EFFECT OF SUBSTITUTING MAIZE GRAIN WITH COBS TREATED WITH A COMBINATION OF UREA AND WOOD ASH ON SHEEP PERFORMANCE AND RUMEN PARAMETERS

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ABSTRACT
This study was aimed at determining the effect of substituting maize grain with maize cobs treated with 25% urea plus 75% wood ash (WA) on intake, digestibility, nitrogen utilization, rumen NH_3, pH and performance of Tswana breed of sheep. Tswana sheep were fed experimental diet whose maize grain was substituted with graded levels of 25U75WA in the dietary ingredients and the treatments were: 100M = 100% maize grain, 66M34C = 66% maize grain plus 34% treated maize cobs, 34M66C = 34% maize grain plus 66% treated maize cobs and 100C = 100% treated maize cobs in a 4×4 Latin Square Design. Treatment 34M66C had CPI, DMI,OMI and NDFI of 0.1334, 0.9500, 0.8921 and 0.4800 kg/d respectively while the CPD, DMD, OMD and NDFD were 79.57, 68.02, 66.26, and 57.8% respectively. All the treatments had similar rumen NH_3 ranging from 23.55 – 24.00 mg/ml while pH were different and ranged from 6.117 – 6.937. Treatment 100M had the lowest pH. Treatment 100M and 34M66C had ADG of 0.1150 and 0.1417 kg/d respectively however treatment 100M had the lowest FCR of 5.217 compared to 7.059 for 34M66C. It was concluded that treatment 34M66C had better nutrient intake, digestibility and performance compared to diet with 100% maize grain and that the substitution could also reduce cost of feed at the same time supplying minerals present in ash to the fed animals.

Key word: Maize grain, maize cob, urea, wood ash, Tswana sheep

INTRODUCTION

Crop residues such as maize cobs are increasingly becoming popular as livestock feed due to feed shortage occasioned by drought and depletion of the rangelands. Other reasons why crop residues are becoming popular could also be attributed to the high cost of grains as a result of competition between man and livestock. However, crop residues are poor nutritionally and needed to be supplemented with other sources of nutrients. According to Wanapat and Rowlinson (2007), maize cobs can be used as source of energy in ruminant feeds. Maize cobs when used as source of non-forage fibre, increase milk fat concentration and also reduce time of rumination when fed in combination with alfalfa in dairy cattle (Depies and Armentos, 1995). Peyton and Conrad (1982) reported that ground maize cob has been used as energy source for dairy cows in concentrate mixture. Ground maize cobs have also been reported by Wanapat *et al.* (2012) as potential replacement for cassava chips as source of energy in swamp buffalo. This study was aimed at determining the effect of substituting maize grain with maize cobs treated with 25% urea plus 75% WA on intake, digestibility, nitrogen utilization, rumen NH_3, pH and performance of Tswana breed of sheep.

MATERIALS AND METHODS

EXPERIMENTAL INGREDIENTS AND LOCATION OF STUDY

The study was conducted at the Botswana University of Agriculture and Natural Resources, Content Farm located 10 Km north of Gaborone in South Eastern Botswana. Maize cobs were sourced from Molepolole village, 70km from Gaborone and milled (4 mm sieve) at the school farm feed mill in Notwane before mixing with the rest of the ingredients.

IN VIVO STUDY

Four Tswana male sheep sourced from the school farm (18 months old, 32±1 kg) were used in a 4×4 Latin Square Design and housed in metabolism cages suitable for collection of urine and faeces separately. Prior to commencement of the trial, sheep were weighed, vaccinated against

Enterotoxaemia Pasteurella followed by deworming with Ecomectin 14 days later. The trial lasted for forty eight days with 7 days of adaptation and 5 days for collection (12 days/period). Each period was restricted to 12 days due to insufficiency of maize cobs to substitute maize grain as a result of the drought experienced in Botswana during the experimental period.

