

COMPARING COST VERSUS BENEFITS OF CORN PROCESSING FOR FEEDLOT CATTLE

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SUMMARY

Corn processing techniques differ in their effects on feedlot performance and carcass characteristics of finishing cattle. Capacity of a feedlot (critical mass) can dictate which processing method is most feasible economically due primarily to fixed costs for equipment. The local and regional corn pricing basis and availability of other ration ingredients also can influence which corn processing equipment/methodology is preferred at different feedlots. Energy cost also will have a major impact on choice of grain processing techniques. The preferred corn processing technique also may differ when ethanol by-products are included in the finishing diets of feedlot cattle. Processing costs were compared with cattle performance benefits based on published data summaries. Processing costs adjusted to a bushel of #2 corn (85% DM) were \$0.03, \$0.05, -\$0.11, and \$0.20 per bushel for dry-rolled corn (DRC), finely-ground corn (FGC), high-moisture corn (HMC), and steam flaked corn (SFC), respectively. Steam flaked corn was the only processing method economically feasible to apply to finishing feedlot cattle diets when using traditional feedlot diets, applying modern processing and energy costs. However, when processing techniques were applied to feedlot diets including corn ethanol by-products, HMC, a combination HMC/DRC, or DRC yielded superior economic returns when compared to SFC. With the rapid expansion of the ethanol industry, an examination of grain processing techniques and costs may be justified, especially with increasing energy costs/inputs.

INTRODUCTION

Corn processing techniques have been evaluated arduously for many years. In fact, most feedlot cattle expansion in the United States has occurred where grain is readily available; new and improved economically viable processing techniques have evolved and been adopted readily during this expansion. Basically, corn is processed to increase starch availability from the corn kernel; this improves energy availability and feed efficiency through benefits in terms of increased daily gain while realizing enhanced carcass value and thus impacting economic returns. Some of these parameters cannot be measured until the cattle have been harvested. Measurements that can be taken during the growth period of cattle (pre-harvest) include daily dry matter intake, fecal starch concentration, manure scores, and incidence of metabolic disorders. Roughage inclusion rate and particle size of the roughage may have a profound impact on the relative value of different grain processing techniques. Most researchers and nutritionists recognize that other ration components also can have a profound impact on the associative affects of feeds and can interact with grain processing techniques. Finally, selection of a processing technique also needs to consider environmental impacts, cattle in-weight, and total days on feed.

A plethora of excellent reviews have examined cattle performance responses to various corn processing techniques (Owens et al., 2005, Zinn et al., 2002, Owens et al., 1997, Huntington., 1997). These reviews generally recognize that other components of the diet, specifically roughage quantity and source, can alter the benefit from a specific grain processing technique. Less information is available that contrasts these benefits of corn processing against the costs of processing. Only by making such a comparison can the cost:benefit ratio of a grain processing method be properly evaluated. Costs associated with grain processing often are a major component that determines the economic viability of an individual feedlot. Once a grain processing technique is selected, investments in grain processing equipment can be huge and it becomes difficult and costly to make major changes. Only with a newly established feedyard or during feedlot expansion can processing procedures be freshly evaluated or altered. Factors that can predicate changes in grain processing method include some alteration in source and availability of grain or grain substitutes, in cost of the grain relative to cost of processing, and in cost of other inputs including energy, labor to operate equipment, and equipment maintenance costs.

Most finishing cattle on feed in the U.S. are fed steam-flaked corn, so steam flaking is the industry standard. The second most prevalent processing method is dry-rolling, and third would be high-moisture corn or some combination of high-moisture with dry-rolled corn. This paper will focus on corn as the grain source and its processing costs and resulting efficiencies.

