# THE EFFECT OF ADDED FAT AND CORN ON THE UTILIZATION BY STEERS OF NITROGEN IN WINTERING RATIONS

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# INTRODUCTION

Agriculture in many areas of Oklahoma has developed to a large extent around the production of roughages. These roughages, commonly in the form of prairie hay and dry range grass, are the main sources of energy in wintering rations for range beef cattle. It is important that these roughages be properly supplemented with protein in order that they may be efficiently digested and in order for the animal to grow and store nitrogen during the winter.

Protein is usually the most expensive portion of the ration and many commercial supplements, which are sold on the basis of their protein content, contain considerable amounts of carbohydrate. Such carbohydrate may be of benefit for furnishing additional energy to cattle having access to limited amounts of roughage. There is little experimental work to indicate that the carbohydrate in protein supplements may exert a significant sparing action upon the protein.

The experiments reported in this thesis were initiated to study the effect of a readily available source of carbohydrate such as corn and an edible source of fat in the form of corn oil on nitrogen metabolism and on the digestibility of ration constituents by steers fed basal wintering rations.

# REVIEW OF LITERATURE

## Some Effects of Carbohydrate on Digestibility

Munro (1951), in an extensive review, cites experiments conducted by European workers in the latter part of the nineteenth century in which the addition of fat or carbohydrate to ruminant rations generally increased nitrogen retention. Lindsey and Smith (1910), working with sheep, showed that molasses caused a decrease in organic matter digestibility whether the basal ration was composed of only hay or hay and concentrate. In the hay basal ration molasses had to be present in relatively high concentration to cause any marked depression. Briggs and Heller (1937) reported on the effect of molasses on the digestibility of a lamb-fattening ration. The basal ration contained 457 gm. alfalfa hay plus 454 gm. of either corn or oats. He found that the substitution of 230 gm. of molasses for 224 gm. of grain caused a decreased apparent digestibility of protein and fat and had no apparent effect on the digestibility of crude fiber and nitrogen-free extract.

Colovos *et al.* (1949), working with dairy heifers, found that the addition of either wood or cane molasses to a grass-legume hay ration caused a decrease in the average apparent digestibility of protein. Davis *et al.* (1955), working with dairy steers, in three digestion trials found that molasses at high levels consistently depressed the digestibility of protein. Digested nitrogen from the rations containing large amounts of molasses appeared to be less useful than digested nitrogen from rations containing corn meal.

Arias and associates (1951) observed the stimulation of cellulose digestion by rumen bacteria in vitro in the presence of small amounts of molasses. This stimulation was not maintained when high levels of molasses were included in the media.

Mitchell and associates (1940) found that the digestibility of crude fiber was decreased 25 per cent by the addition of glucose to beef calf rations of different protein content.

Hamilton (1942), working with sheep, studied the effect of added glucose on the digestibility of the ration. The basal ration consisted of timothy hay, ground yellow corn, and cottonseed meal. The animals were fed 1.64 lb. of basal ration per 100 lb. live-weight. When sugar was fed, the animals received, in addition to the basal ration, 150 to 200 gm. of corn sugar daily. The average apparent digestion coefficients were for the basal ration and the basal ration plus sugar, respectively: dry matter, 65.4 and 67.7 per cent; total nitrogen, 61.9 and 54.1 per cent; crude fiber, 43.8 and 31.9 per cent; and nitrogen-free extract, 76.7 and 79.7 per cent. The addition of the sugar caused a significant decrease in apparent crude protein and crude fiber digestibility and a significant increase in the apparent digestibility of nitrogen-free extract. Swift et al. (1947), in studies with sheep, found that the addition of 58 gm. of starch resulted in a depression in the apparent digestibility of protein and crude fiber in a ration which contained mixed alfalfa and timothy hay, cornmeal and linseed meal. When 58 gm. of cerelose was added instead of the starch, there was a significant increase in the digestibility of the dry matter but no significant change in the apparent digestibility of protein. When the level of cerelose was increased to 116 gm.

there was a significant decrease in the apparent digestibility of protein and crude fiber. No appreciable changes in the digestion coefficients for dry matter and energy were observed.

Burroughs et al. (1949), in a series of digestion trials with steers, studied the effect of corn starch on the digestibility of roughage dry-matter. When corn cobs or corn cobs and a limited amount of alfalfa hay made up the roughage part of the ration, the addition of corn starch caused a marked reduction in the apparent digestibility of the roughage dry matter.

## Some Effects of Energy on Nitrogen Utilization and Digestion

Forbes et al. (1939) studied the effect of fat and carbohydrate addition on nitrogen utilization by young male albino rats fed quantities of basal diets adequate for maintenance. The authors found that supplementing the basal ration with either 1.24 gm. of lard or 3 gm. of dextrin resulted in a marked decrease in the average urinary nitrogen excretion and a marked increase in the percentage nitrogen retention. Differences between the effects of fat and carbohydrate on nitrogen retention were not reported.

Forbes and Swift (1944) showed that the percentage nitrogen excreted in the urine was reduced considerably by feeding cerelose and lard, alone or in combination, to mature rats fed a basal diet.

Working with growing mice, Bosshardt et al. (1948) showed that when dietary calories were restricted by decreasing the consumption of fat and carbohydrate, while keeping the protein intake constant, there was decreased protein utilization and decreased growth. Protein utilization was measured as the percentage of the absorbed nitrogen utilized for body gain. Fat and carbohydrate were equal in their protein-sparing effect.

Munro and Naismith (1953) fed rats diets either rich in protein or deficient in protein, in combination with various levels of energy supplied by either carbohydrate or fat. In experiments 1 and 2 the animals were fed protein-containing diets and in experiments 3 and 4 they were fed protein-free diets. In experiments 1 and 3 carbohydrate was used to furnish the additional energy and in experiments 2 and 4 fat was used. They found a linear relationship between energy intake and change in body weight. However, the influence of energy intake on body weight was greater in the experiments in which protein-containing diets were fed. The influence of energy intake on nitrogen balance was found to be dependent on protein intake. When carbohydrate was added to the protein-containing diet, nitrogen balance increased in a strictly linear fashion with increments in energy intake. A curvi-linear relation was apparent between energy intake and nitrogen balance when carbohydrate was added to the protein-free diet. The addition of increasing amounts of fat to the protein-containing diet resulted in a linear increase in nitrogen balance. However, when it was added to the protein-free diet, no improvement in nitrogen balance was noted. They suggest that when the supply of amino acids circulating to the tissues comes solely from endogenous sources this becomes a limiting factor in the rate of protein synthesis at low levels of energy intake. When the diet supplies adequate amounts of protein the limitation no longer exists.

Rosenthal (1952) studied the effect of caloric restriction and dietary fat on protein utilization. Varying the fat content had no effect when caloric intake was 50 to 100 per cent normal; however, when caloric intake was reduced to 25 per cent normal nitrogen index was reduced.

