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Development of a Berry Processing Score for Sorghum Silage

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Summary

This study was done in an effort to develop a berry processing score (BPS) for sorghum silage, similar to the kernel processing score (KPS) currently used for corn silage. Sorghum silage samples were collected from 3 dairies in Kansas and processed in the Grain Science & Industry grain processing laboratory at Kansas State University using one of four different roll gap settings to give four differently processed samples: unprocessed, 1.5, 1.0, or 0.5 mm. After drying, samples were placed into a Ro-Tap particle separation machine for 10 minutes until the whole sample was separated. Whole samples, as well as separated fiber and whole berry portions were analyzed for percent starch retained on each screen. As the roll gap was reduced, mean particle size (MPS) was also reduced. Percent starch passing through the 1.7 mm screen was greater at the 0.5 mm roll gap for both the whole sample and the whole berry samples, indicating successful processing of the samples. Using these data, we have determined that the appropriate screen to use in determining a BPS for sorghum silage is the 1.7 mm screen. A BPS for any sorghum silage sample can be calculated by analyzing the whole sample for the percent starch that passes through the 1.7 mm screen. This study is still ongoing and more research is needed to determine the recommended BPS in sorghum silage.

Key words: milo, sorghum, dairy cattle, feed, processing, silage

Introduction

Sorghum has become an increasingly important forage crop for dairy producers, particularly in the Midwestern and plains regions of the U.S. that routinely experience conditions of insufficient water. When compared to corn silage, sorghum silage uses ~30-50% less water, making sorghum more heat and drought tolerant. This is especially important in areas where irrigation is limited and where elevated temperatures and drought are common.

Sorghum silage has long been known to have reduced whole-plant digestibility compared to corn silage and therefore, milk yield often decreases when replacing corn silage with sorghum silage in dairy cattle diets. A primary reason for reduced digestibility is that the starch contained within the sorghum berry is extremely dense, hard, and resistant to digestion. The protein matrix binds starch more tightly in sorghum than in corn, leading to lower digestibilities and milk yield often observed with sorghum.

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Kernel processing via on-board kernel processors have been used extensively in the harvest of corn silage in an effort to better expose the starch within grain (increase surface area), ultimately aiming to increase total tract starch digestibility (TTSD) for the dairy cow. Ten years ago, Wisconsin researchers established a method to determine the degree of kernel processing, or breakage, in whole plant corn harvested as silage. However, no such method has been developed for sorghum silage. Therefore, the objective of this study was to develop a similar scoring system for sorghum silage. This study is still ongoing and further results will become available in the future.

Experimental Procedures

Sorghum silage samples (Croplan BMR 108, Croplan Genetics, St. Paul, MN) to be used for analysis were collected from 3 commercial dairy farms in Kansas. Eight samples were collected from each dairy resulting in a total of 24 samples. Upon returning to the lab, samples were either left unprocessed and used as the control, or run through a 9 × 6 roller mill (Ross Machine & Mill Supply, Inc., Oklahoma City, OK) using a roll gap setting of either 1.5 mm, 1.0 mm or 0.5 mm. From each dairy, 2 samples were left unprocessed and 2 samples were processed at one of the aforementioned roll gap settings. Samples were then dried in a forced-air oven at 55°C for 72 h to ensure complete removal of moisture, resulting in samples weighing ~100 g on a DM basis. Following DM determination, samples were separated using a Ro-Tap 3-dimensional separator (W. S. Tylor, Mentor, OH) fitted with screens containing square apertures of 9.50, 6.70, 4.75, 4.00, 3.35, 2.80, 2.36, 1.70, 1.18, and 0.6 mm (in addition to a pan). Samples were placed into the Ro-Tap machine for 10 min to determine mean particle size (MPS) and the percent material retained on each screen by weight was calculated. Whole sorghum berries retained on the 4.00, 3.35, 2.80, 2.36, and 1.70 mm screen were separated from the remaining sample, counted, and weighed. Preliminary research showed that all whole sorghum berries were retained below the 4.75 mm screen and above the 1.70 mm screen. Once separated, whole berry samples and the remaining fiber samples were sent to Rock River Laboratory (Watertown, WI) for DM, starch, and fiber (aNDF) analysis using wet chemistry techniques. Material retained on the 9.50, 6.70, and 4.75 mm screen were combined into a single sample prior to analysis since no whole berries were retained on those screens.

