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RESEARCH ARTICLE

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Biochemical and Haematological Evaluation of the Replacement of Ensiled Cassava Pulp with Cocoa Pod in the Diet of West African Dwarf Goats

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ABSTRACT

This experiment was conducted to evaluate the effects of supplementing cassava pulp with cocoa pod and acacia leaf on the blood metabolites of WAD goats. Twenty-eight WAD bucks aged 5 months with the mean body weight of 7 ± 0.2 kg were used in this completely randomized experiment. The goats were randomly assigned to seven dietary treatments in different ratios of 0:60:40 (T1), 10:50:40 (T2), 20:40:40 (T3), 30:30:40 (T4), 40:20:40 (T5), 50:10:40 (T6), and 60:0:40 (T7) g/kg DM. The collected data were analyzed by the analysis of variance using SPSS. The ob-tained results showed that the highest PCV was obtained from treatment 1 (26.83%), followed by treatments 2 (23.40%) and 3 (22.27%). Haemoglobin concentration was the highest in treatment 1 (11.4 g/dl), followed by treatments 2 (11.15 g/dl) and 3 (10.37 g/dl). At the end of the experiment, there was a sharp decline in the PCV and haemoglobin values of the goats in treatments 5, 6, and 7. RBC values significantly ($p < 0.05$) decreased as the levels of cocoa pod increased. Total protein and albumin had the ranges of 7.23-5 and 3.7-2.1 g/dl, respectively and Total protein were significantly ($p < 0.05$) different among the groups. The hepatic enzymes ALT, ALP, and AST were within the normal range. Our study revealed that supplementing cassava pulp with cocoa pod and acacia leaf at the combinations of 0% cocoa pod, 60% cassava pulp, and 40% acacia leaf to 20% cocoa pod, 40% cassava pulp, and 40% acacia leaf had no negative effects on the blood profile of WAD goats.

Keywords

Cassava pulp, Cocoa pod, Acacia leaf, Haematology, Serum biochemistry, WAD goats

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Abbreviations

WAD: West African Dwarf
PCV: Packed cell volume
RBC: Red blood cell
WBC: White blood cell
Hb: Haemoglobin
MCHC: Mean corpuscular haemoglobin concentration
MCV: Mean corpuscular volume
MCH: Mean corpuscular haemoglobin
AST: Aspartate aminotransferase
ALP: Alkaline phosphatase
ALT: Alanine aminotransferase
Ph: Phosphorus

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Introduction

The livestock sector plays a significant economic role in most developing countries and is essential for the survival of the population. The productivity of animals is low due to inadequacy and poor quality of the feeds, which in turn influences the feedintake by the animals. Some agroindustrial byproducts can be processed into valuable livestock feeds, such as cocoa pod and cassava pulp, which can beserved as a substitute for maize in formulating rationsfor chickens, pigs, and small ruminants. However,these ingredients must be included at optimal levels that will not pose any risk to the animal [1].

Cocoa pod contains flavonoids, which are antiox idants needed by animal for the proper functioing of the heart and brain. The nitrogen content of cocoa and cassava are made of water-soluble alkaloids, namely theobromine, caffeine, and cyanide which can be tolerated by the animals to some extent. Alkaloids exist in byproducts in small quantities. As a result, there is a need to subject the byproducts to different treatments before utilizing them as animals' feed [2]. Cocoapod theobromine can be minimized or removed by chemical or biological means [3]. Cyanide in cassava wastes could also be treated with chemical or physi cal methods, such as sundry or air dried. These prod-ucts are served as panacea to feed challenges becauseof their availability at all seasons [4]. Many browsesare also used as feeds for ruminants due to availability throughout the year [5]. Agro-industrial by products such as cocoa pod and cassava pulp served as panacea to feed challenges because of their availability at all seasons [4]. are readily available at low costs and are accepted for usage by most farmers after thorough processing.

An early study showed that the inclusion of 9%cocoa shell in the diets of lambs/kids stimulated feed intake and growth. However, higher inclusion rates caused a reduction in feed intake and weight gain.

