

## HISTORY OF FEED PROCESSING

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### INTRODUCTION

Since cattle have the ability to masticate and regurgitate the feed(s) which they consume we would assume that it was not necessary to process (mechanically or by other means) the feed for them. In the early days, conditions were different when cattle survived by grazing on pasture or were fed harvested forages and fed a minimum quantity of grain.

As time changed to increase the performance of animals it became necessary to increase the energy level in the diet by feeding a larger quantity of concentrates. Various grains became available. The cereal grains were found to possess varying characteristics such as shape, size, texture, etc. The

digestibility and palatability of these grains in their natural condition were found to be different to some degree. Through technology the development and introduction of processed cereal grains (as well as roughages) brought about the increase in animal performance and efficiency of meat and milk production.

### CHRONOLOGY (HISTORICAL EVENTS RELATED TO FEED PROCESSING)

Although there have been numerous events that have transpired through the years in connection with feeding cattle, especially with high concentrate feeds, a few of these events are listed to tie in with history of feed processing. These events are listed in chronological order:

#### *Chronology: Historical events related to feed processing*

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- 1800 Heavy grain feeding to beef cattle started in Ohio.
  - 1840 Corn sheller and hammer mill were invented.
  - 1852 Land-grant colleges endowed under Morrill Act.
  - 1885 Commercial feed manufacturing industry began in Chicago.
  - 1898 First publication of "Feeds and Feeding" by W.A. Henry.
  - 1908 American Society of Animal Science adopted (formerly American Society of Animal Nutrition and American Society of Animal Production).
  - 1920 Hybrid seed corn was produced and sold on limited basis.
  - 1939 The rumen fistula was introduced for digestion studies (by Michigan State University researchers, C.F. Huffman and associates).
  - 1942 Commercial cattle feeding began to emerge.
  - 1962 Flaked corn introduced to large feedlots.
  - 1963 The Net Energy system was designed by Lofgreen and Garrett for the beef cattle industry.
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### WHY PROCESS FEEDS?

There are several cereal grains that are available for livestock feeding. The production and harvesting rates as well as the prices of these grains usually varies with the geographical and climatic conditions. Livestock feeds (cereal grains) in harvested condition differ in many characteristics and therefore may be justifiable for processing prior to cattle feeding. These characteristic differences are noted in Table 1. The nutrient content of the grain may also be a contributing factor.

**Table 1.** Why process feeds?

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Livestock feeds (grains) in harvested condition differ in:
1. Size
2. Texture
3. Shape
4. Maturity
5. Moisture (length of storage)
6. Palatability ???

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### GRAIN PROCESSING METHODS

Prior to the introduction of hybrid corn around 1920, flint and dent corn were fed to fattening cattle.

This type of corn was hard and flinty. Hence, the practice of soaking the kernels emerged. An interesting trial in Kansas compared the performance of steers fed dry whole corn or whole soaked corn. Pigs followed the steers in each pen and the performance of pigs was also compared. The results provided the following thumb rule: “Ten pigs per ten steers.”

There was another interesting observation in scanning through the early history of feed processing. Although Indian corn was not commonly used for livestock feed this type of corn became a useful tool for “rate of passage” study. Again, the Kansas researchers fed two pens of steers – one pen was fed “white” colored whole corn and the second pen was fed “red” colored whole corn. The “test”

was to determine the “time” it took the kernels to pass through the digestive tract by counting the undigested kernels in the droppings every hour after feeding. White kernels were found to be easier to count and more consistent in the results.

There are probably more than a dozen different methods of processing grains for cattle, particularly feedlot cattle. Many of these processing methods were investigated between 1950 and 1975. During this period, there were more than 200 research trials that were published.

Among the various methods of processing grains it appears appropriate to classify them into two categories – Dry or Wet process. The processing methods with the beginning date of each method are shown in Table 2.

**Table 2.** Grain processing methods

Dry Process		Wet Process	
Method	Year Started <sup>1</sup>	Method	Year Started <sup>1</sup>
Grinding	1840	Soaking <sup>2</sup>	????
Crimping	1930	Cooking, boiling <sup>2</sup>	????
Pelleting	1957	Steam rolling (barley)	1930
Extruding	1966	Steam flaking (corn)	1950
Popping	1966	High moisture-ensile	1958
Micronizing	1970	Pressure cooker-roll	1966
Roasting	1975	Reconstitute <sup>3</sup> (milo)	1968
		Exploding (milo)	1972

<sup>1</sup>Approximate dates.

