THE RELATIVE FEEDING VALUE OF RAW AND COOKED HOMINY FOR DAIRY CATTLE

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THE RELATIVE FEEDING VALUE OF RAW AND COOKED HOMINY FOR DAIRY CATTLE

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

TABLE		Page
1	COEFFICIENTS OF APPARENT DIGESTIBILITY OF NITROGEN-FREE EXTRACT.	52
2	COEFFICIENTS OF APPARENT DIGESTIBILITY OF ETHER EXTRACT.	53
3	COEFFICIENTS OF APPARENT DIGESTIBILITY OF DRY MATTER	54
4	COEFFICIENTS OF APPARENT DIGESTIBILITY OF CRUDE PROTEIN.	55
5	COEFFICIENTS OF APPARENT DIGESTIBILITY OF CRUDE FIBER.	56
6	COEFFICIENTS OF APPARENT DIGESTIBILITY OF ORGANIC MATTER	57
7	AVERAGE TOTAL DIGESTIBLE NUTRIENTS	58

INTRODUCTION

Considerable interest has been shown recently in the possibility of changing the fat percentage of milk by varying feeding practices. Several of these feeding practices have been shown to affect the fat percentage, namely cooking concentrates, varying the roughage concentrate ratio, changing the physical form of the roughage by grinding or pelleting and varying the type of fat in the diet. These ration alterations are thought to cause changes in rumen fermentation which would affect levels of various end products of digestion in the rumen and consequently the blood stream. Availability of these various products such as short chain volatile fatty acids to enter various metabolic pathways could affect the amount and composition of milk produced.

Cooking or steaming feed is not a new practice. Steaming meal for dairy cows was a practice almost unanimously used by dairy farmers in south and west Scotland during the last half of the nineteenth century. Henry (1900) reported that many establishments in this country had elaborate setups for steaming or boiling roughage around 1850. By 1900 the practice had been almost universally abandoned as experimental evidence indicated that by cooking digestibility was decreased, especially that of protein. Since 1900 interest in cooking had declined in this country until Shaw, working at Maryland in the early 1950's discovered that pooled milk from farms in that area was often below normal in butterfat. Investigation showed that it was due to feeding of stale bread, evidently a common practice in that area.

Prior to 1938 little work had been performed on any of the dietary factors affecting composition of milk. Eckles stated in 1927 that the effect of feed on milk composition was a settled question. However, Powell (1938) working for one of the major feed companies, discovered that cubed rations which were high in concentrate and low in roughage markedly lowered fat percentage. With publication of Shaw's work in the early 1950's interest greatly increased in the subject.

Considerable experimental work has been performed in which cooked corn has been fed at various levels with different kinds and amounts of roughages. However, many of these rations had a high concentrate, low roughage ratio or included the roughage in a finely ground state. The object of this experiment was to see if feeding dairy cows low levels of cooked hominy with normal levels of long hay would affect milk production or fat percentage.

REVIEW OF LITERATURE

Physical Form of Roughage

Milk production

Balch et al. (1954) compared a high concentrate ration containing 8 lb. long hay with one containing 8 lb. ground hay. Differences in milk production were not significant. Ensor (1959) and Ensor et al. (1959) reported a trial in which 38-42 lb. of long hay was compared with the same amount of ground hay. The average milk production decreased 17.7% for ground hay as compared to 11.1% for the long hay. Whether these differences were significant or not was not reported. Powell (1938) compared finely ground, cubed rations with regular rations for dairy cows. Most of his rations, however, contained high concentrate low roughage ratios. In comparisons where the regular ration was fairly close in composition to the cubed ration it appeared as though grinding and cubing did not have a major effect upon milk production.

Milk fat percentage

Finely ground roughage seems to have a depressing effect upon milk fat percentage. Powell (1938) reported a large drop in milk fat percentage with cows fed ground and cubed rations, low in roughage and high in concentrate. Ground alfalfa hay (0.5 to 1.0 inches long) increased fat percentage over that of finely ground hay. Five pounds of long hay was more effective in this respect than 15 lb. of silage. The fact that the form of roughage is important was exemplified by one cow that produced milk of 3.5% butterfat for a lactation on a normal herd ration. The following year on a ground cubed ration containing [illegible].7 lb. hay and 2[illegible].5 lb. concentrates, this cow produced milk of 2.1% fat for the lactation period. The third year, this cow on a ground cubed ration containing 1[illegible].1 lb. hay and 17.5 lb. concentrates produced milk containing 2.0% fat. Hope and Cannon, (1959) failed to confirm the data of Powell. Their experiment included ground hay; however, silage was also fed which they failed to grind. Silage also contains large amounts of acetic acid which has been shown by Stoddard and Allen (1949), Van Soest and Allen (1954), Balch and Rowland (1957), and Van Soest and Allen (1959) to increase milk fat in cows on a fat depressing ration. Balch et al. (1954 b) fed a group of cattle 16 lb. of long hay plus 4 lb. concentrates per 10 lb. milk daily. When the hay was reduced to 8 lb. daily and the concentrate increased to give the ration a starch equivalent equal to the control ration, the milk fat percentage dropped from 3.9% to 2.4%. Replacing the long hay with

8 lb. ground hay resulted in a further decrease to 1.57%. Balch et al. (1955 A) reported a decline in fat percentage when 2.0 lb. of hay and 20 lb. of concentrates were fed. Feeding of 5.0 lb. of macerated straw pulp brought about no recovery.

Volatile fatty acids

Balch and Rowland (1957) reported that rumen liquor contained [illegible] to 14.0 meq. of fatty acids/100 ml. of rumen liquor when hay alone was fed. When the hay was finely ground, the fatty acids varied from 7.0 to 11.5 meq./100 ml. Acetic/propionic acid ratios were decreased by replacing long hay with ground hay. These workers suggested that cows given ground feeds would salivate less and therefore the rumen would have less buffering capacity and consequently a lower pH. Balch (1958) showed that the texture of the feed did affect salivation with cows secreting 45-57 lb. saliva per 10 lb. of hay consumed as compared to 12-15 lb. of saliva per 10 lb. of concentrates consumed. The increasing acidic conditions may encourage proliferation of organisms that produce a low acetic/propionic acid ratio. The work of Balch and Rowland (1957) showed that the pH of the rumen did fluctuate more with ground or low hay rations dropping as low as 4.3 at the peak of fermentation. Shaw et al. (1959) compared ground alfalfa meal pellets with long hay and found no change in the proportion of volatile fatty acids.

Effects of Roughage to Concentrate Ratios

Milk production

When Balch *et al.* (1952) changed from a ration containing 17-21 lb. hay, 40 lb. mangolds and 4 lb. concentrates/10 lb. milk to one containing 6 lb. hay plus 9 lb. extra concentrates, milk production increased significantly. Reducing the hay to 2 lb. per day caused a slight decrease in milk production when compared to the control period. In another experiment Balch *et al.* (1954 A) fed a control ration consisting of 15 lb. hay plus 4 lb. grain/10 lb. milk. Replacing 14 lb. of the hay with 6 lb. grain caused no significant change in milk production.

