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The Effect of Sulfur Dioxide (SO_2) and Sodium Hydroxide (NaOH) on Chemical Composition and Degradability of Wheat Straw

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Abstract: Degradability characteristics of Dry Matter (DM) was estimated in wheat straw treated by different levels of Sulfur dioxide (SO_2) and Sodium Hydroxide (NaOH) using the nylon bag technique for an incubation time of 72 h using permanently fistuated steers. The chemical composition was determined by laboratory analysis. Four levels of SO_2 including 0, 1.25, 2.5 and 5% (W/W as DM) were applied for 2 or 4 days. These levels of sulfur dioxide plus 2 levels of NaOH including 0 and 4% were applied to the wheat straw for a period of 4 days in the second experiment. The results indicated that the sulfur dioxide treating of wheat straw had significantly effect ($p<0.01$) on dry matter degradability increase in compared to the untreated samples. The duration of sulfur dioxide application was also significantly ($p<0.01$) effective in upgrading the wheat straw degradability. NaOH treatment also led to significantly higher degradation values. The best effetive level of sulfur dioxide and NaOH on wheat straw degradability was 5 and 4%, respectively. The average level of wheat straw degradation for the mentioned level of sulfur dioxide and NaOH was 71.3% whereas the value for the untreated straw was only 48.9%. The mean values of the Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) were not showed significant different. It was concluded that treating low-quality roughages with the both chemical (SO_2 and NaOH) could be a practical method for increasing the feeding value of the wheat straw and other similar rougheges.

Key words: Sulfur dioxide, sodium hydroxide, degradability, wheat straw

INTRODUCTION

At present the agricultural by-products as rice, corn, barley and wheat straw have important consequences in Asian countries because they forma significant part of the animals feed (Mowat and Ololade, 1970; Jayasuriya, 1979; Huber, 1980). Attempts to improve the nutritional quality of fibrous residues have been confined mainly to physical, chemical or microbial treatments either singly or in combination (Varvikko and Lindberg, 1985; Oshea and Baldwin, 1986). Nowdays, carried out most researches on chemical treatments, particularly NaOH treatment, which have been used successfully in order to increase the feeding value of poor quality roughages (Han, 1987; Sundstaf, 1988; Djajanegara and Doyle, 1989). The effect of sodium hydroxide is to dissolve lignin, silica and hemicelluloses (Berger *et al*., 1991; Ben-Ghedalia and Yosef, 1994; Yosef *et al*., 1994). Incubation of test feed stuffs in nylon bags in the rumen of fistulated animals have been used to evaluate not only the extent, but also the rate at which feed fractions are degraded in the rumen (Kimambo *et al*., 1994; Shem *et al*., 1995). Similar evaluation methods have been used by other workers elsewhere for nylon bag technique (Weisbjerg *et al*., 1990; Stensig *et al*., 1994). The nylon bag technique, is a powerful tool in order to evaluate the potential feeding value of alkali-treated straw (Mgheni *et al*., 1996). Results of many experiments on alkali-treated straw by researchers showed that chemical treatment of wheat straw by SO_2 and NaOH gases had significant effects on it's digestibility (Oshea and Baldwin, 1986; Berger *et al*., 1991; Miron and Ben-Ghedalia, 1994), chemical composition (LeSoning and Klopfenstein, 1981; Givens *et al*., 1989; Ben-Ghedalia and Miron, 2001) and dry matter degradability of cellulosic and lignocellulosic materials (Michalet-Doreau and Ould-Beh, 1992; Miron *et al*., 2001a, b; Brown and Kunkle, 2005).

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An experiment was therefore conducted to evaluate the effects of different levels of Sulfur dioxide (SO_2) and sodium Hydroxide (NaOH) on chemical composition and degradability of wheat straw.

MATERIALS AND METHODS

Treating samples: The wheat straw samples supplied by threshing-machine with approximate size of 3-4 cm. The sulfur dioxide treatment of wheat straw carried out by tradition method of SO_2 treatment of raisin (Maraghea local method). Two kilogramms straw, were ressigned to wooden cages of 0.8×0.5×0.3 m which these cages were completely covered by thick plastic in order to prevent from exit of SO_2 gas. Moreover, was prepared special metallic dish for burn of sulfur. The rate of sulfur and volume of fire was regulated for ensuring of sufficient SO_2 gas of treatments.

