# THE EFFECTS OF AUREOMYCIN ON THE DIGESTIBILITY OF VARIOUS RATIONS BY DAIRY CALVES

by

KENNETH LAVONNE WHEATCROFT

B. S., Kansas State College
of Agriculture and Applied Science, 1950

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A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Chemistry

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1952

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# INTRODUCTION

Animal products (meat scraps or fisheries' by-products) have been used in the best feeds for many years to achieve good growth and health. It was shown that animal proteins were essential to supply certain growth factors, and the name Animal Protein Factor (abbreviated A.P.F.) came into wide use to designate this factor or factors (64). Further research, however, demonstrated that the factor (or factors) was not animal protein per se, but was probably vitamin $B_{12}$ normally present in the animal protein (49). In addition to being present in animal products, vitamin $B_{12}$ is produced by certain microorganisms during fermentation (62). One of the first commercial sources of the vitamin $B_{12}$ group of factors was fermentation products of Streptomyces aureofaciens (62). Further research revealed that the growth stimulation obtained with supplements composed of fermentation products exceeded that obtained with crystalline vitamin $B_{12}$ or animal protein supplements (28). The additional benefit was thought due, at least in part, to the antibiotic in the fermentation products. The antibiotic aureomycin is produced by Streptomyces aureofaciens. On October 4, 1950, the term, Animal Protein Factor, was discarded from official use by the American Association of Feed Control Officials (2). It was replaced by the terms "vitamin $B_{12}$ supplement" and "antibiotic feed supplement".

The announcement of a new growth factor or factors in aureomycin fermentation products, active for the chick in the presence of adequate amounts of all the known vitamins, including vitamin $B_{12}$, led to an immediate and concentrated investigation of the factor or factors. Various antibiotics and antibiotic fermentation products were investigated with different species of animals.

Chicks (1, 10, 27, 39, 40, 42, 64, 70), turkeys (4, 41, 61, 63), rats (11, 24), and swine (12, 17, 20, 25, 26, 38, 67) were used as experimental animals in these studies. In general, results indicate that antibiotics have a markedly favorable effect on growth, gastro-intestinal disorders, and physical appearance.

The nutritional studies on aureomycin and other fermentation products have been extended to dairy calves and other ruminants, although the studies got underway somewhat more slowly than those with the animals mentioned in the foregoing section. Much of the initial work with dairy calves was done by Bartley et al. (6). Results indicated that aureomycin caused a stimulation of growth and a reduction in incidence of scours. Experimental calves, on an average, were thriftier and in better condition than control calves. Other investigators (7, 13, 31, 36, 37, 46, 59, 66) feeding antibiotic and antibiotic fermentation supplements to dairy calves have reported increased rates of growth.

Beef cattle have been shown to tolerate aureomycin (48) in contrast to earlier work reporting that the antibiotic fermentation concentrate was toxic (8). Lambs have been reported to show increased growth when fed aureomycin (32).

The mechanism whereby the beneficial results of antibiotic feeding are obtained is not yet known. Some investigators suggest that the antibiotics exert their influence by altering intestinal and rumen microflora. Possible ways in which this can occur include : (a) inhibition of certain bacteria which tend to destroy, or utilize for their own needs, essential nutrients supplied by the food; (b) stimulation of growth of favorable bacterial types over other types, resulting in a greater synthesis of useful nutrients by the former; and (c) less injury to the animals by small amounts of toxic products of bacterial origin normally formed in the intestinal tract (73). The antibiotic may have some systemic effect exerted outside the gastro-intestinal tract as indicated in the report by Elam and associates (27). The acting antibiotic molecule, or a fragment of it, may act as a metabolite within the animal (27).

At the time that the present study was undertaken, no work had appeared in the literature on the effect of antibiotics on the digestibility of feeds by dairy calves. It was thought that an investigation of the digestibility of feeds by animals receiving antibiotics would perhaps help explain the mode of action of the antibiotics. Accordingly, digestion trials were conducted to investigate the effect of feeding crystalline aureomycin on the digestibility of various rations by dairy calves.

## REVIEW OF LITERATURE

### Discovery of the Nutritional Value of Antibiotics

It was found in preliminary investigations by Cary and associates (16) that an unidentified nutrient in liver and milk was essential for the normal growth and survival of rats. They termed this "factor X". Similar results were confirmed in a later report (54). It was later isolated as vitamin $B_{12}$ by Rickes and associates (55) of Merck and Company. The activity of crystalline vitamin $B_{12}$ in promoting chick growth was demonstrated by Ott, Rickes, and Wood (49). In addition to being present in animal products, vitamin $B_{12}$ was produced by certain microorganisms during fermentation. Stokstad et al. (64) reported that whole fermented mash from the growth of Streptomyces aureofaciens contained an unidentified chick growth factor. Further research revealed that the growth stimulation obtained with products of this fermented mash exceeded that obtained by vitamin $B_{12}$ or animal protein supplements (28, 62). This additional stimulation was thought due, at least in part, to the antibiotic contained in these materials (62). Crystalline aureomycin has been shown to increase the rate of growth of chicks (70), turkeys (63), swine (20), lambs (32), and dairy calves (7) when included in their ration.

### Effect of Antibiotics on Poultry

Moore et al. (42) in 1946, first reported that when streptomycin and streptothricin were added to a purified diet, the growth of chicks was increased and numbers of coliform bacteria in the feces were reduced. Stokstad and Jukes (62) and Stokstad et al. (64) reported growth stimulation of chicks from including aureomycin fermentation product[1] in the diet. Whitehill et al. (70) have reported growth stimulation when crystalline aureomycin hydrochloride, penicillin, or streptomycin were given orally to chicks. However no growth stimulation was observed when it was injected. Berg et al. (9), and Reed and Couch (53) reported increased chick growth from feeding an aureomycin supplement. Groschke and Evans (28) and McGinnis et al. (40) reported increased feed utilization by chickens when an aureomycin fermentation product was included in the ration. Increased feed utilization by chickens when aureomycin was added to a corn-soybean diet containing vitamin $B_{12}$ was reported by Machlin et al. (39). They also reported that the protein requirement for early growth of chickens appeared to be decreased slightly by addition of aureomycin to the diet. Reed and Couch (53) found greater growth response

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[1]Throughout this paper the term aureomycin fermentation product will be used to refer to such various products of aureomycin fermentation produced by Lederle Laboratories, as Aurofac (guaranteed to contain 1.8g aureomycin and 1.8g vitamin $B_{12}$ per pound), Aurofac A (Guaranteed to contain 1.8g aureomycin per pound and appreciable amounts of vitamin $B_{12}$ per pound), and Aurofac 2A (guaranteed to contain 3.6g aureomycin per pound and appreciable amounts of vitamin $B_{12}$).

and lower mortality on broilers raised under practical range conditions, when aureomycin supplements were included in the ration. Couch et al. (23) reported an increase in hatchibility and egg production when hens were fed a ration considered inadequate for good egg production, but containing aureomycin supplement. However, results with the supplemented diets did not compare with those of a practical ration. Elam et al. (27) reported increase rate of growth of chicks receiving parenterally administered penicillin, autoclaved penicillin, and bacitracin.

Turkey growth was markedly increased by adding aureomycin to a basal ration of 20 percent corn, 14.5 percent wheat, 56 percent soybean meal, 2.5 percent alfalfa, and adequate minerals and vitamins (Stokstad and Jukes, 63). Almquist and Merritt (1) reported that vitamin $B_{12}$ caused only a minor increase in growth when added alone, but aureomycin caused a large increase in growth of toms and hens on a 50 percent soybean meal basal diet.

Results of the combination of the two supplements were no better than for crystalline aureomycin alone. Singsen and Matterson (61) demonstrated that excess choline did not replace the beneficial results of aureomycin supplements on growth of turkey poults. They found greater efficiency in feed utilization to be part of the beneficial results of feeding aureomycin. McGinnis and Stern (41) reported increased gain in turkeys when antibiotics other than aureomycin were included in the diet. Penicillin, terramycin, and streptomycin were as effective as aureomycin in promoting early growth. It appeared that streptomycin, although effective, was required at a level somewhat higher than the other antibiotics. They reported that growth results were variable when bacitracin was used on turkey poults. Atkinson and Couch (4) reported increased egg production by turkeys receiving aureomycin.

## Effect of Antibiotics on Swine

Catron et al. (19, 20) reported that the addition of aureomycin to swine growing rations resulted in increased growth and lowering of incidence of scouring. They reported no significant differences in feed efficiency. In investigations by Cunha et al. (25) on the effect of vitamin $B_{12}$ and an aureomycin fermentation product on swine, it was found that the aureomycin fermentation product increased growth rates even if adequate vitamin $B_{12}$ was present in the ration. Cunha et al. suggested that the antibiotic may have had a sparing action on the methionine requirement of swine, Jukes et al. (33) reported a growth promoting effect of both aureomycin and an aureomycin fermentation products when added to swine rations.

Carpenter (17) reported that aureomycin fed to unthrifty pigs caused increased growth rates over control pigs. The most spectacular results from the use of fermentation products as supplements were in the transformation of runts into healthy pigs (16). Blight et al. (12) reported that unthrifty weanling pigs fed a well balanced diet supplemented by vitamin $B_{12}$ did not significantly increase in growth over controls. Similar pigs receiving aureomycin as a supplement grew at a significantly faster rate. Greatest response was on the lighter and most unthrifty pigs. Luecke et al. (38) studied the effects of vitamin $B_{12}$, an aureomycin fermentation product, and streptomycin in the rations of swine. These workers reported that superior growth resulted from the antibiotics over that obtained from vitamin $B_{12}$ alone. Wahlstrom and Johnson (67) reported crystalline aureomycin did not have a beneficial effect on pigs fed a diet deficient in vitamin $B_{12}$. Cortisone enhanced the deficiency in the presence of aureomycin. Brown and Luther (14) reported a growth promoting effect of terramycin, streptomycin, penicillin, and aureomycin in rations of fattening and growing hogs. Edwards et al. (26) found that crystalline aureomycin plus vitamin $B_{12}$ stimulated growth of swine, but not as much as did the aureomycin fermentation product, indicating that, possibly, other unknown factors were present in the fermentation product.

## Effect of Antibiotics on Rats

Cravioto-Munoz et al. (24) reported an increased growth response when rations containing crystalline aureomycin were fed to rats. They found that aureomycin had a sparing action on the vitamin $B_{12}$ requirement. When the antibiotic activity was destroyed, the growth stimulation was not observed. Black and Bratzler (11) reported increased growth rate in rats on a ration containing an aureomycin fermentation product. Linkswiler et al. (35) found that in the presence of aureomycin, rat growth was equivalent with either pyridoxal, pyridoxine, and pyroxadine as a source of vitamin $B_6$. Without aureomycin, pyridoxamine, was a more potent source of vitamin $B_6$. Waisman et al. (68) reported aureomycin would counteract the effect of "folic acid" deficiencies caused by feeding aminopterin in the diet and would produce superior growth results over the basal ration. Aureomycin was without effect on folic acid deficiencies caused by sulfa drugs. Citrovorum factor overcame both types of deficiencies and autoclaved crystalline aureomycin had no effect. Lih and Baumann (34) reported that aureomycin, streptomycin, and penicillin stimulated growth of rats on a diet limited in thiamine, riboflavin, and pantothenic acid. Antibiotics had a maximum stimulating effect when vitamin concentration was only enough for half maximum growth.

## Effect of Antibiotics on Dairy Calves

Bartley, Fountaine, and Atkeson (6) were among the first to investigate the action of antibiotics on ruminants. Using 12 dairy calves of four breeds, they fed 8 of these calves an aureomycin fermentation product (Aurofac) at the rate of 3 g per 100 pounds of body weight daily, and used the other 4 calves as controls. Colostrum was fed to the calves from birth to 3 days of age, followed by whole milk at the rate of 10 percent of the body weight daily. The whole milk was gradually changed to skim milk starting at 3 weeks of age. Hay and grain were allowed starting on the seventh day of age. At 6 weeks of age the supplemented calves had gained an average of 30.8 pounds and the controls an average of 18.0 pounds. The experimental calves did not achieve the expected gain according to the Ragsdale growth standard (52). It was thought that poor environmental conditions under which the experiment was conducted contributed to the poor rates of growth. A lower incidence of scouring was noted in the supplemented calves.

Loosli and Wallace (36) investigated the effect of feeding aureomycin and an aureomycin fermentation product on the rate of growth of dairy calves. The fermentation product was fed at the rate of 10 g per kg of dry matter ingested, and the crystalline aureomycin was fed at the rate of 10 g per ton of feed. A few days after birth calves were paired according to size, age, and sex, and assigned at random to the aureomycin fermentation products or held as controls. The ration was composed of a milk substitute consisting of dried skim milk, dried whey, or a combination of the two, and was fed from 2 weeks to 8 weeks of age. Calves receiving the aureomycin fermentation product, or the crystalline aureomycin, gained an average of 1.11 pounds per day and the control calves gained 0.92 pounds per day to 8 weeks of age. A lowering in the incidence and severity of scours in the experimental calves was also noted.

Rusoff (57, 58) studied the effect of feeding an all-plant protein ration plus 2 percent aureomycin fermentation product to 14-week old Jersey male calves. The ration was composed of cottonseed meal, corn meal, bonemeal, and salt. Lespedeza hay and pasture were allowed free choice. Calves receiving the aureomycin fermentation product gained an average of 0.36 pounds more per calf daily than the controls for the first six weeks of supplementation. After 6 weeks, the gains by the experimental calves over the controls became less significant, and after 20 weeks both groups of calves gained at a similar rate. Rusoff reported that the experimental calves had a smoother hair coat and a more solid muscular appearance than the controls.

Bartley et al. (7) reported that dairy calves fed either 3 g or 9 g of aureomycin fermentation product per 100 pounds body weight from 1 to 22 weeks of age did not differ significantly in rate of growth, but that rate of growth of both groups exceeded that of the control group and of the Ragsdale standard. The calves were fed as previously reported by Bartley et al. (6). At 22 weeks of age, the calves receiving 3 g of aureomycin fermentation product per 100 pounds body weight averaged 410 percent of initial weight, the calves receiving 9 g of aureomycin fermentation product per 100 pounds body weight averaged 400 percent of inital weight, and the controls averaged 356 percent of inital weight.

One 16 week old calf not previously fed aureomycin, was fed 2500 mg of aureomycin daily for 4 weeks with no noticeable deleterious effect on feed consumption, rumination, and growth (7). Similar results were obtained feeding a few calves 200 to 800 mg of aureomycin per 100 pounds body weight daily from 12 weeks to 16 weeks of age. Bartley (5) fed six yearling dairy heifer calves 1 g of crystalline aureomycin daily for 6 weeks. No adverse effects were noted. Bartley (5) found some mature dairy cows were able to tolerate 1200 mg of aureomycin daily, but some cows tested went off feed within 24 hours after 600 mg of aureomycin was fed daily. Rumination was noted to cease in these latter cases.

Loosli et al. (37) studied a total of 39 pairs of Holstein calves, feeding a variety of diets including milk and milk replacements. An aureomycin fermentation product was fed at the rate of 2 percent of the milk replacement to one of each pair. The authors consistently noted a 20 percent increase in rate of gain for aureomycin fed calves over controls up to 8 weeks of age. The average gain for calves receiving aureomycin was 1.16 pounds daily and for the control calves, 0.95 pounds daily. The incidence and severity of scours was reduced in the aureomycin supplemented calves. Aureomycin fed calves consumed 40 percent more concentrate than the controls and required less T. D. N. per pound of gain. Loosli et al. reported further that preliminary studies of rumen microflora did not indicate significant differences between experimental and control calves in regard to total bacterial count or morphological types of bacteria.

Rusoff and Davis (59) studied the effect of an aureomycin fermentation product and crystalline aureomycin on 24 Jersey and Holstein calves from birth through 16 weeks of age. The calves were divided into 3 groups. Group one received a 19.4 percent digestible protein calf starter containing no animal protein, group two received the starter plus 2 percent aureomycin fermentation product (2.5 mg aureomycin per pound of supplement), and group three received the starter plus crystalline aureomycin at the rate of 75 to 150 mg per calf daily. Calves were weaned from milk at one month of age and were fed a calf starter and clover hay free choice beginning at 7 days of age. The crystalline aureomycin was fed starting at 14 days of age. From birth through 16 weeks of age the Jersey calves on aureomycin and the aureomycin fermentation product, in groups 2 and 3 gained 25 percent more than the Jersey controls; the Holsteins gained 15 percent more than their controls. All aureomycin fed calves of both breeds made an average daily gain of 1.44 pounds compared to 1.19 pounds for the controls. A lower incidence of scours was reported for the experimental calves.