Results and Discussion

Mean particle size (Figure 1) of sorghum silage was reduced when processed with a roll gap setting of 0.5 mm. After sample separation, material retained on each screen was measured (Figure 2). While no differences were found between treatments for screen size $\geq$ 3.35 mm, there was a significant reduction in material retained on the 2.8 and 2.36 mm screens as roll gap spacing was reduced. This led to an increase in material retained on the 1.18 and 0.6 mm screens as well as the pan for more heavily processed (narrower roll gap) sorghum silage. As expected, whole berries per gram of sample weight were reduced as the roll gap setting was reduced (Figure 3). This indicates that the different roll gap settings used were effective at processing the sorghum berries. Percent starch retained by screen of the whole sample is shown in Figure 4. Starch retained below the 1.7 mm screen was greater for the 0.5 and 1.0 mm roll gap samples. After separating the whole sample into whole berry and fiber fractions, the percent starch retained on each screen was analyzed. For the fiber only portion (Figure 5), unprocessed samples had greater starch retained on the 1.7 mm screen compared to processed samples, while results were mixed for screens < 1.7 mm. For the whole berry only samples (Figure 6), all whole berries were retained above the 1.18 mm screen. There was a significant increase in starch retained on the 1.7 mm screen for samples processed at 0.5 mm compared to other treatments. This indicates that only the smallest berries were able to pass through the rollers and remain unprocessed.

Conclusions

From these data, we conclude that by measuring the amount of starch passing through the 1.7 mm screen, we can calculate a BPS for sorghum silage, similar to what is used for corn silage, which measures the percent of starch passing through the 4.75 mm screen. While digestibility issues of sorghum are still an issue, the development of a BPS for sorghum silage will give the industry a standard by which to measure the degree of processing. The next step in this process is to collect sorghum silage samples and run *in situ* rumen analysis at each of the different processing levels described above to determine the impact of reduced particle size on digestibility of the sorghum berries.

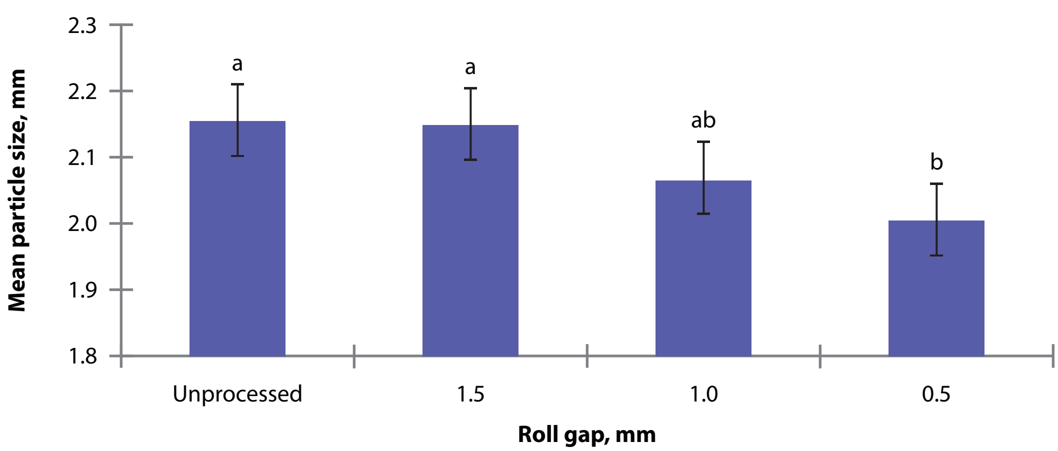

Figure 1. Least squares means for mean particle size at each roll gap setting (unprocessed, 1.5, 1.0, or 0.5 mm). Treatment effect: *P* = 0.09.
[ab] Means differ ($P < 0.05$).

