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The Efect of Processing with High Steam and Sodium Hydroxide on Nutritive Value of Sugarcane Pith by *in vitro* Gas Production

M. Chaji, T. Mohammadabadi, M. Mamouei and S. Tabatabaei
Department of Animal Science, Ramin Agriculture and Natural Resource University, Molasani, Ahvaz, Iran

Abstract: This trial was conducted to determine the effect of high steam (180-210°C, 3 min) and sodium Hydroxide (NaOH) on fermentative activity and nutritive value of sugarcane pith by *in vitro* gas production. Experimental samples were including; untreated sugarcane pith, treated with high steam, treated with 50 g kg^{-1} DM NaOH and treated with steam + NaOH. The results showed sugarcane pith treated with steam + NaOH have the highest potential gas production (B) (143.5 mL). High steam and NaOH caused to increase *in vitro* cell wall degradation, Organic Matter Digestibility (OMD), Metabolisable Energy (ME) and Short Chain Fatty Acid (SCFA) of sugarcane pith and the highest was for sugarcane pith treated with steam+NaOH (87%, 703.26 g kg^{-1} OM, 10.03 MJ kg^{-1} DM and 0.96 μmol L^{-1}, respectively). Therefore, it appears that the degradability and nutritive value of sugarcane pith are influenced by high steam and NaOH.

Key words: Sugarcane pith, high steam, NaOH, degradation, OMD, ME

INTRODUCTION

Sugarcane pith, the residue after rind removal, annually much amount of them is produced in Iran and world. However, the high lignin and low digestibility are considered as the main reasons for unsatisfactory performance of animals fed these roughages (De La-Cruz, 1990). Many methods have proved successful in disrupting cell wall material e.g., using high-pressure steam (Castro and Machado, 1990) that caused to release acetyl groups from the hemicellulose matrix and suitable levels of cell wall disruption are achieved (Muzzy *et al*., 1983). Morjanoff and Gray (1987) reported that high-pressure steam also resulted in formation of furfural by secondary dehydration reactions of hemicellulosic pentoses that inhibit the activity of rumen microbes (Brownell *et al*., 1986). Steam and pressure treatments alone or allied with chemical treatments are known to disrupt lignocellulosics in a way which allows improved utilization of cell wall polysaccharides by cell-free enzymes and rumen microbes (Castro and Machado, 1990). The resraechers reported that proccessing with sodium hydroxide may breakdown hemicellulose, hydrolyze the ester bonds between lignin and hemicellulose, expose the cellulose to microbial attachment and improve organic matter digestibility (Goto *et al*., 1993). The objective of this experiment was to determine the effect high-pressure steam and NaOH on nutritive value, fermentation and cell wall digestion of sugarcane pith in *in vitro* condition.

MATERIALS AND METHODS

Samples and inoculum prepration: Sodium hydroxide (NaOH) solution was added to untreated or high-pressure steam treated sugarcane pith (100 g, about 92% DM) to obtain samples of approximately 30% Dry Mater (DM) content of 0.0 and 50 g kg^{-1} NaOH on a DM basis. Then samples oven-dried at 55°C, therefore samples were Untreated Sugarcane Pith (USP), treated with high pressure steam (SSP), treated with 50 g kg^{-1} DM NaOH (NSP) and treated with steam + NaOH (S + NSP). Rumen fluid was collected from two fistulated sheep prior to the morning feeding. Animals fed 250 g concentrate and 750 g forage once at day. Collected rumen contents were strained through four layers of cheesecloth.

Gas production: *In vitro* fermentation of different samples was estimated by Gas Production (GP) method as described by Menke and Steingass (1988). Rumen fluid was added to the anaerobic buffer before transfer to the sytinges (three parallel syringes of each treatment). The glass syringes were prewarmed to 39°C and then 30 mL of mixed culture medium (ratio 1:2) were pipetted into each glass syringe followed by incubation in a water bath at 39°C for 2, 4, 6, 8, 10, 12, 16, 24, 48, 72 and 96 h.