Murley et al. (47) fed different rations with and without aureomycin to three groups of calves from 4 to 60 days of age, in order to investigate the response to aureomycin. Whole milk, hay, and a concentrate mixture were fed group one; reconstituted skim milk, hay and a concentrate were fed group two, and reconstituted skim milk alone was fed group three. Half the number of calves in each group received 80 mg of crystalline aureomycin per calf daily, mixed in the milk. Aureomycin fed calves had a greater growth and feed efficiency than the controls. A better physical appearance was noted for the aureomycin fed calves. The supplemented calves showed fewer cases of scours than did the controls.

Cason and Voelker (18) studied the effect of a terramycin supplement on the growth and well being of 28 Holstein and Jersey calves. The calves received colostrum until 3 days of age. They then were started on the experiment, which lasted for 8 weeks. Lespedeza hay and a grain mixture containing skim milk were fed ad libitum. Whole milk was fed at the level of 1 pound milk per 8 pounds body weight for Jersey calves, and 1 pound of milk per 10 pounds body weight for Holstein calves. One-third of the calves of each breed served as controls. Terramycin was fed orally to the rest of the calves at the rate of 15 or 30 mg per 100 pounds body weight daily. No significant growth differences were noted in the two groups. Although the feces of terramycin fed calves were more solid than feces of the control calves, there was no difference in the incidence of scours in the two groups.

Bloom and Knodt (13) studied the effect of vitamin $B_{12}$, d-l methionine, K penicillin, and aureomycin in a milk replacement formula fordairy calves. Twenty-four male Holstein calves, 5 days of age were divided into four groups and fed four milk replacement formulas in trial I. The first group received the basal replacement; the second group received the basal replacement plus 50 g of vitamin $B_{12}$ supplement per 100 pounds body weight (6 mg vitamin $B_{12}$ per pound supplement); the third group received the basal replacement plus 0.3 percent d-l methionine; and the fourth group received the basal replacement plus K penicillin (10ppm). Up to 12 weeks of age the addition of vitamin $B_{12}$ and d-l methionine to the formula did not increase growth rates of calves. The penicillin ration decreased the rate of gain. In trial II, 8 groups of 4 Holstein calves each were fed calf starter. An aureomycin fermentation supplement was fed at different levels and it increased the rate of gain up to 20 percent more than the control animals. Aureomycin stimulated the calves to eat more starter and to begin consuming it at an earlier age.

Jacobson et al. (31) investigated the effect of aureomycin on the growth of dairy calves. Twenty-six calves were divided into two groups according to breed, sex, and weight. They were fed milk, hay, and grain from 4 to 116 days of age. The calves in the experimental group received 80 mg of crystalline aureomycin daily. At 116 days of age the aureomycin fed calves had made a 30 percent greater increase in weight than the controls. At 116 days of age crystalline aureomycin was replaced by Aurofac for half of the experimental calves. The body weights of 7 calves fed aureomycin continuously from 4 to 200 days of age were 30 percent above the controls. The authors also reported that no adverse effects resulted from the inital inclusion of aureomycin in the ration of calves or from the removal of aureomycin from the ration at 116 days of age.

Voelker and Cason (66) investigated the effect of an aureomycin fermentation product and terramycin on the growth of 40 Jersey and Holstein calves in 3 experiments. In the first experiment, the calves were fed 30 mg of terramycin per 100 pounds body weight daily and gained 21 percent more than their controls. In the second experiment, calves fed 100 mg terramycin per 100 pounds of body weight gained 28 percent more than controls. In the third experiment, 10 calves 4.8 months of age were fed Aurofac for 8 weeks while grazing pasture and 10 other calves served as controls. The calves receiving Aurofac gained 17 percent more than the controls during six weeks of supplementation. A series of measurements of 8 different body parts of each calf indicated that antibiotic fed calves had a greater structural body growth than calves not receiving antibiotics. Calves receiving terramycin and aureomycin had firmer feces than the control animals.

Murley et al. (46) studied the effect of aureomycin on feed utilization by ten young Holstein dairy calves. A diet of reconstituted skim milk (1 part non-fat dry milk solids, 4 parts water) was fed to the ten male Holstein calves. Half of the calves received 80 mg of crystalline aureomycin per calf daily. Three successive 24 hour samples of urine and feces were collected at 2, 5, and 8 weeks of age. Determinations were made for reducing sugars and nitrogen of the urine and for dry matter, reducing sugars, nitrogen, ether extract, and ash of the feces. No differences in nutrient utilization was found that were attributable to aureomycin supplementation. Blood samples were taken at feeding time and at 2, 4, 6, 8, and 10 hours past, once during each collection period, and were analyzed for reducing sugars. The mean reducing sugar level was slightly higher and rose more rapidly in samples from aureomycin fed calves than in those from controls.

Morrison and Deal (44) investigated the effect of an aureomycin fermentation product on 18 heifer calves. After removal from the dam (3rd day), half the calves were fed an aureomycin fermentation product at the rate of 1 percent of the dry matter of the milk for 2 weeks. Milk was fed up to 12 weeks of age. Lespedeza hay was fed ad libitum starting at 18 days of age. The calves were allowed calf meal according to their appetites up to a maximum of 3 pounds for Jerseys and Guernseys, and 4 pounds for Holsteins. There were no differences in incidence of scours, general health, gain in weight to 12 weeks, milk consumption, hay consumption, or grain consumption of aureomycin fed calves as compared to control calves.

### Effect of Antibiotics on Other Ruminants

Colby, Rau, and Miller (21) studied the effects of aureomycin, penicillin, and streptomycin on the growth of fattening lambs. Two trials were conducted involving a total of 39 lambs. In the first trial 100 mg of aureomycin was fed daily by capsule, and in the second trial 100 mg of penicillin and 100 mg of streptomycin were fed daily. Aureomycin fed labs went almost completely off feed, and lost approximately 0.20 pounds of weight per day. The antibiotics penicillin and streptomycin also caused the animals to go off feed and lose weight. The lambs had diarrhea for almost a week following antibiotic feeding, followed by a period of gradual recovery. At the conclusion of the second trial the weight of the experimental animals was less than that of the control animals. The harmful effects of streptomycin upon fattening lambs was less severe than aureomycin and penicillin.

Jordan and Bell (32) studied the effect of feeding aureomycin to lambs. Aureomycin was fed at the rate of 5 mg per lamb daily for 6 weeks. Ten lambs made an average gain of 0.64 pounds daily as compared to ten control lambs that made an average gain of 0.54 pounds daily. Four lambs drenched with

15 mg of aureomycin made an average daily gain of 0.59 pounds. All the lambs receiving aureomycin were normal. Jordan and Bell also conducted two trials with fattening lambs full-fed a standard corn-alfalfa ration. In trial I, lambs fed aureomycin (6 to 12 mg daily) made a daily gain of 0.49 pounds per lamb as compared to 0.39 pounds per lamb daily for the controls. The treated lambs required 22 percent less concentrates per 100 pounds of gain. In trial II, 16 experimental lambs receiving 10.8 mg of aureomycin per lamb daily made a gain of 0.40 pounds per lamb daily, as compared to the controls which made a gain of 0.36 pounds.

Bell et al. (8) reported adverse effects from feeding 600 mg of aureomycin daily to six 620 pound beef steers. A ration of corn, soybean meal, and prairie hay was fed to four steers, while two steers received the same ration plus urea. Experimental steers developed anorexia and diarrhea within 2 to 3 days. When aureomycin was removed from the ration the steers went back on feed. When 200 mg of aureomycin was fed to the steers daily, two animals developed anorexia and diarrhea, while a third had to be removed from the experiment. The digestibility of dry matter and crude fiber was lowered 15 percent and 50 percent respectively by the addition of aureomycin in the ration of steers.

Newmann et al. (48) reported no adverse effects from feeding aureomycin to year old beef cattle. Aureomycin was fed at the rate of 2 mg per pound of air dry feed to 18 yearling beef heifers for 150 days. The ration was composed of ground yellow corn, corn silage, linseed meal, and salt. The level of aureomycin fed was lower than fed by Bell (8) as previously cited. There was a severe reduction of appetite for a few days following aureomycin feeding but partial recovery was made, and for the 150 day feeding period, the heifers receiving aureomycin consumed a daily ration equal to approximately 2 percent of their body weight. Diarrhea was never observed and no signs of abnormal paunch distension were seen. Approximately equal daily gains (2.06, 1.94, and 1.96 pounds respectively) were made during the first 75 days, while the heifers in three groups were fed the basal ration, basal plus crystalline aureomycin, or basal plus aureomycin fermentation product. By the end of the 150 days, average daily gains were not statistically different and were 1.82, 1.74, and 1.81 pounds respectively.

### Effect of Antibiotics on Intestinal and Ruminal Microflora

Jacob et al. (30) investigated the effect of intravenously administered aureomycin on the intestinal flora of dog and man. They reported a lowering of the intestinal bacterial count, the effect being more pronounced in man than in dog. They presumed that the excretion of the antibiotic into the intestinal tract took place via the salivary glands and bile.

Robins (56) found a decrease in the bacterial count of intestinal micro-flora of man fed aureomycin orally. Robins reported the feces of man were less solid, practically odorless, brown to green, and sometimes increased in bulk when aureomycin was fed at therapeutic levels (1 to 2 grams daily for 2 to 9 days). He suggested that the color resulted from smaller numbers of intestinal flora, and therefore less reduction of bilirubin and derivatives. He thought B. putrificus and E. coli along with other coliform organisms might be suppressed. Munoz and Geister (45) in vitro studies found that aureomycin at 100$\mu$g/ml levels inhibited phagocytosis of Micrococus pyrogenes var albus. cells by polynuclear leucocytes. Gunnison et al. (29) studied the interference of aureomycin and terramycin on the action of penicillin. In vitro aureomycin and terramycin slowed the bactericidial action of penicillin on S. pyrogens and K. pneumoniae. Possible competition between drugs for "receptors" of bacterial cells was suggested.

Newmann et al. (48) in bacteriological studies of rumen material of dairy heifer calves found that the total bacterial counts were about the same in aureomycin supplemented and unsupplemented calves. The types of organisms found in the heifers receiving aureomycin were much less diverse, suggesting that normal bacterial flora had been disturbed. Rusoff and Davis (60) as the result of the examination of 122 rumen smears from 22 different calves, 1 to 16 weeks of age, failed to find any effect of feeding an aureomycin fermentation product or crystalline aureomycin on the microflora of the rumen. They stated that if the development of the microbial groups, as described by Pounden and Hibbs (50), was an indication of rumen development, the beneficial effect of aureomycin and aureomycin fermentation product was not because of this action. They reported that the number of different morphological types of bacteria was too low to be significant. In many instances week to week variation of the morphological types of bacteria within an individual calf were as great as the variations between groups of calves. In none of the calves studied did protozoa appear in any number approaching that found in mature animals. They found that the heterogenity of morphologically identical forms made microscopic examination of rumen contents of questionable value. Elam et al. (27) studying function and metabolic significance of penicillin and bacitracin in the chick, found that parenteral administered penicillin, bacitracin, and autoclaved penicillin increased the rate of growth and yet had little effect on fecal aerobic microflora count. They suggested that antibiotics may have stimulated growth by some other method. Possibly the antibiotic molecule or a fragment of it acted as a metabolite within the bird. Bartley et al. (7) reported that in rumen microflora studies, direct microscopic examinations did not indicate a consistant difference between controls and aureomycin fed calves. Loosli et al. (37) reported similar observations.

## Rumen Development and Digestibility

Wallace et al. (69) compared the digestibility of rations containing starter, hay, and different milk substitute mixtures. Digestion trials consisting of a 10 day preliminary and a 10 day collection period were conducted on 5 and 8 week old calves. All nutrients of the ration were more fully digested by the 8 week old calves than by the 5 week old calves, indicating the development of the rumen.

Turk and Burke (65) made the following observations as to how completely calves digest hay or grain, when the feeds are first consumed. Two week old calves would eat some starter and hay, but not until they were 7 to 10 weeks old could the consumption of a starter be relied upon as a complete replacement for milk. Protein snythesis by rumen microorganisms was sufficiently great at 16 weeks to permit replacement of animal protein with all-vegetable protein. The digestive capacity was sufficient at one year of age to permit replacement of all grain with good green roughage in the ration of dairy calves.

Pounden and Hibbs (50) investigated the influence of the ratio of grain to hay in the ration of dairy calves, on certain rumen microorganisms. They reported that rumen microorganisms characteristicallypresent in the rumen of hay consuming calves, could be reduced or replaced by other types of organisms by increasing the proportion of grain in the ration. In later studies, Conrad et al. (22) changed one calf from a ration of hay to a ration of grain and using the rumen inoculation technique, introduced the microorganisms commonly found in the rumen of a hay eating calf. This calf was then changed to a hay ration and a digestion trial conducted. The apparent coefficient of digestion for crude fiber was greatly reduced. The inoculation procedure consisted of placing pieces of cud from mature cows into the posterior part of the mouths of calves (51). Such inoculations assisted in establishing protozoa in the rumens of calves that were fed milk and hay, or milk with grain and hay. Uninoculated calves failed to establish protozoa in their rumens. There were no differences in weight gains between inoculated and uninoculated calves. Although protozoa failed to appear in the rumens of uninoculated calves fed milk and hay alone, the calves readily established rumen flora of the types usually present in abundance in mature cows that were fed hay.

Burris (15) reported the following apparent coefficients of digestion of a milk ration by 15-day old dairy calves: crude protein, 93.1; ether extract, 97.7; carbohydrates, 99.3; and ash, 95.0. He also reported the following apparent coefficients of digestion for a 35 day old dairy calf fed a ration consisting of 12 pounds of milk and 100 grams of alfalfa hay daily: crude protein, 90.5; ether extract, 97.7; N.F.E., 94.9; crude fiber, 19.2; carbohydrates, 61.5; and ash, 70.9

Burris (15) further extended his digestibility studies to 60-day old dairy calves fed three different rations. Ration 1 contained milk and alfalfa, ration 2 contained milk and oats, and ration 3 contained milk, alfalfa, and oats. The digestion trials consisted of 10-day preliminary and 7-day collection periods. His results are shown in Table 1.

Table 1. Apparent digestion coefficients of nutrients of various rations obtained with five 60-day old dairy calves.

| Ration | Crude protein | Ether extract | Crude fiber | Ash | N.F.E. | Carbo-hydrates |
|---|---|---|---|---|---|---|
| 1 | 87.4 | 95.4 | 43.6 | 78.1 | 95.1 | 82.8 |
| | 86.5 | 95.9 | 44.6 | 76.6 | 87.6 | 78.4 |
| 2 | 87.5 | 97.1 | -17.4 | 76.0 | 85.0 | 79.1 |
| 3 | 84.8 | 95.5 | 17.1 | 63.1 | 76.4 | 61.7 |
| | 84.0 | 95.0 | 20.4 | 65.3 | 82.1 | 73.0 |

## METHODS

### Experimental Design

This study was initiated for the purpose of studying the effects of aureomycin on the digestibility of various rations of dairy calves. The design of the experiment is illustrated in Table 2. Twelve male dairy calves (6 Holsteins, 4 Jerseys, and 2 Guernseys) were paired by breed and age. Each pair was assigned at random to one of three ration groups. The calves assigned to ration group 1 received milk only, calves in ration group 2 received milk and oats, and those in ration group 3 received milk and alfalfa hay. One member of each pair was selected at random to receive aureomycin and the other member served as a control. With the exception of three calves (25A, 26A, and 27A) that were obtained from local Jersey breeders, the calves were born in the Kansas State College dairy herd.

The calves were removed from their dams at about 3 days of age and housed in individual pens in the calf barn. Four days prior to the start of the first digestion trial (49 days of age), the calves were removed from the calf barn and placed in metabolism cages (Fig. 1), in order to accustom them to their new surroundings. Digestion trial I, was initiated at 53 days of age. This consisted of a 10 day preliminary period (53 to 63 days of age), and a 7 day collection period (63 to 70 days of age). At the end of the collection period the calves were returned to the calf barn. At 77 days of age the calves were again placed in metabolism cages. A second digestion trial was started at 81 days of age. This also consisted of a 10 day preliminary period (81 to 91 days of age) and a 7 day collection period (91 to 98 days of age).

When the calves were not in metabolism cages they were housed in individual pens in the calf barn. Wood shavings were used as bedding. Each pen had facilities for feeding grain, hay and water.