DATA COLLECTION AND CHEMICAL ANALYSIS

Feed offered and refused were recorded daily throughout the experimental period. Feed were offered twice daily (500g at 8am and 500g at 4pm) while samples of the experimental diets including refusals and faeces (5% samples) were collected daily in the morning before feeding during the 5 days collection period. Samples of concentrate mixture and faeces for each treatment group were then composited and stored at -20^{o}C for later chemical analysis. The samples were divided into two parts, first part for dry matter (DM) analysis, while the second part was kept and pooled for analysis of ash, crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL). Feeds, refusals and faecal DM (DM, ID number 930.15) for all samples were determined by drying in forced air oven at 60^{o} C for 24 hr. Organic matter (OM) (OM, ID number 942.05) and ash were obtained by difference in weight after ignition at 550^{o} C in a muffle furnace (Muffle Furnace Size 3, Gallenkamp, UK). The NDF, ADF and ADL were determined with ANKOM fiber analyzer (Ankom Technology Corporation, Fairport, NY, USA) according to the procedure of Van Soest *et al.* (1991). In the analysis of NDF, sodium sulphite and alpha amylase were also added. Nitrogen was determined by a Kjeldahl method (ID number 955.04) according to AOAC (1999) and CP determined as N*6.25 (ID number 954.01).

Daily collection of urine for each treatment before feeding was acidified with 50% H_2SO_4 to prevent ammonia volatilization, stored and then mixed at the end of the trial. The urine samples were then analyzed for N according to AOAC (1999). Rumen liquor was collected 3 hours post feeding after every period in the morning using a mechanical suction pump. The rumen fluid was then measured for pH using digital pH meter and the fluid sample was then strained through four layers of cheesecloth. Forty five ml of the rumen fluid was kept in a plastic bottle to which 5 ml of 1M H_2SO_4 was added to stop fermentation. About 20 to 30 ml of supernatant was collected and analyzed for NH_3- N according to AOAC (1999).

STATISTICAL ANALYSIS

Data generated from various *in vivo* parameters were analyzed using a 4×4 Latin Square Design with GLM procedure of SAS (2002) and means separated with Duncan's Multiple Range Test (Steel and Torrie, 1984).

RESULTS

Nutrient intake and digestibility of experimental diets (Table 1) are shown in Table 2. Effect of treatments was observed on CPI, DMI, OMI and NDFI. Effect of treatments was observed on crude CPD, DMD, OMD and NDFD. Nitrogen utilization of sheep fed experimental diets is shown in Table 3. Effect of treatments was also observed on NI, FN, UN and NB.

Table 1: Ingredients and chemical composition (g/kg) of experimental diet

Types of treatment					
Ingredients (%)	100M	66M34C	34M66C	100C	
Maize cob	0	15	30	45	
Maize grain	45	30	15	0	
Lucerne	39	36	32.5	29.5	
Wheat bran	10	10	10	10	
Sun Flower Cake	5	8	11.5	14.5	
Salt	0.5	0.5	0.5	0.5	
DCP	0.5	0.5	0.5	0.5	
Chemical composition (g/kg)					SD±
DM	945.0	950.0	950.0	955.0	4.630
ASH	82.01	100.0	107.9	175.4	38.68
OM	918.0	900.0	892.1	824.6	38.68
CP	134.3	131.0	133.5	133.5	3.740
NDF	470.0	470.0	480.0	570.0	54.97
ADF	160.0	220.0	250.0	360.0	78.51
ADL	53.20	63.20	85.20	114.4	28.61
HC	310.0	250.0	230.0	210.0	53.45
NDS	530.0	530.0	520.0	430.0	54.97
ME MJ/kg	18.94	19.19	19.28	17.24	0.938

DM= dry matter, OM=organic matter, CP=crude protein, NDF=neutral detergent fibre, ADF=acid detergent fibre, ADL=acid detergent lignin, HC=hemicellulose, NDS=neutral detergent soluble, ME=metabolizable energy, DCP= Di calcium phosphate. 100M= 100% maize, 66M34C=66% maize 34% treated maize cobs, 34M66C=34% maize

66% treated maize cobs, 100= 100% treated maize cobs.

