

MAKING HIGH CORN SILAGE DIETS WORK

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Corn silage is a commonly used source of forage in Minnesota dairy rations. Minnesota dairy producers feed anywhere from just a few pounds of corn silage per cow per day to 100% of the forage source as corn silage, but most producers feed between one-third and two-thirds of the forage dry matter (DM) as corn silage. Both economical value and milk production yield from corn silage are important factors in assessing how much corn silage to feed. Hybrid, agronomic practices, growing conditions, harvest time and method, fermentation and diet formulation all affect the feeding value of corn silage. This paper will look at hybrid effects, harvesting and diet formulation effects on the feeding value of corn silage. This paper will not discuss agronomic practices associated with growing corn for silage.

Corn Silage Hybrids

There are many corn hybrids that can be grown for silage. The best hybrid is the one that is most profitable for the dairy farm. Profitability is related to hybrid cost, yield, nutrient content and DM intake potential. In general, the most profitable hybrid will be one that maximizes income over feed cost for the dairy. This implies corn silage can be grown or purchased at a lower cost than other forages or feed ingredients and/or milk production is higher when corn silage is fed compared with other ingredients.

Silage production costs. The cost of producing corn silage is mainly related to differences in seed cost and yield. Planting, fertilization, weed and pest control along with land value also are cost factors, but beyond the scope of this paper. Harvest costs on an acre basis are probably similar across hybrids, but will vary when figured on yield basis. Therefore, the principle determinates of corn silage production cost are seed cost and yield with higher yielding hybrids having a lower cost than a lower yielding hybrid at equal seed cost.

Nutritive value. The nutritive value of corn silage is dependent on nutrient content and digestibility of the nutrients. MILK2000 is an index method developed by agronomy and dairy scientists at the University of Wisconsin that evaluates corn silages based on DM yield and energy content. A spreadsheet for calculating MILK2000 is available at www.wisc.edu/dysci. The energy calculation is based on the amount and estimated digestibility of the crude protein (CP), neutral detergent fiber (NDF), starch and non-starch components and fat content of the corn silage. The starch and non-starch digestibility estimate considers the effect of whole plant DM content and silage processing on kernel starch availability. The NDF digestibility is estimated from an in vitro measurement rather than calculated using a lignin based equation (Schwab and Shaver, 2001).

MILK2000 is a good way of comparing corn silage hybrids as it considers the two most important factors related to profitable corn silage feeding: silage yield and nutrient availability. The limitation is using MILK2000 is the energy calculation as it is only as good as the inputs that go into the equation. Methods for accurately measuring or predicting (NIR) NDF digestibility and starch digestibility are the current limitations.

Pricing corn silage. The price of corn has generally been the basis used to derive a price for corn silage. A commonly used formula is: 10 times the bushel price of corn equals the price of a ton of corn silage at 35% DM. The problem with a corn based pricing method is it does not give any credit to the forage portion of corn silage which averages 50% of the DM. A more recent formula has been developed in an attempt to give value to both the grain and forage portions of corn silage and differentiate the price of corn silages based on starch and fiber content (Linn, 2002). The formula is based on the starch content of the corn silage and the NDF digestibility. The formula calculating the price of a ton of corn silage DM is: \$/ton DM = Base price/ton DM + Starch Adjustment + NDF Adjustment. Adjustments and examples are as follows:

Starch Adjustment = ((% starch (DM basis) – 29%) x .5 bushels) x corn \$/bushel

Example - 26% starch and corn price of \$2.40/bushel

Adjustment = ((26 – 29) x 0.5) x \$2.40 = -\$3.60/ton silage DM

NDF digestibility Adjustment

Example 59% NDF digestibility (48 hour in vitro) and milk at \$13.50/cwt

Adjustment = 59% x .6 x .1350 = \$4.78/ton silage DM

Base price - established based on planting, seed, agronomic and harvest costs

Example - \$20/ton at 33% DM = \$60.60/ton DM

\$/ton of corn silage DM = Base + Starch Adjustment + NDF dig Adjustment.

= \$60.60 + (-\$3.60) + \$4.78

= \$61.78/ton DM or \$20.39/ ton at 33% DM

Effect of hybrid on milk production. In recent years, the focus of corn silage research has been on three types of hybrids; low lignin (brown midrib, BMR), leafy (2 to 4 more leaves above the ear) and high oil (4 to 7% oil in silage). Milk production and DM intakes from some recent studies with these hybrids are summarized below.

