ISSN 1819-1878

Asian Journal of Animal Sciences

http://knowledgiascientific.com

Knowledgia SCIENTIFIC
A Place to Publish Outstanding Research

OPEN ACCESS Asian Journal of Animal Sciences

ISSN 1819-1878
DOI: 10.3923/ajas.2022.1.9

Research Article
Estimation of Chemical Composition and Digestibility of Rabbits Fed on Cocoa Pod Husk Treated with Various Plant Ash Extract

[1]Kana Sagne Augustin Derrick, [1,2]Defang Henry Fualefac, [1]Mube Kuietche Hervé, [1]Matho Amandine, [1]Mouchili Mama and [1]Ebile Dayan Agwah

[1]Department of Animal Production, Faculty of Agronomy and Agricultural Sciences, University of Dschang, P.O. Box 222,Dschang, Cameroon
[2]Faculty of Agriculture and Veterinary Medicines, Government Technical Teachers Training College, Kumba, University of Buea, P.O. Box 249, Buea Road, 237 Kumba, Cameroun

Abstract

Background and Objective: Forage is the main source of fiber in herbivorous diet, in the context of sustainable development, valorization of agricultural by product is a huge priority. Current article deals with the study of banana plantain ash (ECB) and bean haulms (ECH) extracts on cocoa pod husk and measured its effect on chemical composition and digestibility in rabbits. **Materials and Methods:** A total of 64-six months old local breed rabbits of average weight 3000±155 g were randomly distributed into 8 experimental rations in a complete randomized designed with 8 rabbits per replicate and each rabbit served as experimental unit. From the control ration T (0-) without cocoa pod husks and T (0+) ration with untreated hulls, six other rations of which three (BT1, BT2, BT3) were formulated with hulls treated with extracts of ash from banana plantain leaves and three others (HT1, HT2, HT3) treated with bean haulms at respective concentrations of 7.5, 10 and 12.5 kg/100 L of water for 12 hrs. **Results:** The results revealed that treatment with as extract lead to a decrease in NDF, ADF, crude proteins and lipids as compared to the control (T0) without treatment. In contrary the level of crude fiber increases with ash treatment. The levels of theobromine and tannin decreases with increasing concentration of ash. Digestibility of CP, NDF, ADF was significantly higher ($p<0.05$) in animals fed rations containing treated hulls compared to those fed with untreated hulls (T0+). **Conclusion:** Results of this study concluded that ash extract from bean haulms at 12.5% concentration could be used in the treatment of cocoa pod husks to improve its digestibility by rabbits.

Key words: Agricultural waste, chemical composition, cocoa pod husks, digestibility, rabbit

Citation: Derrick, A.K.S., D.H. Fualefac, M.K. Hervé, M. Amandine, M. Mama and E.D. Agwah, 2022. Estimation of chemical composition and digestibility of rabbits fed on cocoa pod husk treated with various plant ash extract. Asian J. Anim. Sci., 16: 1-9.

Corresponding Author: Mube Kuietche Hervé, Department of Animal Production, Faculty of Agronomy and Agricultural Sciences, University of Dschang, P.O. Box 222, Dschang, Cameroon Tel: +237 233 45 13 81

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Diet is most often the main limiting factor in the production potential of animals in tropical environments[1]. The cost of feed corresponds to nearly 70% of the production cost in intensive farming[2]. For herbivorous monogastrics such as rabbits, the diet may consist mainly of forage[3]. However, this method of feeding is generally reserved for small-scale farming[2], because of the difficulties associated with storing the forage, its fermentation or the presence of aflatoxins produced by molds[4]. With regard to intensive livestock production, it is recommended to use granulated feed, which, in addition to being complete and balanced, offers a longer storage period compared to forages[3]. However, the design of granulated feed obeys certain requirements relating to the nutritional needs of the rabbit. Rabbits need in addition to proteins, lipids, carbohydrates, vitamins and minerals from dietary fibers which have the role of providing energy, ensuring balance of the intestinal microbiota and promoting the development of the digestive tract which improves production performance[5]. This is the reason why agro-pastoralists are looking for sources of cellulose other than fodder that can be incorporated into this type of feed in order to allow rabbit breeders to practice large-scale breeding. Agricultural by-products such as cocoa pod husk (*Theobroma cocoa*) can be used as potential alternatives. Cocoa pod husk are available feed resources with the capacity to produce much conventional feeds. They represent 52-56% of ripe cocoa pod. Cameroon between 2018-2019 produce around 245,000 tonnes of cocoa with availability in shell of nearly 140,000 tonnes[6]. However, after harvest, they are generally left in the fields without valorization no matter their nutrients content (Crude protein 6.8-10% DM; lipid 1.5-2% DM; carbohydrate 32-46.6% DM; crude fiber 24-35.4% DM; minerals 6.4-8.4% DM[7,8]. Several studies have shown that they can be effectively used in the feed of broilers[9], pigs and fish[8], rabbit[10]. However, the high rigidity of their walls, as well as the presence of anti-nutritional factors (tannins and theobromine) still limit their use in animal feed. The effects of cocoa pod husk on growth performance and hematological parameters of rabbits, feeding rabbits with cocoa pod husk greater than 20% decrease live weight and weight gain[10,11]. They attributed this decline to poor digestibility and the presence of anti-nutritional factors. They also observed a decrease in the level of red blood cell in rations containing cockles which could be the attributed decrease in presence of tannins that have the ability to form complexes with iron atoms; which are building blocks of hemoglobin. According to Asmaand Mohmed[12], it is possible to weaken the plant walls by treatment with ash extracts. This work revealed that the cell walls content (NDF) of rice straw treated with banana ash extracts was lower compared to that of untreated straw. This is explained by the fact that the constituents of the cell wall of the straw were attacked during the treatment; which led to the weakening of the wall through the breaking of the ester bonds between lignin-hemicellulose -cellulose; therefore, allowing better results in digestibility. Likewise, ash extracts as alkaline solutions can also allow significant elimination of anti-nutritional factors (tannins, theobromine) present in these hulls as reported by D' Mello *et al.*[13].Therefore, cocoa pod husks after treatment with ash extracts can be used as source crude fiber by rabbit breeders in intensive rabbit. The purpose of this study was to determine the best ash extracts for the treatment of cocoa pod husks through digestibility study with by rabbits.

