12-1971

Effect of level of feeding and age upon feed digestibility

Ray C. Jordan

To the Graduate Council:

I am submitting herewith a thesis written by Ray C. Jordan entitled "Effect of level of feeding and age upon feed digestibility." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Eric W. Swanson, Major Professor

We have read this thesis and recommend its acceptance:

J. T. Miles, J. A. Corrick Jr., J. K. Bletner

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

151

November 23, 1971

To the Graduate Council:

I am submitting herewith a thesis written by Ray C. Jordan entitled "Effect of Level of Feeding and Age Upon Feed Digestibility." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Dairying.

Eric W. Swanson
Major Professor

We have read this thesis
and recommend its acceptance:

J. T. Miles

J. K. Bletner

J. A. Carroll, Jr.

Accepted for the Council:

Stetson A. Smith
Vice Chancellor for
Graduate Studies and Research

EFFECT OF LEVEL OF FEEDING AND AGE UPON FEED DIGESTIBILITY

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Ray C. Jordan

December 1971

ACKNOWLEDGMENTS

The author wishes to express his appreciation to Dr. E. W. Swanson for his advice and guidance in conducting the research and the preparation of this thesis. The author is indebted to Dr. J. T. Miles, Dr. J. A. Corrick, Jr., and Dr. J. K. Bletner for their review and advice in the preparation of this thesis.

The author expresses appreciation to Mr. Clyde Holmes, the barn crew, and graduate students for their cooperation and help during the investigation, and to Mrs. Ann Lacava for typing the manuscript.

Sincere appreciation is also expressed to his wife, Wilma, for her encouragement and help throughout his graduate work.

ABSTRACT

A digestion trial was conducted to study the effect of age and level of feeding on the digestibility of feed. The 36 Holstein heifers used were part of a growth experiment in which an attempt was made to calculate the total digestible nutrients (TDN) required to obtain 0.8, 1.2, and 1.6 pounds average daily gain (low, medium, high).

The digestibility values were determined by either the total collection or chromic oxide indicator method, using a diet of two parts hay to one part grain mixture. Feed allowances were based on average TDN values of corn (75%) and hay (50%). Three age levels, 7-, 14-, and 19-months, were investigated to compare age effects on digestibility of feed at each of the three feeding levels.

Twelve heifers at each age level were divided into low, medium, or high level of feeding. There were no significant differences ($P>.05$) between the digestion coefficients of energy, crude protein, organic matter, or in TDN at any one of the three levels of feeding, but crude fiber digestibility was significantly lower at the low level of feeding. Significant differences ($P<.05$) were noted in the digestibility of crude protein, crude fiber, organic matter, energy, and in TDN between the 7 month-old heifers and both of the older groups.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Animals can use for growth only a portion of that energy and those nutrients which can be digested from the ration the animals are fed. Fecal losses comprise the major losses determining efficiency of feed utilization. Many workers have estimated or determined the digestible nutrient requirements of dairy cattle for growth. Heifers should be fed so they can be raised as economically as possible and be acceptable in size when production is begun at about two years of age.

It was the objective of this experiment to determine the digestibility of the feed consumed by Holstein heifers on a growth experiment which were fed to gain at 0.8, 1.2, or 1.6 pounds per day. The possibility of differences at three age periods within the growth period was also investigated since preliminary data indicated that the younger animals and those on the lower feeding levels were growing faster than was anticipated from the average relationship between feed intake and daily gain (42).

CHAPTER II

REVIEW OF LITERATURE

Introduction

Experiments comparing different feeding levels of a concentrate-forage mixture at a constant proportion and the effect of age of cattle on digestibility are limited. Work in this general area comparing the level of intake to digestibility often deals with varying ratios of concentrate to forage or different levels of forage alone.

Digestibility of Mixed Rations at Varying Levels of Intake

Blaxter and Wainman (8) observed that higher levels of feeding at all ratios of hay to grain resulted in a decrease in digestibility when the plane of nutrition of cattle and sheep was increased from slightly below maintenance to twice maintenance allowances. Andersen et al. (1) noted that in one of a series of digestion experiments, dry matter digestibility decreased significantly on a 60 percent concentrate ration from an intake of 0.5 times maintenance to 2.7 times maintenance. In two other trials the digestibility of mixed diets decreased as the level of grain consumption increased. However, the digestibility of the same ration and of mixed rations of different proportions was not affected by the level of intake in a group of younger animals. Andersen et al. (1) further noted that with young growing cattle fed up to 2.5 times maintenance there was no evidence that digestibility was lower than at maintenance levels. Kesler and Spahr (20) as well as Conrad et al. (13)

observed that increasing the proportion of concentrates above 60 percent lead to a slight reduction in intake in some cases. Intake response varied among animals because of individual preference for certain feeds. Kesler and Spahr (20) concluded that increased consumption of a ration not changing in composition apparently decreased digestibility.

Dry matter and crude protein digestibility were found to increase as the proportion of concentrates increased in the diet (11, 15, 21, 22, 30, 31, 36). At the same time an opposite effect resulted in decreasing digestibility of crude fiber as the level of intake and proportion of grain increased. Reid (37) noted that the rate of decrease in digestibility, as intake increases, is quite variable among diets. It appears to be more marked for high concentrate diets than for those containing smaller proportions of concentrates. Reid (38) surmised that part of the variation in feeding effects is related to the fact that many total digestible nutrient (TDN) values have been determined at or slightly above maintenance. The extent of the effect of level of feeding on digestibility is variable and is influenced by the composition of the ration. Reid (38) postulated that the TDN values of mixed rations composed of forages and concentrates decline at an ever increasing rate as the amount of ration ingested per unit time increases.

