SILAGE FOR BEEF CATTLE
2018 CONFERENCE

SPONSORED BY:

N EXTENSION

LALLEMAND
LALLEMAND ANIMAL NUTRITION

IOWA STATE UNIVERSITY
Extension and Outreach
Iowa Beef Center

CONSIDERATIONS FOR USING SILAGE, EARLAGE, AND HMC IN FINISHING CATTLE

Allen Stateler, PhD
Nutritionist,
Nutrition Services Associates
allen@feedyard.com

Dr. Allen Stateler is a partner in Nutrition Service Associates and is based out of northeast NE. Allen consults with feedyard, seedstock, cow-calf, bull stud, and stocker operations in the Midwest and Southeast. Allen received his BS and MS degrees from The University of Florida in 1991 and 1993 and his Ph.D. from South Dakota State University in 1997.

INTRODUCTION

In feedlot diets corn is king. Yes, we periodically feed some small grains such as wheat, barley, oats, etc. but for the most part corn makes up the majority of finishing diets. In many feedyards, the corn plant actually represents 90+% of the finishing diet either from corn grain, corn silage, earlage, snaplage, stover, and(or) corn coproducts such as distillers grains and corn gluten feed. Often, the only dietary components not derived from corn are the supplemental vitamins and minerals and maybe their carrier and any roughage not coming from the corn plant. So it is clear that corn is an important crop to finishing cattle. Given that fact, it's no surprise that there is much thought and debate around the best ways to economically capture and preserve the energy (starch) and fibrous (stover) fractions of the corn plant. This paper will discuss various ideas and concerns about the use of the corn plant in finishing diets with emphasis put on crops that capture both fiber and energy (silage and snaplage). This will, by no means, be a comprehensive review as much more informed scientists have devoted their lives to the study of this topic and have written volumes of information on the topic. For an in depth review on the subject, I would point you to a publication recently presented by Fred Owens at the 2018 Plains Nutrition Council Spring Conference (Owens et al., 2018).

WHY IS CORN GROWN SO PREVALENTLY?

Church (1977) noted that Indian corn (Zea mays) can produce more digestible energy per unit of land than any other grain crop. Today this would be a gross understatement as the agronomic yield of corn can now produce around twice the ME/acre as small grains and three times ME/acre as vegetables while having similar protein yield/acre as alfalfa, and greater fiber (NDF) yield than most other roughages such as alfalfa, sorghum, and grass hays (Owens et al., 2018). So it's no wonder that corn finds itself easily atop the throne of plants grown for livestock food production and is the standard by which all other energy feedstuffs are measured.

WHAT FEEDSTUFFS CAN WE HARVEST FROM THE CORN PLANT?

There are several ways to slice up the proverbial pie that is the corn plant, being dependent on the maturity of the crop, portions of the crop parts wanted/needed, and the harvest method. The major variance in these different forms is the ratio of corn to stover captured. Stover is the non-grain (high NDF) portion of the corn plant and can include stalk, leaves, shank, husk, and cob. Different harvest methods capture varying proportions of grain and stover. Table 1 gives an overview of several products that can be harvested from the corn crop.

TABLE 1.

Characteristics of various products harvested from the corn crop.

Product	Equipment	Plant Parts Harvested	Typical DM, %
Silage	Chopper	Whole Plant	28-45
Earlage	Chopper w/ all crop head	Grain, Cob, Husk, Shank, Stalk	60-75
Snaplage	Chopper w/ snapper head	Grain, Cob, Husk, Shank	60-75
HM Corn	Combine	Grain	66-75
Ear Corn	Corn Picker	Grain, Cob	77-90
Dry Corn	Combine	Grain	84-90
Stover	Rake and Baler or other	Stalk, husk, shank, cob	70-90

When harvesting silage, earlage, snaplage, or HM corn, the product must be properly harvested, processed, delivered to storage (upright silo, bunker silo, pile, or bag), packed, and sealed for the ensiling process to proceed efficiently. Most of the management practices that apply to silage will also apply to the remainder of the ensiled feeds derived from the corn plant and will be covered by other speakers.

