

What's New with Corn Silage?

Randy Shaver
Ph.D., PAS, ACAS-Nutrition Dipl.
Department of Dairy Science
University of Wisconsin – Madison
University of Wisconsin – Extension

Room 280 Animal Sciences Building
1675 Observatory Drive
University of Wisconsin, Madison, WI 53706
Email: rdshaver@wisc.edu

Introduction

High quality whole-plant corn silage (**WPCS**) contributes greatly to supplying the energy, starch and forage neutral detergent fiber needs of high-producing dairy cows, reducing purchased feed costs from expensive grain and byproduct supplements, and generating milk revenues for dairy producers throughout the world. The purpose of this paper is to review selected recent developments and considerations for WPCS. Refer to Figure 1 for an overview of the factors that influence the nutritive value of WPCS.

Corn silage harvest practices

Processing and Length of Cut

Ferraretto and Shaver (2012) reported on an experiment to determine the effect of feeding a conventional WPCS hybrid harvested as Shredlage® (**SHRD**) compared to the same hybrid harvested as conventionally-processed WPCS (**CPCS**) on lactation performance by dairy cows. Both the percentage of material on the top screen of the Penn State shaker box and processing score were greater for SHRD (30 mm theoretical length of cut [TLOC] and 2.5 mm roll gap) than CPCS (19 mm TLOC and 2 mm roll gap). Cows fed SHRD tended to consume 0.7 kg/d more DM. Milk yield and milk composition were similar between treatments. Yield of 3.5% FCM tended to be 1 kg/day greater for cows fed SHRD. Ruminal in situ digestibility of starch, but not NDF, was greater for SHRD than CPCS. Total tract digestibility of dietary starch and NDF were greater for SHRD than CPCS.

We recently conducted a feeding trial to evaluate SHRD versus CPCS using a brown midrib (BMR) WPCS hybrid and also to determine the physically-effective NDF in SHRD compared to chopped hay in TMR fed to 120 high producing dairy cows. Dry matter intake, lactation performance, and total tract dietary starch and NDF digestibilities were determined, and rumination activity was determined using SCR collars. Data had not been not been summarized by the deadline

for this paper, but preliminary results from the experiment will be presented at the conference.

Although alternative processing methods, greater speed differential with conventional rolls, and type of processor, intermeshing discs, are now being used in the field, there is a lack of information with regard to processing score, particle size, and TLOC capability or animal performance for them relative to CPCS or SHRD. These alternative approaches to WPCS processing will be discussed at the conference.

Silage Fermentation

Hoffman et al. (2011) reported that ensiling high-moisture corn (**HMC**) for 240 d reduced zein protein subunits that cross-link starch granules, and suggested that the starch-protein matrix was degraded by proteolytic activity over an extended ensiling period. The Larson and Hoffman (2008) turbidity assay did not detect a reduction in zein protein over the ensiling period for HMC as was measured by high-performance liquid chromatography (Hoffman et al., 2011).

Ammonia-N content increased, however, as HPLC zein protein subunits in HMC decreased (Hoffman et al., 2011), and ammonia-N was used in combination with mean particle size for modeling the effects of corn maturity, moisture content and extent of silage fermentation on ruminal and total-tract starch digestibilities for HMC at feed out (Hoffman et al., 2012a, b). Ferraretto et al. (2014c), using a data set comprised of 6,131 HMC samples (55 to 80% DM) obtained from a commercial feed analysis laboratory, reported that ammonia-N was positively related to ruminal in vitro starch digestibility (**ivStarchD**; $R^2 = 0.61$) and combined, ammonia-N, DM, soluble-CP and pH provided a good prediction of ivStarchD (adjusted $R^2 = 0.70$).

In WPCS fermented for 0, 45, 90, 180, 270, and 360 d, ammonia-N and soluble-CP contents and ivStarch increased over time and soluble CP, but not ammonia-N, was highly correlated with ivStarchD ($R^2 = 0.78$

versus 0.24). Young et al. (2012) and Windle et al. (2014) reported that increases in WPCS ammonia-N and soluble-CP contents were accompanied by increases in ivStarchD in response to increased time of ensiling and exogenous protease addition.

Ferraretto et al. (2014b) reported 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 ivStarchD were similar for the 2 hybrid types and there was no hybrid type \times time of ensiling interaction detected. Increases in WPCS ammonia-N and soluble-CP contents were accompanied by increases in ivStarchD in response to increased time of ensiling. Positive relationships between ivStarchD and ammonia-N ($R^2 = 0.67$) and soluble-CP ($R^2 = 0.55$) were observed. Ammonia-N and soluble-CP were both good indicators of ivStarchD in WPCS in this study. It appears that ammonia-N and soluble-CP can be used in models to predict starch digestibility for WPCS as has been done for HMC, however, more research is needed especially with regard to combining the particle size of the kernels in WPCS along with these N measures into predictive models.