<sup>2</sup>These methods did not alter physical characteristics. Used for hard, dry grains.

<sup>3</sup>Add hot water (160 °F), 20-30% moisture, cure 21 days in air tight silo, and roll.

## THE BEGINNING OF COMMERCIAL CATTLE FEEDING

When commercial cattle feeding began to emerge in the mid to late 1940s, the race for the title of “King of the cattle feedlot industry” started. The three contenders were:

1. Warren H. Monfort, Greeley, Colorado
2. Louis Dinklage, Wisner, Nebraska
3. Earle Brookover, Garden City, Kansas

The three feeders met periodically, usually in West Point or Omaha, Neb., to discuss various means of improving their feeding operation. They invited John Matsushima from the University of Nebraska quite frequently. All three operators kept accurate records and agreed that the *feed cost* was the most expensive part of their business –

approximately 75 to 80 percent. What can be done to reduce this feed cost?

At one meeting in Omaha on a cold winter day when the temperature was several degrees below zero the three feeders and Matsushima were having breakfast. Instead of having the regular menu of bacon and eggs the four orders were either oat meal or corn flakes with “hot milk.” A bright idea flashed Matsushima’s brain -- “Why not feed corn flakes to the cattle in the feedlot?” The idea might have been good but the big question was “how will the corn be processed and who will do it?”

At another meeting in Omaha, in the late 1950s, it was decided to approach a large feed manufacturing plant, John Nixon & Co. to design equipment to make corn flakes for a feedlot operation. Russ Kendall, the

mill operator and salesman for Nixon & Co. offered to assist.

Before the plans went too far along Matsushima was lured away from Nebraska to Colorado by Warren Monfort. Louis Dinklage's offer of a new

Cadillac to Matsushima to remain at Nebraska went for naught and the corn flake idea went to Colorado in 1961. The results from the first two feeding trials at Colorado convinced Warren and Kenny (son of Warren) to switch from ground corn to flake corn. In 1964, they installed 16 new flaking machines.

**Table 3.** Early corn flaking process, Colorado State University, 1962

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1. No. 2 grade, 12% moisture corn used.
  2. Gravity flow of whole corn into 15 in. x 34 in. x 6 ft. steam chamber.
  3. Five steam jets located in chamber.
  4. Duration of steam treatment – 11 to 12 minutes.
  5. Temperature in steam chamber – approx. 200oF.
  6. Two corrugated steel rollers at bottom of steam chamber.\*
  7. Setting of two rollers – produce 1/32 inch thick flaked corn.
  8. Moisture content of flaked corn leaving rollers – 20%.
  9. Denver Roll; Roskamp Mfg. and Ross Machine & Mill Supply.\*
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\*1962-1964.

### **PROTOTYPE DEVELOPMENT OF FLAKING MACHINE**

In order to prepare “corn flakes,” starting with whole dry corn, it was necessary to have two pieces of equipment – one to add moisture to the dry grain and the other to flatten the kernels. To add moisture to the grain, steam is much faster than using ordinary cold water. To flatten the kernel that has been moistened, appropriate roller machine is necessary to make flakes of proper thickness. The production rate is very important and therefore the design of the moisture adding compartment must coincide with the capacity to which the roller equipment can handle.

In order to prepare the desired “corn flakes” for cattle feeding it took nearly two years to develop prototype flaking equipment. The assistance of three roller machine companies was involved. The most difficult portion of developing the prototype was the moisture addition (steam chamber) – the location and number of steam jets and the shape plus the dimensions (width, depth and length). Brief description and results in the prototype development of the steamed corn flakes are noted in Table 3.

### **EARLY FEEDING TRIAL (COLORADO)**

While the prototype flaking equipment was undergoing several changes at Colorado State University a cooperative feeding trial was conducted with a small commercial feedlot. The results from this test are shown in Table 4.

As the commercial feedlot test was being completed another similar feeding trial was started at the Colorado State University research center. The results from the feeding trial are shown in Table 5.