In the first experiment, sulfur dioxide gases in 4 levels including 0, 1.25, 2.5 and 5% (W/WDM) were applied for 2 or 4 days. These levels of sulfur dioxide plus 2 levels of NaOH including 0 and 4% were applied to the wheat straw for a period of 4 days in the second experiment. The rate of treated straw and treatment method in the second experiment was similar to the first experiment with the exception soaking of straw samples by water to 1:1 ratio. The wet straws, then, were treated by sulfur dioxide gases for a period of 4 days. The treated samples were placed in free weather for a period of 2 days, then, content of 100 g from either treatments and replications samples used for the next process of experiment.

Animals, feeds and feeding: The nylon bag method (AFRC, 1992) was used to determine the rate of degradability of DM of wheat straw samples when suspended in the rumens of four rumen-fistulated steers that fed 5.2 kg (as DM basis) of good quality alfalfa, 1.2 kg (as DM basis) corn silage and 2 kg concentrate (as DM basis) per cow per day were used. Minerals and vitamins were provided sufficiently for microbial activity (NRC, 2001). The animals were fed twice per day at 0800 and 1400 h and had free access to water. The same period of incubation time of 72 h were used in this study for experimental samples. The bags after exit from rumen were washed by a adequate volume of water and were completely dried in owen at 60°C for 48 h (Michalet-Doreau and Ould-Beh, 1992).

Degradability calculation: The experimental samples were obtained from first stage and dried in owen at 105°C for 24 h then grinded by mill with a sieve of 2 mm size. The fistulated steers were used in order to The calculated of degradability wheat straw to In Sacco method. The nylon bags were used in experiment at 17.5×9 cm and content passages to size of 52 μm (Mehrez and Orskov, 1997). Five gramms from treated samples raised in each bag and these nylon bags equipped with a string (50 cm long) immersed in rumen via fistula. Dry matter degradability of the treated wheat straw was calculated via wheight difference achived from first sample with it^s, residual volume after an rumen incubation time of 72 h. The ADF and NDF was measured according to the methods described by Van Soest and Jones (1968).

Statistical analysis: A completely randomised design with factorial arrangement (4×2) was used for the first experiment contaning 4 levels of sulfur dioxide including 0, 1.25, 2.5 and 5% (W/WDM) for 2 or 4 days. The completely randomised design with four replicates and treatment means were compared by the Duncan test. The second experiment was also, based on a completely randomised design with factorial arrangement (4×2) contaning 4 rates of sulfur (0, 1.25, 2.5 and 5%, W/WDM) plus 2 levels of NaOH including 0 and 4% (W/WDM). The data were analysed by means of one-way ANOVA. When analysis of variance indicated a significant treatment the means were compared by tukey test.

RESULTS AND DISCUSSION

The results of achived from first experiment is shown in Table 1. The sulfur dioxide treating of wheat straw significantly increased ($p<0.01$). Dry Matter Degradability (DMD) (after rumen incubation time of 72 h). The most rate of DMD observed from SO_2 treating in 5% levels for a period of 4 days that increased DMD compared to control samples (Fig. 1). In this experiment, treating periods were indicated significant differents ($p<0.01$). The comparision of means, not showed significant difference in DMD of treated samples with SO_2 gas throughout a 2-d smoking period than control treatment. These results are in agreement with those reported for wheat straw their botanical fractions (Ben-Ghedalia and Miron, 1984; Nasseven and Kincaid, 1992).

