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Case Study: Effect of type of processor on corn silage processing score in samples of whole-plant corn silage

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ABSTRACT

The objective of this study was to evaluate the effect of processor type on fermentation profile, corn silage processing score, and physically effective NDF of whole-plant corn silage samples. A data set composed of 3,900 whole-plant corn silage samples was obtained from Rock River Laboratory (Watertown, WI). All samples were collected from 2013 to 2016 by the Chr. Hansen team under specific protocols to label samples as shredlage (SHRD) only if confirmed by farmers or custom harvesters. A total of 309 and 3,591 samples were labeled as SHRD and nonshredlage (CONV), respectively. Samples had been previously analyzed for corn silage processing score, physically effective NDF, and predicted ruminal in vitro NDF digestibility at 30 h (using near-infrared spectroscopy). In addition, 2,394 samples (272 SHRD and 2,394 CONV) had previously been analyzed via wet chemistry for fermentation profile. Loss of DM during fermentation was calculated with a predictive equation. Data were analyzed using Proc Glimmix in SAS with type of processor (SHRD vs. CONV) as a fixed effect. Statistical significance and trends were declared at $P \leq 0.05$ and $0.05 < P < 0.10$, respectively. The pH was less ($P = 0.01$; 3.90 vs. 3.97) for SHRD than CONV, which was related to greater ($P = 0.001$; 4.89 vs. 4.34% of DM) lactic acid concentrations. Concentrations of acetate, propionate, butyrate, and ethanol did not differ ($P > 0.10$) and averaged 2.27, 0.35, 0.36, and 0.57%, respectively. Recovery of DM was improved ($P = 0.05$; 2.42 vs. 2.73%) for SHRD, but the difference is of minor importance. Corn silage processing score was 4.6 percentage units greater for SHRD than for CONV silages ($P = 0.001$; 68.1 vs. 63.53% starch passing through a 4.75-mm sieve). In contrast, physically effective NDF and predicted ruminal in vitro NDF digestibility were ($P = 0.001$) 1.8 and 1.6 percentage units greater for CONV. Our results suggest that harvesting whole-plant corn silage as SHRD improved kernel breakage while maintaining adequate fermentation patterns compared with CONV.

Key words: corn silage processing score, shredlage, fermentation

INTRODUCTION

Due to the nutrient demands of lactation, dairy cows require high energy intake to support milk production and body condition (Zebeli et al., 2012). In addition to energy, dairy cattle diets must contain sufficient physically effective NDF (**peNDF**). Whole-plant corn silage (**WPCS**) is an important source of energy, primarily from starch, and peNDF in the diets of dairy cattle. The peNDF concept (Mertens, 1997) was created as a simple system to combine the physical (i.e., particle size) and chemical (i.e., NDF concentration) characteristics of fiber to meet the forage or minimum fiber requirements of lactating dairy cows (Hall and Mertens, 2017). This concept was previously established as an index of ruminal mat formation, chewing activity, digestion, and milk fat content (Allen, 1997; Mertens, 1997); thus, harvesting WPCS with a greater proportion of coarse particles to achieve the recommendation of this index became desirable (Johnson et al., 1999). Various on-farm (Lammers et al., 1996) and laboratory methods to determine peNDF are available. Among them, the most commonly used procedure in commercial laboratories requires the dry sieving of samples using a vertical shaker to determine the proportion of particles retained on the 1.18-mm sieve, followed by the determination of NDF concentration of the fraction retained on the 1.18-mm sieve (Mertens, 1997). The latter step eliminates the assumption that NDF is evenly distributed across all particle sizes (Mertens, 1997).

One of the primary strategies for optimizing the digestibility of the starch, and thereby energy availability in WPCS, is to increase kernel breakage (Johnson et al., 1999; Ferraretto and Shaver, 2012b). The reduction in kernel particle size enhances starch digestibility by increasing surface area for microbial attachment and enzymatic digestion (Johnson et al., 2002). Corn silage processing score (**CSPS**; Ferreira and Mertens, 2005) is a fragmentation index widely used in the dairy industry for determination of processing effectiveness. This method is expressed as percentage of starch passing through the 4.75-mm sieve of

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a vertical shaker and represents, theoretically, the proportion of kernels broken into at least one-fourth of a kernel.

