Manureology 101

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Dairy managers watch manure changes as a guide when making feed changes and evaluating rations. Fresh, undisturbed piles of feces or droppings may provide valuable clues and should be part of your tool box when evaluating the nutritional status of the dairy herd. Four aspects of manure evaluation can be considered to be part of your tool box.

Washing manure samples

Washing manure through a screen (6 to 8 squares to the inch) allows the dairy manager and nutritionist to quickly find or "see" if feed processing and digestion is optimal. Take a cup of fresh manure and wash it with a stream of warm water (cold water takes longer) through the screen removing the digested material. It typically takes about 30 seconds if your screen has sides allowing for more water pressure. Look for the following remaining feed particles. Finding pieces of barley or corn grain with white starch remaining indicates that some feed value was lost. If the seed and starch pieces are hard, additional grinding or processing may be needed to expose the starch to rumen microbial fermentation or lower gut enzymatic digestion. Corn kernels from corn silage reflect that the seed was too hard for digestion and chewing by the cow. Mature and dry corn silage can cause this observation as grain is hard. Some corn silage varieties can be selected for softer kernels allowing for more digestion. Whole cottonseeds or soybean splits (half of a soybean seed) that appear in the washed manure reflect a loss of feed nutrients. The cottonseeds are not caught in the rumen mat and do not allow for rechewing. If roasted soybean seeds are hard, they must be processed finer. Wisconsin workers suggest breaking soybeans into fourths or eighths. Forage particles over ½ inch long may reflect a lack of long forage particles to maintain the rumen mat and adequate cud chewing. A higher rate of passage reduces the time needed in the rumen to digest the fiber properly. The Cargill Manure Separator (NASCO Digestion Analyzer) is commercially available through NASCO (price is $195 plus shipping and handling). Users can decide to use the top screen only or two to three screens depending on time and personal bias and experience.

Scoring manure

Michigan workers developed a scoring system to evaluate fresh manure. Consistency is dependent on water and fiber content of the manure, type of feed, and passage rate. A

scale of 1 to 5 is listed below with a score 3 optimal.

- Score 1. This manure is very liquid with the consistency of pea soup. The manure may actually "arc" from the cow. Excess protein or starch, too much mineral, or lack of fiber can lead to this score. Excess urea in the hindgut can create an osmotic gradient drawing water in the manure. Cow with diarrhea will be in this category.

- Score 2. This manure appears runny and does not form a distinct pile. It will measure less than on inch in height and splatters when it hits the ground or concrete. Cows on lush pasture may have this manure score. Low fiber or a lack of functional fiber can also lead to this manure score.

- Score 3. This is the optimal score! The manure has a porridge-like appearance, will stack up 1 ½ to 2 inches, have several concentric rings, a small depression or dimple in the middle, make a plopping sound with it hits concrete floors, and it will stick to the toe of your shoe.

- Score 4. The manure is thicker and stacks up over 2 inches. Dry cows and older heifers may have this type of manure (this may reflect that low quality forages are fed and/or a shortage of protein). Adding more grain or protein can lower this manure score or improve forage quality.

- Score 5. This manure appears as firm fecal balls. Feeding a straw-based diet or dehydration could contribute to this score. Cows with a digestive blockage may exhibit this score.

Manure scores 1 and 5 are not desirable and may reflect a health problem besides dietary limitations. Score under score 2 and over score 4 manure scores may reflect a need to rebalance the ration. As cows progress through their lactation, manure score may also shift as outlined below.

- Early lactation cows (2 ½ to 3)
- Late lactation cows (3 to 3 ½)
- Far off dry cows (3 to 4)
- Close up dry cows (3 to 3 ½)

Increasing the amount of degradable, soluble, or total protein, deceasing the amount or physical form of the fiber; increasing starch level, decreasing grain particle size (such as fine grinding or steam flaking), and consuming excess minerals (especially potassium and sodium) can cause manure scores to decline.

A University of Illinois study investigated relationships between dairy fecal scores and physical fiber property based on manure score, fiber particle size, and fecal dry matter content. Fecal samples were collected with 17 pooled fecal samples from 42 dairy cows based on their fecal score (1 to 5). After collecting fresh samples over three weeks, the samples were labeled, mixed, washed, and dried. The amount collected was 500 g of

manure per sample. For samples less than 500 g, an adjustment was calculated to correct to 500 g. Each sample was collected based on its manure score and given a letter assigned (A-F). Samples were washed using warm water with a Cargill Manure Separator containing three stainless steel screens (3/16, 3/32, and 1/16 inch hole openings). The fibrous fraction on each screen was oven dried for two days at 45 degrees centigrade. Each sample was weighed and recorded. Individual samples and fecal score summary were listed in table 1.

