What did we learn about shredlage?

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Project Summary

- 12 week study utilizing 2 pens of 152 second and greater lactation cows that averaged 115 DIM for the shredlage diet and 120 DIM for the conventional diet.
- Daily milk weights and daily pen DMI recorded
- Corn silage tested similar for weeks 3 to 9 of the study. Shredlage: 33.9 % DM Starch and 42.5 % DM aNDF. Conventional: 33.1 % DM Starch and 43.1 % DM aNDF. (Table 1 and 9)
- Percentage of material on the top screen of the Penn State Shake Box was higher for the shredlage corn silage (SCS) than for the conventional corn silage (CCS) (36.8 % and 13.9 %, respectively) while the middle screen was higher for the CCS than the SCS (64.8 % and 39.1 %, respectively). The lower screen and the bottom were similar (22.9 % SCS and 20.2 CCS on the lower and 1.2 % SCS and 1.0 % CCS on the bottom). (Table 2)
- Dry matter intake differences varied across all weeks of the study (Table 3)
- Milk production averaged 2.5 lbs/cow/day higher in the shredlage pen then the conventional pen over the 12 weeks of the study (Table 4 and Figure 1).
- Milk quality did not differ between diets at weeks 6 or 12. In week 6, fat % averaged 3.69 ± 0.78, protein % averaged 3.03 ± 0.42, SCC x 1,000 averaged 61.5 ± 208, and MUN average 13.0 ± 2.2. In week 12 fat % averaged 3.71 ± 0.67, protein % average 3.09 ± 0.33, SCC x 1,000 averaged 81.9 ± 214, and MUN average 13.0 ± 2.0. (Table 3).
- No sorting of diets was found in either pen (Table 6 and 7).
- No differences in fecal starch and samples averaged <2.0 % DM (Table 8).
- The CSPS averaged 62.2 ± 2.8 and 56.2 ± 4.0 for the shredlage and conventionally processed corn silage, respectively (Figure 2).
- Poor relationship between CSPS and milk production (Figure 3).
- The relationship of the coarse and medium fraction starch % and aNDF % to milk production should be further investigated. (Figure 5, 6, 8 and 9).

Introduction

During the spring of this year, from March to June, the Dairy One Forage Lab collaborated with Allenwaite Farm in Schaghticoke, NY to run a 12 week study on feeding shredlage. Shredlage is corn silage that is processed through a shredlage processing unit on a corn silage chopper. The shredlage processor rips the forage longitudinally, opens up the rind of the plant, and smashes the corn kernels, resulting in higher corn silage processing scores (CSPS) than in conventionally processed corn silage. The objectives of the project were to:

1. Help the farm decide what direction to go with processing corn silage
2. Explore and develop lab measurements to better characterize the differences in shredlage and conventionally processed corn silage.

Project Design

The diets were fed to two pens of 2nd and greater lactation cows with 152 cows per pen. The cows in the conventional (C) pen averaged 120 DIM and the cows in the shredlage (S) pen averaged 115 DIM at the start of the project. In the C pen, 136 of the cows were in the pen for all 12 weeks of the study, and in the S pen, 143 cows were in the pen for all 12 weeks of the study. Working with Russ Saville and Sue Greth from Cargill Animal Nutrition, diets were formulated to have 22.4 lbs (38 % of diet DM) of dry matter from either conventionally processed corn silage (CCS) or shredlage (SCS). Other ingredients in the diet were the same: 7.9 lbs of dry matter haylage, 28.0 lbs dry matter premix concentrate, and 0.8 lbs of dry matter whey (59.1 lbs DM).

Milk production was recorded daily for all cows. The weight of feed delivered and refused by the pen was recorded daily using FeedWatch. Milk quality measures (Fat %, Protein %, SCC, and MUN) were measured the day before diets were started, at week 6 and at week 12. During week 6 and week 12 of the project TMR and ORTS (refusal) samples were taken for analysis with the Penn State Shaker and for nutrient composition. The CCS and SCS were sampled and tested weekly.

Results

Dry matter was similar all weeks and averaged 31.9 % for CCS and 32.3 % for SCS (Table 1). Starch (% DM) was higher in the SCS in weeks, 1, 2, 10, 11, and 12 (Table 1). Starch digestibility was similar from weeks 3 to 9 (Table 1). In week 2 aNDF (% DM) was 3.9 % higher in the CCS than in the SCS, but was similar in all other weeks (Table 1).

The percentage of material in the top screen of the Penn State Shake Box was higher for the SCS than for the CCS, while the middle screen was higher for the CCS. The action of the processing rolls in the Shredlage® unit are designed to have more long particles and improve kernel processing at the same time.

Table 1. Forage analysis results for CCS and SCS.

Week	Dry Matter, %		Starch, % DM		Starch Digestibility		aNDF, % DM		NDFD 30h, % NDF		CP, % DP	
	CCS	SCS	CCS	SCS	CCS	SCS	CCS	SCS	CCS	SCS	CCS	SCS
0	29.9	29.2	28.5	**31.5**	79	88	46.9	43.3	55	56	7.1	7.4
1	31.0	31.0	32.2	**35.6**	77	74	**45.7**	**41.8**	57	54	6.9	6.7
2	32.0	31.4	31.8	**33.3**	78	90	43.8	42.8	57	65	7.0	8.0
3	32.3	32.5	33.4	**34.3**	83	81	43.4	42.2	55	57	6.8	7.6
4	32.9	32.0	34.8	**34.7**	85	82	42.5	41.5	56	57	6.8	7.8
5	32.0	32.4	32.1	**33.4**	85	81	44.5	43.4	60	57	7.5	7.7
6	31.6	32.2	35.4	**34.1**	88	83	41.4	41.9	57	59	7.1	7.7
7	31.9	33.5	32.4	**33.7**	83	77	43.2	42.1	58	57	7.1	7.8
8	32.8	33.0	32.0	**33.9**	86	81	44.1	41.5	57	57	7.2	7.3
9	32.3	32.8	33.5	**33.3**	85	84	42.6	44.8	57	53	7.0	7.6
10	32.3	33.2	**32.0**	**34.0**	90	84	44.1	42.5	56	55	7.4	7.8
11	32.4	32.7	**30.5**	**36.5**	85	83	44.8	43.8	55	56	7.7	7.8
12	31.4	33.3	**29.2**	**35.6**	90	88	46.0	41.6	55	56	7.4	8.1

