



# **SILAGE FOR BEEF CATTLE**

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# KEY STEPS TO IMPROVE NUTRITIVE VALUE OF CORN SILAGE

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Dr. Luiz Ferraretto is originally from Brazil where he earned his B.S. in Animal Science from São Paulo State University in 2008. Immediately after the completion of his B.S. Degree, Luiz joined the University of Wisconsin-Madison for an internship (2009) followed by a M.S. (2011) and Ph.D. (2015) in dairy science with focus on applied dairy nutrition and forage quality. After the completion of his Ph.D., Luiz joined The William H. Miner Agricultural Research Institute as a Post-doctoral Research Associate. Currently, Luiz is an Assistant Professor of Livestock Nutrition in the Department of Animal Sciences at University of Florida and his research interests are applied dairy cattle nutrition and management with emphasis on starch and fiber utilization by dairy cows, corn silage and high-moisture corn quality and digestibility, the use of alternative by-products as feed ingredients, and supplementation of amino acids and feed additives to lactating cows.

## INTRODUCTION

Whole-plant corn silage (**WPCS**) is the predominant forage used in dairy cattle diets worldwide. Furthermore, there is a continuous increase in the interest to include WPCS to beef cattle diets. On average, 116 million tons of fresh corn forage was harvested per year in the United States over the last decade. High quality WPCS contributes greatly to supplying the energy, starch and forage NDF needs of high-producing animals, reducing purchased feed costs from expensive grain and byproduct supplements, and generating revenues for producers throughout the world. The purpose of this paper is to review selected strategies that may enhance the nutritive value of WPCS.

## KERNEL PROCESSING AND THEORETICAL LENGTH OF CUT

The energy value of WPCS contributed by starch is approximately 50% (calculated from NRC Dairy, 2001). An increase in starch digestion may lead to better nutrient utilization and decreased feed costs. However, starch digestibility of WPCS may be affected by several factors. First, corn is a seed and has a hard coat, the pericarp, which surrounds and protects the embryo and the starch endosperm from external threats. If intact, the pericarp is highly resistant to microbial attachment (McAllister et al., 1994); therefore, the breakdown of the pericarp and correspondent exposure of the starch endosperm must be the primary objective at harvest to maximize energy availability.

It is well established that the use of kernel processors enhance kernel breakdown at harvest. Ferraretto and Shaver (2012), from a meta-analysis of WPCS trials with lactating dairy cows, reported greater total tract starch digestibility (**TTSD**) when WPCS was processed using 1 to 3 mm (0.04 to 0.12 inches) roll gap settings compared with 4 to 8 mm (0.16 to 0.31 inches) processed and unprocessed WPCS. This is related to increased surface area for bacterial and enzymatic digestion of finer particles (Huntington, 1997).

Degree of kernel processing in WPCS, however, may be inhibited by other factors. Length of cut settings is one of these factors. Processing increased the diet TTSD when theoretical length of cut (**TLOC**) was set at 0.93 - 2.86 cm (0.37 to 1.13 inches) but not when length of cut was shorter or longer (Ferraretto and Shaver, 2012). This is likely related to greater kernel breakage by cutting knives when using short TLOC settings (Johnson et al., 1999) or inhibition of kernel breakage during passage through the rollers by the stover portion at the longer TLOC. No overall effect of TLOC on TTSD was observed. (Ferraretto and Shaver, 2012) suggesting that the combined effects of TLOC and kernel processing is more important than TLOC alone with regard to TTSD.

Delayed WPCS harvest may increase concentration of starch while reducing concentrations of CP, NDF and ash. Thus, it was suggested as tool to enhance starch and DM yield per acre. However, maturity at harvest may also influence the breakdown of kernels. Kernel vitreous endosperm proportion increases with increased DM content of WPCS (Phillipeau and Michalet-Doureau, 1997) and thereby kernel hardness which in turn causes kernels in very dry WPCS to be less susceptible to breakage during kernel processing at harvest. This explains why processing increased TTSD for diets

containing WPCS with 32% to 40% DM at feed-out, but not when WPCS was above 40% DM in the review by Ferraretto and Shaver (2012).

Other factors, such as proper processor maintenance from wear, frequent quality-control monitoring of kernel breakage during harvest and adequate TLOC and roll-gap settings for the chopper and processor used are also crucial for obtaining optimal kernel processing. It is always important to remember that optimal kernel processing requires constant monitoring of silage physical characteristics throughout harvesting.

## MATURITY AT HARVEST

Although the breakdown of kernels with a corresponding exposure of starch endosperm for digestion is the primary limiting factor on starch digestibility in WPCS, even the exposed endosperm is not fully digested due to existence of a starch-protein matrix formed by the chemical bonds of zein proteins with starch granules (Kotarski et al., 1992). Reduced TTSD observed in diets containing WPCS above 40% DM in the meta-analysis review by Ferraretto and Shaver (2012) may be related to an increase in the proportion of vitreous endosperm in the kernel associated with greater maturity (Ngonyamo-Majee et al., 2009). Alternatively, a reduction in the extent of fermentation for drier WPCS (Der Bedrosian et al., 2012) may attenuate proteolysis of zein proteins during fermentation (Hoffman et al., 2011).