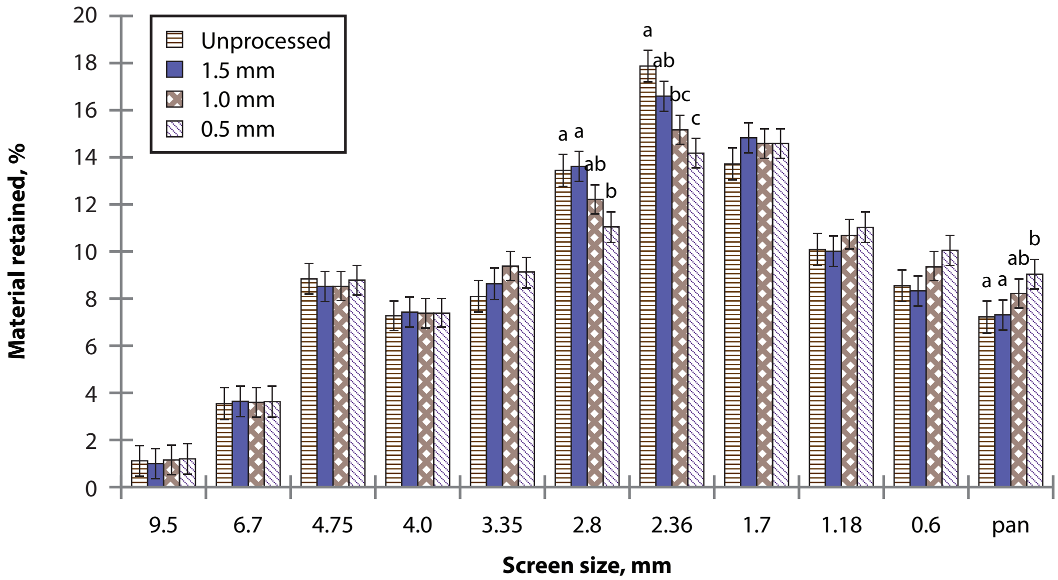

Figure 2. Percent material retained on each screen at each roll gap setting (unprocessed, 1.5, 1.0 or 0.5 mm) after complete separation using a Ro-Tap particle separator.
abc Means differ ($P < 0.05$).

