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Effect of Corn Residue Harvest Method on In Vivo and In Vitro Digestibility

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Summary

A digestion study was conducted using 18 crossbred wether lambs to evaluate the effects of corn residue harvesting method and ensiling on the digestibility of corn residue. Husks had the greatest digestibility compared to any of the harvesting methods. No differences were observed for the digestibility of husklage, ensiled husklage, or stalklage. None of the harvest methods resulted in residue digestibilities similar to husks.

Introduction

The digestibilities of various residue components from corn differ. The husk is the most digestible while the stem is the least (*2012 Nebraska Beef Cattle Report*, pp.11–12). Advancements in residue harvesting technology now allow producers to decrease the proportion of stem in the bale compared to conventional baling. A previous evaluation of harvest methods reported improved *in vitro* digestibility estimates for residues harvested with methods that minimized the proportion of stalk (*2015 Nebraska Beef Cattle Report*, pp.62–63). Additionally, steers consuming residue harvested using new harvesting technology had improved F:G compared to steers consuming diets with conventional harvested corn residue (2015 *Nebraska Beef Cattle Report* pp. 42–44).

Digestibility estimates from *in vitro* techniques are known to be variable. However, *in vitro* estimates may be adjusted to *in vivo* values if forage samples with known *in vivo* digestibilities are included in each run as internal standards (2007 *Nebraska Beef Cattle Report* pp. 109–111). Currently, no internal standards exist for crop residues. The objectives of the current study were to determine the effects of corn residue harvest method on *in vivo* digestibility and to determine if internal standards can be used to adjust *in vitro* data to *in vivo* digestibility values for corn residues.

Procedure

A 64-d digestion study utilized 18 crossbred wethers (BW = 57.4 lb, SD = 9.9 lb) in a Latin square design with three independent squares. Wethers were blocked into three blocks based on previous DMI, and then assigned randomly to one of six treatment diets. Five of those treatments are reported here, while the remaining treatment comparisons are reported in another report (2016 *Nebraska Beef Cattle Report pp.* 74–75).

The trial was comprised of four, 16-d periods. Days 1–8 allowed for adaptation to the diet. Wethers were also allowed to adapt to the metabolism crates and fecal collection bags on day 8. Total fecal collections were performed on days 9–16. Five forage based diets were used for three of the periods, consisting of: husk, husklage, ensiled husklage, stalklage, or brome. Diet composition is shown in Table 1.

Husks were obtained from Hoegemeyer Seed. Husks were sifted through a 3 foot by 5 foot metal screen by hand to remove any remaining corn. The husklage and ensiled husklage were produced with the use of a John Deere 569 round baler that was modified with the Hillco single pass round bale system (SPRB). This modification to the baler allows for the baler to connect to the combine, where it collects the residue after it passes through the combine. The producer can harvest both corn and residue in one pass through the field. To ensile the husklage, water was added to a target DM of 35%, and the mixture was bagged in an agricultural bag for a minimum of 30 days. The residue collected was 27% leaf, 17% husk, 42% cob and 14% upper stem. In order to obtain the bales of stalklage, a New Holland Cornrower Corn Head was used. The Cornrower corn head was described in the 2015 *Nebraska Beef Cattle Report* (pp. 62–63).

The fourth period of the digestion trial consisted of a *Sweet Bran®*/ brome mixture (Table 1.).This mixture was fed to determine the amount of feces that was contributed by the *Sweet Bran®*/ brome in the treatment diets collected in the first three periods. The contribution from *Sweet Bran®*

Table 1. Composition of diets (DM basis)

Ingredient, % DM	Husk	Husklage	Ensiled Husklage	Stalklage	Brome	Sweet Bran®
Husk[a]	64.18	—	—	—	—	—
Husklage[b]	—	64.18	—	—	—	—
Ensiled Husklage[c]	—	—	64.18	—	—	—
Stalklage[d]	—	—	—	64.18	—	—
Brome hay	3.22	3.22	3.22	3.22	97.25	9.6
Sweet Bran®	29.73	29.73	29.73	29.73	—	86.4
Supplement	2.15	2.15	2.15	2.15	2.0	2.0
Limestone	0.72	0.72	0.72	0.72	0.75	2.0

[a]Husk were obtained from Hoegemeyer Seed and sifted through a screen to remove remaining grain
[b]Husklage was produced with the John Deere 569 round bailer modified with the Hillco single pass round bale system
[c]Ensiled Husklage was produced the same as the husklage, then water was added to target of 35% DM and bagged in an agricultural bag for a minimum of 30 days
[d]Stalklage was produced with the New Holland Cornrower cornhead, with all 8 rows operating

and brome to the total fecal output was then subtracted to determine the digestibility of the residue.

Fecal samples were composited on a wet basis by wether within period. Both feed and fecal samples were dried and ground through a 1-mm screen. The ground samples were then ashed. The residue left was used to calculate OM. All samples were analyzed for DM, OM, and NDF.

