A STUDY OF THE COMPARATIVE NUTRITIVE VALUE OF THE DRY MATTER IN ATLAS SORGO SILAGE AND GROUND ATLAS SORGO FODDER

by

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INTRODUCTION AND HISTORICAL

From the earliest times of which we have any record, the principle of the silo has been used in the preservation of food. Miles (18)[1] quotes Pliny as recommending trenches for the preservation of grain and mentioning their use in Cappadocia, Thrace, Spain, and Africa. The Egyptians made use of the same principle, but used rooms of masonry instead of trenches. As early as 1786 (30) references were made to the practice of storing green plant material in pits for cattle. The use of this principle of feed preservation has, since that time, spread throughout the world.

The problem of the preservation of feed in silos is of tremendous importance and a large amount of data have been accumulated concerning the silo, and the uses and values of the preserved plant material as a feed for livestock. The history, uses, values and relations of the silo and silage have been fully discussed by Baker (4).

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(1) Numbers in parentheses are references to publications listed in the citation to literature.

Although much data have been accumulated concerning the value of silage as a feed for livestock, very little data have been reported directly comparing the dry roughage (fodder) and silage from the same plant.

Armsby and Caldwell (2) in connection with a comparative feeding experiment, using ensilage and dry corn fodder, reported that in the feeding of the whole fodder twenty-three per cent was wasted. They found that the dry matter portion of the fodder that was consumed was equal to the dry matter of the silage pound for pound. They state, however, that the silage was more palatable than the fodder.

Woll (32) in summarizing six years' work, in which silage and fodder were compared for milch cows, stated that practically no difference exists between the two feeds, and that corn silage and dry corn fodder, both properly prepared, possess equal feeding value.

Mumford (23) summarized an 88-day test, in which silage and shock corn were fed to two year old steers, by saying, "It should be noted that the silage-fed lot consumed less feed than the shock corn-fed lot, and less feed per pound of gain whether beef alone is considered or beef and pork combined. The amount of dry matter required to

produce a pound of gain of meat where corn was fed in the form of silage was 6.52 pounds and when fed in the form of shock corn was 8.57 pounds."

McCampbell (12) in reporting the results of feeding experiments conducted at the Fort Hays Branch of the Kansas Agricultural Experiment Station in 1920, pointed out that cane fodder produced slightly larger gains than did cane silage and that one ton of fodder was equivalent to 1.2 tons of silage, when fed to mature cows. A continuation of this study reported by McCampbell (13) in 1922 shows approximately the same results.

McCampbell (14) in 1928, observed that yearling steers fed kafir silage 112 days made greater daily gains but slightly less gain per ton than did yearling steers fed fodder.

It should be noticed, however, that in most instances silage and whole fodder were compared. Armsby and Caldwell (2) have shown that as much as twenty-three per cent of the whole fodder was wasted whereas very little of the silage was refused. Many of the advantages of the silo are based upon such results which failed to account for the wasted fodder. The results of such experiments are

doubtless of much practical value but they throw little light on the question of the relative value of the dry matter in silage and fodder.

Since that time modern engineering has produced various types of grinders which are efficient for preparing roughage for livestock. McCampbell (15) found that very little of the ground kafir fodder was refused by cattle, and ground kafir fodder produced more gain per ton of feed eaten than did whole or shredded kafir fodder. He pointed out later (17), however, that the advantage in grinding kafir fodder lies largely in grinding the grain in the fodder and thereby increasing the amount of grain digested by cattle.

McCampbell (15) in 1929 reported that in a 150-day trial in which ground kafir fodder and kafir silage were compared the daily gains were approximately the same and ground fodder produced 35 pounds more gain per ton of feed eaten than did silage. From a continuation of this work in 1930 (16) the same observations were made. In 1931 (17), however, the silage produced slightly larger gains than did the ground fodder, but the ground fodder produced 29 pounds more gain per ton of feed eaten. During the same year a

comparison of corn silage and ground corn fodder was made and no differences from the previous three years work were reported.

Thalman, Gramlich, and Lewis (29) report a weighted average of three trials, conducted in 1929-'30, 1930-'31 and 1931-'32, where corn silage and ground corn fodder were compared for wintering stock calves. They found that ground corn fodder plus one pound of cottonseed cake produced 89.24 per cent as much gain as silage and cottonseed cake, and that more gain was produced from one pound of dry matter in the form of silage than was produced from one pound of dry matter in the form of ground corn fodder.

Christensen (5) summarized a 140-day test, comparing corn silage and ground corn fodder for yearling steers, by saying, "When allowance is made for difference in the water content it appears that the water free material in corn fodder is equal to that in the corn silage, pound for pound. The losses in curing the fodder are greater than in making of silage and the silage is more palatable and therefore preferred as a feed." His data, however, show that more pounds of dry matter were eaten in the form of ground corn fodder than in the form of corn silage. One

would, therefore, hesitate to conclude that silage is more palatable than ground fodder on a dry matter basis.

The available literature on the comparative nutritive value of ground fodder and silage are varied and scattered. It is evident that the opinions as well as the investigational results are not entirely in accord, and conclusions have been made on varied bases of approach.