MATERIALS AND METHODS

Area of study: This study was conducted at the Animal Nutrition and Production Research Unit (URPRONAN) of the University of Dschang. It is located at an altitude of 1420 m above sea level, between latitude 05°26'N and longitude 10°26'E. The climate of the region is equatorial of Cameroonian type with the rainy season that last from mid-March to mid-November and the dry season from mid-November to mid-March[14]. Rainfall varies between 1,500 and 2,000 mm per year and temperatures range from 14°C (July-August) to 25°C (February) with an average temperature of about 21°C. The average annual insolation is 1873 hrs and the average relative humidity is 76.8%.

Preparation of ash extracts and treatment of cocoa pod husk: The ash extracts were obtained according to the method of Rahman[14]. Banana-plantain leaves and bean haulms were harvested and burn to ashes. The ashes obtained were sieved and dissolved in water at different concentrations of 7.5, 10 and 12.5 kg/100 L of water. The mixtures were homogenized and left to stand for 48 hrs. The resulting solutions were filtered to obtain ash extracts.

1 kg of previously chopped cocoa pod husk collected from Penja (Mongo division) was soaked in 5 L of extract solutions for 12 hrs. The husks were then sun-dried to constant weight, crushed and stored in large air-tied plastic bags from which samples were collected for bromatological analyzes.

Experimental diet and management: A total of 64-six months old local breed, rabbits of average weight 3000±155 g were used in this study. The animals were housed in wired cages made of metal measuring 97×46×26 cm placed in a well-

Table 1: Composition (%) of digestibility rations

	Rations							
Ingredients (%)	T0-	T0+	BT1	BT2	BT3	HT1	HT2	HT3
Red corn	25.00	24.00	26.50	25.00	26.50	26.00	25.50	26.00
WheatBran	17.00	3.50	3.00	3.00	2.50	3.00	3.00	3.00
Rice bran	17.00	17.50	16.00	16.00	15.00	16.50	15.50	15.00
Cocoa pod husk	0.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Trypsacum L	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cotton cake	6.00	8.00	8.00	8.50	8.50	8.00	8.50	8.50
Soybean meal	6.00	8.50	8.50	9.00	8.50	9.00	8.50	8.50
Palm kernel cake	11.50	12.50	12.00	11.50	11.50	10.00	11.50	11.50
Fishmeal	2.00	2.00	2.00	2.00	2.50	2.50	2.50	2.50
Shell	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Palm oil	2.50	3.00	3.00	4.00	4.00	4.00	4.00	4.00
Premix 0.5%	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Analyzed chemical composition								
Crude protein (%)	16.49	16.12	16.03	16.00	16.03	16.01	16.04	16.04
ME (Kcal kg^{-1})	2443.75	2414.57	2401.14	2413.01	2401.45	2409.53	2409.66	2402.21
Crude fiber (%)	13.47	13.01	13.02	13.06	13.07	13.06	13.21	13.22

*Composition of the premix: Vit A: 3,000.000IU, Vit D: 50,0000IU, Vit E: 6,000 mg, Vit K: 600 mg, Vit B1: 600 mg, Vit B2: 800 mg, Vit 3: 1800 mg, Vit B6: 400 mg, Vit12: 6 mg, Folic acid: 250 mg, Nacine: 600 mg, Cl: 86,500 mg, Fe: 12,000 mg, Cu: 1200 mg, Mn: 12,000 mg, Zn: 10,000 mg, I: 100 mg, Se: 40 mg, Mg: 3397 mg, Na: 283 mg, Ca: 215.166 mg, Methionine: 130,000 mg, Lysine: 50,000 mg, ME: Metabolizable energy

ventilated room. They were randomly distributed into 8 experimental rations in a complete randomized designed with 8 rabbits per treatment and each rabbit served as experimental unit. From the control ration T (0-) without cocoa pod husks and T (0+) ration with untreated hulls, six other rations of which three (BT1, BT2, BT3) were formulated with husks treated with extracts of ash from banana-plantain leaves and three others (HT, HT2, HT3) treated with bean haulms at respective concentrations of 7.5, 10 and 12.5 kg/100 L of water (Table 1). Feed and water were served ad libitum throughout the test period. At the start and end of the study, the building, cages, feeders and drinkers were thoroughly washed and disinfected. They animals received anti-stress before and after each manipulation and anti-coccidian (amproline). A digestibility device was used to collect faeces and urine.

