NITRITIVE VALUE IMPROVEMENT OF RICE STRAW VARIETIES FOR RUMINANTS AS DETERMINED BY CHEMICAL COMPOSITION AND IN VITRO ORGANIC MATTER DIGESTIBILITY

YULISTIANI, D.1; J.R. GALLAGHER2; R. VAN BARNEVELD3

1Research Institute for Animal Production
PO Box 221, Bogor 16002, Indonesia
2Department of Animal Science. The University of Adelaide
3Pig and Poultry Production Institute, South Australia

(Received by the editor 6 July 1999)

ABSTRACT

A study was conducted to evaluate the nutritive value of various rice straws and the effect of urea treatment, using measurements of chemical composition (nitrogen/N; neutral detergent fibre/NDF; acid detergent fibre/ADF; hemicellulose/HC; lignin and silica) and IVOMD (in vitro organic matter digestibility). Straws from eight varieties obtained from Yanco Agricultural Institute, Leeton, N.S.W. was used. Straws were cut into upper and lower part in equal length, then chopped. Chopped straw from each varieties and each part was treated with urea at 4% DM. The experiment used an 8x2x2 factorial design. Results showed that the chemical composition and IVOMD varied between varieties. Before treatment with urea, in all varieties the N content was higher in the upper (8.1-11.1 g/kg) than the lower part (5.8-8.3 g/kg). The IVOMD of the lower part was higher than that of the upper part except for IIb, and Yrl varieties. The IVOMD of the lower part untreated straw ranged from 325 - 498 g/kg whereas in the upper part it ranged from 325-439 g/kg. Urea treatment consistently increased the N content and IVOMD of both parts in all varieties. After urea treatment there was no significant difference in IVOMD between upper and lower part in any variety. The increase of IVOMD in response to urea treatment was higher when the original quality of straw is low where the increase IVOMD is 53% (from 325 to 499 g/kg). There was no consistent effect of urea treatment on the other chemical components. This study concluded that the urea treatment would be more beneficial for use with low quality rice straw.

Key words: Rice straw, variety, urea treatment, chemical composition, in vitro organic matter digestibility
**INTRODUCTION**

Rice straw is a crop residue that is widely available in tropical countries and is used in an attempt to meet the energy requirements of growing and lactating ruminants (Colucci et al., 1992; Doyle et al., 1986). However, its nitrogen content and digestibility are too low to meet the nutrient requirements of ruminants. These limitations must be overcome if it is to be used as a feed source. The classical approach has been to treat crop residues physically or chemically. Sodium hydroxide (Jackson, 1977) and ammonia (Sunotol and Coxworth, 1978) have been the most widely used chemicals to improve straw quality. Urea has also been used to treat straw, and this treatment involves the conversion of urea to ammonia by the action of bacterial urease (Williams et al., 1984).

The economic feasibility of adopting chemical treatment to improve the feeding value of rice straw in developing countries has increasingly been questioned (Schiere and Nell, 1993; Capper, 1988) due to the cost of chemicals and labour. An alternative method of improving the feeding value of straw would be to examine the prospects for increasing the nutritive value of crop residues through plant breeding and selection of varieties with straw of high nutritive value which also retain a high grain yield (Capper, 1988). Givens et al. (1988) found that considerable variability exists in the quality of untreated straw and suggested that identification of the highest quality straw for ruminant production may prove cost effective compared to chemical treatment.

The objectives of the present study were (i) to evaluate the chemical composition and IVOMD (in vitro organic matter digestibility) of several varieties of rice straw and the relationship between these two measures, and (ii) to assess the effect of urea treatment on the nutritional value of the rice straws.

**MATERIALS AND METHODS**

**Sample preparation**

Eight, semi-dwarf varieties of rice straw were obtained from the Yanco Agricultural Institute, Yanco, Leeton, N.S.W. Doongara (Dong), Ammaroo (Amr), Illabong (Iib), Pelde (Pld), Millin (Mil), Langi (Lan), YRL-39 (Yrl) and YRM-43 (Yrm) straws were divided equally by length into upper and lower parts and dried in a forced draught oven at 60°C for 48 hours. Dried straws were then chopped into 3 cm lengths. A subsample of the chopped straws was then ground in a laboratory hammer mill with a 1 mm screen. Ground samples were stored in air-tight containers prior to chemical analysis and an in vitro digestibility study.

