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Full Length Research

Nutritional improvement of rice straw treated with urea-molasses and its effect on *in vitro* digestibility

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ABSTRACT: Rice straw was treated with urea-molasses and concealed in a polythene bag for a week. The resultant impact of the treatment on the chemical composition and *in vitro gas* production parameters was analyzed. Feed grade urea was dissolved in water containing molasses equivalent to 0.5% (T_2), 1.0% (T_3), 1.5% (T_4) and 2% T_5 (w/v) were sprayed on 100 g quadruplicate samples. The result obtained showed significant ($p<0.05$) variations in the chemical composition. The NDF (%) ranged from 75.12 (T_1) to 48.78 (T_5), ADF (%) 42.34 (T_1) to 34.96 (T_5) and ADL (%) 16.42 (T_1) to 10.25 (T_5). These contents decreased progressively with increased inclusion of urea-molasses. However, treatment effect as affected by cellulose content was not significant ($p>0.05$). The (b, ml) ranged from 6 (T_1) to 26 (T_5). Treatments 4 had the highest crude protein (13.1%) and ash (2.83%). Gas volume at 24 hours differed significantly ($p<0.05$) with values increasing with inclusion of urea-molasses from 14 ml (T_1) to 30 ml (T_5). The methane production increases proportionally with Gv24 with values ranging from 5.33 ml (T_1) to 16.00 ml (T_5). Treatment of rice straw was affected SCFA (µmol) production. Treatment effect on potassium and phosphorus was significant ($p<0.05$) while Na, Ca, Mg, Cu, Fe, Zn and Mn were not significantly ($p>0.05$) affected by treatment. Urea-molasses treatment rice straw improved the fermentation quality and, estimated organic matter digestibility, metabolisable energy and short chain fatty acid.

Keywords: *In vitro* gas production, rice straw, ruminant, urea-molasses.

INTRODUCTION

In the developing part of the world such as Nigeria, ruminants depend practically on natural pastures, crop residues and agricultural by-products. In the Northern part of Nigeria where the largest numbers of ruminants are concentrated, the availability of rice straw decreases from the onset of dry season and continued throughout the season. The low nutrient content of the available pasture is evident in its content of digestible energy and crude protein. When this happens, the farmers are left with no options other than the use of available crop residues and agricultural by-products. Such scarcity of forages both in quantity and quality is perhaps the reason for the movement of nomadic herdsmen from the Northern part of the country to the Southern part where, perhaps their livestock may scavenge for forages. Rice straw is what is left after threshing of the rice crop. Such straw is available in large quantities in rice producing areas of the country. Sarnklong et al. (2010) indicated that feeding only rice straw does not provide nutrients to the ruminant to maintain high production levels due to the low nutritive value of these highly lignified materials. Van Soest (2006) suggested that the high level of lignifications and silification, the slow and limited ruminal degradation of the carbohydrates and the low content of nitrogen are the main deficiencies of rice straw, affecting its value as feed for ruminants. Elsewhere, Conrad (1996) observed that the straw is poorly fermented; it has low rates of passage through the rumen, reducing feed intake. Fadel Elseed, (2005) and Wanapat et al. (2009) advised that with urea or calcium hydroxide or by supplementing rice straw with protein, intake, degradability and milk yield can be enhanced, compared to untreated rice straw alone.

In the past, several studies have been reported on the physical and chemical utilization of rice straw as ruminant feed (Shem et al., 1998; Abou-El-Enin et al., 1999; Vadiveloo, 2000; 2003; Akinfemi and Ladipo, 2013). Furthermore, several interventions such as physical, chemical and biological treatments including supplementation with other foodstuffs or components in order to improve the utilization of rice straw by ruminants (Reddy, 1996; Karunanandaa and Varga, 1996a,b; Vu et al., 1999; Liu and Orskov, 2000; Selim et al., 2004; Akinfemi and Ladipo, 2013).

Although, previous studies on the utilization of urea in the treatment of rice straw abounds, however, these studies apply a modification by the combination of urea with molasses, fertilizer grade urea is used for this experiment. Farmers are familiar with urea; it is a non-protein-nitrogen and this improves the nitrogen content of the treated straw. It is safe to use and environmentally friendly and can be easily applied on the farm. Therefore, the use of rice straw as an animal feed as well as its treatment is always an economic decision (Sarnklong et al., 2010). Urea does not contain energy and therefore, the addition of molasses as a source of energy and soluble carbohydrate. Since the treatment of urea-molasses seems technically sound, economically beneficial and socially acceptable, it is expected to have a high probability of being adopted (Mudzengi et al., 2014).