Feed intake and digestibility assessment of rations: Feeds was served every morning at 7:00 am. The quantity of feed served was registered and the left over was collected daily and weighed before any new distribution.Weekly feed intake was calculated as the difference between the amount of feed distributed during the week and the leftover collected at the end of the same week.

The digestibility test followed a 7 days adaptation period of the animals to digestibility cages and pelleted rations. During this period, the amounts of feed served was adjusted to the estimated consumption of 150 g/animal/day. Data was collected, each morning within a period of seven days, faeces and urine were collected, then faeces were weighed and dried at 60°C in a ventilated oven. Analysis of Dry Matter (DM), Organic Matter (OM), Crude Protein (CP) Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Crude Fiber (CF) content was carried out according to the method described by AOAC (2000). The apparent digestibility coefficients of dry matter, organic matter, crude proteins and crude fiber were calculated according to the formula of Roberge and Toutain:

$$\text{Digestibility (\%)} = \frac{\text{Nutrient intake (g)-Nutrient excreted in faeces (g)}}{\text{Nutrient intake (g)}} \times 100$$

Statistical analysis: Data collected on feed intake and nutrient digestibility whose rations contained treated cocoa pod husks were subjected to 2 way-analysis of variance (source and concentration of ash) following the general linear model of statistical package for social science (SPSS.21.0) software. where significant differences existed between treatments, the mean were separated by the Waller Duncan's test at 5% significance level.

RESULTS

Effects of treatment with ash extracts from banana-plantain leaves and bean haulms on bromatological composition of cocoa pod husk: The effects of treatment with extracts of ash from banana-plantain leaves and bean haulms on the bromatological composition of cocoa hulls shows that,

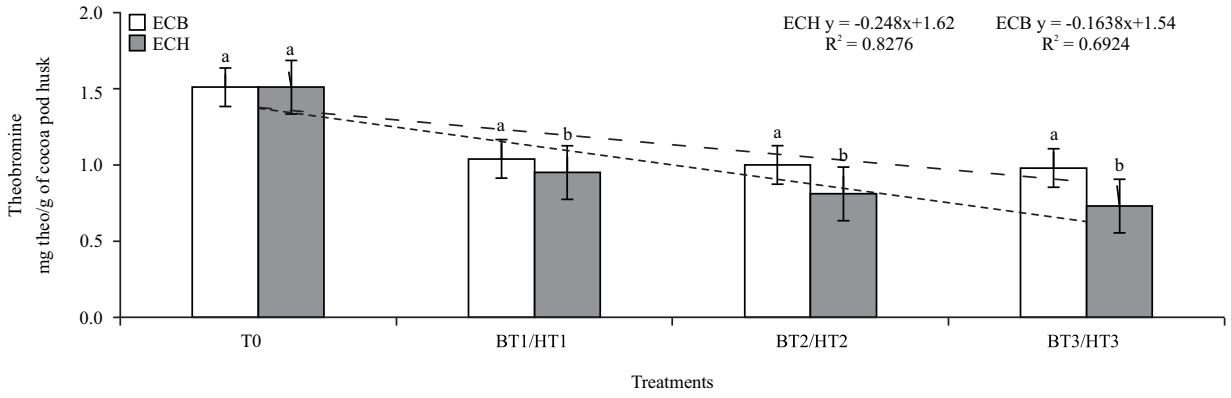

Fig. 1: Theobromine level of cocoa pod husk as affected by ash sources and concentrations

ECB: Cocoa pod husk treated with extracts of banana-plantain ash, ECH: Cocoa pod husk treated with extracts of bean haulms ash, Mg: Milligram, g: Gram. T0: Untreated cocoa pod husk, BT1/HT1: Cocoa pod husk treated with extracts of banana-plantain ash/bean haulms (7.5%), BT2/HT2: Cocoa pod husk treated with extracts of banana-plantain ash/bean haulms (10%), BT3/HT3: Cocoa pod husk treated with banana-plantain ash extracts/bean haulms (12.5%)

Table 2: Effects of treatment with extracts of ash from banana-plantain leaves and bean haulms on the bromatological composition of cocoa pod husks

