Improving the Feeding Value of Cotton Stalk, Wheat Straw and Rice Straw with Ozonation

Meiji Okamoto
Obihiro University, Japan

Masaaki Hanada
Obihiro University, Japan

R. Aoyama
Obihiro University, Japan

R. Kim
Obihiro University, Japan

N. Kaiga
Toshiba Corporation, Japan

The XIX International Grassland Congress took place in São Pedro, São Paulo, Brazil from February 11 through February 21, 2001.

Proceedings published by Fundacao de Estudos Agrarios Luiz de Queiroz

ID # 21-21

IMPROVING THE FEEDING VALUE OF COTTON STALK, WHEAT STRAW AND RICE STRAW WITH OZONATION

M.Okamoto[1], M. Hanada[1], R. Aoyama[1], R. Kim[1] and N. Kaiga[2]

[1]Department of Agro-enviromental Science. Obihiro University, Inada Obihiro Hokkaido, 080-8555□JAPAN, mokamoto@obihiro.ac.jp

[2]Toshiba Corporation, Fuchu, Tokyo 183, JAPAN

Abstract

□ The experiment was conducted to study the effect of ozone treatment on the feed value of cotton stalk, wheat straw and rice straw. These feeds were cut into 2 cm and 4 cm lengths, and rolled before ozonizing. The ozonizing periods were 30 min. 60min and. 120 min. The Acid Detergent Lignin (ADL) concentration of the feeds decreased with ozone treatment. Except for rice straw, the short cutting treatment (2cm) decreased the concentration of ADL and Cellulose of the ozonized cotton stalk and wheat straw. Rolling and ozone treatment were effective in decreasing the ADL concentration of cotton stalk. IVDMD (*In Vitro* Dry Matter Digestibility) of feeds rose 17 points in the cotton stalk, 4 points in the wheat straw and the rice straw with ozonizing. The short cut (2cm) cotton stalk and the wheat straw showed an increase in IVDMD but the rice straw showed no change. Rolled and ozonized cotton stalk was the only feed to show a rise in IVDMD. The concentration of ADL and Hemicellulose of all feeds decreased with ozonation but the IVDMD was related to the decrease in the contents of ADL of feeds.The higher ADL concentration in the feeds, higher the ozonation effect.

Keywords: Ozone treatment, cotton stalk, wheat straw, rice straw, *In vitro* digestibility, lignin,□ cellulose

Introduction

The Asian wheat cotton and rice yields represents about 43%, 60% and 90% respectively of the world yield. As the world population increases, there is a large demand for animal protein foods. In order to supply the human food needs**,** the feedstuff supply should increase in order to spare food for human use. Therefore, it is essential to make use of and improve the feed value of cellulose rich by- products. Although by-products like crop residues have been used as one of the feedstuffs for ruminants, their feed value is remarkably low due

to their highly undegradable structure. Ozonizing improves roughage quality by changing the carbon double bond of the lignin in the the plant cell wall**,** into a single bond and in addition, the sugar dissociates from the hemicellulose side-chains (Ben-Ghedalia et al.1982). The effect is expected to improve the nutritional value of the low quality roughage by the strong oxidizability with the ozone not only of straw but also cotton stalks of Dicotyledoneae, etc. (Ben-Ghedalia et al.1983). The experiment was carried out in order to examine the best conditions for ozonizing agriculture by-products in order to improve their nutritional value.

Material and Method

Three agriculture by-products were used cotton stalk, wheat straw, and rice straw. For the purpose of the physical processing, the samples were cut in 2cm and 4cm sections; in addition they were maintained whole or rolled respectively before ozonizing. A 20g sample was put into a 500ml Erlenmeyer flask and water added to reduce the DM to 70%, then they were left 24 hours for hydration before ozonizing. (The ozonizer made the ozone evolution quantity to be 1.5g/hour-using TOSHIBA WOR-1.5.) The sample was exposed for 30 minutes, 60 minutes, 120 minutes and the ozone amount per sample of 1g during these time periods were 37.7mg, 75mg and 150mg. After ionizing, the samples were dried at 60 ^{o}C and ground to pass through a 1mm mesh. The water content of feeds was determined by drying at 135 ^{o}C for 2 hours. NDF, ADF, ADL contents of feeds were analyzed according to Goering and Van Soest (1970), and DM digestibility in vitro was measured according to Tilley and Terry□1963□. Cellulose was determined by subtracting ADL from ADF and Hemicellulose was determined by subtracting ADF from NDF.