Table 2. Penn State Shaker Box (As-fed Basis) for SCS and CCS

Sample	% Upper	% Middle	% Lower	% Bottom
SCS	36.8	39.1	22.9	1.2
CCS	13.9	64.8	20.2	1.0

Due to the differences in the corn silage analysis in weeks 1, 2, 10, 11, and 12 (Table 1), comparison of DMI and milk production were focused on weeks 3 to 9. Dry matter intake (DMI) was similar from weeks 3 to 9 (Table 3). In week 1, the S Pen had a much higher DMI, that is likely related to the lower NDF concentration in the SCS that week (Table 1). Dry matter intake difference have been variable among the shredlage research that has been published. One of the trials run at the University of Wisconsin (UW 1) had cows consuming 1.54 lbs DM/day more than the conventionally processed corn silage. However, a second study at the University of Wisconsin (UW 2, Shaver, 2014). A recent project at Cornell University reported no difference in DMI (Larry Chase, Cornell).

Table 3. Average dry matter intake per cow by week, lbs/cow/day

Diet	0	1	2	3	4	5	6	7	8	9	10	11	12
S Pen, DMI lbs/cow/day	**52.90**	**59.71**	**56.72**	**55.79**	**55.90**	**55.75**	**55.46**	**55.33**	**54.84**	**58.64**	**57.85**	**57.76**	**57.09**
Standard Error	4.00	0.40	0.49	0.71	0.82	0.19	0.73	0.18	0.38	0.37	0.27	0.44	0.25
C Pen, DMI lbs/cow/day	**54.46**	**55.34**	**55.39**	**53.63**	**56.56**	**55.26**	**56.25**	**57.07**	**55.02**	**56.38**	**57.29**	**58.26**	**58.61**
Standard Error	0.51	0.25	0.27	0.57	0.29	0.58	0.63	0.31	0.51	0.52	0.24	0.18	0.53
Difference	**-1.55**	**4.37**	**1.33**	**2.16**	**-0.66**	**0.49**	**-0.80**	**-1.75**	**-0.18**	**2.27**	**0.56**	**-0.50**	**-1.53**

While DMI bounced back and forth between the two groups, cows in the S Pen produced between 2.2 and 3.2 lbs/day more milk (Table 4, Figure 1) between weeks 3 and 9. The milk production response to shredlage was greater in this project than has been reported in earlier studies. In the UW 1 trial a 1.76 lbs/day increase in milk production was reported when shredlage was fed versus conventional corn silage. Milk production response to shredlage varied by week in the UW 2 study (Shaver, 2014). In this project milk production was always higher in the cows fed SCS (Figure 1). The recent Cornell study found no difference in milk production when shredlage replaced conventionally processed corn silage (Larry Chase, Cornell).

Table 4. Average milk production per cow by week, lbs/cow/day

Diet	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
S Pen, Milk lbs/cow/day	**92.47**	**98.78**	**94.07**	**93.63**	**92.35**	**91.42**	**90.95**	**91.09**	**88.73**	**90.51**	**88.35**	**88.07**	**85.06**
Standard Error	1.36	1.56	1.51	1.49	1.04	1.48	1.48	1.49	1.54	1.61	1.62	1.68	1.66
C Pen, Milk lbs/cow/day	**91.83**	**95.35**	**90.48**	**90.43**	**89.75**	**88.86**	**88.10**	**88.20**	**86.57**	**88.20**	**86.63**	**86.12**	**83.84**
Standard Error	1.33	1.46	1.39	1.39	0.91	1.39	1.42	1.41	1.45	1.50	1.52	1.55	1.58
Difference	**0.64**	**3.43**	**3.59**	**3.20**	**2.60**	**2.56**	**2.86**	**2.89**	**2.16**	**2.31**	**1.72**	**1.96**	**1.22**