CORN SILAGE

Corn silage is obtained by harvesting and ensiling the whole corn plant with an all-crop head on a forage chopper. Harvest height is typically around 6 inches unless nitrates are a concern and chop height is raised to avoid the higher nitrate levels that accumulate in the lower stalk. Rough terrain may also necessitate raising the chop height.

There is a wealth of research and summary publications on the proper timing and methodology of corn silage chopping and preservation. Several university extension programs such as The University of Wisconsin (http://corn.agronomy.wisc.edy) and Penn State University (https://extension.psu.edu/corn-silage-production-and-management), have excellent websites to review the overall topic, in addition to information that will be presented at this symposium.

Snaplage is ensiled corn grain, cobs and husks plus a portion of the shank. Snaplage is typically harvested with a forage harvester equipped with a corn snapper head, chopped, and ensiled (Lardy & Anderson, 2016).

Earlage is harvested similarly but with an all-crop head on the forage chopper which yields corn grain, cobs, husks, shank, and a portion of the stalk above the ear. Earlage yields more tonnage but is lower in energy and protein content and is more difficult to pack and ensile than snaplage. The generic term earlage is commonly used to describe both earlage and snaplage (and sometimes HM ear corn). Twenty years ago I would see true earlage (containing part of the upper stalk) put up but I can't say I have seen much in the past 10 years or so. What we mostly put up is snaplage but we call it earlage. Consequently, the earlage of today versus 20 years ago tends to test higher in energy (starch) and lower in fiber (NDF).

High moisture ear corn (HMEC) is produced when a conventional combine or corn picker is used to harvest, grind, and ensile mainly corn with a portion of the cob. Some would also call this HM corn and cob meal. I don't run into this much so it will not be discussed here.

High moisture corn (HMC), in the broadest sense, is any corn harvested above 15.5% moisture (the standard for shell corn). However, if improving starch digestibility is on the list of goals for harvesting corn as high moisture, the moisture content should be in the 26-34% range. HMC is harvested by combine, usually processed through a roller mill, hammer mill, or tub grinder and packed in to an appropriate structure for anaerobic fermentation. HMC generally ferments slower and less complete than corn silage (Hoffman & Muck, 2011) with the extent of fermentation being directly proportional to the moisture.

NUTRIENT CONTENT.

The nutrient content of feedstuffs has long been tabulated by various university and industry groups from the available laboratory analyses and limited feeding trials. While nutrient content estimates abound for dry corn, HMC, and corn silage, the estimates for snaplage and earlage are more limited. Table 2 shows tabular values from the University of Nebraska (Stock et al. 1995), North Dakota State University (Lardy & Anderson, 2016) and Feedstuffs Magazine (Preston, 2016). Note that the

TABLE 2.

Nutrient content of various products harvest from the corn crop.

PRODUCT	DM %	CP %	DIP %	TDN %	NEm Mcal/lb	NEg Mcal/lb
Dry Rolled Corn						
Stock[1]	86	10.0	40	90	102	70
Lardy & Anderson[2]	86	9.8	-	90	102	70
Preston[3]	88	9.0	46	88	98	65
High-Moisture Corn						
Stock[1]	75	10.0	60	90	102	70
Lardy & Anderson[2]	75	10.0	-	90	102	70
Preston[3]	74	10.0	58	93	104	71
Ear Corn						
Lardy & Anderson[2]	87	9.0	-	83	92	62
Preston[3] (corn & cob meal)	87	9.0	48	82	89	59
Earlage (all crop head)						
Lardy & Anderson[2] (well eared)	60-70	8.8	-	78	86	57
Lardy & Anderson[2] (less grain)	60-70	8.8	-	74	80	52
Snaplage						
Stock[1] (high moisture snapped)	74	8.8	60	81	90	59
Lardy & Anderson[2] (snapper head)	75	8.7	-	83	92	62
Corn Silage						
Stock[1]	35	8.0	75	72	74	47
Lardy & Anderson[2]	35	8.0	-	70	74	47
Preston[3]	34	8.0	72	72	75	47

[1]Stock et al. (1995) [2]Lardy and Anderson (2016) [3]Preston (2016)

“book values” are mostly in agreement but differ quite a bit from the Dairyland Laboratories one- year and five-year averages (Table 3). This underlines the necessity for nutrient analysis of the feedstuffs used on each feedyard rather than simply using book values.