### **DENSITY CHARACTERISTICS OF FLAKED GRAINS**

Concurrently with the feeding trials various laboratory tests were conducted. One of the tests included the density (weight per volume) comparisons between flaked corn and cracked corn (Table 6). The milo comparisons are data from Oklahoma.

Theurer et al (1999) indicated “...decreasing flake density from 437 to 283g/l (34 to 22 lb/bu) of steam processed corn or sorghum increased the proportion of starch digested in the rumen and digestive tract, resulting in less dietary starch digested in the small intestine. Decreasing flake density increased N digestibility when fed sorghum grain but not when they were fed corn.”

**Table 4.** Flaked corn vs. cracked corn; 1962. First cooperative field trial. Colorado\*

Treatment	Dry, Cracked Corn	Steam Flaked Corn
No. cattle	49	52
Initial weight, lbs	784.60	805.60
Final weight, lbs	1102.90	1140.80
Total gain, lbs	318.30	335.20
Avg. daily gain, lbs	2.51	2.64
Feed intake/day/head	20.28	19.77
Grain/lb of gain	8.08	7.50
Grain intake as percent of body wt, %	2.15	2.04
Roughage (dry basis) intake as percent of body wt, %	0.60	0.57
Dressing percent	64	63.74

\*CSU in cooperation with Red Bird Feed & Grain Co., Eaton and Henry Schneider and Henry Ruff (commercial feeders), Ault, Colorado.

**Table 5.** Flaked corn vs. cracked corn vs. cooked-cracked corn\*

Treatment	Regular Cracked Corn <sup>1</sup>	Cooked, Cracked Corn <sup>2</sup>	Cooked, Flaked Grain <sup>3</sup>
Initial weight, lbs	517	515	516
Final weight, lbs	920	896	904
Avg. daily gain, lbs	2.63	2.49	2.54
Avg. daily ration, lbs	21.20	21.80	19.60
Feed required/cwt gain (air dry), lbs	803	877	772
Dressing percent	61.70	62.90	62.90
Carcass grade <sup>4</sup>	17.30	17.70	16.90

\* 1963. Colorado.

<sup>1</sup>70% corn and 30% barley mix.

<sup>2</sup>70% corn and 30% barley mix; cooked 12 minutes at 200°F.

<sup>3</sup>70% corn and 30% barley mix; cooked 12 minutes at 200°F and rolled.

<sup>4</sup>Ch+ = 18; Cho = 17.

**Table 6.** Change in weight per volume by processing

Corn <sup>a</sup>		Milo <sup>b</sup>	
	Wt/bu, lbs <sup>c</sup>		Wt/bu, lbs <sup>c</sup>
Whole dry corn	56.5	Whole dry milo	59.1
Regular cracked corn	50.6	Coarsely ground	49.7
Steam flaked	24.2	Steam flaked	23.3

<sup>a</sup>Colorado State University.

<sup>b</sup>Oklahoma State University.

<sup>c</sup>Air dry basis.

Swingle et al (1999) reported that “Steam flaking of sorghum grain improves feeding value by 12-15 % principally by improving digestibility of starch in the rumen and total tract. Optimal flake density for steam flake sorghum appears to be 360 g/l (28 lb /bu).”

Daily feed intake, daily gain, feed efficiency and carcass grades between the two comparisons

were quite similar. (Hence, small feedlot operations can use flaked corn that was processed several days before feeding). Zinn and Barrajas (1997) reported “Retrogradation or loss of starch solubility was not enhanced by air drying corn after steam flaking. The characteristics of digestion and hence the feeding value of steam flaked corn are not altered by air drying before feeding.”

**Table 7.** Findings from early trials\*

1. Flaked corn was lower in density vs. cracked corn:  
27 lbs/bu (flaked) vs 38 lbs/bu (cracked) at 13% moisture. (Approximately 30% lighter.)
2. When fed in feedlot rations, flaked corn ration resulted in lower feed intake but daily gains were similar to cattle fed cracked corn.
  - (a) Hence, feed efficiency was increased 8 – 10%.
  - (b) No difference in carcass grade.
3. Results were comparable when flaked corn was fed *immediately* after processing or *air dried* to around 15% moisture and then fed.