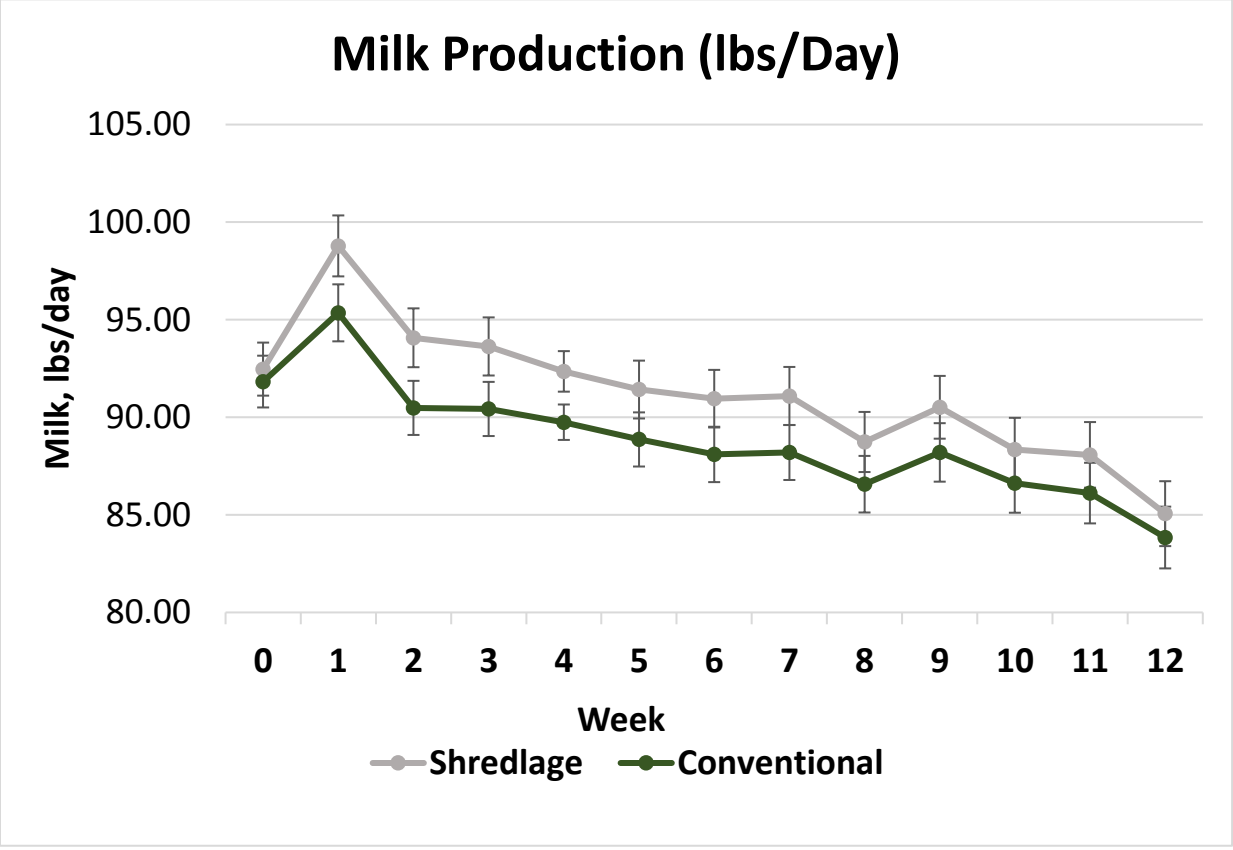

Figure 1. Milk production by week.

Milk quality did not differ between diets at 6 weeks or 12 weeks (Table 5). None of the previous shredlage studies have reported any difference in milk quality measures when shredlage was fed (Shaver, 2014 and Ferraretto and Shaver, 2012). A difference in milk fat % would be indicative of sorting of the larger particles in the shredlage or over processing in the conventional silage.

Table 5. Average milk quality measures

Treatment	Week 6				Week 12			
	Fat %	Protein %	SCC x1000	MUN	Fat %	Protein %	SCC x1000	MUN
S Pen	3.68 ± 0.67	3.09 ± 0.33	75.2 ± 127.8	12.9 ± 1.99	3.68 ± 0.83	3.01 ± 0.46	76.1 ± 277.9	13.0 ± 2.34
C Pen	3.73 ± 0.67	3.10 ± 0.33	88.8 ± 277.3	13.2 ± 2.08	3.71 ± 0.72	3.06 ± 0.39	53.6 ± 87.2	12.9 ± 2.09

During week 6 and week 12 TMR and refusals (ORTS) samples were analyzed with the Penn State Shaker Box and no evidence of sorting was seen (Table 6). Further, the chemical analysis of TMR and ORTS do not indicate sorting in either diet (Table 7). As with milk quality there have been no other shredlage studies that have reported any sorting of shredlage diets (Shaver, 2014 and Ferraretto and Shaver, 2012).

Table 6. Penn State Shaker results for TMR and ORTS.

Week	TRT	Type	% Upper, avg	% Middle, avg	% Lower, avg	% Bottom, avg
6	S	TMR	26.3	29.8	35.9	8.0
6	S	ORTS	28.2	36.3	32.0	3.6
6	C	TMR	15.0	41.7	35.4	7.8
6	C	ORTS	25.2	40.2	28.1	6.6
12	S	TMR	19.4	31.3	38.7	10.6
12	S	ORTS	25.2	32.1	35.8	6.9
12	C	TMR	17.0	34.1	38.7	10.3
12	C	ORTS	12.3	42.5	38.0	7.2

Table 7. Chemical analysis for TMR and ORTS.

Week	Diet	Type	DM %	CP, % DM	ADF, % DM	NDF, % DM	Starch	Ash
6	S	TMR	39.9	17.3	18.8	31.3	30.2	7.6
6	S	ORTS	37.3	16.0	21.5	34.1	27.2	9.4
6	C	TMR	39.9	17.0	18.6	31.1	30.2	7.7
6	C	ORTS	39.4	15.7	21.1	33.7	28.1	9.6
12	S	TMR	41.4	17.5	19.6	31.6	29.1	7.9
12	S	ORTS	41.8	16.8	20.1	33.4	27.6	10.1
12	C	TMR	40.4	17.0	18.6	30.0	29.6	7.7
12	C	ORTS	41.0	17.0	19.5	32.1	27.7	8.5

Fecal starch was 2% or less, indicating very good starch use and digestion in both diets and was not different between treatments. Other studies have not reported differences in total tract starch digestibility when cows were fed shredlage (Shaver, 2014 and Ferraretto and Shaver, 2012).

Table 8. Fecal Starch results.

Treatment	6 Week Fecal Starch, % DM	6 Week ±	12 Week Fecal Starch, % DM	12 Week ±
S Pen	2.18	1.16	1.46	0.64
C Pen	1.95	0.78	1.66	0.86

Corn Silage Characterization

The second objective of this project was to explore and develop lab measurements to better characterize the differences in shredlage and conventionally processed corn silage. Both types of corn silage were analyzed with the Penn State Shaker, chemical analysis, corn silage processing score, and chemical analysis of the fractions of the corn silage processing score.

As has been reported in previous shredlage projects, shredlage processing results in more sample retained on the top screen of the Penn State Shaker (Table 2; Shaver, 2014 and Ferraretto and Shaver, 2012). Chemical analysis by week varied and was closest between weeks 3 and 9 (Table 1). On average over the 12 weeks the CCS was 1.52% higher in NDF and 2.1% lower in starch (Table 9). However, the starch digestibility was 1.75% higher in the CCS than in the SCS (Table 9). Starch concentration of both silages was above the Dairy One historical average of 30.3 ± 7.6 %.

Table 9. 12 week average for CCS and SCS.

