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RESEARCH ARTICLE

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

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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 T_1, T_2, T_3, T_4, T_5 and T_6 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 T_2 and T_4 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 ($7.0\text{-}9.6\times10^6$) 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 thresh hold 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^{o} 11^{I} North of the equator and Longitude 13^{o} 45^{I} east of the Greenwich Meridian at an altitude of 696 m above sea level. It has a land area of 4,728.77 m^2 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: T_1: 90% Maize bran +10% Cotton seed cake, T_2: 80% Maize bran +10% corn cobs+ 10% cotton seed cake, T_3: 70% Maize bran +20% corn cobs +10% cotton seed cake, T_4: 60% Maize bran+30% corn cobs+10% cotton seed cake, T_5: 50% Maize bran+40% corn cobs+10% cotton seed cake, T_6: 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	*ad lib*	*ad lib*	*ad lib*	*ad lib*	*ad lib*	***ad lib***
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: Metabolizeable 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 Metabolizeable 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: Metabolizeable 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						
	T_1	T_2	T_3	T_4	T_5	T_6	SEM
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						
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	TREATMENTS							
	Time	**T_1**	**T_2**	**T_2**	**T_4**	**T_5**	**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 Metabolizeable 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 T_2 and T_4 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 T_1 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 $7.0\text{-}9.6\times10^5$ 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 (NH_3-N) ranged from 10.65-12.20mg/100ml of rumen liquor before feeding and 9.50-11.50mg/100ml after feeding. The rumen NH_3-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 NH_3-N is beneficial to the animal as stated by Agle, *et al.* that rumen NH_3-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 NH_3-N into microbial protein, thus bypassing the ammonia pool. Therefore, feeding of complete feed stabilizes rumen fermentation, minimizes fermentation loss and ensures better NH_3-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.

Reference

1. Kallio GA, Ayuk AA (2011) Food-Feed crop Production and Agro by-product Availability for village goat production in Cross River State, Nigeria. Proceedings of the 16th Annual Conference of Animal Science Association of Nigeria (ASAN) held at Kogi State University, Ayingba, Nigeria. 12th-15th, September, 2012. 447-50.

2. Ocheja JO, Ebiloma SO, Oguche HE, Lalabe BC, Okpe AA, et al. (2012) Digestibility, Nutrients intake and Performance of Weaner Rams Fed varying proportions of a mixture of Bambara nuts waste and Rice Offal as supplements to Pennisetum purpureum. Adamawa State University Journal of Agricultural Sciences. 2: 64-5.

3. Wang Y, McAllister TA (2012) Rumen Microbes and Feed Digestion-A Review. Agriculture and Agri-Food, Canada Research Centre. 1659-70.

4. Njidda AA, Binuomote RT (2011) In Sacco Degradability of Neutral Detergent Fiber of selected Browse forages of North Eastern Nigeria. Proceedings of 16th Annual conference of Animal Science Association of Nigeria (ASAN) held at Kogi State University, Ayingba, 12th-15th September 2011. 438-40.

5. Nagadi S, Herrero M, Jessop NS (2000) The effect of fermentable Nitrogen availability on In vitro gas production and degradability of Neutral Detergent Fiber (NDF). Ann Feed Service Technol 87: 241-51.

6. Anigbogu NM, Onyejekwe IE (2011) Metabolism of Protein and Energy by Maradi Goats Fed Zymomonas mobilis Degraded Rice Hull Diets. Proceedings of the 16th Annual Conference of Animal Science Association of Nigeria held at Kogi State University, Ayingba, Nigeria. 12th-15th September, 2012. 99-100.

7. Shittu OO, Smith OF, Osinowo OA (2010) The Ratio of Roughage to Concentrate on Milk Secretion Rate in Goats. Proceedings of the 15th Annual Conference of Animal Science Association of Nigeria (ASAN) held At University of Uyo, 13th-15th September, 2010 583-4.

8. Finangwai HI, Ehoche OW, Akpa GN (2010) Effects of Urea treated Maize Stover Based Diets on the Biochemical changes in the Rumen and Blood Parameters of Crossbred Bulls. Proceedings of the 15th Annual conference Of the Animal Science Association of Nigeria (ASAN) held at University of Uyo, 13th-15th September, 2010 609-10.

9. Reddy GVN, Reddy MN (1996) Effect of feeding extruded complete diets containing maize cobs in Ongole bull calves. Ind J Ani Nutri 16: 210-2.

10. Richard OK, Church DC (2010) Livestock Feeds and Feeding, 6th Edition. Published by Pearson Education Books, USA, 13-5.

11. Jane AP, Justin DR (2008) Fiber in Beef Cattle Diet. Mississippi University Extension Publication Service 2489.

12. Saidu I, Gadiga BL (2004) Population: A write up in Mubi Region, A Geographical synthesis by Adebayo A.A. Published by Paraclette Publishers Yola 117-9.

13. Prasad J, Neeraj J (2008) Principles and Practices of Animal Nutrition 2nd Edition. Published by Kalyani Publishers, New Delhi, India. 335-54.

14. Ranjhan SK (2004) Animal Nutrition in the Tropics 5th Revised Edition. Published by VIKAS Publishing House, PVT LTD, New Delhi, India, 34-7.

15. Naik PK, Sengar SS (1999) Rumen fermentation pattern in Buffaloes maintained on complete diets with different sources of nitrogen. Ind J Ani Nutri 16: 233-5.

16. SAS (2001) Statistical Analysis System, SAS 2001, SAS/STAT Software Release 8.02, SAS Institute Inc. Cary, NC. USA.

17. David F (2013) Principles of Ruminant Nutrition. Alaminos Goat Farm Production.

18. Jane AP, Riviera JD (2009) Understanding the ruminant animal digestive system. Mississippi University Extension Service Publication 2503.

19. Samanta AK, Singh KK, Das MM, Maity SB, Kundu SS (2002) Effect of Complete feed Block on nutrients utilization and rumen fermentation in Barbari goats. Small RuminantResearch 48: 95-102.

20. Carro MP, Gonzalez JS, Ronilla MJ, Valdes C (2005) Digestion and Digesta flow kinetics in goats fed two diets differing in forage to concentrate ratio. Options méditerranéennes.

21. Rash MO (2006) Goat Ruminal bacteria, their counts and antibacterial effects against gram-positive Bacteria. Basra J Vet Res 5: 138.

22. Naraja TG (2012) A Microbiologist's View on improving Nutrient utilization in Ruminants. Kansas State University College of Veterinary Medicine Session note.

23. Satter LD, Slyter LL (2004) Effects of Ammonia concentration on rumen microbial protein production in vitro. British J Nutri 32: 199-208.

24. Wallace RJ (2009) Effects of ammonia concentration on the composition, hydrolytic activity and nitrogen metabolism of microbial flora of the rumen. J App Bacteriol 47: 443-5.

25. Agle M, Hristov AN, Zaman S, Schneider C, Ndegwa PM, Vadella VK (2010) Effects of Dietary concentrates on Rumen fermentation, Digestibility and Nitrogen losses in Dairy Cows. J Dairy Sci 93: 421-2.

26. Song MK, Kennelly LM (2009) In situ Degradation of feed ingredients, Fermentation pattern and microbial population as influenced by Ruminal ammonia concentration. Canadian J Ani Sci 69: 999-1006.