

Effects of Replacing Maize Bran with Maize Cob on Nutrients Utilization, Rumen Metabolites and Microbes of Red Sokoto Bucks

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Citation: Babale DM, Yahaya SM, Nyako HD, Mbahi TF (2018) Effects of Replacing Maize Bran with Maize Cob on Nutrients Utilization, Rumen Metabolites and Microbes of Red Sokoto Bucks. J Vet Ani Res 1: 102

Article history: Received: 18 March 2018, Accepted: 28 May 2018, Published: 29 May 2018

Abstract

The experiment examined the effects of replacements levels of maize cob for maize bran on nutrients utilization, rumen metabolites and microbes of 24 Red Sokoto goats. Maize cob replaced maize bran at 0, 10, 20, 30, 40, and 50% levels designated as treatments T₁, T₂, T₃, T₄, T₅ and T₆ respectively. Unto each treatment, was added 10% cotton seed cake. Cowpea husk was fed *ad libitum* as basal diet. The experiment ran for 21 days made up of 7 days adaptation and 14 days of data collection. Parameters determined were proximate composition of feed ingredients and experimental diets, dry matter intakes, nutrients digestibility, rumen pH, Ammonia Nitrogen, volatile fatty acids and bacterial counts before and after feeding of the diets. It was found that the nutrient compositions of the diets differed significantly ($P<0.05$) with increasing levels of maize cob inclusion in the diets. There was also significant ($P<0.05$) difference for dry matter and nutrients digestibility across treatments with treatments T₂ and T₄ having the highest for all the parameters. However, metabolic nutrient intakes significantly differed ($P<0.05$) among treatments. Rumen pH, Ammonia nitrogen and volatile fatty acids decreased after feeding the diets while bacteria counts increased. Ranges of rumen pH (6.20-6.50), Volatile fatty acids (29.03-31.23 Mmol/100mls) bacterial counts ($7.0-9.6\times 10^6$) and Ammonia nitrogen of 10.65-12.20mg/100mls were found. It was concluded that despite the increase in maize cob inclusion in the diets, with increase in energy, crude fiber and decrease in crude protein levels, the diets still supplied adequate nutrients for the animals to maintain balanced rumen environment conducive for microbial growth and activities resulting in favorable nutrients utilization and weight increments. Maize cob could replace maize bran up to 40 % level of inclusion to reduce cost of production.

Keywords: Maize bran; Maize cob; Rumen Metabolites; Rumen microbes

Introduction

It was estimated that by 2020, the demand for livestock products will double and meat and milk production in the developing countries like Nigeria will grow at annual rates of 2.7 and 3.2% respectively [1]. Meeting these demands will be constrained by the inability of the producers to feed their animals adequately throughout the year. also stated that because of the direct competition between man and animals over the conventional feed resources, it becomes imperative to maximize the use of crop by-products in feeding animals especially the small ruminants [1]. This will involve finding alternative supplementary feed sources that are cheap and nutritionally adequate, readily available and not in direct use by humans [2]. The authors further stated that devising a means of evaluating agro-processing wastes to supplement limiting nutrients such as protein and energy becomes essential.

Plant cell walls are degraded by a combination of bacteria, fungi and protozoa with bacteria and fungi contributing about 80% of the degradative activity and protozoa 20% [3]. They also reported that rumen microbes digest feed through the action of enzymes they produce. Contact between the enzymes and their substrate is necessary for hydrolysis to occur. Adhesion is absolutely essential for efficient digestion of forages and cereal grains in the rumen.

Ruminal microbes that interact with feed particles are functionally divided into three distinct subpopulations: those associated with Ruminal fluid, those loosely attached to feed particles and those firmly attached to feed particles as well as those that survive on soluble feed components within the Ruminal fluid and have little direct involvement in the digestion of insoluble feed particles. However, they form an integral part of the rumen ecosystem [3]. They colonize and initiate digestion of newly fed particles. These two subpopulations account for 70-80% of the microbial matter in the rumen.

