Extension
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New insights about corn silage fatty acids

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Feeding to maximize milk components has been an indispensable practice to optimize dairy profitability and homegrown forages are vital for this process. High-quality corn silage supplies energy for both maintenance and lactation of high-producing cows. Coarser corn silage particles serve as physically effective fiber, the foundation of the ruminal mat, and stimulate chewing, salivation, and rumination, as well as gut motility and health.

Photo credit: A. Bjurstrom

Starch and fiber are the primary sources of energy for dairy cows fed corn silage-based diets and improvements in the digestibility of these nutrients increase milk and milk protein production and reduce feed costs through enhanced feed efficiency. But understanding other nutrients, such as fatty acids, is key for the implementation of high-forage diets. This article will discuss considerations for long chain fatty acids in corn silage.

From rumen to milk

Massive changes to fat and individual fatty acids occur in the rumen of dairy cows and these changes influence the profile of fatty acids that will be absorbed and utilized by the cow. Rumen bacteria are sensitive to unsaturated long chain fatty acids (C18:1, C18:2 and C18:3, oleic, linoleic, and linolenic acids, respectively). To get rid of these fatty acids, bacteria add hydrogen to them, transforming into other fatty acids (C18:0, stearic acid). But a combination of fast passage rates and low rumen pH sometimes stops this process before transformations are completed, where some intermediates remain and are absorbed, eventually reaching the mammary gland. Some of these intermediates are problematic and cause milk fat depression by inhibiting fat synthesis in the mammary gland.

Even though fatty acids comprise a small fraction of corn silage (1.5% of DM, on average; see Table 1), these are primarily unsaturated fatty acids (about 75% of total fatty acids). And if feeding multiple types of corn including forages, feeds, and byproducts, these numbers add up quickly. Table 2 exemplifies the effects of feeding high concentrations of fatty acids to dairy cows. Briefly, this is a comparison of studies feeding high-oil and conventional corn silage hybrids. Feeding hybrids with increased concentration of ether extract had no effects on intake and milk yield but reduced milk fat percentage and yield. Even though fatty acids supplied by the diet can be captured by the mammary gland and secreted in milk, it does not compensate for the negative effects caused to milk fat synthesis. Another downside of feeding excessive fatty acids was the reduction in milk protein concentration. Long-chain fatty acids inhibit the growth of rumen bacteria and consequently microbial protein synthesis, which is crucial for milk protein production.

In addition to corn silage hybrid selection, other silage practices can change concentration and digestibility of nutrients (i.e., fiber and starch) and could change fatty acid concentrations and proportions as well. This concern often brings up questions by nutritionists.

Harvesting maturity

Delaying harvest until corn plants are closer to black-layer stage (kernel physiological maturity) potentially increases biomass and grain yields. But this benefit usually comes at the expense of reduced fiber and starch digestibility. Recently, we also compared fatty acid profile of corn silage from three maturities. Overall, total fatty acid concentrations increase along with maturity and cause small changes in profile (minor shift from linolenic to linoleic acid as maturity progressed; Table 3). Although changes in fatty acids look minimal, we ran an exercise to predict its effect on milk fat production. By feeding more fatty acids, cows would produce slightly less milk fat. However, this effect could be easily fixed by reducing the amount of other corn sources in the diet, which was not accounted for in our exercise. This highlights the awareness producers and nutritionists need when manipulating corn silage as changes could have unintentional impacts on fatty acids and may cause subsequent problems.

Storage length

Storage length is another practice producers use to manipulate silage nutritive value as prolonged storage increases starch availability. Storage had very minor effects on oleic and linoleic acids (Table 4). Ensiling increased linoleic and linolenic acids, but this effect does not occur throughout fermentation. Prolonged fermentation increased the concentration of free fatty acids from 0.98% of DM at 30 to 1.20% of DM at 240 d. Let us consider a dairy cow consuming 25 pounds of corn silage dry matter per day to address this effect. The corn silage fermented for 30 d provides 109 g of free fatty acids whereas the corn silage fermented for 240 d provides 136 g of free fatty acids. This is a very minor difference and overall, research underscores that unsaturated fatty acid profile derived from whole-plant corn forage samples at harvesting would be adequate to formulate diets.