Corn shredlage (**SHRD**), a relatively new method of processing WPCS, has potential to optimize the energy availability, through kernel particle-size reduction, and physical effectiveness of WPCS. This method harvests WPCS with a commercially available, self-propelled forage harvester fitted with after-market, cross-grooved, crop-processing rolls set for 2 to 3 mm of roll gap and approximately 20% greater roll speed differential than had typically been used previously. Moreover, a longer (22–26 mm) theoretical length of cut (**TLOC**) than that traditionally used (19 mm) is recommended by the developer of this processor (Shredlage LLC, Tea, SD, http://www.shredlage.com/). Ferraretto and Shaver (2012a) and Vanderwerff et al. (2015) reported greater kernel breakage for WPCS harvested at longer TLOC and processed as SHRD compared with conventionally processed WPCS. However, due to the longer TLOC used when harvesting SHRD, there is concern that the extent of fermentation may be less for SHRD compared with conventionally processed WPCS.

Therefore, the objective of this study was to evaluate the effect of processor type on the fermentation profile, CSPS, and peNDF of WPCS samples. Our hypothesis was that processor type would affect CSPS but not peNDF nor fermentation profile.

MATERIALS AND METHODS

A data set composed of 3,900 WPCS samples was obtained from Rock River Laboratory Inc. (Watertown, WI). Samples were collected from 2013 to 2016 by team members at Chr. Hansen (Milwaukee, WI) from the major dairy producing states across the country, but with the majority of the samples being collected in the Midwest of the United States. With regard to processing, samples were labeled SHRD only if confirmed by farmers or custom harvesters. A total of 309 and 3,591 samples were labeled as SHRD and nonshredlage (**CONV**), respectively; all CONV samples were processed at harvest as confirmed by farmers or custom harvesters, although we did not receive information of processing conditions, such as gap between processing rolls. Samples had been previously analyzed by near-infrared spectroscopy prediction equations (FOSS 5000, FOSS Analytical, Hillerød, Denmark) for DM, CP, NDF determined with heat-stable alpha-amylase and inclusive of residual ash, ADF, fat, lignin, starch, ethanol-soluble carbohydrates, and ash. Samples had also been analyzed for CSPS, peNDF, and predicted ruminal in vitro NDF digestibility at 30 h (predicted **NDFD**). Physically effective NDF and CSPS were determined according to procedures by Mertens (1997) and Ferreira and Mertens (2005) and were calculated as the percentage of NDF retained on a 1.18-mm sieve and the percentage of starch passing through the 4.75-mm sieve, respectively. Predicted NDFD was analyzed by near-infrared spectroscopy prediction equations, using a wet chemistry database built using a modified Goering and Van Soest (1970) in vitro NDFD technique. In addition, 2,394 samples (272 SHRD and 2,394 CONV) had been previously analyzed by wet chemistry procedures for pH, organic acids, and ammonia-N (% of CP), as well as yeast and mold counts (log cfu/g) and DM loss. For organic acids analyses, 20 g of undried and unground sample was diluted in double distilled water to 10% (mass/mass), blended for 30 s in a high-speed blender, and filtered through a filter funnel with a 2-mm filter screen. The extract was collected and analyzed for pH using a pH meter (Thermo-Orion Dual Star; Thermo Fisher Scientific Inc., Waltham, MA) fitted with a glass pH electrode (Thermo-Orion 9172BNWP; Thermo Fisher Scientific Inc.). After pH was measured, the extract was centrifuged (750 × g) for 20 min at 25°C, and the supernatant was combined with 1.0 mL of calcium hydroxide solu-

Table 1. Effect of processing[1] on nutrient composition of whole-plant corn silage (2013 to 2016)

Item[2]	CONV	SHRD	Greatest SEM	*P*-value
DM (% as fed)	35.8	35.2	0.26	0.02
CP (% of DM)	7.8	7.8	0.06	0.28
aNDF (% of DM)	42.8	41.6	0.28	0.001
ADF (% of DM)	24.6	24.6	0.17	0.21
Lignin (% of DM)	3.4	3.5	0.03	0.23
Fat (% of DM)	2.4	2.4	0.04	0.51
Starch (% of DM)	32.5	32.1	0.33	0.40
ESC (% of DM)	1.4	0.9	0.06	0.001
Ash (% of DM)	3.9	4.0	0.05	0.37

[1]CONV = whole-plant corn silage reported as conventional or not reported as shredlage; SHRD = whole-plant corn silage reported as shredlage.

[2]aNDF = NDF determined with heat-stable alpha-amylase and inclusive of residual ash; ESC = ethanol-soluble carbohydrates.