Nig. J. Anim. Prod. 2009, 36(2):313 - 324

Assessment of the nutritive value of bovine liquor and urea treated corn-straw and corn-cobs as feed for the West African dwarf sheep and goats

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Abstract

Corn-straw (CS) and corn-cob (CC) were treated with bovine liquor (BL) to enhance their nutritive values. Eight preparations consisting of CC, CS, CC + BL, CS + BL, CC + urea, CS + urea, CC + BL + urea and CS + BL + urea were made to ferment for five days under anaerobic condition. The final products were assessed for their chemical composition, in vitro gas production and feed preference by sheep and goats. Crude protein contents in CC and CS significantly (P < 0.05) increased from 3.5% and 2.7% to 8.6% and 3.4% respectively without urea but addition of urea increased the contents to 14.6% and 6.8% respectively. Crude fibre, neutral detergent fibre, acid detergent fibre, acid detergent lignin, cellulose and hemicellulose of the treated CS and CC were significantly (P < 0.05) reduced. Similar trends were observed for gas production characteristics as the potentially degradable fraction 'b' and the potential degradability 'a + b' of treated straw and cobs were better (P < 0.05) than the untreated. The rate 'c' of gas production was slower for the treated than the untreated CC and CS. Both sheep and goats separately preferred the treated CC and CS to the untreated after three days and subsequent days of consumption. Since the bovine liquor showed the tendency of enhancing the nutrient contents of corn-cobs and corn-straw and that small ruminant preferred the treated materials than the untreated, sheep and goats can be sustained during the dry season.

Key words: Corn-straw, corn-cob, bovine liquor, nutritive value, acceptability

Introduction

The prohibitive cost of conventional feedstuffs for livestock production in Nigeria is a concern to researchers and as a result, looking for alternatives from cereal residues and by-products is inevitable. Corn is extensively cultivated in Nigeria and the estimated total grain yield amounts to 1.37 million tonnes per year, with an annual growth of 10.2% (FMAWR, 1988), suggesting abundance and availability of corn residues, principally straw, husk, skin trimmings, cobs and bran. FMAWR (1988) anticipated 4.11 million tonnes of corn residues for the present millennium. Corn-cob and corn-straw are perhaps the most prominent of cereal by-product in Nigeria and about 392, 450 tonnes of corn-cobs especially are permitted to decay, heaped up, ploughed into the soil and set ablaze (FOS, 1986). Corn-cob and corn-straw are potentially valuable feed resources for ruminant production (Urio and Kategile, 1987) and can supply considerable amount of energy and other nutrients in ruminant ration (Ward and Perry, 1982). Adebowale (1988) reported that corn residues accounted for almost 25% of the total feed energy suitable for ruminant production but are limited in use due to the preponderance of fibre and squat protein contents. Processing the wastes can produce a proficient exploitation in ruminant production.

Alkali and urea treatments of crop residues are well researched (Dirar, 1992; Eruvbetine and Adegboyega, 1995). Urea application may be better than alkali method as the latter requires handling of anhydrous ammonia (Berger *et al.*, 1979). However, in Nigeria, urea is expensive to procure and sometimes unavailable when desired, as aresultof the high demand as fertilizer for arable crops. An alternative to urea is the use of alkaline treatment but this hydrolysis the crop residues without improvement on the nutrient contents.

There is dearth of information on the processing of corn wastes and by-products, using rumen liquor. Bovine liquor is daily available as over 300 heads of cattle are slaughtered (Unpublished data) every day in each major cities of Nigeria. The content promotes environmental pollution. Since rumen liquor contains micro organisms and it is therefore, capable of biodegrading and enhancing the nutritive value of corn residues (Adeyemi and Familade, 2003). The present study was undertaken to determine the biodegradation effect of bovine liquor and urea to enhance the nutritive value of corn-cob and corn-straw as cheaper feedstuffs for ruminants in Nigeria.

