J. Natn. Sci. Coun. Sri Lanka 1979 7(1) : 11—17

Alkali Treatment of Paddy Straw. Effect of Energy and non-protein Nitrogen Supplementation on Digestibility and Intake by Sheep

M. C. N. JAYASURIYA
Department of Animal Husbandry, Faculty of Agriculture, University of Peradeniya Peradeniya, Sri Lanka.

(*Paper accepted* : 01 *February* 1979)

Abstract : A feeding trial with crossbred sheep, to investigate the influence of energy and non-protein nitrogen supplementation of sodium hydroxide treated paddy straw, on digestibility and voluntary intake, is reported. Untreated or treated straw supplemented with urea in concentrate, urea in concentrate and molasses, or urea dissolved in molasses were compared. The treatment having urea in concentrate carried 18 g urea/100 g concentrate while the treatment having urea in molasses contained 3.6 g urea in 7.0 ml of molasses diluted in 100 ml water/100 g straw. Molasses solutions were sprayed in the same manner as sodium hydroxide. Alkali treatment significantly increased both dry matter and organic matter digestibility. Addition of molasses increased the digestibility of untreated straw but depressed the digestibility of treated material. However, supplementing alkali treated straw with molasses increased dry matter intake by 34% compared to untreated material. Combining urea with molasses did not result in any additional advantage. It is concluded that alkali treatment can substantially increase the feeding value of paddy straw. Addition of molasses as practised in factory-scale production of treated straw pellets may lead to an increase in digestible energy intake and a higher energy balance.

1. Introduction

A major limiting factor in the production of high quality proteins through animal agriculture is the shortage of suitable feedstuffs for these animals. This is particularly true to Sri Lanka where the tropical climate encourages rapid growth and the subsequent overmaturity of plant material suitable for livestock raising. However Sri Lanka, like many developing countries, produces large quantities of highly lignified plant byproducts, such as paddy straw, sugar cane bagasse and grain hulls, which are high in energy yielding cell wall material, but often little used as feedstuffs for ruminants.

Paddy straw the largest annually harvested agricultural by product in Sri Lanka, is little used as an animal feed because of its low nutritive value. Chemical procedures have been elaborated in recent years for upgrading poor quality roughages[2,3,8,12,14], and sodium hydroxide (NaOH) treatment has been claimed to be the most effective.[5,11] Recent trials in Sri Lanka[7] have indicated that paddy straw can be successfully upgraded in feeding value, to a medium quality hay by spray treatment with sodium hydroxide solution.

The experiment presented in this paper was designed to investigate, the influence of energy and non-protein nitrogen supplementation of sodium hydroxide treated paddy straw (variety H4), on digestibility and voluntary intake by sheep. 6 g of

NaOH dissolved in 120 ml H_2O/100 g straw was selected as the level of treatment, as results from the previous trial[7] suggested that optimal treatment level for paddy straw variety H_4 would be between 4 to 8 g of NaOH carried in 120 ml H_2O/100 g straw.

2. Experimental

Paddy straw, variety H_4, chopped into 20 to 50mm lengths, was treated with 6 g of NaOH dissolved in 120ml water per 100 g straw according to the method previously described[7] but without neutralization of excess alkali. The experiment was designed as a completely randomized block experiment with six treatments, each treatment having three replicates. Treated or untreated straw was supplemented with urea, either in concentrate component of the ration or sprayed along with molasses, (viscosity—14,500 centipoise, at 26.5°C, density—1.37 g/cm^3) (Table 1). The molasses solutions were sprayed in the same way as sodium hydroxide. Urea (18 g/100 g concentrate) when added increased the crude protein equivalent of the concentrate (ground maize) to 60%.

Air dried treated or untreated straw was given to appetite in amounts 10% greater than the previous days intake. The amount of concentrate supplementation was fixed (100 g/animal/day) and contributed approximately 20% of the total dry matter intake.

The digestibility of straw rations were determined using Jaffna Bikaneri female sheep of average live weight 23.0 kg. All animals had access to *ad libitum* water and a standard mineral mixture (bone meal, shell grit powder and salt in the ratio of 5 : 3 : 2) throughout the experimental period.

Housing of animals collection of faeces and urine and sampling of feed for chemical analysis was as described earlier.[7] In addition to dry matter, ash, crude protein and crude fibre, samples were also analysed for acid detergent fibre, cellulose and silica by the method of Goering and Van Soest.[4]

The digestibility of straw organic matter was calculated by assuming the organic matter digestibility of the concentrate to be 85%.

TABLE 1. Composition of rations used in the feeding trial

Ingredients	Treatments					
	Untreated straw			Treated straw		
Treatment number	1	2	3	4	5	6
Amount of NaOH (g/100 g straw)	0	0	0	6	6	6
Volume of water (ml/100 g straw)	0	0	0	120	120	120
Quantity of molasses (ml/100 ml water)	0	7.0	7.0	0	7.0	7.0
Amount of urea in molasses (g/100 g straw)	0	0	3.6	0	0	3.6
Concentrate fed with straw (g/animal/day)	100	100	100	100	100	100
Amount of urea in concentrate (g/100 g concentrate)	18.0	18.0	0	18.0	18.0	0

TABLE 2. The average chemical composition of concentrate and treated straws used in the feeding trial.