The use from Non-biological treatments methods after, physical treatments as size reduction, which are resulting increases in the surface area of cellulosic and lignocellulosic residues (Nystrom, 1975) and decreases the crystallinity (Friis Kristensen, 1975) and therefore, increases the susceptibility to chemical action (Jackson, 1978; Han *et al*., 1978) or enzymatic attack (Jayasuriya, 1979; Ben-Ghedalia and Miron, 1981). The alkali causes swelling and separation of the cellulose,

Table 1: The effects of SO_2 gases and time of smok on Dry Matter Degradability (DMD) and chemical composition of wheat straw (First experiment)

	Item (%DM)		
Treatment	Dry matter degradability	ADF	NDF
[1]S_1d_1	48.89±1.69[a]	62.25±0.62	44.00±1.00
S_2d_1	50.57±1.36[a]	67.00±1.19	43.50±0.89
S_2d_2	57.94±2.25[b]	66.50±0.69	43.33±0.95
S_3d_1	52.66±3.44[ac]	66.70±1.72	43.50±0.69
S_3d_2	57.43±1.48[bcd]	66.00±0.84	42.50±1.14
S_4d_1	55.98±1.71[abcde]	66.33±1.00	41.00±1.45
S_4d_2	57.43±1.84[bd]	65.00±0.59	40.00±0.91
[2]SEM	1.89	0.95	1.00
Significant level			
SO_2 gas level	0.0052	0.675	0.672
Smok day	0.0001	0.405	0.682
SO_2 gas level×smok day	0.227	0.933	0.957

[a, b, c, d]: Values in the same row and variable with no common superscript differ significantly. [2]: Values are the means of four observations per treatment and their standard error means. [1]: S_1d_1 = control, S_2d_1 and S_2d_2 = 1.25% SO_2 + 2 and 4 days smok, respectively, S_3d_1 and S_3d_2 = 2.5% SO_2 + 2 and 4 days smok, respectively, S_4d_1 and S_4d_2 = 5% SO_2 + 2 and 4 days smok, respectively

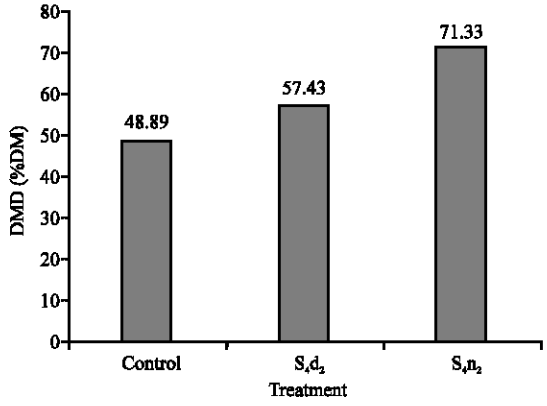

Fig. 1: The comparing effect of smok (4 days) with SO_2 gas, singly or in combination to NaOH on the wheat straw degradability

Table 2: The effects of SO_2 and NaOH gases on Dry Matter Degradability (DMD) and chemical composition of wheat straw (Second experiment)

	[1]Item (%DM)		
Treatment	Dry matter degradability	ADF	NDF
[2]S_1n_1	48.89±1.69[a]	67.25±0.60[a]	46.00±1.00[a]
S_1n_2	50.93±3.12[a]	[3]DN	DN
S_2d_1	50.57±1.36[a]	66.50±0.99[a]	45.33±1.08[a]
S_2d_2	63.88±0.30[b]	60.00±1.09[b]	44.50±1.28[ab]
S_3d_1	52.66±3.44[a]	66.00±1.11[a]	41.00±1.60[b]
S_3d_2	68.30±1.18[bc]	58.50±0.74[bc]	43.50±0.84[ab]
S_4d_1	56.90±1.43[a]	65.00±0.69[a]	40.70±0.49[b]
S_4d_2	71.33±1.54[bc]	56.00±1.32[bc]	38.00±0.70[c]
SEM	1.75	0.93	0.99
Significant level			
SO_2 gas level	<0.0001	0.0003	0.0061
NaOH level	<0.0001	0.0001	0.0094
SO_2×NaOH	0.0008	0.437	0.219

[a, b, c, d]: Values in the same row and variable with no common superscript differ significantly. [1]Values are the means of four observations per treatment and their standard error means. [2]S_1n_1 = control, S_1n_2 = 0% SO2 + 4% NaOH, S_2n_1 and S_2n_2 = 1.25% SO_2 + 0 and 4% NaOH, respectively, S_3n_1 and S_3n_2 = 2.5% SO_2 +0 and 4% NaOH, respectively, S_4n_1 and S_4n_2 = 5% SO_2 + 0 and 4 % NaOH, respectively. [3]Data nodetected