Moe et al. (28), using high producing dairy cows, found that the apparent digestibility of the ration was depressed at levels of intake required for high milk production. Moe et al. (28) speculated that a high level of intake of a ration containing a relatively poor-quality forage might result in a large ruminal fill, possibly resulting in an increased passage of the more digestible portion of the diet.

While most of the rations discussed previously contained corn as the primary concentrate, Watson et al. (44) found no significant difference in the digestibility of dry matter, organic matter, or ether extract when animals were fed equal parts of a grass-clover hay and barley mixture at 1.0, 2.0, 3.0, 4.0, 5.0 kg of each per day. There was also no significant change in the crude fiber digestibility as the plane of nutrition increased. Donefer et al. (15) fed varying proportions of an alfalfa and barley diet to sheep. As the ratio of alfalfa to barley changed from 100:0 to 85:15, 70:30, 55:45, or 40:60, the increase in barley was accompanied by a lower relative ration intake and at the same time an increased digestion coefficient of dry matter, crude protein, crude fiber and ether extract.

Wiktorsson (45) conducted a digestibility experiment with producing cows fed hay, beet pulp and increasing levels of concentrates. He found that there was a significant linear relationship between consumed and digested organic matter, consumed and digested crude protein, consumed and digested ether extract, and consumed and digested nitrogen-free extract. There was no tendency toward a decreased digestibility as the percentage of concentrate increased. If digestibility changed at different levels of feeding, the regression of digested constituent on intakes would have been curvilinear.

Effect of Level of Intake on Protein Digestibility

Conrad and Hibbs (12) found that the apparent digestibility of protein increased when higher proportions of concentrates were included in the ration. He also noted that nitrogen retention in the rumen was

less on the low concentrate diets possibly because of the lower energy level of the ration. Lofgreen et al. (23) showed that additional energy added to a ration low in readily digestible nutrients increased nitrogen retention and demonstrated a direct influence of the energy level in the feed on the rate of nitrogen retention. Blaxter and Wainman (8) found that the digestibility of nitrogen increased with increasing percentage of corn in the ration, and that the rate of digestibility increase was most marked with about 60 percent corn.

Broster et al. (10) found that increasing crude protein above 1.7 pounds per day gave little response in rate of gain of dairy heifers. He found that there was a general trend of additional energy decreasing the digestibility of protein except in one treatment in which no decrease in protein digestibility was noted. Additional protein increased digestibility of crude fiber, but additional protein plus energy decreased crude fiber digestibility. Fecal nitrogen excretion per unit of digestible dry matter was significantly less on higher dry matter rations. Broster et al. (10) also stated that the dry matter digestibility of high energy rations was higher than that of low energy rations, but crude protein and crude fiber digestibility were less.

Digestibility of Energy and Energy Losses

Blaxter (6) in a review, concluded that decided reductions in the metabolizability of feed have been obtained at high nutritional levels and that these reductions necessarily reduce the net energy value of a unit weight of feed at the high levels. He also concluded that the nutritive value of a unit weight of feed is not a constant in the

individual but depends on the amount of feed given. Reid and Tyrrell (39) computed data from Mitchell and Hamilton (27) which showed that as dry matter intake increased the digestible energy as a percentage of gross energy decreased.

Moe et al. (29) found that there were digestibility differences among different types of rations and that in some feeds, much of the increased loss of energy in feces at high levels was compensated for by decreased losses of energy in the methane and urine.

Paladines et al. (33) fed three rations containing chopped hay, chopped-pelleted hay and a pelleted mixture of 55 percent hay-45 percent corn. These three rations were fed at three levels: (1) low--just above maintenance, (2) medium--midway between low and high, (3) and high--ad libitum feeding. They noted that there was less energy loss in feces from sheep from a hay-corn pelleted ration than from the other rations. There was no difference in energy loss between the other two rations. In all trials the fecal energy loss as a percentage of the gross energy intake increased as the level of intake of the two pelleted diets increased. Brody and Procter (9) showed that energy losses in feces increased with increase in plane of nutrition. The digestibility of fiber at all planes of nutrition decreased with increasing dietary gross energy. Garrett et al. (16) found that plane of nutrition had no effect on digestibility of energy.

Effect of Physical Form and Level of Intake on Forage Digestibility

Loosli et al. (24) concluded that there was considerable variation between feeds in the effect of level of feeding on nutrient availability.

Factors which are known to affect digestibility at high levels of feeding include physical form, fineness of grinding, and pelleting. Reid and Tyrrell (39) stated that the digestibility of long or chopped forage (1, 7, 33, 43) is not affected, but finely ground or pelleted forages (4, 6, 7, 11, 24, 33) usually decreased in digestibility as the level of input increased. Reid (37) stated that the digestibility of roughage feeds not containing grain does not decline as the level of intake increases. Blaxter et al. (7) fed hay in three forms: long, medium-ground and cubed, and finely ground and cubed. He found that the ground, cubed hay passed through the digestive tract faster and had a lower digestibility than the long hay. Increasing the feeding level resulted in an increased rate of passage of feed and a fall in digestibility. The most marked differences were found among feeding levels of the cubed, finely ground material. Watson et al. (43) fed hay at 2.5 kg, 4.5 kg, 6.0 kg, 7.5 kg and 9.0 kg per day. The 2.5 kg level was a semi-starvation diet, and 9.0 kg per day represented the limit of capacity of the animal. They found that feed was eaten rapidly and possibly not ruminated or digested completely or normally on the semi-starvation diet. The digestion coefficient of dry matter was only slightly lower at 2.5 kg than for the other diets, which were constant in digestibility at all levels from 4.5 to 9.0 kg of intake. It was generally concluded that the plane of nutrition had no effect on digestibility of dried roughage.

Balch and Campling (4) suggest that their results, using ground roughages, show that the rate of flow of digesta from the rumen may be faster, but the total time of retention in the gut may be lengthened

by presence of large amounts of digesta in the lower gut. This was an attempt to explain earlier results in which grinding had been shown to increase intake slightly, but was accompanied by a depression in digestibility. Rodrigue and Allen (40) showed that the rate of passage and digestibility differed with the degree of grinding.