Others observed a reduction in body weight when cocoa shell was included in the daily ration of sheep and goats. This phenomenon was reversed when cocoa materials were excluded from the diet [6]. According to Olugosi [7], the dietary inclusion of biologically up-graded cocoa pod husk (BPCHM) up to 10% supports the performance and stability of the haemato-biochemical indices of broiler chickens. After the delivery of pups, no abnormal litter characteristics or tera togenic effects were observed relative to the control, suggesting further that the feeds with 30% Talaromyces verruculosus-treated cocoa pod substitution had no adverse reproductive or genotoxic effects [8].

Evaluating blood profile may suggest the potentials of dietary treatment to meet the metabolic needs of animals and their effects on blood constituents which help draw conclusion on the nutritive quality of the feeds [9] and the health status of the animals [10]. Mostly, blood profile is influenced by the qualty, quantity, toxicity, and anti-nutritional factors of the feeds [11]. Sometimes, reduction in PCV and haemoglobin suggests feed toxicity which would have effects on blood indices. Likewise, decrease in RBC and PCV might result from low nutritional feed intake or mild anaemia [12]. Generally, the haematological and biochemical indices of an animal suggest their physiological disposition to the nutritional composition of the feeds.The aim of this study was to evaluate the effects of replacing ensiled cassava pulpwith cocoa pod on haematological and serum biochemical profile in WAD goats. We hypothesized that the combinations of cassava pulp and cocoa pod at the optimal level would not pose detrimental effects on animal health.

Result

The results of the haematological parameters are shown in Table 1. All the measured parameters, except monocyte count, were significantly ($p < 0.05$) different between dietary treatments. The results of the serum biochemical indices are summarized in Table 2. The evaluated biochemical parameters, except total cholesterol, albumin, potassium, urea, and creatinine, were significantly ($p < 0.05$) different between treatments. At the end of the experiment, sodium content (136.13 mmol/l) was significantly ($p < 0.05$) higher in the control group compared to other groups, followed by the combination of 10% cocoa pod, 50% cassava pulp, and 40% acacia leaf (Diet 2) (121.17 mmol/l).

On the other hand, the lowest value was found in T7 group with 60% cocoa pod, 0% cassava pulp, and 40% acacia leaf (99.7 mmol/l). Total protein value was higher in the control group (7.23 g/dl) than in the group with the high concentration of cocoa pod group (Diet 7). Creatinine level was higher in T7, which had a high concentration of cocoa pod (2.3 mg/dl) compared to the control group (0.9 mg/dl).

Discussion

The diets in this study caused significant differences ($p < 0.05$) in the blood profile of the animals. Most of the erythrocyte indices remained in the normal range reported for haematological factors by Daramola et al. [12], Blood et al. [13], and Arash [14].

It is believed that haematological indices reveal the physiological state and health status of the animals which help in diagnosing the suspected toxicant in feed given [15].

The results of the analysis showed that PCV values corroborated the reports of Swati and Varsha [16].

Table 1.
Effect of ensiled combinations of cocoa pod and cassava pulp and acacia leaf on Haematological Parameters of West African Dwarf Goat