A battery of six metabolism cages were used for the digestion trials and were located in a room adjacent to the calf barn (Fig. 1). The individual metabolism cages were 4x4x4 feet in size and were mounted on a platform 18 inches above the floor, to permit cleaning under the cages. The bottoms of the cages were made of 5/8-inch mesh, 16 guage expanded metal, and the sides of the pens and partitions were made of wire or wood. One side of each cage was removable. The floor of the room was washed down with water at least once a day to clean it of calf excretions that were not being collected. When feces was not being collected in special bags for analysis, the expanded metal floors of cages housing calves were cleaned daily.

Table 2. Design of experiment showing allotment of male dairy calves (paired by breed and age), to three ration groups. One member of each pair received aureomycin.

| Ration group | Breed | Aureomycin fed calves | | Control calves | |
|---|---|---|---|---|---|
| | | Calf No. | Birth date | Calf No. | Birth date |
| Group 1 | Holstein | 0151 | 3/15/51 | 0152 | 3/22/51 |
| milk only | Jersey | 0341 | 3/20/51 | 27A | 5/27/51 |
| Group 2 | Holstein | 0153 | 3/31/51 | 0154 | 4/2/51 |
| milk and oats | Holstein | 0157 | 6/9/51 | 0156 | 6/7/51 |
| Group 3 | Jersey | 25A | 4/22/51 | 26A | 4/25/51 |
| milk and alfalfa hay | Guernsey | 0227 | 6/8/51 | 0228 | 6/13/51 |

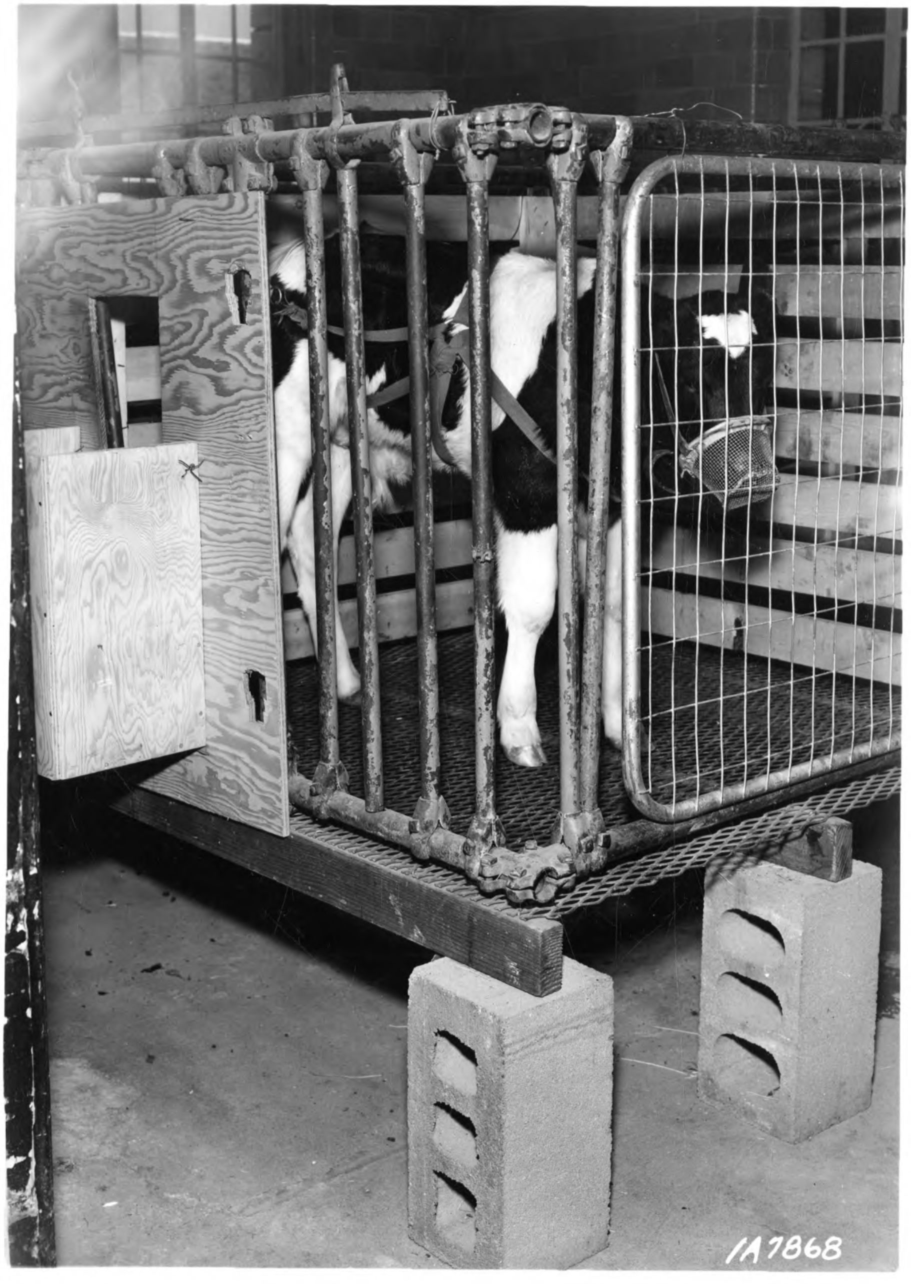


Fig. 1. Metabolism pen with a calf during digestion trial.

Except at feeding time, the calves were kept muzzled during the digestion trials to prevent them from chewing on wood, chewing on the harnesses and collection bags, and from ingesting hair by licking themselves. The muzzles were made of wire and held in place by a leather strap (Fig. 2).

The apparatus used for collection of feces during the digestion trials consisted of a heavy canvas collection bag held in place by a harness made of web belting (Fig. 2). The collection bag had a hole in the top for the calf's tail and was attached to the harness by rings and snaps. Plastic bags were inserted in the canvas bags to facilitate easy and complete removal of the feces. To accustom the calves to this apparatus it usually was attached to the calves four days prior to the collection period.

## Feeds and Feeding

The calves received colostrum for the first 3 to 5 days of life. All calves were then fed unstandardized whole milk from Holstein cows until time for the digestion trials. Milk, warmed to approximately 100° F. was bucket fed to the calves at the daily rate of 10 pounds for each 100 pounds of body weight. The milk feedings were adjusted weekly. Calves in ration groups 2 and 3 were offered ground oats or coarsely ground alfalfa hay ad libitum, at 19 days of age. Records were kept of the amounts of hay and grain consumed by each calf.

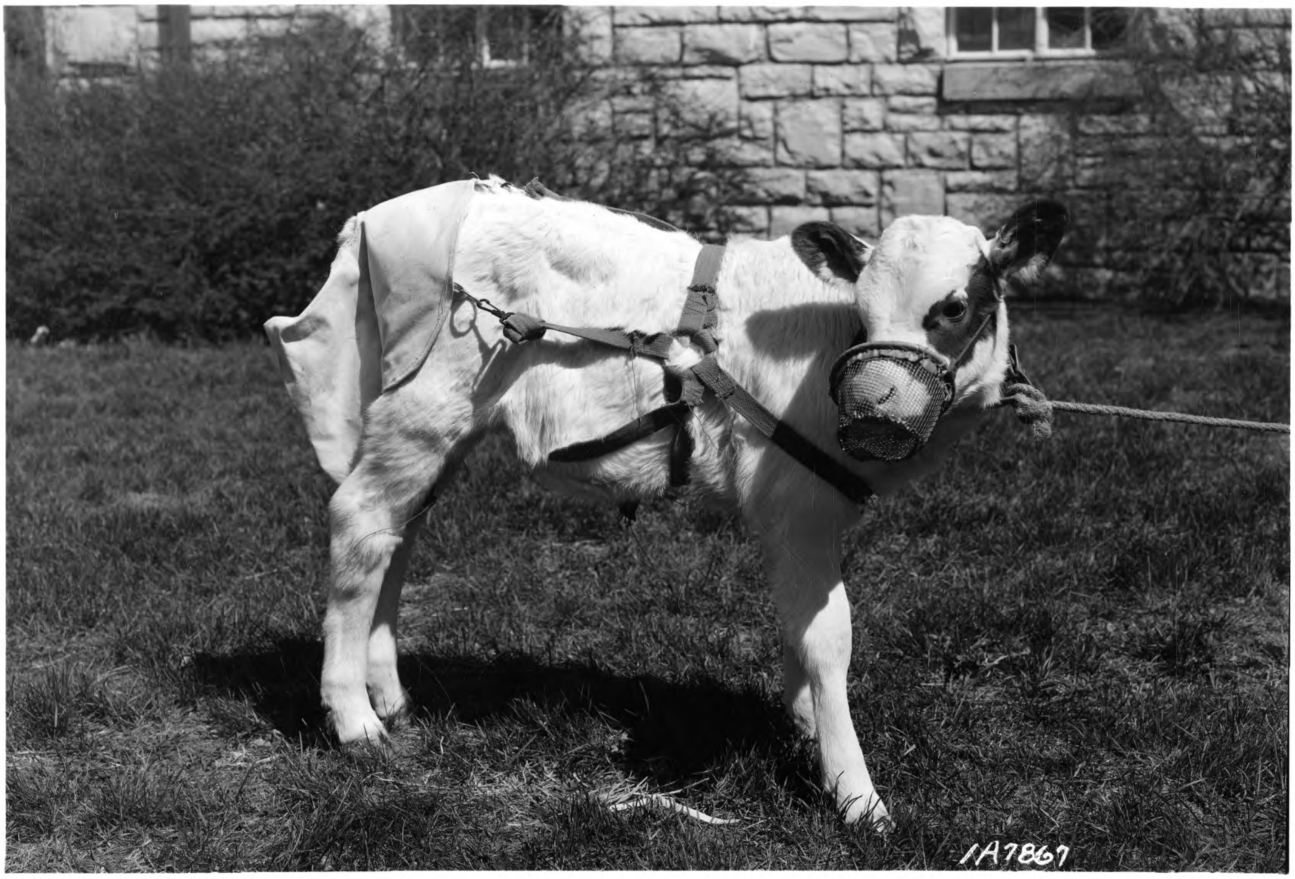


Fig. 2. Harness, collection bag, and muzzle used in digestion trial of dairy calves.

In the metabolism cages, under conditions of the digestion trial, calves were fed herd milk standardized to approximately 3 percent fat content. The Babcock test was used to determine the original fat content of the milk, and standardization was made by adding skim milk. The milk was standardized often enough to insure freshness, standardizations usually being made every other day. After standardization, the milk was cooled and kept under refrigeration until feeding time. At feeding time, the milk to be fed was removed from the refrigerator, warmed to approximately 100° F., and mixed well with a stirrer. Milk was bucket fed at the rate of 10 pounds per 100 pounds of body weight daily, adjusted at the beginning of the digestion trial. No trouble was encountered in teaching the calves to drink from a bucket. Samples (approximately one half pint) of milk were taken of milk fed to calves during the collection period and kept under refrigeration for later analysis.

Calves in rations groups 2 and 3 were fed grain or hay at the same rate per unit of body weight. The daily level fed was 200 g per 100 pounds body weight daily during digestion trial I, and 400 g per 100 pounds body weight during digestion trial II. The grain or hay was fed prior to milk feeding to insure that the calves would clean up the dry feeds and there would be no weigh-backs. Enough grain and hay was obtained from one source at the beginning of the experiment to last the entire trial. The hay was coarsely ground alfalfa of good quality, and the grain was medium ground oats of good quality. Preceding a digestion trial for a calf in ration groups 2 or 3, enough semi-daily portions of hay or grain were weighed up to last the entire trial. Samples of hay and grain for analysis were taken at the time these semi-daily portions were weighed. The samples were obtained by taking a small amount of hay or grain from each sack being weighed and compositing them in a moisture proof bag. The semi-daily portions for feeding were placed in marked paper sacks and kept separately for each calf in a large tin container. The tin container offered protection against rodents and moisture.

The calves were fed at approximately 6 a.m. and between 5 and 6 p.m. Four hundred international units of vitamin D in the form of irradiated dried yeast was fed once daily to all calves by capsule. The experimental calves received crystalline aureomycin hydrochloride, fed daily, by capsule, at the rate of 25 mg per 100 pounds body weight throughout the experiment.

## Collection of Feces

Feces was collected at least twice daily or oftener when necessary. The collection was accomplished by unhooking the three top snaps of the harness from the canvas bag and sliding the bag down and away from the calf, the bottom of the bag remaining connected to the harness. The calf's tail was pulled out of the hole made for it in the canvas bag, the plastic bag containing the feces was removed, and a new plastic bag was inserted in its place. The procedure could be rapidly carried out and also enabled the collector to catch any feces deficated while the plastic bag was being changed. While the canvas bag was down a phenol disinfectant was applied to the calf around the area covered by the collection bag. This was to protect against flies and their maggots. The plastic bags containing feces were tied shut and tagged, recording the calf name and the time of collection. Feces was kept under refrigeration until the conclusion of a trial.

## Processing Feed and Feces Samples

Grain and hay samples were taken from the moisture proof bags and mixed well before grinding through a Wiley mill containing a medium screen. The ground samples again were mixed and put into labeled air tight bottles. These bottles were sent to the laboratory for complete feedstuffs analysis by official methods of the A.O.A.C. (3). The analysis made were those for moisture, crude protein, ether extract, crude fiber, and ash. Nitrogen free extract and carbohydrates were calculated in the usual manner.

The feces from calves receiving a ration containing crude fiber (rations 2 and 3) were processed differently than the feces from calves receiving milk only, because of the bulk of the feces and the larger amount of undigested matter in it. The feces from calves of the former groups was removed from the refrigerator and cleaned from the plastic bags and was composited into one sample for each calf. This was accomplished by cutting the bag open and scraping it with a spatula. The feces samples were composited for the seven-day collection period and mixed well. The total amount or an aliquot of it was evenly spread in a flat enamel pan. Squares were cut in the feces to allow faster and more complete drying, and it was dried in a forced air oven at approximately 80$^{o}$ C. for 48 to 72 hours. The dried feces was removed from the oven, cooled and crushed. The pans of feces then were covered and left until the moisture in the feces had come to equilibrium with the humidity of the air. The feces was weighed to obtain the air dry weight and ground through a Wiley mill using the medium screen. The ground material was put in air tight bottles to be sent to the laboratory for complete feedstuffs analysis.

The feces from calves receiving a ration of whole milk was composited and well mixed before part of it was put in an air tight bottle for analysis.

Milk samples were taken from the refrigerator and allowed to warm to room temperature. Aliquots of the well mixed milk were composited. The amount of milk taken for an aliquot was determined by the percent that the sample represented in the total feeding. It was attempted to analyze milk samples of a 7 day collection period in 3 and 4 day intervals, but in some trials, only one composite sample was analyzed for the entire 7 days. Moisture, crude protein, ether extract, and ash were determined on the milk samples; N.F.E. (in this case essentially lactose) was found by difference.

## Analytical Procedures

Moisture was determined by drying 10 g samples at approximately 103° C. for 12 hours. The dried samples were ignited in a muffle furnace for 12 hours at approximately 500° C. to determine the ash content. Nitrogen determination was by official methods of A.O.A.C. (3). Ten g samples were used for the analysis of milk and 3 g samples for feces. Protein was calculated by multiplying the percentage nitrogen by the factor 6.25.

Samples were prepared for extraction of fat by mixing with anhydrous sodium sulfate to absorb the moisture. Ten g samples of wet feces were mixed with 90 g of sodium sulfate by grinding it in a mortar. One fifth of this mixture, determined by weight, (representing 2 g of feces) was placed in a corundum thimble and extracted for 12 hours with anhydrous ether. Milk samples of 1.5 g were mixed with 19 g of sulfate by grinding in a mortar, placed in a corundum thimble, and extracted for 12 hours with anhydrous ether.

Nitrogen-free extract was determined by subtracting the sum of the percentages of moisture, crude protein, ether extract, and ash from 100 percent.

### Determination of Digestion Coefficients

Apparent coefficients of digestion were calculated by dividing the amount of a nutrient apparently absorbed by the amount of that nutrient ingested by the animal. The amount of nutrient absorbed was found by subtracting the amount of nutrient in the feces from the amount of nutrient ingested in the feed.