Corresponding Author: M. Chaji, Department of Animal Science, Ramin Agriculture and Natural Resource University, Molasani, Ahvaz, Iran

Sampling and statistical analysis: Syringes were used to measure the gas production and DM degradation of experimental samples within 96 h. The culture fluid of each sample was carefully removed; the residues in the syringes were washed into a tube, carefully with distilled water separately. Then the residues were dried at 105°C for 12 h and used to calculate the degradation of samples. Gas production was measured directly from the graduations on the syringes at 2, 4, 6, 8, 10, 12, 16, 24, 48, 72 and 96 h. Cumulative gas production data were fitted to the exponential equation:

$$Y = b (1-e^{-ct})$$

Where:

b = The gas production from the fermentable fraction (mL)
c = The gas production rate constant c (mL h^{-1})
t = The incubation time (h)
Y = The gas produced at time t

The values of Organic Matter Digestibility (OMD) and Metabolisable Energy (ME) of samples were calculated by the equation of (Menke and Steingass, 1988), OMD (g kg^{-1} OM) = 148.8 + 8.89 GP + 4.5 CP + 0.651A and ME (MJ kg^{-1} DM) = 2.20 + 0.136 GP + 0.057 CP + 0.0029 CP^2. Short Chain Fatty Acids (SCFA) were determined by the equation reported by (Getachew *et al*., 1999). SCFA (μmol L^{-1}) = 0.0239 GP-0.0601. CP and XA were crude protein, ash and GP was the net gas production after 24 h incubation.

Data of cell wall degradability, OMD, ME and SCFA were subjected to analysis as a completely randomized block design using the General Linear Model procedures of SAS (1996). Duncan's multiple range test was used to compare the means at $p<0.05$.

RESULTS AND DISCUSSION

In vitro gas production parameters (B and C), OMD, ME and the SCFA of experimental samples are shown in Table 1. Processing with high steam and or NaOH caused to increase these parameters and the highest was for sugarcane pith treated with high steam + NaOH ($p<0.05$). The result of this study showed that treating sugarcane pith with high steam + NaOH had the highest cell wall degradability ($p<0.05$). The researchers reported by applying the steam explosion process to sugarcane bagasse, the susceptibility of cellulose to enzymatic hydrolysis was increased (Kling *et al*., 1987), also cellulose will be more accessible for rumen microbial enzymes (Castro and Machado, 1990) and cell-free enzymes (Liua and Orskovb, 2000). Liu *et al*. (1999) concluded any improvement in digestibility of bagasse resulting from steam treatment was due to the formation of water soluble substances. Also, Chaji and Naserian (2006) reported increasing of *in vitro* dry matter digestibility for sugarcane pith treated with steam by about 14%. Steam treatment may be caused to partial or complete hydrolysis of hemicellulose fraction (Grohmann *et al*., 1985), changing it into more soluble components and following increasing digestibility (Toussaint *et al*., 1991) (Fig. 1).

It is reported that alkali also solubilizes the inhibitory phenolic compounds and hemicellulose (Chen *et al*., 2007), cleaves ester linkages between lignin and the cell wall polysaccarid (Theander and Aman, 1984) and improves of the ruminal degradation of plant cell walls (Euna *et al*., 2006). Gould (1984) proposed that alkali react with lignocellulosics to yield partially delignified products

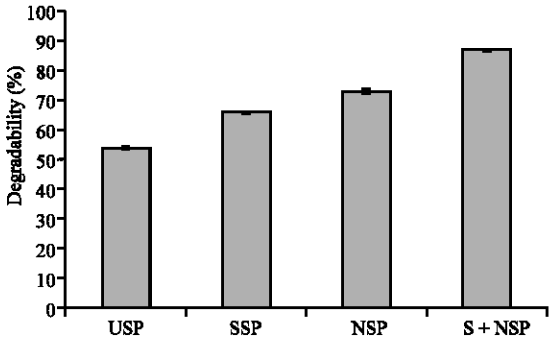

Fig. 1: Cell walls degradability of sugarcane pith treated with high steam and NaOH after 96 h *in vitro* fermentation, Untreated Sugarcane Pith (USP), treated with high-pressure steam (SSP), treated with 50 g kg^{-1} DM NaOH v(NSP) and treated with steam + NaOH (S + NSP)