Parameters	Range	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7
At the start of experimen								
PCV (%)	22-38	26.30^{a} ± 1.20	*22.40^{b} ± 1.35*	21.80^{b} ± 1.73	20.70^{c} ± 1.84	20.30^{d} ± 1.23	19.10^{e} ± 1.35	19.80^{e} ± 0.80
RBC (10^{6}/UL)	8-18	7.50^{a} ± 0.89	*6.20^{b} ± 0.65*	6.00^{b} ± 0.57	5.60^{c} ± 0.63	5.20^{c} ± 0.87	5.30^{c} ± 0.76	5.10^{c} ± 0.67
WBC (10^{9}/L)	4-13	4.80^{e} ± 0.68	*5.35^{e} ± 0.38*	6.30^{d} ± 0.43	7.60c ± 0.46	8.40^{b} ± 0.56	8.90^{b} ± 0.34	9.30^{a} ± 0.47
HB (g/dl)	7-15	11.70^{a} ± 0.43	*11.20^{a} ± 0.67*	10.50^{b} ± 0.58	9.70c ± 0.45	9.50^{c} ± 0.48	8.90^{c} ± 0.54	7.60^{d} ± 0.75
MCHC (g/L)	30-36	33.20 ± 0.06	*33.20 ± 0.48*	33.40 ± 0.52	33.60 ± 0.66	33.83 ± 0.67	33.85 ± 0.48	33.90 ± 0.53
MCH (pg	5.2-8	12.82^{a} ± 1.04	*12.51^{a} ± 0.23*	11.90^{b} ± 0.83	11.40^{b} ± 0.57	10.81^{c} ± 0.34	10.64^{c} ± 0.83	10.53^{c} ± 0.67
MCV (fl)	16-25	33.72^{a} ± 2.45	*30.14^{b} ± 2.13*	29.56^{c} ± 2.00	29.43^{c} ± 2.02	29.23^{c} ± 2.57	28.64^{d} ± 2.54	27.63^{e} ± 2.56
Lymphocyte (%)	50-70	58.36^{a} ± 2.23	*57.83^{a} ± 2.33*	56.82^{b} ± 2.54	53.85^{c} ± 2.43	48.82^{d} ± 2.46	45.13^{e} ± 2.34	45.00^{e} ± 2.14
Monocyte (%)	0-4	3.30 ± 1.37	*3.32 ± 1.34*	3.50 ± 1.46	3.44 ± 1.62	3.32 ± 1.53	3.23 ± 1.66	3.20 ± 1.54
Neutrophils (%)	30-48	33.82^{a} ± 1.32	*33.00^{a} ± 1.53*	29.87^{b} ± 1.45	26.02^{b} ± 1.68	25.83^{c} ± 1.47	22.50^{d} ± 1.58	22.00^{d} ± 1.63
Eosinophil (%)	1-8	3.83^{a} ± 0.31	*3.75^{a} ± 0.43*	3.00^{b} ± 0.23	3.23^{b} ± 0.43	2.74^{c} ± 0.53	2.45^{c} ± 0.64	2.35^{d} ± 0.37
After the experiment								
PCV (%)	22-38	24.70^{a} ± 1.44	21.50^{ab} ± 1.55	20.70^{ab} ± 1.84	20.50^{b}±1.88	18.70^{b} ± 1.10	17.50^{b} ± 1.31	18.70^{b} ± 0.78
RBC (106/UL)	7-18	7.20^{a} ± 0.91	5.90^{b} ± 0.55	6.80^{b} ± 0.46	5.00^{b} ± 0.55	4.60^{c} ± 0.76	4.20^{c} ± 0.86	4.50^{c} ± 0.57
WBC (109/L)	4-13	5.60^{e} ± 0.75	*6.02^{d} ± 0.73*	6.90^{d} ± 0.66	8.20^{c} ± 0.50	8.70^{c} ± 0.40	9.40^{b} ± 0.60	10.20^{a} ± 0.64
HB (g/dl)	7-15	10.60^{a} ± 0.92	*10.60^{a} ± 0.78*	9.80^{a} ± 0.51	9.00^{b} ± 0.70	8.70^{c} ± 0.85	8.10^{c} ± 0.75	6.50^{d} ± 0.74
MCHC (g/L)	30-36	33.40^{a} ± 0.30	*33.50^{a} ± 0.30*	33.50^{a} ± 0.60	33.80^{a} ±0.10	33.93^{a} ± 0.23	34.00^{b} ± 0.57	34.10^{b} ± 0.35
MCH (pg)	5.2-8	11.70^{a} ± 1.05	*11.40^{a} ± 0.10*	10.97^{b} ± 0.14	10.77^{b}± 0.71	10.40^{b} ± 0.46	10.13^{c} ± 0.57	10.00^{c} ± 0.71
MCV (fl)	16-25	33.13^{a} ± 2.59	*32.12^{a} ± 2.16*	31.27^{c} ± 2.80	31.13^{c} ± 2.03	31.00^{c} ± 2.61	30.53^{d} ± 2.01	30.25^{d} ± 1.90
Lymphocyte(%)	50-70	55.67^{a} ± 2.65	*55.50^{a} ± 2.08*	55.03^{a} ± 2.64	51.90^{ac} ± 2.55	46.47bc± 2.84	43.57^{b} ± 2.00	43.85$^{b\,c}$ ± 2.63
Monocyte (%)	0-4	2.44 ± 1.62	*3.17 ± 1.17*	3.43 ± 1.25	3.23 ± 1.40	3.17 ± 1.26	3.16 ± 1.40	3.14 ± 1.13
Neutrophils (%)	30-48	30.70^{ab} ± 1.69	*32.00^{a} ± 1.56*	27.03^{ab} ± 1.75	24.83^{ab} ±1.04	24.27^{ab} ± 1.24	21.67^{b} ±1.27	21.65^{ab} ± 0.49
Eosinophil (%)	1-8	3.20^{a} ± 0.53	*3.13^{a} ± 0.51*	2.90^{ab} ± 0.17	3.00^{ab} ± 0.00	2.30^{ab} ± 0.36	2.17^{b} ± 0.20	2.30^{ab} ± 0.00

