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Cane molasses and NaOH-treated bagacillo diets for lambs

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The effect of alkali-treated bagacillo in diets varying in proportion of bagacillo and molasses was studied in lambs. The bagacillo was treated with a concentrated solution of NaOH in a horizontal drum-type mixer to give a final concentration of 6% NaOH in the processed material with a 20% moisture content. ADG and feed efficiency were higher on the treated than on the untreated bagacillo diets. For all cell wall constituents, especially hemicellulose, digestibility was greater for the NaOH-treated when compared with the untreated bagacillo diets. Lambs fed the treated diets also had an increased N retention. The superior performance of lambs fed the treated bagacillo diets could be accounted for by an increase in intake and digestibility.

Die effek van alkoli-behandelde bagacillo in rantsoene wat verskil in die verhouding van bagacillo melasse is by lammers ondersoek. Die bagacillo is behandel met 'n gekonsentreerde oplossing van NaOH in 'n horisontale drom-tipe menger om 'n finale konsentrasie van 6% NaOH in die behandelde materiaal met 20% voginhoud te gee. ADG en doeltreffendheid van voeding was hoër op die behandelde as op die onbehandelde bagacillo rantsoene. Die verteerbaarheid van al die selwandbestanddele, veral hemisellulose was hoër vir die NaOH-behandelde rantsoene in vergelyking met die onbehandelde bagacillo rantsoene. Lammers wat die behandelde rantsoene gevoer is, het ook 'n verhoogde N retensie getoon. Die feit dat lammers wat behandelde bagacillorantsoene gevoer is, beter presteer het, kan toegeskryf word aan die verhoogde inname en verteerbaarheid.

Keywords: Sugar cane bagasse, NaOH treatment, feed conversion, digestibility, nitrogen retention

Introduction

In tropical America ruminants depend almost exclusively on forages, the dry season being limiting for beef and milk production, unless conserved feed and/or by-products and crop residues are available. The utilization of the latter would markedly increase the currently low animal feed supply. However, full benefit is not at present derived from lignocellulosic feed because limited information is available regarding chemical composition, processing, limiting factors and proper use of feeding and production systems. In addition to biological, technological and economical considerations, lignocellulosic residues have a low density and consequently transport problems. Thus their use implies integrated crop-agroindustrial-processing-animal production systems.

In Venezuela the short fibre of sugar cane bagasse, or 'bagacillo' is an important lignocellulosic residue, with a yearly production of about 400 000 MT and it is used mainly as fuel energy and as feed filler. The nutritive value of bagacillo was increased with a NaOH treatment developed in our laboratory using a highly concentrated solution of the alkali in a horizontal mixer, to obtain a final product with a very low moisture content. Previous feeding trials with sheep on diets containing 70% bagacillo indicated a 51% increase in body weight gains when comparing the treated diet with the control diet (García *et al.*, 1981). The objective of this research was to determine further the effect of alkali-treated bagacillo in bagacillo/molasses diets on the performance of tropical lambs.

Materials and Methods

Forty-eight West African lambs (18,7 kg) were divided into six uniform groups according to age and body weight and

assigned to six experimental diets, in a 2 × 2 factorial design, with the following treatment combinations: (i) 70% treated or untreated bagacillo with 22% molasses; (ii) 46% treated or untreated bagacillo with 46% molasses; and (iii) 22% treated or untreated bagacillo with 70% molasses. All rations had a protein, mineral and vitamin nucleus, made up of 4,5% sesame, 1% complete mineral mix and 50 000 I.U. of vitamin A/kg. The particle size of bagacillo was between 8 and 35 mesh with a gross density of 0,083 g/cm^3. The lignocellulosic material was uniformly treated with a concentrated solution of NaOH in a 100 kg/h horizontal drum-type mixer, to give a final concentration of 6 kg NaOH/100 kg of processed material with a 20% moisture content. The experimental diets were isonitrogenous (12% crude protein equivalent) by calculation. Each animal group was further divided into two sub-groups, each being randomly assigned to feeding pens. The diets were fed *ad libitum* with daily control of intake. The feeding period lasted 112 days, with body weight measurements taken every 28 days. At the end of the feeding period, three animals/treatment were randomly selected and placed in metabolism crates for a 7-day adjustment period followed by a 7-day collection period to determine the apparent digestibility and nitrogen balance. Two additional animals/treatment were given a single oral dose of 10 g chromic oxide (Cr_2O_3) and faecal collections were carried out at 6-h intervals to determine their rate of passage. All feed and faeces samples were analysed for nitrogen, cell wall constituents, and urine for nitrogen only, by conventional methods. In addition, Cr_2O_3 was determined in faeces by atomic absorption spectrophotometry. The data were analysed using analysis of variance; correlation and regression and the difference between means were determined by Duncan's multiple range test.