TABLE 3.

Dairyland Laboratories Inc. dry corn, HMC, and earlage/snaplage analyes.[1]

	DM	CP	aNDF	Starch	OARDC NEg	
PRODUCT	**%**	**%**	**%**	**%**	**Mcal/cwt**	**n**
Dry Corn (<18% moisture)						
2017 Crop	86.1	8.41	7.28	71.2	66.8	1393
5 year average	85.6	8.25	8.21	69.5	66.3	9022
HMC (>22% moisture)						
2017 Crop	71.4	8.16	7.57	70.0	66.2	5169
5 Year Average	70.7	8.06	8.00	69.0	66.0	39544
Earlage/Snaplage (<30% moisture)						
2017 Crop	60.0	7.45	19.2	57.9	60.5	3038
5-Year Average	60.4	7.37	19.6	57.7	60.2	19806
Corn Silage						
2017 Crop	36.4	6.86	38.4	35.8	47.5	37517
5 Year Average	38	7.18	39.1	33.5	47.4	322311

[1]Compiled by Neal Wininger, Dairyland Laboratories Inc.

FINISHING DIET GOALS.

Finishing diets are generally formulated to provide rapid, efficient, cost-effective growth to achieve a desired end-weight and carcass composition. The prevailing paradigm for several decades has been to feed high energy diets that contain the minimal amount of roughage (scratch) to avoid metabolic disturbances while maximizing energy intake. Determining that minimal roughage level and the acceptable level of metabolic disturbances have been explored experimentally. However, on-yard adjustment of finishing diet roughage level relies more heavily on nutritionist and(or) feedyard experience as each feeding situation has its own set of unique facility x management x feedstuffs x goals interactions. As feed conversion is one of the major measurements by which commercial feedyards are currently evaluated, much attention is paid to minimizing the roughage level of finishing diets.

WHAT TO HARVEST?

Determining what product to make from the corn crop is not as simple as it may seem. Each product that can be produced has its own set of agronomic and nutritional strengths and weaknesses and those must all be weighed and balanced against the feedyard nutrient needs. For the most part, we can evaluate corn silage, snaplage, and earlage based on the fractions of corn (starch) and roughage (NDF) that will be harvested, although there are a few feeding interactions that must be considered. Since we know there is a need for some minimal level of roughage in finishing diets, if we are to get both our energy and roughage from the corn crop, then harvesting a crop that contains at least some level of built-in roughage seems prudent (rather than going back to get the stover later). However, proper harvesting, packing, and ensiling of corn silage and snaplage requires a large footprint, focused labor, and attention to detail. Absence of any of those will result in a less than favorable fermentation and excessive shrink and spoilage, potentially negating the positives.

HIGH-MOISTURE CORN IN FINISHING.

Advantages of harvesting HMC include the elimination of drying costs, potential increase in corn yield due to less ear drop, earlier harvest, potential to grow longer season, higher yielding varieties, and earlier availability of corn stalk grazing. Disadvantages include limited marketing flexibility (feeding to cattle is the only outlet), the need for storage facilities and equipment, potential spoilage and shrink during ensilation and feedout, and the need to account for the higher fermentation potential in diet formulation and bunk management. There is much debate about the actual feeding value of HMC as its feeding value has been shown to be affected by moisture level, feeding rate, degree of processing, roughage source (Mader et al., 1991) and level, corn coproduct and level, and blending with DRC.