Milk fat percentage

As mentioned earlier, Powell (1938) reduced the fat percentage in cows milk with cubed rations containing finely ground roughage and a low roughage high concentrate ratio. Although replacing the hay with long hay increased milk fat percentage, it remained significantly low when compared to a ration containing normal amounts of roughage. Cows that had produced low fat milk for three lactations on low roughage rations returned to normal when given adequate amounts of roughage. A later report, Powell (1939) stated that fat content of milk could be changed up to 60% by varying the physical characteristics and total intake of roughage. Loosli et al. (1945) fed cows 5 lb. of hay or less along with sufficient grain to satisfy energy requirements. This treatment gave a significant drop in fat percentage although considerably less than that reported by Powell (1938). These cows, however, were placed on experiment fairly late in lactation, a time when cows show less response to ration changes. Stoddard et al. (1949) fed several cows 5 lb. or less of hay and up to 45 lb. of concentrates per day. Fat percentage declined markedly in most cases. McClymont (1950) in several field observations noted that cows on short lush pasture and high concentrate levels, or bare pastures plus limited or fine roughage along with high concentrate levels showed a decrease in fat percentage. Tyznik and Allen (1951) reduced the roughage of 8 cows to 3 lb. and fed concentrates ad lib. and found that after two weeks the fat test was depressed by 1-2%. Van Soest et al. (1954) restricted the roughage of six lactating cows to 3 lb. per day and fed high levels of concentrates. Butterfat declined from 4.6% to 2.1%. Shaw et al. (1957 A, B) fed 4 lb. of hay with a high and low protein concentrate. In both cases, only insignificant decreases in fat percentage occurred. Balch *et al.* (1952) fed a control ration of 17-21 lb. of hay and 30 lb. of mangolds along with 4 lb. of concentrates for each 10 lb. of milk produced per day. Dropping the roughage level to 6 lb. of hay per day and increasing the concentrates by 9 lb. resulted in a drop in milk fat from 3.8% to 3.3%. Further decreasing the hay to 2 lb. resulted in a drop in milk fat to 3.2%. Balch *et al.* (1955, A) decreased the hay intake to 2 lb. and increased concentrates to 24 lb. This resulted in a fat percentage decline to one-half that of the control period. The concentrate mixture, however, contained flaked maize which probably affected the results. In several instances, these workers used flaked maize when comparing other factors. Balch *et al.* (1954 A) lowered the roughage concentrate ratio and varied the protein content of the concentrate. The milk fat percentage decreased regardless of whether the concentrate was high or low in protein.

VFA

Card and Schultz (1953) found the following fatty acid ratios in the rumen with mixed hay; acetic acid 60%, propionic acid 21%, and butyric acid 19%. When grain was added to the ration, the relative percentage of acetic acid dropped slightly, butyric acid increased and propionic acid remained about the same. On an all grain ration, acetic/butyric acid ratios showed a larger drop with propionic acid again remaining unchanged. El-Shasley (1952) increased the relative percentage of butyric and higher acids by increased protein intake in the form of casein. Gray and Pilgrim (1952) reported a trial in which cellulose was fed along with 0 to 20% casein. As the level of casein in the ration increased, the relative amount of butyric acid increased from 7-22%, propionic acid decreased from 42-29% and acetate decreased from 51 to 45%.

Stoddard et al. (1949), Tysnik and Allen (1951), and Balch et al. (1955 A) reported that low roughage/high concentrate rations decreased the ratio of acetic to propionic acid. Saarinen (1955) reported that a ration containing 18 lb. of hay and 3 lb. of concentrates produced 71.0% acetic, 16.8% propionic, 8.6% butyric, and 2.7% higher acids in the rumen. Upon changing to 24 lb. of concentrates and 2 lb. of hay, acetic acid fell to 40.6%, propionic acid increased to 38.0%, butyric acid fell slightly to 8.0%, and higher acids increased to 12.3%. The author suggested that the increase in higher acids may have been due primarily to lactic acid. Brown et al. (1958) fed hay and concentrates in the ratios of 4:1, 3:2, 1:3, and 1:4. Molar percentage of acetic acid decreased from 60% to 40% and propionic acid increased from 20 to 40% as the roughage/concentrate ratio decreased. Molar percentages of butyric and higher acids were not appreciably affected.

Blood glucose

Blood glucose values have been reported in only a limited number of experiments in which roughage/concentrate ratios have been changed. Van Soest et al. (1954) conducted a feeding experiment with a low roughage high concentrate ration and found no significant increase in blood glucose. Balch et al. (1955 A) changed cows from a control ration of 16 lb. hay and 20 lb. concentrates to a ration of 2 lb. hay and 24 lb. concentrates of which 50% was flaked maize. No change in blood glucose occurred.

Digestibility

Balch et al. (1954 C), (1955 A) reported a decrease in crude fiber digestibility, when cows were changed from a normal ration to one with a high concentrate-low roughage ratio. Armsby (1917) conducted digestion experiments in which various amounts of starch were added to a hay ration. As the amount of starch increased, the digestibility of the hay decreased. Armsby concluded that this was probably due to a diversion of microorganisms to the more readily attacked starch.

Effects of Feeding Volatile Fatty Acids

Milk production

Schultz (1958) fed 0.25 lb. of sodium propionate per day to dairy cows and found an increase in milk production. Schmidt and Schultz (1958) reported no change in milk production when ½ lb. of sodium propionate was fed per day. Miller and Allen (1955) found no change in milk production due to feeding of 1 lb. of sodium acetate daily for ten-day periods. Lassiter et al. (1958) reported no change in milk production due to feeding valeric acid, isovaleric acid or a combination of the two.

Milk fat percentage

Balch and Rowland (1959) reported that the feeding of 0.5 to 1.5 kg. of sodium acetate to cows in which fat percentage had been reduced by diets low in hay and high in concentrate brought about a partial to almost complete recovery in fat percentage. Butyrate fed to one cow brought about recovery comparable to acetate. Five hundred grams of sodium propionate affected no recovery in fat percentage. Van Soest et al. (1954) fed 1 lb. of sodium acetate to cows whose milk fat percentage had been depressed by restricting roughage feeding and found a partial recovery in fat percentage. An equivalent amount of sodium propionate brought no recovery. Stoddard and Allen (1949) also reported a recovery in butterfat percentage with cows that had a low fat percentage due to low roughage high concentrate rations when acetic acid was given by stomach tube while propionic acid had no effect. Amounts of acid given were not reported.

Miller and Allen (1955), Balch and Rowland (1959) fed acetate to cows on a normal ration and found no change in milk fat percentage. It was suggested by Miller and Allen that a minimal amount of acetic acid is required for normal milk production while amounts above this level give no appreciable gain.

Miller and Allen (1955) found no significant drop in fat percentage with cows fed 1 lb. sodium propionate per day as a supplement to a normal ration. Schmidt and Schultz (1958) fed 0.5 lb. of sodium propionate to cows on a normal ration and found a non-significant 0.11% decrease in milk fat. Hawkins (1959) compared a conventional concentrate with one containing either 7.9% sodium propionate or 29.1% dextrin. Hay was fed at the rate of 1.8 lb./100 lb. body weight. Both experimental rations caused a decrease in fat percentage which approached significance.

Lassiter <u>et al</u>. (1958) fed valeric, isovaleric and a combination of the two acids and observed no change in fat percentage.

Blood glucose

Certain of the volatile fatty acids are known to be possible glucose precursors. Ringer (1912) was the first to show that propionic acid was glucogenic. He administered 10 gm. of propionic acid subcutaneously to phloridzinized dogs and got more glucose in the urine than could be theoretically attributed to propionic acid with complete conversion to glucose. Deuel et al. (1935) confirmed Ringer's work by showing that propionate, valerate and heptoate administered as sodium salts to rats subcutaneously caused glycogen deposition in the liver. Acetate and butyrate had no effect.