Results and Discussion

The effects of the experimental diets upon body weight, dry matter consumption and feed conversion are illustrated in Table 1. Average daily gains were higher ($P<0,01$) in the treated bagacillo diets compared with the untreated diets. As the proportion of treated bagacillo increased in the diet weight increase remained the same, whereas with untreated bagacillo there was a pronounced decrease in weight gain. The latter showed a negative correlation ($r = -0,81$; $P<0,01$) between percentage bagacillo (x) and body weight change (y) which can be described by the following regression equation: $y = 106,967 - 1,590\,x$ ($R^2 = 0,66$).

Intake (g/day) was greater ($P<0,01$) in the treated diets containing 46 and 70% bagacillo. An increase in the level of bagacillo (x) was related to an increase in the intake of the treated diet (y) ($r = 0,98$; $P<0,01$), described by the equation $y = 596,071 + 9,456x$($R^2 = 0,96$), while the untreated bagacillo showed a negative relation which was not statistically significant. A similar trend was also observed when intake was expressed as a function of metabolic body weight.

Feed conversion was better ($P<0,01$) in the treated bagacillo diets when compared with the untreated diets although both showed a decreasing trend as the level of bagacillo in the diet increased. The data reveal that the greater body weight gains in the NaOH-treated diets appear to be associated with increased intake, as also reported by Greenhalgh *et al.* (1976).

Results on digestibility measurements of dry matter, protein and cell wall constituents are presented in Table 2. Dry matter digestibility was greater (12,3% units as an overall mean) in the treated bagacillo diets ($P<0,01$) and was not influenced by bagacillo levels. The increase of dry matter digestibility by NaOH treatment supports the finding that straw treated with NaOH rarely increases *in vivo* digestibility by more than 10% units (reviewed by Jackson, 1978).

Protein digestibility was not affected by NaOH treatment, while bagacillo level had a negative ($P<0,05$) effect, both in the treated ($y = 80,327 - 0,275x$; $R^2 = 0,61$) and untreated diets ($y = 76,375 - 0,207x$; $R^2 = 0,49$). This negative effect was probably a result of a decrease in available energy for the utilization of diet NPN since molasses was replaced with bagacillo.

For all cell wall constituents, digestibility was generally greater in the treated bagacillo diets ($P<0,05$), showing an increasing trend as the level of bagacillo increased in both treated and untreated diets. Among cell wall constituents, hemicellulose showed the greatest effect with digestibility increasing by 12,7 to 21,1% units and alkali treatment depending on bagacillo level. This supports earlier findings

Table 1 Body weight gains and feed consumption of tropical lambs fed NaOH-treated and untreated bagacillo/molasses diets[a]

	Bagacillo/molasses ratio					
	22/70		46/46		70/22	
Observations	+ NaOH	− NaOH	+ NaOH	− NaOH	+ NaOH	− NaOH
Av. initial wt, kg	18,9	18,7	18,7	18,6	18,7	18,6
Av. final wt, kg	29,6	27,0	28,2	23,9	28,9	17,2
Av. daily gains, g	95,6^{b}	74,2^{b}	84,6^{b}	49,5^{c}	91,5^{b}	−12,3^{d}
Feed consumption, g/animal/day	787 ^{b}	829 ^{b}	1066 ^{cd}	904 ^{bc}	1240 ^{d}	657 ^{bc}
Consumption g/ka^{0,75}	73,6^{b}	79,5^{b}	99,5^{c}	91,7^{c}	110,2^{d}	72,6^{b}
Feed efficiency	9,5^{b}	11,4^{c}	12,6^{ce}	21,4^{d}	13,4^{dc}	–

[a]Means based on eight animals/treatment

[b,c,d,e]Means in the same line bearing different superscript letters differ significantly ($P<0,01$)

Table 2 Digestibility of NaOH-treated and untreated bagacillo/molasses diets in lambs[a]