Owens et al. (1997) summarized 164 grain processing studies from 1974 to the mid 1990's. In this summary, while the observed ME for HMC (grain alone) was greater ($P < 0.05$) than for DRC (1.55 vs 1.48 Mcal/lb), total ME intake (calculated by Buchanan-Smith, 1997) was lower ($P < 0.05$) for HMC diets (27.6 vs 28.2 Mcal/d) due to lower DMI ($P < 0.05$). This resulted in lower ($P < 0.05$) performance for HMC versus DRC (3.02 vs 3.20 lb/d) with similar ($P > 0.05$) feed:gain (F:G). It should be noted that the roughage (DM basis) levels in this summary were 7.0 for HMC and 7.9 for DRC. One potential reason for lower DMI associated with the feeding of HMC may be an increase in subacute ruminal acidosis resulting from increased ruminal starch digestion (Owens & Soderlund, 2006) causing lower ruminal pH for HMC-fed cattle as observed by Krause et al. (2002).

CORN SILAGE IN FINISHING.

It has been demonstrated that cattle can be finished (reach a desirable carcass endpoint) fed diets that vary in ingredient makeup and energy density and that cattle can sometimes maintain ADG by offsetting a lower energy concentration with increased DMI. DiCostanzo et al. (1997) demonstrated a linear increase ($P < 0.05$) in DMI with similar ($P > 0.05$) ADG and an increase in F:G in cattle fed corn silage up to 48% of diet DM. More recently, the University of Nebraska has shown renewed interest in using higher levels of corn silage to produce moderate-energy finishing diets. In a series of trials they consistently showed a reduction in gain and an increase in F:G with higher levels of corn silage inclusion (45% vs 15% of diet DM) with variable effects on DMI (Burken et al., 2013a, Burken et al., 2013b, Burken et al., 2014, Burken et al., 2015 and Hilscher, et al., 2018), however they have sparked some interesting conversations about cost of gain and feedstuff valuation, both of which will be covered by Galen Erickson at this symposium.

With the renewed interest in higher corn silage finishing diets, there has also been renewed interest in the brown midrib (bm3) mutation which yields silage with lower lignin content and higher NDF digestibility. In the past, the limitations to bm3 have been lower yield, susceptibility to weather damage due to lower lignin content, and the need to identify the crop to be put up as silage at planting time, however there are efforts to advance the breeding to bring bm3 more into the mainstream. Hilscher et al. (2018) looked at feeding a standard silage hybrid (CON), a bm3 hybrid (BM3), and an experimental softer endosperm bm3 hybrid (BM3-EXP) at 15 or 45% of diet DM to steers. The premise was that the improvement in NDF digestibility of the bm3 might offset the negative effects on gain and conversion previously seen with feeding the higher level of corn silage. At the 45% inclusion rate BM3 and BM3-EXP improved ($P < 0.05$) ADG over CON (3.67 and 3.68 vs 3.49 lb, respectively), with BM3 also improving ($P < 0.05$) F:G over CON (6.09 vs 6.38). At the 15% silage inclusion rate, BM3-EXP improved ($P < 0.05$) ADG (3.88 vs 3.73 and 3.73, respectively) and F:G (5.63 vs 5.77 and 5.92, respectively) over both CON and BM3. Since BM3 and BM3-EXP at 45% silage inclusion had similar ADG to CON at 15% silage inclusion, they concluded that the improvement in digestibility from the bm3 trait allowed more corn silage to be fed without compromising ADG. Feed conversion, however, was poorer in the comparison suggesting that, while not statistically significant, the trend is still that it takes additional DMI to hold ADG together when feeding elevated levels of corn silage. It is also of interest that even though the fixed effect of silage concentration showed a decrease ($P < 0.1$) in dressing percentage with the 45 versus 15% silage inclusion rate, the bm3 trait was able to alleviate that effect.

It will be interesting to see how the bm3 research progresses. As of now, the agronomic limitations of bm3 along with the feedyard industry's focus on feed efficiency will likely dictate that we continue to harvest conventional hybrids for corn silage production at least for the near future.

