Challenges in the utilization of high moisture grains silage for ruminants

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Abstract

The advantages of the high moisture grains regarding the dry grains are widely emphasized in the literature. In Brazil, the usage of high moisture corn started in the eighties and since then it is a constant expansion technology. Besides the economic and loss reduction aspects it is highlighted the better animal performance.

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Ensilage effect on the grains stored

According to H. J. (1961), the composition of the rumen

Introduction

Practices

The use of higher moisture grains especially from corn, is

Considering the research results in Brazil and abroad in nutritional

The increase of the final ethanol yield in the process of

This technology may yield advantageous results to the producers.

Furthermore, other processes must be considered to add quality

With importance to the quality (nutritive value) and to the ensiling

Ensiling effect on the grains stored

Conclusions in the utilization of high moisture grains for ruminants
72°C) for this gelatinization to occur are not reached. However, according to Rooney and Pfugfelder (1986), starch can be gelatinized by the action of chemical agents. This way, silage acids can also contribute for a better starch digestibility. The pH reduction, due to acids production in grain ensiling process, results in acid hydrolysis, both the starch and the protein fraction, which favors the increase in gastric retention and pepsin activation time determining an increase in silage (Jones et al., 1974).

The corn starch preserved in silage form, both from the whole plant and moisture grains, is also digested mostly and more quickly in the rumen and only a small fraction goes to small gut (Owens et al., 1986). In ruminants the low starch degradation in the rumen may reduce the total digestibility in tract and harm the rumen microbial protein production. Nevertheless, the rumen is the main local of starch digestion, with volatile fatty acids and microbial protein production (Theurer, 1986).

**Grain processing and starch use**

It is known that grains which suffer intense physical processing (triturated or compressed) and/or chemical processing (gelatinization) present higher ruminal digestion. The processing purpose is digestibility improvement by breaking the barriers that make it impossible the access of ruminal microorganisms and enzymes in the nutritive components of feeding (McAllister et al., 1990).

The grains processing increases excessively the starch ruminal digestion, because it acts in the increase of grains surface area or in the increase of starch granules solubility in water (Antunes and Rodrigues, 2006). Thus, grain starch and protein availability in the rumen and small gut also increases changing ruminal fermentation and passage rate characteristics and the digestion site (Theurer, 1986; Owens et al., 1986), making energy available for the microbial development and consequently in a higher volatile fatty acids production (Owens et al., 1997). The rate and extension of starch digestion in the rumen differ among the starch sources (Rooney and Pfugfelder, 1986) and from processing method and intensity (Theurer, 1999).

**Maturation stage and genotype effect in grains use**

*In situ* incubation studies revealed differences among and inside starch sources in ruminal degradation due to the differences in the content of amylase and amylpectin, crystallinity, particles size and the technical process used (Tammenga et al., 1990; Tammenga, 1997). Chemically, starch is constituted by amyllose and amylpectin polysaccharides, interlinked and wrapped up by a protein matrix or layer (Rooney and Pfugfelder, 1986).

The starch digestibility is inversely proportional to the amyllose content, due to interactions with this protein matrix of starch granule (Rooney and Pfugfelder, 1986; Zeoula and Caldas Neto, 2001). This way, starch sources with bigger amylpectin contents, such as unripe corn grain, can present higher digestibility (Jobim et al., 2003). McAllister et al. (1993), consider that in practice starch digestion extension in the rumen seems to be more determinate by the material type which surrounds and protects the starch granule than by its physical and chemical properties. The protein matrix of corn endosperm is extremely resistant to digestion by ruminal microorganism (McAllister et al., 1990). Also for the sorghum, a potential limitation for the use of grain silage is the low digestibility due to the dense protein matrix of the peripheral endosperm (Gutierrez et al., 1982), which makes the starch little accessible to ruminal digestibility.

In this context, McAllister et al. (1991), using scanning probe microscopy, observed that the corn protein matrix limits the ruminal bacteria access to the starch granules. After the pericarp breaking by chewing or processing, the fermentation rate of starch granules is determined by the protein matrix rigidity and by the presence of cellular wall of the endosperm cells (Antunes and Rodrigues, 2006).