abcde = means within the same row with different superscripts are significantly ($P<0.05$) different.
T1: 0% cocoa pod, 60% cassava pulp and 40% acacia leaf; T2: 10% cocoa pod, 50% cassava pulp and 40% acacia leaf; T3: 20% cocoa pod, 40% cassava pulp and 40% acacia leaf; T4: 30% cocoa pod, 30% cassava pulp and 40% acacia leaf; T5: 40% cocoa pod, 20% cassava pulp and 40% acacia leaf; T6: 50% cocoa pod, 10% cassava pulp and 40% acacia leaf; T7: 60% cocoa pod, 0% cassava pulp and 40% acacia leaf
*Reference ranges by Daramola et al. (2005); **Blood, et al. (2007).

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Table 2.
Serum Biochemical Parameters of West African Dwarf Goats fed combinations of cocoa pod and cassava pulp and Acacia leaves

Parameters	Range	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7	*P-value*
At the start of experiment									
Total Protein (g/dl)	51.0-74.5	$7.30^{a} \pm 0.52$	$6.90^{b} \pm 0.45$	$6.73^{b} \pm 0.06$	$6.52^{b} \pm 0.27$	$6.13^{bc} \pm 0.42$	$5.85^{c} \pm 0.35$	$5.70^{c} \pm 0.54$	0.001
Albumin (g/dl)	2.8-4.3	4.00 ± 0.01	3.92 ± 0.34	3.58 ± 0.64	3.45 ± 0.05	3.33 ± 0.57	3.17 ± 0.45	2.64 ± 0.63	0.210
Total Cholesterol (mg/dl)	65.0-136.0	80.90 ± 3.57	92.84 ± 3.46	102.22 ± 4.78	114.00 ± 5.54	121.5 ± 4.34	125.87 ± 5.49	127.35 ± 5.55	0.465
Sodium (mmol/L)	124.0-146.0	$136.00^{a} \pm 5.34$	$131.7^{a} \pm 5.47$	$118.83^{b} \pm 4.36$	$111.78^{b} \pm 4.42$	$108.37^{c} \pm 4.30$	$102.35^{c} \pm 4.56$	$101.10^{c} \pm 4.38$	0.000
Potassium(mmol/L)	0.8-9.7	4.97 ± 0.25	5.33 ± 0.65	5.50 ± 0.80	5.63 ± 1.01	5.83 ± 0.90	6.00 ± 0.85	6.50 ± 0.71	0.758
Urea (mg/dl)	12.6-27.0	16.90 ± 2.00	17.43 ± 2.11	18.00 ± 2.71	20.43 ± 3.44	23.47 ± 3.45	25.60 ± 3.56	26.85 ± 3.69	0.885
Glucose(mg/dl)	48.2-76.0	$38.20^{d} \pm 3.45$	$45.80^{c} \pm 4.30$	$51.40^{b} \pm 4.52$	$52.25^{b} \pm 4.65$	$58.11^{b} \pm 5.32$	$63.73^{a} \pm 5.67$	$68.70^{a} \pm 5.43$	0.040
Creatinine(mg/dl)	0.7-1.50	1.00 ± 0.12	1.82 ± 0.35	2.33 ± 0.54	2.46 ± 0.48	2.63 ± 0.52	2.70 ± 0.12	2.85 ± 0.54	0.180
AST (IU/L)	66-230	$95.30^{e} \pm 5.54$	$112.52^{d} \pm 5.43$	$115.33^{d} \pm 5.46$	$138.90^{b} \pm 6.45$	$143.3^{a} \pm 6.51$	$146.70^{a} \pm 6.23$	$148.70^{a} \pm 6.50$	0.001
ALT(IU/L)	2.0-221	$53.70^{d} \pm 3.45$	$74.71^{d} \pm 3.43$	$83.80^{c} \pm 3.54$	$95.52^{c} \pm 4.35$	$104.1^{b} \pm 5.42$	$115.40^{a} \pm 5.56$	$122.60^{a} \pm 5.67$	0.002