The number of ethanol plants continues to expand, especially plants that use corn as a substrate. One by-product of the ethanol milling process is wet distillers grains plus solubles (WDGS). Because ethanol plants extract most of the available starch from the corn, the resulting WDGS has little starch. Many feedlots in the ethanol belt (also known as the corn-belt) include WDGS at approximately 30% of the dry matter of finishing cattle diets. It is not the objective of this paper to evaluate the optimal inclusion rate of WDGS, but rather to suggest that 30% (DM basis) WDGS is the current industry standard (Vander Pol et al., 2006). When feedlots substitute WDGS for 30% (DMB) of the dietary grain, starch content is decreased markedly. Many researchers have questioned if greater processing of corn (e.g., fine-grinding) is justified when WDGS can be included into finishing diets due to the low starch content of such diets. Obviously, processing can be increased, but greater processing increases the cost of processing.

With ethanol plants now competing for corn, cost of corn as a livestock feedstuff has increased. This competition has drastically increased the price of corn within the United States. With energy prices beginning to influence the price of corn, the concurrent costs associated with drying high-moisture corn versus ensiling becomes a pertinent questions. Historically, the grain industry had created a large negative price basis for corn within the ethanol belt. Drying costs are currently high enough (\$0.04-0.05 per point of drying to 85% dry matter; Peters-personal information, 2006) to encourage feedlots to offer corn producers a dockage of only \$0.02 per point of moisture. Thus, HMC often has been priced favorably for use by feedlots as the grain source in finishing cattle diets.

Macken et al. (2006) discussed the efficiencies of scale and operational differences in constructing and operating various corn processing facilities. These investigators discussed the initial costs and daily costs

to process corn using SFC, DRC or HMC. They recognized that critical mass (amortization of processing equipment assets related to size of feedyard) is an important consideration for determining the processing system preferable for each feedlot. Variable costs such as natural gas, electric rates and labor costs also will influence the choice of processing equipment and the degree of corn processing.

The objective of this paper is to combine current processing costs with previously published cattle performance responses from various processing techniques and compare economics. The paper is an attempt to consider parameters appropriate for a minimum size feedlot of 5-10,000 head capacity for DRC, FGC or HMC. Steam flaking is not considered because to justify the initial capital requirements for a steam flaked system, a feedlot would need to have at least 20,000 head to create positive economic returns. Economic efficiencies and comparisons for these differing corn processing systems will be compared based first for traditional finishing diets (devoid of by-products) and secondly for finishing diets containing 30% WDGS.

MATERIALS AND METHODS

High-Moisture Corn

Although numerous variables are involved with ensiling of HMC, modern equipment has markedly reduced the costs associated with harvesting, processing and storage. Owens et al. (2006) states that the preferred moisture content for corn for maximum feed efficiency and ruminal starch digestion, coupled with sufficient fermentation duration, is 26-31% moisture. For simplicity, HMC will be indexed at 30% moisture. Modern HMC management practices would include application of a fermentation inoculant and processing of kernels to about 1200 to 1550 micron geometric mean diameter (moderate rolled). Storage methods used across the feedlot industry for HMC vary substantially from upright silos, plastic storage bags, bunker silo's, to flat drive-over piles. The economic analysis for HMC storage will include plastic covered, bunker style storage using split tires holding down the plastic. Many feedlots have advanced to drive-over piles of HMC that are adequately packed but devoid of concrete sidewalls. These drive-over piles allow greater flexibility in the amount of corn and depth of

pile and reduced cost of the storage area. Labor requirements for ensiling HMC are intense during harvest times. HMC must be received, processed,

packed, and covered in a short time period to insure optimal fermentation and reduce DM loss.

Table 1. Pricing high-moisture corn vs. dry corn by the bushel and ton

Base price, \$/bushel	\$3.00	\$3.00	\$4.00	\$4.00
Moisture	15%	30%	15%	30%
With moisture discount, bu ¹	\$3.00	\$2.47	\$4.00	\$3.29
With elevator discount, bu ²	\$2.81	\$1.51	\$3.81	\$2.30
With feedyard discount, bu ³	\$3.00	\$2.00	\$4.00	\$2.79
With moisture discount, ton	\$107.14	\$88.24	\$142.86	\$117.65
With elevator discount, ton	\$100.36	\$53.75	\$136.07	\$81.96
With feedyard discount, ton	\$107.14	\$71.25	\$142.86	\$99.46

¹Moisture discount = 1.4% per point.