\*1962-1964. Colorado.

**Table 8.** Early questions on feed processing<sup>1</sup>

1. Which grain processing method improves "feed efficiency" in feedlot cattle?
2. What factors account for this increase in feed efficiency?
  - a. Increase in density of processed grain?
  - b. Change in surface area for easier access to rumen microorganisms?
  - c. Change in starch (gelatinization)? (birefringence)?
  - d. Increase in moisture absorption?
  - e. Change in rate of passage through digestive tract?
  - f. Shift in proportion of volatile fatty acids?
  - g. All of the above?

<sup>1</sup>Timeframe: 1960 – 1980.

**Table 9.** Water uptake of corn particles due to processing\*

Method of Process	Soaking Time Minutes	Water Uptake, grams/ 100 grams
Dry roll (cracked)	1	43
Flaked	1	90
Dry roll (cracked)	10	49
Flaked	10	75
Dry roll (cracked)	30	60
Flaked	30	153

\*1966. Colorado.

### EARLY QUESTIONS ON FEED PROCESSING

In the early stages when the flaking process of grain, particularly corn, was getting under way (Table 7), there were many unanswered questions. These questions are listed in Table 8.

### EFFECT OF PROCESSING ON MOISTURE ABSORPTION

Undoubtedly there are many factors that will determine the extent of moisture absorption in the *processed* grain. Table 9 shows the rapid rate of water absorption by flaked corn as compared to cracked corn.

Moisture absorption in whole dry corn in the steam chamber can be increased at a faster rate by the application of a tempering agent.

### EFFECT OF THICKNESS OF FLAKES

The flaking process introduced a number of questions when the method emerged. One of these was: "How 'thick' should the flakes be?" Results from the first feeding trial at Colorado (1967) indicated that "thin flakes" appeared to be superior to "thick" flakes. (Table 10). Average daily gain was 4.3% greater by the steers fed the thin flake and feed efficiency was 7.8% superior as compared to the steers fed the thick flake.

**Table 10.** Thickness of flaked corn\*

Treatment	Thin 1/32 in	Thick 1/12 in	Fine Ground 1/4 in
Initial weight, lbs	485	483	490
Final weight, lbs	946	923	922
Avg. daily gain, lbs	2.82	2.70	2.65
Avg. daily corn consumption, lbs <sup>1</sup>	(12.41)	(12.66)	(12.83)
Avg. daily feed consumption <sup>1</sup>			
Feed consumed/ lb gain <sup>1</sup>	6.14	6.66	6.88
Dressing percent, %	64.21	63.71	63.25
Carcass grade: % Choice	93	92	92
% Good	7	8	8

\*1967. Colorado Expt. Station.

<sup>1</sup>Air dry basis.

Osman et al (1970) indicated "...degree of increase in starch digestion in barley and sorghum grain appears to be linearly related to thickness of flakes, thinner the flakes, the better the grain is utilized."

Zinn (1993) found that "steam processing in addition to rolling will further increase the net energy for maintenance value of barley by 2.8 to 7.0%, depending on the thinness of the flake. The comparative feeding values of dry-rolled, steam rolled course, and steam-rolled thin barley are 90, 92, and 96% of the value of steam-flaked corn."

Brown et al (2000) suggested that the optimum rate and efficiency of gain in feedlot steers occurred when corn was steam flaked to a bulk density between .36 and .26 kg/l (28 to 20 lb/bu). They also found that by increasing the degree of processing the enzymatic starch availability increased but the protein and ash content of the product decreased.

**Table 11.** Methods of starch gelatinization analysis (Colorado)

1. Early methods of gelatinization analysis
  - a. Optical birefringence.
  - b. Congo orange staining
  - c. Enzymatic hydrolysis (beta amylase)  
(Early data showed this method to be most consistent.)
2. Early data showed 50% gelatinization to be optimal.

### ***B. Greatest gelatinization: at steaming vs. at rolling***

The degree of *total* starch gelatinization in the flaking process should be more important than comparing the degree of gelatinization during the steaming period or during the rolling period.