	Bagacillo/molasses ratio					
	22/70		46/46		70/22	
Observations	+ NaOH	− NaOH	+ NaOH	− NaOH	+ NaOH	− NaOH
Dry matter digest., %	66,8^{b}	53,9^{c}	65,3^{b}	49,9^{c}	59,6^{bc}	50,9^{c}
Protein digest., %	70,0^{b}	69,3^{b}	68,2^{b}	65,0^{bc}	55,3^{c}	59,8^{c}
NDF digest., %	34,4^{b}	24,0^{c}	48,5^{d}	39,9^{b}	47,2^{d}	47,6^{d}
ADF digest., %	33,2^{b}	24,6^{c}	35,0^{b}	33,9^{b}	45,7^{d}	43,6^{d}
Cellulose digest., %	46,9^{b}	40,7^{b}	63,7^{c}	51,4^{d}	65,0^{c}	57,3^{cd}
Hemicellulose digest., %	35,2^{b}	14,1^{c}	66,8^{d}	50,8^{c}	65,7^{d}	55,0^{c}

[a]Means based on three animals/treatment

[b,c,d]Means in the same line bearing different superscript letters differ significantly ($P<0,05$)

Table 3 Nitrogen balance and Cr_2O_3 recovery in lambs fed NaOH-treated and untreated bagacillo/molasses diets

	Bagacillo/molasses ratio					
	22/70		46/46		70/22	
Observations	+ NaOH	− NaOH	+ NaOH	− NaOH	+ NaOH	− NaOH
Nitrogen balance[a]						
Intake, gN/day	19,5^{c}	24,6^{d}	23,8^{d}	23,4^{d}	25,8^{d}	9,3^{e}
Faecal loss, gN/day	6,1^{c}	7,8^{cd}	7,6^{cd}	8,3^{cd}	11,5^{e}	3,7^{f}
Urinary loss, gN/day	4,6^{c}	8,6^{d}	7,2^{d}	6,5^{cd}	7,7^{d}	5,6^{c}
Nitrogen retention, g/day	8,8^{c}	8,2^{c}	9,1^{d}	8,6^{c}	5,2^{c}	0,5^{f}
Nitrogen retention, % N intake	44,9^{c}	33,3^{d}	38,1^{cd}	36,6^{d}	20,1^{e}	4,8^{f}
Cr_2O_3 recovery[b]	0,267^{c}	0,289^{c}	0,541^{d}	0,544^{d}	0,645^{f}	0,375^{c}

[a]Means based on three animals/treatment

[b]Means based on two animals/treatment

[c,d,e,f]Means in the same line bearing different superscript letters differ significantly ($P<0,05$)

that NaOH has an effect on the saponification of uronic acid esters associated with xylan chains. (Tarkow & Feist, 1969). The increase in bagacillo level was related to a greater digestibility of the cell wall constituents, being significant ($P<0,05$) in the NaOH-treated diets for cellulose (y = 41,231 + 0,372x; R^2 = 0,49) and hemicellulose (y = − 19,891 + 3,116x − 0,027x^2; R = 0,93), and in the untreated diets for NDF (y = 14,604 + 0,49x; R^2 = 0,58) and ADF (y = 15,814 + 396x; R^2 = 0,48).

Nitrogen retention and faecal Cr_2O_3 recovery data are summarized in Table 3. A significant increase ($P<0,01$) in nitrogen retention, expressed as per cent nitrogen intake, was obtained on NaOH-treated diets while increase in level of bagacillo had a negative effect ($P<0,05$) in both treated (y = 52,111 − 0,147x; R^2 = 0,41) and untreated diets (y = 48,855 − 0,532x; R^2 = 0,47). A similar trend was also reported for protein digestibility.

The superior performance of lambs fed treated bagacillo diets was accounted for mainly by an increase in digestibility and intake. The latter was also related to a greater rate of passage of the treated diets. The rate of Cr_2O_3 recovery (cumulative %/h calculated by regression) was greater ($P<0,10$) in the treated when compared with the untreated diets (0,48% *vs* 0,40%) and increased ($P<0,01$) up to the level of 46% bagacillo in the diet. In addition, the recovery of Cr_2O_3 was correlated with intake (r = 0,77) and can be described by the following equation: y = 472,57 + 994,77x (R^2 = 0,60) where 'y' is intake and 'x' is % Cr_2O_3 recovery.

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