Likewise, digestibility of NDF in WPCS is limited primarily by the cross-linking of lignin to other fibrous components (Jung et al., 2012). As maturity progresses, lignin content in WPCS increases (Cone and Engels, 1993). Therefore, increased maturity at harvest may limit not only starch, but also NDF digestibility of WPCS. Interestingly, however, Ferraretto and Shaver (2012) reported greater NDF digestibility when WPCS was harvested above 40% DM in a meta-analysis. This was thought to be related to negative effects of greater starch digestibility in the rumen on NDF digestibility (Russell and Wilson, 1996). However, this is in contrast to the commonly reported ruminal in situ NDF digestibility reduction with very dry corn silage (Bal et al., 2000).

## CHOP HEIGHT

Another harvesting management option to reduce lignin concentration is chop height. Lignin is an important structure component concentrated in the bottom part of corn plants. With enhanced chop height more lignin is left with the portion that remains in the field, and thus, digestibility of the harvested material is greater. Results from a recent industry-university collaborative study from our group is in Table 1 (Ferraretto et al., 2017). Although our study compared 6 vs. 24 inches, these results are similar to other trials comparing 6 vs. 18 inches of chop height. Briefly, DM yield is reduced as the row-crop head is raised. This is consistent across several studies conducted across the United States. However, decreased DM yields are offset by an increase in the milk per ton estimates at the higher chop height. Greater milk estimate is a response to the greater fiber digestibility and starch

concentration of the harvested material. In addition, most studies reported that estimated milk per acre is reduced by only 1 to 3% with high-chop. Also, increased quantities of high-chop silage could be included in the diet, rather than corn grain being added to the diet, providing an economic benefit to implementing increased chop heights. Team discussions among farmers, nutritionists and crop consultants is advised to determine individual farm priorities for maximum yield versus higher quality, prior to the establishment of new chop height guidelines. Those needs may vary in different years depending upon the yield and quality of the crop and existing on farm inventories.

## SILAGE FERMENTATION

Experiments evaluating extended WPCS storage length consistently reported a gradual increase in starch digestibility as fermentation progressed. Across these studies, at 30 or 45 days of ensiling, ruminal in vitro starch digestibility (**ivSD**) was increased by 7 percentage units. Interestingly, these studies also showed a gradual increase in ivSD after 30 or 45 days of additional storage (approximately 60 to 90 days of fermentation). Proteolysis, the main mechanism responsible for the disruption of the zein-proteins cross-linked to starch granules, occurs under acidic conditions suggesting that continuous alterations in fermentation profile as storage progressed may directly affect starch digestibility.

Ferraretto et al. (2015) evaluated the interaction between hybrid type and ensiling time on a study where 8 WPCS hybrids (4 BMR and 4 leafy) were ensiled for 0, 30, 120 and 240 d. Fermentation profile, ammonia-N and soluble-CP contents, and ivSD were similar for the 2 hybrid types and there was no hybrid type × time of ensiling interaction detected. Increases in WPCS ammonia-N and soluble-CP contents were accompanied by increases in ivSD in response to increased time of ensiling. The effects of ensiling time and exogenous protease addition on fermentation profile, N fractions and ivSD in WPCS of various hybrids, maturities and chop lengths were evaluated by Ferraretto et al. (2015a). Extended time in storage increased ammonia-N, soluble CP and ivSD in WPCS of various hybrids, maturities and chop lengths. However, contrary to our hypothesis, extended ensiling time did not attenuate the negative effects of kernel vitreousness and maturity at harvest on ivSD. Exogenous protease attenuated but did not overcome negative effects of maturity on WPCS ivSD.

Although allowing an extended ensiling period may be beneficial for increasing starch digestibility, research does not support the same fate for neutral detergent fiber (NDF) digestibility. Overall, data from several sites across the U.S. demonstrate that extended storage does not change or slightly reduces NDF digestibility in corn silage.

In summary, research supports the use of inventory planning so a newly harvested crop would be fed only after four months in storage. Although prolonged storage of corn silage would be a valid management practice, it requires proper silo management during filling, packing and covering to ensure beneficial fermentation patterns.

**TABLE 1.****Effect of cutting height on whole-plant corn silage nutrient composition, digestibility and yield<sup>1</sup>**

Item	Low	High
Cutting height, inches	6	24
NDF, % of DM	37.7	33.8
Starch, % of DM	37.5	41.7
ivNDFD <sup>2</sup> , % of NDF	49.6	52.7
Yield, ton/acre	8.9	8.1
Milk, lb/ton	2224	2378
Milk, lb/acre	24009	23498

<sup>1</sup> Adapted from Ferraretto et al. (2017).

<sup>2</sup> Ruminal in vitro NDF digestibility at 30 h.

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