## **FLAKING AND STARCH GELATINIZATION**

### ***A. Methods of measuring starch gelatinization:***

Since starch is the major component of cereal grains its contribution to the effectiveness of feed processing is quite obvious. The application of steam to the whole grain should be the initial step in the starch gelatinization process. Further gelatinization should occur as the moisturized grain passes through the rollers.

Three methods were used at Colorado during the initial period when the flaking process emerged. The three methods used are shown in Table 11. The enzymatic hydrolysis, using beta amylase, was determined to be the most reliable method. During the mid 1960s the starch gelatinization data was compared to the feedlot trial data where the thickness of flake trial were being conducted. The early data comparisons showed that 50% starch gelatinization was optimal.

Variations in the results will probably occur due to such conditions as: duration of steaming, type of roller, setting of the rollers, etc. The Kansas data (1966) indicates that the greatest gelatinization occurs during the *rolling* process (Table 12).

**Table 12.** Starch gelatinization of corn and milo<sup>1</sup>

	% moisture	% gelatinization
Corn grain	17.1	----
Corn after steaming	22.0	16
Corn after flaking	20.5	48
Flaked corn after airlift	20.6	40
Milo grain	13.6	----
Milo after steaming	17.8	12
Milo after flaking	14.2	40-70 <sup>2</sup>
Flaked milo after airlift	14.6	47-69 <sup>2</sup>

<sup>1</sup>Phil Phar, Kansas (1966).<sup>2</sup>% gelatinization variation, may be due to thickness of flakes.**Table 13.** Effect of processing on starch granules and digestibility\*

	Method of Processing			
	Cracked	Flaked	Flake-Cracked	Cook-Cracked
Starch granules:				
Per cent <sup>1</sup>	99	50-75	50-60	98
Digestibility:				
Dry matter, %	70.1	77.5	77.1	72.4
Protein, %	59.6	66.8	65.6	62.5
Acid detergent fiber, %	33.3	40.9	38.7	40.2

\*1966. Colorado. (Johnson).

<sup>1</sup>Birefringence (starch granules examined with polarizing microscope).

## EFFECT OF PROCESSING ON STARCH GRANULES

Processing of feeds changes the physical characteristics of cereal grains, certain processing methods alter the starch granules. Johnson (1966) determined the differences in corn starch granules due to processing by the “birefringence” method. The starch granules were examined with a polarizing microscope. The results are shown in Table 13.

Steam flaked corn showed considerable difference in starch granules as compared to dry cracked corn. Digestibility of protein and dry matter were slightly higher in steam flaked corn than in cracked corn. (Table 13).

Microscopic determination of loss of birefringence is the most rapid, sensitive, reproducible method for the determination of gelatinization (Seib, 1971). Other methods such as bulk measurement, water absorbing capacity, diastatic enzyme conversion and artificial rumen digestion by measuring VFA production have been used to measure starch alteration due to feed processing (McLaren, 1968).

## SITE AND EXTENT OF STARCH DIGESTION

Even prior to the entrance of the processed grain into the digestive tract of the feedlot steer such feed as steam flaked corn or other steam flaked grains, the grain starch has already been prepared for microbial and enzymatic digestion through gelatinization. The extent or degree of gelatinization in the feed processing could then potentially affect the site and extent of starch digestion through the digestive tract.

Diet and intake can affect ruminal fermentation and subsequent supply of starch to the small intestine (Richards et al. 2003). Stock et al. 1987) found that at high diet intakes, 400 to 2,300 g of starch can flow to the small intestine of beef steers. Owens et al. 1986) indicated small intestinal starch digestibility ranging from 47 to 88%. Starch digestion in the small intestine is theoretically more energetically efficient than ruminal fermentation (Harmon and McLeod, 2001).

**Table 14.** Starch digestion in the small intestine (SI)\*

Source	Diet	Digestibility entering SI, %
McCullough	88% whole corn	88.3
Laudert	80% cracked corn	59.1
Remillard	60% cracked corn	68.1
DeLay	90% flaked corn	69.5
McCullough	88% flaked corn	86.2
McLaren	80% extruded corn, 10% gelat.	15.0
	80% extruded corn, 40% gelat.	9.8
	80% extruded corn, 90% gelat.	6.1

\*Colorado State University: Animal Science graduate students.

