The Feeding Value of Heat Damaged Corn Grain in Cattle Diets

A.S. Leaflet R2591

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Summary and Implications

Heat damaged grain, if not completely destroyed by fire, takes on a roasted appearance ranging from a slight brownish tint to black. This grain can be salvaged and used in cattle rations. The color can be used to determine relative digestibility and available energy in the diets of cattle.

Introduction

Heat damaged grain can result from excessive mechanical drying or inadequate drying prior to storage. This grain may be completely lost if fire consumes it; however, in many circumstances it is not burnt but only damaged. This grain, although not acceptable in many markets, can be salvaged and utilized in cattle rations as an energy source. Depending on the extent of heating and time of exposure to the heat a discoloration will occur to the outer surface of the corn grain. Mild exposure to heat may slightly tint the outer seed coat from yellow to tan while longer exposure and/or higher temperatures will turn the seed coat black. If the inner starch of the kernel is still white to tan in color the feeding value of the grain may still be relatively good. Since grain damaged by heat is a fairly common problem this trial investigated the salvage value of this grain as an energy source in growing cattle diets.

Materials and Methods

Samples of heat damaged corn grain were collected. The kernels were separated into 7 levels of heat damage ranging from no damage, called *Level 0* to heavily charred (with a tan inner starch), *Level 6*. The break down is shown in pictures 1 through 8. Although not shown, there could be an addition level, Level 7. This level would be completely burnt all the way through the inside of the kernel and would be considered of no value. An intact sample of each damage level was sent to Dairyland Laboratories, Arcadia, WI to evaluate using Near Infrared (NIR) analysis in estimating the crude protein, starch, NDF, ADF and subsequent energy concentrations of the grain. Another sample of each level was ground, placed in dacron bags which then were set in the rumen of fistulated steers for either 24 or 48 hours. The steers basal diet was a moderate growing ration. The weight of the ground corn was measured going into and coming out of these animals and the loss of dry matter was calculated. A sample of the remaining, undigested material that was left in the Dacron bag was also sent to Dairyland Laboratories for nutrient analysis. The result of the dry matter disappearance and the estimate of post-rumen digestion was then compared to the original estimate of energy content of the undamaged grain (level 0 grain) to generate adjustment factors that could be utilized for placing a nutrient value on this grain.

Picture 1 – Level 0.

Picture 2 – Blended Damaged Corn.

Picture 1 – Level 1.

Picture 1 – Level 2.

Picture 1 – Level 3.

Picture 1 – Level 4.

Picture 1 – Level 5.

Picture 1 – Level 6.

Results and Discussion

The initial NIR analyses along with the post 48 hour rumen digestion NIR laboratory analysis results are provided in Table 1. The NIR analysis did not indicated any notable differences in corn energy content of the intact samples although it did indicate a difference in the digested material after the 48 hour incubation period. Comparing the different levels of heating to the undamaged sample indicates different patterns in rumen digestion where the less damaged grains tend to have a higher level of starch disappearance relative to the other measured components. Table 2 provides the results of total dry matter disappearance and when combining these two tables together one can see that not only is starch digested more rapidly, but the total amount of dry matte also tends to be more readily digested in the samples that are less damaged. Table 2 also provides the evidence that the extent of this digestion is dependent on the rate of passage through the rumen. Notice that the dry matter disappearance in the sample left in the rumen 24 hours is considerably lower than that sample allowed to be retained 48 hours.

Along with the measured results, Table 2 also uses two estimated values. The first is a 30 hour digestion disappearance which was the rumen retention time of grain of growing cattle based on earlier work. This value was extrapolated from the 24 and 48 hour retention data. The second is the post-rumen digestion of starch in the animal. Earlier estimates of undamaged corn place this digestion at 80%. In this trial, since we did not look at this aspect of digestion we estimated it to be somewhat less than 80%.

From this trial, it is evident that heat damaged grains are of more value to animals with lower dry matter intakes relative to body size since the rate of passage would be reduced in these animals. Thus feeder cattle or stock cows on maintenance rations would benefit the most from this grain while animals with high intakes such as high producing dairy cows would not glean as much of the potential energy due to the reduced digestion time in the rumen. It should also be noted that the basic NIR tests are not adequate in evaluating the energy content of these grains since they are not calibrated to the extent necessary to detect the effect of heat damage. The NIR evaluated grain should be adjusted by the adjustment factors given in Table 2.