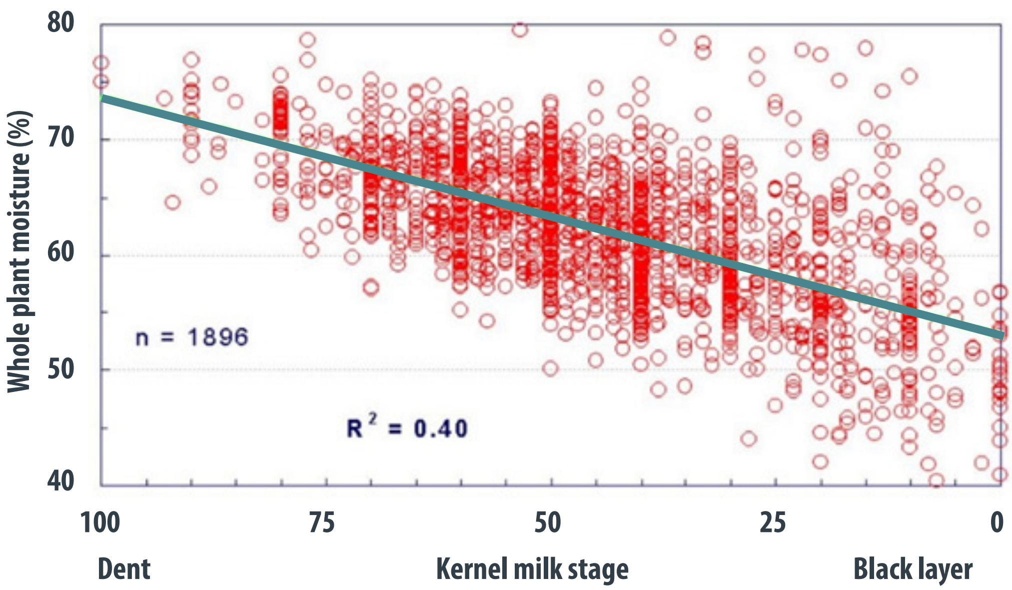
At minimum, corn silage can be used to provide all of the roughage needs in a finisher diet. With a roughage (non-grain) concentration in the 45-55% range (DM basis), corn silage is typically included at 15-20% of diet DM providing approximately 7.5% to 10% roughage, which generally provides adequate effective NDF (eNDF) as evaluated by the NRC model (NRC, 1986). In finishing diets formulated to maximize gain and feed conversion, we could speculate that the ideal corn silage would be high in starch content and low in NDF concentration and digestibility allowing us to meet the scratch requirement while having minimal effect on energy concentration.

WHEN TO CHOP CORN SILAGE?

The combination of moisture and maturity will define the best time for corn silage harvest. However, there is a paradox here; the more mature the corn plant is, the higher the starch content and energy yield/acre but the harder the crop is to properly pack and ensile due to lower moisture. Corn silage is easiest to pack and ensile when the DM of the whole plant is in the 32 to 38% range but the weight of grain, cob, and husk is not maximized until the whole plant reaches somewhere in the 45 to 55% DM range (Owens et al., 2018). While plant moisture and kernel maturity (as measured by milk line) are positively correlated, the variation is quite high (Figure 1). For these reasons, both kernel maturity (milk line) and whole plant moisture must be monitored to optimize nutrient yield and silage preservation. In a perfect world, we would have kernels that are mature (black layer) while the whole plant DM remains at or below 40%. Typically we end up harvesting corn silage at ¾ milk line to balance maturity and moisture. Hilscher et al. (2016) harvested corn silage at 37 and 43% DM and fed at either 15 or 45% of the diet to yearling steers. Later harvesting of silage improved total silage yield, raised the starch level of the silage from 35.4 to 40.8% and reduced the NDF from 31.55 to 28.88% while having no statistically detectable effect ($P > 0.05$) on performance. However, harvesting corn silage at 43% DM did numerically increase ADG from 3.89 to 4.05 lb at the 15% inclusion level due to a numerical increase in DM intake (DMI) from 27.8 to 29.0 lb/d. It is interesting to note that the 43% DM silage would have produced a diet higher in starch and lower in roughage than the 37% DM silage as both silages were fed at the same inclusion rates. Implications?