²Elevator discount = \$0.11/bu. Storage charge, \$0.08/bu. In/Out charge, and \$0.045/point drying charge.

³Feedyard discount = \$0.025/point drying charge, no In/Out or storage charge.

Pricing often is the most attractive attribute of high moisture corn. In the ethanol belt, many people grow and harvest large tracts of corn land, and the advantages from earlier harvesting corn (30% moisture HMC) are numerous. Harvesting of HMC can begin when drying the grain to #2 yellow corn (85% DM), would be cost prohibitive. As seen in Table 1, large shrink, drying costs and storage charges are associated with drying corn. In times of low corn prices (below loan rate economics), earlier harvest (30% moisture) usually allows crop farmers to take advantage of the USDA-Loan Deficiency Payment (LDP) because early harvest often is associated with lower cash corn prices. Earlier harvest of corn also expedites the entire harvest process and reduces losses of grain due to shattering, lodging of plants, and ear drop. Parameters 1 describes charges terminal elevators associate with grain delivery. Although it is difficult to set up a long term pricing strategy for feedlots to purchase HMC, the advantages usually out-weigh the disadvantages. Disadvantages associated with purchasing large quantities of HMC

include basis negotiations, carrying costs, additional moisture added to diets, and convenience factor for delivery and processing and pricing strategies (parameters 2) to name a few. However, the positive attributes associated with purchasing HMC often reaps huge economic benefits. Shown in Table 2, HMC provides an 11-cent per bushel advantage for the feedlot over processing costs when the parameters described in pricing are included. This economic advantage obviously is obtained most easily obtained when a feedlot is situated within a corn growing area.

Parameters 1. Corn pricing at terminal markets

Common elevator charges for 2006

1. Basis irregularities and variation!
2. Storage charges: 1 – 100 days is \$0.11/bu
3. In/out charges (handling) is \$0.08/bu
4. Adjusted to 84.5% dry matter
5. Shrink is 1.4 to 1.5%
6. Drying costs averaged \$0.045 per point
7. Delivery costs and time is expensive

Parameters 2. Negotiated basis & timing of pricing for high-moisture corn

1. At harvest: Large positive basis over locals
2. December 15 (or river freeze): Small positive basis over locals
3. On Dec. 15th for March board (and payment) is local basis (no storage cost)
 - ONE HAF DRYING COST CHARGE on 26 – 32% moisture, $\frac{3}{4}$ cost on 18 – 26, full drying costs on >32 moisture
 - 1.4% shrink, no storage or in/out charge

Table 2. Corn processing costs for a 10,000 head (DRC, FGC, HMC) or 20,000 head (SFC) feedlot¹

Item	DRC	FGC	HMC	SFC
Fixed Costs				
Dep. & Int.	0.63	0.84	1.08	0.62
Insurance	0.02	0.02		0.02
Taxes	0.01	0.02	0.03	0.02
Total fixed costs	0.66	0.88	1.11	0.66
Variable costs				
Labor	0.38	0.60	1.41	0.52
O&M	0.15	0.25	2.35	0.64
Natural gas				4.32
Electricity	0.05	0.06		1.06
Yearly storage			5.32	
Moisture discount			-16.99	
Carry costs			2.82	
Total variable costs	0.58	0.91	-5.09	6.55
Total cost per U.S. ton (as-fed basis)	1.24	1.79	-3.98	7.21
Total cost per U.S. ton (dry matter basis)	1.46	2.11	-4.68	8.48
Total cost per bushel, No. 2 yellow corn	0.03	0.05	-0.11	0.20

¹DRC, dry rolled corn; FGC, fine ground corn; HMC, high-moisture corn; SFC, steam flaked corn.

