Rumen Undegradable Protein Content and Digestibility of Corn Silage and High-moisture Corn

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Summary with Implications

Two studies were conducted to determine rumen undegradable protein (RUP) content and digestibility in corn silage. In Exp. 1, 37 and 42% DM corn silage were incubated in situ with two ruminally and one duodenally cannulated steer to calculate RUP content and RUP digestibility. In Exp. 2, dry rolled corn was reconstituted to 75, 70, 65, and 50% DM and ensiled in mini silos for 30, 90, 180, or 270 days. After ensiling, samples were ruminally incubated to determine RUP content of the grain. The grain within corn silage is less than 50% DM, as moisture content increases and time of ensiling increases, RUP content of this grain decreases. Results from these experiments suggest the RUP content of corn silage is 10% of the CP or the CP within corn silage is 90% rumen degradable protein.

Introduction

Feeding corn silage allows cattle feeders to harvest the entire corn plant at the time of greatest forage quality and provides a large quantity of affordable forage. When formulating rations it is important to correctly account for the CP, rumen degradable protein (RDP), and rumen undegradable protein (RUP) content of corn silage. Because lab techniques designed to measure RUP values of feedstuffs are specific to either forages or concentrates, and corn silage is a blend of both, quantifying RUP of corn silage is difficult. Furthermore, moisture content and ensiling time probably impact protein degradability of the corn silage (2005 Nebraska Beef Report, pp 31–33). At silage harvest, forage is wetter than the grain and during storage the grain absorbs moisture from the forage, becoming very wet high moisture corn (HMC). As the grain absorbs moisture, the protein has a greater degree of rumen degradability. Therefore, the objectives of these experiments were to determine the RUP content and RUP digestibility of corn silage.

Procedure

In Exp. 1, corn silage was harvested at the Eastern Nebraska Research and Extension Center (ENREC) near Mead, NE at 37 or 42% DM to mimic traditional corn silage harvest or a delayed harvest. Harvest began when the field was at approximately ¾ milkline for the 37% DM corn silage (9/4/2014), and then delayed two weeks coinciding with black layer formation for the 42% DM corn silage (9/16/2014). After harvesting, silages were stored in sealed Silo bags. After 28 days, approximately 25 lb of corn silage was brought to the University of Nebraska-Lincoln Animal Science building and freeze dried. Both the 37 and 42% corn silages were then analyzed for RUP content using an *in situ* technique.

Feed samples were ground through a 2-mm screen and 1.25 g of sample was added to Ankom bags, with 16 replicate bags per sample. Bags were ruminally incubated for either 20 or 30 hours in one of two ruminally fistulated steers on a 30% concentrate diet. After the designated incubation time, bags were removed, rinsed, and half of the bags were frozen for duodenal incubation. The remaining bags were divided in half again with half refluxed in neutral detergent (ND) solution using an ANKOM Fiber Analyzer to remove microbial contamination from residue. Bags were dried in a 60°C forced-air oven for 24 hours to dry and weighed to determine DM disappearance.

Four bags of each feed sample were duodenally incubated. Of the bags that were duodenally incubated, half of them (two bags of each feed) were washed in ND solution to remove microbial contamination from residue. The bags were incubated in a duodenally fistulated steer consuming a concentrate diet. Bags were retrieved from fecal matter approximately 12 hours after being placed in the cannula. Once all bags were retrieved, bags were rinsed, oven dried, and then allowed to air equilibrate for 12 hours before being weighed. After all bags (ruminally and duodenally incubated) were weighed, bags were cut open and N analysis was conducted on the remaining feed residue to calculate CP remaining.

In Exp. 2, dry rolled corn (DRC) was retrieved from the feed mill located at the ENREC near Mead, NE and brought to the University of Nebraska-Lincoln Animal Science building. Using a small feed mixer, different proportions of water and corn were mixed to reconstitute DRC to 50, 65, 70, and 75% DM HMC. It is important to note that we attempted to reconstitute corn down to 40% DM; however, we found that this was too much water and the corn was not able to absorb it all. Once corn was reconstituted to its designated DM, wet corn was packed into mini silos (0.08 ft^3) using a packing density of 45 lb DM/ft^3. Silos were sealed with gas release lids and stored for 30, 90, 180 or 270 days.

On the designated opening day, silos were weighed, emptied and sub-sampled for DM and CP. Within 1 hour of being out of the silo, corn was weighed into Ankom *in situ* bags. In order to get 5.0 g of DM content in each bag, different as-is amounts of HMC were added to the bags based on the DM at which the corn was ensiled at. There were 4 *in situ* bags per steer (2) for each incubation time (2), therefore 16 bags / silo were made. Bags were ruminally incubated for 20 or 30 hours, in cattle consuming a 30% concentrate diet. After the designated incubation time, bags were