Barnes and Bosshardt (1946) studied the effect of caloric intake on protein utilization in growing rats and mice. In one study rats were fed isocaloric rations of varying protein content *ad libitum*. The caloric intake varied from 11.1 to 15.3 calories per 100 square centimeters of body surface. The protein content of the diets, expressed as per cent of protein calories in the diet, varied from 3.7 to 35.4. It was found that efficiency of protein utilization was highest when the caloric intake was 15.3 calories per 100 square centimeters. This did not coincide with the highest protein level.

In the experiment with mice isocaloric diets of variable protein content were again fed *ad libitum*. The per cent of protein calories in the diet varied from 2.79 to 29.70. The caloric intake varied from 2.37 to 2.87 calories per gram average weight. As in the former experiment with rats, the highest caloric intake coincided with the highest protein utilization.

Allison and Anderson (1945) conducted a study with dogs. Nitrogen balance and biological value were measured at different levels of absorbed nitrogen and at two caloric intake levels, 80 and 100 calories per kilogram body weight. They demonstrated that increasing the caloric intake from 80 to 100 calories per kilogram body weight resulted in an increased nitrogen balance, but was without effect on biological value.

Allison *et al.* (1946) showed that caloric restriction had to be severe before nitrogen utilization was affected in adult dogs. They used the nitrogen balance index as the criterion of nitrogen utilization. Dried, uncooked egg albumin was the source of dietary protein nitrogen. Three caloric intakes were used, adequate, 50 per cent adequate and 25 per cent adequate. The nitrogen balance index was

0.96 for the dogs receiving an adequate caloric intake or 50 per cent of that amount. However, when the intake was reduced to 25 per cent of the adequate amount, the utilization of egg white was reduced. At this low caloric intake the dogs were not put in positive nitrogen balance even with nitrogen intakes as high as 4 gm. per square meter body surface. Increases in nitrogen intake were accompanied by large increases in urinary nitrogen. When the caloric intake was increased to 50 per cent adequate by adding sucrose or lard, nitrogen retention was increased and urinary nitrogen lowered, thus demonstrating the protein-sparing action of carbohydrate and fat.

Stevenson et al. (1946) observed that the incorporation of egg in a basal ration at a level equivalent to 3.5 per cent protein resulted in a marked depression in the quantity of nitrogen (100 mg. less in 7 days) present in the urine of adult rats reduced to a constant plane of metabolism by feeding a nitrogen-low, 20-per cent fat ration. They showed that upon systematic reduction of the energy value of the diet, the sparing action of the egg protein was lost when the caloric intake was cut to less than 50 per cent of normal intake.

Working with rats that were receiving only one-fourth normal caloric intake, Willman and associates (1947) found that the animals fed the low-fat diet had a much greater urinary nitrogen than those fed a 20-per cent fat diet. Whether the rats were fed the high- or low-fat diet, when the caloric intake was restricted to 25 per cent normal there was an increase in nitrogen excretion. Rosenthal and Allison (1951) found that caloric restriction increased nitrogen excretion by adult dogs and depressed nitrogen balance, but did not alter the nitrogen balance index of the dietary protein. The protein intake of each animal was kept constant and the calories were increased or decreased by adding or removing carbohydrate.

Larson and Chaikoff (1937) studied the effect of time of feeding of a carbohydrate supplement on nitrogen excretion by adult dogs. The test animals were fed a diet furnishing about 60 cal. per kg. body weight and containing sufficient protein to maintain nitrogen equilibrium. The diet was fed in one meal. In addition, the dogs were fed 50 gm. glucose with the meal and 1, 2, 3, 4, 10, 18, 20, 22 and 23 hours after the meal. They showed that when glucose was fed with the meal and 1, 2 and 3 hours after the last feeding there was a depression in urinary nitrogen excretion during the 24-hours period. Beyond the 1-hour period, the reduction diminished as time progressed. When the supplement was fed 4 hours after the meal, a slight inconsistent effect was noted. Feeding glucose from 10 to 18 hours after the meal had no effect. Supplemental glucose feeding 4 hours, 2 hours and 1 hour before the next feeding resulted in a depression in urinary nitrogen during the second 24-hour period. From these observations the authors postulated that there is a time interval during which the extra carbohydrate is able to exert a nitrogen-sparing action, this interval being limited to 4 hours before and 4 hours after ingestion of the daily meal. In another experiment these workers fed either 30 or 50 gm. of glucose with the meal for 4 to 7 consecutive days. Nitrogen excretion decreased during each 24-hour period.

Munro (1949) fed adult male rats diets with the carbohydrate fed apart from the protein and then the same diet with part of the carbohydrate fed along with the protein. The immediate effect of this change in the time of carbohydrate feeding was a considerable improvement in nitrogen balance. After a few days, however, nitrogen balance returned to its original level. Subsequent separation of the times of ingestion of carbohydrate and protein caused a transient impairment of nitrogen balance. It has been concluded that protein utilization is affected by the presence of carbohydrate in the same meal. No change in nitrogen balance was observed in experiments involving similar alterations in the time of feeding fat. Feeding fat a short time before the protein meal had no effect on nitrogen balance.

Lofgreen and associates (1951) studied the influence of energy intake on nitrogen retention of growing dairy calves. Eighteen Holstein heifer calves weighing about 150 lb. were divided into four lots and placed on four dietary treatments. The treatments were low energy-low protein, high energy-low protein, low energy-high protein, and high energy-high protein intakes. The low protein level was the crude protein allowance as recommended by Morrison (1936) and the high protein was 160 per cent of this allowance. The low energy level was the total digestible nutrient allowance recommended by the Morrison standard and the high energy level was 115 per cent of the allowance. The hay used was good quality alfalfa, timothy or clover hay. The concentrate mixture was a 16-per cent protein commercial calf starter at the start of the experiement and was changed to a growing mixture when the animals reached about 250 lb. The proportion of protein was maintained by supplementing the starter or growing mixture with a mixture of protein supplements. To furnish the high energy level, the total feed allowance was increased while maintaining the protein intake constant by the proper reduction in the percentage of protein in the concentrate mixture. Nitrogen balances were determined when the calves weighed 150, 200, 250, and 300 lb. Feces and urine were collected during

5-day collection periods preceded by 7-day preliminary periods. The average nitrogen retention expressed as the per cent of consumed nitrogen was 25.8, 31.6, 24.4, and 21.5, respectively, for the animals fed low energy-low protein, high energy-low protein, low energy-high protein, and high energy-high protein ration. Increasing the non-nitrogenous total digestible nutrient consumption resulted in a marked increase in the nitrogen retention of dairy calves fed a moderate protein level but was without effect when the calves were fed a high protein level.

In a series of three experiments with steers, Fontenot et al. (1955) determined the effect of adding different amounts of cerelose to wintering rations containing approximately 8, 10 and 12 per cent protein. The basal wintering rations were composed of prairie hay, cottonseed meal and minerals in the proportions frequently fed to wintering beef cattle.