FIGURE 1.

Relationship between corn silage moisture and kernel maturity (1990-1999). (Lauren, 1999)



SNAPLAGE IN FINISHING.

Advantages of snaplage over high-moisture corn include ~15-20% more dry matter yield per acre (snaplage is typically 80-85% corn), built-in roughage that can either provide all of the needed roughage or at least reduce the need for additional roughage, simple, rapid, and economical harvest using a snapper head on a chopper, earlier harvest, and faster fermentation due to availability of sugars from the cob. Disadvantages include being more difficult to adequately pack which can lead to more shrink and spoilage, additional storage capacity, and potential mycotoxin in the cob fraction.

The timing of snaplage harvest is between corn silage and HMC with much overlap across fields so timeliness of harvest can be a concern, especially if you are relying on custom harvesting. Harvest moisture is critical for snaplage, probably more so than with corn silage or HMC. Harvest should begin when the kernels are black layered and the kernel moisture is at 35% with the goal of getting the pile put up with kernel moisture in the 30-35% range. This will typically result in snaplage with a moisture level of 35-40% due to the cob carrying more moisture than the grain. Snaplage that is harvested too dry can lead to poor packing and fermentation and lower NDF digestibility. Snaplage that is harvested too wet will produce lower DM yields and incur seepage loss at the pit, however it is more favorable to harvest snaplage too wet than too dry. Attention should also be paid to chopping and processing of snaplage with chop length being as small as you can get it (consider a recutter screen) and the kernel processor set between 1 and 2 mm with 40+% differential. Beyond that, good silage making practices should be followed.

Although earlage/snaplage has been a staple in the feeding industry for a long time, there really has been very little research on the feeding value. The simplest is to view it as HMC with added roughage. If we consider snaplage to be around 15 to 20% roughage then the practical feeding rate is up to about 70% of diet DM (depending on the earlage roughage level) when fed with a corn coproduct if we are trying to hold energy concentration up and meet the minimum scratch needs. However, in my experience, most feedyards don't typically put up enough earlage to maximize the inclusion rate and end up feeding some combination of earlage with corn silage or dry roughage to meet the scratch needs along with another energy source such as DRC for the balance of the energy. This can be a good strategy as the combination of snaplage and DRC is favorable from a ruminal fermentation standpoint. It is important to remember that the corn in snaplage should be treated with the same considerations as HMC with regards to diet balancing (roughage level, DIP needs, coproduct interactions, etc.).