Varying results have been reported on the effects of pelleting on digestibility. Meyer et al. (26) and Wright et al. (46) both found that pelleted ground hay fed at or slightly above maintenance resulted in coefficients of digestibility not different from that of long or chopped hay. Montgomery and Baumgardt (30) found that grinding and pelleting hay significantly depressed cellulose digestibility, but not the digestibility of total dry matter or energy.

Effect of Age of Animal on Digestibility

Andersen et al. (1) concluded that in young growing animals fed up to 2.5 times maintenance, there was no evidence that digestibility was lower than at maintenance levels. Lassiter et al. (21) noted that in experiments in which decreased digestibility was observed, older animals were used. However, he reported variation in digestibility between rations where younger animals were used. McArthur (25) fed grass to three mature cows and three heifers 8-10 weeks of age and found no difference in digestibility of dry matter, organic matter, crude fiber, ether extract, and nitrogen-free extract. Lower digestion coefficients for crude protein were noted from younger than older animals. Hogue et al. (18) found no differences in digestibility of dry matter, crude fiber, crude protein, ether extract, or nitrogen-free extract between

7 and 16 weeks of age. Preston et al. (35) and Armstrong et al. (2) observed a 75.0 percent dry matter digestion coefficient for grass fed to calves 10 to 12 weeks of age. This value is comparable to that reported in feeding tables obtained with older cattle. An effect comparable to age or feeding level could be expected when digestibility of the same ration is determined with "thin" cows vs. "fat" cows. Graham (17) and Bines et al. (5) found the digestibility of feed was not affected by body condition when intakes were alike.

Comparison of Total Collection Vs. Chromic Oxide Method for Nutrient Digestibility Determination

The oldest and probably the most used method of determining digestibility is the total collection method. By collecting all the fecal matter, an accurate weight can be obtained and a sample taken that will give the examiner a good idea of the digestibility of the ingredients fed.

The indicator method involves using an indigestible, unabsorbable substance, such as chromic oxide, that can be determined accurately in the feces. When a constant amount is fed, the fecal concentration is inversely related to the amount of feces. Phar et al. (34) found that daily feed intake was not significantly affected by the total fecal collection apparatus. There was no significant difference in crude protein, crude fiber, ether extract, nitrogen-free extract or gross energy digestion coefficients calculated by the conventional or the chromic oxide indicator method, but there was a significantly lower dry matter digestion coefficient. Animals receiving chromic oxide

and wearing the collection apparatus to determine the effect of the apparatus showed no effect on the digestibility of dry matter, crude protein, crude fiber, ether extract, and gross energy. Nitrogen-free extract digestibility was significantly lower without the fecal collection apparatus. Kane et al. (19) demonstrated very close agreement between the digestibility of all nutrients as determined by the total collection method, the chromic oxide method, and the lignin indicator method. Recovery of the chromic oxide from the four animals used averaged 99.9 percent of that fed.

Crampton and Lloyd (14) found that if chromic oxide was fed as a premix with a minimum of a five-day preliminary period, it gave very similar results to the conventional total collection method in sheep. Stevenson and deLangen (41) were able to obtain high repeatability of digestion determinations with chromic oxide. Noblitt et al. (32) used chromic oxide results as a reference to determine the effect of 24-hour manual collections on digestibility. He noted a significantly higher digestibility for the animals from which constant collections were made and postulated that the stress of manual collection caused the small but significantly higher digestibility of dry matter and all of its components ($P<.01$). Causes for the higher digestibility were unknown, but Noblitt et al. (32) noted an increase in time the manually collected animals stood up and that they were more restless.

CHAPTER III

EXPERIMENTAL PROCEDURE

Objective of Experiment

This experiment was conducted to determine if there was a difference in feed digestibility at three levels of feeding at each of three different age levels. A digestion trial was conducted using 36 purebred Holstein heifers, 12 at each of three age levels: 19 months, 14 months, and 7 months of age. All animals were being used in a growth experiment and were housed in a stanchion barn. They were all fed a diet consisting of two parts chopped hay to one part of grain in two equal feedings per day. Allowances were calculated according to body weight and projected average daily gain (42).

Materials and Methods

Digestibility determinations. Each of the two older groups of animals was fitted with harness and bag for total collection of the feces. Intake was predetermined by the animals' body weight and target rate of gain and was held constant for a nine-day preliminary period plus a five-day collection period. The collection bags were put on the animals three days before the collection period. Feces were collected twice per day, weighed and recorded, and a 2 percent sample was placed in a polyethylene bag. The samples were frozen until a composite was made at the end of the collection period. The composite was dried in a forced air furnace at 65 degrees Centigrade, and then allowed to

equilibrate to room air-dry basis. The total dry sample was ground in a Wylie mill and stored for laboratory analysis.

The smallest group of heifers could not be satisfactorily fitted with the collection harness so digestibility was determined by use of chromic oxide as an indicator. These animals received 5 grams of chromic oxide thoroughly mixed into the feed, divided into two equal feedings per day. The chromic oxide was made into a premix with part of the grain ration at a 1:10 ratio, and then 25 gram packets were added to each feeding over a nine-day preliminary period followed by a five-day collection period. During the collection period, grab samples of feces were taken twice daily at random times from each animal, placed in plastic bags, labeled and refrigerated. At the end of the collection period, a composite was made from 200 grams of each day's collection, and it was dried in a forced draft oven at 65 degrees Centigrade. The air-dried composite was ground through a Wylie mill and stored for laboratory analyses.