Brown midrib (BMR). A summary of studies (Greenfield et al, 2001; Oba and Allen, 1999; Nennich et al, 2001; Ballard et al., 2001; Bal et al., 2000; Eastridge, 1999) show cows fed BMR silage ate an average of 3.4 lb more DM and produce 3.5 lb more milk per day than cows fed isogenic BMR or other hybrid silages. Digestibility of BMR silage is greater at equal DM intakes than other silages (Tine et al., 2001) however; the effect of decreasing energy content of a diet or feed with increasing DM intake minimizes any energy advantage for BMR. The available studies strongly suggest the increased milk production from feeding BMR corn silage is from an increased DM intake and not an increased energy

content of the silage. Nutrient content of BMR corn silages is generally similar to silages made from other corn hybrids.

Leafy corn silages. In six studies (Bal et al., 2000; Ballard et al., 2001; Clark et al., 2002; Kuehn et al., 1999; Nennich et al., 2003; Thomas et al., 2001) comparing leafy corn hybrid silages with other corn silages, cows fed leafy silages consumed 0.3 lb less DM and produced 0.5 lb more milk per day than cows fed other silages. There was no overall nutrient (CP, NDF, NFC) composition difference and no energy difference between leafy and the hybrids it was compared to based on equivalent DM intakes and milk production responses. Thus, any advantage for leafy hybrids over other corn hybrids is probably in DM yield or agronomic trait rather than dairy cow performance.

High oil corn silages. Three studies have compared high oil silages to conventional grain silages (Dhiman et al., 1999; Weiss and Wyatt, 2000; Minnesota 2001, unpublished). Results from these studies indicate cows fed hi oil corn silage diets ate an average of 3.1 lb more DM and produced 3 lb more milk per day than cows fed conventional grain silages. The higher fat content of the high oil silage, 1 to 3%, increased the energy content of the corn silage, but energetic efficiency for milk production was not increased as cows ate 3 lb more DM to produce 3 lb more milk.

Harvest and Storage

Corn silage should be harvested based on kernel milk line and moisture content of the whole plant. Harvesting should be done when milk line is 1/3 to 1/2 and whole plant moisture content is 63 to 68%. Research from Wisconsin (Bal, et al., 1997) in Table 1 shows the changes in nutrient content of corn silages with increasing milk line and decreasing moisture content. Maximum starch content and a constant NDF content is reached by 2/3 milk line. Further maturing of the plant only decreases the digestibility of both fiber and starch.

Table 1. Effect of milk line on nutritive value of corn silage.*

	Early dent	1/4 milk line	2/3 milk line	Black line
DM, %	30.1	32.4	35.1	42.0
CP, %	7.5	7.3	7.1	7.0
NDF, %	52.0	44.4	40.5	41.3
Starch, %	18.2	28.7	37.2	37.4
ADF digestibility, %	45.7	38.3	33.6	29.4
Starch digestibility, %	94.1	92.9	92.2	87.7

*Adapted from Bal et al. 1997.

The optimum moisture content for storage will vary slightly with storage structure, chop length of the silage and whether it is processed or not. General guidelines are in Table 2.

Table 2. Moisture (%) guidelines for storage of corn silage.

Chop length (TLC)	Storage structure		
	Bunker	Stave	Bag
	-----Unprocessed-----		
1/4 – 1/2 inch	66 – 70	63 - 68	60 - 68
	-----Processed-----		
1/2 – 3/4 inch	65 – 70	60 – 68	60 -68

Fermentation profile. Well preserved corn silage should have a pH between 3.8 and 4.2 with the following acid concentrations (% of DM): lactic acid >4.0%, acetic acid >1.5%, and propionic acid <0.1%. Johnson et al. (2003a) found no to very minimal effects of processing corn silage on nutrient composition and fermentation compared to well preserved unprocessed corn silage. The value of processing corn silage is to allow for a slightly longer corn silage particle size that is uniform and packs well in storage structures when harvested within optimum moisture ranges.

Feeding and sampling corn silage

Silage removal from storage. Removal of adequate amounts of silage from the face of any storage structure each day is necessary to ensure good quality silage is fed. Good face management prevents and reduces losses from heating and molding. Removal of 4 inches or more per day is recommended for stave silos. In bunkers and piles, 6 inches per day or more is recommended. Recent information from the Dairy Forage Lab in Wisconsin (Muck and Holmes, 2002) shows density of corn silage in bag silos is 12-13 lb/ft³ compared to 14 to 17 lb/ft³ for bunkers and therefore 6 inches or more per day removal from bags is recommended.