Table 2: Nutrient intake and digestibility of sheep fed experimental diet

Parameters	Types of treatment					
	100M	66M34C	34M66C	100C	SE	P value
Intake (kg/day)						
CPI	0.0805^{c}	0.1309^{a}	0.1334^{a}	0.0934^{b}	0.0060	<0.0001
DMI	0.6685^{b}	0.9500^{a}	0.9500^{a}	0.5670^{c}	0.0438	<0.0001
OMI	0.5507^{c}	0.9000^{a}	0.8921^{a}	0.5772^{b}	0.0429	<0.0001
NDFI	0.3720^{d}	0.5300^{a}	0.4800^{b}	0.4060^{c}	0.0164	<0.0001
Digestibility (%)						
CPD	94.14^{a}	81.33^{b}	79.57^{b}	81.41^{b}	1.629	0.0011
DMD	59.12^{c}	65.54^{b}	68.02^{b}	56.23^{d}	1.258	<0.0001
OMD	59.79^{b}	66.28^{a}	67.20^{a}	50.58^{c}	1.797	0.0003
NDFD	56.82^{a}	56.00^{a}	57.80^{a}	50.12^{b}	0.8908	0.0199

100M= 100% maize, 66M34C=66%maize 34% treated maize cobs, 34M66C=34% maize 66% treated maize cobs, 100C= 100% treated maize cobs, CPI= crude protein intake, DMI= dry matter intake, OMI=organic matter intake, NDFI= neutral detergent fibre intake, CPD=crude protein digestibility, DMD= dry matter digestibility, OMI= organic matter digestibility, NDFD= neutral detergent fibre digestibility.

Table 3: Nitrogen utilization of sheep fed experimental diet

Parameters (g/day)	Types of treatment					
	100M	66M34C	34M66C	100C	SE	P value
Nitrogen intake	12.89^{c}	20.95^{a}	21.35^{a}	14.94^{b}	0.9614	<0.0001
Fecal nitrogen	1.161^{c}	6.490^{a}	7.496^{a}	4.097^{b}	0.6523	<0.0001
Urinary nitrogen	2.120^{b}	8.250^{a}	9.372^{a}	9.768^{a}	0.8293	<0.0001
Nitrogen balance	9.609^{a}	6.215^{b}	4.483^{b}	1.081^{c}	0.8321	0.0002

100M= 100% maize, 66M34C=66%maize 34% treated maize cobs, 34M66C=34% maize 66% treated maize cobs, 100C= 100% treated maize cobs, Rumen ammonia and pH of sheep fed experimental diets are shown in Table 4. Effect of treatments was not observed on rumen ammonia while it was observed on rumen pH. Treatment 100M had the lowest pH (6.12) while 100C had the highest (6.94). Treatments 66M34C and 34M66C had similar pH of 6.77 and 6.74 respectively. Performance characteristics of sheep fed experimental diets are shown in table 5. Effect of treatments was observed on FI, FW, WG, ADG and FCR.

Table 4: Rumen ammonia and pH of sheep fed experimental diet

	types of treatment					
Parameters	100M	66M34C	34M66C	100C	SE	P value
Rumen ammonia (mg/ml)	24.00	23.62	23.55	23.75	0.1023	0.5638
Rumen pH	6.120[c]	6.770[b]	6.740[b]	6.940[a]	0.0824	<0.0001

100M= 100% maize, 66M34C=66%maize 34% treated maize cobs, 34M66C=34% maize 66% treated maize cobs, 100C= 100% treated maize cobs,

Table 5: Performance characteristics of sheep fed experimental diets

	Types of treatment					
Parameters	100M	66M34C	34M66C	100C	SE	P value
FI(kg)	0.6000[c]	1.0000[a]	1.0000[a]	0.7000[b]	0.0461	<0.0001
IW(kg)	32.07[bc]	32.40[b]	33.55[a]	31.80[c]	0.4614	<0.0001
FW (kg)	33.45[c]	34.00[b]	35.25[a]	33.00[c]	0.4802	<0.0001
WG (kg)	1.380[c]	1.600[b]	1.700[a]	1.200[d]	0.0501	<0.0001
ADG kg/d	0.1150[c]	0.1333[b]	0.1417[a]	0.1000[d]	0.0042	<0.0001
FCR	5.217[d]	7.500[a]	7.059[b]	7.000[c]	0.2257	<0.0001

100M= 100% maize, 66M34C=66%maize 34% treated maize cobs, 34M66C=34% maize 66% treated maize cobs, 100C= 100% treated maize cobs, FI= feed intake, IW= Initial weight, FW=Final weight, WG= Weight gain, ADG= Average daily gain, FCR= Feed conversion ratio.

