Key Points in Harvesting and Storing High Moisture Corn

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Abstract

There are key management decisions involved in harvesting and storing of high moisture corn products. Harvesting and storing of high moisture corn is a common practice on many dairy operations. Recently the dairy industry has witnessed tremendous increases in corn grain prices, grain drying cost, and fluctuations in milk prices. These have greatly increased the cost of corn grain in dairy rations and impacted dairy farm profits. This should be motivating dairy producers and their nutritionist to review their management decisions on the key points involved with the harvesting, processing, and storage of high moisture corn products. With the current economic situation, dairy operations can not afford mistakes involved in the harvesting and storage of high moisture corn. The high moisture corn products that will be covered in this paper are: high moisture shelled corn, high moisture ear corn, and snaplage (kernels, cob, husk, and some upper plant material).

High Moisture Corn Products: Shelled Corn, Ear Corn, Snaplage

These 3 products are harvested differently, resulting in the products having different nutrient compositions, in particular, the percentages of starch and neutral detergent fiber **(NDF)** (Table 1). Which product or combination of products to use will depend on an individual farm business's situation and the herd's feeding program. Also, keep in mind that dry shelled corn fits well into a feeding program with a high moisture corn product and should be included in a farm's cropping and feeding program planning process.

High moisture shelled corn is the easiest to define. It is harvested with a combine or picker-sheller at a kernel moisture range of 24 to 36%. The corn can be processed using a roller mill or grinder before going into storage or it can go into storage unprocessed depending on the type of storage system.

Ear corn is harvested at a kernel moisture range of 24 to 36% with a combine that is adjusted to allow some of the cob to go with the kernels into the combine's bin and is then processed using a roller mill or grinder. A corn picker that husks the cob but retains the kernels on the cob can also be used for harvesting.

Snaplage is harvested with a forage chopper equipped with a kernel processor and a snapper head that is designed to harvest the cob, kernels, husk and some of the upper corn plant material. Snaplage is harvested at kernel moisture ranges of 24 to 34%. At that kernel moisture range, the combined material of cob, kernel, husk, and upper plant parts will have a moisture range between 49 to 67%. Snaplage, because it contains cob, kernels, and upper plant parts, has a nutrient starch and NDF composition between high moisture shelled corn and corn silage (Table 1). Snaplage has recently gained

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popularity in some regions of the US because fall weather conditions have not allowed corn grain to dry sufficiently in the field to allow a combine to adequately husk and remove the grain from the cob. This resulted in large field losses because harvesting conditions deteriorated to an extent that some farm operations never harvested the corn designated for shelled corn. Another plus for snaplage is it allows a dairy operation and custom harvesters to more fully utilize their forage harvester (Mahanna, 2008; Lardy and Anderson, 2010).

Harvesting: Moisture is Key Point

Kernel moisture is the key indicator of when corn kernels have reached physiological maturity and maximum starch composition. This occurs at approximately 25 to 28% kernel moisture. Black layer formation at the kernel tip is a visual indicator of physiological maturity and also occurs at that moisture range. The most accurate and simplest method for determining when to harvest corn for high moisture grain, ear corn, or snaplage is to use a moisture tester. Moisture as the corn product goes into a storage system effects how well the ensiled corn product will ferment, the concentration of fermentation acid production, and how well spoilage will be controlled during storage and feed out. Recommended kernel moisture ranges for different high moisture corn products and storage systems are outlined in Table 2. For high moisture ear corn, note that the cob contains about 20% more moisture than the kernels, and this is important to understand when harvesting, storing, and feeding of high moisture ear corn (Table 3).

Harvesting at wetter than recommended moisture ranges can result in excessive fermentation end-product production that can result in increased starch digestibility, to an extent that may limit the amount of high moisture corn that can be included in a ration in order to control digestive tract disorders. This increase in starch digestibility occurring during storage increases when corn is ensiled at increasing higher moisture and also with increasing number of days in storage (Allen et al., 2003; Hoffman et al., 2010). Conversely, harvesting at dryer than recommended moisture ranges can result in insufficient fermentation acid production required to control spoilage during storage and at feed out.

Processing

High moisture shelled corn harvested with a combine is typically processed going into storage because processing post storage is difficult with bunker and bagged storage. However when stored in a sealed silo, the corn is often stored whole and processed before feeding. Two methods of processing are rolling and grinding. With rolling, the kernels are cracked into multiple pieces, trying to limit the amount of fines. Grinding usually results in a much finer material than with rolling. Ear corn harvested with a picker will be processed by grinding as it goes into storage. Snaplage processing is accomplished by setting the kernel processor so that all kernels are broken. This may require different rollers than for corn silage.