In ruminant work, Potter (1952) produced hypoglycemic conculsions in lambs by fasting and intravenous injection of insulin. Propionic acid injected into the jugular vein relieved symptoms and raised blood glucose levels 30-40 mg. %. Butyric acid relieved symptoms even more spectacularly and raised blood glucose levels 50-60 mg. %. Jarrett et al. (1952) reported that intravenous injection of acetic acid in sheep caused no significant rise in the concentration of blood glucose, lactic acid or pyruvic acid. Injected propionic acid increased blood levels of all three of these substances; the last two, lactic acid and pyruvic acid, being glucose precursors. Butyric acid was glucogenic in some cases. It was found, however, that injection of butyric acid caused a rapid increase in respiration rate and a general stressed condition in the animals, which was not in evidence when acetic and propionic acids were injected. The authors suggested that the stress was due to the ketogenic action of butyric acid and was probably mediated through the sympatho-adrenal system causing glycogenolysis. Kronfield (1957) intravenously infused sheep with salts of acetic and butyric acids. Butyrate caused a rise in blood glucose when initial levels were low and a fall when initial levels were high. Acetate caused a slight rise in blood glucose. Johnson (1955) reported that infusion of propionic acid caused a marked rise in blood glucose levels in goats. Acetic and butyric acids had no effect.

Schultz and Smith (1951) working with alloxan diabetic sheep reported that acetic acid given orally had no effect upon blood glucose. Propionic acid caused an initial rise in blood glucose, while butyric acid caused an initial rise in blood glucose followed by a decrease. Miller and Allen (1955) fed sodium acetate and sodium propionate to dairy cows at the rate of one pound per day, and found no significant changes in blood glucose. Schultz (1958) fed 0.25 lb. of sodium propionate per day to dairy cows in an attempt to prevent ketosis and noted a rise in blood glucose. Schmidt and Schultz (1958) fed

0.5 lb. of sodium propionate per day to dairy cattle and got a slight but non-significant rise in blood glucose. Hueter et al. (1956) added sodium lactate to the rumen and obtained a rise in blood glucose. Clark and Malan (1956) dosed sheep with 0.5 gm. moles of fatty acids via rumen fistulas. Acetate did not affect blood glucose levels. Propionate caused a marked rise in blood glucose levels while butyrate caused it to fall.

McCarthy (1959) in liver perfusion studies reported that valerate, butyrate and propionate are metabolized by the liver where they are converted chiefly to glycogen and further that the majority of blood acetate is not removed by the liver and it is assumed that it is available to other tissues of the body. Kennedy (1957) proposed the following reactions as the major pathway of propionate metabolism in non-ruminants.

Propionate + ATP + CoASH $\rightarrow$ Propionyl CoA + AMP + P P

Propionyl CoA + ATP + CO_2 $\rightarrow$ Methyl Malonyl CoA + ADP + Pi

Methyl Malonyl CoA $\longrightarrow$ Succinyl CoA

Succinyl CoA can be transformed into glucose by way of the Krebs cycle.

Effects of Cooking of Concentrates

Milk production

Probably one of the earliest experiments upon the effect of cooking was conducted by Speir (1891), a Scottish farmer. Noting that cooking or steaming concentrates was a common practice in Southwest Scotland, the area in which he lived, with no real knowledge of the value of this practice, Speir decided to investigate this matter. He set up an elaborate reversal type of experiment in which the cows were switched four times and found that cows on the steamed concentrate produced an average of about 0.6 lb. more milk per day than cows on a control ration. The results were not analysed statistically; however, Speir concluded that there was a significant increase in milk production, but not enough to pay for the cost of steaming. Balch et al. (1955 B) compared a normal ration with one containing a low roughage-high concentrate ratio in which the concentrate was made up of 50% ground corn and found no significant change in milk production. Replacing the ground corn with flaked maize resulted in a significant drop in milk yield.

Milk fat percentage

In the experiment by Speir (1891), fat percentage was checked using a cream gauge, and no discernible differences were found between the cooked and the uncooked rations. Shaw (1957) fed bread along with a low hay ration and obtained a significant drop in milk fat percentage. Feeding uncooked concentrates with this level of hay caused only an insignificant drop in fat percentage. In another experiment with a cooked ration low in hay and high in concentrates, a drop in milk fat percentage did not occur. Shaw theorized that the metabolites for milk fat must have been mobilized from body reserves. Ensor (1959) compared several rations with 38-42 lb. of long hay per cow daily. Twenty-six pounds of pelleted hay plus 4 lb. of ground corn decreased fat percentage only 13%. When 28 lb. of pelleted hay was fed with 4 lb. of cooked corn, fat percentage decreased 51%. Six pounds of long hay plus 18 lb. of cooked corn resulted in a drop in fat of only 5%. Balch <u>et al</u>. (1954 C) fed one ration of 4 lb. hay with the remainder of the requirements being met with a cubed concentrate containing 9.5% crude fiber. No drop in fat percentage occurred. When they substituted the concentrate with one containing 50% flaked corn, the fat percentage dropped sharply. Balch <u>et al</u>. (1955 B) in another study with a low-hay high-concentrate ration substituted 10 lb. of corn meal for 10 lb. of oats and barley and obtained a 0.71% drop in fat. When flaked maize was substituted for the corn meal, a further drop of 0.51% resulted. Balch postulated that when the ration is low in hay and high in concentrate, the type of starch is of great importance in determining fat percentage.

<u>VFA</u>

Shaw (1957) compared high and low protein, low roughage rations with normal rations. A slight decrease in the acetic/propionic acid ratio occurred in both cases. When bread was substituted as the concentrate a much larger drop occurred in the ratio of acetic to propionic acid. Butyric acid levels remained about the same. The higher acids showed some relative increase on the high bread rations. Shaw <u>et al</u>. (1959) compared alfalfa meal pellets with long hay. The proportion of volatile fatty acids did not change. When alfalfa meal pellets were supplemented with 4 lb. of ground corn, a slight decrease in the acetate/propionate ratio occurred. Replacing the ground corn with steamed corn resulted in a sharp drop in the acetic/propionic acid ratio. Butyric acid percentage remained about the same. Eusebio <u>et al</u>. (1959) reported that changing from a ration containing 15.9 lb. alfalfa hay and 5.9 lb. of ground corn to one containing 12.0 lb. of ground corn resulted in a large drop in the acetic/propionic acid ratio a slight drop in the percentage of butyric acid and a slight rise in the percentage of higher acids. Replacing the ground corn with 12.0 lb. of flaked corn caused a further drop in acetic/propionic acid ratios, butyric acid percentage and a marked increase in the percentage of acids containing six carbons or more.

Phillipson (1952) fed lambs hay plus a concentrate made up of ten parts flaked corn and one part corn gluten feed. Following this treatment, pH of the rumen decreased markedly and lactic acid often exceeded 7 meq.% and overshadowed a concomitant narrowing of acetic/propionic acid ratios. Balch and Rowland (1957) found that on low roughage rations which were high in flaked corn, 90-270 mg.% of lactic acid appeared about two hours after feeding and disappeared rapidly. Other low roughage high concentrate rations produced only traces of lactic acid.

Hungate *et al.* (1952) reported a buildup of lactic acid in the rumen of sheep when large amounts of glucose or readily fermentable carbohydrate was added to the rumen through a rumen fistula. The pH of the rumen often dropped as low as 4.2 at which point death occurred. Since the concentrate was not fed there would be less salivation and consequently less buffering capacity in the rumen. The lactic acid evidently was not appreciably fermented. Jayasuriya and Hungate (1959) reported a low rate of lactate fermentation when excess lactates were added to the rumen of hay-fed cattle. These workers postulated that suddenly switching to a high grain ration favors lactacidogenic organisms which multiply rapidly. By the time lactate utilizers can multiply, the pH of the rumen becomes so acid that fermentation stops. Changing to a high concentrate ration slowly allows the lactic acid utilizers to increase at a fast enough rate. With flaked corn the lactic acid producers maintain predominance evident in the sudden administration of grain or glucose. On a flaked ration the propiogenic lactate utilizers evidently increase due to the large proportion of propionate formed with these types of rations.