Corn Silage Hybrid Type

UW Lactation Trial 1

Ferraretto and Shaver (2014a) conducted a study to determine the effect of feeding a TMR containing a floury-leafy WPCS hybrid (LFY) compared to a BMR hybrid for intake, lactation performance, and total tract nutrient digestibility in dairy cows. The WPCS ivStarchD was greater for LFY than BMR, while ruminal in vitro NDF digestibility (**ivNDFD**) was greater for BMR than LFY. The DM content, Penn State shaker box, and processing score measures were similar for the 2 WPCS treatments. Both TMR contained 65% total forage of which 65% was WPCS (DM basis).

Cows fed BMR consumed 1.7 kg/d more DM than LFY ($P < 0.01$). Milk yield was greater ($P < 0.01$; 49.0 vs. 46.8 kg/d) and energy- and solids-corrected milk yields tended ($P < 0.10$) to be greater for BMR than LFY, however, feed efficiency measures (kg milk or component-corrected milk per kg DMI) did not differ by treatment ($P > 0.10$). Fat-corrected milk (50.3 kg/d on average) and milk fat yield (1.84 kg/d on average) were similar ($P > 0.10$), as milk fat content was greater ($P < 0.01$) for cows fed LFY (4.05%) than BMR (3.83%). Cows fed BMR had lower ($P < 0.001$) MUN concentration and greater ($P < 0.05$) milk protein and lactose yields compared to LFY. Total tract starch digestibility was 5%-units greater ($P < 0.001$) for cows fed the LFY. Trial results suggest that WPCS hybrid selection programs which focus on increasing starch digestibility by dairy cows through selection of softer

kernel texture can be effective. Results also denote, however, the importance of NDF digestibility in WPCS hybrid selection programs.

UW Lactation Trial 2

Akins and Shaver (2012) reported on an experiment with its primary objective to determine lactation performance by dairy cows fed NutriDense® (**ND**; NutriDense 905823; BASF Plant Science, Raleigh, Durham, NC) compared to dual-purpose (**DP**; Pioneer Hi-Bred A DuPont Business, Des Moines, IA) and BMR (**BM**; Mycogen Seeds, Dow AgroSciences LLC, Indianapolis, IN) WPCS hybrids at the same concentration of WPCS in the treatment diets. This study was a follow-up to the report of Chase (2010) where greater milk production was observed for BM, while greater feed efficiency was observed for ND. A secondary objective of the UW trial was to determine lactation performance by dairy cows fed ND at two different concentrations of WPCS in the treatment diets.

Three treatments (DP40, BM40 and ND40) contained 60% forage DM with 2/3rd (40% of TMR DM) from the respective WPCS and 1/3rd alfalfa silage (DM basis). The fourth treatment contained 65% forage DM entirely from ND corn silage (ND65). All diets were formulated to be isonitrogenous. A 2-wk covariate period with all pens receiving a TMR containing equal DM proportions of DP40, BM40 and ND40 was followed by an 11-wk treatment period with pens (16 pens of 8 cows each) fed their assigned treatment TMR.

Although harvest of the three WPCS treatments commenced as soon as possible after being assessed at the one-half kernel milkline stage of maturity, the BM averaged 41.8% DM and was 6.6 and 4.5%-units drier than DP and ND, respectively. For the BM, five days elapsed between the decision to harvest and the actual harvest with weather conditions favoring a rapid dry-down during that time period which resulted in the DM content being greater than desired for that WPCS treatment. The concentrations of NDF and starch in WPCS were similar for DP and BM. The ND WPCS NDF content was 3.4%-units lower and starch content was 4.9%-units greater compared to the average for DP and BM. All three WPCS treatments were well processed with processing scores ranging from 68% to 77%.

The ivNDFD was 14%-units greater for BM than the average of DP and ND which were similar. The ivStarchD was similar ranging from 84% to 89% across the WPCS treatments. It should be noted that the WPCS treatments had been in the silo bags for ten months before commencing with the feeding trial and silage sampling over a subsequent four month period, which would likely have attenuated any inher-

ent differences in starch digestibility that may have existed between the WPCS hybrids.

Actual milk yield tended to be 1.9 kg/d greater ($P = 0.09$) and milk protein and lactose yields were greater ($P < 0.01$ and $P = 0.03$, respectively) for ND40 than DP40. Although DMI was similar ($P = 0.15$) the intakes of fat, NFC, starch and rumen digestible starch were greater ($P < 0.01$) for ND40 than DP40, which could explain the production differences between these two treatments. Cows fed BM40 had 1.9 kg/d greater ($P = 0.02$) milk yield than DP40. The lack of DMI response ($P = 0.71$) for BM40 with its greater WPCS ivNDFD compared to ND40 or DP40 was surprising, but may have been related to the trial being performed on midlactation cows between 100 and 200 DIM where rumen fill may not be limiting energy intake relative to production requirements. The trial of Chase (2010) which found greater DMI and milk production for BM WPCS was conducted with early lactation cows.