Total dry matter in samples increased as manure score increased. The percentage of dry matter on the top screen (the largest particle size) increased as manure score increased (Table 2) while the percent of dry matter on the bottom and middle screens decreased. The number of whole fuzzy cottonseeds found in the feces samples increased as fecal scores increased. During week two of manure collection, the ration contained 50 percent less fuzzy cottonseed (2.5 pounds compared to 5 pounds). This decrease was reflected in the number of whole fuzzy cottonseeds found in the fecal samples in week two.

Manure color

The color of manure is influenced by feed, amount of bile, and passage rate. Manure from cows on pasture is dark green while hay-based rations are brown. Manure from high grain-based diets is more gray-like. Slower rates of passage cause the color to darken and become more ball-shaped with a shine on the surface due to mucus coating. Score 1 may be more pale due to more water and less bile content. Hemorrhage in the small intestine causes black and tar-like manure while bleeding in the rectum results in red to brown discoloration or streaks of red.

Fecal starch evaluation

As corn prices have increase, the need to optimize the starch digestibility in the dairy cow continues to important. Kernel or plant processing corn silage, grinding corn grain (900 to 1100 microns), *invitro* rumen starch fermentation values, level of prolamin (type of protein related to vitreousness), and the NRC energy values based on the rumen model program illustrate the important of total tract starch digestibility. University of Pennsylvania published a formula to predict total tract starch digestibility using fecal starch and fecal lignin along with ration starch and lignin. Lignin was used as a marker to estimate starch utilization. This approach could be useful to evaluate starch utilization on farms. The Pennsylvania data concluded that for each increase in fecal starch, the potential loss in milk yield was 0.7 pound per day with a range of 4 to 10 percent starch in group or herd values. Cumberland Valley Lab analyzed 1420 fecal samples with starch content ranging from 0.20 to 38.9 percent with 62 percent containing less than five percent starch. Rock River Lab reported 52 samples averaged 7.9 percent starch with an apparent total tract digestibility of 84.8 percent.

An Illinois field study using nineteen Holstein herds in southwestern Illinois evaluated the fecal starch digestion using the Pennsylvania equation. The manure samples used in this project were taken from undisturbed, fresh pies in the cow lot. On average, four to

five pies were sampled, mixed together, and placed into the quart sized containers supplied by Rock River Lab. They were refrigerated until all samples were collected and shipped by UPS to the lab using cold packs to prevent the samples from bursting out of the containers in transit. Rock River Labs conducted feed and fecal starch and NDF analysis. Results were statistically analyzed using SAS software to evaluate feed and fecal results and statistically determine which parameters were significant in predicting a prediction model for starch digestibility.

Table 2 summarizes data collected at each farm illustrating variation from farm to farm. Table 3 summarizes the average, standard deviation, and range associated with each variable evaluated. Milk yield was converted to 3.5% fat-corrected milk using plant milk fat test. Feed values were calculated using rations balancing software and forages tested results. The equation from University of Pennsylvania used to estimate starch digestibility is listed below that calculated starch total tract digestibility values in Table 2.

> Percent starch apparent digestibility = 1 – ((% lignin in feed x % starch in feces) / (% lignin in feces x % starch in feed))

When entering all variables in Table 4, fecal starch and fecal NDFD were the two variable that were correlated with a $P < 0.01$ to calculated starch digestibility. Statistical trends ($P > 0.05$) were observed for feed NDF levels and fecal dry matter content. Based on the statistical evaluation, the following Illinois prediction equation was developed:

> Percent starch apparent digestibility = 0.9373 – (0.0261 x fecal starch) + (0.0091 x fecal lignin).

The R-squared value for the equation was 73 indicating 73 percent of the variation in starch digestibility can be explained by the equation and variable used with $P < 0.0001$. The equation must be used with care as the values are based on 19 Holstein herds, the manure samples procedure, and analytical lab procedures. Additional studies are needed to confirm and/or refine the equation. Dairy managers and consultants may want to add fecal starch and fecal lignin analysis to monitor starch utilization by their dairy herd.