Materials and Methods

Location, sample collection and preparation

Dry season corn-cobs and corn-straw coinciding with the month of January, 2006 were obtained from the Teaching and Research Farm, University of Ibadan, Nigeria. The location for the collection is 7°27'N and 3°45'E at altitude 200 - 300 m above sea level; mean temperature of 25 - 29 °C and the average annual rainfall of about 1250 mm (Babayemi, 2007). The agro-industrial by-products were milled to pass through a 3.5 mm. Bovine liquor content was collected from ten simultaneously slaughtered and freshly disemboweled cattle at Bodija central abattoir, Ibadan, Nigeria. The content was squeezed to obtain partial filtrate and then passed through four layers of cheese cloth. A stream of CO_2 was flushed into the liquor to maintain the anaerobic condition and keep the microbes alive. Urea and ground soyabean were obtained from the Department of Agronomy, University of Ibadan, Nigeria.

There were eight preparations of corn-cob and corn-straw with different combinations of bovine liquor and solution of urea and soybean as: corn-cob, corn-straw, corn-cob + liquor, corn-straw + liquor, corn-cob + urea/soyabean, corn-straw + urea/soyabean, corn-cob + liquor + urea/soyabean and corn-straw + liquor + urea/

soyabean. Corn residue was fermented with liquor (1:1, kg/liter). Equal amount of urea and soybean (1:1, w/w) was used and the addition of the two was made to form a solution with water (1:1, kg/liter). The corn residue was fermented with solution of urea/soybean (1:1, kg/liter). The solid and the liquid (1:1, kg/liter) were thoroughly mixed together and air tight polythene bag was used to pack 40 kg of the sample per treatment and each was replicated five times. The content in the bag was compressed and tightened under anaerobic condition. The fermentation lasted for five days as recommended (Jayasuriya, 1984). Having terminated the fermentation, the temperature and the pH of the samples were immediately taken. Representative samples were oven dried at 105 °C until constant weight was obtained for the determination of dry matter. The fermented samples were sun dried and kept in a store under room temperature.

In vitro gas production

Rumen fluid was obtained from three West African dwarf female goats. The rumen fluid was collected using suction stomach tube from goats that were previously fed with 40% concentrate (40% corn, 10% wheat offal, 10% palm kernel cake, 20% groundnut cake, 5% soyabean meal, 10% dried brewers grain, 1% common salt, 3.75% oyster shell and 0.25% fish meal) and 60% *Panicum maximum* at 5% body weight of the animals before they were offered the morning feed. The rumen liquor was collected into the thermo flask that had been pre-warmed to a temperature of 39 °C. Incubation procedure was as reported by Menke and Steingass (1988) using 120 ml calibrated transparent plastic syringes with fitted silicon tube. The sample weighing 200 mg (n = 3) was carefully dropped into the syringes and thereafter, 30 ml inoculums containing cheese cloth strained rumen liquor and buffer (g/liter) of 9.8 $NaHCO_3$ + 2.77 Na_2HPO_4 + 0.57 KCl + 0.47 NaCl + 2.16 $MgSO_4.7H_2O$ + 0.16 $CaCl_2.2H_2O$) (1:4 v/v) under continuous flushing with CO_2 was dispensed using another 50 ml plastic calibrated syringe. The syringe was tapped and pushed upward by the piston in order to completely eliminate air in the inoculums. The silicon tube in the syringe was then tightened by a metal clip so as to prevent escape of gas. Incubation was carried out at 39 ±1 °C and the volume of gas production was measured at 6, 12, 18, 24 and 30 h. At post incubation period, 4 ml of NaOH (10 M) was introduced to estimate methane production following the method described by Fievez *et al.* (2005). The average of the volume of gas produced from the blanks was deducted from the volume of gas produced per sample. Volume of the gas produced at intervals was plotted against the incubation time, and from the graph, the gas production characteristics were estimated using the equation $y = a + b(1 - e^{-ct})$ as described by Ørskov and McDonald (1979), 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.

