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# 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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Considering the research results in Brazil and abroad, in ruminants fed with high moisture corn, it is evident that the application of this technology may bring advantageous results to the producers. In Brazil, the increase of the finish beef cattle in feedlot has been one of the factors which demand the increase of grain silages use. Besides corn, the use of sorghum grain in the ruminants feed has also increased, which stipulates investments to explain some issues which have not been consolidated by the research.

## Introduction

The use of high moisture grain silage, especially from corn, is a technology which has become more and more important in the animal production systems where the grain use is an important compound in the diet. In Brazil, the increase of finish beef cattle in feedlot system receiving diets with high grain has made an increase in the use of high moisture corn. Emphasis is given to the lower cost of production and to better silage feed conversion in relation to the dry grains. The lower production cost (estimated between 7 and 15%) is determined by elimination of stages such as transport to the grain storage silo, cleanliness, drying, elimination and break due to high moisture.

The animal feeding in feedlot or semi-feedlot system deserves special attention, not only regarding the nutritive demands, but also specially because of the feedstuff costs, mainly concentrate. Due to it, it is necessary to find technological use which allows efficiency and economy in the exploration. In this context, the grains silages use may constitute an important alternative for the grains in the concentrate formulation. In Brazil, corn is the principal grain used in the ruminant feeding. However, other grains can present great possibilities of usage because of quality and regional availability. As an example, it is possible to mention sorghum grain, millet, white oat and triticale. The use of these grains is still small when compared to the corn use, but there are already some studies of these grains use in silage form to the feeding of different animal species (Jobim et al., 2003; Oliveira et al., 2007; Catelan et al., 2009).





Nevertheless, other progresses must be searched to add quality to these silages. Today the main issues are regarded to the microbial or nutritive additive use, chemical composition of the grains, with inference to its quality (nutritive value), and to the ensiling processing.

## Ensiling effect on the grains starch

According to Mello Jr. (1991), the carbohydrates of the ruminant diets can be enzimatically digested in the rumen and large gut by microbial enzymes and, in the small gut, by the intestine and pancreatic enzymes. In the rumen, the starch is easily and quickly fermented by the amilolytic microorganisms, although the level which this occurs depends mainly on the physical and chemical properties of the starch granules. The effect on the matrix protein solubility which encapsulates the endosperm starch granules has been considered the most important factor that affects the usage efficiency. Studies made in the 70s and 80s (McNeill et al., 1975, Theurer, 1986) reveal that the ensiling process may improve the availability and/or the use of grain starch, depending on the ensiling technology, animal specie and grain source. The corn grain endosperm is formed by vitreous and floury zones and both present differences in chemical and physical composition. The corn grain presents texture differences, being classified as flint corn, dent corn or semi flint corn. An important way to evaluate grain texture is the Kernel vitreousness, due to the relation with the quantity of vitreous and floury endosperm. The bigger quantity of vitreous endosperm, harder the grain is, on the other hand, the more dent the grain is, the bigger the quantity of floury endosperm.

In the ensiling, the higher content of moisture, regarding the dry grain, favors the fermentation inside the silo, resulting in higher nutrients solubility and in an increase of the starch susceptibility to enzymatic hydrolysis, causing improvement in the animal feeding efficiency (Gill et al., 1982; Simas, 1997) and in the microbial protein synthesis. Also, the starch gelatinization by heating can favor its digestibility, but this will hardly happen in ensiling normal conditions of corn grains, once the necessary temperatures (62 a

72ºC) for this gelatinization to occurs are not reached. However, according to Rooney and Pflugfelder (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 amylose and amylopectin, crystalinity, particles size and the technical process used (Tamminga et al., 1990; Tamminga, 1997). Chemically, starch is constituted by amylose and amylopectin polysaccharides, interlinked and wrapped up by a protein matrix or layer (Rooney and Pflegfelder, 1986).

The starch digestibility is inversely proportional to the amylose content, due to interactions with this protein matrix of starch granule (Rooney and Pflugfelder, 1986; Zeoula and Caldas Neto, 2001). This way, starch sources with bigger amylopectin 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 proprieties. 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 Rodriguez, 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



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al., 1996). Because of this, the corn harvest for silage with higher moisture content, comparing to dry grain, has beneficial effect on the digestibility in the rumen (Jobim et al., 2003).