Table 1: Gas production parameters of sugarcane pith treated with high steam and NaOH

Treatments	b (mL)	c (mL h^{-1})	OMD (g kg^{-1} OM)	ME (MJ kg^{-1} DM)	SCFA (μmol L^{-1})
USP	107.6^{d}	0.01^{d}	425.20^{d}	6.10^{d}	0.64^{d}
SSP	118.5^{c}	0.03^{c}	517.62^{c}	8.81^{c}	0.72^{c}
NSP	125.2^{b}	0.04^{b}	535.46^{b}	8.62^{b}	0.79^{b}
S + NSP	143.5^{a}	0.06^{a}	703.26^{a}	10.03^{a}	0.96^{a}
SEM	5.9	0.001	4.20	0.08	0.02

Untreated Sugarcane Pith (USP), treated with high-pressure steam (SSP), treated with 50 g kg^{-1} DM NaOH (NSP) and treated with steam + NaOH (S + NSP), SEM: Standard Error of Mean, means within each column with different letters are significantly different ($p<0.05$)

that are highly susceptible to enzymatic and microbial attach. About 20% loss in the initial DM following sodium hydroxide treatment reported by Fahey *et al.* (1993). Castro and Machado (1990) reported steam and pressure treatments alone or allied with chemical treatments are known to disrupt lignocellulosics in a way which allows improved utilization of cell wall polysaccharides by cell-free enzymes (Grohmann *et al.*, 1985).

The result of this experiment showed that and fural production from steam had not any negative effect on rumen microbes. Furan derivatives (furfural) can be formed during steam treatments by extensive dehydration of pentoses and these may be toxic to the rumen microbes (Kyuma *et al.*, 1991; Castro *et al.*, 1995). But, Zahedifar (1996) indirectly demonstrated that the furan derivatives were not toxic to rumen microbes and they can almost completely degrade furfural within 6 h *in vitro* fermentation.

CONCLUSION

This study showed that high-pressure steam (180-210°C, 3 min) and NaOH (50 g kg^{-1} DM) increased gas production parameters, cell wall degradability, OMD, ME and SCFA content, also producing furals from steam had not any negative effect on rumen microbes. Therefore, it is suggested that high steam associated with 50 g kg^{-1} sodium hydroxide used for improving digestion and nutritional values of sugarcane pith.

REFERENCES

Brownell, H.H., E.K.C. Yu and J.N. Saddler, 1986. Steam-explosion pretreatment of wood: Effect of chip size, acid, moisture content and pressure drop. Biotechnol. Bioeng., 28: 792-801.

Castro, F.B. and P.F. Machado, 1990. Feeding value of steam sugar cane bagasse in ruminant ration. Livest. Res. Rural Dev., 2: 1-6.

Castro, F.B., P.M. Hotten and E.R. Orskov, 1995. Inhibition of rumen microbes by compounds formed in the steam treatment of wheat straw. Bioresour. Technol., 50: 25-30.

Chaji, M. and A.A. Naserian, 2006. Chemical composition and *in situ* dry matter degradability of Sugar cane pith treated with steam at high pressures. Proc. Br. Soci. Anim. Sci.

Chen, X.L., J.K. Wang, Y.M. Wu and J.X. Liu, 2007. Effects of chemical treatments of rice straw on rumen fermentation characteristics, fibrolytic enzyme activities and populations of liquid and solid-associated ruminal microbes *in vitro*. Anim. Feed Sci. Technol., 141: 1-14.

De La-Cruz, H.O., 1990. Steam treated bagasse for fattening cattle, effect of supplementation with *Gliricidia sepium* and urea/molasses. Livest. Res. Rural Dev., 2: 18-25.

Euna, J.S., K.A. Beauchemin, S.H. Hong and M.W. Bauer, 2006. Exogenous enzymes added to untreated or ammoniated rice straw: Effects on *in vitro* fermentation characteristics and degradability. Anim. Feed Sci. Technol., 131: 86-101.