DISCUSSION

Despite the fact that the maize grain-based diet (100M) had low NDF, ADF and ADL, it was characterized by low intake and digestibility. All animals on this treatment had diarrhea and not willing to eat much probably because they initially selected the more palatable grains that were rapidly fermented. The reason for the low intake and digestibility may be attributed to the rapid fermentation of the grain leading to a drop in the rumen pH, hence the inability of the microbes to digest fibre (Nocek and Tamminga, 1991). According to Oba and Allen (2000) when forages that are more fermentable are fed, rumen pH could be lowered leading to low NDF digestibility.

Low intake and digestibility also observed on treatment 100C may be attributed to its high NDF, ADF and ADL compared to the rest of the treatments since more fibrous feed reside longer in the rumen thereby reducing passage rate and hence low intake. Allen and Mertens (1988) reported that NDF digestibility is determined by the fraction of NDF that is potentially digestible, the rate of NDF degradability in the rumen and the rate of passage from the rumen.

The reason why treatments 66M34C and 34M66C lost more nitrogen in faeces and urine may be attributed to their higher intakes of nitrogen compared to treatments 100M and 100C. Van Soest (1994) reported that excess nitrogen derived from microbial nitrogen and proteins that are not part of microbial proteins is normally secreted in milk or lost in faeces and urine of ruminants. Groff and Wu (2005) also reported that when CP in diets is increased there is a general increase in intake and this leads to increased losses of nitrogen into milk, urine and faeces. Even though all the treatment groups had positive nitrogen balance, treatment 100M had the highest because its nitrogen losses to faeces and urine were minimal compared to the rest of the treatments.

The rumen ammonia concentrations in all treatments were similar. The range of NH_3-N concentration was 23.55 to 24.00 mg/100ml. This observation was similar to the figures reported by Hamad *et al*. (2010) who reported values of 22.87 to 23.64 mg/100 ml in lambs fed maize cob-based diet measured 6 hrs post feeding. Khan *et al*. (2006) reported 20.6 to 25.3 mg/100 ml concentration after 6 hours in buffalo bulls fed restricted diets containing urea treated maize cobs ensiled with or without different additives. The result of the rumen pH showed that it ranged from 6.117 to 6.937. Orskov and Ryle (1990) reported that cellulolytic bacteria require pH of 6.2 – 7 while Wanapat and Pimpa (1999) also reported that optimum level of pH in the rumen should be 6.5 to 7.0 which were optimal for microbial growth when animals feed mostly on roughages. The normal rumen pH implied that volatile fatty acids (VFA's) which are by-products of fermentation rapidly diffused through the rumen wall instead of accumulating within the rumen. Accumulation of VFA's could lead to drop in pH because of increased acidic environment hence resulting in decreased DM digestibility. The low pH recorded for the 100% maize grain-based diet might have led to the low intake and digestibility observed as a result of the rapid fermentation of the maize grain in the rumen.

The higher feed intake and digestibility recorded for treatment 34M66C had also translated into higher WG and ADG as compared to the rest of the treatments. However, treatment 100M had lower feed consumption to gain ratio which was as a result of the lower feed intake. Various authors have also reported improvement in intake and digestibility of ruminants fed urea treated maize cobs (Khan *et al*., 2006; Hamad *et al*., 2010; Wanapat *et al*., 2012).

CONCLUSION

It was concluded that maize cobs treated with a combination of urea and wood ash could replace 66% maize grain in sheep diet with added advantage of reducing cost of feed at the same time supplying minerals present in wood ash to the animal.

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