Therefore, the objective of this research is to assess changes in nutritional composition of urea-molasses treated rice straw.

MATERIALS AND METHODS

Samples of rice straw was obtained from a commercial rice farm in Agbowa, Lagos was chopped into smaller pieces (approximately 1 cm). Feed grade urea dissolved in water containing molasses equivalent to 0.5% (T_2), 1.0% (T_3), 1.5% (T_4) and 2% T_5 (w/v) were sprayed on 100 g quadruplicate samples on DM bases. The thoroughly mixed samples were sun dried while the samples required for proximate composition and *in vitro* digestibility were oven dried at 105^0C for hours, to constant weight. Chemical composition of the treated (T_2 to T_5) and untreated sample T_1, were determined using standard methods (AOAC, 1995; Van Soest et al., 1991). Rumen liquor was obtained from three WAD female goats through suction tube before morning feed. The preparation is buffer solutions and rumen innocula was as described by Menke and Steingass (1988). Gas production was measured three hourly and at 24 hours gas production, 4 ml sodium hydroxide (10 ml) was introduced after 24 hours post incubation to estimate methane production. The average of the volume of gas produced from the blank was deducted from the volume of gas produced per sample. Metabolizable Energy (ME) was calculated as ME = 2.20 + 0.136GV + 0.057CP + 0.0029CF (Menke and Steingass, 1988), organic matter digestibility (OMD, %) = 14.88 + 0.88Gv + 0.45CP + 0.651 XA (Menke and Steingass, 1998). Short chain fatty Acids (SCFA) as 0.0239Gv – 0.0601 (Getachew et al., 1991) was obtained where Gv, CP, CF and XA are total gas volume, crude protein crude fiber and ash respectively.

Statistical analysis

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 (Statistical Analysis System Institute Inc. 1988 options).

RESULTS AND DISCUSSION

The result of the proximate composition and the crude fiber fractions of urea-molasses treated rice husk is shown in Table 1. The crude protein (CP) content of the treated rice straw increased as urea-molasses treatment increased from 0 to 4% such increase may be traced to the addition of urea (non-protein nitrogen) (Ramirez et al., 2007). Earlier studies (Fall, 1988; Aregheore, 2005) observed increase in crude protein content (6-15%) of corn stover treated with 0% and 7% fertilizer grade urea. Whereas, Golmahi et al. (2006) obtained a small increment (4%) in CP of barley straw treated with urea at 0 and 4%.

In this experiment, as urea treatment increased the contents of NDF, ADF and ADF decreased while there was no statistical difference in the cellulose contents. The NDF content of the urea treated straw might have decreased as a result of hemicelluloses solubilization (Sundstol and Coxworta, 1984). Previous studies further confirmed reduction in the NDF in urea-treated crop residues and grass hays (Ramirez et al., 2007). Other studies (Dias-De-Silva et al., 1988; Chesnot et al., 1991, Joy et al., 1992) proved that in general, a dosage of 4 to 6% urea can be considered sufficient to obtain maximum digestion of dry matter and reduction of NDF. Also, Brown and Kunwe (1992) when ammoniated *Cynodon dactylon* hay with 4% feed grade urea reported that NDF decreased and *in vitro* DM digestibility increased. Others (Hill and Leaver, 1999) reported that application of urea at a rate of 4% (DM) increased reduction in NDF content compared to untreated samples. Their observation is consistent with the present research.

The predominant components cell wall contents of rice straw as observed in this study are cellulose, hemicellulose and lignin. To break down this component cellulose and hemicellulose, lignase is required to act on the cell wall constituents (Schiere and Ibrahim, 1989). Therefore, the decrease in such components as obtained in the present experiment could be attributed to the treatment of urea-molasses. Earlier studies indicated that even if lignin could be degraded in the rumen, it would not

Table 1. Proximate composition and crude fractions (g/100gDM) of rice straw treated with urea-molasses.