Starch digestion studies in the small intestine at Colorado indicated that the method of processing corn may vary from 6.1 to 86.2% with a high of 88.3% for whole corn. When the corn was processed through an extruder the digestibility of the starch was very low. The comparisons are shown in Table 14.

#### FECAL STARCH AS A MEASURE OF FEED PROCESSING EFFECT

Starch in steam flaked corn is digested to a greater extent in the rumen and entire digestive tract than

starch in whole shelled corn (Galyean et al., 1976). Although it would be rather rare to feed a combination of flaked corn and whole shelled corn in an ordinary feedlot ration the New Mexico researchers (Lee et al., 1982) found no difference in the percentage of fecal starch when flaked corn and whole shelled corn were fed in equal proportions. However, when flaked corn and whole shelled corn were fed separately, as expected, the percentage of fecal starch from the steers fed flaked corn was 39 to 59% lower than the steers fed the whole corn ration (Table 15).

**Table 15.** Fecal starch and pH changes during feeding period of steam flaked corn and whole corn\*

Diet <sup>f</sup>	Days on Feed							
	56 days		84 days		112 days		140 days	
	pH	%starch <sup>e</sup>	pH	%starch <sup>e</sup>	pH	%starch <sup>e</sup>	pH	%starch <sup>e</sup>
100W:0SFC	6.30 <sup>a</sup>	14.0 <sup>a</sup>	6.19 <sup>ab</sup>	11.4 <sup>b</sup>	6.49	21.2 <sup>a</sup>	6.06 <sup>a</sup>	21.7 <sup>a</sup>
75W:25SFC	6.35 <sup>a</sup>	13.9 <sup>a</sup>	6.33 <sup>a</sup>	14.8 <sup>a</sup>	6.40	14.9 <sup>b</sup>	6.04 <sup>a</sup>	8.7 <sup>b</sup>
50W:50SFC	6.58 <sup>b</sup>	12.2 <sup>b</sup>	6.43 <sup>a</sup>	13.9 <sup>a</sup>	6.33	13.8 <sup>b</sup>	6.09 <sup>a</sup>	8.9 <sup>b</sup>
25W:75SFC	6.74 <sup>b</sup>	10.1 <sup>c</sup>	6.74 <sup>c</sup>	7.1 <sup>c</sup>	6.39	9.4 <sup>c</sup>	6.36 <sup>b</sup>	5.6 <sup>c</sup>
0W:100SFC	6.81 <sup>b</sup>	5.7 <sup>d</sup>	6.42 <sup>a</sup>	4.5 <sup>d</sup>	6.36	3.6 <sup>d</sup>	6.20 <sup>b</sup>	3.3 <sup>d</sup>

\*New Mexico (1982:Lee, Galyean and Lofgreen).

<sup>a,b,c,d</sup>Means in the same column with different superscripts differ ( $P < 0.05$ ).

<sup>e</sup>dry matter basis.

<sup>f</sup>W = whole corn; SFC = steam flaked corn.

**Table 16.** Fecal starch and pH of whole corn and cracked corn at 140 days feeding period\*

	Whole	Cracked	Fine Ground	Whole-Crack Mixture**	Whole-Fine Mixture**
Experiment 1					
Fecal starch, %	16.8	17.0	20.4	16.3	20.3
Fecal pH	5.73	5.78	5.69	5.82	5.67
Experiment 2					
Fecal starch, %	23.7	23.6	20.5	23.5	21.6
Fecal pH	(data not given)				

\*Nebraska (Turgeon, Brink and Britton).

\*\*50-50 mixture.

Results from Nebraska (Turgeon et al., 1983) found 16.8% and 23.8% fecal starch in two separate trials (Table 16). These figures compare closely to the 21.7% fecal starch found by the New Mexico researchers.

### EFFECT OF FEED PROCESSING ON VOLATILE FATTY ACIDS (VFA)

The concentration and proportion of various volatile fatty acids can be obtained

from the rumen by a stomach tube or from fistulated animals. The results obtained from either method were found to be quite comparable (Table 17, 1966).

Whole corn has a higher percentage (42%) of butyric acid but a lower percentage (33%) of propionic acid as compared to ground corn (Sharp et al., 1982) (see Table 18).