## RESULTS AND DISCUSSION

The effect of aureomycin on the digestibility of a ration of milk only by calves (ration group I) is shown in Table 3. The apparent coefficients of digestion of dry matter, crude protein, ether extract, and N.F.E. were approximately the same at 63 to 70 days and at 91 to 98 days of age for both experimental and control calves. These results are in agreement with work reported by Murley et al. (46) in which aureomycin did not affect the ability of dairy calves to utilize a ration of reconstituted milk. The nutrients in milk were highly digested both in trials I and II. The high apparent coefficients of digestion of milk correspond favorably with those reported by Burris (15) and coefficients compiled by Morrison (43). The apparent coefficient of digestion of ash varied somewhat among calves. This has been reported in other trials (15), and possibly can be explained by the relatively small daily ingestion of ash (Table 3). The second digestion trial for calf 27A was of only 5 days duration instead of seven because, on the fifth day of the collection period the muzzle came off and the calf ate part of the muzzle strap. The calf also began to scour on the same day and it was thought desirable to remove the calf from the digestion trial.

The effect of aureomycin on the digestibility of a ration of milk and oats is shown in Table 4. The apparent coefficients of digestion of dry matter, crude protein, ether extract, ash and N.F.E. were approximately the same at both 63 to 70 days and at 91 to 98 days of age for experimental and control calves. Ash was digested better by control calves than by experimental calves in trial II but about the same in trial I. At 63 to 70 days of age, crude fiber was digested -0.9 percent by experimental calves and 20.5 percent by control calves, the negative result being due to a digestion coefficient of -28.1 for crude fiber for calf 25A. The other experimental calf (0227) in this group digested 26.3 percent crude fiber at 63 to 70 days of age. Average digestion coefficients for crude fiber at 91 to 98 days of age were: controls, 46.0, aureomycin fed, 18.0. The control calves increased in

Table 3. The effect of aureomycin on the digestibility of milk by dairy calves in ration group 1.[1]

| Breed | Calf no. | Treatment | Apparent coefficients of digestion | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Trial I 63-70 days of age | | | | | Trial II 91-98 days of age | | | | |
| | | | Dry matter | Crude protein | Ether extract | N.F.E. | Ash | Dry matter | Crude protein | Ether extract | N.F.E | Ash |
| Holstein | 0151 | Aureomycin | 98.5 | 98.1 | 99.2 | 99.3 | 92.9 | 98.7 | 95.5 | 98.3 | 99.0 | 88.5 |
| Holstein | 0152 | Control | 98.2 | 97.1 | 98.9 | 99.5 | 92.8 | 95.8 | 94.6 | 97.4 | 98.1 | 81.6 |
| Jersey | 0341 | Aureomycin | 97.5 | 95.9 | 99.6 | 99.5 | 92.0 | 96.4 | 94.9 | 97.7 | 98.0 | 87.7 |
| Jersey | 27A | Control | 94.0 | 89.7 | 94.3 | 96.6 | 77.0 | 94.4[2] | 93.0 | 95.2 | 98.1 | 86.4 |
| Average | | Aureomycin | 98.0 | 97.0 | 99.4 | 99.4 | 92.5 | 97.5 | 95.2 | 98.0 | 98.5 | 88.1 |
| Average | | Control | 96.1 | 93.4 | 98.1 | 98.1 | 87.4 | 95.1 | 93.8 | 96.8 | 98.1 | 83.5 |
| Average intake | | (g) | 3750 | 1112 | 1034 | 1358 | 245 | 5200 | 1488 | 1521 | 1853 | 338 |

[1]Calves in ration group 1 received milk (3 percent fat content) at the rate of 1 pound per 10 pounds body weight daily. Experimental calves fed aureomycin received 25 mg aureomycin per 100 pounds of body weight daily.

[2]Five day collection period during trial 2.

Table 4. The effect of aureomycin on the digestibility of milk and oats by dairy calves in ration group 2.[1]

| | | | Apparent coefficients of digestion | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Trial I 63-70 days of age | | | | | | Trail II 91-98 days of age | | | | | |
| Breed | Calf no. | Treatment | Dry matter | Crude protein | Ether extract | N.F.E. | Ash | Crude fiber | Dry matter | Crude protein | Ether extract | N.F.E. | Ash | Crude fiber |
| Jersey | 25A | Aureomycin | 86.7 | 92.0 | 98.3 | 86.2 | 75.6 | -28.1 | 86.4 | 91.2 | 97.2 | 88.4 | 73.6 | 19.8 |
| Jersey | 26A | Control | 90.2 | 91.9 | 98.8 | 86.8 | 77.3 | 18.3 | 90.1 | 92.9 | 97.2 | 92.6 | 83.9 | 53.2 |
| Guernsey | 0227 | Aureomycin | 90.5 | 93.5 | 98.9 | 86.5 | 81.3 | 26.3 | 86.7 | 90.8 | 96.9 | 88.5 | 76.3 | 16.2 |
| Guernsey | 0228 | Control | 90.1 | 93.7 | 98.2 | 90.8 | 79.7 | 22.6 | 90.4 | 92.8 | 97.2 | 91.9 | 82.1 | 38.7 |
| Average | | Aureomycin | 88.6 | 92.8 | 98.6 | 86.4 | 78.5 | - 0.9 | 86.6 | 91.0 | 97.1 | 88.4 | 74.6 | 18.0 |
| Average | | Control | 90.2 | 92.8 | 98.5 | 88.8 | 78.5 | 20.5 | 90.3 | 92.9 | 97.5 | 92.3 | 83.0 | 46.0 |
| Average intake (g) | | | 4457 | 1071 | 909 | 2083 | 261 | 129 | 7432 | 1639 | 1139 | 3958 | 387 | 313 |

[1]Calves in ration group 2 received milk (3 percent fat) at the rate of 1 pound per 10 pounds of body weight daily during digestion trials I and II. Ground oats was fed at the rate of 20 g per 10 pounds body weight daily during digestion trial I and at the rate of 40 g per 10 pounds body weight daily during digestion trial II. Experimental calves received 25 mg aureomycin per 100 pounds body weight daily.

ability to digest crude fiber approximately two fold between 63 to 70 days of age and 91 to 98 days of age. The aureomycin may have exerted a bacteriostatic action on development of crude fiber digesting micoorganisms in the calf's rumen. The negative digestion coefficient for crude fiber by calf 25A at 63 to 70 days of age may have been because of errors due to the small amount of crude fiber that was fed to calves at this early age or due to the calf ingesting some extraneous source of crude fiber. It has been suggested that a portion of the crude fiber may accumulate in the rumen for several days before passing on through the digestive tract (15). With the exception of crude fiber and ash, calves digested a milk and oats ration at 63 to 70 days of age to about the same extent as they did at 91 to 98 days of age.

The effect of aureomycin on digestibility of a ration composed of milk and alfalfa hay is shown in Table 5. At 63 to 70 days of age average digestion coefficients for crude fiber were 15.2 for calves receiving aureomycin and 41.6 for control calves. The individual results for crude fiber digestion by aureomycin fed calves were variable. The apparent coefficients of digestion for other nutrients indicated little difference between experimental and control calves. At 91 to 98 days of age all nutrients were digested to approximately the same extent by experimental and control calves. The apparent coefficient of digestion of crude fiber for experimental calves was increased approximately 3 times between the 63 to 70 day and the 91 to 98 day periods. The ability of control calves to digest crude fiber did not change appreciably between 63 to 70 and 91 to 98 days of age. These results for crude fiber digestion are not in agreement with those obtained for calves in ration group II. It is difficult to find a satisfactory explanation for this situation. Pounden and Hibbs (51) reported that the microorganisms characteristic of the rumen contents of older cattle failed to become established in the rumen of young calves, mainly because they did not ingest good quality roughage. The approximate two fold increase in the amount of hay ingested during digestion trial II as compared to digestion trial I may have influenced development of rumen microflora. Tables compiled by Morrison (43) indicate that the crude fiber of alfalfa hay is more highly digested than that of oats.

The average apparent coefficients of digestion of dry matter, crude protein, ether extract, N.F.E., and ash for trials I and II for each of the 2 aureomycin fed calves and 2 control calves in ration groups 1, 2, and 3, were approximately the same (Table 6). In both trials I and II the average digestion coefficients of crude fiber are higher for control calves than for experimental calves in both ration groups 2 and 3. The average coefficients of digestion obtained with all experimental calves and all control calves were similar, except for crude fiber in which the digestibility was higher by control calves.

Table 5. The effect of aureomycin on the digestibility of milk and alfalfa hay by dairy calves in ration group 3.[1]

| Breed | Calf no. | Treatment | Apparent coefficients of digestion | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Trial I 63-70 days of age | | | | | | Trial II 91-98 days of age | | | | | |
| | | | Dry matter | Crude protein | Ether extract | N.F.E. | Ash | Crude fiber | Dry matter | Crude protein | Ether extract | N.F.E. | Ash | Crude fiber |
| Holstein | 0153 | Aureomycin | 79.0 | 82.8 | 92.7 | 83.1 | 65.7 | 20.0 | 82.1 | 85.0 | 94.7 | 85.9 | 73.4 | 46.5 |
| Holstein | 0154 | Control | 81.9 | 83.3 | 93.8 | 85.0 | 67.9 | 42.0 | 82.6 | 85.1 | 93.7 | 86.2 | 74.1 | 47.0 |
| Holstein | 0157 | Aureomycin | 71.1 | 77.4 | 89.4 | 96.2 | 51.2 | 10.3 | 83.5 | 85.9 | 94.6 | 86.1 | 69.4 | 50.0 |
| Holstein | 0156 | Control | 81.1 | 83.5 | 93.0 | 86.1 | 87.0 | 41.2 | 82.1 | 85.4 | 93.6 | 87.5 | 70.3 | 41.6 |
| Average | | Aureomycin | 75.1 | 80.1 | 91.1 | 89.6 | 58.4 | 15.2 | 82.8 | 85.5 | 94.7 | 86.0 | 71.4 | 48.3 |
| Average | | Control | 81.5 | 83.4 | 93.4 | 85.5 | 68.0 | 41.6 | 82.4 | 85.3 | 93.7 | 86.9 | 72.2 | 44.3 |
| Total average intake | | | 6842 | 1771 | 1199 | 2734 | 535 | 602 | 10153 | 2482 | 1630 | 4180 | 761 | 1099 |

[1]Calves in ration group 3 received milk (3 percent fat content) at the rate of 1 pound per 10 pounds body weight daily. Ground alfalfa hay was fed during digestion trial I at the rate of 20 g per 10 pounds body weight daily. During digestion trial II, calves were fed alfalfa at the rate of 40g per 10 pounds body weight daily. Experimental calves received aureomycin at the rate of 25 mg per 100 pounds of body weight daily.

No definite conclusion on the effect of aureomycin on the digestibility of crude fiber by dairy calves can be drawn because of the variation in coefficients of digestion of crude fiber between digestion trials of individual calves, and the small number of calves. However, there is an indication by the averages of all calves in all ration groups receiving aureomycin, that crude fiber digestion was lowered. Milk was the most highly digested of the three rations fed.

The effect of aureomycin on the growth of calves in ration groups 1, 2, and 3 is shown in Table 7. At 12 weeks of age the weight of aureomycin fed calves receiving a ration of milk only averaged 175 percent of the birth weight and the control calves averaged 167 percent. The Ragsdale growth standard (52) ---weighted by breed and sex ---indicates an expected weight at 12 weeks of 231 percent of birth weight (Table 8). It will be noted from Fig. 3 that the experimental calves weighed more than control calves throughout the 12 weeks, although both groups failed to reach the expected weight. Aureomycin fed calves receiving a ration of milk and oats weighed 199 percent of their birth weight and control calves in this group weighed 177 percent of their birth weight at 12 weeks of age (Table 7, Fig. 4). The expected weight for this group was 228 percent of the birth weight. Aureomycin

Table 6. Average apparent coefficients of digestion, trials I and II.

| Ration group | Treatment | Description | Dry matter | Crude protein | Ether extract | N.F.E. | Ash | Crude fiber |
|---|---|---|---|---|---|---|---|---|
| Milk | Aureomycin | Average of trials I & II | 97.75 | 96.10 | 97.70 | 98.95 | 90.30 | |
| Milk | Control | Average of trials I & II | 95.60 | 93.60 | 97.45 | 98.10 | 84.20 | |
| Milk-Oats | Aureomycin | Average of trials I & II | 87.60 | 91.90 | 97.85 | 87.90 | 76.55 | 8.5 |
| Milk-Oats | Control | Average of trials I & II | 90.20 | 92.85 | 98.00 | 90.55 | 80.75 | 33.25 |
| Milk-Alfalfa | Aureomycin | Average of trials I & II | 78.95 | 82.80 | 92.90 | 87.80 | 64.90 | 31.60 |
| Milk-Alfalfa | Control | Average of trials I & II | 81.95 | 84.35 | 93.55 | 86.20 | 70.10 | 42.95 |
| All Groups | Aureomycin | Average of all aureomycin calves | 88.15 | 90.28 | 96.48 | 91.55 | 77.25 | 20.05 |
| All Groups | Control | Average of all control calves | 89.25 | 90.36 | 96.00 | 89.95 | 78.35 | 38.17 |
| All Groups | Control & Aureomycin | Average of all calves | 88.70 | 90.31 | 96.24 | 90.75 | 77.80 | 29.11 |
| Milk | Control & Aureomycin | Average of all calves in group 1 | 96.67 | 94.85 | 97.57 | 98.53 | 87.25 | |
| Milk-Oats | Control & Aureomycin | Average of all calves in group 2 | 88.90 | 92.37 | 97.92 | 89.22 | 78.65 | 20.87 |
| Milk-Alfalfa | Control & Aureomycin | Average of all calves in group 3 | 80.45 | 83.57 | 93.22 | 87.00 | 67.50 | 37.27 |

fed calves receiving a ration of milk and alfalfa weighed 186 percent of their birth weight at 12 weeks of age, and control calves weighed 173 percent of their birth weight (Table 7, Fig. 5). The expected weight was 225 percent of the birth weight at 12 weeks of age. The average weight of all aureomycin fed calves at 12 weeks of age was 184 percent and for all control calves was 178 percent of birth weight (Fig. 6). The expected weight of all calves was 226 percent of birth weight.

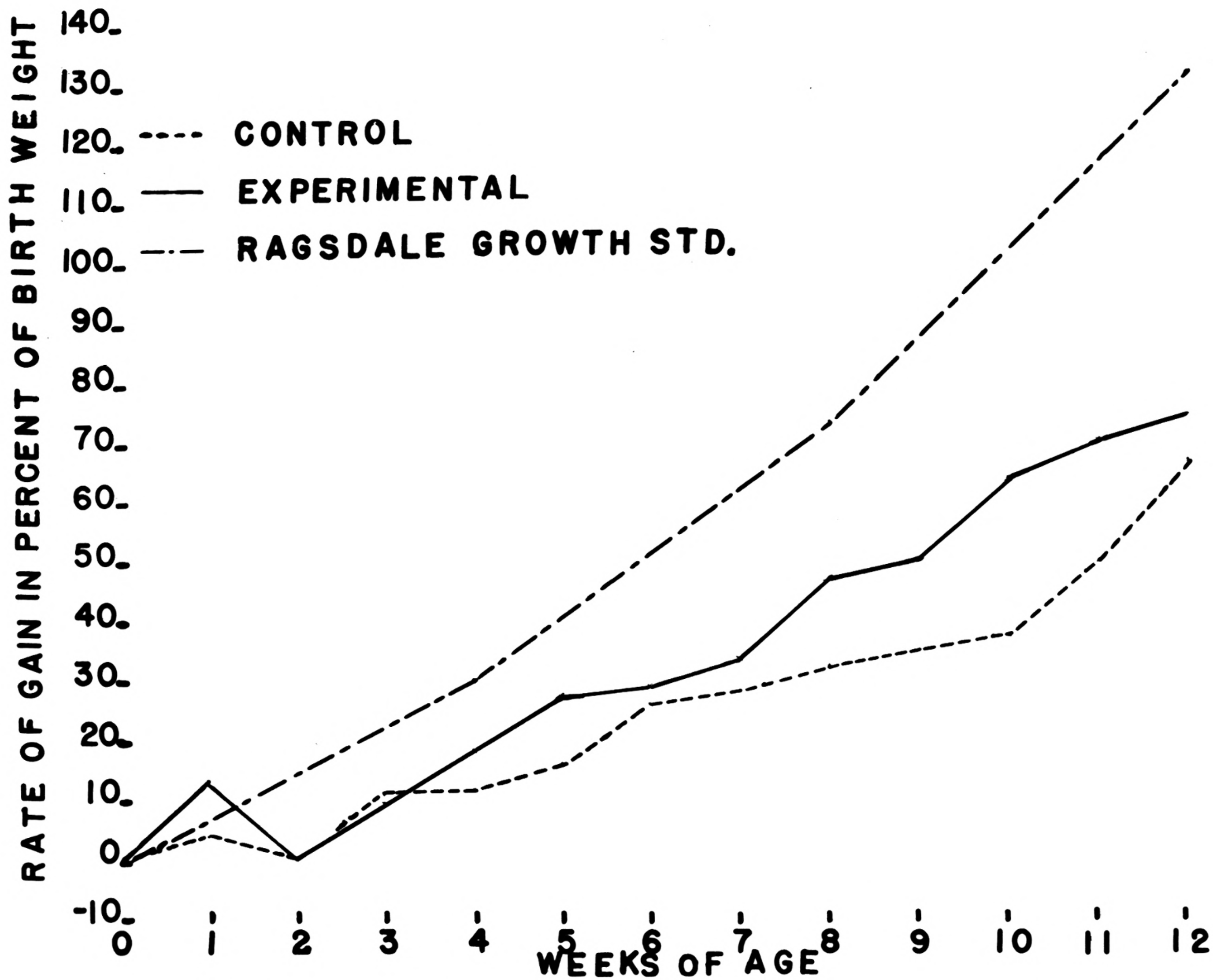


Fig. 3. The effect of aureomycin on the rate of gain by dairy calves receiving milk only.

