

RUMINAL MINERAL RELEASE FROM CORN AND COTTONSEED MEAL

M. S. Brown, C. D. Drager, E. M. Cochran, and E. A. Lauterbach

Division of Agriculture, West Texas A&M University, Canyon, TX and Texas Agricultural Experiment Station, Amarillo, TX

Summary

Corn and cottonseed meal were incubated up to 24 hours on replicate days in the rumen of two heifers adapted to an 85% concentrate diet. Effective ruminal degradability (assuming 4%/h passage rate) of sulfur (60 vs 51%), phosphorus (95 vs 88%), magnesium (95 vs 85%), and zinc (70 vs 33%) was greater ($P < 0.05$) for corn than cottonseed meal, respectively; degradability of calcium, potassium, and copper did not differ between substrates.

Introduction

Formulation targets for Zn and other trace minerals often reflect desired supplemental mineral addition, likely because Zn and other trace minerals in basal ingredients can be variable in content and availability. Ruminal trace mineral availability is a key prerequisite for the formation of insoluble complexes that may or may not become solubilized for absorption at the appropriate sites (Spears, 2003). Some data exist describing ruminal disappearance of forage minerals (Emanuele and Staples, 1990; 1994), but quantitative data regarding ruminal availability of Zn and other minerals in cereals or oilseed meals are not available. The objective of the present experiment was to assess in situ mineral disappearance in select dietary ingredients.

Experimental Procedures

Two ruminally cannulated heifers were adapted over a period of three weeks to an 85% concentrate diet formulated to contain 13% CP (8.25% degradable intake protein) and fed at 2% of BW. Approximately 500 g each of unprocessed corn and cottonseed meal were obtained, foreign material removed, and ground to pass a 2-mm screen. Four-gram aliquots of each feedstuff were weighed into at least duplicate nylon bags measuring 4 in x 8 in (no. R1020; Ankom Technology, Macedon, NY) and heat-sealed. One set of bags, including duplicate blank bags, was prepared for each animal for each of five incubation times. Sets of sample bags were placed in a larger mesh bag (14 in x 16 in) and mesh bags were fastened to a 24-in nylon cord fitted with a 2-lb weight (Huntington and Givens, 1997). All bags for a given animal were simultaneously inserted, and later removed after 3, 6, 9, 15, and 24 h. Zero-hour bags were not inserted into the rumen, but otherwise handled similarly. This procedure was replicated on two days, and data were later pooled across animals.

Bags were rinsed following ruminal incubation by immersion in approximately 12 gal of cold water in a washing machine, agitating for 1 minute, and spinning for 2 minutes; this process was repeated four additional times (Vanzant et al., 1998) and a final rinse used distilled water.

Samples of each substrate and in situ residues were dried at 100°C for 24 h, cooled in a desiccator, and weighed to determine DM loss. Aliquots were ashed (500°C for 12 h) and assayed for minerals. Means for each incubation time on each replicate day were tabulated as the average of both heifers.

Potential degradability was calculated using the Marquardt method in nonlinear regression (SAS Inst. Cary, NC) by fitting disappearance data to the model, $PD = a + b(1 - e^{-ct})$; where t = time, and a , b , and c are degradation constants from iteration (Orskov and McDonald, 1979). Because of difficulty in having sufficient analyte to assay indigestible minerals, extent of degradation was assumed to be 100% for each mineral. Effective degradability was determined at an assumed passage rate of 4%/h by the model, $ED = a + bc/(c + k)$ where k = passage rate and a , b , and c represent the degradation constants discussed previously (Orskov and McDonald, 1979). In situ degradation constants and effective degradability for each mineral was analyzed as a completely randomized design (SAS Inst., Cary, NC).

Results and Discussion

A thorough understanding of mineral bioavailability is needed to allow adequate dietary fortification to support optimum animal performance but minimize unnecessary mineral excretion. Although mineral content of dietary ingredients is variable in commercial production and numerous mineral antagonisms exist that influence absorption and(or) retention, our interest in the present study was to quantify ruminal availability of Zn and other minerals in corn grain and cottonseed meal; these ingredients commonly represent approximately 80% of DM in diets fed to finishing cattle.