Preference study

Ten West African dwarf (WAD) female goats at 16 months old and weighing 10 ± 0.6 kg and ten (WAD) sheep at 12 months old weighing 15 ± 0.3 kg were used for the preference study. The goats and the sheep were purchased from the neighbouring villages of the Teaching and Research Farm, University of Ibadan. The age of the animals was estimated using their dentitions. The animals were immediately placed on prophylactic treatment through the administration of antibiotics (Long acting) at a rate of 1 ml/10 kg body weight by the University veterinarian. The animals were also treated against endoparasites using 5% levamisol and ectoparasites using di-asuntol. During the four week adaptation period, the goats and sheep were fed with the feedstuffs (wheat bran, corn glutton, cassava peels and corn offals) that they were used to consume from where they were purchased. All the goats and sheep were kept each in separate common pens that accommodated about 15 sheep or goats at a time. The floor of the pen was covered with wood shavings to a depth of 5 cm. Fifteen (15) kg each of the degraded corn residues (DCR) consisting of either corn-cobs or corn-straw were placed in strategic locations in feeder trough (2 m x 5 m). The sheep and goats were separately kept and were allowed to feed from 10:00 to 18:00 h daily for fifteen days. Consumption was measured by deducting remnants from the amount of feed offered. The DCR preferred was assessed from the coefficient of preference (COP) value, calculated from the ratio between the intake of each individual DCR, divided by the average intake of the DCR (Babayemi *et al.*, 2006). Therefore, DCR was inferred to be relatively accepted provided the COP was greater than the unity.

Chemical analysis

Crude protein, crude fibre, ether extract and ash contents of the corn-cob, corn-straw and the bovine liquor and urea/soybean degraded corn-cob and corn-straw were determined according to AOAC (1990). Crude protein (CP) analysis was by the process of Kjeldahl. It was effected through the breaking down of 2 g sample (n = 2) in 25 ml concentrated tetraoxo sulphate VI acids plus selenium, using Gerhardt Kjeldahtherm (Gerdart GmbH + Co. KG Fabrik fur Laborgerate Postfach 1628 D53006 Bonn) until an opaque colour was obtained. The digested sample was rested for 12 hours, diluted with distilled water and made up to the mark of 250 ml volumetric flask. Five ml of the digest was taken and distilled with 40% sodium hydroxide and the ionised ammonium was trapped by boric acid. The distillate was immediately titrated (n = 3) with 0.01N hydrogen chloride. In order to obtain the percentage CP, the amount of nitrogen was multiplied by a factor 6.25. Neutral detergent fibre, acid detergent fibre and acid detergent lignin were determined as reported by Van Soest *et al.* (1991).

Statistical analysis

Data were subjected to analysis of variance in a completely randomized design using the General

Linear Model procedure (SAS, 1988) and where significance differences existed, means were separated using Duncan multiple range F-test (DMRT).

Results and Discussion

Chemical composition

Proximate composition of degraded corn-cob (CC) and corn-straw (CS) with rumen liquor and urea are in Table 1. The dry matter ranged from 44.7% in CC with Urea (CCWU) to 85.5% in CC. Crude protein varied between 2.7% in CS and 14.6% in CC combined with Liquor and Urea (CCLU). The value (%) for crude fibre ranged from 32 in CCLU to 54 in CS. The ash content of the crop residues varied between 4% in CCLU and 9.5% in CS with Liquor (CSWL). The oil contents (%) ranged from 5 in CC to 11 in CCLU. There were significant ($p < 0.05$) differences in DM, CP, CF, ash, EE and NFE between the undegraded and degraded crop residues. Both rumen liquor and urea significantly ($p < 0.05$) reduced the DM and CF. The observation showed that the CP, ash and EE were enhanced in the degraded CC and CS. The CP in the treated CC was more improved ($p < 0.05$) by either the liquor or urea than those of CS. Presented in Table 2 are neutral detergent fibre, acid detergent fibre, acid detergent lignin, cellulose and hemicellulose of degraded and untreated corn cob and straw. Fibre fractions of the crop residues were affected by the applications of rumen liquor and urea. The treatment significantly ($p < 0.05$) reduced the fibre contents of the crop residues.