Economics

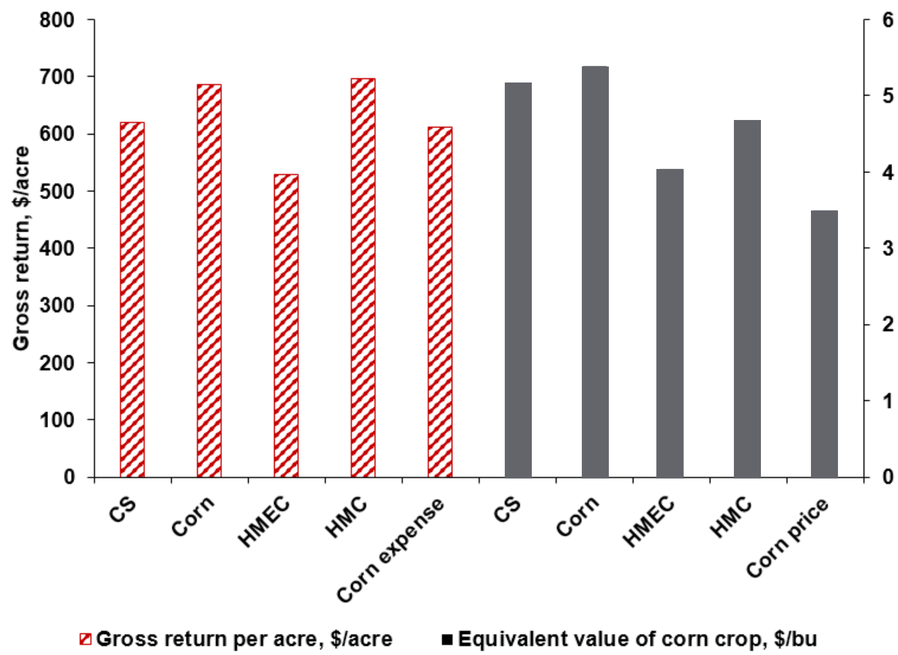
There has been little work done to determine which product is better to harvest from the corn crop. It is simply an arduous task to undertake and there are so many variables and interactions. Johnson et al. (2016) undertook such a study where they harvested and fed the corn plant to yearling steers as either DRC, HMC, HMEC, or silage at 75% of diet DM. Predictably, ADG was lowest for the higher NDF crops (silage and HMEC), with HMC being intermediate (and not different from HMEC) and highest for DRC ($P < 0.05$). Decreased DMI was seen feeding HMC vs DRC as previously discussed.

It should be noted that in this trial HMEC was harvested with a silage harvester head raised to just below the ear. Therefore, the HMEC included all of the upper portion of the plant and was only 53% corn, not much higher than the corn silage at 45% corn, and resulted in a diet that was approximately 33% roughage. I would consider this product a high-roughage earlage and not snaplage or HMEC as typical snaplage will contain 80 to 85% corn. This underlines the importance of properly defining the actual product produced from the corn crop when making crop endpoint decisions. Had the HMEC in this trial been harvested with a snapper head, results of the HMEC treatment might have been expected to rival the HMC treatment. Hill et al. (1995) compared HMEC with or without 8% added alfalfa hay to HMC with 8% added alfalfa hay fed to finishing steers. Similar ($P > 0.05$) ADG, F:G and calculated corn and dietary ME values were noted for all three treatments. Interestingly, the addition of 8% alfalfa to the HMEC diet did not reduce animal performance, suggesting that the dilution of energy by adding roughage to a diet comprised of a highly fermentable feedstuff may be offset by improved digestibility, presumably related to less propensity for subacute acidosis.

From the performance and yield data, Johnson et al. (2016) calculated gross return ($/acre) and equivalent value of the corn crop ($/bu). The authors concluded that despite the differences in agronomic yields and animal feed conversion, interactions between these parameters resulted in no differences in gross return per acre or value of the crops expressed as $/bu of corn harvested (Figure 2).

FIGURE 2.

Gross return per acre and realized grain value for corn silage (CS), corn (fed as DRC), high-moisture ear corn (HMEC) or HMC expressed as $/bu after feeding yearling steers. Corn expense and corn price refer to the total dollars spent to plant, grow and harvest corn and market price at the time of analysis, respectively (Johnson et al., 2016).



The levels of corn silage and HMEC fed in this trial are well above the levels that most nutritionists would practically feed in finishing diets, given the high roughage content of the HMEC, but the performance data may not be the primary point. The authors suggested that since no differences were seen in gross return per acre of equivalent value of the corn crop, the results suggest flexibility in choice of harvest endpoint, which would allow the growing, harvesting, and feeding of a combination of these crops to optimize ruminal starch fermentation while retaining gross returns per acre at least similar to harvesting shell corn.

REFERENCES

Buchanan-Smith, J. G. 2006. Factors limiting feed or energy intake of processed grains. Cattle Grain Processing Symposium. MP-177:214-220). Okla. State Univ., Tulsa.

Burken, D. B., B. L. Nuttelman, T. J. Klopfenstein, and G. E. Erickson. 2013a. Feeding elevated levels of corn silage in finishing diets containing MDGS. Neb. Beef Cattle Rep. MP98:74-75.