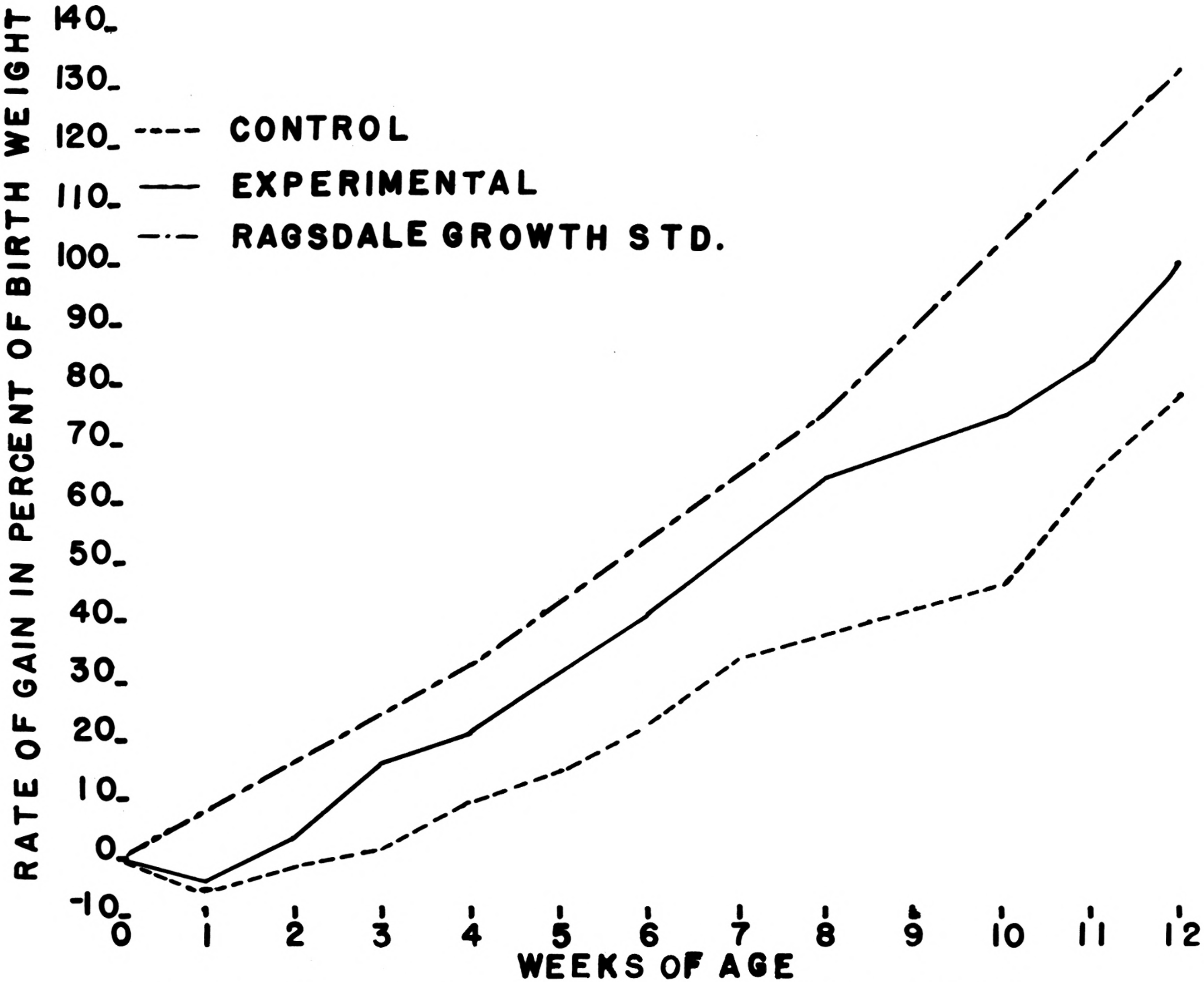


Fig. 4. The effect of aureomycin on the rate of gain by dairy calves receiving milk and oats.

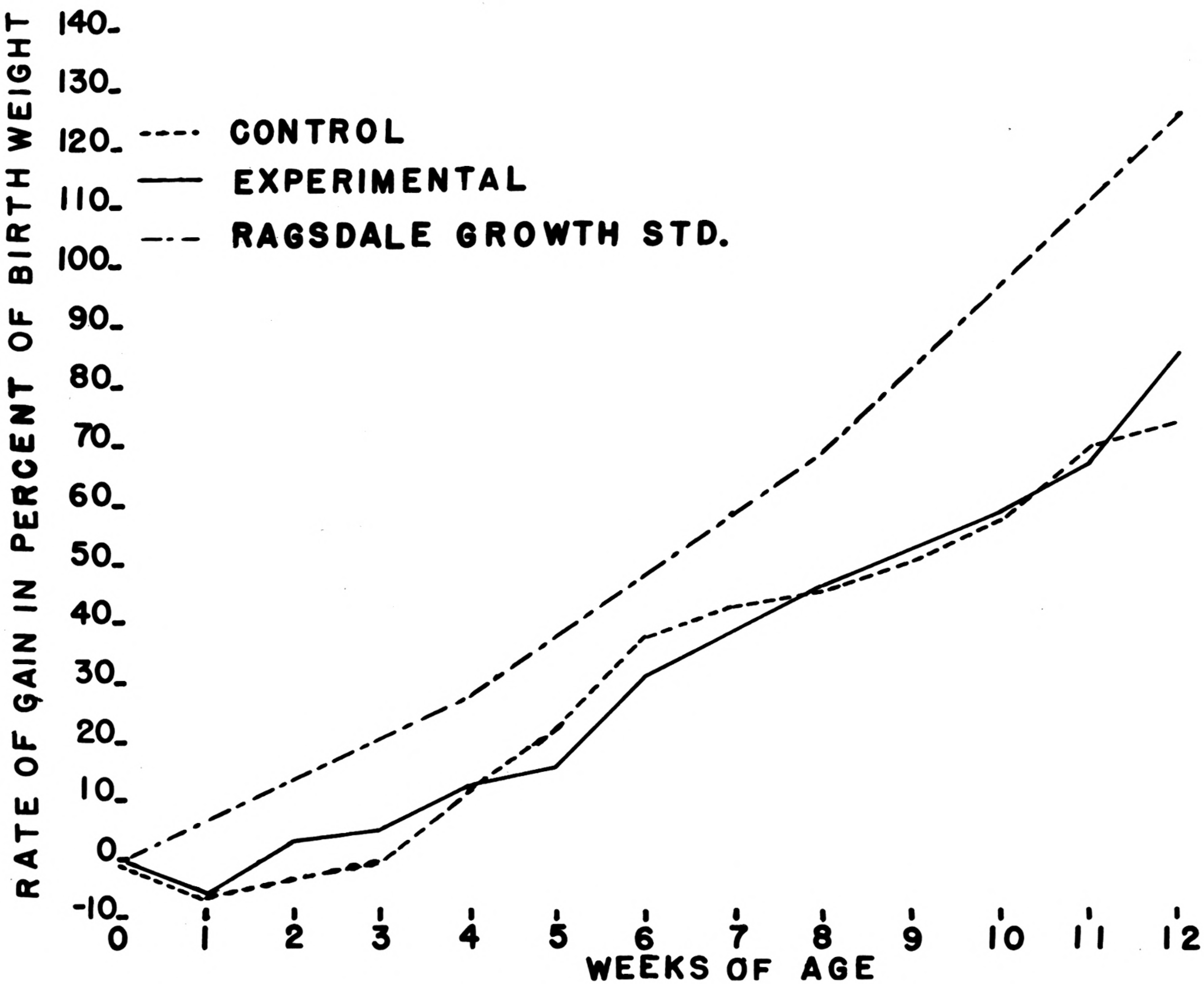


Fig. 5. The effect of aureomycin on the rate of gain by dairy calves receiving milk and alfalfa.

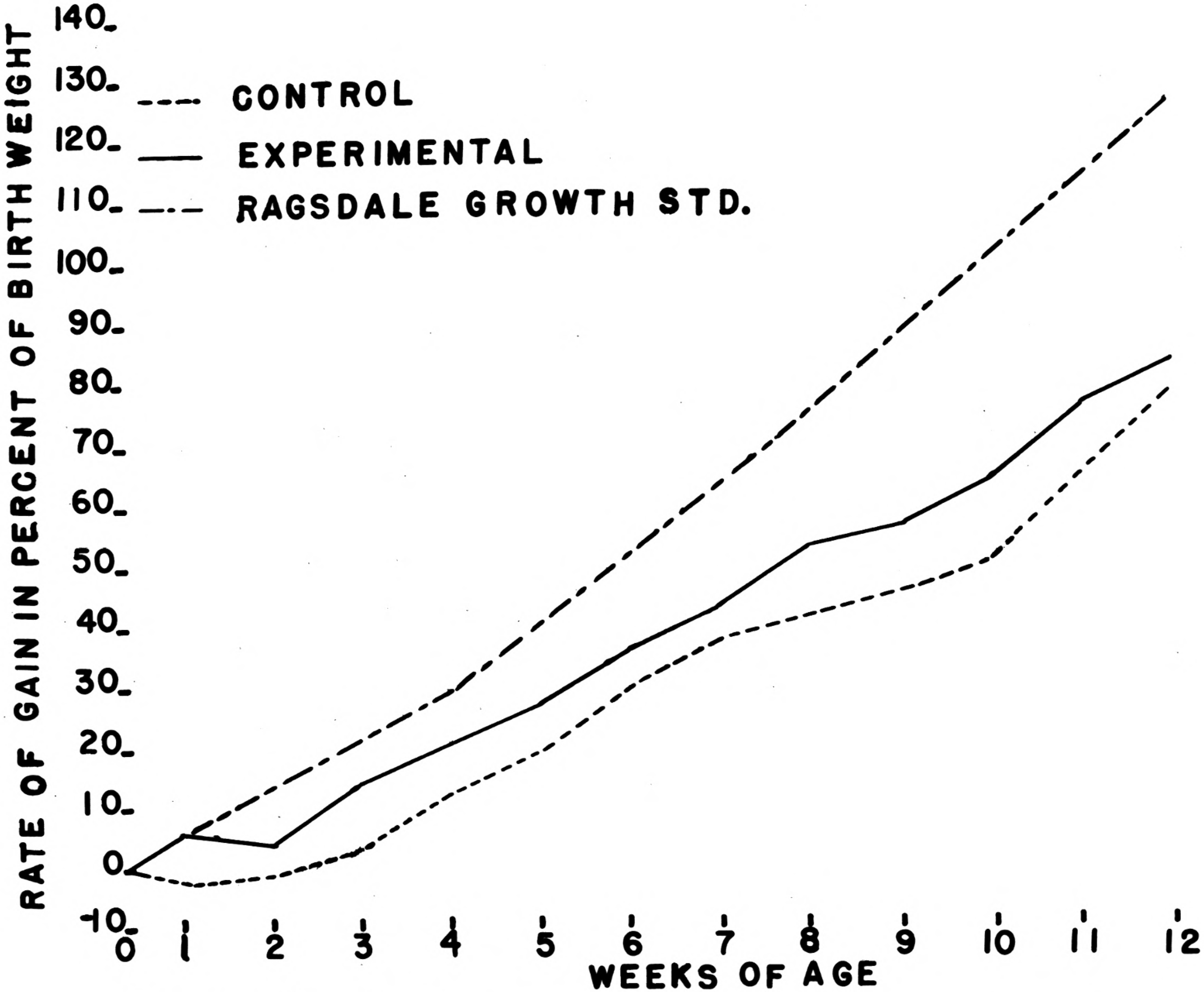


Fig. 6. The effect of aureomycin on the average rate of gain by dairy calves receiving rations of milk, milk-oats, and milk-alfalfa hay.

Table 7. The effect of aureomycin on the weight of dairy calves receiving milk, milk and oats, and milk and alfalfa hay.

| Ration | Calf no. | Treatment | Weeks of age: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk | 0151 | Aureomycin | 113.0[1] | 92.6 | 104.6 | 116.7 | 124.1 | 128 | 134 | 145 | 148 | 171 | 177 | 185 |
| | 0341 | Aureomycin | 115.4 | 109.3 | 115.4 | 121.3 | 132.3 | 130 | 135 | 150 | 153 | 158 | 163 | 164 |
| | Average | | 113.7 | 100.9 | 110.0 | 119.0 | 128.2 | 129 | 135 | 148 | 151 | 165 | 170 | 175 |
| | 0152 | Control | 100.0 | 107.3 | 106.3 | 106.3 | 112.6 | 121 | 125 | 130 | 135 | 136 | 153 | 183 |
| | 27A | Control | 109.4 | 94.3 | 117.0 | 118.6 | 120.8 | 132 | 134 | 136 | 137 | 139 | 148 | 152 |
| | Average | | 104.7 | 100.8 | 111.6 | 112.6 | 116.7 | 127 | 130 | 133 | 135 | 138 | 150 | 167 |
| Milk & Oats | 0153 | Aureomycin | 98.8 | 99.4 | 115.0 | 112.3 | 124.7 | 135 | 147 | 160 | 161 | 163 | 192 | 200 |
| | 0157 | Aureomycin | 95.1 | 112.8 | 118.6 | 130.4 | 137.3 | 148 | 157 | 168 | 177 | 185 | 195 | 199 |
| | Average | | 96.4 | 103.8 | 116.7 | 121.4 | 131.0 | 141 | 152 | 164 | 169 | 174 | 183 | 199 |
| | 0154 | Control | 94.1 | 92.9 | 102.4 | 107.0 | 113.0 | 120 | 132 | 134 | 137 | 140 | 155 | 167 |
| | 0156 | Control | 93.1 | 104.0 | 101.0 | 111.8 | 115.7 | 125 | 134 | 140 | 146 | 151 | 174 | 187 |
| | Average | | 94.6 | 99.3 | 101.7 | 109.4 | 114.3 | 122 | 133 | 137 | 142 | 146 | 164 | 177 |
| Milk & Alfalfa | 25A | Aureomycin | 85.4 | 95.0 | 93.6 | 100.0 | 109.8 | 117 | 123 | 132 | 138 | 144 | 151 | 168 |
| | 0227 | Aureomycin | 104.0 | 111.6 | 116.6 | 126.7 | 123.7 | 145 | 154 | 160 | 164 | 173 | 184 | 204 |
| | Average | | 94.7 | 103.3 | 104.7 | 113.4 | 116.7 | 131 | 138 | 146 | 152 | 158 | 168 | 186 |
| | 26A | Control | 89.2 | 91.3 | 91.3 | 108.7 | 121.7 | 141 | 141 | 143 | 149 | 155 | 161 | 162 |
| | 0228 | Control | 100.0 | 102.0 | 107.8 | 116.5 | 123.3 | 133 | 144 | 148 | 152 | 159 | 178 | 185 |
| | Average | | 94.6 | 94.7 | 99.5 | 112.6 | 122.5 | 137 | 143 | 145 | 151 | 157 | 169 | 173 |
| Average all aureomycin | | | 105.9 | 104.0 | 114.6 | 121.1 | 127.1 | 136 | 143 | 153 | 156 | 164 | 176 | 184 |
| Average all control | | | 97.6 | 98.8 | 102.8 | 112.2 | 118.9 | 130 | 138 | 141 | 146 | 150 | 166 | 178 |

[1] Weekly weight expressed as percent of birth weight. Calculated as follows: Weight (pounds) / birth weight (pounds) x 100.

