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Effect of urea-molasses treatment on chemical composition and *in vitro* digestibility of maize cobs

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***Target audience:** Researchers, Small ruminants, Farmers and Animal scientists*

Abstract

An experiment was conducted to evaluate changes in the chemical composition and in vitro digestibility of urea-molasses treated maize cobs. Maize cob (Zea mays) was treated with fertilizer grade urea and molasses dissolved in water equivalent to 0.5 % (T_2), 1.0% (T_3), 1.5% (T_4) and 2% (T_5) (w/v) to which was added 500g of molasses and sprayed on 100g quadruplicate samples on Dry Matter (DM) basis while the untreated cobs represent the control (T_1). The resulting products were sundried and kept in polythene bags for further investigation. Samples from the untreated (T_1) and the treated (T_2 to T_5) were investigated for proximate composition, in vitro gas production characteristic, estimated organic matter digestibility (OMD, %), metabolisable energy (MJ/Kg DM) and short chain fatty acid (SCFA, µmol). Changes in the mineral composition were also determined. Results obtained showed a wide variation in the proximate composition (%) with crude protein ranging from1.50 (T_1) to 12.81 (T_5). The contents of Neutral Detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL) differed (significantly $P < 0.05$) with values ranging from 26.50% (T_5) to 70.25%(T_1). Fermentation of the insoluble but degradable fraction (b, ml) was best in T4 (36.0) with the least observed in T_2 (22.0). The estimated OMD and ME were highest in T_5 (55.30% and 14.47 MJ/kg) respectively. In conclusion, treatment of maize cobs with urea and molasses could be an effective way of upgrading the nutritive value low of maize cobs. Maize cobs treated with 2% urea recorded the best content of crude protein, ME, calcium, magnesium, and zinc and can be exploited as a feedstuff in ruminant production systems.

Keywords: maize cob, urea, molasses, chemical composition, *in vitro* gas, digestibility

Description of Problem

One of the most relished and important cereal crop grown in Nigeria for human consumption is maize (*Zea mays*). The production of maize over the years has improved. With the encouragement of government and improved maize seeds, maize yield has increased with the consequent increase in maize residue and wastes. Reports (1) estimated, about 800 million tons of maize is produced worldwide every year. Africa produces 6.5% of this volume consisting mainly straw, husk, skins and trimmings, cobs and bran. The residues and wastes generated from the harvesting or processing of maize are mostly burnt, added to the soil as manure and sometimes thrown away. The consequence of burning most times results in environmental hazards, and contributes to the depletion of ozone layer. In the Northern part of Nigeria where large proportions of Nigerian cattle, sheep and goats are raised, maize is produced once in a year because of the rainfall pattern, except in few places close to the dam. However, in the southern part, maize is produced twice in a year because of the favorable rainfall pattern. Maize cobs, which are readily available by-products from the maize-cropping season, have been found to be poor in nutritive value and therefore contribute very little to the nutritional well being of livestock. With the challenge of shortage of feedstuffs or forages, especially during the dry season, it may be necessary to develop a livestock system based on treated maize residues. This study therefore evaluates the potential of maize cobs treated with urea and molasses as an alternative to the already existing feeding methods in the dry season feeding of ruminants.

Material and Methods

Treatment of Maize cobs

Samples of milled maize cobs were obtained from the Yaba College of Technology, Lagos. Fertilizer grade urea dissolved in water equivalent to 0.5 % (T_2), 1.0% (T_3) , 1.5% (T_4) and 2% (T_5) (w/v) to which was added 500g of molasses and sprayed on 100g quadruplicate samples on Dry Matter (DM) basis. The treated samples were thoroughly mixed, spread on a plastic sheet and kept in the sun to dry for two weeks. After dryness, they were placed in plastic containers for further experiment.

In vitro gas production

Rumen fluid was obtained from, three West African Dwarf female goats through suction tube via the oesophagus before morning feed (2). The animals were fed with 40% concentrate feed (40% corn, 10% wheat offal, 10% palm kernel cake 20% groundnut cake, 5% soybean meal, 10% brewers grain, 1% common salt, 3.75% oyster shell and 0.25% fishmeal) and 60% Guinea grass. Incubation was carried out according to standard methods (3) using 120ml calibrated syringes in three batches at 39^0C. To 200mg sample in the syringe was added 30ml inoculum that contained cheese cloth strained rumen liquor and buffer (9.8g $NaHCO_3$ + 2.77g Na_2HPO_4 + 0.57g KCL + 0.47g NaCl + 0.12g $MgSO_4$. $7H_20$ + 0.16g $CaCI_2$. $2H_20$ in a ratio (1:4 v/v) under continuous flushing with CO_2. Sodium Hydroxide was dispensed using another 50ml plastic calibrated syringe. The syringe was tapped and pushed upward by the piston in order to completely eliminate air in the inoculums. A metal clip so as to prevent an escape of gas then tightened the silicon tube in the syringe. Incubation was carried out at 39± 1^0C and the volume of gas production was measure at 6, 12, 18, 24 and 30h. The post incubation parameters such as metabolizable energy, organic matter digestibility and short chain fatty acids were estimated at 24hours post gas collection according to standard methods (3). The average volume of gas produced from the blanks was deducted from the volume of gas produced per sample.