Feeds. Grain mixes of two parts corn and one part oats were ground and thoroughly mixed in a vertical auger mixer. Each mixture was sampled, and the samples were stored in polyethylene bags for grinding in the Wylie mill and laboratory analyses. A composite was made of weekly hay (alfalfa-orchardgrass) samples for the first four weeks from a lot of hay that had been chopped with a forage harvester and stored for the experiment. A second lot of hay of similar quality was used for the last two groups of heifers and was handled in the same manner as the first lot.

Chemical analyses. The wet feces were brought to an air-dry basis by drying in enameled pans at 65 degrees Centigrade for 24 hours in a forced air oven and then allowing the pans to set in the laboratory for 48 hours. The dry matter content of the air-dry rations and feces was determined by drying in a convection oven at 109 degrees Centigrade overnight.

Energy determinations on the ration samples and feces samples were made with a Parr plain (isothermal jacket) bomb calorimeter. Repeatable results with the calorimeter were difficult to obtain at first because of the failure to get a complete burn of the sample material. Sample particles or portions of the sample pellet popped out of the sample cup and also seemed to be affected by the proximity of the ignition wire to the sample pellet. After several trials it was found that a loose sample performed better than pelleted samples if care was taken to add the oxygen slowly. It was also noted that 20 atmospheres of oxygen worked better with the loose sample than the higher recommended limits of 30 atmospheres. Determinations of crude protein, crude fiber, ether extract, ash, and nitrogen-free extract were made according to standard feed analysis procedures (3).

CHAPTER IV

RESULTS AND DISCUSSION

Digestion coefficients of dry matter, crude protein, energy, crude fiber, ether extract, and nitrogen-free extract were determined by using either total collection or chromic oxide indicator in the digestion trial. Complete data for individual heifers are presented in Appendix Tables 6 through 12. The chemical compositions of each of the rations fed (two parts chopped hay and one part corn) are presented in Table 1. All analyses were made in duplicate. Results are reported on a dry matter basis. The schedule for feeding the different feed mixtures (Table 1) to heifers of varying ages to gain at 0.8, 1.2, 1.6 pounds average daily gain (low, medium, high) for the digestion trial is presented in Table 2.

The average digestion coefficients according to age of heifers are presented in Table 3. Significant differences were noted between the digestibilities of feed mixtures at different ages. Significant differences ($P<.05$) were noted in the digestibility of energy, crude fiber, and organic matter between the 7-, 14- and 19-month age groups, but differences between the 14- and 19-month age heifers were not significant. There was also a significant difference in calculated TDN between the younger heifers and the two older groups of heifers. The seven-month heifers were all fed the same mixture (no. 5) and none of the older heifers received this mixture. The method of determining digestibility was also different for the seven-month heifers (chromic oxide indicator) than for the older heifers (total collection).

TABLE 1

PROXIMATE ANALYSES COMPOSITION OF DIETS AS FED[a]

Feed Mixture	Dry Matter	Crude Protein	Crude Fiber	Ether Extract	Ash	N.F.E.	Energy
(No.)	%						(cal/g)
1	87.61	12.14	19.77	1.93	5.24	48.54	4142
2	88.16	12.21	19.75	2.08	5.28	48.83	4226
3	87.62	12.22	19.66	2.05	5.04	48.65	4241
4	87.85	12.17	19.46	2.04	4.84	49.34	4164
5	88.40	13.45	20.02	1.97	5.04	47.92	4330

[a]Analyses of hay and grain used in these mixtures in Table 11, Appendix.

TABLE 2

SCHEDULE OF MIXTURE FED DURING DIGESTION TRIAL

Level	19-Mo. Age Group			14-Mo. Age Group			7-Mo. Age Group		
	Animal	Ration	Intake	Animal	Ration	Intake	Animal	Ration	Intake
	(No.)	(No.)	(g/day)	(No.)	(No.)	(g/day)	(No.)	(No.)	(g/day)
Low	559	1	6810	606	4	5584	635	5	4358
	560	1	7082	610	4	5176	639	5	4631
	570	2	6674	607	3	5584	651	5	4631
	571	2	6129	611	4	4903	654	5	4358
Medium	558	1	8852	595	4	7627	634	5	5993
	561	1	8308	608	4	6538	636	5	5857
	566	2	8308	609	3	6946	653	5	5448
	569	2	8308	598	3	6946	657	5	5584
High	562	1	9670	599	4	7900	637	5	7219
	563	1	10624	600	4	8444	640	5	7082
	567	2	10487	594	3	8717	652	5	6538
	568	2	10079	597	3	8717	656	5	6538

TABLE 3

DIGESTIBILITY EVALUATIONS OF DIETS FOR ALL HEIFERS GROUPED BY AGE

Age	TDN	Digestion Coefficients			
		Organic Matter	Energy	Crude Protein	Crude Fiber
(Months)	(%)				
7	58.71±0.70[a,b]	62.00±0.68	58.44±0.75	61.47±0.52	40.69±1.69
14	65.22±0.62	68.65±0.76	64.46±0.84	65.78±0.71	48.57±1.19
19	64.97±1.52	68.33±1.03	65.71±1.09	68.79±0.71	47.66±2.10

[a] TDN, energy, and crude protein of 7-month group significantly ($P<.05$) different from 14- and 19-month groups. Organic matter and crude fiber of 7-month group significantly ($P<.01$) different from 14- and 19-month groups. Other differences among ages nonsignificant.

[b] Standard error of the mean.

The results in Table 4 show that there was no significant difference ($P<.05$) in the digestibility of crude protein, energy, or organic matter between the feeding levels for 0.8, 1.2, and 1.6 pounds average daily gain. There was also no difference in TDN between the low, medium, or high levels of feeding. Crude fiber digestibility was significantly different at the lower level of feeding, but there was no difference between the two higher levels. Average digestibilities were lower but not statistically significant ($P>.05$) except in the case of crude fiber digestion. Digestible energy, crude protein, organic matter, and TDN, while not significantly higher, were generally higher for those animals fed to gain 1.6 pounds per day. Increasing energy fed did not result in a decrease in digestibility of crude protein as was observed by Broster et al. (10).