Chop height

Increasing chop height is a great tool to improve fiber digestibility and starch concentration in corn silage. But concentrating the same amount of corn kernels in less plant material slightly changes fatty acid concentrations and profile. Table 5 shows an example of this effect. Like maturity, increasing the proportion of kernels increases total fatty acids. Also, it slightly reduces linolenic while increasing linoleic acid.

Summary

Overall, many factors contribute to milk fat depression. Corn silage contributes to the total unsaturated fatty acid load and could promote milk fat depression. But changes in fatty acids associated with common silage practices are relatively minor and would easily be corrected for by reducing other sources of corn in the diet, which may already be done when feeding later maturity or higher chopped silage due to increased concentrations of starch.

Table 1. Concentration of fatty acids in corn silage[1]

Item	Normal range[2]
Ether extract, % of DM	2.14 – 3.00
Fatty acids, % of DM	1.49 – 2.09
C18:0, % total FA	1.8 – 2.1
C18:1, % total FA	20.1 – 22.1
C18:2, % total FA	46.1 – 49.7
C18:3, % total FA	4.1 – 7.9

[1]Summary of multi-year data set courtesy of Rock River Laboratories.
[2]Normal range represents the range of the central 2/3rds of the samples in the data set.

Table 2. Effect of feeding high-oil corn silage to dairy cows[1,2]

Item	Control[3]	Difference
Ether extract, % of DM	3.2	+1.6
Dry matter intake, lb/d	52.2	ND
Milk yield, lb/d	79.8	ND
Milk fat, %	3.51	-0.33
Milk fat, lb/d	2.79	-0.14
Milk protein, %	3.15	0.12
Milk protein, lb/d	2.48	ND

[1]Adapted from Ferraretto and Shaver (2015); Journal of Dairy Science 98:2662-2675.
[2]Difference calculated as high-oil minus control corn silage, ND – no difference observed.
[3]Control included conventional, dual-purpose, and isogenic counterpart corn hybrids.

Table 3. Concentration of fatty acids in corn silage at different maturities[1,2]

Item	Early	Mid	Late
Fatty acids, % of DM	1.69	2.16	2.36
Free fatty acids, % of DM	0.91	1.09	0.97
C18:0, % total FA	3.0	2.8	3.0
C18:1, % total FA	24.9	26.7	27.5
C18:2, % total FA	35.5	39.8	42.0
C18:3, % total FA	11.8	7.8	5.5

[1]Adapted from Saylor et al. (2021); Agriculture 11:574.
[2]Corn silage was harvested at 1/4 (early), 1/2 (mid) or 3/4 (late) of kernel milk line.

Table 4. Concentration of fatty acids in corn silage stored for different periods[1,2]

Item	0 d	30 d	120 d	240 d
Fatty acids, % of DM	2.00	2.08	2.18	2.02
Free fatty acids, % of DM	0.78	0.98	0.99	1.21
C18:0, % total FA	3.0	2.9	2.8	3.0
C18:1, % total FA	29.0	26.0	26.2	25.3
C18:2, % total FA	37.0	39.4	40.8	39.6
C18:3, % total FA	6.0	8.7	8.7	8.9

[1]Adapted from Saylor et al. (2021); Agriculture 11:574.
[2] Corn silage was stored for 0, 30, 120 or 240 d.

Table 5. Concentration of fatty acids in corn silage harvested at different heights[1,2]

Item	Regular	High
Fatty acids, % of DM	1.73	1.90
C18:1, % total FA	21.3	22.1
C18:2, % total FA	51.7	52.8
C18:3, % total FA	7.7	6.2

[1]Unpublished data of samples from Diepersloot et al. (2022); TAS 6:txac037.
[2] Corn silage was harvested at 10- or 25-inches height (Regular and high, respectively).

Developed by UW–Madison Department of Animal & Dairy Sciences and Division of Extension Assistant Professor and Dairy Nutritionist Luiz Ferraretto for the 2023 Badger Dairy Insight Webinar: Corn Silage, Strong Suits, and Compliments. Adaptation of this article was originally published in the Midwest Forage Association Focus, March 2023.