Fahey Jr., G.C., L.D. Bourquin, E.C. Titgemeyer and D.G. Atwell, 1993. Postharvest Treatment of Fibrous Feedstuffs to Improve their Nutritive Value. In: Forage Cell Wall Structure and Digestibility, Jung, H.G., D.R. Buxton, R.D. Hatfield and J. Ralph (Eds.). American Society of Agronomy, Madison, WI, USA., pp: 715-66.

Getachew, G., H.P.S. Makkar and K. Becker, 1999. Stoichiometric relationship between short chains fatty acid and *in vitro* gas production in presence and absence of polyethylene glycol for tannin containing browses. Proceeding of the EAAP Satellite Symposium on Gas Production: Fermentation Kinetics for Feed Evaluation and to Assess Microbial Activity, Aug. 18-19, Wageningen, The Netherlands, pp: 18-19.

Goto, M., Y. Yokoe, K. Takabe, S. Nisikawa and O. Morita, 1993. Effects of gaseous ammonia on chemical and structural features of cell walls in spring barley straw. Anim. Feed Sci. Technol., 40: 207-221.

Gould, J.M., 1984. Alkaline peroxide delignification of agricultural residues to enhance enzymatic saccarification. Biotechnol. Bioeng., 26: 46-52.

Grohmann, K., R. Torget and M. Himmel, 1985. Optimization of dilute acid pre-treatment of biomass. Biotechnol. Bioeng. Symp., 15: 59-80.

Kling, S.H., C. Carvalho-Neto, M.A. Ferrara, J.C.R. Torres, D.B. Magalhaes and D.D.Y. Ryu, 1987. Enhancement of enzymatic hydrolysis of sugar cane bagasse by steam explosion treatment. Biotechnol. Bioeng., 29: 1035-1039.

Kyuma, T., M. Ishida and A. Takigawa, 1991. Influence of furfural contents in steamed wood on the feed consumption and digestibility in goats. Bull. Nat. Inst. Anim. Ind., 51: 59-63.

Liu, J.X., E.R. Orskov and X.B. Chen, 1999. Optimization of steam treatment as method for upgrading rice straw as feeds. J. Anim. Feed Sci. Techol., 76: 345-357.

Liua, J.X. and E.R. Orskovb, 2000. Cellulase treatment of untreated and steam pre-treated rice straw-effect on *in vitro* fermentation characteristics. Anim. Feed Sci. Technol., 88: 189-200.

Menke, K.H. and H. Steingass, 1988. Estimation of the energetic feed value obtained from chemical analysis and gas production using rumen fluid. Anim. Res. Dev., 28: 7-55.

Morjanoff, P.J. and P.P. Gray, 1987. Optimization of steam explosion as a method for increasing susceptibility of sugarcane bagasse to enzymatic saccharification. Biotechnol. Bioeng., 29: 733-741.

Muzzy, J.D., R.S. Roberts, C.A. Fieber, G.S. Faass and T.M. Mann, 1983. Pre-treatment of Hardwood by Continuous Hydrolysis. In: Wood and Agricultural Residues, Soltes, J. (Ed.). Academic Press, New York, pp: 351-368.

SAS, 1996. SAS/STAT User's Guide, Version 6. 4th Edn., SAS Inst. Inc., Cary, NC.

Theander, O. and P. Aman, 1984. Anatomical and Chemical Characteristics. In: Straw and Other Fibrous by Products as Feed, Sundstol, F. and E. Owen (Eds.). Elsevier, Amsterdam, The Netherlands, pp: 45-78.

Toussaint, B., G. Excoffer and M.R. Vignon, 1991. Effect of steam explosion treatment on the physico-chemical characteristics and enzymic hydrolysis of poplar cell wall components. Anim. Feed Sci. Technol., 32: 235-242.

Zahedifar, M., 1996. Novel uses of lignin and hemicellulosic sugars from acid-hydrolyzed lignocellulosic materials. Ph.D. Thesis, University of Aberdeen, Scotland, UK.