Additions of cerelose to the extent of 350, 700 and 1050 gm. to the 8-per cent ration, and 700 and 1050 gm. to the 10- and 12-per cent rations, resulted in a significant increase in nitrogen retention when the basal ration contained 10 per cent protein, and a small but not statistically significant increase when the basal ration contained 12 per cent protein. The added cerelose increased the estimated (Thomas-Mitchell) biological value of the nitrogen of all three basal rations. It decreased the apparent, but not the true, digestibility of protein, depressed the digestibility of crude fiber, and increased the digestibility of nitrogen-free extract. At each level of protein, the trend of results was toward an increase in these effects with increasing cerelose intake.

It is apparent that nitrogen balance can be affected by factors affecting endogenous nitrogen excretion in the urine and metabolic nitrogen excretion in feces. Mitchell (1924), working with rats, found that the amount of fecal metabolic nitrogen was influenced by the crude fiber content of the diet and by the amount of dry matter consumed. In these same studies he showed that the size of the animal influenced the urinary excretion of endogenous nitrogen, heavier animals having a higher excretion than lighter ones.

### Some Effects of Fat on Nitrogen Utilization and Digestion

Sheer et al. (1947) found that when rats were fed diets containing 0, 5, 10, 20, and 40 per cent fat the animals on the 20 and 40 per cent levels made more efficient gains than the animals on the lower levels.

Swanson (1951), using male rats 6-months-old, showed that reduced caloric intake had a greater influence on nitrogen metabolism when low-fat diets were fed than when high-fat diets were fed. In these tests the animals were brought to an approximately steady state of nitrogen metabolism by being maintained on a protein-free but otherwise adequate diet for 18 days. During this depletion period, one group of animals was fed a high-fat ration and the other a low-fat ration. Various nitrogen balances were conducted during the following 14-16 days. Part of the animals were then fed nitrogen-poor diets low in calories while the remaining animals were continued on a full-caloric diet and their balances were redetermined. Nitrogen balance was measured at 25, 50, 75 and 100 per cent normal intake. It was found that nitrogen metabolism was not markedly altered by reducing the caloric intake to 75 per cent of normal. When the caloric intake was reduced to 50 per cent, it lowered nitrogen balance drastically on the low-fat diets but did not affect to any extent the animals on the high-fat diets. When the caloric intake was reduced to 25 per cent of normal, it lowered the nitrogen balance of both groups of animals. However, the nitrogen balance of the animals on the low-fat diets was still much less than that of the rats fed the high-fat diet.

French and co-workers (1953) found that rats fed a diet containing 22.7 per cent fat grew as rapidly as those fed a diet containing 3.4 per cent fat. The life span of rats ingesting the high-fat diet decreased markedly. Increased efficiency of utilization of the diet was correlated with decrease in life span. The livers of the rats on the high-fat diet contained significantly more fat than those fed the carbohydrate diet. The histopathological data, however, revealed nothing that could be interpreted as a fat-induced cause of premature death.

The effect of dietary fat upon digestibility of other ration components was studied by Lucas and Loosli (1944). They found lowered digestibility of dry matter, nitrogen-free extract and crude fiber in rations for dairy cattle in which ether extract had been increased to 7 per cent by the addition of corn oil or soybean oil.

Swift *et al.* (1948) fed sheep rations which were made isocaloric by reciprocal variation between added fat and carbohydrate. The rations contained 3, 4, 5, 6, 7 and 8 per cent fat and furnished equal amounts of protein. Determinations were made of nutrient digestibility, heat production and methane production. The utilization of protein and energy by the sheep was found to be approximately the same on all rations.

Byers and others (1949) found that a ration of alfalfa hay and ground soybeans containing 5.2 per cent fat did not increase milk production in dairy cows over that obtained with a ration of alfalfa hay and soybean meal containing 2.7 per cent fat.

Gullickson and associates (1942) ran feeding tests with dairy calves which indicated that calves fed butter fat (3.5 per cent) excelled over those fed lard, tallow, corn oil, cottonseed oil, or soybean oil. Jacobson et al. (1949) reported that dairy calves fed hydrogenated soybean oil at a 3 per cent level grew as well as calves fed whole milk, while calves fed from 2 to 3 per cent crude expeller soybean oil showed poor growth and a high mortality rate.

Wiley and associates (1952) fed steer calves from different rations: low fat-low energy, low fat-high energy, high fat-low energy and high fat-high energy. Fat levels measured as ether extract ranged from 2.84 per cent in the low level ration to 7.54 per cent in the high level ration. The efficiency of feed utilization was greater on the high-fat ration than on the low-fat ration and appeared to be independent of the energy level.

Schweigert and Wilder (1954) fed two lots of 12 steers each a ration of corn, dried brewers grain, molasses, minerals and hay. One pound of stabilized fat which replaced 2.5 pounds of corn in the basal ration was fed to the second group of steers. The animals were on trial 109 days and then slaughtered. Rate of gain and carcass grade was approximately the same for both groups. Total feed intake was below maximum and the caloric intake was the same for each ration. The authors were trying to evaluate caloric utilization from the fat as compared to corn rather than the economy of gain for each group on full feed. These researchers concluded since carcass grades and rates of gain were almost the same for both groups, the animal fat had an energy value two and one-half times that of the corn.

Brooks et al. (1954), in studies conducted in vitro, found that corn oil reduced the digestibility of cellulose by ovine rumen organisms. Also, corn oil added to a basal ration of cottonseed hulls and casein significantly reduced the digestibility of cellulose and protein by sheep. Rumen ingesta from the sheep had a putrid odor, a turbid color and a lowered volatile fatty acid content. The depressing effects of added corn oil were partially overcome by the addition of alfalfa ash. These workers believe that added fat depresses cellulose digestion more than the naturally contained fat in feed. Tillman et al. (1956) fed 10 per cent corn oil in a fattening-type ration to sheep. Gains of the sheep were only one-half those of sheep fed the control ration which contained no fat. The addition of 15 per cent mixed animal fat to a fattening-type ration caused the sheep to lose weight. Alfalfa ash did not improve gain, while the addition of potassium bicarbonate or sodium bicarbonate appeared to increase the detrimental effect of the fat.

In a Nebraska test, Matsushima et al. (1953) fed steers a pelleted ration containing (1) no added fat, (2) 5.5 per cent beef tallow and (3) 5.5 per cent corn oil. The average daily gains of steers fed these three rations were 2.11, 2.00 and 1.77 lb., respectively. The authors stated that the corn oil became rancid and this rancidity probably resulted in decreased feed consumption. Matsushima and associates (1955), in a continuation of this work, state that the energy from high grade inedible fat was utilized almost as effectively as the energy from corn when the level of fat did not exceed one pound per day. Some digestive disturbances were observed when the animals were fed one and a half pounds daily. Jones et al. (1942) fed steers a fattening ration containing approximately 6 per cent cottonseed oil and reported the oil to be a satisfactory source of energy.