The rate and extent of dry matter fermentation in the rumen are crucial determinants of the amount of nutrients available to animals [4]. The main factor influencing rate of fermentation of feed is the structure of the carbohydrate fraction, especially the extent of lignifications of the cell walls [5]. The enhancement of fiber digestion in the rumen is dependent on characterization of enzymes involved in feed digestion. If this lags behind, it affects the rate at which the feed is metabolized since it affects the cell wall hydrolysis [6].

For an effective rumen digestion of low quality feed, a continuous supply of protein is necessary to maintain effective fermentation in the rumen. Improving the use of fibrous residues rely on enhancing the rate of degradation of the more readily fermentable cell wall constituents [6]. The metabolites needed for body synthesis include glucose, acetate, propionate, butyrate and non-esterified fatty acids. The way these metabolites are used depends on the nutritional status of the animal [7]. These volatile fatty acids (VFA) are the major energy substrates for ruminants, accounting for 60-70% of the available digestive energy [8]. The increase in total volatile fatty acid in ruminant feed is an indication of the increase in the digestibility of such feed material [9].

The type of organism in the rumen depends on the composition of the feed being consumed. If the animal consumes high forage diet which are high in cellulose, the microorganisms that digest these substrates will proliferate. When diets high in cereal grains are consumed, the organisms that digest starch proliferate and in highest concentration [10]. That the maximum number of microorganisms will be present 2-3 hours after a high concentrate (grain/starch) diet has been consumed and 4-5 hours after a high-roughage (cellulose-hemicelluloses) diet has been consumed.

Jane and Justin also reported that in the rumen, fiber-digesting bacteria digest structural carbohydrate while starch-digesting bacteria digest non-structural carbohydrate [11]. In general, the starch digesters tolerate low PH levels but the fiber digesters are inhibited by low PH. If the goal is to maximize forage intake and digestibility, it will be counterproductive to add grain or concentrate to the diet beyond a threshold of about 0.5% of body weight daily because of reduced rumen pH effect.

There is scarcity of information on the effects of replacement levels of maize cob for maize bran on nutrients utilization and rumen metabolites of Red Sokoto goats. This research therefore was conducted to bridge the information gap.

Material and Methods

Study Site

The experiment was conducted at the Department of Animal Production Sheep and Goat unit of the Livestock Teaching and Research farm, Adamawa State University, Mubi, Nigeria. Mubi is situated in the Northern part of Adamawa State between Latitude 90° 11' North of the equator and Longitude 13° 45' east of the Greenwich Meridian at an altitude of 696 m above sea level. It has a land area of 4,728.77 m² and population of 245,460, Mubi region falls within the Sudan Savanna vegetation zone of the country [12].

Experimental animal and their management

Twenty four Red Sokoto bucks of average age of 12 months and mean live weight of 12.00 Kg were sourced from the local markets in and around Mubi. Their ages were determined through their dental formulae. They were then housed individually in pens measuring 1.5 m² and 1.5m high. The floor of the house was of concrete and covered with wood shavings to absorb moisture from the animals' dung and urine. Towards the end of the experimental period, metallic metabolism cages were used to individually house the animals for faecal and urine collection which was used for digestibility determination.

The animals were quarantined for one week during which they were fed the experimental diets for adaptation and dewormed with Banminth. At the end of the adaptation period, the animals were tagged, randomly allocated to treatments and balanced on weight basis for all the treatments. They were weighted to get the initial weights before embarking on data collection which lasted for two weeks.