In vitro DM (IVOMD) and *in vitro* OM (IVOMD) digestibility estimates were performed on the residue samples. Samples were dried and ground through a 1-mm screen. Test tubes contained 0.5 grams of feed and 50 mL of inoculum. The was a combination of ruminal fluid from two donor steers that were consuming a 70:30 roughage:concentrate diet (DM basis). McDougall's buffer was mixed into the ruminal fluid at a 1:1 ratio, along with the inclusion of 1 gram of urea/L.

Inoculated tubes were incubated in a water bath to allow fermentation. To end fermentation, each test tube received 6 mL of 20% HCL and 2mL of 5% pepsin solution were added. Tubes remained in the water bath for an additional 24 hours. At the end of the 24 hours, the residue was filtered through a non-ash filter. Filters containing the residues were placed in an oven to obtain the IVDMD. After obtaining IVDMD, filters were ashed. Remaining residue allowed for calculation of IVOMD.

Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). For *in vivo* digestion data, the model included treatment, block, period, and wether within block as fixed effects. For *in vitro* data, the response variable was IVDMD or IVOMD, with the tube being the experimental unit. The *in vivo* digestibility estimates were regressed with *in vitro* digestibility estimates for DM and OM to determine if of *in vitro* digestibilities of residues can predict *in vivo* estimates.

Results

Nutrient composition of the feed ingredients is presented in Table 2. Dry matter and NDF intakes of the residues were not significantly different ($P \leq 0.83$, Table 3.), whereas the brome had the greatest DM and NDF intake ($P < 0.01$). The husk had the greatest digestibility of DM, OM, and NDF (68.11%, 70.49, and 75.28% respectively), compared to the other treatments ($P < 0.01$) which is consistent with previous observations. The digestibility of OM and NDF did not differ among the two residues collected using alternative harvesting methods (i.e. husklage and stalklage; $P > 0.12$). Ensiling the husklage did not significantly change DM or OM intakes compared to non-ensiled husklage ($P = 0.33$ and $P = 0.32$, respectively). The NDF digestibility of the ensiled husklage, 57.52%, tended to be less than the NDF digestibility of the husklage ($P = 0.11$). There were no significant differences between the ensiled husklage and stalklage on DM, OM, and NDF digestibilities ($P > 0.88$). While ensiling the husklage appeared to numerically increase DMI, we could not observe a difference statistically ($P = 0.33$).

The brome treatment had the greatest 7 day period DM, OM, and NDF intakes, 10.04 lb, 9.45 lb, and 7.51 lb, respectively, across all treatments ($P < 0.01$). The DM digestibility of the brome (45.11%) was similar only to the stalklage (49.37%; $P = 0.14$). The OM and NDF digestibilities of the brome treatment were the lowest, 47.77% and 46.92%, respectively, across all treatments ($P \leq 0.06$).

The IVDMD and IVOMD of each of the forages were different from other forages ($P < 0.01$; Table 4). The husk had the greatest IVDMD and IVOMD, which is consistent across many observations. The average OM digestibility was 10.8 units greater for the *in vivo* analysis than the *in vitro* analysis. A regression analysis was performed for both the DMD and OMD of the residue from both the experiments. The DMD had an $R^2 = 0.65$, (Figure 1) meaning that the *in vivo* and *in vitro* digestibilities are 65% related to each other. The OMD, (Figure 2) however, had an $R^2 = 0.88$. Ideally the relationship between *in vitro* and *in vivo*

Table 2. Nutrient composition of different corn residues (DM-basis)

Residue	DM	OM	NDF	CP
Husk	93.27	96.53	85.48	5.74
Husklage	88.54	97.37	90.82	5.95
Ensiled Husklage	36.15	96.32	84.78	7.46
Stalklage	89.80	92.28	86.74	5.48
Brome	92.78	93.60	74.35	10.89

Table 3. Effects of harvest method on intakes and in vivo digestibilities in wether lambs.

	Husk	Husklage	Ensiled Husklage	Stalklage	Brome	SEM	*P*-value
DM							
Intake, lb/period	5.55^{b}	5.74^{b}	6.59^{b}	5.78^{b}	10.04^{a}	0.62	< 0.0001
Fecal output, lb	1.92^{c}	2.65^{bc}	3.34^{b}	2.95^{b}	5.48^{a}	0.34	< 0.0001
Digestibility, %	68.11^{a}	54.07^{b}	50.90^{bc}	49.37^{cd}	45.11^{d}	2.07	< 0.0001
OM							
Intake, lb	5.36^{b}	5.55^{b}	6.38^{b}	5.32^{b}	9.45^{a}	0.58	< 0.0001
Fecal output, lb	1.72^{d}	2.43^{bc}	3.09^{b}	2.28^{cd}	4.92^{a}	0.31	< 0.0001
Digestibility, %	70.49^{a}	56.40^{b}	53.30^{b}	57.58^{b}	47.77^{c}	2.18	< 0.0001
NDF							
Intake, lb	4.68^{b}	5.13^{b}	5.54^{b}	4.99^{b}	7.51^{a}	0.50	< 0.0001
Fecal output, lb	1.24^{c}	1.95^{b}	2.46^{b}	2.12^{b}	3.98^{a}	0.26	< 0.0001
Digestibility, %	75.28^{a}	62.40^{b}	57.52^{b}	57.94^{b}	46.92^{c}	2.14	< 0.0001