The improvement on the corn residues by fermentation with rumen liquor and urea was encouraging. Earlier fermentation studies (Eka, 1979; Eruvbetine and Adegboyega, 1995; Adeyemi and Adeyemi, 2000; Adeyemi and Familade 2003) indicated that fermentation enhances the nutritive value of feed stuff. Ghoul and Engasser (1983) reported a positive effect on crude protein when cassava was fermented. The increase in the crude protein might be

Table 1: Proximate composition (g/100 g DM) of rumen liquor and urea treated corn-cob and corn-straw

Feedstuffs	Nutrient composition					
	Dry matter	Crude protein	Crude fibre	Ash	Ether extract	Nitrogen free extract
Corn-cob	85.5^{a}	3.5^{d}	46.0b	5.0^{de}	5.0^{c}	40.5^{a}
Corn-straw	85.3^{a}	2.7^{d}	54.0a	8.5^{ab}	7.0^{b}	27.8^{c}
Corn-cob + liquor	45.3^{c}	8.6^{b}	35.0f	7.0^{bc}	6.8^{b}	42.6^{b}
Corn-straw + liquor	45.1^{c}	3.4^{d}	42.0c	9.5^{a}	6.7^{b}	38.4^{c}
Corn-cob + urea	44.7^{c}	9.3^{f}	33.0g	6.5^{cd}	10.0^{a}	41.2^{bc}
Corn-straw + urea	46.0^{c}	6.2^{c}	41.0e	8.0^{abc}	8.0^{b}	36.8^{f}
Corn-cob + liquor + urea	49.9^{b}	14.6^{a}	32.0h	4.0^{e}	11.0^{a}	38.4^{d}
Corn-straw + liquor + urea	49.2^{b}	6.8^{c}	39.0d	5.0^{de}	8.0^{b}	41.2^{e}
SEM	0.70	0.58	0.58	0.58	0.53	0.92

a, b, c, d, e, f, g Means with different superscripts in a column differ significantly ($P<0.05$)

ıble 2: Fibre fractions (g/100 g DM) of rumen liquor and urea treated corn-cob and corn-straw

edstuff	Fibre components				
	NDF	ADF	ADL	Cellulose	Hemicellulose
rn-cob	65.0^{b}	28.0^{d}	7.0^{c}	31.0^{c}	34.0^{ab}
orn-straw	67.0^{a}	36.0^{a}	12.0^{b}	46.3^{a}	21.0^{c}
rn-cob + liquor	60.5^{c}	27.0^{d}	8.0^{c}	29.3^{c}	51.5^{b}
rn-straw + liquor	56.0^{d}	34.0^{b}	11.0^{b}	45.0^{a}	31.2^{e}
rn-cob + urea	62.0^{c}	27.0^{d}	7.0^{c}	30.0^{c}	32.0^{b}
rn-straw + urea	54.0^{d}	31.0^{c}	13.0^{ab}	38.8^{b}	15.2^{d}
rn-cob + liquor + urea	64.0^{b}	25.0^{e}	6.0^{c}	29.0^{c}	35.0^{a}
orn-straw + liquor + urea	61.0^{c}	31.8^{c}	15.0^{a}	38.0^{b}	23.0^{c}
EM	2.0	1.7	0.8	0.7	0.9

Means with different superscripts in a column differ significantly ($P<0.05$)

ociated with proliferation of microbial bodies. he effectiveness of a significant reduction in ude fiber of the rumen liquor fermented corn sidues was probably due to the presence of icrobes in the liquor, which were able to nthesize beta-glucanase. Sniffen (1987) ported that betaglucanase is always used by e microbes to break down cellulose, emicellulose and phenolic polymers.

The untreated maize residues were characterized by low nitrogen content and high cell wall contents with little soluble cell contents. The hemicellulose and cellulose was lowered or reduced due to the treatment that was used for the maize residues. Generally, treatment of the corn residues with rumen liquor and urea were preferred to alkali in the present study. Alkali method has been reported to disrupt the cell wall by solubilizing hemicellulose, lignin and silica. It also hydrolyses uronic acid, acetic acid, esters and causes the swelling of cellulose (Jackson, 1977). Sundstol and Cox worth (1984) reported that ammonia gas generated from urea hydrolysis the chemical and physical bonds between lignin cellulose and hemicellulose in the plant cell wall. The hydrolysis of these bonds makes the cellulose and hemicellulose more accessible to micro-organisms in the rumen and improves both the total and rate of fermentation.