Dry matter intake and milk yield were reduced by 1.8 ($P < 0.01$) and 2.2 kg/d ($P = 0.02$), respectively, for ND65 compared to ND40. Furthermore, milk fat content and yield were reduced by 0.45%-units ($P = 0.01$) and 0.33 kg/d ($P < 0.01$), respectively, for ND65 compared to ND40. Reduced DMI and thus nutrient intakes (OM, CP, fat, NFC, and starch; $P < 0.01$) and consequently milk yield along with reduced milk fat could be related to greater ruminal starch digestion for ND65 compared to ND40. Of the total dietary starch 52% for ND40 and 85% for ND65 was provided by WPCS with greater ruminal digestibility than the dry ground shelled corn which comprised most of the remainder of dietary starch. Coincident with the milk yield differences, yields of protein ($P < 0.01$) and lactose ($P = 0.01$) were reduced for ND65 compared to ND40. The resultant calculated yields of FCM, ECM and SCM were also reduced ($P < 0.01$) for ND65 compared to ND40. The MUN concentration was 12% greater ($P < 0.01$) for ND65 than ND40. This response may have been related to a reduced ruminal pH from greater starch digestibility, as suggested by milk fat depression, reducing the efficiency of rumen microbial protein synthesis. Results suggest that high ruminal starch digestibility may be a limitation to feeding diets comprised of a high proportion of long-ensiled WPCS.

References

- Akins, M. S., and R. D. Shaver. 2012. Influence of corn silage hybrid on lactation performance by dairy cows. *J. Dairy Sci.* 95(E-Suppl. 1): 605(Abstr.).
- Chase, L. E. 2010. Milk production and feed efficiency in dairy cows fed corn silage hybrids varying in fiber digestibility. *J. Dairy Sci.* 93(E-Suppl. 1): 755(Abstr.).
- Der Bedrosian, M.C., K.E. Nestor Jr., and L. Kung Jr. 2012. The effects of hybrid, maturity, and length of storage on the composition and nutritive value of corn silage. *J. Dairy Sci.* 95:5115–5126.
- Ferraretto, L.F., and R.D. Shaver. 2012. Effect of Corn Shredlage™ on lactation performance and total tract starch digestibility by dairy cows. *The Prof. Anim. Sci.* 28:639-647.
- Ferraretto, L.F., A.C. Fonseca, C.J. Sniffen, A. Formigoni, and R.D. Shaver. 2014a. Effect of corn silage hybrids differing in starch and NDF digestibility on lactation performance and total tract nutrient digestibility by dairy cows. *ADSA Annual Mtg. Abstr.* In press.
- Ferraretto, L.F., R.D. Shaver, S. Massie, R Singo, D.M. Taysom and J.P. Brouillette. 2014b. Effect of ensiling time on fermentation profile and starch digestibility in whole plant corn silage from two different hybrid types. *ADSA Annual Mtg. Abstr.* In press.
- Ferraretto, L.F., K. Taysom, D.M. Taysom, R.D. Shaver, and P.C. Hoffman. 2014c. Relationships between dry matter content, ensiling, ammonia-nitrogen and ruminal in vitro starch digestibility in high-moisture corn samples. *J. Dairy Sci.* In press. <http://dx.doi.org/10.3168/jds.2013-7680>
- Hoffman, P.C., N.M. Esser, R.D. Shaver, W.K. Coblenz, M.P. Scott, A.L. Bodnar, R.J. Schmidt and R.C. Charley. 2011. Influence of ensiling time and inoculation on alteration of the starch-protein matrix in high moisture corn. *J. Dairy Sci.* 94:2465-2474.
- Hoffman, P.C., D.R. Mertens, J. Larson, W.K. Coblenz, and R.D. Shaver. 2012a. A query for effective mean particle size in dry and high-moisture corns. *J. Dairy Sci.* 95:3467-3477.
- Hoffman, P.C., R. Shaver, and D. Mertens. 2012b. Feed Grain 2.0 Evaluation System. Accessed July 12, 2012. <http://www.uwex.edu/ces/dairynutrition/documents/FeedGrainV2.0b.xlsx>
- Larson, J., and P. C. Hoffman. 2008. Technical Note: A method to quantify prolamin proteins in corn that are negatively related to starch digestibility in ruminants. *J. Dairy Sci.* 91:4834-4839.

Windle, M.C., N. Walker, and L. Kung Jr. 2014. Effects of an exogenous protease on the fermentation and nutritive value of corn silage harvested at different dry matter contents and ensiled for various lengths of time. *J. Dairy Sci.* <http://dx.doi.org/10.3168/jds.2013-7586>.

Young, K. M., J. M. Lim, M. C. Der Bedrosian, and L. Kung Jr. 2012. Effect of exogenous protease enzymes on the fermentation and nutritive value of corn silage. *J. Dairy Sci.* 95:6687-6694.