Blood glucose

Balch et al. (1955 B) found no change in blood glucose in an experiment with a low-hay and high-concentrate ration, in which 50% of the concentrate was flaked corn.

Digestibility

Henry (1900) reviewed the early American work on cooking concentrates. Cooking on the average decreased the digestibility of the dairy feeds about 6%. Balch et al. (1954 C), feeding a low roughage, high-concentrate ration of which 50% was flaked maize, noted a decrease in crude fiber digestibility despite a lower rate of passage. Louw (1943) supplemented poor veld hay with increasing quantities of flaked maize and got a progressive decrease in cellulose digestibility. Wood (1958) also supplemented a poor hay ration with small amounts of flaked maize and observed a decreased cellulose digestibility. Data by Woodman (1927) showed that flaked maize was superior to ground corn in digestibility of proteins, nitrogen-free extract and amount of total digestible nutrients. These data are in direct contrast to the experimental evidence presented by Colovos _et al._ (1955), who reported that ground corn was superior to steamed flaked corn in digestibility of protein, nitrogen-free extract and T.D.N. Shaw (1959) reported data on a feeding trial with 16 steers using hay and ground corn in equal amounts. With one group, the corn was ground and the hay fed long, while with the other group, the hay was ground and pelleted and the corn was steamed. Grinding the hay and steaming the corn caused no change in the digestibility of the carbohydrate or fat, but protein digestibility increased from 55.3 to 66.[illegible]%. In this trial, the steers fed the ground and steamed ration gained 2.44 lb. in comparison to 2.00 lb. per day for the control ration. Shaw attributed 35% of this gain to an increase in protein digestibility and 65% to a relative increase of propionate to acetate production in the rumen. Propionate is metabolized with less heat loss.

Garner (1957) conducted in vitro experiments upon the physical form of feed on the rate of digestion. By placing corn of varying coarseness in rumen fluid, he found the finer the physical state of the corn, the faster the buildup of fatty acids. However, when flaked corn was added to the rumen fluid, the buildup of volatile fatty acids was greater than the finely ground corn even though the surface area was much less. Garner (1957) concluded that cooking made the starch more available to bacterial attack.

EXPERIMENTAL PROCEDURE

Methods

Design of experiment

Sixteen cows of the Holstein breed were divided into two groups, balanced for equal 4% FCM and placed on a double reversal type experiment. The experiment was extended over three 24-day periods. The first six days of each period were designated as the preliminary period and the remaining 18 days were used for the collection of experimental data. The experiment started May 13 and ended September 4. The design of the experiment is illustrated in Table 1.

Rations

Both groups of cows were fed 30 lb. of medium quality alfalfa hay daily throughout the entire experimental period. Group A was started on 6 lb. of uncooked hominy while Group B received 6 lb. of cooked hominy per cow per day for the initial period. The chemical analysis of the hay and hominy is given in Table 2. Hominy is a type of feed prepared by removing the hulls from the kernels of corn. Half of the hominy used in this trial was cooked for 35 min. then passed through rollers and

TABLE 1

EXPERIMENTAL DESIGN

Lot	Cow No.	Periods A		B		C	
		preliminary 6 days	collection 18 days	preliminary 6 days	collection 18 days	preliminary 6 days	collection 18 days
I	A-108 K-239 A-125 T-17 T-15 A-98 A-127 A-60	UNCOOKED HOMINY		COOKED HOMINY		UNCOOKED HOMINY	
		preliminary 6 days	collection 18 days	preliminary 6 days	collection 18 days	preliminary 6 days	collection 18 days
II	A-123 A-109 K-303 A-94 A-71 A-95 A-118 A-145	COOKED HOMINY		UNCOOKED HOMINY		COOKED HOMINY	

TABLE 2

COMPOSITION OF FEEDS

Feed	Ash	Crude Fiber	Ether Extract	Water	Protein	NFE
	%	%	%	%	%	%
Cooked Hominy	3.29	2.60	4.49	7.45	11.44	70.73
Hominy	2.03	3.57	6.44	10.81	10.19	66.96
Hay	7.02	27.15	1.42	11.44	18.63	34.38

dried. Both the cooked and the uncooked hominy were in a finely ground state.

Animals

The cows were fed twice a day at 7 a.m. and 4 p.m. They were milked twice a day with milk weights taken at each milking. Samples for butterfat tests were also taken at each milking. However, a three-day composite sample was made up for the actual butterfat test. Three-day body weights were taken at the beginning of each experimental period and at the end of the experiment. The cows were housed in a stanchion barn and allowed about an hour exercise at noon each day in an outside lot except on days when scheduled for a blood sample.

Blood analysis

Blood samples were collected from all cows on the first and last day of each experimental period making a total of six samples per cow. Collection time was at noon. The samples were taken from the jugular vein with a bleeding needle and collected in a 50 ml. tube, which was previously coated with calcium oxalate to prevent coagulation and sodium fluoride to poison enzyme systems in the blood and slow breakdown of the glucose. The samples were analyzed for blood glucose the same afternoon they were collected using the method of Somogyi (1945 A,B).

Digestion trials

One digestion trial each was run with the hay, the cooked and uncooked hominy using dry cows. Four cows each were used for the hay and cooked hominy trials, while only two cows were used for the uncooked hominy trial due to a shortage of feed. A seven-day preliminary period was followed by a seven-day collection period. Feces and hay were sampled daily during the collection period. A composite sample was taken for the hominy feeds from several bags of feed. A one percent aliquot of the feces was taken for analysis. Twenty pounds of hay per day were fed during the hay digestion trial. For the hominy digestion trials, ten pounds of hominy was fed with four pounds of hay. The digestibility of the hominy was calculated by difference. All hay, feed and feces analyses were performed by the author at the Agricultural Chemistry Laboratories at Michigan State University using standard methods according to A.O.A.C. (1955). All statistical analyses were performed according to methods by Snedecor (1948).

RESULTS AND DISCUSSION

Milk Production

Details of 4% FCM are given in Table 3. The 4% fat corrected milk production of animals fed the two experimental rations did not differ significantly. A comparison of the first and last experimental periods with

TABLE 3

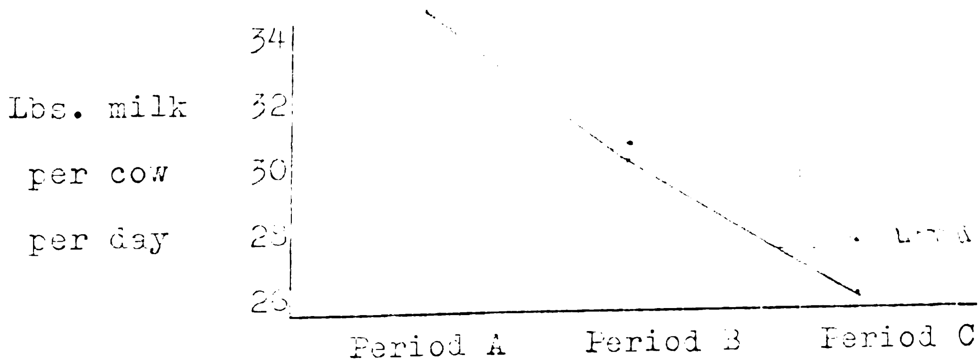
DAILY PRODUCTION OF 4% FAT CORRECTED MILK