Parameter	T_1	T_2	T_3	T_4	T_5	SEM
Crude protein	11.71^{d}	12.06^{c}	12.61^{b}	12.81^{b}	13.11^{a}	0.04
Crude fibre	5.65^{a}	5.42^{ab}	5.19^{bc}	4.89^{dc}	4.67^{d}	0.07
Ether extract	4.58^{c}	4.53^{c}	4.69^{c}	5.57^{a}	4.99^{b}	0.03
Ash	2.28^{c}	1.74^{d}	2.72^{b}	2.68^{b}	2.83^{a}	0.02
Carbohydrate	75.78^{a}	76.25^{a}	74.58^{b}	74.25^{b}	74.39^{b}	0.09
NDF	75.12^{a}	64.78^{b}	58.96^{c}	54.77^{d}	48.78^{e}	0.71
ADF	42.34^{a}	39.58^{ab}	37.23^{b}	37.12^{b}	34.96^{b}	0.86
ADL	16.42^{a}	13.54^{b}	11.11^{c}	11.06^{c}	10.25^{c}	0.40
Cellulose	25.92	26.05	26.17	26.01	24.71	0.88
Hemicellulose	32.78^{a}	25.19^{b}	21.72^{bc}	17.66^{cd}	13.82^{d}	1.18

$^{a\text{-}d}$ mean along the same row with different superscript are significant P < 0.05 SEM = Standard error of mean, NDF = Neutral detergent fiber, ADF = Acid detergent fiber ADL = Acid detergent lignin.

Table 2. Gas Production characteristics and estimated parameters for rice straw treated with urea-molasses.

Parameter	T_1	T_2	T_3	T_4	T_5	SEM
b,ml	6.00^{dc}	12.67^{bc}	20.67^{ab}	21.33^{ab}	26.00^{a}	1.39
Gv24(ml)	14.00^{a}	20.67^{bc}	28.67^{ab}	28.00^{ab}	30.00^{a}	1.48
OMD (%)	33.96^{b}	39.63^{b}	47.64^{a}	46.94^{a}	49.02^{a}	1.31
ME (MJ/KgDM)	17.02^{c}	23.71^{bc}	31.75^{ab}	31.07^{ab}	33.09^{a}	1.48
SCFA (µmol)	0.274^{c}	0.433^{bc}	0.625^{ab}	0.609^{ab}	0.656^{a}	0.04
CH4 ml/200mg	5.33^{c}	10.00^{cb}	12.00^{ab}	13.00^{cb}	16.00^{a}	0.82

provide much energy for the animals (Sarnklong et al., 2010), hence, the reason for the addition of molasses. Molasses is a by-production of sugar production with good contents of digestible soluble carbohydrates and energy. Urea also does not contain energy. The combination of urea-molasses in the treatment of rice straw is expected to improve the nutrient content and the available energy content.

Table 2 shows the gas production characteristics and estimated parameters for rice straw. The fermentation of the insoluble but degradable fraction (b, ml) differed significantly ($p<0.05$) with values ranging from 6 (T_1) to 26 (T_5). The highest fermentation of the insoluble, but degradable fraction (b, ml) was observed in T_5 (26.00), possibly as a result of the carbohydrate fractions readily available to microbial population (Chumpawadee et al., 2007). The improvement, by the addition of nitrogen to the treated rice straw also may be responsible for the improved b, ml. These treatments enable the rumen microorganisms to attack more easily the structural carbohydrates, enhancing degradability and palatability of the rice straw (Prasad et al., 1998; Shen et al., 1999; Selim et al., 2004). Gas volume at 24 hours of incubation progressively increased with increment in urea-molasses treatment. Generally, gas production is a function and a mirror of degradable carbohydrate and therefore the amount depends on the nature of the carbohydrates (Demeyer and Van Nevel, 1975; Blummel and Becker, 1997). Also, high crude protein in feed enhances microbial multiplication in the rumen, which in turn determines the extent of fermentation (Babayemi, 2007).

Organic matter digestibility ranged from 33.96% (T_1) to 49.02% (T_5). The values observed improved with increase in urea-molasses treatment. This implies that the microbes in the rumen and animal have high nutrient uptake. There seems to be an inverse relationship in the crude fiber content and the values of OMD obtained in the experiment. The decrease in the content of NDF, ADF and ADL as observed in this study may be responsible for the improved results observed for OMD along the treatments. High NDF and ADL contents in feedstuffs results in lower fiber degradation (Van Soest, 1988).