Burken, D. B., T. J. Klopfenstein, and G. E. Erickson. 2013b. Economics of feeding elevated levels of corn silage in finishing diets containing MDGS. Neb. Beef Cattle Rep. MP98:76-77.

Burken, D. B., B. L. Nuttelman, T. J. Klopfenstein, and G. E. Erickson. 2014. Feeding elevated levels of corn silage and MDGS in finishing diets. Neb. Beef Cattle Rep. MP99:88-89.

Burken, D. B., B. L. Nuttleman, C. J. Bittner, T. J. Klopfenstein, and G. E. Erickson. 2015. Feeding elevated levels of corn silage and MDGS in finishing diets. Neb. Beef Cattle Rep. MP101:66-67.

Church, D. C. 1977. Chapter 8 - High Energy Feedstuffs. In: Livestock Feeds and Feeding. D. C. Church, Corvallis. p. 82-96

Hill, W. J., D. S. Secrist, F. N. Owens, M. T. Van Koevering, C. A. Strasia, and D. R. Gill. 1995. High moisture ear-corn with no added roughage for feedlot steers. Anim. Sci. Res. Rep. P-943:11. Okla. Ag. Exp. Sta., Okla. State Univ., Tulsa.

Hilscher, F. H., C. J. Bittner, J. N. Anderson, and G. E. Erickson. 2018. Evaluation of corn silage hybrids with brown midrib trait and silage inclusion for finishing cattle. Neb. Beef Cattle Rep. MP105:86-88.

Hilscher, F. H., D. B. Burken, C. J. Bittner, J. L. Harding, and G. E. Erickson. 2016. The effect of delayed corn silage harvest on corn silage yield and finishing performance in yearling steers. Neb. Beef Cattle Rep. MP103:146-148.

Hoffman, P., and R. Muck. 2011. Innoculating high moisture corn. Univ. of Wisc. - Ext., Madison. Available from: https://fyi.uwex.edu/forage/inoculating-high-moisture-corn/

Johnson, T., A. Hohertz, and A. DiCostanzo. 2016. Gross return to corn acres through cattle feeding as influenced by choice of harvest endpoint. J. Anim. Sci. 94 (Supp. 2):47.

Lardy, G., and V. Anderson. 2016. Harvesting, storing, and feeding corn as snaplage. AS1490. North Dakota State Univ. Ext., Fargo. Available from: https://www.ag.ndsu.edu/publications/livestock/harvesting-storing-and-feeding-corn-as-earlage

Lauer, J. 1999. Kernel milkline: How should we use it for harvesting silage? Agronomy Advice. Field Crops 28.47-23. Univ. of Wisc. - Ext., Madison. Available from: http://corn.agronomy.wisc.edu/AA/A023 and http://corn.agronomy.wisc.edu/Management/L031.aspx

Mader, T. L., J. M. Dahlquist, and L. D. Schmidt. 1991. Roughage sources in beef cattle finishing diets. J. Anim. Sci., 69:462-471.

Owens, F. N., and S. Soderlund. 2006. Ruminal and postruminal starch digestion by cattle. Cattle Grain Processing Symposium. MP-177:116-127. Okla. State Univ., Tulsa.

Owens, F. N., D. S. Secrist, W. J. Hill, and D. R. Gill. 1997. The effects of grain source and grain processing on performance of feedlot cattle: A review. J. Anim. Sci. 75:868-879.

Owens, F. N., A. DiCostanzo, and T. Johnson. 2018. Efficiency of various corn cropping and feeding Systems. Plains Nutrition Council Spring Conference (pp. 38-82), San Antonio. Texas A&M Agilife Res. and Ext. Center, Amarillo.

Preston, R. 2016. 2016 feed composition table. beefmagazine.com. Mar:16-34.

Stock, R., R. Grant, and T. Klopfenstein. 1995. Average composition of feedstuffs used in Nebraska. G91-1048-A. Univ. of Neb., Lincoln.