The volume of gas produced at intervals was plotted against the incubation time and from the graph, the gas production characteristics were estimated using the equation $a + b\ (1 - e^{-ct})$ as described (4), where y = volume of gas produced at time ‘t’, a = intercept (gas produced from the soluble fraction), b = gas production from the insoluble fraction, c = gas production rate constant for the insoluble fraction (b), t = incubation time. Metabolizable energy (ME) was calculated as ME = 2.20 + 0.136 GV + 0.057Cp + 0.0029CF (3). Organic matter digestibility (OMD %) was assessed as OMD = 14.88 + 0.889GV + 0.45CP + 0.651XA (3) where GV, CP, CF and XA are total gas volume, crude protein, crude fibre and ash, respectively. Short chain fatty acids (SCFA) was obtained as 0.0239 GV – 0.0601 using the method of (5), where GV, CP, CF and XA are total gas volume, crude protein, crude fibre and ash, respectively. Data obtained were subjected to analysis of variance. Where significant differences occurred, the means were separated using Duncan multiple range F-test of the SAS (1988) options.

Chemical composition

Crude protein, ether extract and ash were determined according to the conventional methods (6). Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL) were determined using standard methods (7). The mineral elemental constituents (Ca, Mg, Fe, Zn, K, Na, Mn, P and S) in seeds were analyzed separately, using atomic absorption spectrophotometer (Hitachi 26100 model) after acid digestion of the samples.

Statistical analysis

Data obtained were subjected to analysis of variance and mean separations where there were significant differences by Duncan multiple range F-test using statistical analysis system (1988) package.

Results and Discussion

The chemical composition (g/100gDM) of urea–molasses treated corn cobs are shown in Table 1. Noticeable variations were observed in the values obtained for crude protein, crude fibre and carbohydrate fractions. The CP (%) values ranged from 2.5 to 12.81, CF (%) from 7.8 to 10.78 and carbohydrate fractions (%) from 68.70 to 71.21. The increase in CP concentration with an increase in urea-molasses addition may be due to non-protein (urea) addition to the corncobs. Earlier reports (8, 9) obtained an increase in CP content (6-15%) in maize stover treated with urea. Similarly, some researchers (10) obtained 4% increment in CP content of barley straw treated with urea.

In the present study, urea-molasses showed an inverse relationship between the crude fibre fractions and crude fibre. The reduction in NDF content is consistent with previous studies (11), which affirmed the effect of hemicelluloses solubilization. This observation may also be responsible for the decreased ADF.

Previous studies (12) concluded that *Brachiaria humidicola* hay ammoniated with a urea solution at 6.0%, decreased NDF content compared to the untreated hay. Additionally, (13) affirmed that NDF concentration was reduced in barley straw treated with urea at 6%. Elsewhere (9,14) observed that maize residues when treated with urea resulted in reduced cell wall content. These observations are consistent with the observations in the present study.

Table 2 presents, the result of gas production characteristics, estimated organic matter digestibility (OMD), matabolizable energy (ME) and short chain fatty acid (SCFA). Gas production rate constant (h^{-1}) ranged from 0.00245 (T_3) to 0.00191 (T_1). The amount of gas released when feeds are incubated in vitro showed a close relationship to digestibility of feed for ruminants (15). Thus, the gas volume can be considered a good reflection of substrate fermentation to VFA's and an estimate of potential digestibility in the rumen (16). Reports elsewhere (16) indicated that when the amount of substrate is increased, browse plants would produce a slight depression in the amount of gas. There are many factors that may determine the amount of gas to be produced during fermentation, depending on the nature and level of fibre, the presence of secondary metabolites (17) and potency of the rumen liquor for incubation (18); which are found applicable to the present study. Therefore, the higher gas production observed for (T_4 and T_5) suggested a higher nutrient digestibility of the treated maize cobs compared to the untreated (T_1). This observation could be a reflection of a higher proportion of carbohydrate available for fermentation (5) since non-protein nitrogen (NPN) is required for the multiplication of nutrient microbes, higher gas production in the treated cobs.