Experimental Diets

There were six treatments with each treatment replicated four times, making a total of twenty four experimental animals. The experimental diets (T) consisted of: T₁: 90% Maize bran +10% Cotton seed cake, T₂: 80% Maize bran +10% corn cobs+ 10% cotton seed cake, T₃: 70% Maize bran +20% corn cobs +10% cotton seed cake, T₄: 60% Maize bran+30% corn cobs+10% cotton seed cake, T₅: 50% Maize bran+40% corn cobs+10% cotton seed cake, T₆: 40% Maize bran+50% corn cobs+10% cotton seed cake. The above formed the concentrate diets for the experiment. The corn cobs which were included at graded levels of 0, 10, 20, 30, 40 and 50% in the six diets replaced Maize bran weight for weight. These formed the concentrate portions and were fed to the animals in two equal halves of 150g/head/day. The cowpea husk formed the basal diet and was fed *ad libitum*. The experimental diets were as presented in table 1. Randomized Complete Block Design (RCBD) was employed in the study.

TREATMENTS						
FEEDS	T ₁ (0%MC)	T ₂ (10% MC)	T ₃ (20%MC)	T ₄ (30%MC)	T ₅ (40%MC)	T ₆ (50%MC)
MCB (%)	0	10	20	30	40	50
MBR (%)	90	80	70	60	50	40

TREATMENTS						
FEEDS	T ₁ (0%MC)	T ₂ (10% MC)	T ₃ (20%MC)	T ₄ (30%MC)	T ₅ (40%MC)	T ₆ (50%MC)
CSC (%)	10	10	10	10	10	10
CPHK	<i>ad lib</i>	<i>ad lib</i>	<i>ad lib</i>	<i>ad lib</i>	<i>ad lib</i>	<i>ad lib</i>
Proximate composition of the experimental diets						
Nutrients						
ME (Kcal/g)	5.208	5.244	5.28	5.316	5.352	5.388
CP (%)	12.84	12.41	12.23	12.01	11.79	11.58
CF (%)	29.28	29.87	30.46	31.04	31.6	32.25
ASH (%)	6.23	6.39	6.56	6.57	6.9	7.07
EE (%)	7.88	8.21	7.67	8.11	7.69	6.01
NFE (%)	43.77	38.55	38.3	36.98	36.56	37.1

MBR: Maize bran; CB: Corn cob; CSC: Cotton seed cake; CPHK: Cow pea husk; ME: Metabolizable energy; CP: Crude protein; EE: Ether extract and NFE: Nitrogen free extract

Table 1: Experimental Diets and Treatments

Parameters Measured

Parameters determined were proximate composition of experimental feed ingredients, Dry matter and nutrients digestibility, metabolic intakes of dry matter and nutrients, The pH, Ammonia Nitrogen, Volatile Fatty Acids (VFA) and Bacterial counts of rumen liquor before and after feeding.

Proximate composition of the experimental feed ingredients being Dry matter, Ash, Crude protein, Ether extract, Crude fiber, Nitrogen Free extract, Organic matter and Metabolizable energy were determined as described by Prasad and Neeraj [13].

Dry matter, Organic matter and Nutrients digestibility were determined using the methods described by Ranjhan [14]. Protein and Nitrogen levels in feeds, faeces and urine were determined by standard Kjeldahl digestion.

Rumen liquor was collected at the end of the digestibility period using stomach tube at three hours intervals before and after feeding. The liquors were analyzed as described by Reddy and Reddy, Naik and Sengar [9,15].

All data obtained were subjected to analysis of variance (ANOVA) using SAS (2001) package. Means was separated using the Duncan multiple range test [16].

Results and Discussions

Proximate compositions of feed ingredients were as presented in Table 2.

FEED INGREDIENTS				
NUTRIENTS	MBR	MCB	CSC	CPHK
DM (%)	88.72	87.65	95.32	90.81
CP (%)	10.22	4.88	40.2	12.25
CF (%)	27.1	41.82	26.2	30.79
ASH (%)	3.69	7.9	3.92	7.84
NFE (%)	51.76	39.8	21.88	42.99
EE (%)	7.23	5.6	7.8	6.13
ME (Kcal/g)	6.32	7.22	5.82	4.5

MBR: Maize bran; MCB: Maize cob; CSC: Cotton seed cake and CPHK: Cowpea husk; ME: Metabolizable energy; CP: Crude protein; CF: Crude fiber; EE: Ether Wextract; NFE: Nitrogen free extract

Table 2: Proximate composition of Feed ingredients

While Dry matter and nutrients digestibility and effects of treatment diets on rumen metabolites and microbes of the animals are presented in Tables 3-5.