Lot	Cow No.	Period: Uncooked A	Period: Cooked B	Period: Uncooked C		Comparison A-2B+C
		lbs.	lbs.	lbs.		
I	A-108	37.2	28.9	31.8		+8.7
	K-239	39.1	35.8	27.9		-4.6
	A-125	28.7	28.8	27.2		-1.7
	T-17	43.3	35.6	34.9		+7.0
	T-15	34.6	28.7	23.2		+0.4
	A-98	38.2	34.8	28.7		-2.7
	A-127	31.5	29.3	28.1		+1.0
	A-80	26.4	25.6	24.3		-0.5
	Average	34.8	30.9	28.0	Sum	+7.6
		Cooked	Uncooked	Cooked		
II	A-123	12.6	10.6	7.8		-0.8
	A-109	40.0	33.8	29.7		+2.1
	K-303	39.5	33.9	31.2		+2.9
	A-94	43.2	37.3	31.0		-0.4
	A-71	46.0	41.2	39.1		+2.7
	A-95	24.5	23.2	19.8		-2.1
	A-118	34.0	30.1	28.7		+2.5
	A-145	39.0	30.8	23.6		+1.0
	Average	34.8	30.1	26.4		+7.9

the second period (fig. 1), showed that the ration had little effect upon the rate of decline in production. Differences in the actual rate of decline in production were undoubtedly due to inherited differences in persistency between groups A and B. In group B, cow number A-123 suffered throughout the experiment from chronic mastitis and had a low production record. Deleting the production figures for this cow did not affect the statistical analysis, so she was included in the data.

FIGURE 1

AVERAGE DAILY MILK PRODUCTION PER COW PER PERIOD



The evidence presented here does not agree with the British viewpoint, that cooking is beneficial for milk production, or with the experiment of Speir (1891) who reported that dairy cows on a cooked concentrate produced 0.6 lb. more milk per day than on an uncooked concentrate. Ensor (1959) and Ensor _et al_. (1959) reported that when cows were fed 6 lb. of long hay with 18 lb. cooked corn their production decreased at the same rate as cows fed an all hay ration, which would indicate a fairly low value for cooked corn in this case. The present trial, however, was designed for a much more normal roughage concentrate ratio.

Fat Percentage

Butterfat percentage of animals fed the two experimental rations did not differ significantly although the analysis showed a slight advantage for cooked hominy. The average test when the cows were on cooked hominy was 3.31% as compared to 3.26% for cows on uncooked hominy. All data on fat percentages are listed in Table 4.

Cow number A-123 had a case of mastitis which was worst during the first period. She was included in the data since her fat percentage figures did not affect the significance of the statistical analysis. It is interesting to note, however, that had the somewhat abnormal fat percentage of cow number A-123 for the first period been 4.1% instead of 5.1%, the sum of the comparison of A-2B+C for Lot II would have been -1.5, which is exactly the same as that for Lot I and would have given an F ratio of 0 upon analysis of variance. In general, both groups of cows showed a decrease in fat percentage as lactation progressed.

TABLE 4

MILK FAT PERCENTAGE

Lot	Cow No.	Period A	Period B	Period C	Comparison	Sum
		Uncooked	Cooked	Uncooked	A-2B+C	
I	A-108	3.40	2.96	3.13	+.61	
	K-239	3.50	3.38	3.35	+.08	
	A-125	3.20	3.20	2.93	-.26	
	T-17	3.46	3.25	3.05	+.01	
	T-15	3.21	2.90	2.43	-.15	
	A-98	3.40	3.59	2.37	-1.41	
	A-127	3.77	3.82	3.46	-.48	
	A-80	3.53	3.33	3.18	+.60	
	Average	3.21	3.29	2.97		-1.54
		Cooked	Uncooked	Cooked		
II	A-123	5.13	3.53	3.26	+1.40	
	A-109	3.11	3.07	2.74	-.28	
	K-303	3.50	3.45	2.83	-.65	
	A-94	3.56	3.29	2.73	-.30	
	A-71	3.69	3.51	3.08	-.25	
	A-95	3.21	3.10	2.83	-.17	
	A-118	3.72	3.57	3.40	-.02	
	A-145	4.49	4.20	3.74	-.13	
	Average	3.66	3.44	3.02		-.55

The data presented in this experiment do not agree with most of the experimental data reported in the literature, which showed that the feeding of cooked concentrates decreases fat percentage (Balch *et al.*, 1954; Balch, 1955; Shaw, 1957; Shaw, 1959). In all these experiments, however, either the roughage concentrate ratio was low or the roughage was in a finely ground state. The closest comparison to the present experiment was one by Ensor (1959) and Ensor et al. (1959) who reported that feeding six pounds of long hay and eighteen pounds of cooked corn reduced the test only 5%.

Blood Glucose

Blood glucose levels of the animals fed the two experimental rations did not differ significantly. Analysis of samples taken from the first of each period showed that the two experimental groups were similar, while those taken from the last day of each experimental period showed a slight advantage in favor of cooked hominy. Results are given in Tables 5 and 6.

In most cases the blood glucose levels decreased as lactation progressed in both groups. The reason for this is not known. It could be due, however, to an excessive drain of metabolites for maintenance and production, not leaving enough three carbon precursors of glucose to enter the tricarboxylic acid cycle.

Jayasuria and Hungate (1959) reported that with a high concentrate ration lactic acid forming organisms increased and initially predominated over lactic acid utilizers. When flaked corn was the concentrate the predominance of lactic acid was maintained with propionic acid forming organisms being the main lactic acid utilizers. Since lactic acid can be absorbed into the blood-stream and can form glucose via the Cori cycle and since propionic acid is known to be glucogenic ([illegible], 191[illegible]; Deuel and Butts, 1955) a rise in blood glucose would be expected with a ration high in flaked corn. The results of the present experiment indicate that this change in rumen fermentation does not take place when flaked corn is fed at low levels, assuming that cooked hominy which was not cooked under pressure would give the same results as flaked corn which is cooked under pressure.

It can not be concluded, however, that no changes occurred in rumen fermentation since ruminants seem to have a high resistance to changes in blood glucose levels. Balch *et al.* (1955 A) fed a high concentrate ration of which 50% was flaked corn and reported no change in blood glucose levels even though butterfat levels dropped below 2% and acetate/propionate ratios declined in the rumen. Van Soest *et al.* (1954) reported only a non significant increase in blood glucose with a high concentrate ration that dropped butterfat from 4.[illegible]2% to [illegible].14%. In experiments of this type analysis of rumen VFA's would give a much more sensitive indication of rumen fermentation changes.