## EXPERIMENT I

This experiment was conducted to determine the effect of the addition of corn upon nitrogen utilization and the digestibility of ration components by steers fed a wintering-type basal ration composed of prairie hay, minerals, and sufficient cottonseed meal to maintain nitrogen equilibrium.

### Procedure

Experiment I was initiated with a group of eight grade Hereford steers weighing an average of 483 lb. at the start of the experiment. The steers were used in two digestion trials extending from January 28, 1955 to February 26, 1955. The experiment was of a reversal design whereby two rations are fed alternately to two groups of animals. The steers were kept in false bottom metabolism stalls as described by Nelson _et al._ (1954). A 10-day preliminary period preceded each 10-day collection period. The steers were fed twice daily. A three-week period of adjustment was given the steers before being placed in the metabolism stalls. During this early preliminary period the steers were handled daily while being kept in hay-bedded box stalls.

The rations fed and the chemical composition of the feeds used in this experiment are given in Table 1. The average chemical composition of the rations is given in Table 2.

The basal ration contained 3000 gm. of prairie hay, 454 gm. of cottonseed meal, 25 gm. of dicalcium phosphate and 25 gm. of salt. This

TABLE 1

Daily Amounts and Average Chemical Composition of Feeds Used in Corn Studies

| Feed | Daily Allowance in Ration | | | Percentage Composition of Dry Matter | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Basal | Basal + Corn | Dry matter | Organic matter | Crude protein | Ether extract | Crude fiber | Nitrogen-free extract | Ash |
| | gm. | gm. | % | | | | | | |
| Prairie hay | | | | | | | | | |
| Trial 1 | 3000 | 3000 | 95.30 | 93.14 | 4.75 | 2.57 | 33.14 | 52.68 | 6.86 |
| Trial 2 | 3000 | 3000 | 95.66 | 92.90 | 4.50 | 2.53 | 32.00 | 53.87 | 7.10 |
| Corn | | | | | | | | | |
| Trial 1 | 0 | 572 | 87.77 | 98.42 | 10.13 | 5.08 | 1.81 | 81.40 | 1.58 |
| Trial 2 | 0 | 572 | 88.03 | 98.56 | 9.93 | 4.79 | 1.81 | 82.03 | 1.44 |
| Cottonseed meal | | | | | | | | | |
| Trial 1 | 454 | 336 | 93.00 | 94.07 | 44.31 | 6.09 | 12.76 | 30.91 | 5.93 |
| Trial 2 | 454 | 336 | 92.76 | 94.24 | 44.56 | 5.98 | 13.11 | 30.59 | 5.76 |
| NaCl | | | | | | | | | |
| Trials 1 & 2 | 25 | 25 | 100.00 | | | | | | 100.00 |
| Dicalcium phosphate | | | | | | | | | |
| Trials 1 & 2 | 25 | 25 | 100.00 | | | | | | 100.00 |

TABLE 2

Average Chemical Composition of Rations Used in Corn Studies

| Ration | Per cent dry matter | Percentage Composition Dry Matter | | | | | |
|---|---|---|---|---|---|---|---|
| | | Organic matter | Crude protein | Ether extract | Crude fiber | Nitrogen-free extract | Ash |
| Basal | 95.21 | 91.77 | 9.58 | 2.95 | 29.61 | 49.63 | 8.23 |
| Basal + Corn | 94.23 | 92.60 | 8.62 | 3.13 | 26.35 | 54.51 | 7.40 |

ration contained 9.58 per cent protein. The basal plus corn ration consisted of 3000 gm. of prairie hay, 336 gm. of cottonseed meal, 572 gm. of corn, 25 gm. of dicalcium phosphate and 25 gm. of salt. The addition of corn lowered the protein content of the ration to 8.62 per cent.

The prairie hay was of average quality and was sorted for weeds before being fed. The cottonseed meal was expeller processed. The corn was No. 2 yellow dent and was relatively finely ground. The dicalcium phosphate was of high purity and the ground rock salt was of feeding grade.

Feces were collected in metal pans and transferred several times daily to covered metal containers. The feces were weighed daily and 5 per cent aliquots were preserved in tightly covered glass jars under refrigeration. Thymol crystals were used as an aid in preservation. Proximate analyses, as described by the Association of Official Agricultural Chemists (1950), were made on 10-day composite samples of the feces. Urine was collected in covered metal cans by means of a metal funnel placed below a grid in the floor of the metabolism stalls. The urine was diluted with water to a constant weight daily and an aliquot was acidified and stored under refrigeration. Nitrogen was determined by the Kjeldahl method on combined daily aliquots.

The Thomas-Mitchell formula was used in the calculation of biological value of the nitrogen:

Biological Value =

$$\frac{\text{N intake} - (\text{fecal N} - \text{metabolic N}) - (\text{urinary N} - \text{endogenous n})}{\text{N intake} - (\text{fecal N} - \text{metabolic N})} \times 100$$

The metabolic nitrogen and endogenous nitrogen were calculated by the method suggested by Swanson and Herman (1943). Fecal metabolic nitrogen was considered to be 5.3 gm. per kg. of dry matter intake. The equation used for the calculation of the endogenous urinary nitrogen was N = 0.712 x 0.42 where N represents the grams of endogenous nitrogen and x the body weight in kilograms. The formula was derived by Swanson and Herman (1943) from results obtained by feeding low-nitrogen rations to dairy heifers.

The statistical methods as described by Snedecor (1946) were used to analyze the nitrogen balances, biological values, and apparent digestibility of nutrients.

## Results and Discussion

The average daily nitrogen balance and biological value data are given in Table 3. The individual data for nitrogen balance and biological value are presented in Table I appendix.

In the trials with added carbohydrate 118 gm. of cottonseed meal was replaced by an iso-nitrogenous amount of corn, 572 gm., representing the addition to the basal ration of an additional 355 gm. of non-nitrogenous nutrients, primarily carbohydrate. The supplement of corn decreased daily nitrogen excretion in the urine from 16.33 gm. to 14.18 gm., but increased the nitrogen in the feces from 22.04 gm. to 24.80 gm. The increased fecal nitrogen excretion was associated with the increased intake and excretion of dry matter and a significant drop ($P<0.01$) in the digestibility of crude fiber. In this respect, the results resembled those obtained with pure carbohydrate by Fontenot et al. (1955). Total nitrogen retention was decreased, but not significantly, from 12.23 gm. to 11.32 gm. when corn was added to the ration. Mitchell and associates (1940) found that the feeding of glucose to beef calves failed to in-