**Botanical fraction separation**

To compare the relative proportion of the botanical fractions, the upper part of each variety was dissected into four components and the lower part into three components. The components were rachis (for the upper part only), leaf blade, leaf sheath and stem. Each component was weighed and then oven dried at 60°C to constant weight. The weights of the components were expressed as a percentage of the part dry matter.

**Urea treatment**

For urea treatment, 200 g samples of chopped straw from each part of each variety were prepared by spraying with urea solution and mixed thoroughly to provide urea and moisture levels of 40 g/kg and 400 g/kg of dry matter respectively. Treated straws were then kept in air-tight plastic bags at 22°C for six weeks. The bags were then opened and the contents dried at 50-60°C for 48 hours (Ibrahim et al., 1988). The treated straws were then ground for further analysis.

**Chemical analysis**

Dry matter (DM), organic matter (OM) and nitrogen (N) content of the samples were determined using the methods of the AOAC (1990). Neutral detergent fibre (NDF), acid detergent fibre (ADF), permanganate lignin and silica (insoluble ash) were determined using the methods of Goering and Van Soest (1970). Hemicellulose (HC) was calculated by subtracting ADF from NDF values (Goering and Van Soest, 1970).

**In vitro digestibility**

In vitro organic matter digestibility (IVOMD) was determined using the two-stage technique of in vitro digestibility as described by Tilley and Terry (1963). Rumen fluid was collected with a stomach tube from three 50 kg Merino sheep which were being fed a maintenance ration of 1,200g DM/day, consisting of 50% lucerne and 50% oat chaff. The ration was fed in equal meals each day at 09.00 and 17.00 hours.

**Statistical analysis**

The experiment used an 8x2x2 factorial design involving 8 straw varieties, upper and lower parts and either untreated or urea-treated straw. Analysis of variance using Genstat 5 (Lawes Agricultural Trust, 1994) was carried out for the values for N, NDF, ADF, hemicellulose, lignin, silica and IVOMD. Significant differences were tested using a 95% confidence interval.
RESULTS AND DISCUSSION

The effect of part, variety and urea treatment on chemical composition

The botanical fraction of all varieties rice straw is presented in Table 1 shows that, the lower parts of the straw contained more stem and less leaf.

There was a highly significant (P<0.01) three-way interactions between parts, varieties and urea treatments for N content. The nitrogen content of the upper part of untreated straw of all varieties was higher than the lower part (Figure 1). The range in N content of the upper part was 8.1-11.1 g/kg, while in the lower part was 5.8-8.3 g/kg. A similar difference was observed by WINUGROHO and SUTARDI (1986). This difference may largely be due to the higher leaf content of the upper part (63.5%) (Table 1). This was supported by SANNASGALA and JAVASURIYA (1986), who reported the N content in leaves to be higher than in stem. There were also significant differences between the N content of the different varieties. The N content of the upper parts of Dong, Amr, Ilb, Lan and Yon, shows similar values and had higher N content compared to Pld, Mil and Yrl. In lower parts the N content of Yon variety was significantly higher than the Amr, Ilb, and Pld varieties, but was similar with the Dong, Mil and Lan (Figure 1). The high N content both in its upper and lower parts of Yon suggested that this variety had higher ability to accumulate N. ROXAS et al. (1985) and IBRAHIM et al. (1988) also observed a difference in N contents between 4 and 6 varieties respectively. In contrast, CHEVA-ISRARKUL and CHEVA-ISRARKUL (1985) observed no significant differences in CP content between seven varieties because of the large variation between samples obtained from a wide range of growing conditions (uncontrolled experiment). In the current experiment the samples were obtained from the same plot with the same treatment, and, therefore, the differences in N content between varieties are likely to be due to varietal, rather than environmental, differences.

Urea treatment significantly increased the nitrogen content of both parts in all varieties. Urea treatment reduced the difference in N content between parts and varieties (Figure 1). N content in the upper part, after treatment with urea ranged from 16 - 18.8 g/kg, while in the lower part it ranged from 15.5 - 20 g/kg. The dramatical increase in N content, after treatment with urea, was in the lower part of variety lib (from 5.8 to 20 g/kg). The N content of the treated lower part of the lib variety was higher than its untreated upper part, while in other varieties the N content of the lower part after treatment with urea, was lower than the upper part. This indicated that the lower part of the lib variety had a higher response to urea treatment. The lowest increase in N content after urea treatment was in the upper part of Yrm (from 11.1 to 18.2 g/kg). The consistency increased the N content of both parts in all varieties after urea treatment also observed by COTTYN and DE BOEVER (1988) in wheat and barley straw. This increase could be due to chemical reactions of urea and the straw and the addition of N by urea to treated straw. The increase in N content after urea treatment was higher in varieties with lower N content (Fig. 1). This suggests that rice straw with low N content could benefit more from urea treatment to improve nutritive value. However, the utilization of the N in the urea treated straw will depend upon its digestibility as some