Table 8. Expected weight in percent of birth weight by calves in ration groups 1, 2, and 3 as adjusted from Ragsdale growth standards.

| Age | Ration group I | Ration group 2 | Ration group 3 | All groups |
|---|---|---|---|---|
| 4 weeks | 130.7 | 132.9 | 127.4 | 129.2 |
| 8 weeks | 173.9 | 174.5 | 168.7 | 170.6 |
| 12 weeks | 231.2 | 227.5 | 225.0 | 225.8 |
| (weighted average by breed) | | | | |

A possible explanation of the failure of calves in this experiment to reach the expected rate of growth according to Ragsdale's standards might be due to the limited feed consumption during the time of the preliminary and collection periods. The only ad libitum feeding of hay or grain was while the calves were housed in the calf barn. All the groups did not receive the same amount of T.D.N. per unit of weight, because all calves received the same level of milk and those in ration groups 2 and 3 received grain or alfalfa in addition. The close confinement of the metabolism cages and harnesses did not present the best growing conditions.

There was no difference noticed in the incidence of scours between the experimental and control calves. Other workers have reported a favorable influence of aureomycin on incidence of scours (6, 36). Failure to find differences in this experiment was probably due to the generally low incidence of scours throughout the entire experiment. The experiment, however, was not designed to study the effect of aureomycin on calf scours. Although sufficient calves were used to obtain information on digestibility, the number was not sufficiently large for the purpose of studying the effect of aureomycin on scours. The usual medication of penicillin, sulfa, or raw eggs were given to the young calves for scours. No cases of scours occurred during digestion trials, except in one case by calf 27A, at which time it was removed from the experiment.

Feed efficiency was calculated as the total digestible nutrients ingested per pound of weight gain from birth to 12 weeks of age. Aureomycin fed calves in all three ration groups had a higher feed efficiency than the controls (Table 9). The largest difference in feed efficiency between the experimental calves and the control calves within the same group was in the ration group receiving milk and oats. The average feed efficiency for all aureomycin fed calves on experiment was 2.18 pounds T.D.N. per pound of gain compared to 2.55 pounds T.D.N. per pound of gain for the controls. Increased feed efficiency resulting from feeding aureomycin to dairy calves also has been reported by several investigators (5, 37, 47).

It was noted in the collection of feces during the digestion trials that the feces from aureomycin fed calves tended to be firmer than the feces of control calves. Cason and Voelker (18) reported firmer feces for calves receiving terramycin and Voelker and Cason (66) reported firmer feces for

Table 9. The effect of aureomycin on the feed efficiency of dairy calves[1] receiving milk, milk and oats, and milk and alfalfa hay.

| Ration | Calf no. | Treatment | Pounds | | | | | T.D.N./lb gain |
|---|---|---|---|---|---|---|---|---|
| | | | Milk | Hay | Grain | T.D.N.[2] | Weight gain | |
| Milk | 0151 | Experimental | 1049 | | | 170.98 | 91.2 | 1.97 |
| Milk | 0341 | Experimental | 660 | | | 107.54 | 41.8 | 2.52 |
| Average | | | | | | | | 2.27 |
| Milk | 0152 | Control | 951 | | | 155.01 | 85.0 | 1.82 |
| Milk | 27A | Control | 578 | | | 94.31 | 27.1 | 3.34 |
| Average | | | | | | | | 2.75 |
| Milk and alfalfa | 0153 | Experimental | 720 | 53.25 | | 144.14 | 80.7 | 1.79 |
| Milk and alfalfa | 0157 | Experimental | 1125 | 72.10 | | 219.64 | 100.6 | 2.18 |
| Average | | | | | | | | 1.89 |
| Milk and alfalfa | 0154 | Control | 787 | 36.75 | | 146.77 | 57.0 | 2.57 |
| Milk and alfalfa | 0156 | Control | 960 | 75.81 | | 192.54 | 99.7 | 1.93 |
| Average | | | | | | | | 2.25 |
| Milk and oats | 25A | Experimental | 318 | | 20.67 | 76.67 | 27.7 | 2.77 |
| Milk and oats | 0227 | Experimental | 950 | | 37.41 | 181.11 | 89.4 | 2.03 |
| Average | | | | | | | | 2.40 |
| Milk and oats | 26A | Control | 426 | | 24.69 | 86.73 | 28.6 | 3.04 |
| Milk and oats | 0228 | Control | 1015 | | 47.58 | 198.80 | 87.2 | 2.29 |
| Average | | | | | | | | 2.66 |
| All ration groups Experimental | | | | | | | | 2.18 |
| All ration groups Control | | | | | | | | 2.55 |

[1]At 12 weeks of age.
[2]T.D.N. obtained from Morrisons (42) average composition of feeds-Table 1.

calves receiving aureomycin. Bell et al. (8) working with beef cattle, and Robins (56) working with man indicate that extremely high levels of aureomycin feeding seem to have an opposite effect and make the feces less firm.

The foregoing data indicate that the feeding of aureomycin to dairy calves does not lower the digestibility of dry matter, crude protein, ether extract, N.F.E., and ash of rations composed of milk, milk and oats, or milk and alfalfa hay. It is difficult to draw any conclusions concerning the effect of aureomycin feeding on the digestibility of crude fiber due to the large amount of variation occuring in the crude fiber digestion coefficients within individual calves. The results of this experiment are interesting since they tend to refute many of the earlier beliefs that antibiotics would be detrimental to ruminant animals because of the possible destruction of necessary rumen microorganisms.

Preliminary bacteriological studies of rumen contents from calves fed antibiotics have revealed that the number of organisms present in the rumen is not reduced (7, 48), but there are indications that bacterial types are altered (48). It is not surprising therefore to find that the feeding of aureomycin to calves does not impair digestibility. The beneficial results on growth and feed efficiency shown by calves fed aureomycin can not be explained by the ability of aureomycin to improve digestibility. It, therefore, appears evident that the action of the antibiotic is not due to a direct affect upon digestibility. As recently suggested, the feeding of aureomycin may produce changes in the rumen or intestinal microflora. However, these data would seem to indicate that any benefits resulting from altering the microflora are not due to an improved ability of the changed flora to digest rations.

## SUMMARY

A series of digestion trials were conducted to determine the effect of aureomycin on the digestibility of various rations for dairy calves. A total of twelve male calves were divided into three ration groups of four calves each. Each ration group contained 2 pairs of calves, paired by breed and date of birth. Holstein, Jersey, and Guernsey calves were used. The pairs were randomly assigned to the ration groups. Ration group 1 received whole milk, ration group 2 received milk and oats, and ration group 3 received milk and alfalfa hay. One calf of each pair was chosen at random to receive 25 mg of crystalline aureomycin HCl per 100 pounds of body weight daily.

Digestion trials were conducted at 63 to 70 days of age and at 91 to 98 days of age. A ten day preliminary trial proceeded all collection periods. The apparent coefficient

of digestibility of dry matter, crude protein, ether extract, crude fiber, N.F.E., and ash was determined for each of the three rations. The rate of growth and feed efficiency were recorded.

Aureomycin did not appear to improve the digestibility of a ration of milk only at 63 to 70 days or at 91 to 98 days of age. The calves had the same ability to digest milk at both ages.

Experimental and control calves fed milk and oats had similar coefficients of digestible dry matter, crude protein, ether extract, N.F.E., and ash at 63 to 70 days and at 91 to 98 days of age. The crude fiber digestion in the first trial (63 to 70 days) for aureomycin fed calves was -0.9 percent and for control calves was 20.5 percent. The negative result was due to a -28.1 crude fiber digestion coefficient for calf 25A. The other experimental calf in this group had a crude fiber digestion coefficient of 26.3. In the second trial (91 to 98 days) the control calves had an average coefficient of digestion for fiber of 46 compared to 18 for the experimental calves.

In ration group 3, receiving milk and alfalfa hay, no differences between aureomycin fed calves and control calves were noted except in the digestibility of crude fiber at 63 to 70 days of age. The control calves in this group digested 15.2 percent crude fiber compared to 41.6 percent for the experimental calves at 63 to 70 days of age. Both groups of calves digested about the same percentage of crude fiber at 91 to 98 days of age.

The average coefficients of digestion of crude fiber for all aureomycin fed calves in ration group 2 and 3 was 20.8 and the average for all control calves was 37.2. Aureomycin did not appear to effect the digestibility of crude fiber by dairy calves in this experiment, because of the variation in digestible crude fiber between individual calves and the small number of experimental subjects.

Aureomycin increased the rate of gain by dairy calves receiving rations of milk, milk and oats, and milk and alfalfa hay. Feed efficiency was higher by aureomycin fed calves in all three ration groups. The greatest difference in feed efficiency between experimental and control calves within a ration group was in ration group 2. A beneficial effect of aureomycin on incidence of scours was not shown in this experiment. The total incidence of scours throughout the entire experiment was low. The feces of aureomycin fed calves was firmer than the feces of control calves.

The beneficial results in growth and feed efficiency shown by aureomycin fed dairy calves can not be explained by the ability of the antibiotic to increase the digestibility of rations of milk, milk and oats, or milk and alfalfa hay. Furthermore, the data indicate that the feeding of aureomycin does not impair the digestibility of these rations.

# ACKNOWLEDGMENTS

The writer wishes to express his appreciation to Dr. D. B. Parrish of the Department of Chemistry and Dr. E. E. Bartley of the Department of Dairy Husbandry for assistance in planning, organizing, and criticizing this investigation; to Dan Burris and Dr. E. E. Bartley for the work done constructing metabolism cages and equipment; and to Russell T. McIntyre for suggestions and information on analytical procedures.

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# APPENDIX

Table 10. Daily feed consumption and composition of rations during digestion trials (duration 7 days).

| Calf no. | Ration | Trial | Pounds | | | Percent | | |
|---|---|---|---|---|---|---|---|---|
| | | | Milk | Oats | Alfalfa | Milk | Oats | Alfalfa |
| 0151 | 1 | I | 15.3 | | | 100 | | |
| | 1 | II | 18.1 | | | 100 | | |
| 0152 | 1 | I | 12.7 | | | 100 | | |
| | 1 | II | 16.0 | | | 100 | | |
| 0341 | 1 | I | 9.3 | | | 100 | | |
| | 1 | II | 10.8 | | | 100 | | |
| 27A | 1 | I | 7.0 | | | 100 | | |
| | 1 | II | 5.9 | | | 100 | | |
| 0153 | 2 | I | 11.0 | 0.6 | | 95.07 | 4.93 | |
| | 2 | II | 15.5 | 1.4 | | 91.88 | 8.12 | |
| 0154 | 2 | I | 10.0 | 0.5 | | 95.11 | 4.89 | |
| | 2 | II | 14.0 | 1.2 | | 91.45 | 8.15 | |
| 0157 | 2 | I | 16.0 | 1.4 | | 91.88 | 8.12 | |
| | 2 | II | 18.7 | 2.1 | | 90.03 | 9.97 | |
| 0156 | 2 | I | 13.8 | 1.2 | | 91.92 | 8.08 | |
| | 2 | II | 18.0 | 1.6 | | 91.84 | 8.16 | |
| 25A | 3 | I | 5.3 | | 0.2 | 95.87 | | 4.13 |
| | 3 | II | 6.7 | | 0.6 | 91.97 | | 8.03 |
| 26A | 3 | I | 6.4 | | 0.3 | 95.54 | | 4.46 |
| | 3 | II | 8.6 | | 0.8 | 91.91 | | 8.09 |
| 0227 | 3 | I | 12.3 | | 0.6 | 95.46 | | 4.54 |
| | 3 | II | 13.1 | | 1.6 | 89.15 | | 10.85 |
| 0228 | 3 | I | 13.0 | | 0.7 | 95.27 | | 4.73 |
| | 3 | II | 17.6 | | 1.7 | 90.33 | | 9.67 |

Table 11. Schedule of experimental procedure.

| Age of calf | Procedure |
|---|---|
| 3-5 days of age | Removed from dam and placed in calf barn |
| 19 days of age | Ration group 2 or 3 started on grain or hay |
| 49 days of age | Placed in metabolism cage |
| 53 days of age | Digestion trial I preliminary period started |
| 63 days of age | Digestion trial I collection period started |
| 70 days of age | Moved from metabolism cages to calf barn |
| 77 days of age | Placed in metabolism cages for trial II |
| 81 days of age | Digestion trial II preliminary period started |
| 91 days of age | Digestion trial II collection period started |
| 98 days of age | Digestion trial II concluded |

Table 12. Analysis and calculations of coefficients of digestion for calf No. 0151.

| Description | Sample No. | Total Amount | Dry Matter | Crude Protein | Ether Extract | N.F.E. | Ash |
|---|---|---|---|---|---|---|---|
| | | | 63 to 70 days of age | | | | |
| Milk analysis percent | A- 1-51 | | 10.99 | 3.27 | 2.95 | 4.06 | .69 |
| Milk analysis percent | A- 2-51 | | 11.04 | 3.13 | 2.83 | 4.38 | .68 |
| Feces analysis percent | A- 3-51 | | 18.77 | 7.15 | 2.72 | 3.21 | 5.68 |
| Milk nutrients g | A- 1-51 | 27760. | 3050.82 | 908.02 | 821.41 | 1127.61 | 193.70 |
| Milk nutrients g | A- 2-51 | 20820. | 2300.19 | 652.70 | 590.24 | 913.78 | 143.34 |
| Ingested nutrients g | | | 5351.0 | 1560.73 | 1411.66 | 2041.40 | 377.04 |
| Feces nutrients g | A- 3-51 | 421.2 | 79.10 | 30.15 | 11.45 | 13.55 | 23.94 |
| Absorbed nutrients g | | | 5271.91 | 1530.58 | 1400.20 | 2027.84 | 313.09 |
| Coefficients of digestion | | | 98.52 | 98.06 | 99.18 | 99.33 | 92.89 |
| | | | 91 to 98 days of age | | | | |
| Milk analysis percent | A-18-51 | | 10.82 | 3.03 | 2.82 | 4.25 | .69 |
| Milk analysis percent | A-11-51 | | 10.82 | 3.24 | 3.01 | 3.83 | .72 |
| Feces analysis percent | A-20-51 | | 7.95 | 8.16 | 2.82 | 2.24 | 4.71 |
| Milk nutrients g | A-18-51 | 24732.0 | 2680.73 | 751.6 | 699.66 | 1052.79 | 172.67 |
| Milk nutrients g | A-11-51 | 32976. | 3565. | 1069.74 | 994.55 | 1264.56 | 240.13 |
| Ingested nutrients g | | | 6245.73 | 1821.34 | 1694.22 | 2317.35 | 412.80 |
| Feces nutrients g | A-20-51 | 1002.8 | 79.74 | 81.88 | 28.35 | 22.50 | 47.27 |
| Absorbed nutrients g | | | 6165.99 | 1739.45 | 1665.86 | 2294.84 | 365.53 |
| Coefficients of digestion | | | 98.72 | 95.50 | 98.32 | 99.02 | 88.54 |

Table 13. Analysis and calculations of coefficients of digestion for calf No. 0341.

| Description | Sample No. | Total Amount | Dry Matter | Crude Protein | Ether Extract | N.F.E. | Ash |
|---|---|---|---|---|---|---|---|
| | | 63 to 70 days of age | | | | | |
| Milk analysis percent | A- 5-51 | | 10.06 | 3.09 | 3.01 | 3.24 | .70 |
| Feces analysis percent | A- 7-51 | | 18.86 | 9.73 | 3.54 | 1.32 | 4.27 |
| Milk nutrients g | A- 5-51 | 29578.0 | 2975.54 | 916.62 | 891.18 | 959.80 | 207.87 |
| Feces nutrients g | A- 7-51 | 388.6 | 73.32 | 37.81 | 13.74 | 5.15 | 16.59 |
| Absorbed nutrients g | | | 2902.22 | 878.80 | 887.44 | 954.65 | 191.27 |
| Coefficients of digestion | | | 97.53 | 95.87 | 99.57 | 99.46 | 92.01 |
| | | 91 to 98 days of age | | | | | |
| Milk analysis percent | A-19-51 | | 10.81 | 3.01 | 2.92 | 4.19 | .67 |
| Milk analysis percent | A-21-51 | | 11.65 | 3.08 | 3.66 | 4.20 | .70 |
| Feces analysis percent | A-24-51 | | 19.05 | 8.59 | 2.05 | 3.49 | 4.91 |
| Feces analysis percent | A-31-51 | | 20.51 | 8.29 | 4.42 | 4.89 | 4.49 |
| Milk nutrients g | A-19-51 | 19568. | 2115.88 | 590.75 | 572.75 | 818.89 | 132.47 |
| Milk nutrients g | A-21-51 | 14676. | 1711.07 | 452.90 | 573.58 | 616.39 | 103.39 |
| Ingested nutrients g | | | 3826.96 | 1043.65 | 1110.33 | 1436.29 | 235.86 |
| Feces nutrients g | A-24-51 | 124.8 | 23.78 | 10.72 | 2.55 | 4.36 | 6.13 |
| Feces nutrients g | A-31-51 | 511.0 | 104.81 | 42.40 | 22.61 | 24.99 | 22.97 |
| Total feces nutrients g | | | 138.59 | 53.12 | 25.17 | 29.35 | 29.10 |
| Absorbed nutrients g | | | 3688.36 | 990.53 | 1085.16 | 1406.93 | 206.76 |
| Coefficients of digestion | | | 96.35 | 94.90 | 97.73 | 97.95 | 87.65 |