TABLE 3

Average Daily Nitrogen Balance and Biological Value Data for Corn Studies

| Ration | Intake | | Excretion | | Nitrogen retention | Metabolic N | Endogenous N | True digested N | Absorbed N utilized | Biological value |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dry matter | Nitrogen | Fecal N | Urinary N | | | | | | |
| | gm. | gm. | gm. | gm. | gm. | gm. | gm. | gm. | gm. | % |
| Basal | 3325.3 | 50.60 | 22.04 | 16.33 | 12.23 | 17.58 | 6.89 | 46.14 | 36.67 | 79.52 |
| Basal + Corn | 3679.6 | 50.30 | 24.80 | 14.18 | 11.32 | 19.46 | 6.87 | 45.02 | 37.80 | 83.91 |

crease nitrogen retention when the basal ration contained approximately 10 per cent or less protein. In an earlier study, Fontenot (1953) fed two rations differing in caloric value but of approximately equal protein content. The higher caloric ration induced the higher average nitrogen retention. In the present experiment there was a highly significant ($P<0.01$) increase in the average biological value (79.52 to 83.91) when corn was added to the ration. Several workers have observed that a decrease in the protein percentage of a ration is usually accompanied by an increase in biological value. Allison et al. (1946), working with dogs, and Bosshardt et al. (1948), working with mice, showed that nitrogen utilization is impaired when caloric intake is restricted.

Average values for the apparent digestibility of nutrients in each ration are shown in Table 4. The individual values are shown in Table II, appendix. The addition of 572 gm. of corn to the basal ration had no apparent effect on organic matter or dry matter digestibility.

The average apparent crude protein digestibility decreased when corn was added to the ration. This decrease was highly significant ($P<0.01$) and was probably due to increased fecal metabolic nitrogen. The data in Table 3, which show that there was no appreciable difference between rations in true digested nitrogen, support this idea. These results are in general agreement with those obtained by Hamilton (1942), Swift et al. (1947) and Fontenot and associates (1955).

The apparent digestibility of crude fiber was decreased by a highly significant ($P<0.01$) amount by the addition of corn. This decrease partially nullifies the value of readily-available carbohydrate in a wintering-type ration. The results are in general agreement with work done by Mitchell et al. (1940), Swift and associates (1947) and

TABLE 4

Average Apparent Digestion Coefficients for Corn Studies

| Ration | Number of animals | Corn intake, gm. | Average Digestion Coefficients | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Dry matter | Organic matter | Crude protein | Ether extract | Crude fiber | N-free extract |
| Basal | 8 | 0 | 60.41 | 63.26 | 56.44 | 54.29 | 68.00 | 62.10 |
| Basal + Corn | 8 | 572 | 60.69 | 63.31 | 50.30 | 57.11 | 64.12 | 65.42 |

Fontenot and co-workers (1955), all of whom observed that relatively high levels of available carbohydrate added to ruminant rations caused a marked depression in crude fiber digestibility.

The apparent digestibility of the nitrogen-free extract in the corn-containing rations was significantly greater ($P < 0.01$) than that in the basal ration.

The increase in digestibility of ether extract when the corn-containing ration was fed was not statistically significant.

## EXPERIMENT II

The purpose of this experiment was to determine the effect of adding corn oil upon nitrogen utilization and the digestibility of ration components by steers fed a ration similar to that in Experiment I.

### Procedure

A group of nine grade Hereford steers weighing an average of 508 lb. at the start of the experiment were used. The steers were fed two different rations during a series of three digestion trials extending from December 21, 1955 to February 8, 1956. The design as well as the manner in which the experiment was conducted was the same as in Experiment I. The rations offered and the chemical composition of the feeds used are given in Table 5. The average chemical composition of the rations is given in Table 6.

The basal ration of all three trials contained 3000 gm. of prairie hay, 454 gm. of cottonseed meal, 25 gm. of dicalcium phosphate and 25 gm. of salt. The corn oil ration in all trials consisted of 3000 gm. of prairie hay, 454 gm. of cottonseed meal, 200 gm. of corn oil (mixed with the cottonseed meal), 25 gm. of dicalcium phosphate and 25 gm. of salt.

The average protein content of the basal ration was 10.14 per cent. The corn oil addition resulted in a lowering of the average protein content to 9.56 per cent. Because of feed refusals, data from six animals were discarded. Four of these animals were in the first trial.

TABLE 5

Daily Amounts and Average Chemical Composition of Feeds Used in Corn Oil Studies

| Feed | Daily Allowance in Ration | | | Percentage Composition of Dry Matter | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Basal | Basal + Corn oil | Dry matter | Organic matter | Crude protein | Ether extract | Crude fiber | Nitrogen-free extract | Ash |
| | gm. | gm. | % | | | | | | |
| Prairie hay | | | | | | | | | |
| Trial 1 | 3000 | 3000 | 93.29 | 93.11 | 5.63 | 3.09 | 31.98 | 52.41 | 6.89 |
| Trial 2 | 3000 | 3000 | 94.86 | 93.76 | 4.63 | 2.53 | 33.65 | 52.95 | 6.24 |
| Trial 3 | 3000 | 3000 | 92.09 | 93.78 | 4.94 | 2.82 | 33.52 | 52.50 | 6.22 |
| Cottonseed meal | | | | | | | | | |
| Trial 1 | 454 | 454 | 92.29 | 92.81 | 45.56 | 4.31 | 10.37 | 32.57 | 7.19 |
| Trial 2 | 454 | 454 | 92.52 | 93.93 | 44.10 | 4.90 | 12.92 | 32.01 | 6.07 |
| Trial 3 | 454 | 454 | 90.46 | 92.93 | 46.75 | 4.44 | 10.19 | 31.55 | 7.07 |
| Corn Oil | | | | | | | | | |
| Trial 1 | | 200 | 100 | 100 | | 100 | | | |
| Trial 2 | | 200 | 100 | 100 | | 100 | | | |
| Trial 3 | | 200 | 100 | 100 | | 100 | | | |
| NaCl | | | | | | | | | |
| Trials 1,2,3 | 25 | 25 | 100 | | | | | | 100 |
| Dicalcium phosphate | | | | | | | | | |
| Trials 1,2,3 | 25 | 25 | 100 | | | | | | 100 |

TABLE 6

Average Chemical Composition of Rations Used in Corn Oil Studies

| Ration | Per cent dry matter | Percentage Composition of Dry Matter | | | | | |
|---|---|---|---|---|---|---|---|
| | | Organic matter | Crude protein | Ether extract | Crude fiber | Nitrogen-free extract | Ash |
| Basal | 93.29 | 92.08 | 10.14 | 2.99 | 29.76 | 49.19 | 7.92 |
| Basal + Corn oil | 93.65 | 92.53 | 9.56 | 8.58 | 28.04 | 46.35 | 7.47 |

## Results and Discussion

The results of the three trials have been combined. The average daily nitrogen balance and biological value data are given in Table 7. The individual data are given in Table III, appendix.