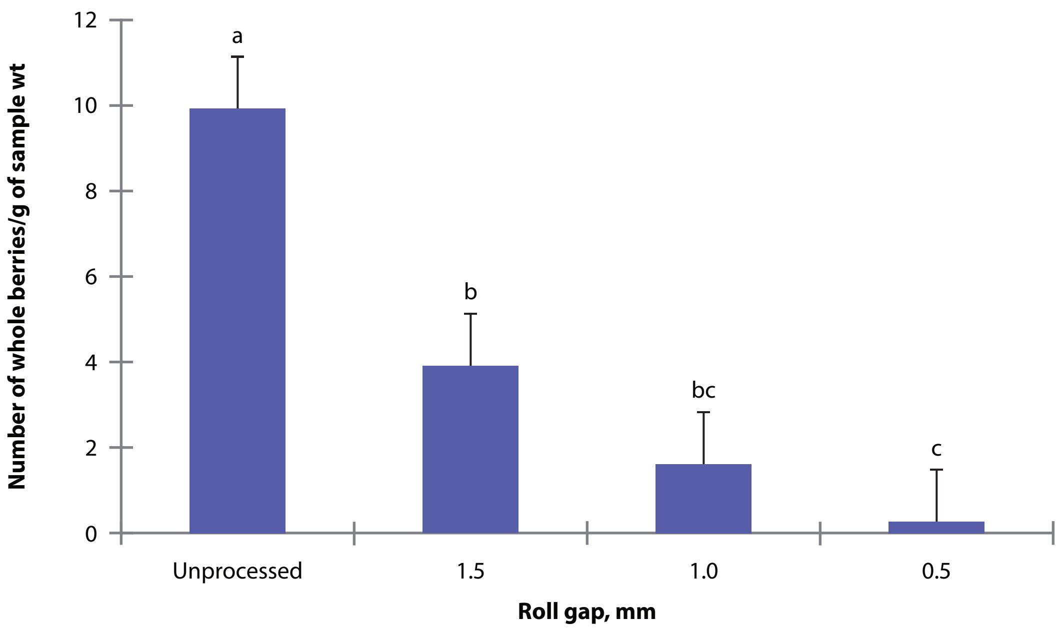

Figure 3. Whole berries per gram of sample for each roll gap setting (unprocessed, 1.5, 1.0, or 0.5 mm). Treatment effect: $P < 0.001$.
abc Means differ ($P < 0.05$).

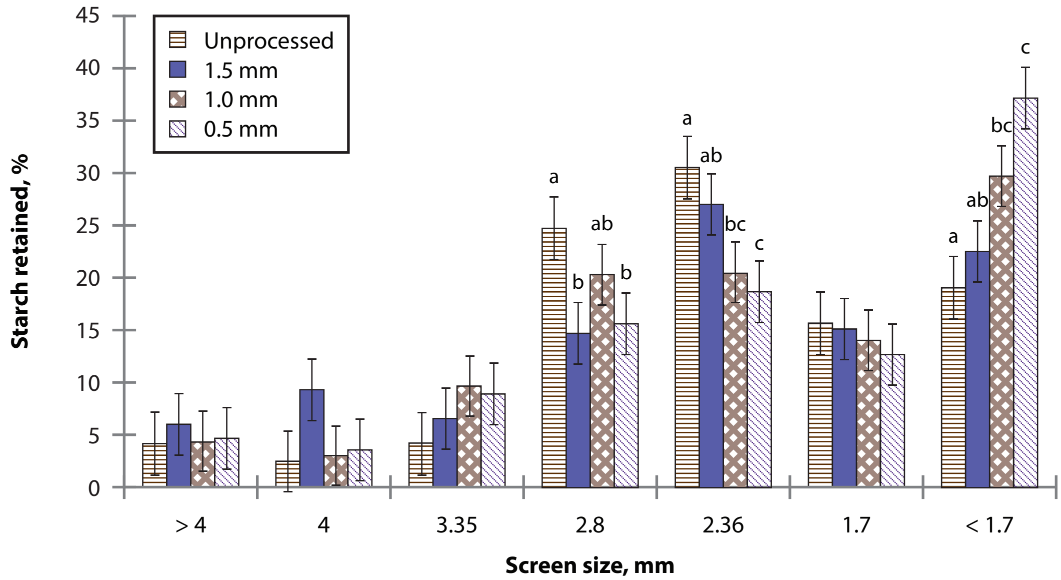

Figure 4. Percent starch retained by screen for each roll gap setting (unprocessed, 1.5, 1.0, or 0.5 mm) of whole sorghum sample after complete separation using a Ro-Tap particle separator.
abc Means differ ($P < 0.05$).