Table 1. Distribution of the botanical fractions on the upper and lower parts of eight varieties rice straw (% dry matter)

<table>
<thead>
<tr>
<th>Part</th>
<th>Botanical Fraction</th>
<th>Dong</th>
<th>Amr</th>
<th>Ilb</th>
<th>Pld</th>
<th>Mil</th>
<th>Lan</th>
<th>Yrl</th>
<th>Yrm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Rachis</td>
<td>19.6</td>
<td>24.1</td>
<td>33.4</td>
<td>24.1</td>
<td>8.7</td>
<td>17.7</td>
<td>21.4</td>
<td>27.3</td>
<td>22.0</td>
</tr>
<tr>
<td>Leaf blade</td>
<td>59.8</td>
<td>41.1</td>
<td>34.2</td>
<td>47.4</td>
<td>22.6</td>
<td>39.3</td>
<td>46.4</td>
<td>25.9</td>
<td>39.6</td>
</tr>
<tr>
<td>Leaf sheath</td>
<td>12.2</td>
<td>20.6</td>
<td>19.8</td>
<td>18.0</td>
<td>41.7</td>
<td>27.8</td>
<td>21.9</td>
<td>29.4</td>
<td>23.9</td>
</tr>
<tr>
<td>Stem</td>
<td>8.3</td>
<td>14.3</td>
<td>12.6</td>
<td>10.5</td>
<td>27.0</td>
<td>15.2</td>
<td>10.3</td>
<td>17.4</td>
<td>14.5</td>
</tr>
<tr>
<td>Lower Leaf blade</td>
<td>14.0</td>
<td>6.1</td>
<td>10.6</td>
<td>19.4</td>
<td>1.9</td>
<td>IIL</td>
<td>22.5</td>
<td>5.4</td>
<td>11.4</td>
</tr>
<tr>
<td>Leaf sheath</td>
<td>44.4</td>
<td>47.6</td>
<td>43.8</td>
<td>37.1</td>
<td>53.6</td>
<td>54.0</td>
<td>37.3</td>
<td>53.1</td>
<td>46.4</td>
</tr>
<tr>
<td>Stem</td>
<td>41.6</td>
<td>46.3</td>
<td>45.6</td>
<td>43.5</td>
<td>44.4</td>
<td>34.8</td>
<td>40.2</td>
<td>41.6</td>
<td>42.3</td>
</tr>
</tbody>
</table>
of the N bound to cell wall in urea treated straw was not fully utilised in the rumen (HASEN and CHENOST, 1992).

The interaction between urea, part and variety on NDF content was significant (P<0.05) (Table 2). The NDF content of the upper and lower parts varied between varieties and between treatments. Before treatment with urea, the NDF content of upper and lower parts was significantly different (P<0.05) between Dong, Ilb, Yrl, Yr varieties. This result is different with SANNASGALA et al. (1985), CHEVAISARAKUL and CHEVA-ISARAKUL (1985), and CHOWDHURY et al. (1995) who reported no significant differences in the NDF content between varieties. In the current study, the variation in the NDF content was higher in the upper part than in the lower part. The lower part of the Dong variety had the lowest NDF content (653 g/kg) while the upper part of variety Pld was the highest (750 g/kg).

There was no consistent effect of urea treatment on NDF content in each variety and part (Table 2). There was no significant effect of urea treatment on NDF content of Amr, Ilb, Pld, and Mil. On the other hand urea treatment significantly increased the NDF content in the lower part of Yrl (from 704 to 743 g/kg), and significantly decreased the NDF content in the upper part of varieties Dong (from 739 to 705) and Lan (from 723 to 682 g/kg).

The interaction between part and variety for ADF content was highly significant (P<0.01) (Table 2). The lower parts of Amr, Ilb and Lan varieties contained significantly higher ADF levels than their upper parts. However with other varieties there were no significant different of ADF content between upper and lower part.

The effect of variety on HC content was highly significant (P<0.01), where Ilb contain the lowest HC. The lower part had significantly lower HC than the upper part. Interaction between the various factors had no significant effect on HC content.