TABLE 5

BLOOD GLUCOSE

Lot	Cow No.	Period A Uncooked	Period B Cooked	Period C Uncooked	Comparison A-2B+C	Sum
	(Samples from first day of experimental period)					
		mg/ml	mg/ml	mg/ml		
	A-108	51.5	[illegible]	45.5	-[illegible]	
	A-299	55.0	57.0	51.0	-10.0	
	A-115	50.0	46.0	45.5	+ [illegible].5	
	T-17	44.5	48.5	45.0	- 7.5	
I	T-15	48.8	50.3	51.0	- 0.8	
	A-70	50.0	48.0	50.0	+ 4.0	
	A-127	46.0	46.5	39.8	- 7.2	
	A-30	45.0	47.5	45.5	- [illegible]	
	Average	46.1	49.5	45.0		-36.4
		Cooked	Uncooked	Cooked		
	A-129	57.8	62.5	46.5	-20.7	
	A-109	54.0	46.5	47.0	+ 8.0	
	A-208	44.5	47.0	44.0	- 5.5	
	A-14	49.8	50.0	54.5	+ 4.3	
	A-71	41.0	[illegible]	[illegible].5	-[illegible].5	
II	A-[illegible]5	[illegible].0	[illegible].0	47.0	-18.0	
	A-110	47.3	51.0	44.0	-10.7	
	A-14[illegible]	[illegible].0	44.0	47.0	+1[illegible].[illegible]	
	Average	4[illegible].3	51.0	48.2		-34.[illegible]

TABLE 6

BLOOD GLUCOSE

Lot	Cow No.	Period A Uncooked	Period B Cooked	Period C Uncooked	Comparison A-2B+C	Sum
	(Samples from last day of experimental period)					
		[illegible]	[illegible]	[illegible]		
I	A-108	47.0	45.5	47.0	+ 3.0	
	A-239	49.3	51.8	51.5	- 2.8	
	A-135	47.3	45.0	46.0	+ 3.3	
	T-17	60.0	49.0	44.5	+ 6.5	
	T-15	55.5	53.5	46.5	- 5.0	
	A-98	53.0	51.8	47.5	- 3.1	
	A-127	51.0	51.0	53.0	+ 2.0	
	A-20	44.5	56.3	46.0	-22.1	
	Average	49.5	50.4	47.8		-18.2
		Cooked	Uncooked	Cooked		
II	A-123	55.5	55.0	48.5	- 6.0	
	A-109	50.5	46.0	46.0	+ 4.5	
	X-303	57.0	44.0	45.0	+14.0	
	A-94	58.0	56.0	48.8	- 5.2	
	A-71	44.5	52.5	42.8	-17.7	
	A-95	48.5	51.8	47.5	- 7.6	
	A-118	46.5	54.0	47.0	-14.5	
	A-145	51.5	47.5	48.0	+ 7.0	
	Average	51.5	50.9	47.6		-44.0

Body Weights

Body weight data are shown in Table 7. Analysis of the differences in body weights revealed a slight advantage in favor of cooked hominy which was not significant at the 5% level. There were large individual variances among the cows in both lots.

This lack of difference in change in body weight between the cows fed cooked and uncooked hominy supports the data on milk production, fat percentage and blood glucose.

Digestibility

Dry matter and organic matter

The apparent digestibility of the dry matter of cooked hominy and uncooked hominy were 64.1% and 61.0% respectively. Differences were not significant at the 5% level although they approached it. The digestibility of the organic matter of cooked hominy and uncooked hominy was 65.6% and 63.2% respectively. This difference was significant at the 5% level. The results are shown in Table 8.

The main increase in the digestibility of organic matter and dry matter due to cooking was from an increase in the digestibility of the carbohydrate fractions.

TABLE 7

BODY WEIGHTS

Lot	Cow No.	Period: Beginning A	End A	End B	End C
		Uncooked		Cooked	Uncooked
		lbs.	lbs.	lbs.	lbs.
I	A-108	1510	1470	1411	1417
	K-239	1264	1280	1256	1211
	A-125	1169	1176	1192	1164
	T-17	1201	1196	1226	1178
	T-15	1318	1296	1320	1271
	A-98	1192	1167	1251	1225
	A-127	1259	1262	1240	1258
	A-80	1437	1456	1445	1458
	Average	1292	1266	1269	1273
		Cooked		Uncooked	Cooked
II	A-123	1050	1060	1069	1107
	A-109	1136	1120	1141	1096
	K-303	1374	1278	1330	1275
	A-94	1314	1247	1258	1230
	A-71	1294	1280	1232	1235
	A-95	1403	1363	1390	1406
	A-118	1072	1092	1133	1057
	A-145	1068	1075	1052	1020
	Average	1225	1179	1200	1178

TABLE 8

AVERAGE COEFFICIENTS OF APPARENT DIGESTIBILITY OF COOKED AND UNCOOKED HOMINY

Group	Cow No.	Ether Extract	Crude Protein	Crude Fiber	Nitro.-Free Extract	Dry Matter	Organic Matter	T.D.N.
	A-15	86.7	62.8	24.7	92.6	85.0	86.5	82.0
Cooked Hominy	A-121	81.6	59.3	29.7	91.6	83.9	85.2	80.6
	CS-203	82.5	58.5	22.5	91.2	82.7	84.6	80.1
	585	87.0	63.0	5.5	92.7	84.8	86.0	81.7
	AVERAGE	84.4*	60.9	20.6	92.0*	84.1	85.6*	81.1
Uncooked Hominy	A-121	90.2	69.4	6.8	89.2	82.5	83.6	80.1
	A-136	90.7	64.1	0	89.6	81.5	82.8	79.6
	AVERAGE	90.5	66.8	3.4	89.4	82.0	83.2	79.9

* Denotes differences between cooked and uncooked hominy significant at the 5% level.

AVERAGE COEFFICIENTS OF APPARENT DIGESTIBILITY OF UNCOOKED HOMINY AS REPORTED By J. B. LINDSEY

Sheep	89.0	74.0	116.6	94.2	90.8
Six Cows	92.5	62.8	60.7	87.9	
Two Cows	88.2	69.5	80.0	92.6	87.6

It appears that the starchy components are rendered more susceptible to bacterial attack by cooking, possibly causing an increase in the types of organisms digesting starch at the expense of those primarily causing breakdown of fats and proteins.

Crude protein

The apparent digestibility of the crude protein in the uncooked hominy was 66.8% as compared to 60.9% for the uncooked hominy. While a fairly large difference exists in favor of uncooked hominy, this difference was not significant at the 5% level (Table 8).

Lindsey reported crude protein digestibility coefficients for uncooked hominy of 62.8 in 1904 and 69.5 in 1906. These figures agree quite well with the present trial. Colovos et al. (1955) reported a crude protein digestion coefficient of 46.95 for ground corn versus 44.17 for steamed flaked corn. While these figures favor uncooked corn they may not be strictly comparable with the figures for hominy in the present experiment.

Ether extract

The apparent digestibility of the ether extract was 90.5% for the uncooked hominy as compared to 84.4% for the cooked hominy. These differences were significant at the 5% level (Table 8).

The variation among animals was fairly large. This is probably due to the small amount of fat in the concentrate which would magnify experimental error. The differences in the composition of the two feeds resulted in an even greater difference in the digestible nutrients from the ether extract. Evidently, some of the compounds composing the ether extract portion were driven off by the high temperature used during the cooking process.

Lindsey reported digestion coefficients for uncooked hominy of 92.5 in 1904 and 88.2 in 1906. These agree very well with the present figure of 90.5. There is a lack of previous data on cooked hominy digestibility. Colovos <u>et</u> <u>al</u>. (1955), however, compared the digestibility of flaked corn with ground corn and found that the ground corn had a slight advantage in digestibility with a coefficient of 90.0 as compared to 88.3 for flaked corn. British figures reported by Woodman (1957) showed that ground corn had an ether extract digestibility of 61.4% as compared to 48.5% for flaked corn.

In comparing data of various workers it is necessary to take into account differences in cooking procedures. The cooked hominy in the present experiment was cooked under atmospheric pressure for thirty-five minutes and then dried. Flaked corn in England is cooked for about ten minutes under steam pressure of 15-40 lbs. The hot partly gelatinized corn is then flaked between rollers (Rowe, 1957). This process may partially dextrinize the starch. The flaked corn used by Colovos et al. (1955) was also steamed under pressure but details were not given.