²Corn dry matter percentage: DRC, 85; FGC, 85; HMC, 70; SFC, 80.

Adapted from Macken et al., 2006.

Dry-rolled Corn and Finely Ground Corn

Except for feeding corn whole, dry rolling is probably the easiest processing methodology to include in feedlot operations. Advantages for utilizing DRC include simplicity of the technique and management and low investments in equipment. Corn can be purchased and inventoried on a “just-in-time” basis. Equipment commonly includes either a single or double stack roller mill. Although feedlots will use different techniques to reduce shrink or temper corn prior and during the rolling process, transfer and processing loss (shrink) is estimated commonly to be about 1.5% of the corn weight. Processing corn through a roller mill requires an initial investment in bins, grain legs, reception pits and other grain handling equipment. Difficulties associated with

DRC include constant monitoring of rolls and of particle size to obtain a uniform or desired particle size, particularly if grain is finely ground (<800 microns). Many dairy operations that include high roughage content (more than 45%) into diets process corn as FGC. Feedlots that include by-products low in starch content, specifically wet gluten feed or WDGS, can safely feed FGC. However, Tables 3 and 4 both show that feedlot performance is poorer for FGC as compared with corn processed more coarsely when diets contain 30% WDGS. However, feedlots continue to investigate the potential for including FGC into diets containing WDGS and include roughage levels over 10% of diet dry matter. Limitations for FGC include the extra electricity inputs and slower processing throughput.

Table 3. Distillers grains & grain processing

Item ²	Processing ¹					
	FGC	SFC	HMC	DRC/HMC	DRC	WC
DMI, lb/d	20.4	20.4	21.0	21.5	22.6	23.1
ADG, lb	3.38	3.59	3.89	3.91	4.05	3.85
F:G	6.15	5.76	5.46	5.61	5.68	6.07
HCW, lb	801	821	852	854	870	849
% Choice	46.1	48.3	65.0	62.4	63.5	60.0
YG	3.06	3.22	3.37	3.30	3.62	3.49

¹FGC, fine-ground corn; SFC, steam-flaked corn; HMC, high-moisture corn; DRC, dry-rolled corn; WC, whole corn.

²DMI, dry matter intake; ADG, average daily gain; F:G, feed to gain ratio; HCW, hot carcass weight; YG, yield grade.

All diets contained 30% wet distillers grains (dry matter basis) and 61.4% corn.

Steers fed 168 days, initial weight = 701 lb.

Vander Pol et al., 2006 Nebraska Beef Report.

Table 4. Wet distillers grains & grain processing based on feed:gain¹

FGC	SFC	HMC	DRC/HMC	DRC	WC
% Improvement					
-1.3	+5.1	+10.1	+7.6	+6.4	--- ^a
-2.1	+8.3	+16.4	+12.4	+10.4	--- ^b

¹FGC, fine-ground corn; SFC, steam-flaked corn; HMC, high-moisture corn; DRC, dry-rolled corn; WC, whole corn.

^aExpressed as % above WC, calculated for entire diet.

^bExpressed as % above WC for the corn fraction only (61.4% of the diet).

Vander Pol et al., 2006 Nebraska Beef Report.

Steam-flaked Corn

Steam-flaked corn results in performance advantages when included in diets that do not contain WDGS. This advantage has been documented in numerous grain processing reviews; as compared with dry whole corn the improvement in feed efficiency is 11 to 12%. Zinn et al., (2002) examined various corn processing techniques and compared efficiency of feedlot cattle fed these diets. Compared to whole corn, SFC improved cattle performance efficiency by 12%. Efficiencies with dry rolled corn and FGC were 5% or 0.2% poorer than for whole corn in finishing cattle diets. As previously stated, most large commercial feedlots steam-flake their corn. Flake density (bushel weight) preference varies among feedlots and processing facilities. Owens et al. (1997) reported that medium flakes (24-29 pounds/bushel) offered improved feed efficiency despite lower DMI and ADG when compared to finer flakes (<23 pounds). For the sake of comparing economic advantages or disadvantages of processing corn, as in this paper, I assumed that SFC had a density of 26 to 28 pounds per bushel.