Sampling corn silage for analysis. An 11 bunker silo study in New York (Stone, 2003) found the following variations in nutrient content of corn silage when samples were taken from the top to bottom of each silo (Table 3). Using the information in Table 3, a corn silage sample with a DM content of 34% could range between 28 and 38% with sampling and DM analysis errors added in (34% x average deviation (.123) = ± 4% in DM). If 20 lb of corn silage DM was the target to feed per cow per day, as fed amounts of corn silage could vary from 71 lb (28% DM) to 53 lb (38% DM) using the variant DM percents to calculate the as fed amount. If the actual DM was really 34%, the as fed amounts would result in a 4 lb error over or under in DM fed and major changes in diet nutrient content.

Table 3. Variation in corn silage nutrient content from samples taken from the top, middle and bottom third of 11 bunker silos.*

Deviation, %	DM	CP	NDF	NE-L	Lactic acid
Maximum	1.3	2.5	0.5	1.4	3.8
Minimum	55.0	29.5	18.6	5.6	48.7
Average	12.3	11	8.6	3.1	25.6

*Adapted from Stone, 2003.

The best method for sampling corn silage from a bunker or pile is to use a face shaver cutting into the face about 4 inches in three locations across the face. The shaved forage should then be mixed in the mixer wagon, unloaded and then 4 to 6 handfuls of silage collected into a bucket, mixed and then a final sample taken for analysis.

Dietary considerations when feeding high corn silage diets

Particle size of corn silage. Several studies have looked at the effect of corn silage particle size on production and digestion parameters (Bal et al., 2000b; Clark et al., 2002; Dhiman et al., 2000; Johnson et al., 2003b, Kononoff and Heinrichs, 2003; Kononoff et al., 2003; Neylon and Kung, 2003; Onetti et al., 2003, Schwab et al., 2002, Weiss and Wyatt, 2000). There does not appear to be any relationship between percent of corn silage particles greater than 3/4 inches (top screen of Penn State box) and DM intake or milk production (Figure 1). The drop in milk production between 7 and 10% weight on the top screen reflects one study with lower milk production cows and not caused by corn silage particle length.

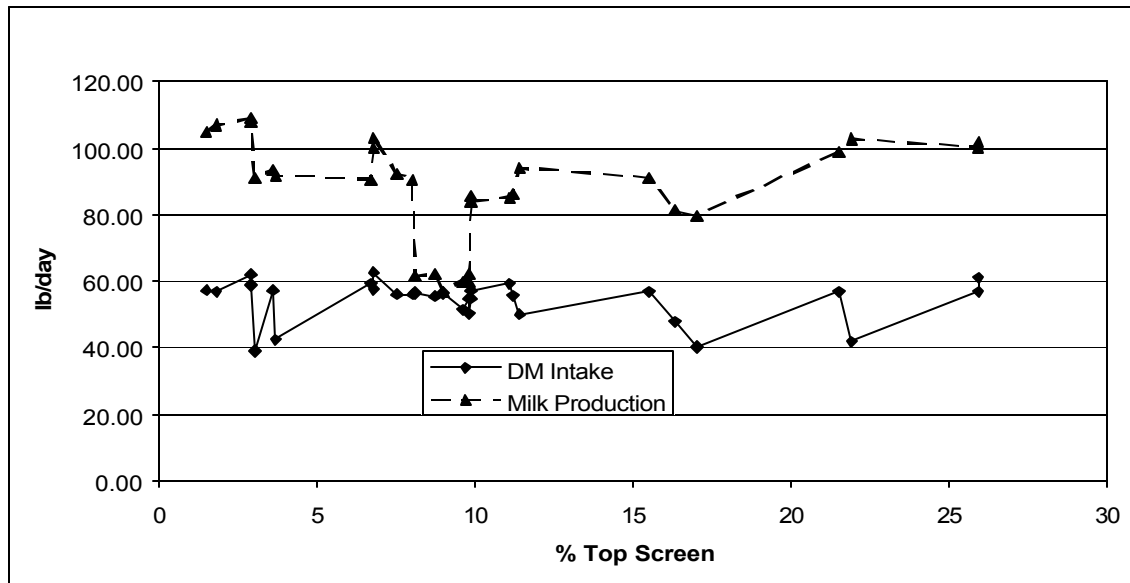


Figure 1. Relationship of corn silage particles greater than 3/4 inch long to DM intake and milk production.

However, several studies (Johnson et al., 2003b, Kononoff and Heinrichs, 2003, Kononoff et al, 2003) have indicated sorting of corn silage from TMR appears to increase as percentage of corn silage particles above 3/4 inch increase. Removing studies from this data set where milk production was less than 80 lb per day and looking at the relationship between milk production and the percent of corn silage particles less than 1/3 inch in length (pan of Penn State box) shows milk production tends to decline as percent in the pan increases (Figure 2).