Item	CCS	SCS
Dry Matter	31.86 ± 0.84	32.48 ± 0.83
CP, % DM	7.08 ± 0.38	7.64 ± 0.55
ADF, % DM	25.69 ± 1.19	25.28 ± 1.10
NDF, % DM	43.99 ± 2.01	42.47 ± 2.18
Lignin, % DM	3.13 ± 0.22	3.03 ± 0.33
NDFD 30, NDF	56.67 ± 1.44	56.92 ± 3.0
Starch, % DM	32.25 ± 2.17	34.35 ± 1.74
Starch Digestibility	84.08 ± 4.34	82.33 ± 4.27
%WSC(Water Sol. Carb)	1.64 ± 0.44	1.66 ± 0.85
% ESC(Simple Sugars)	1.55 ± 0.25	1.66 ± 0.66
Ash, % DM	3.61 ± 0.64	3.81 ± 0.61

Corn Silage Processing Score (CSPS)

Corn Silage Processing Score (CSPS) was developed by Dave Mertens at the US Dairy Forage Lab to assess the adequacy of kernel processing. Corn Silage Processing Score is determined by drying a corn silage sample and shaking for 10 minutes on a series of sieves.

The material on the sieves > 4.75 mm will stimulate chewing activity. The starch in the particles will be poorly digested. The rate of digestion will be slow and it may escape the rumen as unchewed particles. This is the coarse fraction. The medium fraction is the materials on the sieves <4.75 mm and >1.18 mm.

The particles that pass through the < 1.18 mm sieve are the fine fraction and may not contribute to chewing activity or physical effectiveness. Starch in the fine particles may ferment very rapidly in the rumen and cause problems when rations low in effective fiber are fed. Knowing what is in this fraction may be a useful tool for trouble shooting some feeding problems.

The percentage of starch that passes through the coarse sieves (< 4.75 mm) are the adequately processed kernels. The percentage of starch passing through the 4.75 mm sieve is determined by subtracting the amount of starch that did not pass through the 4.75 mm sieve from the total starch in the sample. The percentage of starch that remains or passed through the 4.75 mm sieve is the CSPS. The guidelines for interpreting the results are:

- Greater than 70% - Optimum,
- 50 – 70% - Adequate,
- Less than 50% - Inadequately Processed.

As seen in other research (Ferraretto and Shaver, 2012) CSPS is higher in shredlage than in conventionally processed corn silage (Figure 2). Only one of the samples tested with an inadequate CSPS in the 12 weeks of the project, CCS week 5 (Figure 2).

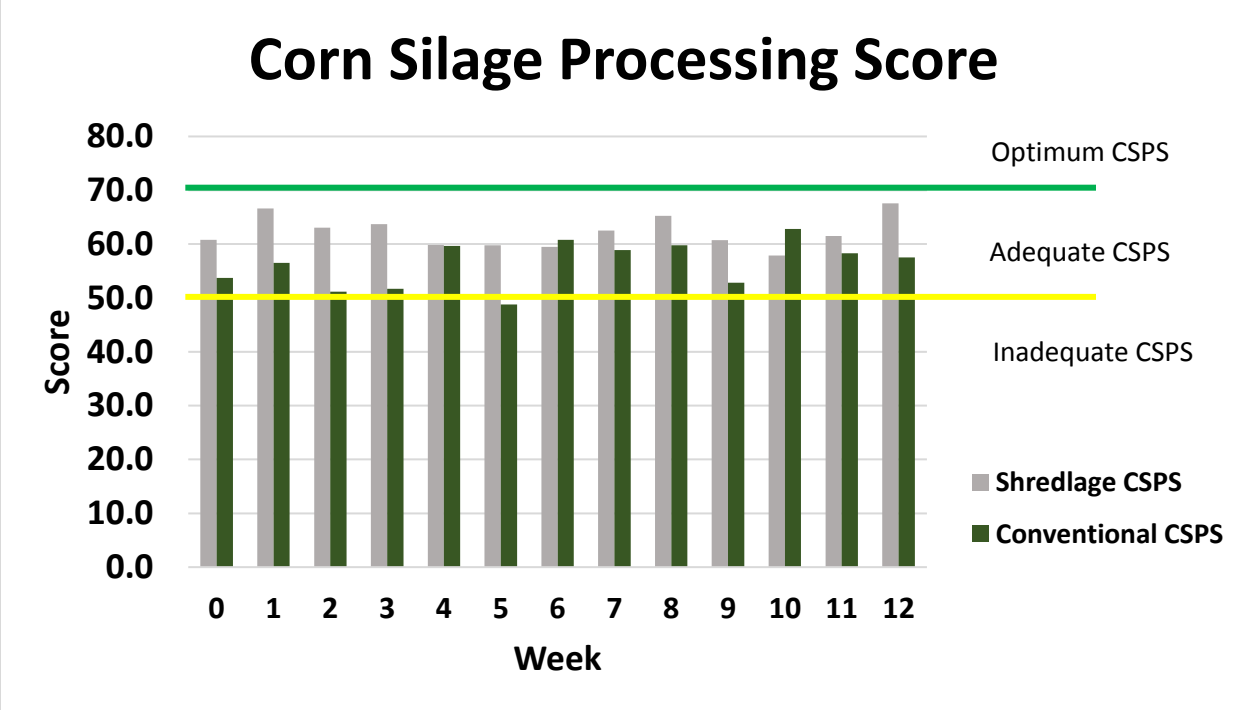

Figure 2. Corn silage processing score (CSPS) by week.

The question is do the differences in CSPS explain the differences in milk production. There is a potential relationship between CSPS and milk production (Figure 3). However, there is no relationship between CSPS and the milk production response in cows fed shredlage (Figure 4).

With additional measurements made on the coarse, medium, and fine fractions of the CSPS the relationships of milk production to corn silage characteristics may be further explained. After the CSPS shaking and weighing was completed the three fractions were analyzed for starch and fiber percentage. The CCS was higher in starch % in the coarse fraction than the SCS, while the SCS was higher in starch % in the medium and fine fractions than the CCS (Table 10). The results were opposite for aNDF % by fraction (Table 10).