Vander Pol et al. (2006; tables 3 and 4) reported that SFC included into diets containing 30% WDGS improved finishing F/G when compared to whole dry corn (WC) by 5.1% but the efficiency was not improved as dramatically as with HMC, a DRC/HMC combination, or DRC (10.1%, 7.6% and 6.4%, respectively).

Steam-flaking corn is a very energy intensive process. Equipment for steam flaking includes a grain handling set-up similar to that for DRC plus a stainless steel steam chest to cook the corn (2 steam chests for a 20,000 feedlot). Flake density must be monitored, so processing is more intensive than other processing techniques. Natural gas requirements are substantial for steam flaking corn or other grains. Macken et al. (2006) described the economic inputs for operating a steam flaking unit and their values were adjusted to current (2006) energy costs. Each feedlot has a different critical mass, energy cost, and operational efficiencies for processing grain.

Parameters 3. What are current corn processing costs?

- Comparing 20,000 head feedlot using steam flaking equipment to 10,000 head feedlot using high-moisture corn or dry rolled corn
- Current electric costs of \$0.07 per kilowatt hour
- Current natural gas costs of \$10.15/1000 ft³ (November 2006)
- Dry rolled corn is > 1800 microns
- Finely rolled corn = 800 microns
- Labor at \$15.00/hour
- Rolling stock at \$40 per hour

COSTS

The input costs associated with differing processing procedures are described in parameters 3 and incorporated into Table 5. Costs used were seven cents per kilowatt-hour for electricity and \$10.15/1000 cubic feet of natural gas (November, 2006 Wall Street Index). Many feedlots have negotiated “peak-shaving” electric rates or a kilowatt hour (kWh) rate that may be substantially less than \$0.07 cents per kWh. Likewise, natural gas rates currently are relatively high and some feedlots negotiate or contract for gas at a “quantity discount” use rate. When these inputs were incorporated into the model generated by Macken et al. (2006) and all processing types were equalized to 85%DM #2 Yellow corn basis, the costs for processing become transparent. Granted, each

individual feedlot will use a different depreciation schedule and this will alter the processing costs.

Prices for equipment also will vary depending on the initial investment cost, the depreciation schedule, and operation and maintenance costs (O&M). Relative costs for construction and upkeep must be benchmarked to realistically compare with animal efficiency differences. As observed in Table 6, the total cost for processing per bushel #2 yellow corn was \$0.03, \$0.05, -\$0.11, and \$0.20 for DRC, FGC, HMC and SFC, respectively. The negative price for the processing cost of HMC is derived from the purchase price advantages shown in parameters 1 and 2.

Table 5. Value of processing corn in rations without by-products (\$3.00 or \$4.00 per bushel)¹

	FGC	SFC	DRC	WC
\$3.00 Corn				
% Increase	(0.2)	12.0	(5.0)	0
Value (\$)/bushel	2.99	3.36	2.85	3.00
\$ Proc/bushel	0.05	0.20	0.03	0
Net \$/bushel	2.94	3.16	2.82	3.00
\$/1000 head	(3,942)	10,512	(11,826)	0
\$4.00 Corn				
Value (\$)/bushel	3.99	4.48	3.80	4.00
\$ Proc/bushel	0.05	0.20	0.03	0.00
Net \$/bushel	3.94	4.28	3.77	4.00
\$/1000 head	(3,942)	18,396	(15,111)	0

¹Based on 550# of gain & 65.7 bushels per head; FGC, fine ground corn; SFC, steam flaked corn; DRC, dry-rolled corn; WC, whole corn. Adapted from Zinn et al., 2002.