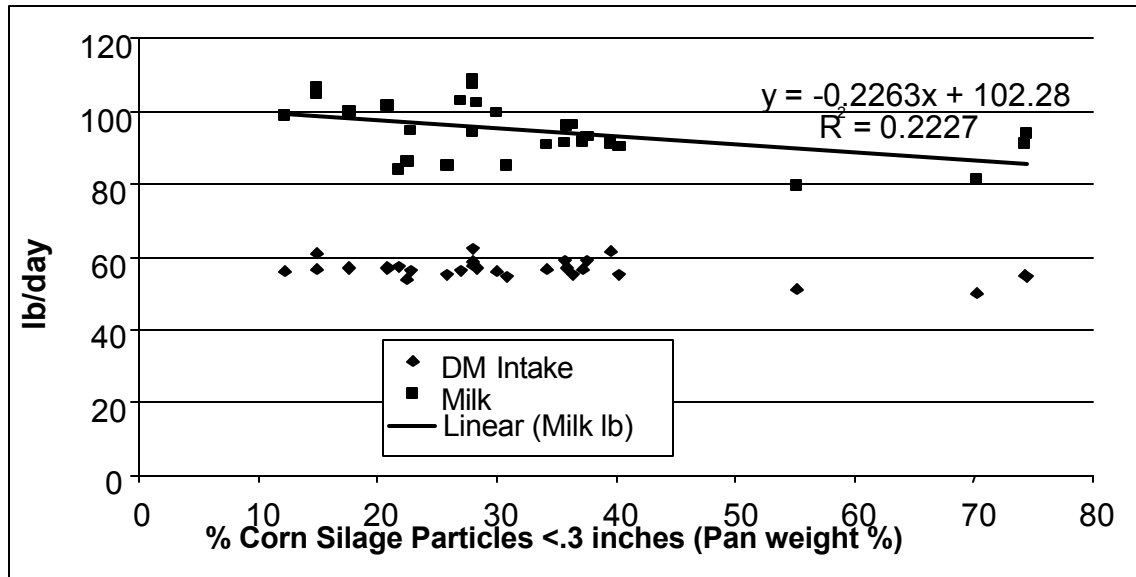


Figure 2. Relationship of corn silage particles less than 1/3 inch to milk production and DM intake.

No relationship was found between percent corn silage in the pan and milk fat percentage. However, 25 of the 38 treatments reviewed had fat tests less than 3.5%. Thus, the decline in milk production with increasing fineness of corn silage particle size is noteworthy. Corn silages with more than 40% in the bottom pan of the particle separator box may not support good rumen function when fed as the only or majority of forage in the diet.

Corn silage particle length was not found to be a significant factor in DM recovery or fermentation characteristics of corn silage (Johnson et al, 2003a,b). Packing is probably the single most important factor in obtaining good fermentation of corn silage. A general guideline for bunkers and piles is 800 lb of tractor per ton of silage packed per hour. Covering the pile or bunker immediately after packing is the second most important factor in minimizing DM losses and spoilage.

Because actual particle sizes of corn silage will vary with maturity and DM at harvest and with chopper/processor, specifying chop lengths should only be viewed as guidelines. Theoretical chop lengths of 1/4 to 1/2 are suggested for unprocessed silage and 5/8 to 3/4 for processed silage. Actual particle size of the corn silage should be measured during chopping using the Penn State box. Guidelines for corn silage particle size whether processed or unprocessed are:

Top	<10%
Middle	>60%
Pan	<30%

Effect of Diet NDF. Studies reviewed for particle size were used to evaluate the effect of total diet NDF on DM intake and milk production. All studies had 35% or more of the diet DM as corn silage. The effect of diet NDF on DM intake and milk production is

shown in Figure 3. Increasing total diet NDF from a recommend minimum of 27% to 33% has very little effect on milk production and appears to slightly increase DM intake. In an unpublished study (Linn), diets ranging from 26 to 38% total NDF and containing 40% to 45% corn silage were found not to affect milk production (average 97 lb/day), but DM intake declined linearly from 63 to 54 lb per day as diet NDF increased from 26 to 38%. Thus, cows fed high corn silage diets can be fed higher than recommended levels of NDF in the diet without loss of milk production. Based on these studies, a minimum of 30% NDF in the total diet can be fed without loss of milk production. High fiber byproduct ingredients with digestible NDF appear to be good ingredients to match with high corn silage diets.

