The Effect of Different Methods of Processing on Nutritive Value and Degradation of Rice Straw by Rumen Mixed Bacteria

M. Chaji, T. Mohammadabadi and A. Aghaei
Department of Animal Science,
Khuzestan Ramin Agricultural and Natural Resources University, Molasani, Ahwaz, Iran

Abstract: The aim of this study was to evaluate rumen bacteria activity on degradation of untreated Rice Straw (RS) and treated with low temperature steam, sodium Hydroxide (NaOH) and exogenous enzyme using disappearance of Dry Matter (DM) and Neutral Detergent Fiber (NDF) in rumen bacteria culture for 96 h incubation. Treatments were including: untreated RS, RS treated with low temperature steam (120°C for 120 min), RS treated with 80 g kg⁻¹ DM NaOH, RS treated with 20 g kg⁻¹ DM exogenous enzyme and RS treated with enzyme+NaOH. The result showed disappearance of dry matter after 96 h incubation by rumen bacteria was 60.3, 75.2, 85.3, 81.3 and 96.2 g/100 g for untreated rice straw and treated with steam, NaOH, enzyme and enzyme+NaOH, respectively. Sodium hydroxide, enzyme and steam caused to increase disappearance NDF of rice straw in media culture in compared with the other samples, 96 h after culturing and the highest increase of NDF disappearance was for rice straw treated with enzyme+NaOH (345.3 mg g⁻¹) (p<0.05). Therefore, it may be resulted that low temperature steam, exogenous enzyme and NaOH influence the growth and activity of rumen bacteria on rice straw in compared to untreated RS.

Key words: Low temperature steam, sodium hydroxide, exogenous enzyme, rumen bacteria, rice straw, Iran

INTRODUCTION

Rice straw is an abundant by-product of rice production. Recently, there has been increasing interest in exploiting low quality straws for ruminant feeding in many Asian countries. However, the nutritive value of rice straw for ruminants is relatively low due to its high lignocellulosic content, poor palatability and low organic matter digestibility. In addition to it contains a high concentration of silica that acts as a physical barrier preventing bacterial attachment. The information on the effect of low temperature steam, sodium hydroxide (NaOH) and enzyme on NDF degradation of rice straw by rumen bacteria are rare. Many methods have proved successful in disrupting cell wall material e.g., using alkali (Canale et al., 1992) and or steam (Castro and Machado, 1990). Under steam conditions, acetyl groups are released from the hemicellulose matrix and suitable levels of cell wall disruption are achieved (Muzzy et al., 1983). Steam associated with chemical treatments is known to disrupt lignocellulosics in a way which allows improved utilization of cell wall polysaccharides by rumen microbes (Castro and Machado, 1990). The researchers reported sodium hydroxide may breakdown hemicellulose, hydrolysis the ester bonds between lignin and hemicellulose, expose the cellulose to microbial attachment and carbohydrates more accessible to the action of rumen micro-organisms and improve organic matter digestibility (Goto et al., 1993). Also, exogenous enzymes increase digestibility (Euna et al., 2006). The aim of this study was to investigate the effect of low temperature steam, enzyme and NaOH on rumen bacteria growth and the in vitro disappearance of Dry Matter (DM) and Neutral Detergent Fiber (NDF) of rice straw.

MATERIALS AND METHODS

Samples preparation and culture of rumen anaerobic bacteria: About 80 g kg⁻¹ NaOH on a DM basis was mixed with the rice straw (1.0 mm screen, about 92% DM) for 48 h. Some samples were autoclaved (120°C for 120 min) and then oven-dried at 55°C. Also 20 g kg⁻¹ DM exogenous enzyme used for processing rice straw and autoclaved rice straw. The enzyme mixture composition was Cellulase, Xylanase, Beta glucanase, Alpha amylase, Pectinase, Phytase, Protease and Lipase as 0.03, 6.6, 10, 0.7, 0.07, 0.5 and 3 MU kg⁻¹, respectively; Bioproton Pty. Ltd. Co. Therefore experimental samples were: untreated Rice Straw (RS), rice straw treated with low temperature Steam (RS1), rice straw treated with 80 g kg⁻¹
DM NaOH (RS2), rice straw treated with exogenous enzyme (RS3), rice straw treated with enzyme+80 g kg\(^{-1}\) DM NaOH (RS4).

Four fistulated sheep which fed 250 g concentrate, 550 g lucerne hay and 200 g wheat straw was used to collect rumen fluid then centrifuged (1000 rpm, 10 min). Supernatant was used to grow bacteria in medium containing fungicides (benomyle, 500 ppm mL\(^{-1}\) medium and metalaxyle, 10 mg mL\(^{-1}\) medium) under anaerobic conditions at 39°C for 24 h. These isolates were then used as a source of inoculum for cultivating bacteria in a serum bottle containing 45 mL of culture medium of rumen bacteria (Caldwell and Bryant, 1966) and 1 g of experimental samples under anaerobic conditions (using three times subculture) at 39°C for 12, 24, 48, 72 and 96 h.