Urea treatment significantly (p< 0.05) increased the ADF content of rice straw but significantly (P<0.05) reduced the HC content of rice straw. The interaction between part and urea treatment was significant (P<0.05) on lignin content (Table 2). The lignin content of the upper part of untreated straw was significantly higher than that of the lower part. After treatment with urea, however, the lignin content was not significantly different between upper and lower parts. There was a highly significant (P<0.01) effect of variety on lignin content (Table 2). Ilb had the highest lignin content (78 g/kg) compared with other varieties. The silica content was not significantly different between upper and lower parts in any varieties except Amr, where the lower part contained a higher silica content (P<0.05). There was no significant effect of urea treatment on silica content.

Lignin and silica content are associated with the lower digestibility of rice straw (VAN SOEST, 1982). In the current study, lignin content varied between varieties, with variety Ilb having the highest lignin content (78 g/kg). The mean value of parts showed that the upper part had a higher lignin content than the lower part. This result suggests that the lower part will have a higher nutritive value, however, digestibility assessment are required to confirm this.

Silica content in paddy plants is important to maintain the erectness of the leaf (GRIST, 1986), therefore, it can be expected that the leaf will have a higher silica content than the stem. In the current study, silica content was not significantly different between parts except for the Amr variety in which the silica content of the lower part was higher than the upper part, even though the upper part contains more leaf. This suggests that the differences in the proportion of leaf had no effect on silica content. In contrast, DOYLE and CHANPONGSANG (1990) reported that leaf blade and leaf sheath contained more ash, and in particular, silica.

Urea treatment increased ADF and lignin content and decreased hemicellulose content. A similar result was reported by SEAWALT et al. (1996) who observed the ADF content of corn stover increased with ammonia treatment. This is due to urea treatment resulting in partial solubilisation of hemicellulose (GIVENS et al., 1988; MASON et al., 1988). The hemicellulose is probably rendered soluble in the neutral detergent solution (VAN SOEST et al., 1983 and MASON et al., 1988). The decreased hemicellulose content results in increased cellulose and lignin levels (GIVENS et al., 1988 and MASON et al., 1988).

VAN SOEST (1988) suggested that the analysis of lignin is the most obvious means to evaluate the efficiency of delignification. A chemical method to evaluate alkali treated straw must distinguish cleaved lignin from uncleaved lignin. Unfortunately, lignin analysis using 72% acid or through oxidation using permanganate solution did not distinguish cleaved from uncleaved lignin. In the present study, the lignin content was determined using permanganate lignin, therefore the changing of lignin content after urea treatment was not consistent and only the lignin content of the lower part significantly increased due to urea treatment.

The effect of part, variety and urea treatment on IVOMD

There was a highly significant (P<0.01) interaction between part, variety and urea treatment on IVOMD (Table 2). The IVOMD of the lower part of all varieties was higher than that of the upper part except in Ilb and Yrl (Figure 2). The IVOMD of the lower part of untreated straw ranged from 325 - 498 g/kg whereas in
### Table 2

Mean values of the chemical composition of the upper and lower part of rice straw varieties either untreated or treated with urea (g/kg dry matter).