Bromatological composition	Ash extract	Cocoa pod husk			
		T0	BT1/HT1	BT2/HT2	BT3/HT3
DM (%)	Banana plantain	92.92	91.22	88.43	91.27
	Bean	92.92	89.47	86.70	92.04
OM	Banana plantain	87.33	86.43	84.04	83.14
	Bean	87.33	83.35	82.94	84.27
Ash	Banana plantain	12.67	13.57	15.96	16.86
	Bean	12.67	16.65	17.06	15.73
CP	Banana plantain	6.47	6.39	5.11	5.10
	Bean	6.47	5.48	5.00	4.57
Lipid	Banana plantain	1.41	1.00	0.88	0.73
	Bean	1.41	0.98	0.70	0.65
NDF	Banana plantain	75.80	73.60	69.20	67.00
	Bean	75.80	71.40	68.80	66.80
ADF	Banana plantain	62.10	47.40	46.20	45.60
	Bean	62.10	46.20	45.80	44.60
CF	Banana plantain	23.89	25.36	25.65	26.84
	Bean	23.89	25.05	25.15	27.42

T0: Untreated cocoa pod husk, BT1/HT1: Cocoa pod husk treated with banana ash extracts-plantain/bean haulms (7.5%), BT2/HT2: Cocoa pod husk treated with banana-plantain ash extracts/bean haulms (10%), BT3/HT3: Cocoa pod husk treated with extracts of banana-plantain ash/bean haulms (12.5%). DM: Dry matter, OM: Organic matter, CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, CF: Crude fibers

regardless of the source of extract used and content the NDF (Neutral Detergent Fiber), ADF (Acid Detergent Fiber), crude protein (PB), lipid, decreased with increasing level of treatment with ash while crude fiber content increased with the increasing level of treatment Table 2.

Effects of treatment with extracts of ash from banana-plantain leaves and bean haulms on theobromine concentration in cocoa pod husks: The effects of extracts of ash from banana-plantain leaves and bean haulms on theobromine level was shown in Fig. 1. It appears that irrespective of the source of extract used, a decrease in the level of theobromine with increasing level of treatment was recorded. Hence, cocoa pod husk treated with bean ash extracts at 12.5% recorded the lowest value for this element (0.73 mg g^{-1}).

Effects of treatment with extracts of ash from banana-plantain leaves and bean haulms on tannin content in cocoa pod husks: Regardless of source of extract used, we observe a decrease in the level of tannin with increasing level of treatment. Moreover, cocoa pod husks treated with extracts of ash from bean haulms recorded the lowest level of tannin compared to those treated with extracts of ash from banana

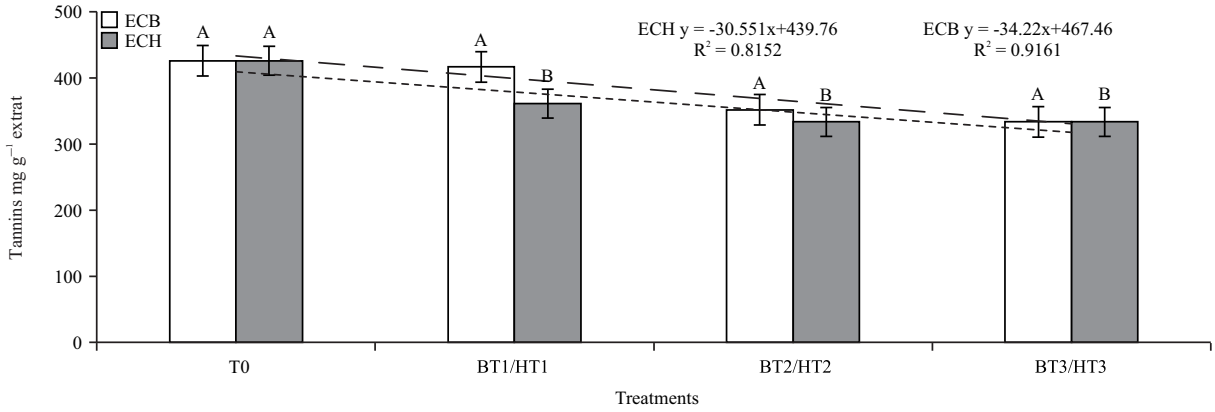

Fig. 2: Tannins level of cocoa pod husk as affected by ash sources and concentrations

ECB: Cocoa pod husk treated with extracts of banana ash-plantain, ECH: Cocoa pod husk treated with extracts of bean leaf ash, Mg EAT: Milligram of tannic acid extracts, g: Gram. T0: Untreated cocoa pod husk, BT1/HT1: Cocoa pod husk treated with extracts of banana-plantain ash/bean haulms (7.5%), BT2/HT2: Cocoa pod husk treated with extracts of banana-plantain ash/bean haulms (10%), BT3/HT3: Cocoa pod husk treated with banana-plantain ash extracts/bean haulms (12.5%)

Table 3: Effects of treatment of cocoa pod husk shells with extracts of ash from banana leaves and bean haulms on the dietary intake of DM, OM, CP, NDF, ADF and CF in rabbits