The observation that digestibility of all nutrients was higher in older animals was opposite to the report by Lassiter et al. (21), but was in agreement with reports by Andersen et al. (1), McArthur (26), and Hogue et al. (18), who found no difference in digestibility coefficients between younger and older animals. The mixture fed the seven-month heifers differed from the others in source of hay. The hay contained slightly more alfalfa and less grass than the hay used for Mixtures 1-4. The main difference between the mixtures in chemical composition was the higher crude protein and crude fiber contents of Mixture 5. It seems reasonable to ascribe the differences in digestion coefficients observed with ages to the different sources of hay. Apparently the Mixture 5 hay was from a more mature cutting of alfalfa than the others, with consequent lowered digestibility.

TABLE 4

DIGESTIBILITY EVALUATIONS OF DIETS FOR ALL HEIFERS GROUPED BY FEEDING LEVEL

Feed Level	TDN	Digestion Coefficients			
		Organic Matter	Energy	Crude Protein	Crude Fiber
	(%)				
Low	60.95±1.49[a]	64.79±1.23	60.91±1.18	64.60±0.88	41.33±2.03[b]
Medium	63.85±1.15	66.98±1.14	63.82±1.24	66.00±1.22	46.53±1.56
High	64.09±1.25	67.13±1.23	63.88±1.33	65.44±1.17	49.07±1.63

[a]Standard error of the mean.

[b]Crude fiber digestibility was significantly different ($P<.05$) between the low level of feeding and the other two levels of feeding. Other differences were not significant.

Another explanation for the age differences could be that the total collection harness caused a stress factor that resulted in a higher digestibility similar to that noted by Noblitt et al. (32). This possibility is considered tenable because it is obvious that some of the individual digestion coefficients were too high to be a true value for the hay-corn mixture. A method of resolving this problem would be to feed an indicator at the same time total collection is used. Phar et al. (34) found no difference in crude protein, crude fiber, or gross energy coefficients using the indicator method and total collection together. Perhaps the adaptation of the heifers to the harness was satisfactory for Phar et al. (34), whereas it may have been a factor in this experiment. A reduction in average daily fecal output of the harnessed heifers of 8 percent would cause the differences observed between ages to disappear.

The growth experiment was set up with the animals fed according to a formula devised by Swanson (42). Animals were fed to gain 0.8, 1.2, or 1.6 pounds per day based on an average TDN value of 75% for corn and 50% for hay. Table 5 shows the actual average gain at the various ages and levels of feeding. Using the average TDN values for low, medium, and high groups from Table 4, the actual average TDN fed can be calculated. The gain expected from TDN actually fed can be calculated. As shown in Table 5, the gains observed and those expected from the TDN fed do not coincide, especially at seven months of age.

TABLE 5

COMPARISON OF ACTUAL AND CALCULATED GAIN WHEN FED FOR 0.8, 1.2, 1.6 POUNDS AVERAGE DAILY GAIN

Age	Feeding Level	Average Weight	Average Daily Gain	Estimated TDN[a]	Actual TDN	Gain from Formula[b]
(Mo.)		lbs.				
7	Low	414	1.31	5.51	5.76	0.92
	Medium	418	1.62	6.36	6.96	1.46
	High	438	2.27	7.46	8.20	1.92
14	Low	651	1.10	7.22	7.54	0.91
	Medium	704	1.54	8.74	9.57	1.47
	High	752	1.82	10.33	11.35	1.93
19	Low	794	1.29	8.16	8.53	0.92
	Medium	916	1.44	10.26	11.23	1.48
	High	997	1.65	12.25	13.46	1.93

[a]Estimated TDN based on as fed TDN of corn of 75 percent, hay 50 percent, and fed two parts hay to one part corn.

[b]$TDN = .102W^{.6}(1 + .567g)$, Swanson (42).

CHAPTER V

SUMMARY AND CONCLUSIONS

Thirty-six Holstein heifers were used in a digestion trial to determine the effects of age and level of feeding on feed digestibility. Twelve animals at each age level were divided into three groups which were fed to gain at 0.8, 1.2, and 1.6 pounds per day. Digestibility was determined by one of two methods, either total collection or by using chromic oxide as an indicator.

It was found that there was no significant difference in TDN or digestibility of energy, crude protein, or organic matter between any of the levels of feeding, but digestibility of crude fiber was significantly lower at the lower level of feeding. It was noted that there was a significantly lower digestibility in the younger animals of each of the ration constituents listed above. There are two possible factors which might have lowered the values obtained. First, the lower digestibility by the younger animals might have been the result of a higher crude fiber content in the ration fed the younger animals. The second possibility is the effect of a stress factor which caused a higher digestibility in those animals wearing the total collection harness. A lowered fecal output would result in higher digestibility. It is obvious from looking at the values for the older groups of heifers that some values are not in the range of what might be expected. Stress would seem to be a reasonable explanation for some of the variation in values.

Use of the indicator and total collection methods together would serve as a check and help to confirm the accuracy of either method.

REFERENCES

REFERENCES

1. Andersen, P. E., J. T. Reid, M. J. Anderson, and J. W. Stroud. 1959. Influence of level of intake upon the apparent digestibility of forage and mixed diets by ruminants. J. Animal Sci., 18:229.

2. Armstrong, D. G., T. R. Preston, and R. H. Armstrong. 1954. Digestibility of a sample of pasture grass by calves. Nature, 174:1182.

3. Association of Official Agricultural Chemists. 1960. Official Methods of Analysis. 9th ed, Washington, D.C.

4. Balch, C. C., and R. C. Campling. 1962. Regulation of voluntary food intake in ruminants. Nutr. Abstracts Review, 32:669.