A way to manipulate the starch degradation rate is by hybrids selection (Philippeau et al., 1999). Studies performed regarding the corn maturation stage show a strong variability in starch ruminal degradation considering the genotype (Philippeau et al., 1996). Corn hybrids differ by endosperm texture (dent, flint) (Majee et al., 2003). There are evidences that the endosperm texture is related with rate and extension of protein and *in vitro* starch and *in situ* ruminal in cattle digestibility (Phillipeau et al., 1999). Kotarski et al. (1992), comparing ruminal disappearance of *in vitro* starch between sorghum cultivars observed a faster disappearing rate for floury endosperm cultivars regarding cultivars with vitreous endosperm. Philippeau et al. (1999), studying relations between starch ruminal degradation and physical characteristics of corn grain in 14 corn hybrids, observed a effective average degradability of 50%, varying from 39.7% for the grains with flint texture to 71.5% to dent grain (Table 1).

The effective degradability of starch was higher to dent corn grain than to flint corn grain, on average of 61.9 e 46.2%, respectively. These two types corn differed in Kernel vitreousness, with averages of 51.4% and 71.8%, respectively. The authors evidenced that the ruminal degradability and the starch physical characteristics varied between the materials, where 88.5% of starch degradability variation in the rumen was associated with the grain endosperm Kernel vitreousness. Therefore, the grain texture seems to make an important part in the starch ruminal degradation (Philippeau et Michalet-Doreau, 1997).

**Table 1.** Influence of corn grain texture on ruminal DM and starch degradation.

| Item | Dent | | | Flint | | | SE | P |
|---|---|---|---|---|---|---|---|---|
| | Average | Min | Max | Average | Min | Max | | |
| Effective DM degradability, % | 55.8 | 51.9 | 71.5 | 42.3 | 39.7 | 45.3 | 1.3 | .0001 |
| Effective starch degradability, % | 61.9 | 55.1 | 77.6 | 46.2 | 40.6 | 50.5 | 1.5 | .0001 |
| Vitreousness, % | 51.4 | 38.5 | 57.3 | 71.8 | 66.8 | 79.1 | 1.4 | .0001 |

Source: Adapted from Philippeau et al. (1999)





Evaluating the influence of the endosperm Kernel vitreousness and the grain moisture extension in corn digestion of high moisture in feedlot cattle, Szasz et al. (2007), observed that the portion readily degradable in the rumen, both for DM and starch, increased linearly with the grain harvesting moisture. This decreased proportionally to insoluble fraction potentially degradable of DM and starch. The authors also highlighted that corn with high moisture and higher Kernel vitreousness presented smaller sized particles and bigger surface area when compared to hybrids with floury endosperm. This smaller particles size was associated with a faster *in situ* digestion and an intestinal and total tract digestibility of starch slightly higher. Thus, these authors concluded that the negative effects on the starch digestion associated with vitreous endosperm can be avoided by ensiling and processing of high moisture corn.

## Microbial additives use

The use of microbial inoculants in grain silages has shown inconsistent results, the same way that the application of these inoculants in plants silages. A relevant aspect is to consider that the grains can present a bacteria population, specialized in lactic acid production, lower regarding the forage volume of the same plant. This because epiphytic bacteria is usually found on leaves surface and in basal region of the plant. Thus, it is possible that the bacteria population added in silage present relevant effect in the fermentative process, with higher preserving efficiency. Then, Schaefer et al. (1989), studied the silages inoculation of the air part and of the high moisture corn and verified higher effects of inoculants addition on the microbiological counting in moisture grains silages. Yet, they did not detect effects on the nutritional quality.

There are evidences that the success in microbial inoculants use in silages depends, among other factors, on the presence of adequate substratum and the bacteria population added via inoculants in relation to the epiphytic population (Muck, 1988). On the other hand, it is possible that the lactic bacteria population (CFU/g of silage) necessary for a good fermentation pattern in grain silages is much smaller than in plant silages. In high moisture silages, this 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, Ítavo 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.

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

*CG = corn grain SG = soybean
Source: Jobim et al. (2002)



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Still emphasizing the increase of grain silage protein content, Jobim et al. (2008) studied the soybean, sunflower grains and urea addition to high moisture corn, evaluating the animal performance in sheep. Nowadays the sunflower crop has been growing, but its production is addressed for the oil extraction, where the sub product has been used in animal feed in the form of meal. Thus, urea was added to corn grains aiming the increasing of crude protein content in silage. This way, Santos (2009), points outs that the use of urea in ration for finishing cattle can be costs reduction source, without reducing the animal performance. Studies performed in the USA and Brazil, comparing the use of urea *vs* true protein in cattle diet, evidence that there is not reduction in the animal performance when urea was used. Santos exemplifies that in a feedlot with 20 thousand animals for a period of 90 days, the substitution of 0.5 kg of soybean meal (R$ 800/t) for 0.5% of the mixture with 87% of corn and 13% of urea (corn = R$ 370/t and urea R$ 1,000.00/t), the savings can reach R$ 313,200.00 (Brazilian Real).