Ether extract digestibility is normally somewhat lower in ruminants than non-ruminants. The reason for this is the protective action of the undigested cellulose surrounding the fat which serves as a barrier against digestive action in general (Maynard and Loosli, 1956).

There are also other ether-extractible materials in the feces arising from internal secretions and bacterial fermentations. Certain rations especially those causing an increase in rumen fatty acids may affect levels of this metabolic fat. Devel (1955) determined a correction factor for this metabolic fat by determining the amount of fecal fatty materials excreted by rats on a sucrose ration. There are no such figures available for ruminants and no assurance that if such figures were available they would not vary with the ration.

Crude fiber

The apparent digestibility of the crude fiber was 20.6% for the cooked hominy as compared to 3.4% for the uncooked hominy. Due to large variations among animals the results were not significant at the 5% level (Table 8).

The data for crude fiber digestibility were not too meaningful. A relatively small change in the digestibility of the large amount of crude fiber in the hay can cause the apparent digestibility of the crude fiber in the concentrate to vary from zero to over 100%. Some hay was fed during the hominy digestion trials to aid in the normal physiological functioning of the rumen. Lindsey (1903), in an uncooked hominy digestion trial reported a crude fiber digestion coefficient of 126.8 while Colovos (1955) reported a crude fiber digestibility of zero with ground corn and steamed flaked corn.

The crude fiber digestion figures were quite low in this trial for both the cooked and uncooked hominy. This is probably due to the higher percentage of starch fed in the hominy than in the hay digestion trials. Armsby (1917) reported that adding increasing amounts of starch to a hay ration decreased the digestibility of the crude fiber in the hay. Armsby suggested that the higher percentage of starch in the ration would encourage starch digesting organisms at the expense of those digesting fibrous carbohydrates. Since hay contains a large amount of crude fiber and concentrates a small amount, a slight drop in the crude fiber digestibility of the hay would cause drop in the apparent digestibility of the crude fiber of the hominy.

Nitrogen-free extract

The apparent digestibility of nitrogen-free extract was 92.0% for the cooked hominy as compared to 89.4% for the uncooked hominy. The differences were significant at the 5% level (Table 8).

The data from the present trial again agrees with earlier work on the digestibility of uncooked hominy in which Lindsey (1904) reported a digestion coefficient of 87.9 and Lindsey (1906) reported a digestion coefficient of 92.6. Woodman (1957) reported that the digestibility of nitrogen-free extract in flaked corn was 97% as compared to 92% for ground corn while Colovos (1955) reported digestion coefficients of 83.1 for ground corn as compared to 75.6 for flaked corn. The evidence in the present trial and that of Woodman are supported by Garner (1957) whose *in vitro* studies showed that cooking makes the starch more susceptible to bacterial attack.

Total Digestible Nutrients

The cooked hominy had a TDN value of 81.1 as compared to 79.9 for the uncooked hominy (Table 8). This difference was not significant at the 5% level.

The difference in total digestible nutrients of 1.2 was small and would not be expected to be a factor in any change in milk production. These would not warrant the cooking of concentrates as economically profitable.

SUMMARY

Sixteen milking cows of the Holstein breed were divided into equal groups and placed on a double reversal experiment for three twenty-four day periods. Both groups received 30 lb. of alfalfa hay per cow daily. Group one received in addition 6 lb. of cooked hominy daily per cow while group two received 6 lb. of uncooked hominy.

No significant differences occurred in 4% FCM, fat percentage, blood glucose, or change in body weight due to the feeding of the two rations.

Digestion trials were conducted on the hay, the cooked and the uncooked hominy using four cows each for the hay and cooked hominy and two cows for the uncooked hominy. The cows on the hay digestion trial were fed 20 lb. of hay per cow daily, while the cows on the hominy digestion trials received 10 lb. of hominy and 4 lb. of hay per cow daily with the digestibility of the hominy being found by difference.

The apparent digestibility of the nitrogen-free extract and dry matter was significantly in favor of cooked hominy. The apparent digestibility of the ether extract was significantly in favor of uncooked hominy. Differences in the apparent digestibility of crude protein, crude fiber, dry matter and total digestible nutrients were not significant at the 5% level.

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APPENDIX

APPENDIX TABLE 1

COEFFICIENTS OF APPARENT DIGESTIBILITY OF NITROGEN-FREE EXTRACT

Group	Cow No.	Per Day Hay Intake	Per Day Grain Intake	NFE Seven-Day Period Intake	NFE Seven-Day Period In Feces	NFE Seven-Day Period Re-tained	NFE Seven-Day Period Dig. Coeff.
		(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(%)
Hay	A-115	20	0	48.16	14.61	33.55	69.7
	A-121	20	0	48.16	16.42	31.74	65.9
	CS-203	20	0	48.16	14.78	33.38	69.3
	505	20	0	48.16	14.55	33.61	69.8
					Ave.	33.07	68.7
Cooked Hominy	A-115	4	10	49.49	3.68	45.81	92.6
	A-121	4	10	49.49	4.15	45.34	91.6
	CS-203	4	10	49.49	4.37	45.12	91.2
	505	4	10	49.49	3.63	45.86	92.7
					Ave.	45.53	92.0
Uncooked Hominy	A-121	4	10	46.87	5.05	41.82	89.2
	A-136	4	10	46.87	4.89	41.98	89.6
					Ave.	41.90	89.4

COMPARISON OF NITROGEN-FREE EXTRACT DIGESTIBILITY BETWEEN COOKED AND UNCOOKED HOMINY

Source of Variation	D.F.	Mean Square	F	F 0.01	F 0.05
Ration	1	9.3	23.3	21.2	7.7
Error	4	.4			

COMPARISON OF NITROGEN-FREE EXTRACT RETAINED BETWEEN COOKED AND UNCOOKED HOMINY

Source of Variation	D. F.	Mean Square	F	F 0.01	F 0.05
Ration	1	17.59	17.6	21.2	7.7
Error	4	.2			

APPENDIX TABLE 2

COEFFICIENTS OF APPARENT DIGESTIBILITY OF ETHER EXTRACT

Group	Cow No.	Per Day: Hay Intake	Per Day: Grain Intake	EE Intake	Seven-Day Period: In Feces	Seven-Day Period: Re-tained	Seven-Day Period: Dig. Coeff.
		(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(%)
Hay	A-115	20	0	1.96	1.44	.52	26.5
	A-121	20	0	1.96	1.48	.48	24.5
	CS-203	20	0	1.96	1.26	.70	35.7
	585	20	0	1.96	1.28	.68	34.7
					Ave.	.60	30.4
Cooked Hominy	A-115	4	10	3.15	.42	2.73	86.7
	A-121	4	10	3.15	.58	2.57	81.6
	CS-203	4	10	3.15	.55	2.60	82.5
	585	4	10	3.15	.41	2.74	87.0
					Ave.	2.66	84.4
Uncooked Hominy	A-121	4	10	4.51	.44	4.07	90.2
	A-136	4	10	4.51	.42	4.09	90.7
					Ave.	4.08	90.5

COMPARISON OF ETHER EXTRACT DIGESTIBILITY BETWEEN COOKED AND UNCOOKED HOMINY

Source of Variation	D.F.	Mean Square	F	Table F: P 0.01	Table F: P 0.05
Ration	1	48.0	8.1	21.2	7.7
Error	4	5.9			

COMPARISON OF DIGESTIBLE ETHER EXTRACT BETWEEN COOKED AND UNCOOKED HOMINY

Source of Variation	D.F.	Mean Square	F	Table F: P 0.01	Table F: P 0.05
Ration	1	2.68	536	21.2	7.7
Error	4	.005			