Table 10. Average starch and aNDF analysis for CSPS fractions of conventionally processed corn silage and shredlage.

Item	CCS	SCS
Coarse Starch%	32.8 ± 1.78	28.3 ± 1.92
Medium Starch%	34.0 ± 2.13	39.8 ± 2.09
Fine Starch%	46.9 ± 2.22	51.9 ± 2.20
Coarse aNDF%	45.5 ± 1.58	48.9 ± 1.65
Medium aNDF%	43.4 ± 1.16	38.8 ± 1.48
Fine aNDF%	31.8 ± 2.56	27.2 ±1.65

The coarse and medium measures of starch % and aNDF % from the CSPS are the measures that appear to have the most potential for additional investigation (Figure 5, 6, 8, and 9). As starch % in the coarse fraction increases milk production tends to decrease (Figure 5) and as the starch % in the medium fraction increase milk production tends to increase (Figure 6). The opposite relationships are apparent for aNDF % in the coarse fraction (Figure 8) and the medium fraction (Figure 9), where milk production increases with higher aNDF % in the coarse fraction (Figure 8) and decreases as aNDF % increases in the medium fraction (Figure 9). There is no apparent relationship of milk production and fine fraction starch % or aNDF % (Figure 7 and 10).

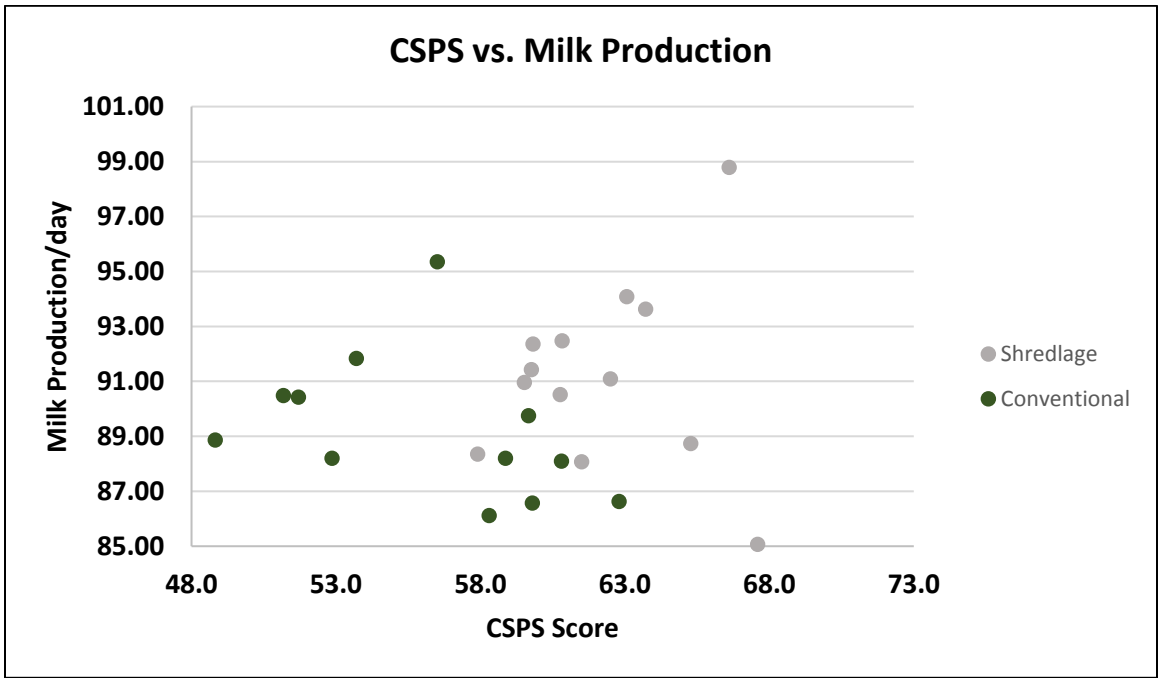

Figure 3. Weekly Corn silage processing score (CSPS) versus weekly pen average milk production (lbs/day).

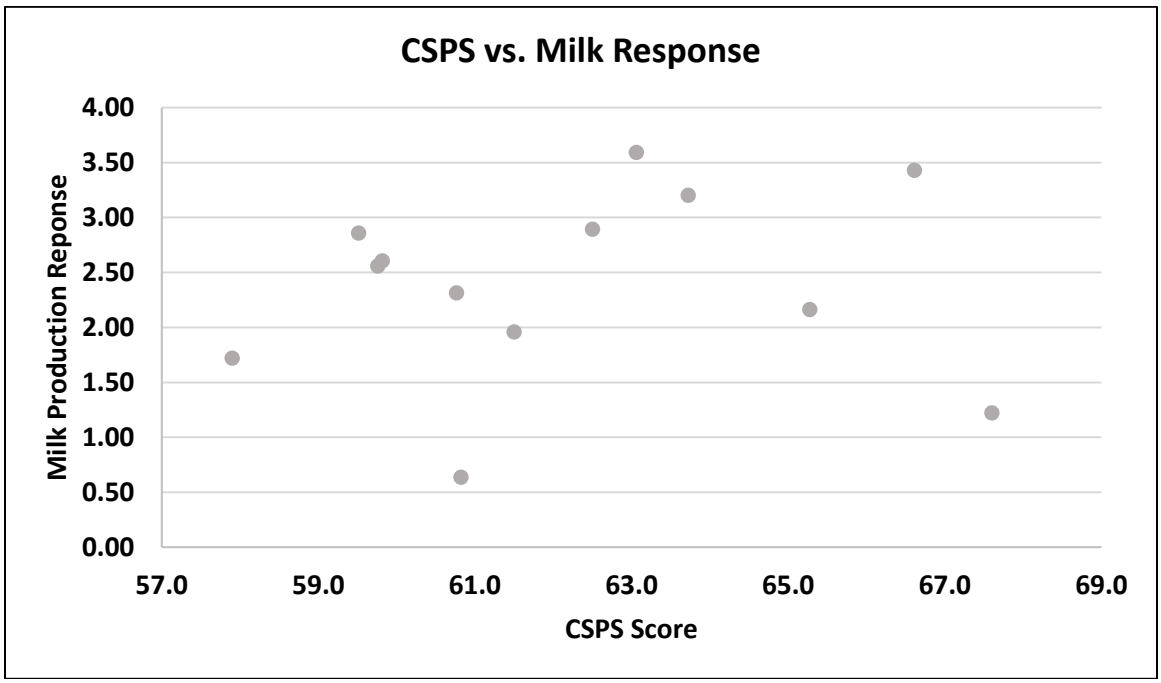

Figure 4. Weekly CSPS score for Shredlage versus weekly milk production response in cows fed shredlage.