	Treatments						
	Untreated straw			Treated straw			Concentrate
Treatment number	1	2	3	4	5	6	
Dry matter (g/100 g straw)	95.1	94.6	94.8	94.8	94.6	93.9	91.2
Energy value (MJ/kg DM)	15.03	19.08	17.61	15.15	15.83	17.53	—
	(g/100 g dry matter)						
Ash	15.4	14.3	14.7	16.6	16.3	16.4	1.48
Crude protein	3.4	3.6	6.9	3.8	3.5	6.8	9.7
Crude fibre	30.4	30.3	29.3	30.5	32.8	31.7	2.2
Acid detergent fibre	60.8	53.6	54.3	51.4	51.4	50.2	—
Cellulose	40.3	37.9	36.1	36.5	36.4	35.9	—
Silica	12.9	12.4	12.7	12.4	10.8	12.6	—

3. Results

The composition of straw rations and concentrate are shown in Tables 1 and 2. The consumption of treated straw had no adverse effect on the health of animals.

Alkali treatment of straw significantly ($P < 0.001$) increased both dry matter and organic matter digestibility. Addition of molasses appeared to increase the digestion coefficient of untreated straw (though not significantly) but depressed the digestion coefficient of treated material. Combining molasses with urea did not result in any additional increase in digestibility than molasses alone.

The maximum intake of straw was attained in about 10 days and remained fairly constant thereafter. Though alkali treatment by itself did not significantly increase the intake of straw dry matter, supplementing alkali treated straw with molasses increased dry matter intake by 34% compared to untreated material. An increase in dry matter intake was also observed with untreated material when molasses was added to it, but this increase was proportionately lower than the increase in intake observed with treated material (Table 3).

The consumption of treated straw did not influence the voluntary intake of water and the output of urine.

4. Discussion

The derived digestibility of untreated straw organic matter in the present experiment was higher than the value reported earlier[7] for the same variety of straw. This could be presumably due to the fact that the straws came from different harvests.

Although alkali treatment significantly ($P < 0.001$) increased the organic matter digestability of straw, the response to treatment was lower than the values reported earlier (17 vs 19 to 28 percentage digestibility units) for paddy straw variety H_4 treated under similar conditions.[7] This could be due to the higher initial digestibility of the straw. As suggested by Mwakatundu[9] and Jayasuriya,[6] response to alkali treatment could be inversely related to the digestibility of the untreated straw. Similar observations were also made by Jayasuriya and Owen[8] for barley straw treated with a dilute solution of sodium hydroxide by a method similar to that of Beckmann.[1]

The depression in digestibility of molasses supplemented treated straw diets could have been due to the higher intake recorded in these treatments. It is also possible that the presence of a readily available source of energy was detrimental to rumen microorganisms leading to the depression in digestibility. The combination of molasses with urea did not result in an increase in digestibility than urea alone (Table 3), presumably because of lack of any additive effect of these two nutrients.[3]

TABLE 3. Intake and apparent digestibility of dietary constituents.

	Treatment Number						S.E. of difference between means.
	Untreated straw			Treated straw			
	1	2	3	4	5	6	
Crude protein in ration (g/100 g dry matter)	13.0	13.59	7.31	13.62	12.17	7.20	—
Estimated metabolizable energy content of ration (MJ/kg DM)	8.31	7.95	7.78	9.30	8.65	8.62	—
Digestibility of dietary constituents (%).							
Dry matter (DMD)	52.9	54.0	52.1	65.8	61.2	61.1	± 1.75
Organic matter (OMD)	56.6	58.9	57.9	70.4	65.5	65.3	± 1.77
Digestible organic matter in dry matter (DOMD)	53.3	51.7	50.6	60.4	56.2	56.0	—
Derived digestibility of straw organic matter	49.9	53.2	52.4	67.0	61.9	61.5	± 2.33
Intake							
Ad libitum intake of straw (excluding added ash) (g dry matter/animal/day)	425.4	481.9	533.5	489.8	570.2	565.5	± 47.6
(g dry matter/kg $W^{0.75}$ / day)	40.3	45.7	50.6	46.5	54.1	53.7	± 4.5
Intake of concentrate (g dry matter/kg $W^{0.75}$/day)	8.6	8.6	8.6	8.6	8.6	8.6	—
Intake of water (voluntary intake —1/day)	2.370	1.543	1.307	2.500	2.357	2.833	± 0.866
Output							
Urine (1/day)	1.133	0.717	0.450	1.440	1.180	1.603	± 0.539

In contrast to the findings reported earlier[7] alkali treatment in the present experiment did not bring about a significant improvement in dry matter intake. It is possible that the higher level of sodium hydroxide used (6 g in the present experiment compared to 4 g/100 g straw in the former) influenced dry matter intake. It has already been suggested,[10] that high levels of sodium hydroxide in treated straw may increase the osmotic pressure in the rumen liquor leading to an inhibition in microbial activity. This in turn could reduce the rate of passage of digesta and influence voluntary intake. As suggested by Rexen and Thomson,[12] the most appropriate sodium hydroxide dosage would therefore be around 4 g/100 g straw.

