This suggests that adding non-protein nitrogen to the test diets had a beneficial impact on the blood urea concentration.

Excess creatinine in the blood serum is associated with muscle wastage which was not observed in the experimental animals; values recorded were within normal range needed for normal healthy animals. Creatinine can also be used to assess renal function. The observed creatinine values were within the normal range for healthy goats; signifying that the animals had functional amino acid metabolism and subsequently optimum renal and heart function (Thiet *et al.,*2022).

Table 4: Biochemical Parameters of Goats fed Water hyacinth and Cassava peel silage

Treatments/Diets	**1**	**2**	**3**	**4**	**5**	
Levels of WH (%)	**0WH**	**15WH**	**30WH**	**45WH**	**60WH**	**±SEM**
Blood Parameters:						
Total Protein (g/L)	40.13^{a}	42.24 ^{a}	37.44^{b}	30.64^{c}	20.02^{d}	0.29
Albumin(g/L)	24 .33^{a}	25.00^{a}	20.54b	16.04c	11.40d	0.34
Globulin (g/L)	15.8^{ab}	17.24^{a}	16.9^{a}	14.6^{b}	8.62^{c}	0.12
Creatinine (mg/dL)	1.06	1.00	1.34	1.60	2.13	0.08
Serum Urea (mg/dL)	12.10^{a}	11.9^{a}	9.71^{b}	8.45^{bc}	7.8^{d}	0.3
Cholesterol (mg/dL)	0.65^{d}	0.61^{d}	0.72^{c}	0.81^{b}	1.03^{a}	0.01
Glucose(mg/dL)	57.00^{b}	58.03^{a}	54.55^{c}	50.1^{d}	45.29^{e}	0.04
Aspartate amino transferase (IU/L)	59.3^{e}	57.09^{d}	63.5^{c}	66.00^{b}	70.06 ^{a}	0.87
Alkaline phosphatase (IU/L)	11.73^{d}	9.67^{e}	14.17^{c}	17.45^{b}	24.38^{a}	0.6
Alanine transferase (IU/L)	50.5^{d}	49.03^{d}	55.10^{c}	59.1^{b}	64.5^{a}	0.83

(Where Diets A: 0:60, B:15:45, C:30:30, D:45:15, E:60:0 proportion of water hyacinth to cassava peels).

Means with the same superscripts along the rows are not significantly different ($P<0.05$). WH = Water hyacinth; SEM = Standard error of mean.

Conclusion

The supplementation of the goat's diet with water, hyacinth, cassava peels, and sundried poultry droppings was found to be sufficient in energy and protein content and did not negatively impact the overall health of the goats, as determined by the hematology and biochemical indices of the West African dwarf goats. The optimal level of water hyacinth supplementation for West African Dwarf goats was determined to be 15%, as this level resulted in the best hematology and biochemical indices. The least physiological performance was observed in goats fed 60% water hyacinth, while the best indices were recorded in goats fed 15% water hyacinth. Further investigation is needed to determine the physiological responses of animals to water hyacinth supplementation levels. Water hyacinth is therefore an excellent supplement to cassava peel at 15% level in West African Dwarf goats' diet without negatively impacting their blood indices.

Ethical Statement

The authors confirm that ethical approval was obtained from the Federal University, Oye-Ekiti ethics committee for animal experiments before the commencement of this study. Protocols of animal husbandry and experimentation were reviewed and approved in accordance with the standards recommended by the Guide for the Care and Use of Laboratory Animals and Directive of the institution.

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