In this line the high moisture corn with urea addition can reduce even more the feeding cost and result in higher profit to the producer. Information obtained in farms allows estimating that the corn grain silage ton cost is R$ 200 to 232.00 (Brazilian Real), while the dry corn cost is between R$ 250.00 a 260.00 (Brazilian Real). The urea addition can result in economical benefits, because it is considered the ensiling cost of corn grain around R$ 200.00 (Brazilian Real). Adding 1% of urea (R$ 870.00/t) the cost would become R$ 208.70/t (Brazilian Real).

Considering the expense with commercial concentrate used in cattle feedlot, with an estimate cost of R$ 0.38 to 0.42/kg Brazilian Real, it can be verified that the soybean or urea addition can result in economical benefits.

In Table 3 some values of chemical composition of high moisture corn with soybean, sunflower or urea addition. These silages presented good preserving quality and, in the animal performance evaluation (feedlot sheep), showed great results. In this study, it was evaluated the chemical composition, the ruminal degradability of dry matter and crude protein and the starch disappearance in the rumen. It was also evaluated the silages aerobic stability.





It was verified that the there was an effect of soybean, sunflower and urea addition in the silages chemical composition, especially on the crude protein and ether extract contents. There was also an effect on the effective DM degradability and crude protein. The silage which presented higher aerobic stability was the high moisture corn added with urea. It can be concluded that the addition of soybean or sunflower or urea in the high moisture corn results in an improvement in the feed chemical composition.

**Table 3.** Chemical composition of high moisture corn and silages with 20% of soybean, 20% of sunflower grain or 1% of urea.

| Treatment | DM (%) | OM (%) | Ash (%) | ENN (%) | CP (%) | Starch |
|---|---|---|---|---|---|---|
| HMC | 62.1 | 94.5 | 5.5 | 5.2 | 10.1 | 64.2 |
| HMC+S | 65.6 | 93.0 | 7.0 | 10.3 | 17.7 | 51.2 |
| HMC+SF | 65.0 | 95.1 | 4.9 | 11.9 | 10.9 | 56.8 |
| HMC+U | 65.7 | 94.4 | 5.6 | 4.9 | 20.2 | 59.3 |

HMC = high moisture corn; HMC+S = high moisture corn + soybean; HMC+SF= high moisture corn + sunflower grain and HMC+U= high moisture corn + urea. *CV = Coefficient of variation.
Source: Jobim et al. (2008)

## Grain silage for ruminant

The use of grain silage, especially from corn, has increased in all the regions of Brazil, principally in properties with technologies. The increase in grain silage usage is promoted by an increase in finish beef cattle. However, the books review show that, in Brazil, there are few studies evaluating the grain silages quality and animal performance. The biggest numbers of studies have been published related to the corn and sorghum use in swine feeding and in lower number relating to cattle, sheep and equine.

### Sheep

When studying the performance and characteristics of carcass in sheep in *Creep Feeding* receiving high moisture corn compared to the dry grain, Almeida Jr. et al. (2004), verified that the average daily gain and slaughter age at 28 kg of live weight were not affected by treatments. For carcass traits and characteristics there was 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.

| Variable | 0% HMC | 50% HMC | 100% HMC |
|---|---|---|---|
| Birth weight (kg) | 4.90 | 4.87 | 5.05 |
| Daily feed intake (kg MS) | 0.387 | 0.308 | 0.365 |
| Average daily gain (kg) | 0.368 | 0.396 | 0.385 |
| Slaughter age (days) | 64.88 | 61.13 | 61.43 |

Source: Almeida Jr. et al. (2004)

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, gramas per day.

| Item | DCG | HMC | HHMC | DCG + HMC 50:50 | DCG + HHMC 50:50 |
|---|---|---|---|---|---|
| Initial weigh | 8.98 | 9.94 | 9.90 | 9.34 | 9.99 |
| ADG 28 days | 108.50a | 154.10a | 150.30a | 114.70b | 93.60b |
| ADG 56 days | 87.30b | 147.40a | 121.20a | 170.40a | 101.10b |
| ADG 73 days | 123.70a | 160.90a | 153.70a | 145.00 | 126.00b |

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)

Regarding the moisture corn grain silage with nutritive additive, Lombardi (2007) verified that the addition of sunflower grains or urea in the ensiling does not interfere in the sheep performance.