Table 14. Analysis and calculations of coefficients of digestion for calf No. 0152.

| Description | Sample No. | Total Amount | Dry Matter | Crude Protein | Ether Extract | N.F.E. | Ash |
|---|---|---|---|---|---|---|---|
| | | 63 to 70 days of age | | | | | |
| Milk analysis percent | A- 6-51 | | 10.50 | 3.15 | 2.78 | 3.88 | .67 |
| Feces analysis percent | A- 8-51 | | 21.98 | 10.39 | 3.66 | 2.30 | 5.62 |
| Milk nutrients g | A- 6-51 | 40222. | 4226.12 | 1269.40 | 1120.18 | 1563.83 | 272.38 |
| Feces nutrients g | A- 8-51 | 350 | 76.99 | 36.40 | 12.81 | 8.08 | 19.68 |
| Absorbed nutrients g | | | 4149.02 | 1232.99 | 1107.36 | 1555.74 | 252.70 |
| Coefficients of digestion | | | 98.17 | 97.13 | 98.85 | 99.48 | 92.80 |
| | | 91 to 98 days of age | | | | | |
| Milk analysis percent | A-22-51 | | 11.73 | 3.21 | 3.75 | 4.04 | .71 |
| Milk analysis percent | A-25-51 | | 10.05 | 3.08 | 3.16 | 3.07 | .72 |
| Feces analysis percent | A-28-51 | | 19.16 | 7.10 | 3.78 | 2.71 | 5.55 |
| Milk nutrients g | A-22-51 | 25368. | 2977.69 | 814.82 | 951.30 | 1025.88 | 181.99 |
| Milk nutrients g | A-25-51 | 25368 | 2549.73 | 783.36 | 808.64 | 780.85 | 182.87 |
| Ingested nutrients g | | | 5527.43 | 1598.18 | 1759.94 | 1806.73 | 364.86 |
| Feces nutrients g | A-28-51 | | 231.28 | 85.80 | 45.62 | 32.78 | 67.07 |
| Absorbed nutrients g | | | 5296.14 | 1512.37 | 1714.31 | 1773.95 | 297.79 |
| Coefficients of digestion | | | 95.81 | 94.63 | 97.40 | 98.18 | 81.61 |

Table 15. Analysis and calculations of coefficients of digestion for calf No. 27A.

| Description | Sample No. | Total Amount | Dry Matter | Crude Protein | Ether Extract | N.F.E. | Ash |
|---|---|---|---|---|---|---|---|
| | | | 63 to 70 days of age | | | | |
| Milk analysis percent | A-54-51 | | 10.96 | 3.0 | 3.2 | 4.02 | .72 |
| Feces analysis percent | A-53-51 | | 22.45 | 10.61 | 2.91 | 3.18 | 5.72 |
| Milk nutrients g | A-54-51 | 22344 | 2448.90 | 670.54 | 715.45 | 900.44 | 162.46 |
| Feces nutrients g | A-53-51 | 652 | 146.41 | 69.17 | 19.03 | 20.85 | 37.34 |
| Absorbed nutrients g | | | 2302.48 | 601.36 | 696.41 | 869.58 | 125.11 |
| Coefficients of digestion | | | 94.02 | 89.68 | 97.33 | 96.57 | 77.01 |
| | | | 91 to 96 days of age | | | | |
| Milk analysis percent | A-70-51 | | 10.45 | 2.96 | 2.73 | 4.07 | .66 |
| Feces analysis percent | A-69-51 | | 13.86 | 5.4 | 3.41 | 2.02 | 3.01 |
| Milk nutrients g | A-70-51 | 18800 | 196.49 | 55.83 | 51.49 | 76.69 | 12.47 |
| Feces nutrients g | A-70-51 | 72 | 9.98 | 3.89 | 2.46 | 1.45 | 2.17 |
| Absorbed nutrients g | | | 185.51 | 51.94 | 49.03 | 75.23 | 10.30 |
| Coefficients of digestion | | | 94.40 | 93.02 | 95.22 | 98.09 | 86.37 |

Table 16. Analysis and calculations of coefficients of digestion of Calf No. 0153.

| Description | Sample Number | Total Amount | Dry Matter | Crude Protein | Ether Extract | Crude Fiber | N.F.E. | Ash |
|---|---|---|---|---|---|---|---|---|
| | | | 63 to 70 days of age | | | | | |
| Milk analysis percent | A- 9-51 | | 10.25 | 3.10 | 3.10 | | 3.36 | .68 |
| Alfalfa analysis percent | A-15-51 | | 87.49 | 18.81 | 2.17 | 25.94 | 37.23 | 8.64 |
| Feces analysis percent | A-12-51 | | 90.75 | 20.50 | 6.88 | 20.64 | 26.13 | 11.40 |
| Milk nutrients g | A- 9-51 | 34874 | 3577.37 | 1082.29 | 1082.29 | | 1172.77 | 240.52 |
| Alfalfa nutrients g | A-15-51 | 1792 | 1567.82 | 337.07 | 38.88 | 369.86 | 667.16 | 154.82 |
| Ingested nutrients g | | | 5145.19 | 1419.37 | 1121.18 | 369.86 | 1839.93 | 395.35 |
| Feces nutrients g | A-12-51 | 1188 | 1079.29 | 243.54 | 81.73 | 308.16 | 310.42 | 135.43 |
| Absorbed nutrients g | | | 4065.89 | 1175.83 | 1039.44 | 61.70 | 1529.50 | 260.92 |
| Coefficients of digestion | | | 79.02 | 82.84 | 92.71 | 20.02 | 83.12 | 65.74 |
| | | | 91 to 98 days of age | | | | | |
| Milk analysis percent | A-29-51 | | 11.38 | 3.16 | 2.83 | | 4.67 | .70 |
| Milk analysis percent | A-42-51 | | 10.97 | 3.18 | 2.81 | | 4.32 | .65 |
| Alfalfa analysis percent | A-32-51 | | 86.52 | 16.50 | 1.74 | 22.22 | 38.55 | 7.51 |
| Feces analysis percent | A-37-51 | | 88.98 | 18.25 | 4.18 | 27.20 | 29.40 | 9.45 |
| Milk nutrients g | A-29-51 | 28080 | 3197.18 | 888.45 | 796.62 | | 1314.03 | 198.07 |
| Milk nutrients g | A-42-51 | 21060 | 2310.99 | 669.89 | 592.16 | | 910.73 | 137.56 |
| Alfalfa nutrients g | A-32-51 | 4340 | 3754.96 | 716.10 | 75.51 | 964.34 | 1673.07 | 325.934 |
| Ingested nutrients g | | | 9263.15 | 2274.44 | 1464.31 | 964.34 | 3897.84 | 661.57 |
| Feces nutrients g | A-37-51 | 6864 | 1658.87 | 340.18 | 77.91 | 516.32 | 548.01 | 176.14 |
| Absorbed nutrients g | | | 7604.28 | 1934.26 | 1386.39 | 448.02 | 3349.82 | 485.42 |
| Coefficients of digestion | | | 82.09 | 85.04 | 94.65 | 46.45 | 85.94 | 73.37 |

Table 17. Analysis and calculations of coefficients of digestion for calf No. 0157.

| Description | Sample Number | Total Amount | Dry Matter | Crude Protein | Ether Extract | Crude Fiber | N.F.E. | Ash |
|---|---|---|---|---|---|---|---|---|
| | | | 63 to 70 days of age | | | | | |
| Milk analysis percent | A-59-51 | | 11.12 | 3.08 | 2.52 | | 4.71 | .80 |
| Milk analysis percent | A-60-51 | | 10.89 | 3.05 | 2.51 | | 4.48 | .82 |
| Alfalfa analysis percent | A-63-51 | | 86.81 | 18.00 | 2.03 | 21.39 | 8.19 | 37.20 |
| Feces analysis percent | A-66-51 | | 90.85 | 17.69 | 4.83 | 28.45 | 12.63 | 27.25 |
| Milk nutrients g | A-59-51 | 28992 | 3226.22 | 895.70 | 732.54 | | 1365.58 | 232.39 |
| Milk nutrients g | A-60-51 | 21744 | 2368.79 | 664.82 | 547.73 | | 975.95 | 180.06 |
| Alfalfa nutrients g | A-63-51 | 4480 | 3889.08 | 806.40 | 90.94 | 958.27 | 1166.56 | 366.91 |
| Ingested nutrients g | | | 9484.10 | 2366.92 | 1371.21 | 958.27 | 4008.09 | 779.37 |
| Feces nutrients g | A-66-51 | 3032 | 2743.67 | 534.23 | 145.86 | 859.19 | 822.95 | 381.42 |
| Absorbed nutrients g | | | 6740.43 | 1832.69 | 1225.34 | 99.08 | 3185.14 | 398.94 |
| Coefficients of digestion | | | 71.07 | 77.42 | 86.36 | 10.33 | 96.17 | 51.18 |
| | | | 91 to 98 days of age | | | | | |
| Milk analysis percent | A-73-51 | | 11.01 | 3.01 | 2.73 | | 4.52 | .73 |
| Alfalfa analysis percent | A-78-51 | | 89.72 | 17.63 | 1.90 | 22.74 | 39.42 | 8.03 |
| Feces analysis percent | A-75-51 | | 94.44 | 17.13 | 3.91 | 30.83 | 36.24 | 12.24 |
| Milk nutrients g | A-73-51 | 59360 | 6537.91 | 1790.23 | 1622.78 | | 2687.82 | 437.06 |
| Alfalfa nutrients g | A-78-51 | 6552 | 5878.45 | 1155.11 | 124.48 | 1489.92 | 2582.79 | 526.12 |
| Ingested nutrients g | | | 12416.36 | 2945.35 | 1747.27 | 1489.92 | 5270.71 | 963.19 |
| Feces nutrients g | A-75-51 | 2416 | 2281.67 | 413.86 | 94.46 | 744.85 | 730.59 | 295.71 |
| Absorbed nutrients g | | | 10134.69 | 2531.49 | 1652.80 | 745.07 | 4540.12 | 668.47 |
| Coefficients of digestion | | | 83.45 | 85.94 | 94.59 | 50.00 | 86.13 | 69.40 |

Table 18. Analysis and calculations of coefficients of digestion for calf No. 0154.

| Description | Sample Number | Total Amount | Dry Matter | Crude Protein | Ether Extract | Crude Fiber | N.F.E. | Ash |
|---|---|---|---|---|---|---|---|---|
| | | | 63 to 70 days of age | | | | | |
| Milk analysis percent | A-10-51 | | 10.43 | 3.15 | 2.96 | | 3.60 | .70 |
| Alfalfa analysis percent | A-14-51 | | 87.52 | 18.81 | 2.30 | 20.48 | 37.03 | 8.90 |
| Feces analysis percent | A-13-51 | | 91.02 | 23.25 | 6.46 | 20.79 | 27.97 | 12.55 |
| Milk nutrients g | A-10-51 | 31710 | 3307.67 | 1001.71 | 939.56 | | 1143.93 | 222.44 |
| Alfalfa nutrients g | A-14-51 | 1652 | 1445.83 | 310.74 | 37.99 | 338.32 | 611.73 | 147.02 |
| Ingested nutrients g | | | 4753.50 | 1312.45 | 977.56 | 338.32 | 1755.66 | 369.47 |
| Feces nutrients g | A-13-51 | 944 | 859.32 | 219.48 | 161.07 | 196.25 | 264.03 | 118.47 |
| Absorbed nutrients g | | | 3894.17 | 1092.97 | 916.48 | 142.07 | 1491.63 | 251.00 |
| Coefficients of digestion | | | 81.92 | 83.27 | 93.75 | 41.99 | 84.96 | 67.93 |
| | | | 91 to 98 days of age | | | | | |
| Milk analysis percent | A-42-51 | | 10.97 | 3.18 | 2.81 | | 4.32 | .65 |
| Milk analysis percent | A-30-51 | | 11.51 | 3.19 | 3.04 | | 4.45 | .72 |
| Alfalfa analysis percent | A-33-51 | | 85.32 | 16.50 | 1.76 | 21.92 | 37.62 | 7.51 |
| Feces analysis percent | A-38-51 | | 90.55 | 19.13 | 4.83 | 28.40 | 29.38 | 9.81 |
| Milk nutrients g | A-30-51 | 25368 | 2919.85 | 809.23 | 772.2 | | 1130.67 | 184.90 |
| Milk nutrients g | A-42-51 | 19026 | 2087.79 | 605.19 | 534.97 | | 824.68 | 124.27 |
| Alfalfa nutrients g | A-33-51 | 3920 | 3344.54 | 646.80 | 68.99 | 859.26 | 1474.70 | 294.39 |
| Ingested nutrients g | | | 8352.19 | 2061.23 | 1376.16 | 859.26 | 3430.06 | 607.57 |
| Feces nutrients g | A-38-51 | 1604 | 1452.42 | 306.84 | 77.47 | 455.53 | 471.25 | 157.35 |
| Absorbed nutrients g | | | 6899.77 | 1754.39 | 1298.69 | 403.72 | 2958.80 | 450.32 |
| Coefficients of digestion | | | 82.61 | 85.11 | 93.71 | 46.98 | 86.26 | 74.11 |

Table 19. Analysis and calculations of coefficients of digestion for calf No. 0156.

| Description | Sample Number | Total Amount | Dry Matter | Crude Protein | Ether Extract | Crude Fiber | N.F.E. | Ash |
|---|---|---|---|---|---|---|---|---|
| | | | 63 to 70 days of age | | | | | |
| Milk analysis percent | A-41-51 | | 10.69 | 2.97 | 2.84 | | 4.21 | .65 |
| Milk analysis percent | A-43-51 | | 10.70 | 2.85 | 2.90 | | 4.24 | .71 |
| Alfalfa analysis percent | A-34-51 | | 86.31 | 18.31 | 1.97 | 19.38 | 38.78 | 7.87 |
| Feces analysis percent | A-50-51 | | 90.59 | 19.63 | 5.57 | 26.15 | 27.81 | 11.43 |
| Milk nutrients g | A-41-51 | 31260 | 3343.47 | 929.57 | 889.78 | | 1318.88 | 205.22 |
| Milk nutrients g | A-43-51 | 12504 | 1338.94 | 356.66 | 363.06 | | 530.16 | 89.04 |
| Alfalfa nutrients g | A-34-51 | 3836 | 3302.22 | 700.54 | 75.37 | 741.47 | 1483.72 | 301.10 |
| Ingested nutrients g | | | 7983.63 | 1989.78 | 1328.22 | 741.47 | 3332.78 | 595.37 |
| Feces nutrients g | A-50-51 | 1668 | 1511.04 | 327.42 | 92.90 | 436.18 | 463.87 | 190.65 |
| Absorbed nutrients g | | | 6472.59 | 1659.35 | 1235.31 | 305.29 | 2868.91 | 404.72 |
| Coefficients of digestion | | | 81.07 | 83.51 | 93.00 | 41.17 | 86.08 | 67.97 |
| | | | 91 to 98 days of age | | | | | |
| Milk analysis percent | A-54-51 | | 10.96 | 3.04 | 3.20 | | 3.98 | .72 |
| Alfalfa analysis percent | A-52-51 | | 83.31 | 17.94 | 2.06 | 21.35 | 36.12 | 7.84 |
| Feces analysis percent | A-57-51 | | 90.94 | 18.50 | 5.90 | 30.33 | 24.62 | 11.59 |
| Milk nutrients g | A-59-51 | 57078 | 6255.74 | 1739.05 | 1827.92 | | 2273.47 | 415.29 |
| Alfalfa nutrients g | A-52-51 | 5068 | 4323.51 | 909.19 | 104.40 | 1082.01 | 1830.56 | 397.33 |
| Ingested nutrients g | | | 10579.25 | 2648.25 | 1932.32 | 1082.01 | 4104.03 | 812.63 |
| Feces nutrients g | A-57-51 | 2085 | 1896.09 | 385.72 | 123.01 | 632.38 | 513.32 | 241.65 |
| Absorbed nutrients g | | | 8683.15 | 2262.52 | 1809.30 | 449.63 | 3590.70 | 570.97 |
| Coefficients of digestion | | | 82.07 | 85.43 | 93.63 | 41.55 | 87.49 | 70.26 |