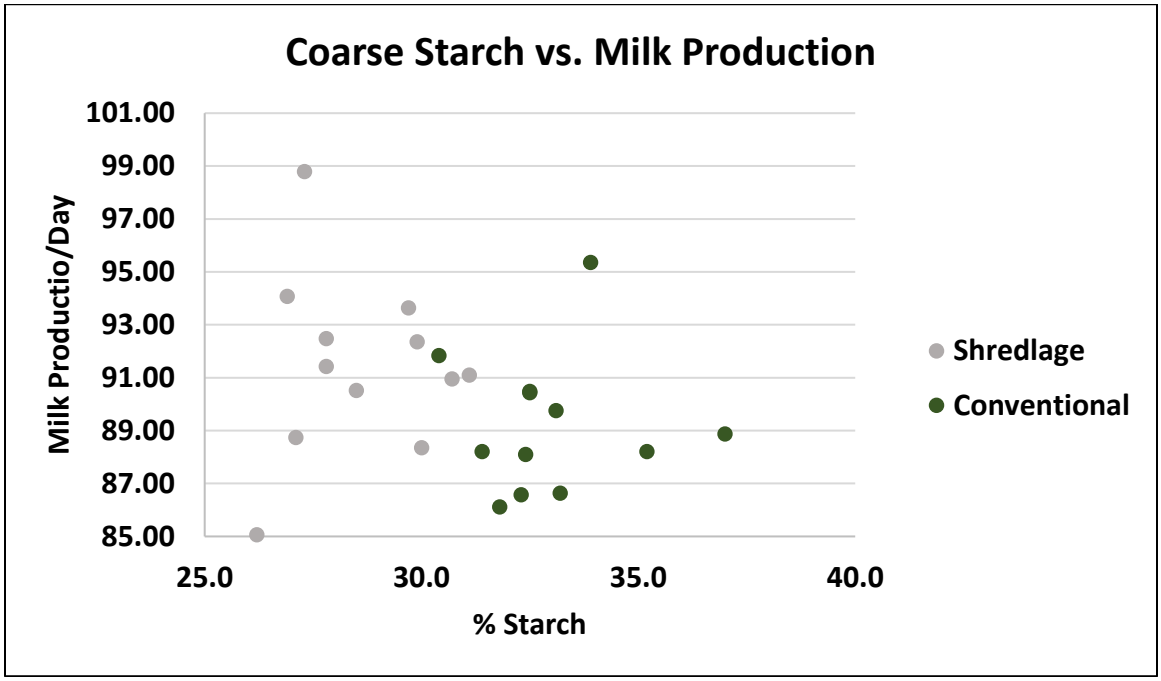

Figure 5. Weekly coarse starch % of conventionally processed corn silage and shredlage versus weekly pen average milk production.

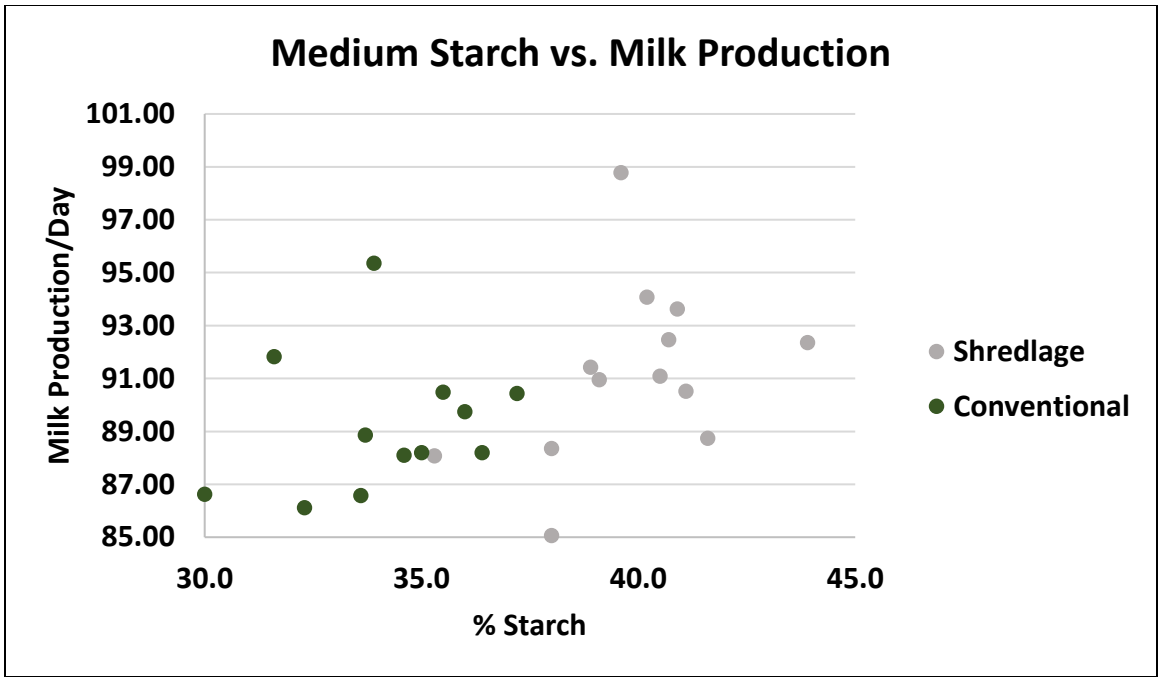

Figure 6. Weekly medium starch % of conventionally processed corn silage and shredlage versus weekly pen average milk production.