The addition of 200 gm. of corn oil decreased the nitrogen in the urine from 17.45 gm. to 15.45 without producing a measurable change in fecal nitrogen (23.44 gm. as compared to 23.87 gm.). This resulted in a significant ($P<0.01$) increase in nitrogen retention. The large increase in absorbed nitrogen indicate a definite sparing action of fat upon nitrogen retention. This is in agreement with work by Fontenot et al. (1953) (1955) who obtained an increase in nitrogen retention by adding readily-available carbohydrate to a basal wintering ration containing 10 per cent protein.

The addition of corn oil resulted in a significant ($P<0.01$) increase in the biological value of nitrogen. The average biological value of nitrogen for the basal ration was 77.42 and for the corn oil ration, 82.05. These results agree with Experiment I in which corn was added to the basal ration.

The average apparent digestion coefficients are given in Table 8. The individual coefficients are presented in Table IV, appendix. The addition of 200 gm. of corn oil to the basal ration resulted in a significant ($P<0.01$) decrease in both organic matter and dry matter digestibility. This is in agreement with work by Brooks et al. (1954) and Tillman et al. (1956) who found lowered cellulose digestion when corn oil was added to rations fed to sheep.

There was a slight decrease in apparent protein digestibility from 55.24 to 54.34 per cent when the corn oil addition was made. This de-

TABLE 7

Average Daily Nitrogen Balance and Biological Value Data for Corn Oil Studies

| Ration | Intake | | Excretion | | Nitrogen retention | Metabolic N | Endogenous N | True digested N | Absorbed N utilized | Biological value |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dry matter | Nitrogen | Fecal N | Urinary N | | | | | | |
| | gm. | gm. | gm. | gm. | gm. | gm. | gm. | gm. | gm. | % |
| Basal | 3260.0 | 52.35 | 23.44 | 17.45 | 11.46 | 17.27 | 6.97 | 46.19 | 35.71 | 77.42 |
| Basal + Corn oil | 3464.0 | 52.64 | 23.87 | 15.45 | 13.32 | 18.36 | 6.97 | 47.13 | 38.66 | 82.05 |

TABLE 8

Average Apparent Digestion Coefficients for Corn Oil Studies

| Ration | Number of animals | Corn intake, gm. | Average Digestion Coefficients: Dry matter | Organic matter | Crude protein | Ether extract | Crude fiber | N-free extract |
|---|---|---|---|---|---|---|---|---|
| Basal | 9 | 0 | 61.38 | 63.62 | 55.24 | 52.43 | 66.34 | 64.26 |
| Basal + Corn oil | 9 | 200 | 60.36 | 62.31 | 54.34 | 80.48 | 62.25 | 60.53 |

crease was less than that obtained when corn was added to the basal ration and was not statistically significant. Difference in protein content of the two rations would account for part of the difference in digestibility.

Crude fiber digestibility decreased from 66.34 per cent to 62.25 by the addition of corn oil. This difference was highly significant ($P<0.01$). This result is in agreement with the results obtained with corn and with work reported by Swift and co-workers (1947), Brooks et al. (1954) and Fontenot et al. (1955) in which pure carbohydrate and fat were added to ruminant rations.

The addition of corn oil caused a highly significant ($P<0.01$) depression in nitrogen-free extract digestibility from 64.26 per cent to 60.53 per cent and a highly significant ($P<0.01$) increase in apparent ether extract digestibility from 52.43 per cent to 80.48 per cent. The depression in nitrogen-free extract digestibility is believed to result from altered composition of rumen organism population and impaired fermentation processes in the rumen. The increase in apparent digestibility of ether extract is directly related to the increase in fat content of the ration and a decrease in the proportion of fecal fat that is of metabolic origin.

The steers showed no signs of digestive disturbances during the trials, although they were fed rations which contained 8.58 per cent ether extract on a dry matter basis. Their feces increased in dry matter content as they were changed from the basal rations to the fat-supplemented rations.

## SUMMARY

In a study of the effect of added carbohydrate and fat in ruminant rations, Hereford steers were fed a basal wintering-type ration (9.58 - 10.14 per cent protein, dry matter basis) of prairie hay, 3000 gm.; cottonseed meal, 454 gm.; and minerals, 50 gm. In the trials with added carbohydrate, 118 gm. of cottonseed meal was replaced by an iso-nitrogenous amount of corn, 572 gm., representing the addition to the basal ration of an extra 355 gm. of non-nitrogenous nutrients, mostly carbohydrate. In the trials with fat, 200 gm. of corn oil was added directly to the cottonseed meal of the basal ration. The supplement of corn decreased nitrogen excretion in the urine but increased it in the feces. The increased fecal nitrogen was associated with the increased intake and excretion of dry matter and a lower digestibility of crude fiber. Total nitrogen retention was decreased from 24.2 per cent of the intake to 22.5 per cent. The supplement of fat decreased urinary nitrogen excretion without affecting fecal nitrogen excretion. Total nitrogen retention was increased from 21.1 per cent of the intake to 24.7 per cent.

The addition of corn resulted in no apparent effect upon organic matter and dry matter digestibilities, while the inclusion of corn oil in the ration caused a significant decrease in the apparent digestibility of both dry matter and organic matter. Crude fiber digestibility was significantly reduced in both experiments. The apparent digestibil-

ity of crude protein was significantly decreased when corn was added to the ration, but not when corn oil was added. There was a highly significant increase in apparent ether extract digestibility when corn oil additions were made. The apparent digestibility of nitrogen-free extract was significantly increased when corn was added to the ration, but significantly decreased when corn oil additions were made. Both corn and corn oil significantly increased biological value of the protein.