One problem that must be recognized is that in many cases damaged grain is blended with grains of different levels of damage. Table 3 provides an example regarding how to utilize the information in Table 2 to evaluate a given blend of damaged grain. Note that a hand grab sample from the lot is taken and the percent of kernels falling into each level are counted. The multiplier from Table 2 is then applied to the quantity of kernels at the respective level and the weighted average is determined from which the energy content of the corn can be adjusted. Note that if the kernel is completely charred black throughout the center when broken open it is considered of no value and the multiplier value would be zero.

Table 1. NIR laboratory analysis.

Sample	Intact Corn Sample					Corn Sample-post rumen***		
	NE m Mcal/cwt		Starch	adj. CP	NDF	Starch	adj. CP	NDF
	OARDC*	ADF*	%	%	%	%	%	%
#2 –no damage	92	90	71.0	7.9	7.1	43.0	9.5	29.1
Blended	91	89	69.3	8.3**	7.1	68.4	10.2	7.3
Level 1 HD	91	91	67.2	8.5	8.8	55.9	10.1	18.9
Level 2 HD	92	90	67.4	8.7**	7.0	-	-	-
Level 3 HD	92	90	69.5	9.2	7.0	64.2	12.2	14.0
Level 4 HD	92	90	70.9	8.9	6.5	71.0	11.0	9.2
Level 5 HD	92	90	68.0	8.6**	6.7	-	-	-
Level 6 HD	90	89	69.7	7.1**	7.8	67.8	9.9	7.0

* Net Energy-maintenance (NE m) values for heat damaged grain calculated using the ADF and Ohio Agriculture Research and Development Center (OARDC) methods**.**

** NIR analysis appeared to detect some heat damage and adjusted crude protein downward.

*** NIR analysis ran on post rumen digested corn grain samples.

Table 2. Digestion results and subsequent NEg adjustment.

Sample	Test Wt.	Percent Digested in the Rumen 24 hr	48 hr	est. 30 hr digest	Mcal/cwt NE g*	% of Normal	Mcal/cwt NE g **	%	**** % of Normal
#2 –no damage	56	91.03	96.26	92.34	65.23	100.0	65.23	(.8) ***	***100.0***
Blended	55.4	61.38	78.40	65.64	45.98	70.5	57.67	(.7)	***88.4***
Level 1 HD	56	91.99	97.57	93.39	65.37	100.2	65.47	(.75)	***100.4***
Level 2 HD	54.7	81.13	94.25	84.41	60.30	92.5	63.79	(.72)	***97.8***
Level 3 HD	54.1	71.89	91.13	76.70	53.50	82.1	60.21	(.7)	***92.3***
Level 4 HD	54.1	59.74	81.78	65.25	42.50	65.2	55.04	(.7)	***84.4***
Level 5 HD	52.2	55.25	78.98	61.19	41.10	63.1	54.82	(.7)	***84.0***
Level 6 HD	51.6	60.50	79.14	65.16	46.34	71.0	58.10	(.7)	***89.1***

* Net Energy gain (NEg) of remaining starch, protein and fiber calculated after 30 hour rumen digestion and divided by #2corn standard . These values are only based on rumen digestion. Post rumen digestion was not estimated on the heat damaged samples in this estimate.

** NEg of remaining starch, protein and fiber calculated after 30 hour rumen digestion and divided by #2 standard and an estimate of post rumen utilization of starch was included.

*** Adjustment factor (in percent) used to estimate starch digestion post rumen – this number is an estimate based on a reference that stated normal corn starch digestion post rumen is approximately 80%. The decreased digestion rate (.75 to .7) for the heat damaged grain was estimated.

**** Use the lab estimate of NE m and NE g times this percent when indicating energy content of the corn sample.

Table 3. Sample calculation.

Corn Sample – grab sample of 200 corn kernels from lot

	% of Kernals	Multiplier	Result	Sum of Results
Level 0	0	100.0	0	9049.5
Level 1	20	100.4	2008	
Level 2	10	97.8	978	
Level 3	15	92.3	1384.5	
Level 4	20	84.4	1688	
Level 5	25	84.0	2100	
Level 6	10	89.1	891	

**"Level"* indicates level of heat damage as shown in pictures 1 through 8.

Weighted Average	Normal NEm	Adjusted NEm
9049.5 / 100= 90.5	1.00 Mcal/lb	1.00 x .905 = 0.905 Mcal / lb
	Normal NEg	**Adjusted NEg**
	0.65 Mcal/lb	0.65 x 0.905 = 0.588 Mcal / lb

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