5. Bines, J. A., S. Suzaki, and C. C. Balch. 1969. The quantitative significance of long-term regulation of food intake in the cow. Brit. J. Nutr., 23:695.

6. Blaxter, K. L. 1956. The nutritive value of feeds as sources of energy: A review. J. Dairy Sci., 39:1396.

7. Blaxter, K. L., N. McC. Graham, and F. W. Wainman. 1956. Some observations on the digestibility of food by sheep. Brit. J. Nutr. 10:69.

8. Blaxter, K. L., and F. W. Wainman. 1964. The utilization of the energy of different rations by sheep and cattle for maintenance and fattening. J. Agricultural Sci., 63:113.

9. Brody S., and R. C. Procter. 1933. Influence of the plane of nutrition on the utilization of feed stuffs. Missouri Agr. Exp. Sta. Bulletin 193.

10. Broster, W. H., V. J. Tuck, T. Smith, and V. W. Johnson. 1969. Experiments on the nutrition of the dairy heifer. J. Agr. Sci., 72:13.

11. Brown, L. D. 1966. Influence of intake on feed utilization. J. Dairy Sci., 49:223.

12. Conrad, H. R., and J. W. Hibbs. 1953. A high roughage system for raising calves based on the early development of rumen inoculations and the ratio of hay to grain on digestibility and nitrogen retention. J. Dairy Sci., 36:1326.

13. Conrad, H. R., J. W. Hibbs, and A. D. Pratt. 1966. Regulation of feed intake in dairy cows. II. Association between digestible dry matter intake and cellulose digestibility in cows fed increasing levels of grain concentrate. J. Dairy Sci., 49:1038.

14. Crampton, E. W., and L. E. Lloyd. 1951. Studies with sheep on the use of chromic oxide as an index of digestibility of ruminant rations. J. of Nutr., 45:319.

15. Donefer, E., L. E. Lloyd, and E. W. Crampton. 1963. Effect of varying alfalfa:barley ratios on energy intake and volatile fatty acid production by sheep. J. Animal Sci., 22:427.

16. Garrett, W. M., J. H. Meyer, and G. P. Lofgreen. 1959. The comparative energy requirements of sheep and cattle for maintenance and gain. J. Animal Sci., 18:528.

17. Graham, N. McC. 1969. The influence of body weight (fatness) on the energetic efficiency of adult sheep. Aust. J. Agr. Research, 20:375.

18. Hogue, D. E., R. G. Warner, C. H. Grippin, and J. K. Loosli. 1956. Digestion coefficients and nitrogen retention of young calves as affected by antibiotics and advancing age. J. Animal Sci., 15:788.

19. Kane, E. A., W. C. Jacobson, and L. A. Moore. 1950. A comparison of techniques used in digestibility studies with dairy cattle. J. of Nutr., 41:583.

20. Kesler, E. M., and S. L. Spahr. 1964. Effect of various levels of grain feeding. J. Dairy Sci., 47:1122.

21. Lassiter, C. A., C. F. Huffman, and C. W. Duncan. 1957. The effect of varying hay:grain ratios and levels of feed intake on feed utilization of dairy cows. J. Dairy Sci., 40:611.

22. Lassiter, C. A., C. F. Huffman, and C. W. Duncan. 1958. Effect of level of feed intake using hay:grain ratios on feed utilization of dairy cows. J. Dairy Sci., 41:721.

23. Lofgreen, G. P., J. K. Loosli, and L. A. Maynard. 1951. The influence of energy intake on nitrogen retention of growing calves. J. Dairy Sci., 34:911.

24. Loosli, J. K., E. E. Bartley, W. P. Flatt, N. L. Jacobson, C. H. Noller, and M. Ronning. 1971. Nutrient Requirements of Dairy Cattle. 4th ed. National Academy of Sciences, National Research Council.

25. McArthur, A. T. G. 1957. The ability of cows and calves to digest grass. New Zealand J. of Sci. and Technology, 38A:696.

26. Meyer, J. H., R. L. Gaskill, G. S. Stoewsand, and W. C. Weir. 1959. Influence of pelleting on the utilization of alfalfa. J. Animal Sci., 18:336.

27. Mitchell, H. H., and T. S. Hamilton. 1932. The effect of the amount of feed consumed by cattle on the utilization of its energy content. J. Agr. Research, 45:163.

28. Moe, P. W., J. T. Reid, and H. F. Tyrrell. 1965. Effect of level of intake on digestibility of dietary energy by high producing cows. J. Dairy Sci., 48:1053.

29. Moe, P. W., W. P. Flatt, and L. A. Moore. 1966. Effect of level of feed intake on energy losses by dairy cows. J. Dairy Sci., 49:714.

30. Montgomery, M. J., and B. R. Baumgardt. 1965. Regulation of food intake in ruminants. 1. Pelleted rations varying in energy concentration. J. Dairy Sci., 48:569.

31. Montgomery, M. J., and B. R. Baumgardt. 1965. Regulation of food intake in ruminants. 2. Rations varying in energy concentration and physical form. I. Dairy Sci., 48:1623.

32. Noblitt, C. G., W. A. Hardison, J. T. Huber, and G. C. Graf. 1963. Effect of manual total collection of feces upon nutrient digestibility. J. Dairy Sci., 46:47.

33. Paladines, O. L., J. T. Reid, B. D. H. Van Niekerk, and A. Bensadoun. 1964. Energy utilization by sheep as influenced by physical form, composition, and level of intake of diet. J. of Nutr., 83:49.

34. Phar, P. A., N. W. Bradley, C. O. Little, L. V. Cundiff, and J. A. Boling. 1971. Nutrient digestibility using fecal collection apparatus and indicator method for steers feed ad libitum. J. Animal Sci., 33:695.