The starch degradation in the rumen varies with the corn maturation stage decreasing with the maturity advance (Jobim et al., 2003). Before grain maturation completion, the protein matrix which covers the starch granules, in flint corn it is already being formed and it will limit starch ruminal digestion (Philippeau et
The use of microbial inoculants in grain storage has shown in:

**Table 1. Influence of com grain size on initial DM and starch degradation**

<table>
<thead>
<tr>
<th>Item</th>
<th>DM (%)</th>
<th>Starch (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 1</td>
<td>10.2%</td>
<td>7.8%</td>
</tr>
<tr>
<td>Item 2</td>
<td>9.5%</td>
<td>8.1%</td>
</tr>
<tr>
<td>Item 3</td>
<td>10.8%</td>
<td>6.9%</td>
</tr>
<tr>
<td>Item 4</td>
<td>9.7%</td>
<td>7.2%</td>
</tr>
</tbody>
</table>

By Michael Doreen, 1999

Embryo or kernel viability depends on the strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, strain, 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is because of the lower buffer capacity (3.17 m.eq NaOH/100 g DM – Calixto Júnior et al., 2009), demanding lower acids production for the ensiled volume stability. This thesis would be proven by lower acids concentration observed in grain silages, with lactic acid values of 0.80 and 0.78% and acetic acid of 0.40 and 0.12% (DeBrabander et al.; 1992, Jobim et al.,1997).

Working with high moisture corn and high moisture sorghum silage, Itavo et al. (2006) verified that the pH values obtained from the sixth day after the ensiling were 4.22 and 4.14, respectively, for control and inoculated silages. As for the silages of high moisture corn, the regression equations for the variable pH, in sorghum silages, inoculated or not, indicated pH stabilization after the third day of ensiling (pH < 4.2). The regression equations for the variable pH, of inoculated or not silages, indicate a pH stabilization on the first days of fermentation. This way, the use of microbial inoculants in grain silages must follow bacteria specificity and product cost criteria.

Nutritional additives use

The impossibility of previously concentrate formulation is a disadvantage for use high moisture grain silage, for being not able to be stored with a mixture ready for a later use. This fact makes it necessary to mix it, daily, to the other diet ingredients, before supplying it to the animals. Thus, the corn grains ensiling with additives which raise the nutritive value, specially referring to crude protein and energy content, is interesting, because it can make a silage with nutritive value available similar to the ones of the commercial concentrate. In this context, the Conservation Forage Group, of Animal Science Department of University of Maringá (UEM) has been performing studies which have proved the feasibility of soybean, sunflower or urea addition in high moisture corn.

The use of nutritive additives in high moisture corn is still rare and the studies are recent (Jobim et al. 2002; Jobim et al., 2008; Andrade et al., 2009; Jobim et al., 2009). The aim of other grains addition, of urea or other product is to improve the chemical composition of silage, resulting in a better quality feed. It is stated that this can be an easy application technology, with an improvement in silage quality. This proceeding can be a viable alternative for producers who intend to reduce the concentrate formulation in feedlot system or even for dairy cows feeding. It is possible to use nutritive additives to obtain silage with protein and energy levels similar to the ones seem in commercial concentrate or formulated on the farm.

The soybean can be an alternative, since the raw soybean is a rich protein, besides being considered good energy source due to its high oil content. At the same time, in specific time of the year, the soybean is available in more accessible prices than defatted meal. The grain of soybean can become a low cost protein source, when produced on the farm or in cases of market prices for sales are very low.

The data presented in Table 2 are results of a study which evaluated quality and chemical composition of corn grain silages with levels of soybean. After one year of storage the silages presented excellent preserving quality, with reduced losses. It was verified that the corn grain ensiling added with raw soybean allows improving the silage feed chemical composition, mainly regarding the protein and energy contents. This way, the soybean use added to corn grain silage can determine the reduction in the commercial concentrate use and, consequently, reduce the production costs, being able to contribute to solve the serious grains storage problems on farms.

### Table 2. Chemical composition and gross energy (GE) content of corn silage added with soybean.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>DM (%)</th>
<th>Ash (%)</th>
<th>CP (%)</th>
<th>NDF (%)</th>
<th>NNE (%)</th>
<th>GE (kcal/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CG *</td>
<td>65.9</td>
<td>1.8</td>
<td>9.5</td>
<td>6.1</td>
<td>5.9</td>
<td>4020</td>
</tr>
<tr>
<td>CG + 10% SG</td>
<td>66.9</td>
<td>2.3</td>
<td>13.7</td>
<td>8.0</td>
<td>7.8</td>
<td>4309</td>
</tr>
<tr>
<td>CG + 20% SG</td>
<td>68.6</td>
<td>2.8</td>
<td>17.9</td>
<td>9.9</td>
<td>9.7</td>
<td>4471</td>
</tr>
<tr>
<td>CG + 30% SG</td>
<td>70.9</td>
<td>3.2</td>
<td>22.1</td>
<td>11.8</td>
<td>11.6</td>
<td>4538</td>
</tr>
<tr>
<td>CG + 40% SG</td>
<td>73.8</td>
<td>3.5</td>
<td>26.3</td>
<td>13.7</td>
<td>13.5</td>
<td>4730</td>
</tr>
</tbody>
</table>