Diet crude protein (CP). High corn silage diets should be fed with adequate amounts of rumen degradable protein to maximize rumen fiber and starch digestion. Inadequate rumen degradable protein will limit microbial protein production and reduce rumen digestion of feedstuffs. A general guideline would be to have 65% of the protein being fed as rumen degradable.

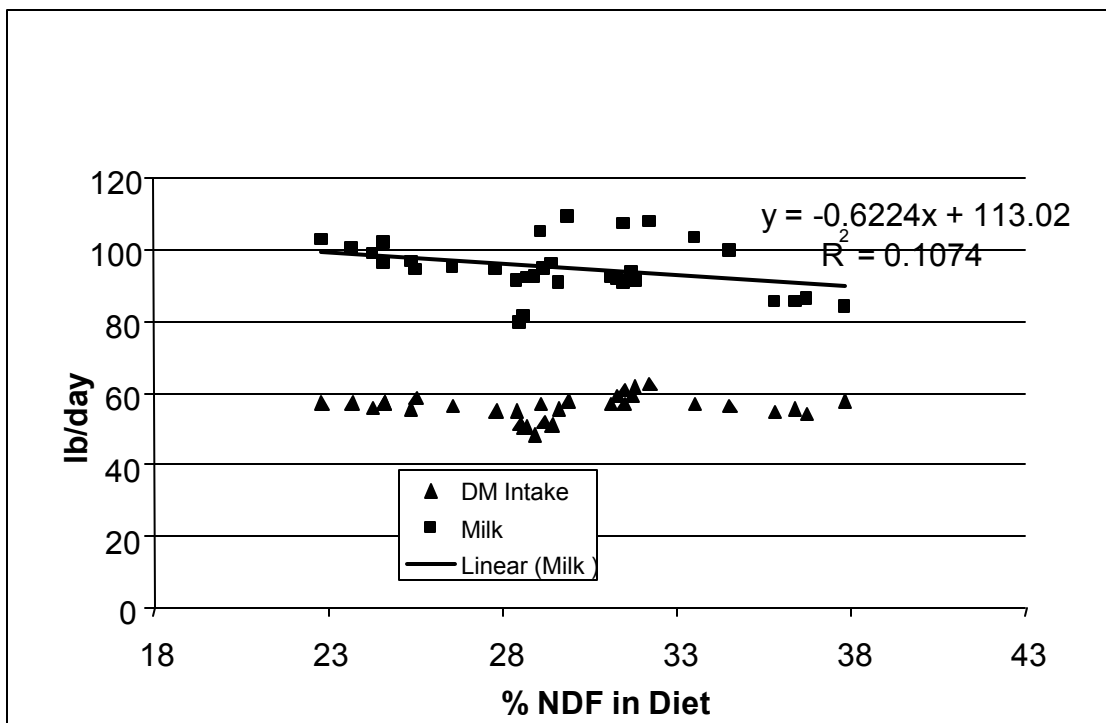


Figure 3. Effect of total diet NDF on production parameters when fed in diets containing 35% or more of the DM as corn silage.

Buffers. Numerous studies have shown the effectiveness of feeding sodium bicarbonate or a similar buffer in diets containing greater than 50% of the forage DM as corn silage. Buffers help to maintain an optimal rumen pH helping to support milk fat percentage and promote DM intake.

Effects of feeding tallow with corn silage. Three recent studies have looked at feeding tallow in high corn silage diets (Onetti et al., 2002; Onetti et al., 2003 and Ruppert et al., 2003). All three studies added 2% tallow to diets of containing either 100% (Onetti et al., 2002, 2003) or 80% (Ruppert et al., 2003) of the forage as corn silage. The addition of tallow to the diet decreased DM intake an average of 2.6 lb per cow per day, but increased milk 1.8 lb per day. Milk fat % decreased in all three studies (average of .23% units) with the addition of tallow. Based on these studies, adding 2% tallow to high corn silage diets (approximately 1 lb per cow per day) will lower DM intake and fat test, however, the cause of these effects are unknown as rumen parameters were not significantly changed.

Summary

Diets high in corn silage, over 50% of the forage DM, can effectively be feed to lactating dairy cows for good milk production. Keys to the success of feeding high corn silage diets are harvesting and preserving good quality silage. Too mature or dry of silage at harvest lacks nutrients and nutrient availability for optimum production. Particle size of corn silage appears to have minimal affects on milk production and silage nutrient content, but preservation could be affected if particle size-moisture relationships hinder good packing. Diets with 40% or more of the DM from corn silage offer the opportunity to increase the total NDF in diets above 30% without apparent reductions in milk production. For many Minnesota dairy producers, corn silage can be an excellent low cost forage that will support high milk productions when fed at levels of 40% or more of the diet DM.

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