Parameter	Experimental Treatments						SEM
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	
Dry matter	66.75 ^b	64.89 ^c	67.54 ^b	68.71 ^a	64.11 ^c	67.32 ^b	1.652
Organic matt	69.44 ^b	75.96 ^a	68.23 ^b	71.63 ^a	68.44 ^b	66.07 ^c	1.553
Crude Protein	86.25 ^b	87.70 ^a	86.77 ^b	87.88 ^a	85.54 ^b	81.74 ^c	2.001

Parameter	Experimental Treatments						
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	SEM
Crude fiber	62.68 ^b	63.36 ^b	63.23 ^b	68.00 ^a	64.02 ^b	63.95^b	1.432
Ether Extract	64.03 ^c	64.26 ^c	66.52 ^b	68.70 ^a	64.11 ^c	67.33 ^b	1.453
N ₂ free extract	63.05 ^b	62.36 ^c	61.33 ^c	64.41 ^a	65.07 ^a	63.37 ^b	1.333

Means in the same line with different superscripts differ significantly (P<0.05)

Table 3: Dry Matter and Nutrients Digestibility (%)

Parameter	Experimental Treatments						
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	SEM
Dry matter	22.68 ^a	19.70 ^c	18.02 ^c	20.52 ^b	20.28 ^b	18.45 ^c	0.456
Crude protein	2.95 ^a	2.45 ^b	2.20 ^c	2.46 ^b	2.39 ^c	2.14 ^c	0.322
Crude fiber	6.64 ^a	5.89 ^c	5.49 ^c	6.37 ^b	6.41 ^b	5.95 ^c	0.225
NFE	10.80 ^a	9.21 ^b	8.28 ^c	9.25 ^b	8.97 ^c	8.01 ^c	0.544
EE	1.5 ^a	1.28 ^b	1.17 ^c	1.31 ^b	1.28 ^b	1.20 ^c	0.221

Means in the same line with different superscripts differ significantly (P<0.05)

Table 4: Nutrients Intake g/Day/W0.75

Parameter	Time	TREATMENTS						
		T ₁	T ₂	T ₂	T ₄	T ₃	T ₆	
pH	BF	6.6	6.25	6.25	6.35	6.45	6.50	BF>AF
	AF	6.4	6.6	6.6	6.05	6.05	5.95	
	Mean	6.5	6.43	6.43	6.2	6.25	6.23	
NH3-N (mg/100ml)	BF	11.15	11.1	11.1	10.65	12.2	12.15	BF>AF
	AF	9.5	9.75	9.75	10.2	11.5	10.75	
	Mean	10.33	10.43	10.43	10.43	11.85	11.45	
VFA (Mmol/100ml)	BF	29.3	29.5	29.5	32.2	32.2	33.3	BF>AF
	AF	28.75	28.7	28.7	28.75	28.85	29.15	
	Mean	29.03	29.1	29.1	30.48	30.53	31.23	
Bact. Count (X 105)	BF	5.5	6.5	6.5	7.8	7.9	8	BF<AF
	AF	8.5	9.1	9.1	10.2	11.3	10.6	
	Mean	7	7.8	7.8	9	9.6	9.3	

NH3-N: Ammonia nitrogen; VFA: Volatile fatty acids; Bact. Count: Bacterial counts; BF: Before feeding; AF: After feeding

Table 5: Effects of Treatment Diets on Rumen Metabolites and Microbes of Goats

The key to formulating high performance rations with tropical feedstuffs is, knowing the extent to which nutrients are used in the rumen and small intestine [17]. The supply and balance of feed nutrients can then be directed towards maximizing the growth of the microorganisms in the rumen as well as providing bypass nutrients to support the animal's productivity potential.