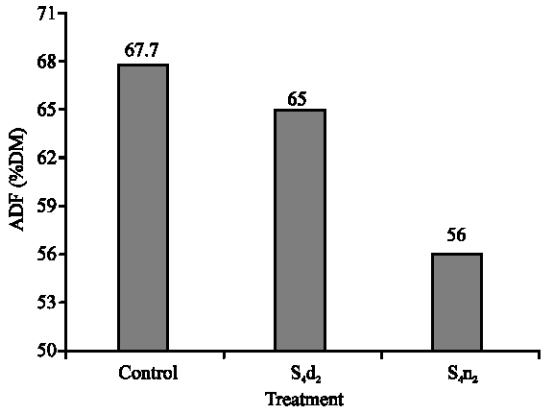

Fig. 2: The comparing effect of smok (4 days) by SO_2 gas, singly or in combination to NaOH on ADF

partial removal of lignin, lowering of the crystallinity of the cellulosic fraction and partial hydrolysis of the hemicellulose (Miron and Ben-Ghedalia, 1994; Ben-Ghedalia and Miron, 2001; Miron *et al.*, 2001a, b; Brown and Kunkle, 2005).

The NDF and ADF values of treated samples of wheat straw, also were calculated. Djajanegara and Doyle (1989) indicated that high NDF, ADF and ADL values decrease intake of rougheages. The treating of the wheat straw by SO_2 not had significant effect on ADF and NDF concentration, but this values were indicated significant decrease ($p<0.01$), in treated samples with SO_2 and NAOH gases that the results of fiest experiment is in contrast with the results of Ben-Ghedalia and Miron (1984, 2001), Miron and Ben-Ghedalia (1994) and Yosef *et al.* (1994) who did observed decrease of ADF and NDF concentration of the wheat straw when was treated by SO_2 gas. However, differences with results of other studies has may related to differenece type of wheat variety, treatment conditions and numbers of samples in different experiments.

Results of the secound experiment is shown in Table 2 and Fig. 2 and 3. The treating of the wheat straw by SO_2 and NaOH significantly increased ($p<0.01$) dry matter degradability ($R^2 = 0.937$).

The many studies indicated increase of solubilization hemicelluloses and digestibility of celluloses and hemicelluloses. This increase is resulting disruption of bonds in the lignocellulosic complex and within the cellusosic fraction and at last break of resisting grafts by microbial digestion and this is not in effect of lignin

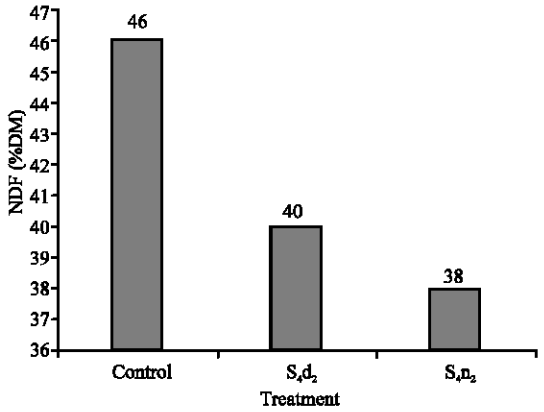

Fig. 3: The effect SO_2 gas, singly or in combination to NaOH on NDF

depresstion (Chandra and Jackson, 1971; Baker *et al*., 1975; Han, 1987; Yosef *et al*., 1994). The polihydric structures of cellulose and lignin molecule's aromatic compounds of cell wall plants are sensitive to chemical oxidization by gases as SO_2 gas (LeSoning and Klopfenstein, 1981; Dryden and Leng, 1988; Givens, 1989; Boda, 1990).

CONCLUSION

Results of this experiment indicated that wheat straw treatment by sulfur dioxide and sodiume hydroxid in levels of four percentage had better effect than treatment with SO_2 gas. Although, further research should be carried out for opportunity applicable results, specially effects of composition of different levels of SO_2 and NaOH.

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