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Exogenous enzymes added to untreated or ammoniated rice straw: Effects on *in vitro* fermentation characteristics and degradability

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Abstract

A study was conducted to evaluate the use of exogenous enzymes as a potential means of improving the cell wall degradation of rice straw. Two developmental cellulases (END), two developmental xylanases (XY), and two commercial enzyme products (EX, supplying a combination of endoglucanases and xylanases; PROT, supplying mostly proteases) were evaluated for their potential to improve *in vitro* degradation of untreated (URS) or ammoniated rice straw (ARS). The END and XY were added to milled samples (0.45 g dry matter [DM]) of URS and ARS at a rate of 200–300 International Units (IU) of endoglucanase or xylanase. The EX supplied 200–300 IU each of endoglucanase and xylanase, whereas PROT supplied mostly protease. Anaerobic buffer medium and strained ruminal fluid were added to the *in vitro* incubations and gas production (GP) was measured during 24 h of incubation. Degradabilities of DM, neutral detergent fibre and acid detergent fibre, and volatile fatty acid profiles were determined at the end of the 24 h incubation. Overall, GP and degradability of rice straw were greatly increased by ammoniation. Adding EX or PROT enzymes increased ($P<0.05$) GP and degradability of URS, whereas END or XY had little impact. Adding XY enzymes to ARS

Abbreviations: ADF, acid detergent fibre; aNDF, neutral detergent fibre; ARS, ammonia-treated rice straw; CP, crude protein (6.25 × N); DM, dry matter; END, cellulase enzymes; EX, fibrolytic enzyme containing mainly cellulases and hemicellulases; GP, gas production; N, nitrogen; OM, organic matter; PROT, proteolytic enzyme; URS, untreated rice straw; VFA, volatile fatty acids; XY, xylanase enzymes

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increased GP (P<0.001) starting at 18 h of fermentation, as well as DM and fibre degradability at 24 h. Adding EX or PROT also increased GP and fibre degradability of ARS, with greater effects for PROT than for EX. There was a synergistic effect between ammonia pretreatment and exogenous enzymes in the case of XY, EX, and PROT for the *in vitro* degradation of rice straw. This synergy may indicate that ammoniation removes phenolic compounds and disrupts the lignin–carbohydrate complexes thereby increasing accessibility of the substrate to enzymatic action. When effective, use of exogenous enzymes shifted fermentation towards decreased acetate to propionate ratio. Combining ammonia treatment and exogenous enzymes increased the ruminal degradation of rice straw and is expected to improve the potential of using rice straw as a ruminant feed.

Keywords: Exogenous enzymes; Ammonia treatment; Rice straw; *In vitro* degradation

1. 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, because the cost of good quality forages is often high and forage availability is limited. However, the nutritive value of rice straw for ruminants is relatively low due to its high lignocellulosic content, low crude protein (CP) content, poor palatability, and low organic matter (OM) digestibility. In addition to its high cell wall content, the ruminal degradability of rice straw is limited by its epidermal surface which contains a high concentration of silica that acts as a physical barrier preventing bacterial attachment (Widyastuti et al., 1987). Considerable effort has been expended to improve the feeding value of cereal straw using pretreatments to upgrade its digestibility (Bae et al., 1997), but commercial application of these pretreatments is limited due to cost and potential environmental hazards.

Use of exogenous fibre-degrading enzymes may be a potential means of increasing the nutritive value of rice straw, as enzyme costs are expected to decline in the future with recent developments in fermentation technology and alternative enzyme production systems (Beauchemin et al., 2004). Supplementing ruminant diets with fibre-degrading enzymes has been shown to improve feed utilization and animal performance (Beauchemin et al., 2003). However, the effectiveness of feed enzymes in ruminant diets is dependant upon substrate–enzyme specificity. Thus, it is important to establish the optimum enzyme activities for the degradation of rice straw. In one study, the use of cellulases improved the degradation characteristics of rice straw, and further improved the nutritional value of steam-treated rice straw (Liu and Ørskov, 2000). However, very little research has been conducted to examine the potential effects of other enzyme activities for rice straw. Furthermore, the effects of supplemental enzymes have not been established for ammoniated rice straw.

The objectives of this study were to investigate whether adding enzymes to untreated (URS) or ammoniated rice straw (ARS) improved fibre degradation and gas production (GP). The study also examined the key enzymic activities required to improve degradation of rice straw.