Ingestion (g day^{-1})	Control		Ash extract	Ash concentrations (%)		
	T0-	T0+		BT1/HT1	BT2/HT2	BT3/HT3
DM	106.76±4.56^{b}	107.66±2.78^{b}	Banana plantain	105.82±2.78^{bA}	106.32±0.92^{bA}	116.01±6.76^{aA}
			Bean	112.32±4.64^{aA}	112.61±1.84^{aA}	112.90±0.93^{aA}
OM	93.05±4.100^{a}	95.94±2.40^{a}	Banana plantain	93.11±2.45^{abA}	91.31±0.79^{bA}	98.93±5.77^{aA}
			Bean	96.66±3.99^{aA}	96.80±1.58^{aA}	96.88±0.49^{aA}
CP	15.88±0.67^{b}	15.05±0.03^{c}	Banana plantain	15.92±0.55^{bA}	18.71±0.24^{aA}	18.67±0.36^{aA}
			Bean	16.76±0.61^{abA}	17.73±1.14^{aA}	18.00±0.89^{aA}
NDF	82.62±0.88^{a}	80.20±1.53^{ab}	Banana plantain	78.89±2.18^{bA}	78.48±1.01^{bA}	75.37±1.11^{cA}
			Bean	77.27±0.79^{cA}	75.01±0.59^{dA}	71.63±1.25^{eA}
ADF	36.30±1.55^{a}	32.73±0.84^{b}	Banana plantain	37.03±0.97^{aA}	36.99±0.74^{aA}	32.33±1.47^{bA}
			Bean	33.99±4.39^{aA}	33.23±0.41^{aA}	32.69±2.32^{aA}
CF	25.78±1.10^{a}	25.78±0.66^{a}	Banana plantain	25.18±0.66^{aA}	25.79±0.22^{aA}	26.91±1.57^{aA}
			Bean	26.95±1.11^{aA}	27.25±0.44^{aA}	27.32±0.22^{aA}

a-e: Means on the same row with the same superscripts do not differ significantly (p>0.05). A, B: The means with the same superscripts in the same column for the same component are not significantly different (p>0.05).T0-: 0% cocoa pod husk, T0$_{+}$: 20% untreated cocoa pod husk, BT1/HT1: 20% cocoa pod husk treated with extracts of banana ash-plantain/bean haulms (7.5%), BT2/HT2: 20% cocoa pod husk treated with extracts of banana ash-plantain/bean haulms (10%), BT3/HT3: 20% cocoa pod husk treated with banana ash extracts-plantain/bean haulms (12.5%)

-plantain leaves (Fig. 2). The high correlation coefficient recorded (81 and 91%, respectively for banana and beans extract) materialize the fact variation in tannin content are mainly related to ash extract.

Effects of treatment with extracts of ash from banana-plantain leaves and bean haulms on the dietary intake of DM, OM, CP, NDF, ADF and CF: The effect of ash extract on nutrient intake was summarized in Table 3. The ingestion of dry matter and crude proteins were significantly (p<0.05) higher for the animals subjected to rations containing treated hulls as compared to the animals of the control group (T0+). A significantly (p<0.05) lower ingestion of NDF was recorded in animals fed rations containing treated cocoa pod husk compared to the animals of the control groups. The same observation was made as regard to the rations containing hulls treated with ash extract from bean haulms. Crude protein intake was significantly (p<0.05) higher with animals fed rations containing treated hulls compared to those in the group control and significantly lower intake of NDF in animals fed rations containing treated hulls compared to those of the control treatment. The ingestion of dry matter was not significantly different (p>0.05) between the different rations. Furthermore, there was no significant difference (p<0.05) in the intake of hulls treated with ash extracts of banana-plantain leaves compared to those treated with extracts of bean haulms.

Table 4: Effects of the treatment of cocoa pod husk shells with extracts of ash from banana-plantain leaves and bean haulms on the digestibility of DM, OM, CP, NDF, ADF and CF in rabbits

	Control			Ash concentrations (%)		
Digestibility (%)	T0-	T0+	Ash extract	BT1/HT1	BT2/HT2	BT3/HT3
DM	67.08±1.43^{a}	66.94±0.92^{a}	Banana plantain	66.20±1.04^{aA}	66.66±0.14^{aA}	66.43±1.69^{aA}
			Bean	65.22±1.90^{aA}	66.73±1.13^{aA}	65.72±1.24^{aA}
OM	67.94±1.49^{a}	65.60±1.45^{a}	Banana plantain	65.10±1.45^{aA}	60.58±3.93^{bA}	59.63±0.27^{bA}
			Bean	59.31±0.44^{dA}	63.24±1.03^{cA}	67.49±0.97^{abA}
CP	76.89±1.18^{a}	65.66±2.21^{c}	Banana plantain	72.92±0.26^{bB}	73.00±0.89^{bA}	71.85±2.21^{bA}
			Bean	73.96±2.04^{abA}	71.99±1.97^{bA}	74.85±1.08^{abA}
NDF	66.25±0.70^{a}	52.83±2.09^{d}	Banana plantain	56.88±1.92^{cB}	60.82±1.23^{bA}	65.59±0.67^{aA}
			Bean	63.25±0.43^{cA}	66.47±0.72^{bA}	70.84±1.39^{aA}
ADF	34.69±1.04^{a}	26.73±1.02^{d}	Banana plantain	29.31±1.60^{cA}	31.82±1.46^{bA}	34.19±0.55^{aA}
			Bean	30.83±0.86^{cA}	33.09±0.93^{bA}	36.03±0.45^{aA}
CF	62.50±2.21^{bc}	61.34±3.28^{c}	Banana plantain	66.02±1.88^{abA}	68.47±1.55^{aA}	68.53±2.01^{aA}
			Bean	67.45±1.09^{aA}	67.77±0.408^{aA}	69.94±0.66^{aA}