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# A P P E N D I X

TABLE I. DAILY NITROGEN BALANCE AND BIOLOGICAL VALUE DATA FOR CORN STUDIES

| Ration | Trial | Steer No. | Intake: Dry matter | Intake: Nitrogen | Excretion: Fecal N | Excretion: Urinary N | N retention | Metabolic N | Endogenous N | True digested N | Absorbed N utilized | Biological value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | gm. | gm. | gm. | gm. | gm. | gm. | gm. | gm. | gm. | % |
| Basal | 1 | 103 | 3331.2 | 51.66 | 22.22 | 16.98 | 12.46 | 17.54 | 6.78 | 46.98 | 36.78 | 78.29 |
| | 1 | 124 | 3331.2 | 51.66 | 22.83 | 15.92 | 12.91 | 17.54 | 6.95 | 46.37 | 37.40 | 80.66 |
| | 1 | 39 | 3331.2 | 51.66 | 22.73 | 16.24 | 12.69 | 17.54 | 6.92 | 46.47 | 37.15 | 79.94 |
| | 1 | 41 | 3244.8 | 47.02 | 20.20 | 14.96 | 11.86 | 17.19 | 6.74 | 44.01 | 35.79 | 81.32 |
| | 2 | 8 | 3340.9 | 50.69 | 22.58 | 18.33 | 9.78 | 17.70 | 6.86 | 45.81 | 34.34 | 74.96 |
| | 2 | 123 | 3340.9 | 50.69 | 20.75 | 15.98 | 13.96 | 17.70 | 6.87 | 47.64 | 38.52 | 80.86 |
| | 2 | 94 | 3340.9 | 50.69 | 22.19 | 16.30 | 12.20 | 17.70 | 6.87 | 46.20 | 36.76 | 79.57 |
| | 2 | 132 | 3340.9 | 50.69 | 22.79 | 15.95 | 11.95 | 17.70 | 7.09 | 45.60 | 36.74 | 80.57 |
| Average | | | 3325.3 | 50.60 | 22.04 | 16.33 | 12.23 | 17.58 | 6.89 | 46.14 | 36.69 | 79.52 |
| Basal | 1 | 132 | 3649.9 | 49.79 | 24.90 | 14.56 | 10.33 | 19.35 | 7.09 | 44.24 | 36.77 | 83.11 |
| + | 1 | 123 | 3666.9 | 51.30 | 24.48 | 13.60 | 13.22 | 19.42 | 6.87 | 46.24 | 39.51 | 85.45 |
| Corn | 1 | 8 | 3693.8 | 51.40 | 24.72 | 15.58 | 11.10 | 19.58 | 6.77 | 46.26 | 38.15 | 82.47 |
| | 1 | 94 | 3643.9 | 50.46 | 26.79 | 16.40 | 7.27 | 19.31 | 6.87 | 42.98 | 33.44 | 77.80 |
| | 2 | 124 | 3713.1 | 50.65 | 23.80 | 13.00 | 13.85 | 19.68 | 6.95 | 46.76 | 40.71 | 87.06 |
| | 2 | 39 | 3734.0 | 50.88 | 25.34 | 13.00 | 12.54 | 19.79 | 6.92 | 45.33 | 39.23 | 86.55 |
| | 2 | 41 | 3601.2 | 47.07 | 23.64 | 13.50 | 9.53 | 19.09 | 6.74 | 42.52 | 35.76 | 84.10 |
| | 2 | 103 | 3734.0 | 50.88 | 24.80 | 13.80 | 12.28 | 19.79 | 6.78 | 45.87 | 38.85 | 84.70 |
| Average | | | 3679.6 | 50.30 | 24.80 | 14.18 | 11.32 | 19.46 | 6.87 | 45.02 | 37.80 | 83.91 |

TABLE II. APPARENT DIGESTION COEFFICIENTS FOR CORN STUDIES

| Ration | Trial | Steer No. | Dry matter intake | Apparent Percentage Digestibility: Dry matter | Organic matter | Crude protein | Ether extract | Crude fiber | Nitrogen-free extract |
|---|---|---|---|---|---|---|---|---|---|
| | | | gm. | | | | | | |
| Basal | 1 | 103 | 3331.2 | 58.04 | 60.72 | 56.89 | 48.99 | 66.20 | 58.21 |
| | 1 | 124 | 3331.2 | 61.50 | 64.20 | 55.80 | 55.02 | 67.69 | 63.67 |
| | 1 | 39 | 3331.2 | 60.33 | 62.91 | 56.12 | 51.51 | 68.56 | 61.50 |
| | 1 | 41 | 3244.8 | 60.35 | 63.07 | 56.95 | 50.38 | 68.61 | 61.51 |
| | 2 | 8 | 3340.9 | 60.24 | 63.45 | 55.35 | 57.48 | 68.21 | 62.57 |
| | 2 | 123 | 3340.9 | 63.69 | 66.33 | 59.05 | 58.68 | 70.22 | 65.89 |
| | 2 | 94 | 3340.9 | 59.75 | 63.03 | 56.32 | 53.93 | 68.19 | 61.77 |
| | 2 | 132 | 3340.9 | 59.40 | 62.35 | 55.03 | 58.25 | 66.41 | 61.61 |
| Average | | | 3325.3 | 60.41 | 63.26 | 56.44 | 54.29 | 68.00 | 62.00 |
| Basal + Corn | 1 | 132 | 3649.9 | 58.91 | 61.75 | 50.05 | 54.63 | 50.03 | 63.75 |
| | 1 | 123 | 3666.9 | 63.32 | 65.64 | 52.27 | 63.44 | 66.63 | 67.42 |
| | 1 | 8 | 3693.8 | 61.75 | 64.50 | 51.90 | 55.55 | 66.43 | 66.10 |
| | 1 | 94 | 3643.9 | 59.20 | 61.01 | 46.83 | 53.38 | 66.56 | 62.35 |
| | 2 | 124 | 3713.1 | 60.91 | 63.49 | 53.31 | 57.92 | 62.48 | 65.89 |
| | 2 | 39 | 3734.0 | 60.32 | 63.14 | 50.10 | 57.10 | 61.72 | 66.15 |
| | 2 | 41 | 3601.2 | 60.45 | 63.41 | 48.35 | 56.88 | 63.57 | 65.79 |
| | 2 | 103 | 3734.0 | 60.70 | 63.53 | 49.70 | 58.01 | 63.20 | 65.92 |
| Average | | | 3679.6 | 60.69 | 63.31 | 50.30 | 57.11 | 64.12 | 65.42 |