The calculated nutrients compositions of the experimental diets showed that the nutrients levels differed with increasing levels of maize cob inclusion in the diets (Table 2). While Metabolizable energy and crude fiber levels increased, the crude protein levels decreased with increasing levels of maize cob.

There were significant differences (P<0.05) for dry matter and nutrients digestibility across the treatments with treatments T₂ and T₄ having the highest for all the parameters (Table 3). However, daily metabolic nutrients intakes did not follow the same trend (Table 4). The highest intakes for all these parameters are in treatment T₁ with significant (P<0.05) difference among treatment means.

The effects of treatment diets on rumen microbes and metabolites before and after feeding are presented in Table 5. Results indicated that rumen pH, Ammonia nitrogen and volatile fatty acids (VFA) decreased with the feeding of the diets. However, bacterial counts increased after feeding of the diets. Rumen pH ranged between 6.20-6.50 which is lower than the 6.50-6.80 normal rumen pH range reported by Jane and Riviera [18]. It is also lower than that (7.30-7.40) range obtained by Samanta, *et al.* on feeding goats with grass forage who concluded that natural grass or forage based diets can be used to ensure higher rumen pH in animals [19].

Volatile fatty acids (VFA) of 29.03-31.23 Mmol/100ml were obtained. There was decrease in VFA after feeding. This is related to the findings of Carro, *et al.* who, in a feeding trial of goats with roughage to concentrates ratios of 80:20 and 20:80, rumen liquor pH decreased whereas VFA concentration increased after feeding time for both diets [20]. Rumen pH was higher for 80:20 diet

than for the 20:80 diet. They concluded that an increase in the acidity of rumen liquor with higher levels of concentrates partially depends on VFA concentration.

Bacterial species of the rumen are considered more important than protozoa and fungi in determining the extent and rate of feed degradation and utilization for the production of microbial protein [21]. The effect of pH is related to the growth of bacteria in the rumen and a PH of less than 6.0 significantly slows down the growth [22]. Bacterial counts of $7.0-9.6 \times 10^5$ ranges were obtained in this research. Satter and Slyter have earlier reported that attempts to establish optimal ammonia concentration have focused on maximal microbial growth and Ruminal degradation of feedstuffs [23]. That in a vitro continuous culture studies, it is found that ammonia concentration of no more than 5mg/100mls gave maximal microbial growth with ammonia concentration in excess of 20mg/100mls for maximal degradation of feedstuffs [24].

Rumen ammonia nitrogen ($\text{NH}_3\text{-N}$) ranged from 10.65-12.20mg/100ml of rumen liquor before feeding and 9.50-11.50mg/100ml after feeding. The rumen $\text{NH}_3\text{-N}$ therefore decreased after feeding. These ranges are within the normal ranges of 7-15mg/100ml stated by Samanta, *et al.* needed for maximum nutrients utilization [19]. The decrease of rumen $\text{NH}_3\text{-N}$ is beneficial to the animal as stated by Agle, *et al.* that rumen $\text{NH}_3\text{-N}$ utilization in the rumen is intrinsically related to carbohydrate availability [25]. That when carbohydrate availability increases, ammonia production in the rumen decreases because of a direct incorporation of $\text{NH}_3\text{-N}$ into microbial protein, thus bypassing the ammonia pool. Therefore, feeding of complete feed stabilizes rumen fermentation, minimizes fermentation loss and ensures better $\text{NH}_3\text{-N}$ utilization [19].

Song and Kennelly have reported that since microbial population in the rumen are influenced by the amount and type of substrate provided; microbial population may differ depending on the structural characteristics of feedstuffs [26].

Conclusion and Recommendation

From the findings of this research, it can be concluded that despite the increase in inclusion levels of maize cob in the diets, they still supplied adequate nutrients to the experimental animals. These maintained nearly balanced rumen environment conducive for microbial growth and activities resulting in favorable nutrients utilization and weight increments. It is therefore recommended that to reduce cost of fattening of small ruminants; Maize cob could be used to replace Maize bran at up to 40% level.

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