ALP (U/L)	61-283	$56.80^{e} \pm 3.67$	$61.81^{d} \pm 3.54$	$77.52^{c} \pm 3.45$	$85.55^{c} \pm 3.76$	$94.33^{b} \pm 3.45$	$105.20^{a} \pm 3.87$	$117.50^{a} \pm 3.89$	0.003
Inorganic Phosphorus (mg/dl)	3.38-5.70	$4.30^{c} \pm 0.05$	$4.53^{c} \pm 0.42$	$4.60^{c} \pm 0.54$	$7.50^{b} \pm 0.48$	$7.80^{b} \pm 0.32$	$7.92^{b} \pm 0.54$	$8.82^{a} \pm 0.43$	0.003
After the experiment									
Total Protein (g/dl)	51.0-74.5	$7.23^{a} \pm 0.06$	$6.67^{ab} \pm 0.40$	$6.50^{abc} \pm 0.20$	$5.90^{abc} \pm 0.56$	$5.60^{bcd} \pm 0.44$	$5.20^{cd} \pm 0.51$	$5.00^{d} \pm 0.99$	0.001
Albumin (g/dl)	2.8-4.3	3.70 ± 0.36	2.97 ± 0.83	2.77 ± 0.70	2.67 ± 0.67	2.40 ± 0.79	2.17 ± 0.81	2.10 ± 0.71	0.206
Total Cholesterol (mg/dl)	65.0-136.0	82.60 ± 3.99	97.77 ± 3.72	108.27 ± 5.32	123.00 ± 6.84	125.07 ± 6.25	128.70 ± 6.23	130.55 ± 5.35	0.460
Sodium (mmol/L)	124.0-146.0	$136.13^{a} \pm 5.61$	$121.17^{b} \pm 5.38$	$114.6^{bc} \pm 5.77$	$110.43^{cd} \pm 1.17$	$106.04^{d} \pm 2.3$	$100.40^{d} \pm 4.55$	$99.70^{d} \pm 2.98$	0.000
Potassium(mmol/L)	0.8-9.7	5.20 ± 0.65	6.00 ± 0.65	6.34 ± 0.50	6.75 ± 1.01	6.73 ± 0.90	6.80 ± 0.85	6.91 ± 0.71	0.753
Urea (mg/dl)	12.6-27.0	12.27 ± 0.33	14.25 ± 0.43	14.80 ± 0.50	17.40 ± 0.46	20.45 ± 0.34	22.20 ± 0.46	23.30 ± 0.05	0.883
Glucose(mg/dl)	48.2-76.0	$35.60^{a} \pm 3.15$	$41.60^{ab} \pm 4.89$	$48.47^{ab} \pm 4.82$	$50.77^{ab} \pm 5.34$	$55.53^{ab} \pm 5.37$	$60.50^{b} \pm 6.76$	$65.30^{ab} \pm 6.47$	0.035
Creatinine(mg/dl)	0.7-1.50	0.90 ± 0.17	1.47 ± 0.49	1.73 ± 0 .67	1.77 ± 0.71	2.10 ± 0.72	2.20 ± 0.70	2.30 ± 0.71	0.189
AST (IU/L)	66-230	$91.57^{a} \pm 6.12$	$104.67^{ab} \pm 7.8$	$111.73^{b} \pm 7.14$	$130.80^{c} \pm 7.31$	$136.1^{c} \pm 7.52$	$141.37^{c} \pm 8.30$	$143.20^{c} \pm 8.78$	0.000
ALT(IU/L)	2.0-221	$45.23^{a} \pm 3.16$	$64.93^{ab} \pm 4.39$	$73.96^{ab} \pm 4.42$	$86.70^{ab} \pm 5.91$	$94.77^{b} \pm 6.92$	$106.03^{b} \pm 6.44$	$104.60^{ab} \pm 6.4$	0.024
ALP (U/L)	61-283	$60.90^{a} \pm 3.63$	$79.63^{ab} \pm 4.41$	$93.77^{abc} \pm 5.82$	$99.73^{abc} \pm 6.63$	$111.53^{c} \pm 6.79$	$130.07^{c} \pm 6.30$	$131.10^{c} \pm 6.23$	0.001
Inorganic Phosphorus (mg/dl)	3.38-5.70	$5.43^{a} \pm 0.21$	$5.52^{ab} \pm 0.59$	$5.63^{abc} \pm 0.65$	$8.47^{bc} \pm 0.87$	$8.77^{bc} \pm 0.95$	$9.37^{bc} \pm 1.50$	$9.45^{d} \pm 0.91$	0.001