Processing before storage is needed to reduce particle size, which helps achieve good packing and air exclusion that is necessary for a good fermentation process. Processing can also increase starch digestibility. Excessive processing results in more fines, which may result in increased starch digestibility occurring during storage, to an extent that feeding rates may need to be limited, especially if the corn is harvested at higher than recommended moisture levels (Bolinger, 2008; Firkins, 2008).

Inoculants

There are good reasons for considering inoculating high moisture corn as it goes into storage. First (1), harvest occurs in the fall when temperatures are cooler than when corn silage was harvested. This results in a lower population of natural bacteria residing on the corn plant material and particularly on corn kernels in the field. And (2), high moisture corn kernels do not contain very much sugar that ensiling bacteria use as a substrate for fermentation. That is quite different than with corn silage that contains sugar concentration in the stalk, which supports a vigorous ensiling fermentation. With high moisture corn, the sugars have been converted in the kernels to starch, a complex sugar matrix. These above 2 factors contribute to a slower rate of fermentation and a lower concentration of fermentation acid production. The fermentation acids are needed for high moisture corn to remain stable during storage, feedout, and in the feed bunk. Inoculants can increase rate of fermentation, reduce DM losses, and increase aerobic stability at feed out and in the feed bunk.

Aerobic instability, heating, and spoilage at feed out and in the feed bunk is due mainly to yeast metabolism. Yeast are naturally present on the corn plant and kernels in the field and accompanies the plant material into storage. Yeast become active when air (oxygen) enters the corn due to mechanical disruption of the face or top of the storage system during feed out. The bacteria during the ensiling fermentation produce acids, primarily lactic acid, which acidify the grain, resulting in the pH to decrease to < 4.5. At this pH, microbial activity stops and the ensiled material remains relatively stable until feed out, when air is allowed to enter. As air enters, yeast metabolism and numbers increase. Yeast metabolize the lactic acid, producing CO_2, water, ethanol, and heat and an increase in pH. This all contributes to an unstable high moisture corn feed ingredient.

Fermentation analysis of high moisture corn products is shown in Table 4. Corn silage was added to the table for comparison purposes. Note the difference in: pH, total VFA, lactic acid, and acetic acid between the high moisture corn products and corn silage. Corn silage has a higher concentration of VFA, lactic acid, and acetic acid, along with a lower pH, that resulted from the corn silage's more vigorous fermentation. This helps corn silage to be more stable during storage and at feed out, as compared to high moisture corn products.

Which inoculant to use? There are a number of commercially available inoculants specifically developed for high moisture corn. Producers and nutritionists should base their choice on a company providing research data that supports their inoculants' effectiveness.

There are 2 types of bacterial inoculants: homofermenters and heterofermenters. Homofermenting bacteria produce a single acid, mainly lactic acid. Heterofermentering bacteria produce multiple acids, mainly lactic and acetic acids. Acetic acid inhibits yeast growth, reproduction, and metabolism. Choosing an inoculant that produces both acetic and lactic acids is desirable. Lactobacillus buchneri is a heterofementing bacterial species that produces both lactic and acetic acids. A number of companies have available inoculants containing Lactobacillus buchneri.

Inoculant application rates are based on "colony forming units" **(cfm)** per gram high moisture corn. Typical application rates range from 100,000 to 500,000 cfm/g. The company supplying the incoulant will provide application rate recommendations, along with storage, mixing, and care of their incoulant products. Incoulants are applied by spraying them onto the corn at the harvester, roller mill, or grinder. (Hoffman and Muck, 2011: Kung, 2011)

Storage

Storage systems should be filled as rapidly possible. Bunkers should be packed well to exclude air and covered with a plastic type material as soon after filling as possible. In addition to covering the top of bunkers the side walls should also be lined to prevent rain water from entering into the bunker (Borreani et al., 2007; Kung, 2011).

Feed out removal from a storage unit needs to be sufficient to prevent heating, especially when ambient temperatures are warm or hot. Often, the surface area of a bunker face is too large to allow a sufficient amount of high moisture corn to be removed on a daily basis to keep ahead of heating and spoilage. Also, bunkers are often constructed too wide, making the feed out face too large to allow for keeping ahead of spoilage.