In vitro gas production characteristics

In vitro gas production characteristics of the treated and untreated CC and CS are shown in Table 3. The value for potentially degradable fraction (b) varied from 32.0 in CCLU to 8.0 in CS. Similar trend was observed for potential degradability (a + b), which also varied between 35.3 for CCLU and 10.0 in CS. The extent of gas production (c) was highest (0.13) in CSLU and lowest (0.06) in CCLU. Methanogenesis, that is methane production varied from 27.0 in CCLU to 8.0 in CS. There were significant ($p < 0.05$) differences in b, a + b and c of the treated and untreated samples. CCLU was significantly highest in b, a + b and methane but the least in the rate of extent of gas production. Untreated

Table 3: In vitro gas characteristics (ml/200 mg DM) of untreated and degraded corn-cob and corn-straw with bovine liquor and urea

Feedstuff	In vitro gas			
	b	a + b	c	Methane
Corn-cob	9.5[e]	12.5[e]	0.064[e]	10.0[de]
Corn-straw	8.0[e]	10.0[f]	0.077[b]	8.0[e]
Corn-cob + liquor	12.0[d]	16.0[d]	0.077[b]	13.0[c]
Corn-straw + liquor	13.5[d]	14.0[e]	0.068[c]	10.0[de]
Corn-cob + urea	26.0[b]	28.0[b]	0.066[d]	22.0[b]
Corn-straw + urea	13.5[d]	14.0[e]	0.068[c]	11.0[cd]
Corn-cob + liquor + urea	32.0[a]	35.3[a]	0.055[f]	27.0[a]
Corn-straw + liquor + urea	21.5[c]	22.5[c]	0.127[a]	20.0[b]
SEM	0.722	0.629	0.0001	0.699

[a, b, c, d e]Means with different superscripts in a column differ significantly ($P<0.05$)

CC and CS were observed to be the least in the gas characteristics.

Comparing the contents of Tables 2 and 3, it was observed that the potentially degradable fraction b, increased as the NDF decreased for treated and fermented maize residues in this study. Also, it was noted that as the crude fiber was decreasing, the potentially degradable fraction b increased. This may suggests an inverse relationship between the potentially degradable fraction b and NDF with crude fiber observed in this study. The potential degradability (a + b) and potentially degradable fraction (b) for control were significantly lower ($P< 0.05$) than the (a + b) and (b) observed in urea treatments in this experiment and this agreed with the observation of Adebowale *et al.* (1991) where they reported an increase in (a + b) potential degradability, when maize stover and corn cob were treated with urea and subjected to in vitro fermentation. This also agrees with the work done by some workers who reported an increase dry matter digestibility in treated barley straw when subjected to in vitro fermentation (Wanapat *et al.*, 1984). The values of 'c' that is, the rate of degradability of b for corn cob was mainly lower than the control for both treatment and fermentation unlike fermented and treated corn straw which higher than the control and this agrees with the findings of Adebowale *et al.*, 1991. The third parameter obtained represents the amount of feed degraded per unit time, which is proportional to the quantity of potentially degradable substrate, which decreases continuously with time. This agrees with the report of Van Milgen and Baumont, 1985). Sundstol and Coxworth (1984) reported that ammonia gas generated from urea hydrolysis the chemical or physical bonds between lignin, cellulose and hemicellulose in the plant cell wall. The hydrolysis of these bonds makes the cellulose and hemicellulose more

Table 4: Mean dry matter intake (MDI) (kg DM) and coefficient of preference (COP) by WAD goats fed bovine liquor and urea degraded corn-cob and corn-straw

	Days							
	1		3		10		15	
Feedstuff	MDI	COP	MDI	COP	MDI	COP	MDI	COP
Corn-cob	1.0	1.05	0.7	0.72	0.3	0.30	0.3	0.32
Corn-straw	1.1	1.15	0.8	1.14	0.5	0.51	0.5	0.53
Corn-cob + liquor	0.5	0.53	0.7	0.72	0.9	0.91	1.1	1.17
Corn-straw + liquor	0.7	0.74	0.7	0.72	1.3	1.32	1.2	1.28
Corn-cob + urea	1.3	1.37	1.0	1.04	1.0	1.01	1.1	1.17
Corn-straw + urea	1.5	1.58	1.2	1.25	1.3	1.32	1.0	1.07
Corn-cob + liquor + urea	0.6	0.63	1.1	1.14	1.2	1.22	1.1	1.17
Corn-straw + liquor + urea	0.9	0.95	1.5	1.56	1.4	1.42	1.2	1.28

accessible to micro-organisms in the rumen and improve both the total and rate of fermentation.