abcde= means within the same row with different superscripts are significantly ($P<0.05$) different.
T1: 0% cocoa pod, 60% cassava pulp and 40% acacia leaf; T2: 10% cocoa pod, 50% cassava pulp and 40% acacia leaf
T3: 20% cocoa pod, 40% cassava pulp and 40% acacia leaf; T4: 30% cocoa pod, 30% cassava pulp and 40% acacia leaf
T5: 40% cocoa pod, 20% cassava pulp and 40% acacia leaf; T6: 50% cocoa pod, 10% cassava pulp and 40% acacia leaf
T7: 60% cocoa pod, 0% cassava pulp and 40% acacia leaf
*Reference ranges by Daramola et al. (2005); **Blood, et al. (2007).

Such high PCV values had been regarded as healthy state and high productivity according to Addass et al. [17]. It was observed that feeding WAD goats with 0%-20% cocoa pod supplementation could probably return PCV to normal level as goat was the only animal with PCV higher than 22% [12, 13]. The low PCV values reported in combinations T4-T7 in the present study could have resulted from hepatic toxicity caused by high cocoa pod intake and high theobromine in the diets according to Adeyina [18]. The Hb values (7.33-11.15 g/dl) of the treatment groups were in the normal range (7-15 g/dl) reported by Tambuwal et al.[19] for WAD goats.

Recently, research indicated that cocoa pod can be developed and processed to be used in highly valuable feed stuffs [20]. At the end of the experiment, the major limitation of cocoa pod in this respect was the alkaloid and theobromine that had cumulative effect on livestock production system as in T4-T7 groups. The RBC count (4.9-7.87×10^6/µl) was also in the normal range of 7-18×10^6/µl. MCHC in this study (33.47-34.27 g/dl) was in the range of 30-36 g/dl reported by Blood et al. [13] and Daramola et al. [12]. The high MCV and MCH values recorded in the present study compared well with the values reported by-Anya [1]. MCH values recorded in the present study compared well with the values reported by Anya [1] who described high MCV as an indication of regenerative anaemia emanating from high destruction which led to erythropoiesis in the tissues.

WBC count of 5.57-6.9×10^9/l in 0%-20% cocoa pod inclusion corroborates the findings of Daramola et al. [12] and Anya [1]. This implied that goats on diets T1-T3 remained clinically healthy as indicated by researchers [21] and animals had good immune system against any foreign body in the circulatory system. WBC played a prominent role in disease resistance, especially regarding antibody generation. High WBC values in T4-T7 have been associated with the toxicity of diets or poor detoxification process as the WBC is responsible for fighting foreign substances in the body [22]. In addition, lymphocytes and neutrophils in this study fell within the broad range of 50%-70% and 30%-48% as reported by Daramola et al. [12], respectively.

Biochemical indices contributed to the knowledge of metabolic profile in feedlots performance o WAD goats and their possible disorders according to Oloche [23]. Total protein and albumin showed a consistently raising trend from the first to the last treatment level (T1-T7). The difference was significant for the former and non-significant for the later parameter, showing it to be healthy to add ensiled cocoa pod to the diet of goats instead of cassava pulp. Total protein and albumin decreased with increasing cocoa pod and differences in the values were significant at widely variable ratios of the feed inputs. Total protein in diets T1-T3 (6.5-7.23 g/dl) were comparable to the normal protein range for WAD goats (6.4-7.5 g/dl) as reported by Dhanotiya [24]. The differences in protein values were suggestive of the influence of feeds on the feed intake of goats according to Anya [1]. Albumin in this study (2.1-3.7 g/dl) was similar to 3.3 g/dl reported by Ibrahim et al. [25]. Therefore, it can be affirmed that protein on combinations T1-T3 was of good quality to meet the nutritional needs of the animals.