**Measurements and statistical analysis:** Samples of rice straw used as the substrate of culture media were collected from each bottle after washing twice with distilled water followed by filtration using grade 1 sintered glass crucibles. They were then freeze dried to constant weight for DM determination. The DM disappearance of each sample was calculated as the difference between initial and the residual weight of the dried substrate. Content of NDF of samples were determined from the freeze-dried samples using the method of Van Soest et al. (1991) and losses of each sample were calculated as the difference between initial and the residual weight of the dried substrate.

Data of DM and NDF disappearance of medium were analyzed as repeated measurement using the General Linear Model (GLM) procedure of SAS (1996). Duncan’s multiple range test was used to compare the means at p<0.05.

**RESULTS AND DISCUSSION**

The data of disappearance of DM and NDF of rice straw treated with low temperature steam, enzyme and NaOH by rumen bacteria culture are shown in Table 1 and 2, respectively. The results showed higher disappearance of DM was observed in the cultures of rice straw treated with enzyme+NaOH that followed by rice straw treated with 80 g kg\(^{-1}\) DM NaOH (RS2), rice straw treated with exogenous enzyme (RS3) and low temperature Steam (RS1) (p<0.05). This result was in agreement with Vadiveloo (2000) by using in vitro digestibility of hay leaf and stem. Also the others reported DM and NDF digestion of the straw treated with an alkali was greater than untreated straw (Bas et al., 1989). The current experiment showed that highest disappearance of NDF was observed in the cultures of rice straw treated with enzyme+NaOH. The alkali solubilizes the inhibitory phenolic compounds and facilitates microbial (P. *Succinogenes*) colonization, increases bacteria populations in cell wall (Chen et al., 2007) and improves of the ruminal degradation plant cell walls (Bana et al., 2006). Goud proposed that alkali react with lignocellulosics to yield partially de-lignified products that are highly susceptible to enzymatic and microbial attack. The enhanced degradability has been ascribed to a solubilisation of total phenolics (Chesson, 1981), arabinoxylans and cellulose (Lindberg et al., 1984) and arising from the cleavage of alkali-labile lignin-carbohydrate linkages (Alexander et al., 1987). It was indicated that 32.5% of the hemicellulose present in the untreated wheat straw was solubilized upon NaOH treatment (Lesoung et al., 1981). In most studies the partial solubilisation of hemicellulose has been demonstrated following alkali treatment (Wadhwa and Makkar, 1995).

The researchers demonstrated the increase in enzymic hydrolysis after steam treatment can be explained by the removal of the hemicellulose but also by the melting and agglomeration of the depolymerized lignin (Toussaint et al., 1991) that caused to increase accessibility and utilization for microbial enzymes (Kling et al., 1987) also cellulose will be more accessible.
for rumen microbial enzymes (Castro and Machado, 1990). Any improvement in in vitro digestibility of bagasse resulting from steam was due to the formation of water soluble substances. Chaji and Naserian (2006) concluded steam treatment of sugarcane pith significantly increased in situ dry matter soluble fraction that solubility might be an estimation of nutrient availability and so digestibility of rumen microbes increased (Dehorthy and Johnson, 1964). The researchers reported phenolic compounds (furfurals) can be formed during steam treatments and these may have an inhibitory activity and toxic to the rumen microbes (Kyuma et al., 1991). Therefore using lower temperatures with a chemical matter (acid) can achieve comparable cell wall disruption to steam treatment at high temperatures (Castro et al., 1994) and results lower amounts of toxic compounds (Clausen and Gaddy, 1983).

The results of present experiment showed that rice straw treated with exogenous enzymes increased disappearance of DM and NDF by rumen bacteria in compared with untreated rice straw. The results of Pincas-Rodriguez et al. (2002) showed that enzyme increased in situ digestibility of DM and cell wall fractions. Also increased degradation of NDF using exogenous enzymes is reported by Colombatto et al. (2003). The researchers reported use of exogenous fibre-degrading enzymes (cellulases) may be improved the degradation characteristics and nutritional value of rice straw. Mongavi et al. (2000) indicated that exogenous enzymes work in synergy with rumen microbial enzymes which increases their hydrolytic potential within the rumen and digestibility of plant cell wall. Colombatto et al. (2003) concluded that some xylanases and proteases improved in vitro degradation of alfalfa hay. Enzymes applied to feed increased solubility of DM and NDF and possibly released more nutrients that were available to support the production of glycoalkyl which is produced by bacteria and permits adhesion between bacteria or between bacteria and substrate (Yang et al., 1999). Yang et al. (1999) reported increased microbial colonization for alfalfa cubes treated with enzyme was likely related to enzyme action. Regarding the factors related to the diet, the effectiveness of fibrolytic enzymes has been shown to vary with forage (Colombatto et al., 2003).

CONCLUSION

The result of this experiment suggested that enzyme (20 g kg⁻¹ DM) associated with NaOH (80 g kg⁻¹ DM) increased in vitro degradation and disappearance of DM and NDF of rice straw by rumen bacteria and therefore improved nutritional values of rice straw more than another treatments.

REFERENCES