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).

| Characteristic | HMC | HMC + S | HMC + U | Average | F | CV (%) |
|---|---|---|---|---|---|---|
| Initial BW, kg | 22.71 | 23.22 | 23.00 | 22.98 | 0.09 | 10.22 |
| Final BW, kg | 31.43 | 30.85 | 30.88 | 31.05 | 0.60 | 3.85 |
| ADG, kg | 0.17 | 0.15 | 0.15 | 0.16 | 0.32 | 19.51 |
| Hot carcass, kg | 13.55 | 13.18 | 13.43 | 13.39 | 0.27 | 7.57 |
| Chilled carcass, kg | 12.95 | 12.54 | 12.92 | 12.80 | 0.44 | 7.61 |
| Carcass yield, % | 50.51 | 50.51 | 50.49 | 50.51 | 0.30 | 5.69 |
| Commercial carcass yield, % | 48.27 | 48.10 | 49.54 | 48.63 | 0.28 | 4.32 |

F = F test
CV = coefficient of variation

## Cattle

In studies performed by researchers from FMV/UNESP-Botucatu, 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 grounded 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 ×



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Nelore), Igarasi et al., (2008), did not observed trait effect on the final live weight, daily weight gain, subcutaneous fat thickness and back fat thickness, indicating that sorghum moisture grain can substitute corn moisture grains in feedlot, in high concentrate diets (Table 7).

**Table 7.** Carcass characteristic and animal performance.

| Item | HMC | HMS | CV (%) | P value |
|---|---|---|---|---|
| Initial BW, kg | 299.69 | 293.69 | — | — |
| Daily gain, kg/day | 1.41 | 1.43 | 13.20 | 0.64 |
| Final BW, kg | 482.54 | 486.81 | 4.86 | 0.40 |
| Initial fat thickness, mm | 1.92 | 2.02 | — | — |
| Final fat thickness, mm | 4.28 | 4.16 | 21.69 | 0.54 |
| Back fat thickness, mm | 5.87 | 5.38 | 21.38 | 0.06 |

Source: Igarasi (2008)

The performance and characteristics of yearling steers carcass fed with corn and sorghum moisture grains silage with different protein levels was evaluated by Passini et al. (2002). The authors do not find significant difference for the daily weight gain in the traits during the total period of feedlot. The average daily gain was satisfactory, that is around 1.219 kg/day. It was not found effect for ribeye area, subcutaneous fat thickness and tenderness which evidences the sorghum grains potential for finish beef cattle.

Berndt et al. (2002), compared the effect of harvested dry corn grain or moisture ensiled, associated to the silage of corn plant or sugar cane bagasse, on the corporal composition and muscle tissue deposition in young bulls and observed that animal fed with moisture corn presented higher rates of lipids and energy deposition, without changing the empty body weight gain. Also Henrique et al. (2007) did not observed difference in carcass characteristics for finishing bulls regarding the type of corn grain, but they verified an improvement of 9.7% in feed efficiency when it was use moisture corn grains silage comparing to the dry grain.





## Conclusion

The high moisture grains ensiling is still an expending technology in Brazil. The ensiled sorghum or corn grains usage in ruminant feeding in motivated by the increase in the feedlot finish beef cattle. Emphasis is given to the lower production cost and better feed conversion of silage comparing to dry grains. However, in Brazil, there are still some issues which must be better evaluated by research for increase in the storage efficiency and animal performance. Also, it is needed studies evaluating other grains (sorghum, millet, oat, triticale), which in certain situations can result in economical benefit. In the authors' opinion, the use of nutritive additives in corn grains ensiling, such as urea and the soybean grain, is an alternative fully justified in most of the production system, given to costs and results observed regarding preserving quality.

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# Strategies to enable the use of legume silage in ruminant production

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## Introduction

The Brazilian livestock is based on pastures use, the ones which represent the more practical and economical way of ruminant feed. Despite having the biggest commercial herd in the world, approximately 200 millions of cattle, the productivity indexes obtained in Brazil in most of animal production systems in pasture

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