35. Preston, T. R., J. D. H. Archibald, and W. Tinkler. 1957. The digestibility of grass by young calves. J. Agricultural Sci., 48:259.

36. Putnam, P. A., and J. K. Loosli. 1959. Effect of feeding different ratios of roughage to concentrate upon milk production and digestibility of the ration. J. Dairy Sci., 42:1070.

37. Reid, J. T. 1956. Some nutritional effects of varying concentrate: roughage ratios in relation to feed input-milk output by dairy cows. Cornell Exp. Sta. Memoir 344.

39. Reid, J. T., and H. F. Tyrrell. 1964. Effect of level of intake on energetic efficiency of animals. Cornell Nutrition Conference 25-38.

40. Rodrigue, C. B., and N. N. Allen. 1960. The effect of fine grinding of hay on ration digestibility, rate of passage, and fat content of milk. Can. J. of Animal Sci., 40:23.

41. Stevenson, A. E., and H. deLangen. 1960. Measurement of feed intake by grazing cattle and sheep. New Zealand J. Agr. Res., 3(2):314.

42. Swanson, E. W. 1971. Feed energy requirements for different rates of growth of dairy heifers. J. Dairy Sci., 52:217.

43. Watson, C. J., G. W. Muir, and W. M. Davidson. 1935. Digestibility studies with ruminants. I. Plane of nutrition and digestibility of hay. Scientific Agr., 15:476.

44. Watson, C. J., J. C. Woodward, W. M. Davidson, G. W. Muir, and C. H. Robinson. 1936. Digestibility studies with ruminants. II. Plane of nutrition and digestibility of a hay-barley ration. Scientific Agr., 17:11.

45. Wiktorsson, H. 1971. Digestibility experiments with dairy cows consuming different quantities of concentrates. J. Dairy Sci., 54:374.

46. Wright, P. L., A. L. Pope, and P. H. Phillips. 1963. Effect of physical form of ration upon digestion and volatile fatty acid production in vivo and in vitro. J. Animal Sci., 22:586.

APPENDIX

TABLE 6

CALCULATED TOTAL DIGESTIBLE NUTRIENTS FOR EACH HEIFER AND GROUP AVERAGES

Feeding Level	19-Mo. Age Group Heifer	19-Mo. Age Group TDN	14-Mo. Age Group Heifer	14-Mo. Age Group TDN	7-Mo. Age Group Heifer	7-Mo. Age Group TDN	Group Mean
	(No.)	(%)	(No.)	(%)	(No.)	(%)	(%)
Low	559	65.32	606	63.50	635	61.50	
	560	67.65	610	62.88	639	56.79	
	570	50.69	607	62.53	651	53.72	
	571	60.96	611	66.94	654	58.95	
	Mean	61.16	Mean	63.96	Mean	57.74	60.95
Medium	558	66.81	595	65.39	634	56.05	
	561	71.01	608	63.49	636	60.84	
	566	64.10	609	66.64	653	58.86	
	569	65.50	598	65.55	657	61.95	
	Mean	66.70	Mean	65.27	Mean	59.43	63.85
High	562	65.06	599	63.57	637	60.55	
	563	70.84	600	65.36	640	59.29	
	567	65.31	594	66.82	652	58.77	
	568	66.37	597	69.94	656	57.24	
	Mean	66.90	Mean	66.42	Mean	58.96	64.09
Means by Age		64.97		65.22		58.71	

TABLE 7

DIGESTION COEFFICIENTS OF ORGANIC MATTER FOR EACH HEIFER AND GROUP AVERAGES

Level	19-Mo. Age Group		14-Mo. Age Group		7-Mo. Age Group		Group Mean
	Heifer	Organic Matter	Heifer	Organic Matter	Heifer	Organic Matter	
	(No.)	(%)	(No.)	(%)	(No.)	(%)	(%)
Low	559	68.81	606	66.86	635	64.69	
	560	70.72	610	65.52	639	60.25	
	570	59.98	607	65.36	651	57.34	
	571	64.51	611	70.94	654	62.47	
	Mean	66.01	Mean	67.17	Mean	61.19	64.79
Medium	558	70.26	595	68.48	634	59.18	
	561	72.09	608	66.12	636	64.11	
	566	67.05	609	71.51	653	61.96	
	569	68.22	598	70.55	657	65.25	
	Mean	69.41	Mean	69.17	Mean	62.63	66.98
High	562	68.13	599	66.23	637	63.60	
	563	73.70	600	68.72	640	62.72	
	567	67.62	594	70.27	652	61.95	
	568	68.92	597	73.22	656	60.50	
	Mean	69.59	Mean	69.61	Mean	62.19	67.13
Means by Age		68.33		68.65		62.00	

TABLE 8

DIGESTION COEFFICIENTS OF ENERGY FOR EACH HEIFER AND GROUP AVERAGES

Feeding Level	19-Mo. Age Group		14-Mo. Age Group		7-Mo. Age Group		Group Mean
	Heifer	Energy	Heifer	Energy	Heifer	Energy	
	(No.)	(%)	(No.)	(%)	(No.)	(%)	(%)
Low	559	64.76	606	63.14	635	61.35	
	560	68.30	610	60.46	639	57.11	
	570	57.20	607	61.70	651	52.67	
	571	62.05	611	63.22	654	58.93	
	Mean	63.08	Mean	62.13	Mean	57.52	60.91
Medium	558	66.62	595	65.02	635	56.26	
	561	71.43	608	62.01	636	59.23	
	566	64.88	609	67.48	653	59.05	
	569	64.60	598	67.24	657	61.99	
	Mean	66.88	Mean	65.44	Mean	59.13	63.82
High	562	65.12	599	61.82	637	60.01	
	563	70.77	600	64.65	640	58.69	
	567	65.61	594	66.97	652	59.98	
	568	67.18	597	69.84	656	55.95	
	Mean	67.17	Mean	65.82	Mean	58.66	63.88
Means by Age		65.71		64.46		58.44	