The rate of gas production (C, h^{-1}) obtained in this study ranged from 0.00191 (T_1) to 0.00245 (T_3). The fast rates of gas production were observed in treatments T_3 to T_5 due possibly to improved soluble carbohydrate fractions readily available to microbial population (19). The lowest rate of gas production was obtained in the control (T_1), indicating that the untreated maize cobs were less available to the microbes in the rumen. Previous studies (20) indicated an improvement in the rate of gas produced by treated maize cob. The potential extent of gas production (a+b) expressed in ml showed that T_4 recorded the highest value. It implies that T4 were readily available in the rumen. It could be observed that T_4 had a reduced NDF compared to the control. This could imply that the change in the nutrient composition after treatment was low to effect change in the (a+b). It could also be the reflection of the lignin content (11%), which is obviously next to the control (14%). The estimated ME (MJ/kg DM) for urea – molasses treated corncobs ranged from 7.60 (T_1) to 14.47 (T_5). The value observed in T_2 to T_5 were higher than the values estimated for energy feedstuffs (19) reported a strong correlation between ME values measured *in vivo* and predicted from 24h *in vitro* gas production and chemical composition of feed. Studies (21) suggested that *in vitro* gas production technique should be considered for estimating ME in tropical feedstuffs.

The SCFA (µmol) predicated from gas production were 0.753(T_1), 0.897(T_3), 0.992(T_4) and 0.929(T_5). There were significant differences among the treatments. The lowest SCFA predicted from gas production in T_1, may be due to a lower absolute gas production. The gas production from cereal straws (22), cereal grains (23) and different classes of feeds (24) incubated *in vitro* in buffered rumen fluid was closely related to the production of SCFA which was based on carbohydrate fermentation. (25) observed a close association between SCFA and gas production *in vitro*. SCFA is an indication of energy availability to the animal. Since T_3 to T_5 recorded higher values of SCFA, which indicated that more energy are likely to be available to the animal fed on those treatments (18). Wide variations were observed in the OMD contents of the different substrates. The improved values observed in T_3 - T_4 for OMD implies that the microbes in the rumen of the animal have high nutrient uptake (19). The higher fibre content of T_1 (untreated corn cobs) probably resulted in lower OMD, since high NDF and ADL content in feedstuffs results in lower fibre degradation (26).

The results of major and trace mineral elements of untreated and treated urea-molasses corn cobs are shown in Table 3. The calcium (mg/kg DM) constituents ranged between 32.12(T_1) and 42.28(T_5). Phosphorus content (mg/kg DM) ranged from 276.79(T_5) and 491.27 (T_4). Magnesium content (mg/kg DM) ranged from 206.49 in the control and 241.52 in T_5. Generally, the Zn, Mn and Cu are generally low and the values ranged from 5.54(T_1) and 8.49(T_5), 4.06(T_1) and 8.85(T_5) and 3.77(T_1) and 7.24(T_5) respectively for Fe, Mn and Cu. The major minerals were within the range previously reported (27). The values obtained are enough to meet the requirement for production. The calcium and phosphorus ratio are not within the approved 1:1 to 2:1 ranged recommended (27).

Conclusion and Applications

1. Urea-Molasses improved the feeding value of the treated maize cobs, by increasing the crude protein content and also enhance the breakdown of fibres providing a better atmosphere for the rumen microbes to operate effectively.
2. The cell wall constituents (NDF, ADF and ADL) were reduced by the treatment. This contributed to the improvement in the organic matter digestibility and the energy content of the resultant substrate compared with the untreated cob.
3. There is a need for further research with live animals so as to evaluate accurately, the performance of ruminants.

Table 1: Proximate composition and crude fiber fractions (g/100g DM) of urea-molasses treated maize cob

Component	T_1	T_2	T_3	T_4	T_5	SEM
Crude Protein	2.5^e	10.75^c	9.96^d	11.69^b	12.81^a	0.02
Crude Fibre	10.75^a	10.15^b	9.40^c	8.45^d	7.85^e	0.03
Ether extract	5.79^d	6.19^b	6.45^a	5.38^e	5.94^c	0.004
Ash	2.88^d	2.75^e	2.98^c	3.29^b	3.67^a	0.004
Neutral detergent fibre	70.25^a	57.75^b	44.75^c	35.50^d	26.50^e	0.40
Acid detergent fibre	42.15^a	34.65^b	26.85^c	21.30^d	15.90^e	0.24
Acid detergent lignin	14.05^a	11.55^b	8.95^c	7.10^d	5.30^e	0.080
Carbohydrate	68.70^d	70.16^b	71.21^a	71.21^a	69.73^e	0.03
Hemicellulose	35.13^a	28.88^b	22.38^c	17.75^d	13.25^e	0.20
Cellulose	21.08^a	17.33^b	13.43^c	10.65^d	7.95^e	0.12