The proportion of S determined to be soluble (including small particle loss) and potentially degradable did not differ ($P > 0.10$) between corn and cottonseed meal (Table 1, Figure 1), but the

faster rate of degradation ($P < 0.05$) for corn S resulted in a greater effective degradability ($P < 0.05$) for S in corn than in cottonseed meal. More corn P was present in the soluble fraction ($P < 0.05$) than cottonseed meal P, thus less potentially degradable P remained ($P < 0.05$) for corn than for cottonseed meal. Effective degradability of P in corn was greater ($P < 0.05$) than in cottonseed meal.

In situ characteristics of Ca and K did not differ ($P > 0.10$) between corn and cottonseed meal; effective degradability of Ca and K averaged approximately 52 and 99%, respectively. Corn Mg was more soluble ($P < 0.05$), disappeared more rapidly ($P < 0.10$), and had greater effective degradability ($P < 0.05$) than cottonseed meal Mg. In situ degradation of Cu did not differ ($P > 0.10$) between corn and cottonseed meal, and effective degradability averaged approximately 57%. Zinc in cottonseed meal was approximately 60% less soluble than Zn in corn ($P < 0.05$), and effective Zn degradability was approximately 50% less ($P < 0.05$) for cottonseed meal than for corn.

Ruminal Ca disappearance averaged 53% for corn and cottonseed meal in the present study, whereas we found K in corn and cottonseed meal to be greater than 80% soluble and completely degraded by 3 h in situ. Effective ruminal degradability of P, K, and Mg from corn or cottonseed meal in the present study was in excess of 85%, and S, Ca, and Cu effective degradability was between 50 and 60%.

Implications

Effective ruminal degradability of P, K, and Mg from corn or cottonseed meal in the present study was in excess of 85%, and S, Ca, and Cu effective degradability was between 50 and 60%. Corn Zn was approximately twice as degradable as cottonseed meal Zn.

Literature Cited

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Table 1. Characteristics of in situ mineral disappearance of whole corn and cottonseed meal^a

| Item | Corn | Cottonseed meal | SE ^b |
|----------------------------|-------------------|-------------------|-----------------|
| Sulfur | | | |
| Soluble fraction, % | 11.4 | 23.1 | 4.1 |
| Potentially degradable, % | 89.5 | 76.9 | 4.7 |
| Rate of degradation, %/h | 4.77 ^w | 2.30 ^x | 0.3 |
| Effective degradability, % | 60.2 ^w | 51.4 ^x | 0.78 |
| Phosphorus | | | |
| Soluble fraction, % | 55.8 ^w | 11.8 ^x | 3.9 |
| Potentially degradable, % | 44.2 ^w | 88.2 ^x | 3.9 |
| Rate of degradation, %/h | 33.1 | 25.9 | 3.2 |
| Effective degradability, % | 95.2 ^w | 88.1 ^x | 1.1 |
| Calcium | | | |
| Soluble fraction, % | 29.0 | 20.5 | 3.9 |
| Potentially degradable, % | 71.0 | 79.5 | 3.9 |
| Rate of degradation, %/h | 2.8 | 2.1 | 0.8 |
| Effective degradability, % | 57.7 | 47.8 | 4.1 |
| Potassium | | | |
| Soluble fraction, % | 87.3 | 85.1 | 2.2 |
| Potentially degradable, % | 12.7 | 14.8 | 2.2 |
| Rate of degradation, %/h | 43.8 | 46.9 | 10.7 |
| Effective degradability, % | 98.9 | 98.8 | 0.2 |
| Magnesium | | | |
| Soluble fraction, % | 53.0 ^w | 10.9 ^x | 4.0 |
| Potentially degradable, % | 47.0 ^w | 89.1 ^x | 4.0 |
| Rate of degradation, %/h | 36.8 ^y | 20.3 ^z | 3.3 |
| Effective degradability, % | 95.3 ^w | 85.3 ^x | 1.3 |
| Copper | | | |
| Soluble fraction, % | 23.3 | 25.8 | 14.2 |
| Potentially degradable, % | 76.7 | 74.2 | 14.2 |
| Rate of degradation, %/h | 3.6 | 2.6 | 1.2 |
| Effective degradability, % | 60.0 | 55.0 | 1.7 |
| Zinc | | | |
| Soluble fraction, % | 38.2 ^w | 14.5 ^x | 2.4 |
| Potentially degradable, % | 61.8 ^w | 85.5 ^x | 2.4 |
| Rate of degradation, %/h | 4.6 | 1.1 | 1.4 |
| Effective degradability, % | 69.9 ^w | 33.1 ^x | 5.1 |

^aSoluble fraction (a; includes small particle loss), potentially degradable fraction (b), and rate of degradation (c) were determined by nonlinear regression (Orskov and McDonald, 1979) or by linear regression procedures. Effective degradability was calculated (Orskov and McDonald, 1979) at an assumed passage rate of 4%/h.