Table 20. Analysis and calculations of coefficients of digestion for calf No. 25A.

| Description | Sample Number | Total Amount | Dry Matter | Crude Protein | Ether Extract | Crude Fiber | N.F.E. | Ash |
|---|---|---|---|---|---|---|---|---|
| | | | 63 to 70 days of age | | | | | |
| Milk analysis percent | A-23-51 | | 11.35 | 3.21 | 3.21 | | 4.19 | .72 |
| Milk analysis percent | A-26-51 | | 11.33 | 3.05 | 3.26 | | 4.31 | .70 |
| Oats analysis percent | A-17-51 | | 89.26 | 12.69 | 3.43 | 9.12 | 60.43 | 3.59 |
| Feces analysis percent | A-35-51 | | 91.14 | 13.13 | 2.62 | 23.12 | 42.73 | 9.54 |
| Milk nutrients g | A-23-51 | 7200 | 817.70 | 231.76 | 231.26 | | 302.25 | 52.35 |
| Milk nutrients g | A-26-51 | 9600 | 1088.06 | 292.89 | 313.52 | | 414.28 | 67.47 |
| Oats nutrients g | A-17-51 | 742 | 662.30 | 94.15 | 35.45 | 67.67 | 448.39 | 26.63 |
| Ingested nutrients g | | | 2568.07 | 618.82 | 570.23 | 67.67 | 1164.92 | 146.46 |
| Feces nutrients g | A-35-51 | 375 | 341.77 | 49.23 | 9.82 | 86.70 | 160.23 | 35.77 |
| Absorbed nutrients g | | | 2226.30 | 569.58 | 560.40 | -19.03 | 1004.68 | 110.69 |
| Coefficients of digestion | | | 86.69 | 92.04 | 98.27 | -28.12 | 86.24 | 75.57 |
| | | | 91 to 98 days of age | | | | | |
| Milk analysis percent | A-44-51 | | 11.66 | 3.45 | 2.47 | | 4.98 | .74 |
| Milk analysis percent | A-46-51 | | 11.75 | 2.92 | 2.55 | | 5.58 | .69 |
| Oats analysis percent | A-39-51 | | 87.22 | 12.13 | 3.42 | 10.10 | 58.20 | 3.37 |
| Feces analysis percent | A-49-51 | | 90.05 | 13.31 | 2.62 | 24.40 | 40.42 | 9.30 |
| Milk nutrients g | A-44-51 | 18216 | 2123.98 | 629.74 | 450.97 | | 908.06 | 135.30 |
| Milk nutrients g | A-46-51 | 3036 | 357.00 | 88.71 | 77.43 | | 169.49 | 21.23 |
| Oats nutrients g | A-39-51 | 1876 | 1636.24 | 227.55 | 64.15 | 189.47 | 1091.83 | 63.22 |
| Ingested nutrients g | | | 4127.23 | 946.01 | 592.56 | 189.47 | 2169.39 | 219.76 |
| Feces nutrients g | A-49-51 | 623 | 561.01 | 82.92 | 16.32 | 152.01 | 251.81 | 57.93 |
| Absorbed nutrients g | | | 3566.22 | 863.09 | 576.24 | 37.46 | 1917.58 | 161.82 |
| Coefficients of digestion | | | 86.40 | 91.23 | 97.24 | 19.77 | 88.39 | 73.63 |

Table 21. Analysis and calculations of coefficients of digestion for calf No. 0227.

| Description | Sample Number | Total Amount | Dry Matter | Crude Protein | Ether Extract | Crude Fiber | N.F.E. | Ash |
|---|---|---|---|---|---|---|---|---|
| | | | 63 to 70 days of age | | | | | |
| Milk analysis percent | A-58-51 | | 10.75 | 3.00 | 2.70 | | 4.19 | .75 |
| Oats analysis percent | A-64-51 | | 89.08 | 13.19 | 3.46 | 9.28 | 60.01 | 3.14 |
| Feces analysis percent | A-61-51 | | 91.17 | 15.19 | 3.31 | 20.41 | 40.51 | 10.75 |
| Milk nutrients g | A-58-51 | 39060 | 4200.90 | 1174.92 | 1055.16 | | 1108.98 | 293.45 |
| Oats nutrients g | A-64-51 | 1848 | 1646.18 | 243.75 | 63.94 | 171.49 | 1638.56 | 58.02 |
| Ingested nutrients g | | | 5847.10 | 1418.67 | 1119.10 | 171.49 | 2747.55 | 351.48 |
| Feces nutrients g | A-61-51 | 610 | 556.68 | 92.75 | 20.21 | 124.62 | 369.47 | 65.63 |
| Absorbed nutrients g | | | 5290.41 | 1325.92 | 1098.89 | 46.87 | 2378.07 | 285.84 |
| Coefficients of digestion | | | 90.47 | 93.46 | 98.87 | 26.60 | 86.55 | 81.32 |
| | | | 91 to 98 days of age | | | | | |
| Milk analysis percent | A-73-51 | | 11.01 | 3.01 | 2.73 | | 4.52 | .73 |
| Oats analysis percent | A-77-51 | | 87.80 | 13.19 | 4.04 | 7.62 | 60.20 | 2.75 |
| Feces analysis percent | A-76-51 | | 9430 | 14.06 | 4.17 | 24.08 | 43.57 | 8.40 |
| Milk nutrients g | A-73-51 | 46172 | 5085.38 | 1392.5 | 1262.25 | | 2090.66 | 339.96 |
| Oats nutrients g | A-77-51 | 5096 | 4474.28 | 672.16 | 205.87 | 388.31 | 3067.79 | 140.14 |
| Ingested nutrients g | | | 9559.67 | 2064.66 | 1478.12 | 388.31 | 5158.46 | 480.14 |
| Feces nutrients g | A-76-51 | 1352 | 1274.93 | 190.09 | 46.37 | 325.56 | 589.06 | 113.56 |
| Absorbed nutrients g | | | 8484.73 | 1874.57 | 1431.75 | 62.75 | 4569.39 | 366.53 |
| Coefficients of digestion | | | 86.66 | 90.79 | 96.86 | 16.16 | 88.50 | 76.34 |

Table 22. Analysis and calculations of coefficients of digestion for calf No. 26A.

| Description | Sample Number | Total Amount | Dry Matter | Crude Protein | Ether Extract | Crude Fiber | N.F.E. | Ash |
|---|---|---|---|---|---|---|---|---|
| | | | 63 to 70 days of age | | | | | |
| Milk analysis percent | A-27-51 | | 11.61 | 3.06 | 3.48 | | 4.36 | .70 |
| Oats analysis percent | A-16-51 | | 89.07 | 12.50 | 3.63 | 9.41 | 60.18 | 3.35 |
| Feces analysis percent | A-36-51 | | 89.98 | 17.38 | 2.66 | 20.10 | 38.07 | 11.77 |
| Milk nutrients g | A-27-51 | 20286 | 2355.81 | 621.36 | 707.16 | | 884.67 | 143.01 |
| Oats nutrients g | A-16-51 | 896 | 798.06 | 112. | 32.52 | 84.31 | 539.21 | 30.01 |
| Ingested nutrients g | | | 3153.88 | 733.36 | 739.69 | 84.31 | 1423.88 | 173.03 |
| Feces nutrients g | A-36-51 | 342 | 308.30 | 59.55 | 9.11 | 68.87 | 130.44 | 40.32 |
| Absorbed nutrients g | | | 2845.57 | 673.81 | 730.57 | 15.44 | 1293.44 | 133.70 |
| Coefficients of digestion | | | 90.22 | 91.87 | 98.76 | 18.31 | 90.83 | 77.27 |
| | | | 91 to 98 days of age | | | | | |
| Milk analysis percent | A-45-51 | | 11.69 | 3.48 | 2.37 | | 5.06 | .76 |
| Milk analysis percent | A-47-51 | | 10.92 | 2.97 | 2.50 | | 4.7 | .73 |
| Oats analysis percent | A-40-51 | | 87.88 | 11.94 | 3.15 | 10.65 | 58.89 | 3.60 |
| Feces analysis percent | A-48-51 | | 90.04 | 15.75 | 3.33 | 23.06 | 38.89 | 9.01 |
| Milk nutrients g | A-45-51 | 11688 | 1366.56 | 406.84 | 277.73 | | 592.18 | 89.78 |
| Milk nutrients g | A-47-51 | 15584 | 1701.77 | 463.81 | 390.09 | | 732.89 | 114.96 |
| Oats nutrients g | A-40-51 | 2408 | 2116.15 | 287.51 | 75.85 | 256.45 | 1409.64 | 86.68 |
| Ingested nutrients g | | | 5184.48 | 1158.17 | 743.68 | 256.45 | 2734.72 | 291.44 |
| Feces nutrients g | A-48-51 | 520 | 468.20 | 81.9 | 17.31 | 119.91 | 202.22 | 46.85 |
| Absorbed nutrients g | | | 4716.27 | 1076.27 | 726.36 | 136.54 | 2532.49 | 244.58 |
| Coefficients of digestion | | | 90.09 | 92.92 | 97.66 | 53.24 | 92.60 | 83.92 |

Table 23. Analysis and calculations of coefficients of digestion for calf No. 0228.

| Description | Sample Number | Total Amount | Dry Matter | Crude Protein | Ether Extract | Crude Fiber | N.F.E. | Ash |
|---|---|---|---|---|---|---|---|---|
| | | | 63 to 70 days of age | | | | | |
| Milk analysis percent | A-58-51 | | 10.75 | 3.0 | 2.70 | | 4.29 | .75 |
| Oats analysis percent | A-64-51 | | 89.08 | 13.19 | 3.46 | 9.28 | 60.01 | 3.14 |
| Feces analysis percent | A-62-51 | | 90.12 | 13.69 | 3.24 | 22.60 | 39.64 | 10.95 |
| Milk nutrients g | A-58-51 | 41216 | 4432.78 | 1239.77 | 1113.40 | | 1772.06 | 309.65 |
| Oats nutrients g | A-64-51 | 2072 | 1845.73 | 273.29 | 71.69 | 192.28 | 1243.50 | 65.06 |
| Ingested nutrients g | | | 6278.51 | 1513.07 | 1185.10 | 192.28 | 3015.56 | 374.71 |
| Feces nutrients g | A-62-51 | 693.9 | 625.34 | 94.99 | 22.48 | 156.82 | 275.06 | 75.98 |
| Absorbed nutrients | | | 5653.17 | 1418.07 | 1163.61 | 35.46 | 2740.50 | 287.73 |
| Coefficients of digestion | | | 90.03 | 93.72 | 98.18 | 22.61 | 90.77 | 79.72 |
| | | | 91 to 98 days of age | | | | | |
| Milk analysis percent | A-73-51 | | 11.01 | 3.01 | 2.73 | | 4.52 | .73 |
| Oats analysis percent | A-77-51 | | 87.80 | 13.19 | 4.04 | 7.62 | 60.20 | 2.75 |
| Feces analysis percent | A-74-51 | | 93.80 | 15.44 | 4.42 | 22.65 | 42.29 | 9.00 |
| Milk nutrients g | A-73-51 | 55706 | 6135.45 | 1680.03 | 1522.89 | | 2522.36 | 410.16 |
| Oats nutrients g | A-77-51 | 5376 | 4720.12 | 709.09 | 217.19 | 409.65 | 3236.35 | 147.84 |
| Ingested nutrients g | | | 10855.58 | 2389.12 | 1740.08 | 409.65 | 5758.71 | 558.0 |
| Feces nutrients g | A-74-51 | 1108 | 1039.30 | 171.07 | 48.97 | 250.96 | 468.57 | 99.72 |
| Absorbed nutrients g | | | 9816.28 | 2218.04 | 1692.10 | 158.68 | 5290.14 | 458.28 |
| Coefficients of digestion | | | 90.42 | 92.83 | 97.24 | 38.73 | 91.86 | 82.12 |

# THE EFFECTS OF AUREOMYCIN ON THE DIGESTIBILITY OF VARIOUS RATIONS BY DAIRY CALVES

by

Kenneth Lavonne Wheatcroft

B. S., Kansas State College
of Agriculture and Applied Science, 1950

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An Abstract of a Thesis

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Chemistry

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1952

Investigators have demonstrated that antibiotics have a markedly favorable effect on growth, gastro-intestinal disorders, and physical appearance of poultry, swine, rats, and dairy calves when included in their diets. The mechanism whereby the beneficial results of antibiotic feeding are obtained is not yet known. Some investigators suggest that the antibiotics exert their influence by altering the populations of intestinal and rumen microflora. It also has been suggested that the antibiotics may have a systemic effect and that possibly the antibiotic molecule or a fragment of it may act as a metabolite within the body. It was thought that an investigation of the digestibility of feeds by animals receiving antibiotics would perhaps help explain the mode of action of the antibiotics.

A series of digestion trials were conducted with dairy calves to determine the effect of aureomycin on the digestibility of various rations with dairy calves. Twelve male dairy calves were paired by breed and age. Each pair was assigned at random to one of three groups. Ration group 1 received a ration of milk only, ration group 2 received a ration of milk and oats, and ration group 3 received a ration of milk and alfalfa hay. One calf in each pair was chosen at random to receive 25 mg of aureomycin per 100 pounds of body weight daily, and the other calf in the pair served as a control.

Digestion trials were conducted when calves were 63 to 70 days of age and 91 to 98 days of age. A ten day preliminary period preceded the seven day collection period. Milk was fed at the rate of 1 pound per 10 pounds body weight daily during both digestion trials. Grain and hay were fed at the rate of 20 g per 10 pounds body weight daily during digestion trial I, and at the rate of 40 g per 10 pounds body weight during digestion trial II. The apparent coefficient of digestion for dry matter, crude protein, ether extract, N.F.E., crude fiber, and ash were determined on the three rations. The rate of growth and feed efficiency were computed from recorded observations.

At 63 to 70 days and at 91 to 98 days of age the digestibility of a ration of milk only by aureomycin fed calves was the same as the digestibility by calves not receiving aureomycin. The calves had the same ability to digest milk at both ages.

Experimental and control calves fed milk and oats had similar coefficients of digestible dry matter, crude protein, ether extract, N.F.E., and ash at 63 to 70 days and at 91 to 98 days of age. At 63 to 70 days of age, crude fiber was digested -0.9 percent by experimental calves and 20.5 percent by control calves. The negative result being due to a -28.1 percent crude fiber for calf 25A. The other experimental calf (0227) digested 26.3 percent crude fiber at 61 to 70 days of age. Average digestion coefficients for crude fiber at 91 to 98 days of age were: controls, 46.0; experimental, 18.0.

The results on ration group 3 receiving milk and alfalfa hay indicated no difference between aureomycin fed calves and control calves except in the digestibility of crude fiber at 63 to 70 days of age. The control calves of this group digested crude fiber better than experimental calves at 63 to 70 days of age but digested about the same percentage of crude fiber at 91 to 98 days of age.

The average coefficient of digestion of crude fiber for all aureomycin fed calves in ration groups 2 and 3 was 25.7 and the average for all control calves was 37.2. Aureomycin did not appear to effect the digestibility of crude fiber in this experiment, because of the variance in digestible crude fiber between individual calves and the small number of experimental subjects.

Aureomycin increased the rate of gain of dairy calves receiving rations of milk, milk and oats, and milk and alfalfa hay. Feed efficiency was higher in aureomycin fed calves in all three ration groups. The feces of aureomycin fed calves was firmer than the feces of control calves.

The beneficial results in growth and feed efficiency shown by aureomycin fed dairy calves can not be explained by the ability of the antibiotic to increase the digestibility of a ration of milk, milk and oats, and milk and alfalfa hay. Conversely, the data indicate that the feeding of aureomycin does not impair digestibility of these rations.