APPENDIX TABLE 3

COEFFICIENTS OF APPARENT DIGESTIBILITY OF DRY MATTER

Group	Cow No.	Hay Intake	Grain Intake	DM Seven-Day Period Intake	In Feces	Retained	Dig. Coeff.
		(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(%)
Hay	A-115	20	0	124.04	45.30	78.74	63.5
	A-121	20	0	124.04	49.82	74.22	59.8
	CS-205	20	0	124.04	45.23	78.81	63.5
	535	20	0	124.04	45.96	78.08	62.9
					Ave.	77.44	62.4
Cooked Hominy	A-115	4	10	64.82	9.73	55.09	85.0
	A-121	4	10	64.82	10.42	54.40	83.9
	CS-205	4	10	64.82	11.21	53.61	82.7
	535	4	10	64.82	9.86	54.96	84.8
					Ave.	54.52	84.1
Uncooked Hominy	A-121	4	10	62.43	10.94	51.49	82.5
	A-136	4	10	62.43	11.55	50.90	81.5
					Ave.	51.20	82.0

COMPARISON OF DRY MATTER DIGESTIBILITY BETWEEN COOKED AND UNCOOKED HOMINY

Source of Variation	D.F.	Mean Square	F	Table F P 0.01	Table F P 0.05
Ration	1	5.80	6.1	21.2	7.7
Error	4	0.95			

COMPARISON OF DIGESTIBLE DRY MATTER BETWEEN COOKED AND UNCOOKED HOMINY

Source of Variation	D.F.	Mean Square	F	Table F P 0.01	Table F P 0.05
Ration	1	16.46	43.18	21.2	7.7
Error	4	0.38			

APPENDIX TABLE 4
COEFFICIENTS OF APPARENT DIGESTIBILITY OF CRUDE PROTEIN

Group	Cow No.	Per Day: Hay Intake	Per Day: Grain Intake	CP Intake	Seven-Day Period: In Feces	Seven-Day Period: Re-tained	Seven-Day Period: Dig. Coeff.
		(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(%)
Hay	A-115	20	0	26.11	7.16	18.95	72.6
	A-121	20	0	26.11	7.69	18.42	70.5
	CS-205	20	0	26.11	7.36	18.75	71.8
	535	20	0	26.11	7.45	18.66	71.5
					Ave.	18.70	71.7
Cooked Hominy	A-115	4	10	7.98	2.97	5.01	62.8
	A-121	4	10	7.98	3.25	4.73	59.3
	CS-205	4	10	7.98	3.31	4.67	58.5
	535	4	10	7.98	2.95	5.03	63.0
					Ave.	4.86	60.9
Uncooked Hominy	A-121	4	10	7.13	2.18	4.95	69.4
	A-135	4	10	7.13	2.56	4.57	64.1
					Ave.	4.76	6[illegible].3

COMPARISON OF CRUDE PROTEIN DIGESTIBILITY
BETWEEN COOKED AND UNCOOKED HOMINY

Source of Variation	D.F.	Mean Square	F	Table F: F 0.01	Table F: F 0.05
Ration	1	45.6	6.0	21.2	7.7
Error	4	7.6			

COMPARISON OF DIGESTIBLE CRUDE PROTEIN
BETWEEN COOKED AND UNCOOKED HOMINY

Source of Variation	D.F.	Mean Square	F	Table F: F 0.01	Table F: F 0.05
Ration	1	.1	2.0	21.2	7.7
Error	4	.05			

APPENDIX TABLE 5

COEFFICIENTS OF APPARENT DIGESTIBILITY OF CRUDE FIBER

Group	Cow No.	Per Day Hay Intake	Per Day Grain Intake	CF Intake	Seven-Day Period In Feces	Seven-Day Period Retained	Seven-Day Period Dig. Coeff.
		(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(%)
Hay	A-115	20	0	[illegible].01	16.[illegible]	21.1[illegible]	55.7
	A-121	20	0	[illegible].01	17.9[illegible]	20.[illegible]	[illegible]
	OS-20[illegible]	20	0	[illegible].01	16.47	21.74	57.2
	5[illegible]	20	0	38.01	17.14	20.77	54.6
					Ave.	20.95	55.1
Cooked hominy	A-115	4	10	1.52	1.57	0.4[illegible]	24.7
	A-121	4	10	1.[illegible]	1.[illegible]	0.[illegible]	[illegible].7
	OS-[illegible]	4	10	1.[illegible]	1.[illegible]1	0.41	22.5
	5[illegible]	4	10	1.52	1.72	[illegible]	[illegible]
					Ave.	[illegible]	[illegible]
Uncooked hominy	A-1[illegible]1	4	10	[illegible]	[illegible]	0.17	[illegible]
	A-1[illegible]	4	10	[illegible]	[illegible]	0.[illegible]	[illegible]
					Ave.	[illegible]	[illegible].4

COMPARISON OF CRUDE FIBER DIGESTIBILITY
BETWEEN COOKED AND UNCOOKED HOMINY

Source of Variation	D.F.	Mean Square	F	Table F F 0.01	Table F F 0.05
Ration	1	[illegible]4.4	4.5	21.2	7.7
Error	4	[illegible]			

[illegible]
BETWEEN COOKED AND UNCOOKED HOMINY

Source of Variation	D.F.	Mean Square	F	Table F F 0.01	Table F F 0.05
Ration	1	0.11	[illegible]	[illegible]	[illegible]
Error	4	0.0[illegible]			

[illegible] TABLE 6

[illegible]

Group	Cow No.	[illegible] Intake	[illegible] Intake	[illegible] Intake	[illegible]	[illegible]	[illegible] Coeff.
		(lb.)	(lb.)	(lb.)	(lb.)	[illegible]	[illegible]
Hay	A-11[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
	A-1[illegible]1	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]1.9
	[illegible]-[illegible]	20	0	114.24	[illegible]	[illegible]	[illegible]
	[illegible]	20	0	114.24	40.57	[illegible]	[illegible]
					Ave.	[illegible]	[illegible]
Cooked [illegible]	A-11[illegible]	4	10	[illegible]	[illegible]	[illegible]	[illegible]
	A-1[illegible]1	4	10	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]-[illegible]	4	10	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	4	10	[illegible]	[illegible]	[illegible]	[illegible]
					Ave.	[illegible]	[illegible]
Uncooked [illegible]	A-1[illegible]1	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	A-1[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					Ave.	[illegible]	[illegible]

[illegible]

Source of Variation	D.F.	Mean Square	F	Table F F 0.01	[illegible]
Ration	1	[illegible]	[illegible]	[illegible]	[illegible]
Error	4	[illegible]			

[illegible]

Source of Variation	D.F.	Mean Square	F	Table F F 0.01	[illegible]
Ration	1	[illegible]	[illegible]	[illegible]	[illegible]
Error	4	[illegible]			

Group	Cow No.	[illegible]	Average
[illegible]	A-11[illegible]	[illegible]	
	A-1[illegible]1	[illegible].9	
	CS-[illegible]	53.9	
	[illegible]	55.[illegible]	[illegible].9
Cooked hominy	A-11[illegible]	[illegible].0	
	A-121	[illegible]	
	CS-[illegible]	[illegible].1	
	5[illegible]	[illegible]1.7	[illegible]1.1
[illegible]	A-1[illegible]1	[illegible].1	
	A-1[illegible]	7[illegible]	[illegible].9

Source of Variation	D.F.	Mean Square	F	Table F F 0.01	Table F F 0.05
Ration	1	[illegible]	[illegible].9	21.2	7.7
Error	4	.7			