The factory-scale manufacture of treated straw pellets would often necessitate the use of molasses,[5] to function as a binding agent as well as to mask the unpleasant flavour of urea that may have to be added to the treated material at the time of processing in order to raise the crude protein equivalent of the finished product. In this context, it is important to note the increase in voluntary intake due to the addition of molasses to alkali treated straw, despite a lowering in digestibility. A greater intake even with a lower digestibility would often mean a higher energy balance when the material fed is in ground and pelleted form.[13]

The estimated metabolizable energy (ME) content of about 8.86 MJ/kg DM (Table 3) suggests that the treated straw diets in the present experiment could be comparable in feeding value to a grass hay of moderate to high digestibility. A material of such feeding value when given to appetite would be able to satisfy both maintenance and production energy requirements of a 400 kg cow producing 10 kg milk/day. Thus, treated straw appears to have considerable application as a replacement for good quality fodder in most dairy cattle rations.

Acknowledgements

The author gratefully acknowledges the financial assistance given by the National Science Council of Sri Lanka.

Sincere thanks are also due to Miss S. Singanayagam for technical assistance, Mr. Howard Ross-Parker for statistical advice and Miss A. Singanayagam for typing this manuscript.

References

1. Beckmann, E. (1921). *Conversion of grain, straw and lupins into feed of high nutrient value Festsch v. Kaiser Wilhelm Ges. Forderung. Wiss Zehnjahrigen Jubilraum* pp. 18-26.
2. Carmona, J. F. & Greenhalgh, J. F. D. (1972). *The digestibility and acceptability to sheep of chopped or milled barley straw soaked or sprayed* with *alkali. J. Agric. Sci. Camb.*, **78**, 477-488.
3. Donefer, E., Adeleye, I. O. A. & Jones, T. A. O. C. (1969). *Effect of urea supplementation on the nutritive value of NaOH treated straw. In Gould, R. F. Ed. Cellulases and their applications. Am. Chem. Soc.*, Washington D. C.

4. GOERING, H. K. & VAN SOEST, P. J. (1970). *Forage fibre analyses. Apparatus, Reagents, Procedures and some applications. Agric. Handbook*. 379. U.S. Dept. of Agric.

5. JACKSON, M. G. (1977). *Review article. The alkali treatment of straw. Anim. Feed Sci. Technol.* **3**, 105-130.

6. JAYASURIYA, M. C. N. (1974). *Treatment of cereal straws with sodium hydroxide to improve their nutritive value for ruminants*. Ph.D. Thesis, University of Reading, U.K.

7. JAYASURIYA, M.C.N. (1979). *Sodium hydroxide treatment of rice straw to improve its nutritive value for ruminants. Trop. Agric. (Trinidad)* **56**, (1) 75—80.

8. JAYASURIYA, M. C. N. & OWEN, E. (1975). *Sodium hydroxide treatment of barley straw : Effect of volume and concentration of solution on digestibility and intake by sheep. Anim. Prod.* **21**, 313-322.

9. MWAKATUNDU, A. G. K. & OWEN, E. (1974). *In vitro digestibility of sodium hydroxide treated grass harvested at different stages of growth. E. Afric. Agric. For. J.* **40**, 1-10.

10. OLOLADE, B. G., MOWAT, D. N., YAO, Y. T., SMITH, G. C. & ASHTON, G. C. (1972). *Sodium hydroxide treated diet and body fluid parameters. J. Anim. Sci.*, **35**, 232-233.

11. OWEN, E. (1976). *Farm wastes, straw and other fibrous materials*. In : Duckham, A. N., Jones, J. G. W. and Roberts, E. H. Ed. *Food production and consumption, the efficiency of human food chains and nutrient cycles*. (North Holland Publishing Co.) pp. 299-318.

12. REXEN, F. & THOMSON, K. V. (1976). *The effect on digestibility of a new technique for alkali treatment of straw. Anim. Feed Sci. Technol.*, **1**, 73-83.

13. WAINMAN, F. W., BLAXTER, K. L. & SMITH, J. S. (1972). *The utilization of the energy of artificially dried grass prepared in different ways. J. Agric. Sci., Camb.*, **78**, 441-447.

14. WILSON, R. K. & PIGDEN, W. J. (1964). *Effect of sodium hydroxide treatment on utilization of wheat straw and poplar wood by rumen microorganisms. Can. J. Anim. Sci.*, **44**, 122-123