Sizing a bunker before construction or filling it is a good management decision. Using movable cement blocks to form a side wall can allow producers to custom design the width of a bunker to allow sufficient amount of high moisture corn to be removed per day to help prevent spoilage.

Often, the face of a bunker is determined to be too wide to keep ahead of spoilage. So in an attempt to fix the problem, the bunker is split by removing a smaller width slice the length of the bunker. This is not a good fix because now the area exposed to air is the slice face that is not currently being fed, this can become quite a large surface area, depending on the length and height of the slice. The surface area of the slice will appear to be only spoiled on the surface, but digging into face will reveal extended spoilage.

Feeding Trial with Snaplage

A snaplage feeding trial with lactating cows was recently completed at the University of Wisconsin, and the results are available in a slide presentation (Akins and Shaver. 2012).

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Table 1. Nutrient composition of different corn products[1].

	Product							
	HMSC[2]		HMEC[2]		Snaplage		Corn Silage	
Nutrient Composition[3]	Mean	Range	Mean	Range	Mean	Range	Mean	Range
DM, %	71.6	65-78	63.6	55-72	58.6	50-67	33.7	24-44
CP, %	8.9	8-10	8.2	7-9	8	7-9	8.2	7-9
NDF, %	10.2	8-13	9.5	6-13	24.1	18-30	43.8	38-50
Lignin, %	1.1	0.8-1	1.6	1-2	1.8	1-2	3.3	3-4
Starch, %	70.7	67-74	60.1	53-67	56	49-64	31	24-39
IVTD-30 h, % DM	94.0	90-98	89.3	85-97	88.9	85-93	82.8	79-86

[1]Source: Dairy One Forage Laboratory, Ithaca, NY.
[2]HMSC = High moisture shelled corn and HMEC = high moisture ear corn.
[3]DM = Dry matter, CP = crude protein, NDF = neutral detergent fiber, and IVTD = in vitro total digestibility.

Table 2. Kernel moisture (%) and dry matter (%) recommended ranges going into storage based on product and storage system.[1]

	Storage System							
	Top-Unloading Silo		Bunker		Bag		Sealed Silo	
Product	Moisture	DM	Moisture	DM	Moisture	DM	Moisture	DM
Shelled corn, processed	26-36	64-74	26-36	64-74	26-36	64-74	24-32	68-76
Shelled corn, un-processed	-	-	-	-	-	-	24-32	68-76
Ear corn, kernels only	26-36	64-74	26-36	64-74	24-30	70-76	26-36	64-74
Snaplage, kernels only	26-34	66-74	26-34	66-74	26-34	66-74	24-30	70-76
Snaplage, all material	33-50[2]	50-67[2]	33-50[2]	50-67[2]	33-50[2]	50-67[2]	33-50[2]	50-67[2]

[1]Data from: Rankin (2009) and Pioneer Hi-Bred International (2011).
[2]Anecdotal by Bucholtz.

Table 3. Approximate moisture content of kernel, cob and the whole ear.[1]

Kernel moisture (%)	Cob moisture (%)	Whole ear moisture (%)
24	44	29
26	46	31
28	48	33
30	50	35
32	53	37
34	55	39
36	57	41
38	59	43
40	60	45

[1]Source: Mader and Erickson (2006).

Table 4. Fermentation analysis of different corn products.[1]

	Product							
	HMSC[2]		HMEC[2]		Snaplage		Corn Silage	
Component	Mean	Range	Mean	Range	Mean	Range	Mean	Range
pH	4.7	4.0-5.0	4.4	3.7-5.1	4.3	3.7-4.8	3.9	3.5-4.3
Ammonia N, % total N	3.9	1.0-6.7	4.7	1.2-8.3	4.6	1.0-8.2	7.0	2.9-11
Total VFA, % of DM	1.4	0.3-2.5	2.1	0.8-3.4	2.2	0.6-3.8	7.9	4.6-11
Lactic Acid, % of DM	1.0	0.1-1.8	1.4	0.5-2.3	1.6	0.4-2.9	4.7	2.5-6.9
Acetic Acid, % of DM	0.3	0.0-0.7	0.5	0.0-1.1	0.4	0.06-0.9	2.3	0.8-3.8
Propionic Acid, % of DM	0.03	0.0-0.09	0.03	0.0-0.09	0.009	0.0-0.01	0.2	0.0-0.6

[1]Source: Dairy One Forage Laboratory, Ithaca, NY.
[2]HMSC = High moisture shelled corn and HMEC = high moisture ear corn.
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