a-d: Means on the same row with the same superscripts do not differ significantly ($p>0.05$). A, B: The means with the same superscripts in the same column for the same component are not significantly different ($p>0.05$).T0-: 0% cocoa pod husk, $T0_{+}$: 20% untreated cocoa pod husk, BT1/HT1: 20% cocoa pod husk treated with extracts of banana ash-plantain/bean haulms (7.5%), BT2/HT2: 20% cocoa pod husk treated with extracts of banana ash-plantain/bean haulms (10%), BT3/HT3: 20% cocoa pod husk treated with banana ash extracts-plantain/bean haulms (12.5%)

Effects of treatment with extracts of ash from banana-plantain leaves and bean haulms on digestibility of DM, OM, CP, NDF, ADF and CF: The effects of treatment of cocoa pod husk with extracts of ash from banana-plantain leaves and bean haulms on digestibility of DM, OM, CP, NDF, ADF and CF in rabbits were summarized in Table 4. It appears that for rations containing hulls treated with ash extracts of banana-plantain leaves, digestibility of CP, NDF, ADF were significantly higher ($p<0.05$) in animals fed rations containing hulls treated compared to those fed on rations containing untreated hulls. However, it should be noted that the animals fed rations containing hulls treated with 12.5% ash extracts from banana-plantain leaves had higher digestive utilization coefficients of NDF, ADF and CF compared to hulls treated with lower concentrations of ash extract.

As for the hulls treated with extracts of ash from bean haulms, digestibility of CP, NDF, ADF were significantly higher ($p<0.05$) in animals fed rations containing treated hulls compared to those whose rations contained untreated hulls; Similarly, the animals fed rations containing hulls treated with 12.5% extracts of ash from bean haulms had higher digestive utilization coefficients of NDF, ADF, CF and CP compared to hulls treated with lower concentrations of ash extract. No significant difference ($p>0.05$) on the digestibility of rations was observed among rabbits fed treated diets. However, the digestive utilization coefficients of PB, NDF, ADF and CF, although not significant, were numerically higher for animals fed rations containing hulls treated with extracts of ash from bean haulms at 12.5%.

DISCUSSION

The effects of the treatment with extracts of ash from banana-plantain leaves and bean haulms on the composition of cocoa husks revealed that, irrespective of the source of extract used, there was a decrease in NDF content. NDF (Neutral Detergent Fiber), ADF (Acid Detergent Fiber) crude protein and fat whereas crude fiber levels increase with increasing level of ash extract treatment. The decrease in NDF, ADF and increased in crude fiber level with the increasing level of ash extract treatment could be explained by the fact that, ash extracts through their alkaline power could have broken the ligno-cellulosic bonds contained in the cell walls of cocoa pod husk. These results were similar to those of Ozung *et al.*[15] who obtained a reduction in NDF, ADF levels with cocoa pod husk treated with hot water. They were also similar to of Chounna *et al.*[16] who obtained a decrease in NDF with rice straw treated with different concentration of extracts of ash from banana-plantain leaves and bean haulms. The observed reductions in crude protein and fat content in this study could be due to their solubilization and their leaching by the ash extract solution. These results were in agreement with those of Ogana *et al.*[17] and Olugusi *et al.*[18] who obtained a decrease in lipid levels with cocoa pod husk treated at different fermentation times. However, the observed reductions in crude protein content in this study were contrary to those obtained by this same author and could be due to the type of treatment used.

The results of the compared effects of ash extracts from banana-plantain leaves and bean haulms on theobromine level showed a decreased in theobromine level with increasing level of treatment. This result could be explained by the fact that treatments with alkaline solutions could be the best methods of detheobromination. In addition, the greater reductions observed for hulls treated with bean ash extracts could be due to the fact that the solutions of ash extract from bean haulms are more alkaline than that from banana-plantain leaves. These results were in agreement with those obtained by Odunsi *et al.*[19] who observed a drop in theobromine level in cocoa pod husk treated with hot water and solutions of cocoa pod ash extracts. It also agreed with those of Adeyeye *et al.*[20] who obtained a drop in theobromine level in cocoa pod husk treated for 7 days with extracts of corn cob ash and those of Olugosi *et al.*[21] who obtained a decrease of theobromine level with increasing fermentation times.

The concentration of tannins decreases with increasing level of treatment; a hulls treated with extracts of ash from bean haulms was lower than those treated with extracts of ash from banana-plantain leaves. This could also be due to the fact that the ash extract solutions from bean tops are more alkaline than those from plantain leaves. These results were in agreement with those of Mensah *et al.*[22] who obtained a decrease in the level of tannins in cocoa pods husk treated by fermentation for 3 days regardless of the variety of cocoa pod used. These results corroborated with those of Adeyeye *et al.*[20] who obtained a decrease in the level of tannins in cocoa pod husks treated for 7 days with extracts of ash corn cob and those of Olugosi *et al.*[21] who observed a decrease in the level of tannins in cocoa pod husks treated with increasing fermentation times.