Results and Discussion

Cotton stalks may contain more than 15% lignin and are considered poor forage for ruminants. However, treating cotton stalks with ozone increase**s** its digestibility and its conversion into productive feed (Solomon et al. 1992). The effects of ozone treatments on the composition of cotton stalk, wheat straw and rice straw are presented in Table 1. The most noticeable effects of the ozone treatments are demonstrated by the decrease in the ADL and Hemicellulose fractions. The change of ADL concentration of each sample before and after processing with ozonation was (16.4%→12.0%)in the cotton stalk, (6.7%→5.7%) in the wheat straw, (3.8%→3.2%)in the rice straw. The ADL concentration of each sample decreased with lengthening the ozonation time. Ozonation time had a small effect on Cellulose content of the wheat straw and on Hemicellulose content of the rice straw. ADL and cellulose concentration

in the cotton stalk, cellulose concentration in the wheat straw were lower on 2cm cut than 4cm cut. There was no effect of the cutting process of the rice straw. The change of IVDMD value of each sample before and after ozonation processing varied from 24.3% to 41.0% in the cotton stalk, from 47.6% to 53.9% in the wheat straw and from 47% to 52.5% in the rice straw. As the ozonation time is lengthened the IVDMD value of each feed rose. The value rapidly rose on IVDMD of the cotton stalk in the first ozonation of 30 minutes; the rise proportion of the cotton stalk was greater than that of wheat straw and rice straw. IVDMD values in the cotton stalk and wheat straw were increased more on 2cm cut than 4cm cut. But there was no effect of the cutting processing in the rice straw. The effect of the rolling process on the IVDMD was observed only in the cotton stalk. In all feeds, the ADL decreasing rate greatly influenced the improvement in the IVDMD value (Fig.1). The relation between hemicellulose decreasing rate and IVDMD value was not clear. The reason why cutting and rolling processing were effective in the cotton stalk is attributed to the richness of cell walls of dicotyledonous lignocelluloses in core or functional lignin, a fraction particularly sensitive to oxidation, which would lead to the opening of the cell walls to the cellulolytic action of rumen micro-organisms (Ben-Ghedalia and, Shefet, 1983, Yosef et al.,1994).

The cutting and rolling processings would destroy the hard cambiums of cotton stems resulting in increased surface area.

In the future, cost of suitable material to lower the processing costs of ozonation needs to be examined.

References

Ben-Ghedalia, D., Shefet G., Miron J. and Dror Y. (1982). Effect of ozone and sodium hydroxide on some chemical characteristics of cotton straw. J. Sci. Food Agric., **33**: 1213-1218.

Ben-Ghedalia, D. and Shefet G. (1983). Chemical treatment for increasing the digestibility of cotton straw. 1.Effect of ozone and sodium hydroxide treatments on rumen metabolism and on the digestibility of cell walls and organic matter. J.agric.Sci.,Camb., **100**: 393-400.

Goering, H.K. and Van Soest P.J. (1970). Forage Fiber Analysis. USDA Agricultural Handbook. No.**379**, United States Department of Agriculture, Washington, DC, 1-19.

Solomon, R.J., Miron A. Rubinstein and Ghedalia D.Ben (1992). Ozone-treated cotton stalks as a component of a ration for growing lambs. Animal Feed Science and Technology, **37**: 185-192.

Tilley, J.M.A. and Terry R.A. (1963). A two stage technique for the *in-vitro* digestion of

forage crops. J.Br.Grassl.Soc., **18**: 104-111.

Yosef, E., Ghedalia D.Ben, Miron J., Huttermann A., Majcherczyk A., Milstein O., Ludemann H.D. and Frund R. (1994). Characterization of some cell wall components of untreated and ozone-treated cotton stalks. J. Agric.Food Chem., **42**: 86-90.