The cholesterol content was the highest and lowest in T7 (127.55 mg/dl) and T1 with no cocoa podinclusion (82.6 mg/dl), respectively. It can be attributed to the cholesterol-reducing ability of protein supplement in T1 used in the present study. These comparable values of cholesterol suggested that the meat from the experimental animals of the T1-T3 groups was safe for consumption according to Igwebuike et al. [26] who reported that serum cholesterol is associated with the quantity and quality of protein supplied in the diet. The results about glucose agreed with thenormal range of 50-75 mg/dl for goats reported byDhanotiya [24]. The glucose concentrations rose sig-nificantly showing a consistent upward trend with the increase in the cocoa pod from 0% (T1) to 60% (T7). Consequently, it appeared plausible to infer that the observed higher serum glucose concentrations in diet combinations T4 (5.77 mg/dl) to T7 were due to cocoa pod intoxication. ALT, AST, and ALP levels increased steadily across T1-T7. The high values in T5-T7 suggested severe liver injury.

Based on the haematological indices and serum-biochemistry, it may be concluded that ensiled cocoa pod, cassava pulp, and acacia leave up to a ratio of 20:40:40 can serve as a sustainable feedstuff for dwarf goats, especially during the dry season without adverse effects. These diets would be rich in nutrients and highly digestible and could meet the nutrient requirements for the growth and maintenance of these animals.

Materials and Methods

Experimental Site

The current study was carried out at the Teaching and Research Farm of the Department of Animal Sciences, Landmark University, Omu Aran, Kwara State, Nigeria.

Animals and Study Design

A total of 28 WAD goats (bucks) aged 4-5 months with an average body weight of 7 ± 0.2 kg were prepared from the local livestock market in Ekiti. Previously, the nutritional properties of 30 silage samples prepared from the combinations of cocoa pod, cassava pulp, and acacia leaf had been evaluated. Based on the obtained results, the best seven dietary combinations of cocoa pod, cassava pulp, and acacia leaf were chosen for the present experiment. They were designated as T1, T2, T3, T4, T5, T6, and T7 as presented in Table 3. Diet T1 was a positive control and contained no cocoa pod, while T7 was the negative control with no cassava pod. Diets T2, T3, T4, T5, and T6 contained 10%, 20%, 30%, 40%, and 50% of cocoa pod and 50%, 40%, 30%, 20%, 10% of cassava pulp, respectively. The animals were allotted to seven dietary treatments after 14 days of acclimatization in a completely randomized design with four animals per treatment under an intensive management system. One goat was penned individually and replicated four times.

Experiment Procedure

Experimental Diets

Silage Preparation

Theobroma cacao (cocoa pods) was collected from a reputable cocoa farm and was sundried to reach a moisture content of 37% and pounded (using mortar and pestle) to an average size of 0.6 cm^2. Cassava pulp was obtained from a cassava processing farm and was sundried to a moisture content of 37% as described by Olawoye [27]. Moreover, acacia leaves were harvested from the pasture plants of the Teaching and Research Farm of the institution. The legume was allowed to wilt in the open air for a day and thereafter chopped at 2-3 cm. The purpose of chopping and compacting the diets for silage was to ensure that all the air was pushed out of the plant material so that when the bag was sealed, the ensiled materials would be free of air. The wilted chopped acacia leaf, cocoa pod, and cassava pulp were mixed with overripe banana (Musa spp.) slurry at the rate of 5% of the weight of the diets. Uniform compaction was ensured until the bags were filled and tightly tied packed in a polythene bag and were put inside plastic bags of 20 liters and ensiled at 37°C as described by Olawoye [27]. Afterwards, each plastic was compacted with a 20 kg weight to remove air and create an anaerobic condition until the expiration of fermentation (7 weeks).