The cost of fecal starch analysis is $15 to $20 per sample. The recommendation is to pool fecal samples from 10 to 15 cows and submit a mixed sample requesting fecal starch. Fecal starch can be another tool to evaluate total track starch utilization.

Selected References

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Table 1. Summary of fecal score group results.

	Score	Score	Score	Score
Fecal score	1	2	3	4
Total number of samples	3	4	6	4
Total number of cows	3	12	19	8
Average percent DM on top screen	7%	18%	24%	24%
Average percent DM on middle screen	28%	24%	25%	20%
Average percent DM on bottom screen	65%	58%	51%	56%
Average total DM	15.6 g	22.6 g	26.6 g	27.3 g
Average number of fuzzy cottonseeds/sample	0.7	2.8	2.6	8.6

Table 2. Summary of data collected on each farm.

Farm	Fecal Data				Feed Data			Production				Starch Dig
	Starch	NDF	Lignin	DM	Starch	NDF	Lignin	DMI (lb)	CS (lb)	Milk (lb)	Fat (%)	(% total)
	---------%(DM basis)----------				----% (DM basis)-------							
1	3.89	77.9	7.85	26.0	21.8	32.8	3.49	51.5	16.9	65	3.8	92
2*	4.19	50.2	4.85	15.8	25.4	31.5	3.14	52.6	10.2	65	3.5	89
3	4.29	53.5	3.67	15.6	21.5	34.4	3.19	47.0	22.7	60	3.9	83
4	4.40	53.6	15.8	17.0	20.4	34.3	3.47	50.4	10.8	60	3.7	95
5 **	4.97	54.3	5.66	14.5	23.8	34.6	2.85	52.2	19.4	80	3.8	89
6 **	5.16	55.5	4.47	16.3	20.8	32.5	2.89	52.8	19.4	72	3.7	84
7	5.16	57.1	19.2	30.3	21.6	32.7	3.54	44.3	12.9	50	4.0	96
8 **	5.38	57.9	4.89	14.0	21.8	31.9	3.35	50.6	12.9	70	3.8	83
9.	5.66	59.9	4.66	17.8	26.4	33.7	2.52	52.6	13.3	64	3.9	88
10	5.82	56.5	5.50	14.8	20.1	32.9	3.40	52.4	12.9	75	3.5	82
11	5.90	56.9	4.82	17.6	23.9	34.8	3.00	51.6	17.1	68	3.7	85
12* **	6.08	58.7	4.76	???	25.7	32.3	3.66	49.5	16.5	60	3.6	82
13	7.02	52.1	6.26	17.6	21.8	34.4	3.08	51.8	12.2	70	3.8	84
14	7.04	53.7	4.87	16.4	23.1	32.3	3.12	51.8	18.6	65	3.8	80
15	7.08	54.75	4.62	14.8	21.6	30.1	3.73	51.8	11.9	84	3.5	74
16	7.34	50.8	4.86	17.0	19.9	31.5	3.68	52.1	8.3	60	3.6	73

17**		9.20	50.7	8.77	15.2	25.0	32.2	3.41	51.3	8.0	60	4.0	86
18*	**	9.89	47.5	6.50	17.1	20.8	29.8	4.10	50.5	11.6	65	3.4	70
19*	**	6.21	53.4	15.4	16.4	20.8	29.8	4.10	50.5	11.6	65	3.4	92

* Added straw
** Added molasses

Table 3. Mean, standard deviation, and range of variable measured on nineteen Illinois dairy farms.

Variable	Mean	Std Dev	Min	Max
Starch digestibility (%)	84.6	7.0	70	96
Fecal starch (%)	6.0	1.6	3.9	9.9
Fecal lignin (%)	7.2	4.4	3.7	19.2
Fecal NDF (%)	55.5	6.3	47.5	77.9
Fecal dry matter (%)	17.5	4.1	14.0	30.3
Feed starch (%)	22.4	2.0	19.9	26.4
Feed NFD (%)	32.6	1.6	29.8	34.8
Feed lignin (%)	3.4	0.4	2.5	4.1
Fat correct milk (lb)	68.0	7.6	53.8	83.7
Dry matter intake (lb)	50.9	2.1	44.3	52.8
Corn silage (lb)	14.1	4.1	8.0	22.7

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