Table1 - The effect of ozone treatment, cutting length and rolling on the composition of feeds

			Ozonation time(min.)			Cutting(cm)		Rolling	
	Constituent	Untreated	30	60	120	2	4	Non.	Rolling
		%							
Cotton	ADL (%)	16,4	12.9[a]	11.7[b]	11.3[b]	11.4′ ′	12.5[a]	12.9[a]	11.0[b]
stalk	Hemicellulose (%)	12,2	11,4	11,1	11,1	11,0	11,4	11,4	11,0
	Cellulose (%)	49,1	45,8	46,0	45,6	45.4[b]	46.3[a]	45,9	45,8
	IVDMD (%)	24,3	36.7[c]	41.2[b]	45.0[a]	43.4[a]	38.5[b]	37.7[b]	44.3[a]
Wheat	ADL (%)	6,7	5.9[a]	5.3[b]	4.8[c]	5,3	5,4	5,4	5,2
straw	Hemicellulose (%)	27,3	23,5	22,8	23,4	22,9	23,5	23.7[a]	22.8[b]
	Cellulose (%)	40,7	40.1[a]	40.0[a]	39.1[b]	39.4[b]	40.0[a]	39,8	39,7
	IVDMD (%)	47,6	49.3[b]	52.6[a]	53.9[a]	53.3[a]	50.6[b]	51,3	52,6
Rice	ADL (%)	3,8	3.4[a]	3.1[b]	3.1[b]	3,3	3,2	3,2	3,3
straw	Hemicellulose (%)	22,1	22.6[a]	21.1[c]	22.0[b]	21,9	21,9	21,9	21,9
	Cellulose (%)	43,2	36.0[b]	36.7[a]	36.8[a]	36,4	36,6	36,4	36,6
	IVDMD (%)	47,1	48.5[c]	51.5[b]	52.5[a]	50,7	51,0	50,6	51,0

Values with different superscripts are significantly different in each treatment ($P<0.05$)
ADL;Acid detergent lignin, IVDMD; In vitro dry matter digestibility

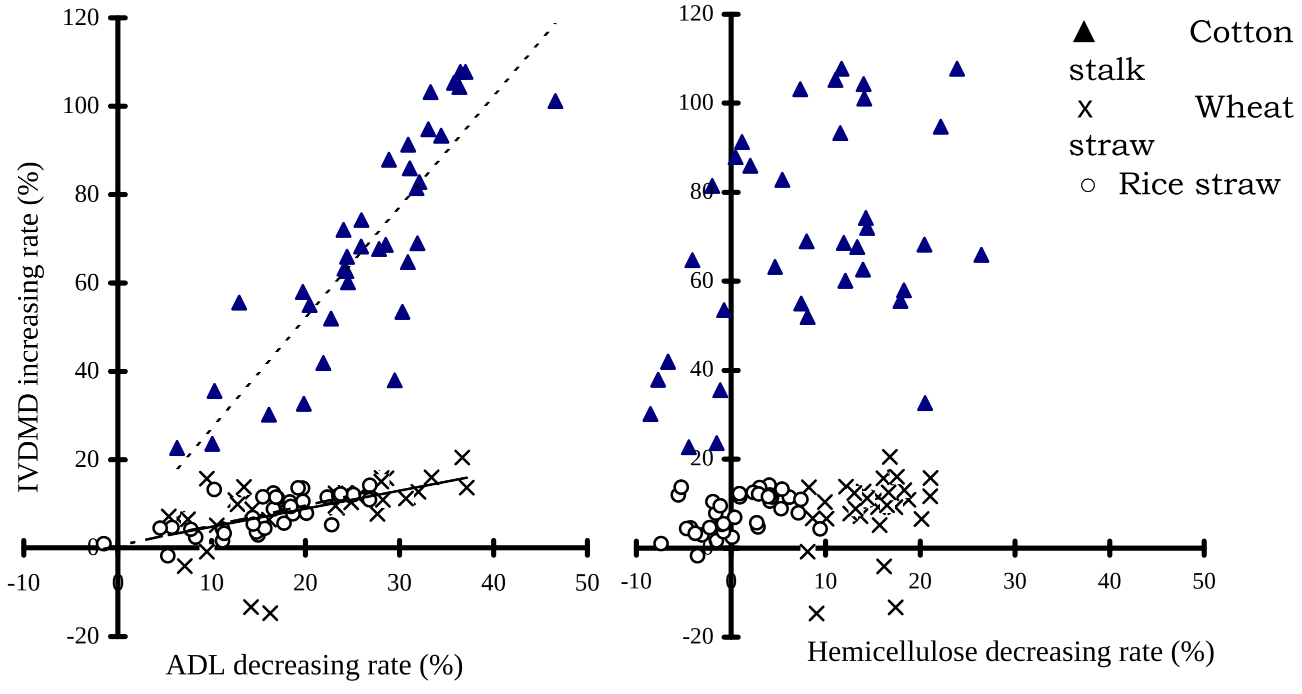

Figure 1 – The relationship between ADL, hemicellulose decreasing rate and IVDMD increasing rate after treatment with ozone