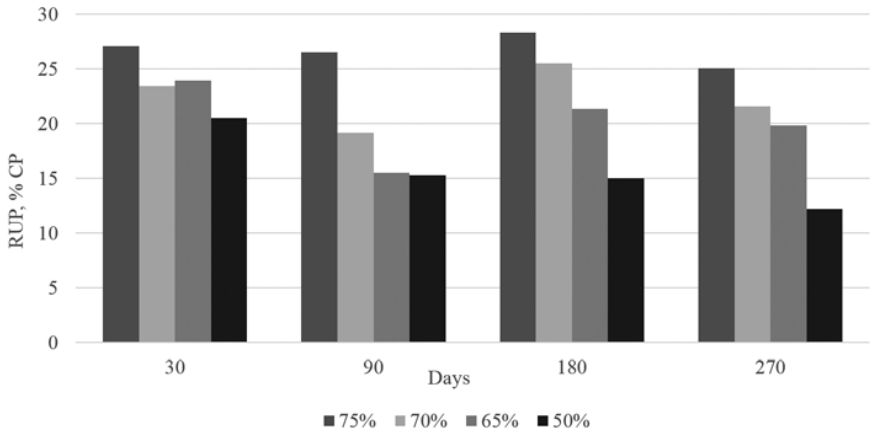

Figure 1. Effect of DM and days ensiled on rumen undegradable protein (RUP) content of high moisture corn
Dry rolled corn was reconstituted to 75, 70, 65, and 50% DM and ensiled for 30, 90, 180, and 270 days to determine effects on RUP content.

Day × DM interaction	Linear $P < 0.01$	Quadratic $P = 0.29$
75% DM	Linear $P = 0.50$	Quadratic $P = 0.23$
70% DM	Linear $P = 0.74$	Quadratic $P = 0.89$
65% DM	Linear $P = 0.28$	Quadratic $P < 0.01$
50% DM	Linear $P < 0.01$	Quadratic $P = 0.05$

Table 1. Dry matter digestibility, rumen undegradable protein, and rumen undegradable protein digestibility of 37 and 42% DM corn silage

	Treatments[1]						
	37% CS		42% CS		SEM	*P*-value[4]	
Incubation, h:	20	30	20	30		DM	Incubation
CP, %	7.2	7.2	6.5	6.5	-	-	-
RUP, No ND, % DM[2]	2.1	1.8	1.7	1.6	0.19	0.15	0.32
RUP, With ND, % DM[3]	0.67	0.64	0.51	0.53	0.02	0.12	0.87
RUP, No ND, % CP[2]	29.2	25.1	26.8	24.7	2.81	0.64	0.73
RUP, With ND, % CP[3]	9.3	8.9	8.9	8.4	0.04	0.07	0.07
RUP Dig., No ND, %[2]	45.0	34.8	35.4	34.8	3.39	0.50	0.46
RUP Dig., With ND, %[3]	32.2	32.3	32.6	31.9	0.59	0.94	0.56

[1]Treatments consisted of either 37 or 42% DM corn silage incubated for either 20 or 30 hours
[2]RUP content and digestibility measured without refluxing in ND solution to correct for microbial contamination after rumen incubation
[3]RUP content and digestibility corrected for microbial contamination by refluxing in ND solution
[4]There were no interactions of feed sample and incubation time ($P \geq 0.30$)

removed, rinsed, oven dried, and then allowed to air equilibrate for 12 hours prior to being weighed and analyzing the residue for remaining CP.

Results

In Exp. 1, as a % of DM, RUP was not different between the two corn silages and was not affected by time incubated in the rumen ($P \geq 0.12$; Table 1). When samples were rinsed in ND solution to remove microbial contamination after rumen incubation, RUP as a % of CP had a tendency ($P = 0.07$) to be less for the 42% corn silage and also had a tendency ($P = 0.07$) to be less for corn silage incubated for 30 hours compared to 20 hours, overall averaging 8.9% of CP. The RUP content, as a % of CP, did not differ by treatment for samples not rinsed in ND solution, averaging 26.5% of CP. Digestibility of the RUP was not different for the two corn silages and was not affected by time incubated in the rumen ($P \geq 0.46$). Bags that were not rinsed in ND solution to remove microbial contamination averaged 37.5% RUP digestibility while bags that were rinsed in ND solution averaged 32.3% RUP digestibility.

In Exp. 2, there was a linear interaction of corn DM and days ensiled ($P < 0.01$) for RUP as a % of CP (Figure 1). For both the 75 and 70% DM corn RUP content did not change as ensiling time increased ($P \geq 0.23$). At each time point the 70% DM corn had less RUP than the 75% DM corn. The 65% DM corn had a quadratic ($P < 0.01$) decrease in RUP as ensiling time increased with the lowest RUP content at 90 days. The wettest corn (50% DM) had a linear decrease ($P < 0.01$) in RUP as ensiling time increased, and had the lowest RUP out of all treatments at each time point.

Microbial contamination is a potential source of error when measuring RUP content of feeds using *in situ* methods. Some bags were washed in ND solution and others were not because it is unclear which procedure should be used with corn silage. Refluxing bags in ND solution removes microbes attached to forage particles, but may also solubilize a portion of the protein remaining in the corn grain. Samples of the 50% DM HMC ensiled for 180 days (from Exp. 2) were rumen incubated for 25 hours and then refluxed in ND solution

to estimate this fraction. This was 0.28% of the DM, but would be lower for grain in corn silage that is wetter than 50% DM. Combining the data from both experiments suggests the RUP content of corn silage is 0.75% of DM or the CP is approximately 10% RUP and 90% RDP.

Conclusion

In situ RUP values are affected by both microbial contamination and washout and vary based on method of analysis used. Individually analyzing the forage and grain components of corn silage suggest the CP within corn silage is 10% RUP, which is much lower than previous estimates. The moisture content of corn silage at the time of harvest and the amount of time corn silage is stored continually impact protein availability with RUP values decreasing with longer ensiling times and wetter corn silage.

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