The estimated ME obtained in the present study is high in the treated samples. Menke and Steingass (1988) reported a strong correlation between ME values measured *in vitro* and predicted from 24 hours *in vitro* gas production and chemical composition of feed. The *in vitro* gas production method has also been widely used to evaluate the energy value of several classes of feeds (Getachew et al, 1998; Getachew et al., 2002; Aiple et al., 1996). Others (Krishnamoorthy et al., 1995) suggested that *in vitro* gas production technique should be considered for estimating ME in tropical feedstuffs because other method requires labour, cost and time.

Getachew et al. (2002) stated that it is well known that gas production is basically the result of fermentation of

Table 3. Effect of urea-molasses treatment on the mineral composition (mg/kg) of rice straw.

Major Minerals	T_1	T_2	T_3	T_4	T_5	SEM
Na	8.24	8.04	7.92	8.13	7046	0.38
K	126.73[b]	129.11[a]	120.87[d]	124.58[c]	120.31[d]	0.33
Ca	29.87	30.18	29.35	29.10	28.46	0.33
P	78.91[a]	75.74[c]	76.92[bc]	78.42[ab]	78.85[a]	0.33
Mg	20.11	18.98	18.78	18.92	20.01	0.33
Cu	1.11	1.12	1.13	1.10	1.12	0.33
Fe	2.81	2.71	2.74	2.96	2.83	0.33
Zn	1.69	1.68	1.71	1.62	1.66	0.33
Mn	0.49	0.51	0.49	0.51	0.48	0.33

carbohydrate to volatile fatty acid (acetate, butyrate and propionate). Also, Menke and steingass (1988) reported that fermentable carbohydrate increased gas production while degradable nitrogen compound decreased gas production to some extent due to building of carbohydrate with ammonia. The short chain fatty acid increased with increased treatment of urea-molasses. The high value recorded for the treated straws indicates a higher availability of energy because SCFA is a reflection of the energy availability in feedstuff. The value of SCFA obtained in this study is consistent with the trend of gas volume.

Presented in Table 3 is the effect of urea-molasses treatment on the mineral composition. Treatment effects as affected by mineral composition were not significant ($p>0.05$) except for the potassium and phosphorus. The most abundant potassium was observed in T_2 (129.11 mg/kg) while the least was recorded in T_5 (120.31). The variation in the potassium content as obtained in this study does not show any pattern and the reason for such is not clear. However, reports by Afolabi et al. (1985) and Olaofe and Sanni (1980) indicated that potassium is the predominant mineral in Nigeria agricultural production. The potassium content of the rice straw used in this study is generally low. The phosphorus content of the rice straw is generally deficient and far below 800 to 1200 mg/kg required daily for normal kidney functioning and transfer of nerve impulse (Davidson and Passmore, 1975). Hegested (1973) reported that phosphorus is an essential component of nucleic acid and nucleoproteins, which are responsible for cell division, reproduction and heredity. Methane (ml/200mg/DM) production ranged from 5.33(T_1) to 16.00(T_5) among the experimental samples. In most cases, feedstuffs that show high capacity for gas production are also observed to be synonymous for high methane production (Babayemi, 2007).

Methane production indicates an energy loss to the ruminant and many tropical foodstuffs have been implicated to increase methanogenesis (Babayemi et al., 2004; Babayemi and Bamikole, 2006a; Babayemi and Bamikole, 2006b) as an integrated part of carbohydrate metabolism (Demeyer and Van Nevel, 1975).

Conclusion

From the result obtained in this study, urea-molasses treatment of rice straw improved the crude protein content and also the digestibility. Therefore, the product could be applied in ruminant diet in combination with other feedstuffs. However, further research is required with use of live animals to ascertain the level of inclusion in the diets of ruminants.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ABBREVIATION

NDF, Neutral Detergent Fiber; **ADF,** Acid Detergent Fiber; **ADL,** Acid Detergent Lignin; **b,** Fermentation of the insoluble but degradable fraction; **SCFA,** Short Chain Fatty Acid; **ME,** Metabolisable Energy; **OMD,** Organic Matter Digestibility; **Gv,** Gas volume; **CP,** crude protein; **CF**, crude fiber; **XA,** ash; **WAD,** West African Dwarf.

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