TABLE III. DAILY NITROGEN BALANCE AND BIOLOGICAL VALUE DATA FOR CORN OIL STUDIES

| Ration | Trial | Steer No. | Intake: Dry matter | Intake: Nitrogen | Excretion: Fecal N | Excretion: Urinary N | N retention | Metabolic N | Endogenous N | True digested N | Absorbed N utilized | Biological value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | gm. | gm. | gm. | gm. | gm. | gm. | gm. | gm. | gm. | % |
| Basal | 1 | 36 | 3138.7 | 54.91 | 24.47 | 18.48 | 11.96 | 16.64 | 6.86 | 47.08 | 35.46 | 75.63 |
| | 1 | 34 | 3267.7 | 55.74 | 24.10 | 21.96 | 9.68 | 17.32 | 6.84 | 48.96 | 33.82 | 69.10 |
| | 2 | 32 | 3315.8 | 50.71 | 23.12 | 17.04 | 10.55 | 17.57 | 7.15 | 45.16 | 35.27 | 78.10 |
| | 2 | 35 | 3315.8 | 50.71 | 23.42 | 16.04 | 11.25 | 17.57 | 7.30 | 44.90 | 36.11 | 80.42 |
| | 2 | 33 | 3315.8 | 50.71 | 23.42 | 16.56 | 10.73 | 17.57 | 7.13 | 44.86 | 35.42 | 78.90 |
| | 2 | 38 | 3315.8 | 50.71 | 20.83 | 16.68 | 13.21 | 17.56 | 6.70 | 47.44 | 37.49 | 79.02 |
| | 3 | 36 | 3223.4 | 52.54 | 23.34 | 17.88 | 11.32 | 17.08 | 6.80 | 46.28 | 35.26 | 76.18 |
| | 3 | 39 | 3223.4 | 52.54 | 24.40 | 15.84 | 12.30 | 17.08 | 7.09 | 45.22 | 36.47 | 80.65 |
| | 3 | 34 | 3223.3 | 52.54 | 23.82 | 16.56 | 12.16 | 17.08 | 6.84 | 45.80 | 36.08 | 78.78 |
| Average | | | 3260.0 | 52.35 | 23.44 | 17.45 | 11.46 | 17.27 | 6.97 | 46.19 | 35.71 | 77.42 |
| Basal | 1 | 33 | 3467.7 | 55.74 | 25.53 | 18.36 | 11.85 | 18.38 | 7.13 | 48.59 | 37.36 | 76.89 |
| + | 1 | 38 | 3467.7 | 55.74 | 26.49 | 16.20 | 13.05 | 18.36 | 6.73 | 47.61 | 38.14 | 80.11 |
| Corn Oil | 2 | 36 | 3515.8 | 50.71 | 21.45 | 16.44 | 12.82 | 18.63 | 6.86 | 47.89 | 38.31 | 79.90 |
| | 2 | 39 | 3515.8 | 50.71 | 23.26 | 13.68 | 13.77 | 18.63 | 7.09 | 36.08 | 39.49 | 85.70 |
| | 2 | 34 | 3515.8 | 50.71 | 22.75 | 15.00 | 12.96 | 18.63 | 6.84 | 46.59 | 38.39 | 82.40 |
| | 3 | 33 | 3423.4 | 52.54 | 23.91 | 16.08 | 12.55 | 18.15 | 7.13 | 46.78 | 37.83 | 80.86 |
| | 3 | 35 | 3423.4 | 52.54 | 23.78 | 15.48 | 13.28 | 18.15 | 7.25 | 46.91 | 38.68 | 82.45 |
| | 3 | 32 | 3423.4 | 52.54 | 24.94 | 14.16 | 13.44 | 18.15 | 7.01 | 45.75 | 38.74 | 84.67 |
| | 3 | 38 | 3423.4 | 52.54 | 22.70 | 13.68 | 16.16 | 18.15 | 6.73 | 47.99 | 41.01 | 85.46 |
| Average | | | 3464.0 | 52.64 | 23.87 | 15.45 | 13.32 | 18.36 | 6.97 | 47.13 | 38.66 | 82.05 |

TABLE IV. APPARENT DIGESTION COEFFICIENTS FOR CORN OIL STUDIES

| Ration | Trial | Steer No. | Dry matter intake gm. | Apparent Percentage Digestibility: Dry matter | Organic matter | Crude protein | Ether extract | Crude fiber | Nitrogen-free extract |
|---|---|---|---|---|---|---|---|---|---|
| Basal | 1 | 36 | 3138.7 | 59.80 | 62.54 | 55.42 | 53.23 | 65.46 | 62.40 |
| | 1 | 34 | 3217.7 | 65.36 | 67.60 | 56.77 | 58.32 | 70.95 | 68.60 |
| | 2 | 32 | 3315.8 | 59.70 | 62.08 | 54.43 | 48.21 | 64.86 | 62.62 |
| | 2 | 35 | 3315.8 | 60.32 | 62.56 | 53.80 | 52.42 | 64.69 | 63.47 |
| | 2 | 33 | 3315.8 | 60.53 | 63.08 | 53.80 | 49.57 | 66.17 | 63.49 |
| | 2 | 38 | 3315.8 | 62.15 | 64.03 | 58.90 | 54.08 | 65.52 | 64.66 |
| | 3 | 36 | 3223.4 | 63.06 | 65.27 | 55.60 | 53.06 | 69.16 | 65.64 |
| | 3 | 39 | 3223.4 | 58.64 | 60.53 | 53.57 | 48.13 | 62.63 | 61.44 |
| | 3 | 34 | 3223.4 | 62.87 | 64.97 | 54.67 | 54.93 | 67.62 | 66.10 |
| Average | | | 3260.0 | 61.38 | 63.62 | 55.24 | 52.43 | 66.34 | 64.26 |
| Basal | 1 | 33 | 3467.7 | 60.63 | 63.65 | 54.20 | 80.37 | 60.41 | 62.43 |
| + | 1 | 38 | 3467.7 | 59.36 | 61.42 | 52.49 | 79.22 | 60.78 | 60.36 |
| Corn Oil | 2 | 36 | 3515.8 | 63.02 | 64.70 | 54.56 | 81.01 | 66.35 | 62.13 |
| | 2 | 39 | 3515.8 | 59.41 | 61.21 | 54.12 | 83.16 | 60.36 | 59.20 |
| | 2 | 34 | 3515.8 | 61.48 | 63.51 | 55.14 | 77.77 | 65.58 | 61.30 |
| | 3 | 33 | 3423.4 | 61.38 | 63.86 | 54.49 | 81.58 | 63.59 | 62.69 |
| | 3 | 35 | 3423.4 | 60.07 | 62.36 | 54.72 | 80.71 | 62.88 | 60.12 |
| | 3 | 32 | 3423.4 | 56.90 | 58.74 | 52.56 | 80.12 | 58.36 | 56.78 |
| | 3 | 38 | 3423.4 | 60.52 | 62.37 | 56.80 | 80.38 | 62.02 | 60.37 |
| Average | | | 3464.0 | 60.36 | 62.31 | 54.34 | 80.48 | 62.25 | 60.53 |

TABLE V. WEIGHTS OF STEERS USED IN CALCULATING BIOLOGICAL VALUES

| Experiment No. | Steer No. | Average weight in lb. [1] |
|---|---|---|
| 1 | 132 | 525 |
| | 123 | 475 |
| | 8 | 770 |
| | 94 | 475 |
| | 124 | 500 |
| | 39 | 495 |
| | 41 | 465 |
| | 103 | 472 |
| 2 | 33 | 533 |
| | 78 | 478 |
| | 36 | 485 |
| | 39 | 525 |
| | 34 | 481 |
| | 33 | 533 |
| | 35 | 552 |
| | 32 | 535 |
| | 38 | 478 |
| | 36 | 485 |

[1] Calculated from initial weight and weight at the end of last trial.

TABLE VI. METHOD USED IN STATISTICAL ANALYSIS

| | Analysis of Variance | |
|---|---|---|
| Experiment | Source | Degrees of Freedom |
| 1 | Total | 15 |
| | Treatment | 1 |
| | Trial | 1 |
| | Treatment X Trial | 1 |
| | Error | 12 |
| 2 | Total | 17 |
| | Treatment | 1 |
| | Trial | 2 |
| | Treatment X Trial | 2 |
| | Error | 12 |

VITA

Niels Whitney Robinson

Candidate for the Degree of

Doctor of Philosophy

Thesis: THE EFFECT OF ADDED FAT AND CORN ON THE UTILIZATION BY STEERS OF NITROGEN IN WINTERING RATIONS

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