Feeding Trials and Laboratory analysis

The animals were housed in well-ventilated pens in an open-sided housing system with corrugated aluminum roofing sheets and concreted slatted floors. The pen was fumigated with Izal solution two weeks prior to the experiment. All the goats were weighed and randomly allotted to different dietary groups individually (Table 3). The animals were dewormed by anthelmintic (super ivermectin) according to their body weight and were sprayed with acaricide (parannex) against external parasites. The goats were fed experimental diets early in the morning (8:00 am) and had access to fresh drinkable water ad libitum during the experimental period. Daily feed offered and refusals were recorded to compute feed intake. The weight parameters were already published in one article under growth parameters. The feeding trial was carried out for 45 days due to the toxicity of the high concentration of cocoa pod which led to the mortality of some animals on diets T4-T7. The possible cause was increased toxic substance due to high theobromine concentration in the diets. In these groups, about 50% of animals died, while there was no record of death in animals on diets T1-T3 because of the minimal inclusion of cocoa pod.

Blood was collected two weeks after dietary adaptability as a baseline sample and experiment termination to determine the effects of the diets at the beginning of the experiment and after the ingestion of diets. Two sets of jugular vein blood samples (10 ml) were taken from each animal per treatment using a syringe and needle into clean bottles. One set was introduced in tubes containing anticoagulant ethylene diamine tetraacetate to evaluate haematological parameters, while the second set of blood samples was in clean bottles devoid of anticoagulant for assessing serum biochemical parameters. All haematological and serum biochemical factors were measured in triplicates using the methods of Al-Eissa and Alkahtani [28]. The PCV was determined by the Hawskey microhematocrit method [29]. The Hb concentration was measured spectrophotometrically by the cyanmethemoglobin method [30] using an SP6-500UV spectrophotometer (PYE, UNICAM, England). RBC, as well as total and differential WBC counts were assessed by the hemocytometer method [29] using improved Hawskey hemocytometer. MCV, MCHC, and MCH

Table 3.
Dietary Composition and Calculated Nutrients of combinations of cocoa pod, cassava pulp and Acacia leaf to WAD Goats (%)

Feedstuffs (%) Control							
	Diet 1	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	**Diet 6**	**Diet 7**
Cocoa pod	00.0	10.0	20.0	30.0	40.0	50.0	60.0
Cassava pulp	60.0	50.0	40.0	30.0	20.0	10.0	00.0
Acacia leaf	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Acacia leaf	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Chemical Composition of the experimental diets (% Dry matter)							
Dry matter	65.08	60.43	73.19	79.07	71.00	82.58	60.23
Moisture Content	34.92	39.57	26.81	20.93	29.00	17. 42	39.77
Crude Protein	12.51	11.23	11.91	13.17	12.07	12.05	13.20
Crude fibre	5.18	7.85	15.66	12.23	11.68	9.91	5.07
Ether Extract	18.10	13.31	18.53	23.12	17.61	24.58	16.30
Ash	2.46	2.75	6.14	8.77	5.78	8.50	3.44
Nitrogen free extract	39.31	36.49	35.05	36.72	35.90	39.55	35.39

were calculated based on PCV, Hb, and RBC [29].

The serum biochemical factors were measured using commercial kits (Randox, England) and a UV spectrophotometer (Jenway Spectrophotometer 6305, England). Serum ALT activity, ALP activity, total protein, albumin, urea, creatinine, andcholesterol were measured by the Reitman-Frankel [31], phenolphthalein monophosphate [32], direct Biuret [33], Bromocresol green [34], modified Berthelot-Searcy [35], modified Jaffe methods [36], and cholesterol oxidase-peroxidase method [37], respectively. Furthermore, sodium and potassium concentrations were measured using the flame photometer (Corning model 400, Corning Scientific Ltd, England) [38] and and phosphorus was determined using spectrophotometer (Biokom, Warsaw, Poland)according to Bauer [39].

Data Analysis

The data obtained from the blood parameters were subjecte to standard methods of statistical analysis using windows based SPSS (Version 20.0) [40]. The one-way analysis of variance was used and the level of significance was set at $p < 0.05$.

Declarations

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Animal Welfare Statement

Ethics approval

The authors confirm that the ethical policies ofthe journal, as noted in the journal authors guide lines, have been adhered to. Approval to perform the research and use animals was obtained from the Ethics Committee of the University of Ilorin, Kwara State, Nigeria.

Authors' Contributions

C.O.R and A.A.A conceived and planned the experiments. Both authors participated in design and coordination. C.O.R performed the experiments, contributed to sample preparation, interpreted the results, and took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analyze, and write the manuscript.

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Competing Interests

The authors declare that there is no conflict of interest.

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