**Table 17.** Volatile fatty acids (VFA) in rumen fluids<sup>1</sup>

Sampling Method	Flaked Corn		Cracked Corn	
	Stomach Tube	Fistula	Stomach Tube	Fistula
	Molar percentage of total VFA			
Acetic	57.3	58.2	55.5	61.7
Propionic	26.4	27.0	29.6	25.1
Butyric	12.9	11.3	11.0	10.1
Valeric	3.5	3.5	3.9	3.1
A/P ratio	2.2	2.2	1.9	2.5

<sup>1</sup>1966. Johnson (Colorado).

**Table 18.** Rumen volatile fatty acid concentrations in whole vs. ground corn (moles/100mol)\*

	Whole Corn	Ground Corn	SE
Acetic	45.5	39.3	4.5
Propionic	31.2 <sup>a</sup>	46.9 <sup>b</sup>	4.6
Butyric	16.24 <sup>a</sup>	9.38 <sup>b</sup>	1.5
Isobutyric	1.00	0.71	0.15
3-methyl butyric	0.80 <sup>a</sup>	0.48 <sup>b</sup>	0.08
Valeric	2.60 <sup>a</sup>	1.83 <sup>b</sup>	0.21
Caproic	1.10 <sup>a</sup>	0.69 <sup>b</sup>	0.13

\*Oklahoma (1982. Sharp, Johnson and Owens).

<sup>a,b</sup>Means with different superscripts differ ( $P < 0.05$ ).

### EFFECT OF PROCESSING ON DIGESTIBILITY OF GRAINS

If processing changes the density, particle size, surface area, starch characteristic of the grain as it enters the rumen its "condition" should be made

favorable for the microflora and thereby increase the digestibility.

A comparison of steam flaked corn with cracked corn in a Colorado trial (Johnson, 1966) showed an increase in dry matter, protein and ether extract digestibility as compared to cracked corn (Table 19).

**Table 19.** Digestibility of flaked and cracked corn, %\*

	Flaked	Cracked
Dry Matter	74.8	70.1
Protein	64.5	59.6
Ether Extract	85.1	78.2
Acid Detergent Fiber	33.6	33.3

\*1966. Colorado (Johnson).

The general pattern as indicated by numerous trials shows that cattle fed steam flaked corn or steam flaked sorghum have higher digestibility of grain and correspondingly superior feed efficiency as compared to cattle fed dry cracked grain.

### EFFECT OF OTHER METHODS OF FEED PROCESSING

During the span of approximately 40 years (1930 to 1970) there were nearly twelve different methods of feed processing that were explored. Besides the steam flaking process another method was investigated and has continued to be adapted to the feedlot industry.

#### A. High moisture grain processing

As the cattle feeding industry started to mushroom in the mid-western section of the United States in the mid 1950s the small cattle feeders began to utilize their home-grown feeds. The harvested corn was usually too high in moisture (30%) and therefore difficult to store in the corn cribs without artificial

drying. Ensiling such corn would preserve the corn without deterioration. Purdue University (1958) reported the first successful feeding trial using high-moisture ear corn. The cattle on high moisture ear corn gained 9% more with 5% better feed efficiency as compared to the cattle fed regular dry ear corn.

Later, high-moisture shelled corn was ground and stored in glass-lined silos or in concrete silos. Commercial feedlots in the mid-west and other cattle feeding areas began to utilize this method of processed grain supply. Some feedlots using corn silage as their only roughage source did not use high-moisture corn in the feeding program because of reduced dry matter intake and daily gain.

Data from Oklahoma (1988) showed that the cattle fed high-moisture corn gained more than the cattle fed steam-flaked corn with comparable feed efficiency. (Table 20).

**Table 20.** Feedlot performance of cattle fed processed grains<sup>1</sup>

Corn	Dry Rolled	Steam Flaked	Whole Shelled	High Moisture
Daily gain, lbs	2.75	2.75	2.75	2.84
Feed intake, lbs <sup>2</sup>	17.07	15.70	17.02	16.50
Feed efficiency, lbs <sup>2</sup>	6.21	5.71	6.19	5.81
Improvement:				
Total ration		+8.1%	+0.3%	+6.5%
Grain only		+10.9%	+0.4%	+8.1%
Grain in diet, %	74	74	78	80

<sup>1</sup>1988. Wagner (Oklahoma).