The value of processing corn is calculated (Table 5) for the various methods by comparing the efficiency improvements summarized by Zinn et al. (2002). These economic values greatly favor SFC when incorporated into feedlot diets without by-products. These economic benefits are compared at

various corn prices in the table. The economic advantage of SFC is magnified when the price of corn increases. In simple economic terms, the 12% improvement in cattle efficiencies far out-weighs the high cost of flaking when compared to DRC or FGC. The negative economic effects of converting whole

corn to DRC and FGC are magnified when the price of corn increases.

Table 6. Value of processing corn in rations with wet distillers grains (\$3.00 & \$4.00 per bushel)¹

	FGC	SFC	HMC	DRC:HMC	DRC	WC
\$3.00/bushel						
% Increase	-2.1	8.3	16.4	12.4	10.4	0
Value (\$)/bu	2.94	3.25	3.49	3.37	3.31	3.00
\$ Proc/bushel	0.05	0.20	(0.11)	(0.08)	0.03	0.00
Net \$/bushel	2.89	3.05	3.60	3.45	3.28	3.00
\$/1000 head	(5,243)	2,274	27,933	20,973	13,085	0
\$4.00/bushel						
Value (\$)/bu	3.92	4.33	4.66	4.50	4.42	4.00
\$Proc/bushel	0.05	0.20	(0.11)	(0.08)	0.03	0.00
Net \$/bushel	3.87	4.13	4.77	4.58	4.39	4.00
\$/1000 head	(6,218)	6,125	35,542	26,726	17,910	0

¹FGC, fine-ground corn; SFC, steam-flaked corn; HMC, high-moisture corn; DRC, dry-rolled corn; WC, whole corn. Based on 550# of gain & 46.4 bushels per head.

Adapted from Vander Pol et al., 2006 Nebraska Beef Report.

When processing costs are calculated for feedlot diets that include WDGS at 30% DM, the economic values change greatly based on the lower value of flaked corn when fed with WDGS (Table 6, adapted from Vander Pol et al., 2006). Compared with the large mass of research information available for diets without WDGS, value of processing methods with diets containing 30% WDGS is rather limited. Nevertheless, based on these data, feed efficiency was improved by 10.1%, 7.6%, 6.4%, 5.1%, and (-1.3%) for HMC, DRC/HMC, DRC, SFC and FGC, respectively. Table 6 compares the value of these processing methods with corn at various prices. These results differ markedly from the calculations with no WDGS in the diet. When WDGS is included in diets, HMC as the grain source provides an overwhelming economic advantage. All processing techniques appear justified when compared to whole corn (WC) with the exception of FGC and SFC. Processing to form HMC, DRC/HMC and DRC are viable and economically beneficial techniques regardless of the purchase price of corn. However, flaking appears justified when corn purchase price exceeds \$3.00 per bushel when diets contain 30% WDGS. Because efficiency advantages will differ depending on numerous factors, e.g., flake density, moisture content of HMC, further trials evaluating processing responses in diets containing WDGS are needed.

IMPLICATIONS

The cattle industry processes corn grain by various techniques primarily to improve starch utilization by feedlot cattle. When cattle are fed in areas where WDGS is not available or economically feasible to incorporate into diets, SFC is the method of choice. The improvements in efficiency for SFC far outweigh the cost associated with the processing technique and the economic benefit or detriment of processing grain is magnified when grain price increases. However, in studies where WDGS has been included in the diet, results indicate that HMC is the economically preferred processing technique. Numerous additional costs associated with these different processing techniques need to be carefully analyzed when constructing and operating or when expanding a feedlot. Operation and management costs may outweigh the cattle performance benefits realized with certain processing methods. As electric costs and natural gas costs fluctuate in price, feedlots should consider whether processing techniques should be altered. Although the quantified animal energy improvements differ among processing techniques, the economic return from certain processing methods may not validate long-term capital investment. As feedlots consider geographic regions for expansion or location, analysis of prices not only of grain but also for by-products and roughage becomes important.

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