*CG = corn grain SG = soybean
Source: Jobim et al. (2003)
Sheep

Chlorine dioxide for ruminal

<table>
<thead>
<tr>
<th>Source: J.D. et al. (2005)</th>
</tr>
</thead>
</table>
| Table 2: Chemical composition of high moisture corn and silages with 20% of | 10650
| 6/10
| 10650
| 6/10

Challenges in the utilization of high moisture corn for feedlots

In the current work, it was also evaluated the sheep feed intake of the dietary treatment that includes a high moisture corn without addition of chlorine dioxide. Sheep were randomly allocated into two treatments: a) control (no addition of chlorine dioxide) and b) treated (addition of chlorine dioxide at 2.0% of the diet). In the control group, the sheep showed a significant decrease in feed intake compared to the treated group. The addition of chlorine dioxide increased the dry matter digestibility and the efficiency of energy utilization, resulting in improved growth performance and feed conversion rate. These results suggest that the use of chlorine dioxide as a feed additive can be a promising strategy to enhance the efﬁciency of nutrition and enhance the animal performance in sheep.
not effect from grain type either. Nevertheless, the animals which received grain silage presented a tendency of lower slaughter age, what can be seen on Table 4.

Table 4. Birth weight average, daily feed intake, average daily gain and slaughter age of feed with (HMC) in lambs on creep feeding.

<table>
<thead>
<tr>
<th>Variable</th>
<th>0% HMC</th>
<th>50% HMC</th>
<th>100% HMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (kg)</td>
<td>4.90</td>
<td>4.87</td>
<td>5.05</td>
</tr>
<tr>
<td>Daily feed intake (kg)</td>
<td>0.387</td>
<td>0.308</td>
<td>0.365</td>
</tr>
<tr>
<td>Average daily gain (kg)</td>
<td>0.368</td>
<td>0.396</td>
<td>0.385</td>
</tr>
<tr>
<td>Slaughter age (days)</td>
<td>64.88</td>
<td>61.13</td>
<td>61.43</td>
</tr>
</tbody>
</table>


The feedlot sheep performance, fed with dry corn (DCG), high moisture grains (HMC) or hydrated corn grains before ensiling (HHMC) was evaluated Reis et al. (2001). The authors verified beneficial effect in the high moisture grain usage regarding the dry grain (Table 5). Regarding the average daily gain (ADG) and feed conversion ratio (FC), it was evidenced that the animals which received DCG + HHMC or DCG + HMC presented better results and that the best answer of animals fed with high moisture corn can be attributed, among other factors, to the starch composition granting higher digestibility.

Table 5. Average initial weight and average daily gain, grams per day.

<table>
<thead>
<tr>
<th>Item</th>
<th>DCG</th>
<th>HMC</th>
<th>HHMC</th>
<th>DCG + HMC 50:50</th>
<th>DCG + HHMC 50:50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial weight</td>
<td>8.98</td>
<td>9.94</td>
<td>9.00</td>
<td>9.34</td>
<td>9.99</td>
</tr>
<tr>
<td>ADG 28 days</td>
<td>108.50a</td>
<td>154.10a</td>
<td>150.30a</td>
<td>114.70a</td>
<td>93.60b</td>
</tr>
<tr>
<td>ADG 56 days</td>
<td>87.30b</td>
<td>147.40a</td>
<td>121.20a</td>
<td>170.40a</td>
<td>101.10b</td>
</tr>
<tr>
<td>ADG 73 days</td>
<td>121.70a</td>
<td>160.90a</td>
<td>153.70a</td>
<td>145.00</td>
<td>126.00b</td>
</tr>
</tbody>
</table>

Within a row, means without a common superscript letter differ (P < 0.05), Tukey test. 
DCG = dry corn grain; HMC = high moisture corn; HHMC = hydrated corn grains before ensiling 
Source: Reis et al. (2001)

In Table 6, data is shown referring to the animal performance in relation to weight gain and carcass variation. It is concluded that corn grain silage associated with 20% of sunflower grains or 1% of urea, in feedlot sheep feeding, do not affect the carcass quantitative variable, recommending its use for feedlot sheep supplying.