^{a,b,c,d} means along the same row with different superscripts are significant ($p < 0.05$), T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, T_4 = Treatment 4 , T_5 = Treatment 5

Table 2: *In vitro* gas production over 24 hours of incubation of Urea-molasses treated maize cob

Component	$T_{1(control)}$	$T_{2(0.5)}$	$T_{3(1.0)}$	$T_{4(1.5)}$	$T_{5(2.0)}$	SEM
3h	3.00	3.00	3.00	3.00	3.00	0.00
6h	5.00^a	3.00^b	3.00^b	3.00^b	3.00^b	0.49
9h	7.33^a	3.00^a	3.33^b	3.00^b	3.00^b	1.19
12h	10.00^a	6.00^a	7.33^{ab}	4.00^b	3.00^b	1.54
15h	12.0^b	18.33^a	14.33^{ab}	16.00^{ab}	13.00^{ab}	1.74
18h	20.00^{aa}	19.33^{aa}	18.00^{aa}	16.00^{aa}	13.00^a	3.10
21h	27.00^{aa}	21.00^a	28.00^a	16.00^a	13.00^a	4.98

24h	29.00^{ab}	25.00^{b}	35.00^{ab}	39.00^{a}	36.33^{ab}	3.96

^{a,b} means along the same row with different superscripts are significant ($p < 0.05$). T_1=control, T_2=0.5 kg urea, T_3=1.0 kg urea, T_4= 1.5kg urea, T_5= 2.0 kg urea

Table 3: *In vitro* characteristics and the estimated parameters of urea-molasses treated maize cob

Component	$T_{1(control)}$	$T_{2(0.5)}$	$T_{3(1.0)}$	$T_{4(1.5)}$	$T_{5(2.0)}$	SEM
a (ml)	3.00	3.00	3.00	3.00	3.00	0.00
b (ml)	27.00^{ab}	22.00^{b}	32.00^{ab}	36.00^{a}	33.33^{b}	0.05
a + b (ml)	29.00^{ab}	25.00^{a}	35.00^{ab}	39.00^{a}	36.33^{b}	2.08
ME(MJ/kgDM)	7.60^{d}	11.76^{c}	12.66^{bc}	14.18^{ab}	14.47^{a}	0.28
OMD (%)	43.66^{b}	43.73^{b}	52.42^{ab}	56.94^{a}	55.30^{a}	1.85
SCFA (μmol)	0.753^{ab}	0.657^{b}	0.897^{ab}	0.992^{a}	0.929^{ab}	0.05

^{a,b} means along the same row with different superscripts are significant ($p < 0.05$). T_1=control, T_2=0.5 kg urea, T_3=1.0 kg urea, T_4= 1.5kg urea, T_5= 2.0 kg urea, a = intercept (gas produced from the soluble fraction), b = fermentation of the insoluble but degradable fraction, ME = Metabolizable energy, OMD = Organic Matter Digestibility SCFA = Short chain Fatty Acids, (a + b) ml = Potential extents of gas production

Table 4: Mineral composition (mg/kg DM) of urea-molasses

Minerals	$T_{1(control)}$	$T_{2(0.5)}$	$T_{3(1.0)}$	$T_{41.5)}$	$T_{5(2.0)}$	SEM
Calcium	32.17^{d}	32.46^{d}	36.63^{c}	38.91^{b}	42.28^{a}	0.01
Potassium	444.85^{e}	454.35^{d}	469.13^{c}	491.27^{a}	482.32^{b}	0.12
Sodium	33.93^{b}	35.01^{a}	33.39^{c}	32.26^{d}	30.34^{e}	0.01
Phosphorus	334.07^{a}	320.12^{d}	306.90^{c}	286.34^{d}	276.79^{e}	0.11
Magnesium	206.49^{e}	218.08^{d}	225.98^{c}	235.02^{b}	241.52^{a}	0.11
Iron	5.54^{e}	6.22^{d}	6.77^{c}	7.54^{b}	8.49^{a}	0.03
Zinc	44.05^{e}	49.28^{d}	51.89^{c}	56.73^{b}	58.04^{a}	0.12
Manganese	4.06^{e}	5.20^{d}	6.14^{c}	7.70^{b}	8.85^{a}	0.01
Copper	3.77^{e}	4.79_{d}	5.61^{c}	6.32^{b}	7.24^{a}	0.01

$^{a-e}$ means along the same row with different superscripts are significant ($p < 0.05$). T_1=control, T_2=0.5 kg urea, T_3=1.0 kg urea, T_4= 1.5kg urea, T_5= 2.0 kg urea

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