<sup>2</sup>Dry matter basis.

**Table 21.** Feedlot performance of cattle fed processed grains<sup>1</sup>

Milo	Dry Rolled	Steam Flaked	High Moisture Processed	Popped, Exploded or Micronized
Daily gain, lbs	2.56	2.76	2.76	2.76
Feed intake, lbs <sup>2</sup>	16.79	16.06	15.7	16.07
Feed efficiency, lbs <sup>2</sup>	6.56	5.82	5.68	5.82
Improvement:				
Total ration		+11.2%	+13.4%	+11.2%
Grain only		+15.1%	+17.2%	+15.2%
Grain in diet, %	74	74	78	74

<sup>1</sup>1988. Wagner (Oklahoma).

<sup>2</sup>Dry matter basis.

### B. Popped, exploded or micronized

Oklahoma researchers (1988) found the cattle fed popped, exploded or micronized milo made similar gains with equal feed efficiency as the cattle fed steam-flaked milo. (See table 21).

### GRAIN PREFERENCE BY CATTLE (CALVES)

Prior to the use of “modern” processed grains (such as steam flaked) a rather unique experiment was conducted by Arkansas researchers in 1959 (Table 22). Three different cereal grains (corn, milo and oats)

were fed whole, coarse grind, fine grind, pellet, and ground pellets on free choice basis to determine the preference by calves. The calves preferred the whole oats of the 15 different choices while the calves offered the ground oat pellets ranked last.

It would be interesting to see a comparison of corn, sorghum, barley and oats with the “modern” feed processing methods -- whole (control) vs. steam-flake vs. high moisture vs. coarse grind in a finishing ration.

**Table 22.** Grain preference by cattle (calves)\*

	Whole	Coarse Grind	Fine Grind	Pellet	Ground Pellets
	lbs	lbs	lbs	lbs	lbs
Corn	139	145	140	93	37
Milo	171	131	61	144	55
Oats	186	176	98	88	27

\*1959. Arkansas (15@315 lb calves, 105 days). Lespedeza hay.

### STEAM-FLAKED CORN VS. STEAM-FLAKED MILO

The choice of using steam-flaked corn or steam-flaked milo in a cattle finishing ration would undoubtedly depend upon the availability and cost of the unprocessed grain.

Slight differences may occur in the fuel cost of processing the two grains since the steam application time to the milo grain is longer. The performance (daily gain and feed efficiency) of cattle and carcass quality are very similar (Table 23).

### SUMMARY

The choice of feed processing by different methods for the beef cattle feedlot industry appears to be *steam-flaking*. The favorable results from the chemical laboratory to the live animal experimental feeding trials in the literature survey of more than 200 published reports reveal this choice. This choice is substantiated by the wide use of the method in the current cattle feeding industry.

There are a number of reasons why steam-flaking is the choice for processing corn and milo. A few of these reasons are noted in Table 24.

**Table 23.** Steam flaked corn vs. steam flaked milo\*

	Steam Flaked Corn	Steam Flaked Milo
Avg. daily gain, kg	1.79	1.79
Daily feed, kg	9.77	9.68
Gain/feed	0.183	0.184
Dressing %	63.0	63.8
% choice grade	83	83

\*1992. Kansas State (Brandt et al.).

**Table 24.** Summary: Why steam-flaking is the choice for feed processing

*Flaking* appears to be the choice for processing corn and milo for feedlot rations in finishing cattle (flaking vs. cracked)

1. 8 to 12% superior feed efficiency (feed/gain).
2. 10 to 30% decrease in density (weight per bushel) on dm. basis.
3. 8 to 10% faster rate of passage through alimentary tract.
4. 3 to 6% increase in dry matter digestibility.
5. 35 to 50% increase in water uptake.
6. Optimum starch gelatinization is approximately 50%.
7. Slight alteration in proportion of volatile fatty acids.
8. Decrease in energy loss as methane gas.
9. No difference in carcass quality.
10. Flaked corn and flaked milo are nearly equal in feedlot rations.

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