Table 6. Performance and carcass characteristics from lambs fed with high moisture corn (HMC), HMC added with sunflower grain (HMC + S), HMC added with urea (HMC + U).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>HMC</th>
<th>HMC + S</th>
<th>HMC + U</th>
<th>Average</th>
<th>F</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial BW, kg</td>
<td>22.71</td>
<td>23.22</td>
<td>23.00</td>
<td>22.98</td>
<td>0.09</td>
<td>10.22</td>
</tr>
<tr>
<td>Final BW, kg</td>
<td>31.43</td>
<td>30.65</td>
<td>30.88</td>
<td>31.05</td>
<td>0.60</td>
<td>3.85</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>0.17</td>
<td>0.15</td>
<td>0.16</td>
<td>0.27</td>
<td>0.32</td>
<td>19.51</td>
</tr>
<tr>
<td>Hot carcass, kg</td>
<td>13.55</td>
<td>13.18</td>
<td>13.43</td>
<td>13.39</td>
<td>0.27</td>
<td>7.57</td>
</tr>
<tr>
<td>Chilled carcass, kg</td>
<td>12.95</td>
<td>12.54</td>
<td>12.92</td>
<td>12.80</td>
<td>0.34</td>
<td>7.61</td>
</tr>
<tr>
<td>Carcass yield, %</td>
<td>50.51</td>
<td>50.51</td>
<td>50.49</td>
<td>50.51</td>
<td>0.30</td>
<td>5.69</td>
</tr>
<tr>
<td>Commercial carcass yield, %</td>
<td>48.27</td>
<td>48.10</td>
<td>49.54</td>
<td>48.63</td>
<td>0.28</td>
<td>4.32</td>
</tr>
</tbody>
</table>

F = F test
CV = coefficient of variation

Cattle

In studies performed by researchers from FMV/UNESP-Butucaru, aiming to get information about the nutritive aspects in feedlot systems, in Brazil, and published by Tonin (2009) reveal that the main grains applied in feedlot cattle diet are corn with 79% and sorghum with 21%. Some studies have compared sorghum grains with corn grain in cattle diet, with satisfactory results. When evaluating dry corn, HMC, tannin - sorghum grain, tannin-sorghum silage, dry sorghum and high moisture sorghum Almeida Jr. et al., (2008), did not verify effect on the weight and slaughter age of calves. Also they did not observed difference for daily gain and live weight total, being then real daily gain of 0.96 kg. The data evidence that sorghum, with or without tannin, in ground dry grains forms or moisture grain silage, and the moisture corn grains silages, can be used for post weaning Holstein calves, with satisfactory performance.

When evaluating HMC or sorghum moisture grains (HMS) silage in a performance experiment of calves (F1 Red Angus ×
The performance and characteristics of feeding steers cross
reference

Table 2. Carcass characteristics and animal performance

![Table 2](image)

Conclusions

Challenges in the Utilization of High Moisture Grain Starch for Ruminants

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how can grains shift components to the dry grain?

An important 9.7% in feed efficiency when it was used more in feeding cattle. In addition, this difference in grain characteristics for the same grain composition and amount does not have a significant difference for the daily weight gain in the dry grain. However, the results for both grains were evaluated by PRESS et al. (2002). The authors also compared the differences in grain characteristics associated with the shift of fat on the grain, while some authors showed similar results for the dry grain.


SANTOS, F.P. Proteína sem desperdício. DBO – A Revista de Negócios da Pecuária. Ano 28. n.345, p.92-93

SCHAFFER, D.M.; BRODT, P.G.; ARP, S.E. et al. Inoculação de cor molhado e inóculo de grãos e de proteína de água e a ação dos efeitos sobre a subsequente fer...
Introduction

Strategies to enable the use of legume silage in ruminal production of forage or grassland systems in Brazil in most of animal production systems in Brazil due to the productivity and efficiency of cattle is an approximately 200 million head of cattle. The productivity of the beef sector is demanded by the Brazilian livestock industry. This Brazilian livestock is based on pastures, i.e., the ones which

KARINA CUNHA RIBEIRO
ANDRE SOARES DE OLIVEIRA
ODILON COMES PEREIRA

production of legume silage in ruminant