The effects of the treatment of cocoa pod husk with ash extracts from banana-plantain leaves and bean haulms on the feed intake of DM in rabbits shows that there was no significant difference ($p>0.05$) between the animals fed rations containing hulls treated with ash extracts from bean haulms and those of the control group (T0 +). Increased intake of crude protein in animals fed rations containing treated hulls corroborate the results obtained by Kanyinji *et al.*[23] who noted that increasing concentration of ash per liter of solution does not affect the intake of dry matter in goats, but improves intake of total nitrogen. However, the decreased observed for the ingestion of NDF in animals fed rations containing treated hulls compared to those of the control group disagree with the results of the same author who obtained an improvement in the ingestion of NDF with increasing level of treatment of rice straw in goats. These observed differences could be either due to the sources of ash extract used, to the concentration of ash extract or to the animal species.

The effects of treatment of cocoa pod husk with ash extracts from banana-plantain leaves and bean haulms on digestibility of DM, OM, CP, NDF, ADF and CF shown that regardless of the ash extract used, digestibility of CP, NDF, ADF were significantly higher ($p<0.05$) in animals fed rations containing treated hulls compared to the control group (T0 +). Increase of digestibility of NDF, ADF and CF could be due to the alkaline power of the ash extracts, which could have weakened the wall of the hulls and broken the ligno-cellulosic bonds; which could have facilitated digestion and allowed greater absorption. Likewise, the significant increase ($p<0.05$) of digestibility of crude proteins in animals fed rations containing treated hulls could be due to the strong elimination of tannins by the ash extracts; tannins have the ability to bind to proteins and form complexes which limit their absorption. These results were in agreement with those of Olugusi *et al.*[18] who obtained higher crude protein, fiber digestibility for rations containing hulls treated at different fermentation times. These results werecontrary to those of Ozung *et al.*[15] who obtained a decrease in the digestibility of proteins and fibers of rations containing hulls treated by fermentation and incorporated up to 25% in the ration. These differences could be due either to the type of treatment carried out on the cocoa hulls or to the level of incorporation of the hulls into the rations. The high values of digestibility of CP, NDF, ADF and CF for animals fed rations containing hulls treated with bean haulms ash extracts, compared to those of hulls treated with ash extracts of banana-plantain leaves could also be due to the fact that the solution of ash extract of bean haulms is more alkaline than that of banana-plantain leaves that allowed greater fragility of the shell wall and greater elimination of anti-nutritional factors. This result was contrary to those of Chounna *et al.*[16] who obtained lower digestibility in animals (goats and sheep) whose rations contained hulls treated with ash extracts of bean haulms and banana-plantain leaves. These differences could be due either to the animal and plant species or to the different concentrations of ash extract used for the treatment.

CONCLUSION

At the end of this study on the treatment of cocoa pod husk at different concentrations of ash extracts (banana-plantain leaves and bean haulms) on the chemical

composition and digestibility in rabbits, results concluded that ash extract from bean haulms at 12.5% concentration could be used in the treatment of cocoa pod husks and to improve its digestibility by rabbits.

SIGNIFICANCE STATEMENT

This manuscript explored the use of novel feed ingredients as cocoa pods in rabbit diet treated with vegetables extract in order to improved his digestibility. Current study concludes that ash extract from bean haulms could be used in the treatment of cocoa pod husks and to improve its digestibility by rabbits. The results of this study contributed in livestock huge challenge in developing country like Feed cost reduction, Pollution reduction and Improved productivity. All this can ensure more meat to meet growing population demands.