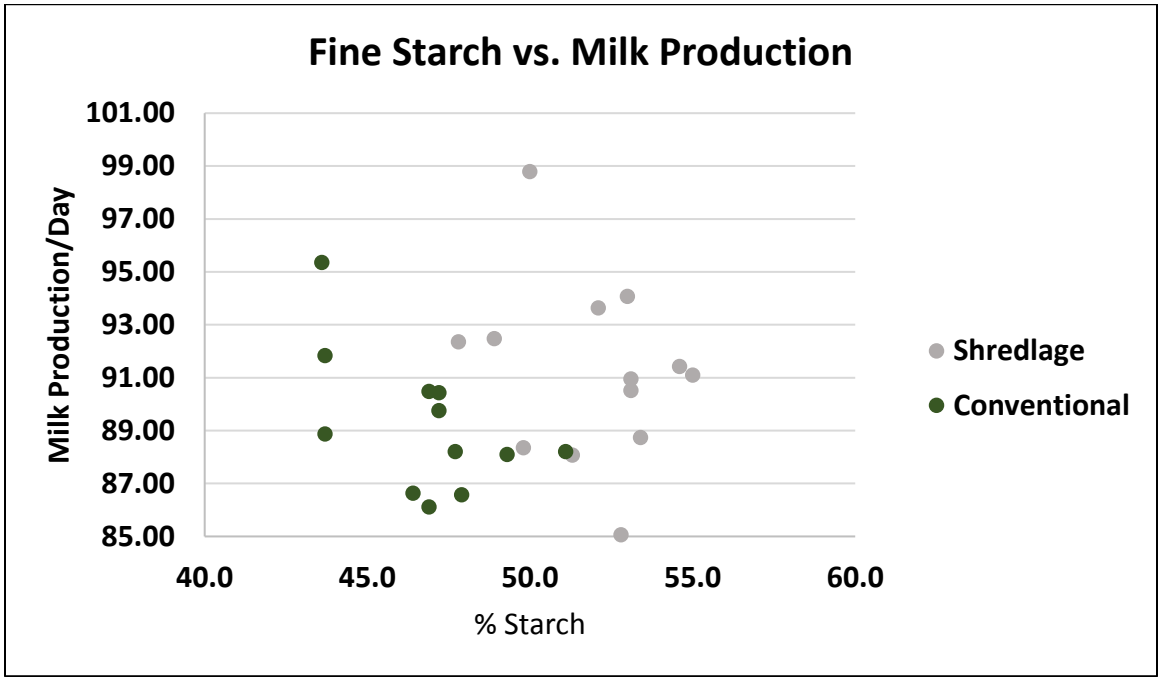

Figure 7. Weekly fine starch % of conventionally processed corn silage and shredlage versus weekly pen average milk production.

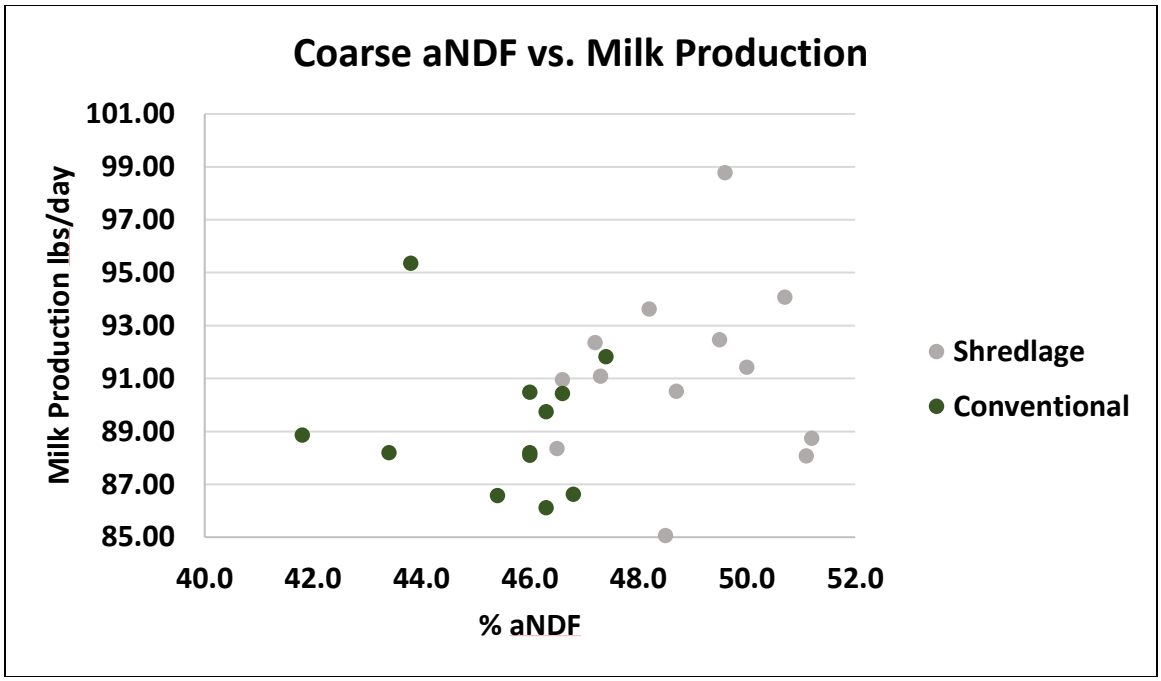

Figure 8. Weekly coarse aNDF % of conventionally processed corn silage and shredlage versus weekly pen average milk production.