TABLE 9

DIGESTION COEFFICIENTS OF CRUDE PROTEIN FOR EACH HEIFER AND GROUP AVERAGES

Feeding Level	19-Mo. Age Group		14-Mo. Age Group		7-Mo. Age Group		Group Mean
	Heifer	Crude Protein	Heifer	Crude Protein	Heifer	Crude Protein	
	(No.)	(%)	(No.)	(%)	(No.)	(%)	(%)
Low	559	68.20	606	64.56	635	64.16	
	560	70.47	610	61.59	639	60.51	
	570	63.93	607	63.20	651	61.16	
	571	67.91	611	66.16	654	63.31	
	Mean	67.63	Mean	63.88	Mean	62.29	64.60
Medium	558	69.58	595	66.06	634	58.06	
	561	72.84	608	65.58	636	62.44	
	566	67.65	609	69.14	653	60.71	
	569	69.43	598	67.26	657	63.25	
	Mean	69.88	Mean	67.01	Mean	61.12	66.00
High	562	67.12	599	64.00	637	63.03	
	563	72.64	600	64.01	640	61.28	
	567	67.81	594	69.11	652	59.95	
	568	67.91	597	68.73	656	59.73	
	Mean	68.87	Mean	66.46	Mean	61.00	65.44
Means by Age		68.79		65.78		61.47	

TABLE 10

DIGESTION COEFFICIENTS OF CRUDE FIBER FOR EACH HEIFER AND GROUP AVERAGES

Feeding Level	19-Mo. Age Group Heifer	19-Mo. Age Group Crude Fiber	14-Mo. Age Group Heifer	14-Mo. Age Group Crude Fiber	8-Mo. Age Group Heifer	8-Mo. Age Group Crude Fiber	Mean
	(No.)	(%)	(No.)	(%)	(No.)	(%)	(%)
Low	559	46.66	606	45.26	635	44.27	
	560	50.71	610	43.89	639	37.22	
	570	31.34	607	45.54	651	26.54	
	571	39.04	611	46.75	654	38.76	
	Mean	41.94	Mean	45.36	Mean	36.70	41.33
Medium	558	49.49	595	47.51	634	35.42	
	561	58.06	608	45.13	636	43.99	
	566	45.64	609	48.83	653	41.43	
	569	45.40	598	50.22	657	47.23	
	Mean	49.65	Mean	47.92	Mean	42.02	46.53
High	562	49.22	599	47.36	637	46.37	
	563	57.57	600	53.74	640	44.85	
	567	48.87	594	50.35	652	38.43	
	568	49.97	597	58.28	656	43.77	
	Mean	51.41	Mean	52.43	Mean	43.36	49.07
Means by Age		47.66		48.57		40.69	

TABLE 11

PROXIMATE ANALYSES OF FEEDS USED IN RATION MIXTURES

Feed Mixture	Dry Matter	Crude Protein	Crude Fiber	Ether Extract	Ash	N.F.E.	Energy
	%						(cal/g)
Corn 1	86.94	9.50	5.00	2.04	3.21	67.19	4120
Corn 2	88.57	9.72	4.95	2.51	3.32	68.07	4303
Corn 3	86.96	9.74	4.96	2.41	2.59	67.53	4268
Corn 4	87.64	9.58	4.09	2.37	1.99	69.61	4151
Hay 1[a]	87.95	13.46	27.15	1.87	6.26	39.21	4187
Corn 5	87.31	9.85	4.02	2.31	2.00	69.13	4139
Hay 2[b]	88.94	15.25	28.02	1.80	6.56	37.31	4426

[a]Hay 1 was used in Feed Mixtures 1-4 which correspond with Corn 1-4.

[b]Hay 2 was used with Corn 5 in Feed Mixture 5 only.

TABLE 12

INDIVIDUAL ANIMAL FECES PRODUCTION AND FECAL ENERGY VALUES

Feeding Level	19-Mo. Age Group			14-Mo. Age Group			7-Mo. Age Group		
	Animal	Daily Feces	Feces Energy	Animal	Daily Feces	Feces Energy	Animal	Daily Feces	Feces Energy
	(No.)	(g)	(cal/g)	(No.)	(g)	(cal/g)	(No.)	(g)	(cal/g)
Low	559	2210	4496	606	1916	4475	635	1592	4560
	560	2162	4303	610	1820	4680	639	1914	4493
	570	2762	4371	607	1996	4543	651	2033	4669
	571	2250	4371	611	1650	4552	654	1694	4576
Medium	558	2740	4466	595	2500	4444	634	2524	4496
	561	2231	4408	608	2270	4556	636	2181	4743
	566	2835	4348	609	2150	4454	635	2140	4515
	569	2730	4554	598	2220	4346	657	2002	4592
High	652	3180	4394	599	2740	4584	637	2704	4622
	563	2900	4433	600	2730	4554	640	2720	4557
	567	3526	4323	594	2680	4556	652	2552	4438
	568	3270	4274	597	2400	4646	656	2653	4702

VITA

Ray Carpenter Jordan was born March 24, 1947, at Lewisburg, Tennessee. He was reared on a dairy farm near Lewisburg where he attended Marshall County public school. After graduation from Marshall County High School in June, 1965, he attended The University of Tennessee and graduated in June, 1969, with a Bachelor of Science degree in Agriculture, with a major in Dairy Production. In July, 1969, he accepted a research assistantship at The University of Tennessee to study toward the Master's degree. During this time he served as an assistant herd manager at the University Dairy Farm.

He is a member of Alpha Zeta, a national honorary agriculture fraternity, and holds a reserve commission in the U.S. Army.