$^{a\text{-}d}$Means within a row without a common superscript are different, ($P < 0.10$)

Table 4. The effect of harvest method of corn residue on IVDMD and IVOMD

	Husk	Husklage	Ensiled Husklage	Stalklage	Brome	SEM	*P*-value
IVDMD, %	61.34[a]	38.71[d]	30.43[e]	42.91[c]	46.67[b]	0.70	< 0.01
IVOMD, %	67.12[a]	43.16[d]	36.27[e]	48.08[c]	50.13[b]	0.67	< 0.01

[a-e]Means within a row without a common superscript are different, ($P < 0.01$)

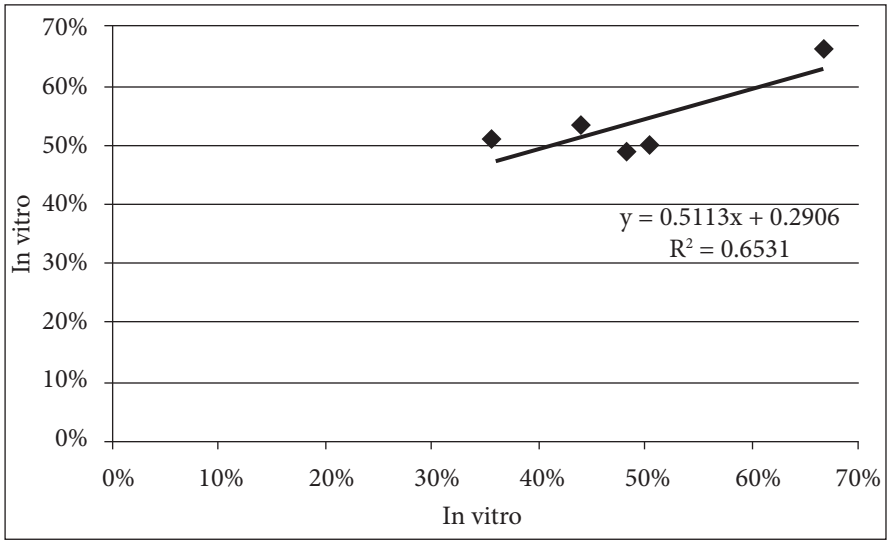

Figure 1. Regression of the dry matter digestibility of corn residue. *In vitro* vs *in vivo*

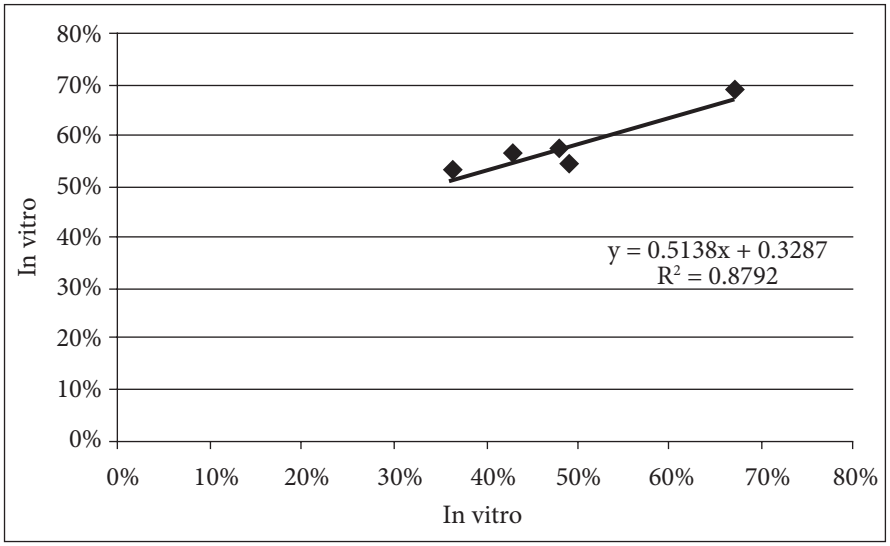

Figure 2. Regression of the organic matter digestibility of corn residue. *In vitro* vs. *in vivo*

values would have a slope of 1 and an intercept of 0. The slopes for both OM and DM were approximately 0.51 and the intercepts were approximately 0.3. These relationships suggest that *in vitro* estimates would need to be adjusted to *in vivo* values.

The methods used to harvest residue appear to influence the digestibility and quality of the residue. The differences are likely due to changing the proportion of husk, leaf, and cob compared to the proportion of stem in the bale. Since *in vitro* digestibility estimates do not accurately predict in vivo digestion values, there is a need to develop lab standards to adjust *in vitro* digestion estimates.

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