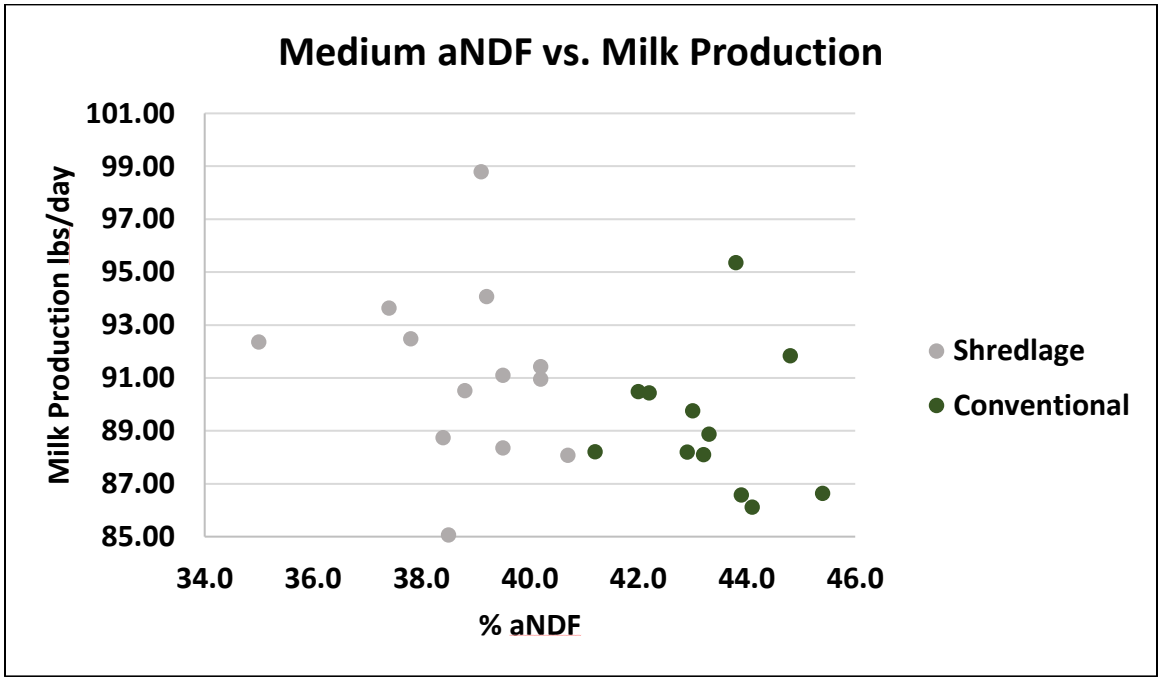

Figure 9. Weekly medium aNDF % of conventionally processed corn silage and shredlage versus weekly pen average milk production.

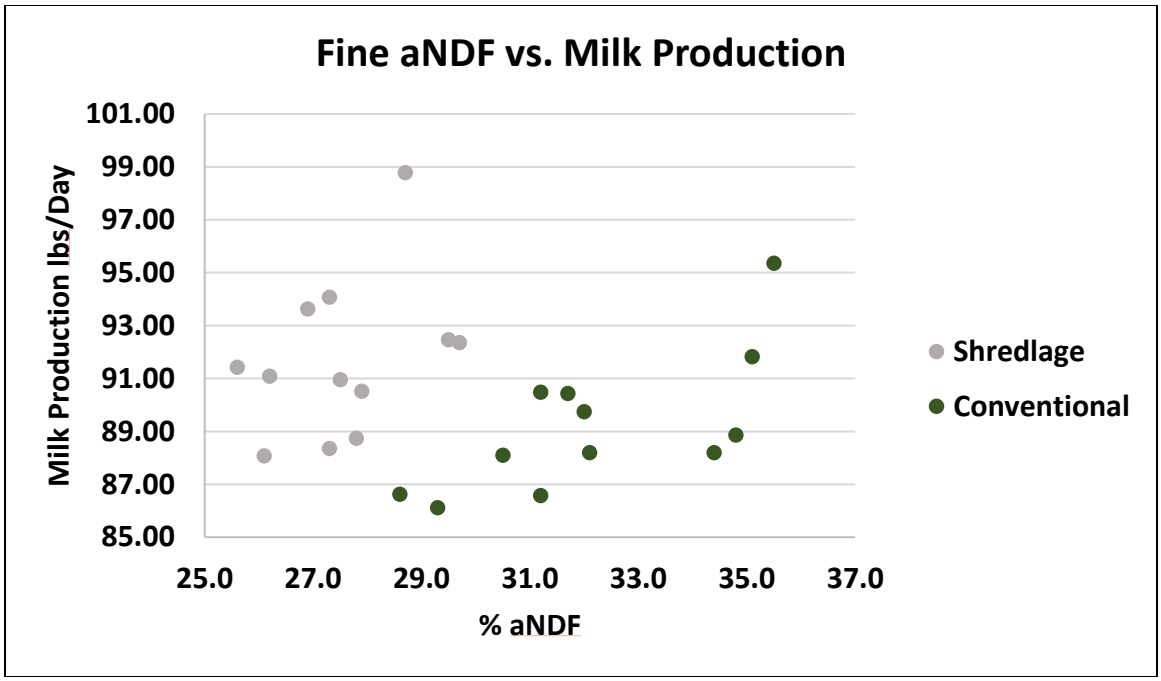

Figure 10. Weekly fine aNDF % of conventionally processed corn silage and shredlage versus weekly pen average milk production.

Summary

Overall results of this project were similar to what has been reported in other studies. Cows did not sort diets, fecal starch was not different, milk quality measures were not different, and CSPS was higher in SCS than in CCS. Milk production response in this study was greater than that reported in the UW studies (Shaver, 2014; Ferraretto and Shaver, 2012).

Measuring only CSPS does not look like the best measure to relate to milk production. There is no apparent relationship of the fine fraction measures of starch % and aNDF % from the CSPS to milk production. The relationship of the coarse and medium fraction starch % and aNDF % to milk production should be further investigated. We are currently working on another project for 2016 comparing shredlage to conventional silage.

Acknowledgements

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