Acceptability of residues by goats and sheep

Although there are many ways of assessing the nutritive value of feeds for ruminants, the direct intake by the animals remains the authentic method. In the recent times, cafeteria technique have been used to access the acceptability of some aquatic weeds (Babayemi *et al.*, 2006) and of some forages (Bamikole *et al.*, 2004; Babayemi, 2007). In the present study, the mean dry matter intake (MDI) and coefficient of preference (COP) by goats and sheep placed on treated and untreated CC and CS are indicated in Tables 4 and 5 respectively. In the first day of the free choice intake, untreated CC, CS and those treated with urea were accepted by goats. Similar trend was observed for the sheep but in addition, sheep accepted the combinations of CS + liquor + urea.

The rejection of the treated materials by both sheep and goats at the initial offer showed that both species may be receiving similar sensations. Robertson *et al.* (2006) observed that sensations are innately associated with post-ingestive feed-backs associated with the consumption of a diverse range of feeds. In the present study, both sheep and goats, after seven days of the continuous supply with the feedstuffs, goats accepted all the treated crop residues and rejected those of untreated CC and CS. Sheep also rejected what goats did not accept but further rejected the CC treated with rumen liquor. The goats and the sheep showed initial displeasure for the residues treated with rumen liquor but later accepted them after two days of offering the feedstuffs. This observation corroborates the earlier report (Forbes and Kyriazakis, 1995) that animal's preference for feed swings in relation with instant over an elongated examination periods. This further suggests that much longer time is essential in carrying out preference studies

Table 5: Mean dry matter intake (MDI) (kg DM) and coefficient of preference (COP) by WAD sheep fed bovine liquor and urea degraded corn-cob and corn-straw

	Days							
	1		3		10		15	
Feedstuff	MDI	COP	MDI	COP	MDI	COP	MDI	CO
Corn-cob	1.1	1.04	0.8	0.64	0.5	0.48	0.1	0.0
Corn-straw	1.4	1.32	1.2	0.97	0.8	0.77	0.6	0.5
Corn-cob + liquor	0.6	0.56	0.9	0.72	0.9	0.87	0.8	0.7
Corn-straw + liquor	1.0	0.84	1.3	1.05	1.5	1.45	1.8	1.
Corn-cob + urea	1.3	1.22	1.1	0.89	0.9	0.87	1.2	1.0
Corn-straw + urea	1.3	1.22	1.6	1.30	1.1	1.06	1.4	1.2
Corn-cob + liquor + urea	0.7	0.66	1.3	1.05	1.3	1.25	1.2	1.0
Corn-straw + liquor + urea	1.1	1.04	1.7	1.37	1.3	1.25	1.9	1.6

for ruminants, thereby paving ways for adjustments.

The acceptability of the residues treated with liquor by sheep was observed much earlier than that of goats. A number of factors may influence acceptability of feed by small ruminants. Provenza and Cincotta (1994) reported that plant physical structure and chemical composition are the most vital factors that influence preference for food. The artificial flavour imposed on the feeds by the addition of rumen liquor and urea during fermentation in the present study probably caused a shift of the acceptability by the sheep and the goats from untreated to treated corn-straw and corn-cobs. Hadjigeorgiou et al. (2003) observed that goats and sheep accepted ammonia treated straw after an adaptation period and also lambs preferred onion to garlic (Nolte and Provenza, 1992).

Conclusion

It has been shown from the study that corn-c and corn-straw are better enriched when treat with bovine liquor. The *in vitro* gas producti characteristics of the treated corn by-produ are enhanced but with a faster rate of productio suggesting a better degradation b microorganisms. The treated by-products a also preferred by sheep and goats after thr days of consumption, indicating short ter adaptation to the feed. Further studies shoul be carried out to explore the full potential o bovine liquor treated corn-cob and corn-stra in the performance of small ruminants.

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(Received 4th October 2007; Accepted 4th Feb.,2009).