<table>
<thead>
<tr>
<th>Variety (V)</th>
<th>Part (P)</th>
<th>Treatment (T)</th>
<th>Chemical composition</th>
<th>NDF</th>
<th>ADF</th>
<th>Lignin</th>
<th>Silica</th>
<th>HC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dongara</td>
<td>Up U</td>
<td>738.6</td>
<td>534.2</td>
<td>59.6</td>
<td>138.4</td>
<td>204.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>653.2</td>
<td>484.8</td>
<td>49.5</td>
<td>101.5</td>
<td>168.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Up T</td>
<td>705.5</td>
<td>548.9</td>
<td>61.7</td>
<td>130.7</td>
<td>156.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>680.7</td>
<td>545.7</td>
<td>69.8</td>
<td>115.7</td>
<td>135.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammaro</td>
<td>Up U</td>
<td>711.6</td>
<td>532.1</td>
<td>57.5</td>
<td>122.9</td>
<td>179.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>737.4</td>
<td>573.2</td>
<td>47.3</td>
<td>140.8</td>
<td>164.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Up T</td>
<td>698.5</td>
<td>572.8</td>
<td>66.0</td>
<td>140.0</td>
<td>125.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>741.9</td>
<td>603.6</td>
<td>67.2</td>
<td>155.1</td>
<td>138.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ilabong</td>
<td>Up U</td>
<td>658.8</td>
<td>557.8</td>
<td>82.4</td>
<td>132.3</td>
<td>128.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>745.2</td>
<td>626.3</td>
<td>80.0</td>
<td>139.8</td>
<td>118.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Up T</td>
<td>695.0</td>
<td>567.7</td>
<td>83.4</td>
<td>124.2</td>
<td>127.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>722.2</td>
<td>615.1</td>
<td>75.1</td>
<td>144.2</td>
<td>107.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pelde</td>
<td>Up U</td>
<td>750.4</td>
<td>577.9</td>
<td>61.5</td>
<td>140.3</td>
<td>172.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>735.3</td>
<td>577.3</td>
<td>60.2</td>
<td>129.7</td>
<td>158.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Up T</td>
<td>739.0</td>
<td>595.3</td>
<td>54.8</td>
<td>138.2</td>
<td>143.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>723.3</td>
<td>579.7</td>
<td>57.3</td>
<td>133.2</td>
<td>146.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Millin</td>
<td>Up U</td>
<td>717.2</td>
<td>566.1</td>
<td>70.4</td>
<td>131.5</td>
<td>151.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>729.1</td>
<td>562.6</td>
<td>50.1</td>
<td>132.3</td>
<td>166.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Up T</td>
<td>713.9</td>
<td>575.2</td>
<td>57.6</td>
<td>144.1</td>
<td>138.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>705.6</td>
<td>568.9</td>
<td>63.6</td>
<td>143.3</td>
<td>136.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Langi</td>
<td>Up U</td>
<td>722.9</td>
<td>530.1</td>
<td>66.4</td>
<td>121.7</td>
<td>192.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>733.4</td>
<td>559.5</td>
<td>55.2</td>
<td>132.5</td>
<td>175.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Up T</td>
<td>682.3</td>
<td>550.2</td>
<td>72.5</td>
<td>127.7</td>
<td>132.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>718.5</td>
<td>591.3</td>
<td>70.8</td>
<td>141.4</td>
<td>127.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yrl</td>
<td>Up U</td>
<td>749.3</td>
<td>573.0</td>
<td>71.3</td>
<td>121.1</td>
<td>176.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>704.2</td>
<td>556.5</td>
<td>63.2</td>
<td>121.1</td>
<td>147.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Up T</td>
<td>742.8</td>
<td>601.1</td>
<td>76.4</td>
<td>124.9</td>
<td>141.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>719.8</td>
<td>571.6</td>
<td>63.8</td>
<td>124.9</td>
<td>148.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yrm</td>
<td>Up U</td>
<td>735.5</td>
<td>565.7</td>
<td>70.2</td>
<td>154.9</td>
<td>169.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>693.5</td>
<td>571.0</td>
<td>59.9</td>
<td>142.7</td>
<td>122.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Up T</td>
<td>730.6</td>
<td>583.3</td>
<td>74.7</td>
<td>134.9</td>
<td>147.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lo</td>
<td>709.8</td>
<td>597.7</td>
<td>67.6</td>
<td>148.5</td>
<td>112.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significant**

<table>
<thead>
<tr>
<th>Main factor:</th>
<th>P</th>
<th>V</th>
<th>U</th>
<th>PXV</th>
<th>UXV</th>
<th>UXP</th>
<th>UXPXV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NS</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

*Up=upper; Lo=untreated; T=treated; NDF=acid detergent fibre; ADF=acid detergent fibre; HC=hemicellulose; ** P<0.01; * P<0.05; NS=non-significant.*
the upper part it ranged from 325 -439 g/kg. The higher
digestibility of the lower part except for I1b and Yrl
was caused by the lower part of rice straw having a
higher stem proportion (42.3%) (Table 1). This is
supported by SANNASGALA and JAYASURYA (1986) who
observed the IVOMD of the stem node and internode was
higher than the leaf fraction. Moreover, SANNASGALA
and JAYASURYA (1987) reported that the narrower the
leaf total stem ratio the higher the IVOMD. Furthermore, RAXAS et al. (1985) reported that variation in the semidwarf (improved) varieties had
higher IVOMD than the traditional varieties because
semi dwarf varieties contained more stem. In contrast,
DOYLE and CHANPONGSANG (1990) found the leaf
blade of rice straw from 4 varieties had a higher
IVOMD than the leaf sheath and stem.