^bn = 2

^{w, x}Means in a row with different superscripts differ, P < 0.05.

^{y, z}Means in a row with different superscripts differ, P < 0.10.

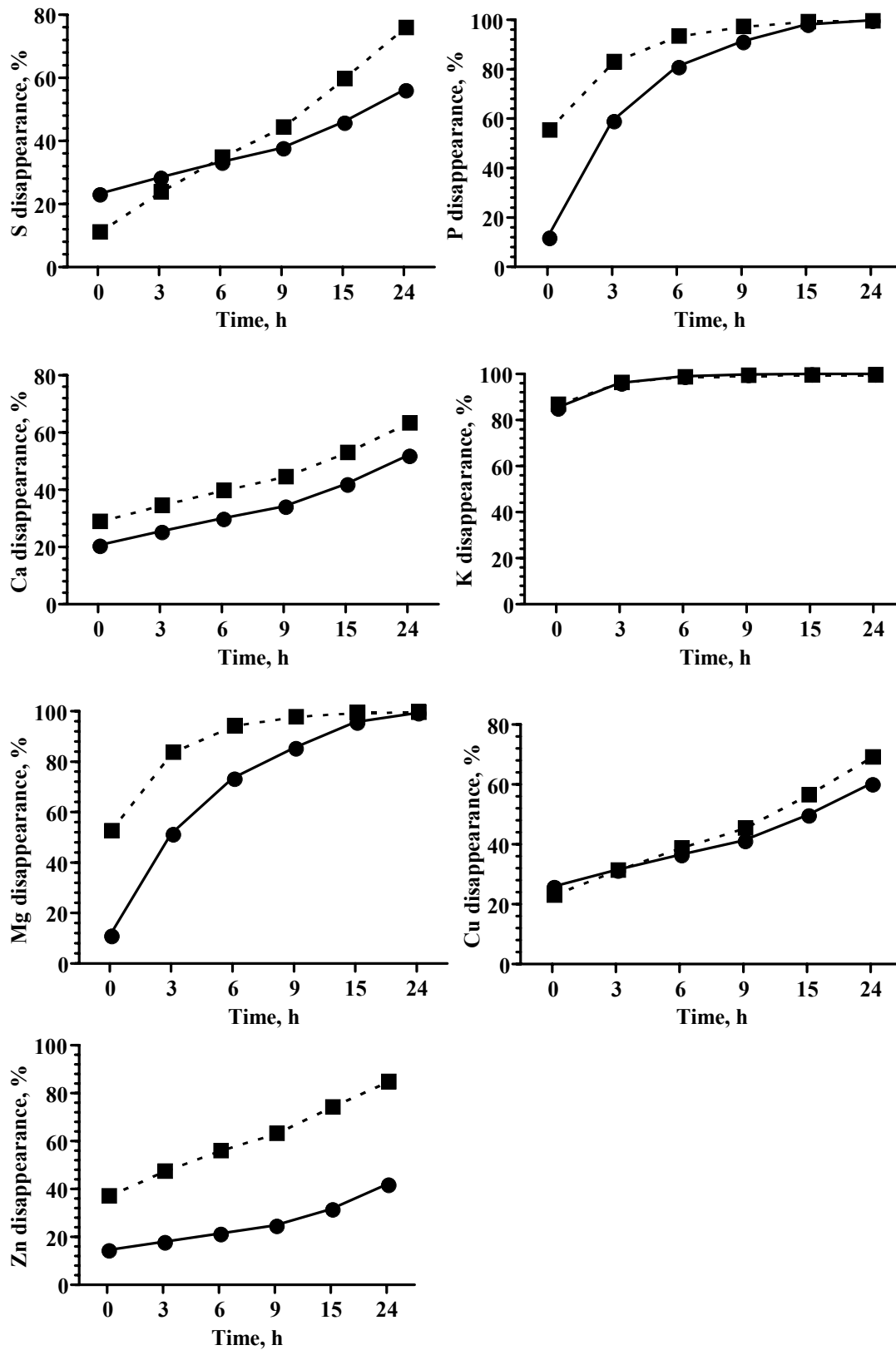


Figure 1. In situ mineral disappearance curves for corn (■) and cottonseed meal (●). Data presented were pooled across replicated days.