REFERENCES

1. Tendonkeng, F., B. Boukila, E.T. Pamo, A.V. Mboko, B.F. Zogang and F.N.E. Matumuini, 2011. Effets direct et résiduel de différents niveaux de fertilisation azotée sur la composition chimique de *Brachiaria ruziziensis* à la floraison à l'ouest cameroun. Int. J. Biol. Chem. Sci., 5: 570-585.
2. Alqaisi, O., O.A. Ndambi and R.B. Williams, 2017. Time series livestock diet optimization: Cost-effective broiler feed substitution using the commodity price spread approach. Agric. Food Econ., Vol. 5. 10.1186/s40100-017-0094-9.
3. Safwat, A.M., L. Sarmiento-Franco, R.H. Santos-Ricalde and D. Nieves, 2014. Determination of tropical forage preferences using two offering methods in rabbits. Asian-Australasian J. Anim. Sci., 27: 524-529.
4. FAO, 1988. L'élevage du lapin. Série apprentissage Agricole N°36 et 37. Rome.
5. Gidenne, T., 2015. Dietary fibres in the nutrition of the growing rabbit and recommendations to preserve digestive health: A review. Animal, 9: 227-242.
6. Caprioli, G., D. Fiorini, F. Maggi, M. Nicoletti and M. Ricciutelli *et al*., 2016. Nutritional composition, bioactive compounds and volatile profile of cocoa beans from different regions of Cameroon. Int. J. Food Sci. Nutr., 67: 422-430.
7. Adamafio, N.A., 2013. Theobromine toxicity and remediation of cocoa by-products: An overview. J. Biol. Sci., 13: 570-576.
8. Lu, F., J. Rodriguez-Garcia, I.V. Damme, N.J. Westwood and L. Shaw *et al*., 2018. Valorisation strategies for cocoa pod husk and its fractions. Curr. Opin. Green Sustainable Chem., 14: 80-88.
9. Teguia, A., H.N.L. Endeley and A.C. Beynen, 2004. Broiler performance upon dietary substitution of cocoa husks for maize. Int. J. Poult. Sci., 3: 779-782.
10. Rojo-Poveda, O., L. Barbosa-Pereira, G. Zeppa and C. Stévigny, 2020. Cocoa bean shell—a by-product with nutritional properties and biofunctional potential. Nutrients, Vol. 12. 10.3390/nu12041123.
11. Adeyeye, S.A., S.O. Ayodele, O.D. Oloruntola and J.O. Agbede, 2019. Processed cocoa pod husk dietary inclusion: effects on the performance, carcass, haematogram, biochemical indices, antioxidant enzyme and histology of the liver and kidney in broiler chicken. Bull. Nat. Res. Cent., Vol. 43. 10.1186/s42269-019-0096-8.
12. Hamed, A.H.M. and E.M. Elimam, 2009. Effects of rabaa ash alkali treatment of sesame straw on chemical composition and degradation in the rumen of Nubian goats. Pak. J. Nutr., 8: 1344-1348.
13. D'Mello, J.P.F., 2000. Anti-Nutritional Factors and Mycotoxins. In: Farm Animal Metabolism and Nutrition, D'Mello, J.P.F. (Ed.)., CAB International, Wallingford, UK, pp: 383-403.
14. Rahman, M.M., M.A. Akbar, K.M.S. Islam, A.B.M. Khaleduzzaman and A.B.M.R. Bostami, 2009. Nutrient digestibility and growth rate of bull calves fed rice straw treated with wood ash extract. Bangladesh J. Anim. Sci., 38: 42-52.
15. Ozung, P.O., O.O.K. Oko, E.A. Agiang, P.O. Eburu, E.I. Evans and C.E. Ewa, 2017. Growth performance and apparent nutrient digestibility coefficients of weaned rabbits fed diets containing different forms of cocoa pod husk meal. Agric. Food Sci. Res., 4: 8-19.
16. Chounna, A., F. Tendonkeng, H.D. Fualefac, J. Lemoufouet and E. Miegoue *et al*., 2020. Effect of plantain (*Musa paradisiaca*) leaves ash extract and the source of rumen fluid on *in vitro* digestibility of rice straw complemented with Calliandra calothyrsus leaves. J. Anim. Health Prod., 8: 122-129.
17. Olugosi, O.A., T. Ogunribido, J.O. Agbede and A.O. Ayeni, 2021. Effect of biologically upgraded cocoa pod husk meal on growth, serum and antioxidant properties of two rabbit breeds. Bull. Nat. Res. Cent., Vol. 45. 10.1186/s42269-020-00454-1.
18. Odunsi, A.A., A.A. Onifade and O.G. Longe, 1999. Effect of alkali or hot water treatment of cocoa bean cake fed to broiler finishers as partial replacement for dietary groundnut cake. Arch. Zootec., 48: 337-342.
19. Adeyeye, S.A., J.O. Agbede, V.A. Aletor and O.D. Oloruntola, 2017. Processed cocoa (*Theobroma cacao*) pod husks in rabbits diet: effect on haematological and serum biochemical indices. Asian J. Adv. Agric. Res., 2: 1-9.

20. Olugosi, O.A., J.O. Agbede, I.A. Adebayo, G.E. Onibi and O.A. Ayeni, 2019. Nutritional enhancement of cocoa pod husk meal through fermentation using *Rhizopus stolonifer*. Afr. J. Biotechnol., 18: 901-908.
21. Adi-Dako, O., K. Ofori-Kwakye, S.F. Manso, M.E. Boakye-Gyasi, C. Sasu and M. Pobee, 2016. Physicochemical and antimicrobial properties of cocoa pod husk pectin intended as a versatile pharmaceutical excipient and nutraceutical. J. Pharmaceutics, Vol. 2016. 10.1155/2016/7608693.
22. Mensah, C.A., N.A. Adamafio, K. Amaning-Kwarteng and F.K. Rodrigues, 2012. Reduced tannin content of laccase-treated cocoa (*Theobroma cacao*) pod husk. Int. J. Biol. Chem., 6: 31-36.
23. Kanyinji, F., J. Chongo and J. Simbaya, 2014. Intake and digestibility of rhodes grass (*Chloris gayana*) hay treated with graded levels of concentration of banana leaf ash solution in local goats. J. Anim. Prod. Adv., 4: 448-454.