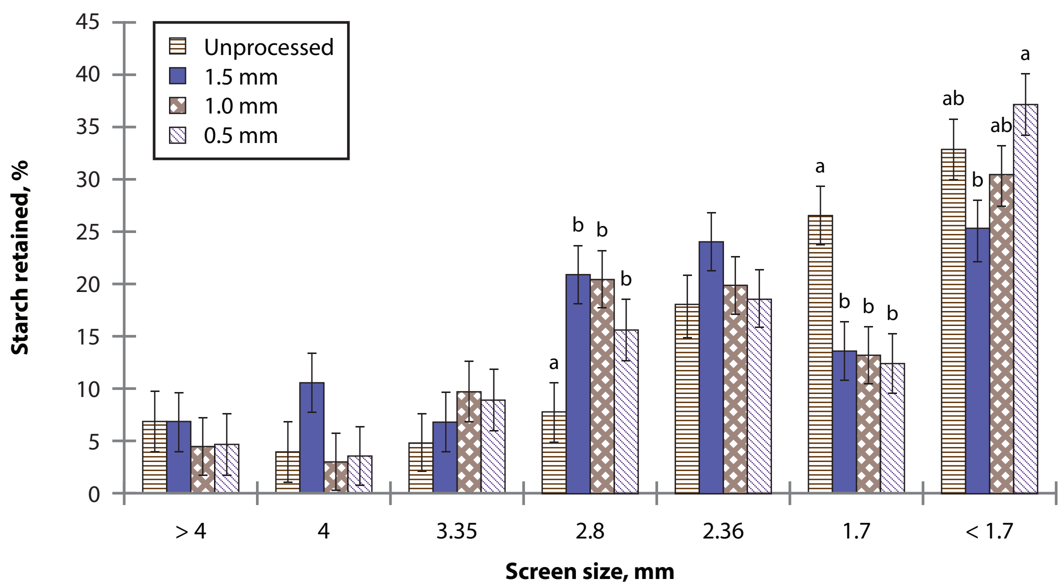

Figure 5. Percent starch retained by screen for each roll gap setting (unprocessed, 1.5, 1.0 or 0.5 mm) of fiber portion of sorghum sample.
abc Means differ ($P < 0.05$).

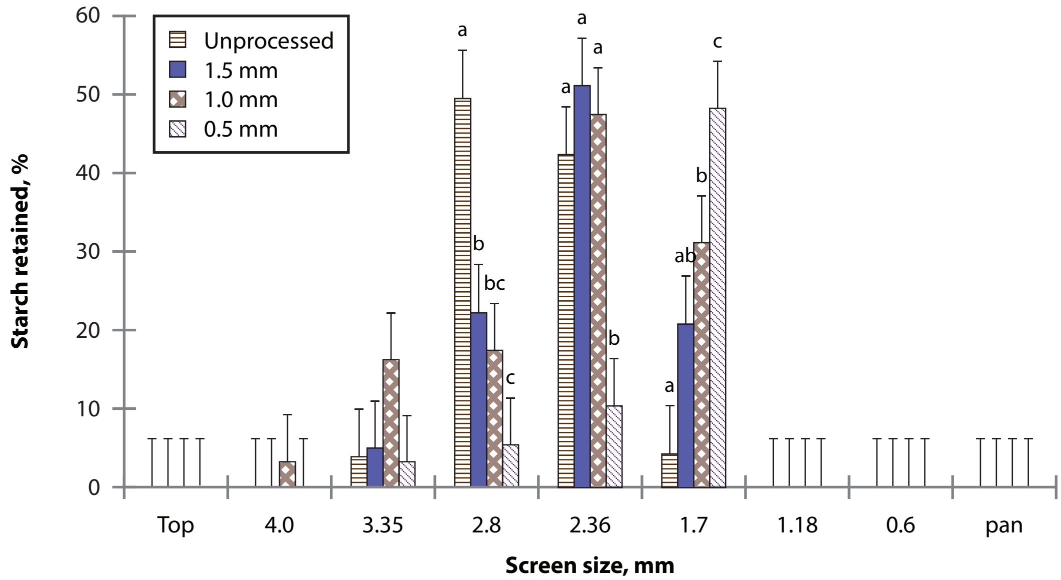

Figure 6. Percent starch retained by screen for each roll gap setting (unprocessed, 1.5 ,1.0, or 0.5 mm) of whole berry portion of sorghum sample.

[abc] Means differ ($P < 0.05$).