In addition to a difference between the IVOMD of
the upper and lower parts within a variety, there was a
difference between the IVOMD of parts between
varieties. BAINTON et al. (1991) found that although
there were differences between varieties in in vitro
digestibility, there was no consistent difference
between modern and traditional varieties overall. In the
current study all the varieties were semi-dwarf. The
lower part of the Dong variety had the highest IVOMD
(498 g/kg), while the lower part of variety Yrl and the
upper part of variety Lan had the lowest IVOMD (325
g/kg each). Most of the upper parts in all varieties the
IVOMD were significantly lower than the lower parts,
except for the I1b variety (Figure 2). The upper parts
were generally low quality (IVOMD<40%), except for
variety I1b which was medium quality (IVOMD=43.9%), while the lower parts were of medium quality (40%<IVOMD< 50%), except for
varieties Pld and Yrl which were low quality (IVOMD
38 and 32.5%, respectively).

A higher increase in IVOMD after urea treatment
was also obtained from low quality rice straws (IVOMD<40%), the increase ranging from 20 - 53%. Similar results have also been observed by CAPPER
(1988). In the current study the maximum response to
urea treatment was obtained from the lower part of the
Yrl variety which had the lowest IVOMD before
treatment with urea (Figure 2). Its IVOMD increased
53% after treatment with urea (from 325 to 499 g/kg).
However, IBRACHIM et al. (1989) reported that the
maximum benefit of urea treatment was obtained with
medium quality rice straw. In the current study, the
increase in the IVOMD of medium quality straw
(40%<IVOMD<50%) with urea treatment only ranged
from 1 - 16%.

Relationship between chemical composition and
IVOMD

The relationship between the IVOMD and chemical
composition of rice straw was investigated. The linear
regressions between cell wall components (NDF, ADF,
Poor linear relationships between IVOMD and chemical composition have also been reported by Sannasgala and Jayasurya (1986) with rice straw, and by Mason et al. (1988) with wheat, barley and oats. In contrast, Van Soest et al. (1983) observed that the relationship between IVOMD and lignin content was significant if the data of treated and untreated straws were regressed separately, but was not significant for the combined data. The difference between untreated and treated populations did not allow crude lignin to become a meaningful measurement. Van Soest et al. (1983) suggested that, generally, urea treatment did not greatly change the lignin content. Treatments mainly resulted in a shift of the regression line. In the current study there was no consistent effect of urea treatment of parts and varieties on lignin content. When the untreated and treated data were separated to assess the relationship between lignin content and IVOMD, the regression line was not significantly different from the untreated straw, and of 0.081 for treated straw. This indicates that the relationship between lignin content and IVOMD was poor with either separated or combined data.

Linear regressions between each chemical component and IVOMD both in the present study and in the literature, resulted in poor correlation. This indicates that each chemical component (N, NDF, ADF, HC, silica) can not be used as a reliable single factor to explain the variability in the IVOMD of rice straw varieties and their parts before and after treatment with urea. The results suggested that the chemical composition is a poor method of assessing the nutritive value of rice straws and subsequent improvement after urea treatment. IVOMD is a better method of assessing the nutritive value of rice straw varieties and improvement after urea treatment. This observation is supported by Orskov et al. (1988) who reported that biological measurement is the most appropriate method to differentiate the nutritive value between varieties, botanical fractions and treatments of cereal straws.

The IVOMD is a function of N, hemicellulose, lignin and silica. This indicates that 60% of the IVOMD is reflected by the N, hemicellulose, lignin and silica content. The equation also indicates that HC, lignin and silica content have negative effects on the IVOMD. Alternatively, Bainton et al. (1991) reported that the in vitro digestibility is a function of ash content and days to maturity, with a coefficient determinant of 0.74. This result provides further evidence that straw digestibility is affected by a range of chemical parameters and not by any single chemical factor, and hence, IVOMD is a better means than chemical analysis alone of evaluating the nutritive value.

**CONCLUSION**

The N content of rice straw was consistently higher in the upper part for all varieties, whereas for other chemical composition (NDF, ADF, HC, lignin and silica) content showed no clear trend between parts and between varieties. The IVOMD values of the lower part of rice straw was consistently higher than upper part in all varieties and that the Dong variety having the highest IVOMD among other varieties.

Urea treatment consistently increased N content and IVOMD. The increase IVOMD due to urea treatment was higher in the original low quality rice straw than medium quality, therefore, urea treatment is more beneficial for use with low quality rice straw to improve its nutritional quality.

IVOMD is more appropriate method than chemical composition for evaluating the nutritive value of rice straw varieties and the effect of urea treatment.

**REFERENCES**


Jurnal Ilmu Ternak dan Veteriner Vol. 5 No. 1 Th 2000