OBJECT OF EXPERIMENT

The object of the experiment herein reported was to determine the comparative nutritive value of the dry matter in Atlas Sorgo silage and ground Atlas Sorgo fodder.

EXPERIMENTAL PROCEDURE

Plan of Experiment

It was recognized at the outset that final results of an experiment of this nature where small numbers of animals were involved might materially be affected by such factors as unequalized food intake, unaccounted wastage of feed, individual appetite of the animals, removal of animals from the experiment and individual differences in animals. Because the paired feeding method of experimentation came

the nearest to controlling all the variables but the one to be studied it was used in conducting this experiment.

The advantages and limitations of the paired feeding method have been fully discussed by Mitchell (22) and Crampton (6), and therefore need not be repeated here.

Animals

Twelve grade yearling Hereford steers, purchased on the Kansas City market and originating in Texas, were used in the experiment. The steers arrived at this Station fully a month before the beginning of the experiment. Two weeks before the experiment was started, the animals were removed to the Animal Husbandry stone barn and placed in individual box stalls in which they were to remain for the duration of the experiment. Each steer was fed according to appetite a mixture of equal parts of Atlas Sorgo silage and ground Atlas Sorgo fodder. This afforded time for the steers to become accustomed to handling, individual feeding and the feeds to be used.

The steers were allotted in pairs on a basis of feeder grade, condition, weight, temperament and probable outcome. Every attempt was made to get both members of each pair as

near alike as possible. No attempt, however, was made to make all pairs conform with each other in the above mentioned characteristics. The writer had the assistance of four members of the Department of Animal Husbandry in allotting the steers.

Equipment

The steers as soon as allotted were assigned individual box stalls, about ten by twelve feet in size. The members of each pair were assigned adjoining stalls in order that variations in lighting and air draft would not affect one steer and not his pair mate. In order fully to control feed consumption, very little bedding was used. At the outset of the experiment the steers were watered in buckets, while in their stalls, at 7:30 A.M. and 5:30 P.M. This practice was discontinued due to freezing weather and the steers were watered together from a large tank in the yard to which they had access from 12:00 noon to 4:15 P.M. The feed was weighed on a beam scale graduated in grams. The weighings were made each afternoon for the two following feedings and a record of the feed for each individual was recorded in a loose leaf book provided for that purpose.

Feeds

The source of nutrients for each steer was limited to the Atlas Sorgo plant plus two pounds of cottonseed meal per head daily. The only variation in the ration, therefore, was in the method of preparation of the plant used to supply the nutrients. Both members of each pair were fed the same amount of dry matter by weight. One steer of each pair received his dry matter in the form of Atlas Sorgo silage and cottonseed meal while the other one received his dry matter in the form of ground Atlas Sorgo fodder and cottonseed meal.

Although two pounds of cottonseed meal per steer per day furnished a greater amount of protein than is recommended for yearling steers by Armsby (3) or Mitchell (19), it was decided arbitrarily to use this amount since the exact protein requirements of cattle are not known. It is known, however, that excess protein in the ration is deaminized and utilized in the body as carbohydrates. No attempt was made to feed balanced rations according to the requirements set forth in feeding standards, therefore, nutritive ratios were not computed.

A two days' supply of silage was removed from the silo at one time. The fodder was fed ground, a two days' supply being ground at one time. The fodder was ground in a hammer type mill. The steers were fed roughage and cotton-seed meal only in such amounts as they would readily clean up. The appetite of the steer consuming the least amount of feed determined the amount of dry matter fed each pair of steers. Each pair was regarded as a unit and no attempt was made to get the steers of all pairs to consume the same amount of dry matter. Water and salt were given ad libitum. Special care was taken to insure that the fodder and silage were always fresh, free from mold and representative of the average of the crop.

The fineness modulus, percentage of grain, percentage of whole grain, percentage of cracked grain on a dry matter basis were determined for the silage and ground fodder. The results are given in Table I.

Table I - Fineness modulus, percentage of grain, percentage of whole grain, percentage of cracked grain in Atlas Sorgo silage and Atlas Sorgo fodder. (Dry matter basis.)

Feed	Fineness modulus	Percentage of grain	Percentage of whole kernels	Percentage of cracked kernels
Atlas Sorgo Silage	4.683	21.81	88.89	11.11
Atlas Sorgo Fodder	3.517	18.04	40.31	59.69

It was recognized that the dry matter content of the silage and fodder would vary during the experiment, therefore, in order to keep the dry matter intake of each pair of steers equal it was necessary to determine the moisture contents of the feeds at regular intervals. This interval was arbitrarily set at four days. Fresh samples of feed were placed in an electric oven at about 98° F. and allowed to dry to constant weight. The loss in weight was considered moisture. From these figures the dry matter rations were computed for the coming four days. Figure 1 shows in graphical form the variation in dry matter content of the silage and fodder at four day intervals during the experiment.

A sufficient supply of cottonseed meal to last throughout the experiment was obtained at the beginning. A carefully selected composite sample was taken and analyzed with the results give in Table II.

The silage and fodder were obtained from the same field, on the Animal Husbandry farm, thus preventing a variation in the quality of the feeds. Composite samples of the green feed at time of cutting, and of the fodder and silage at the beginning of the experiment were taken and analyzed. The results of these analyses are also given in Table II.

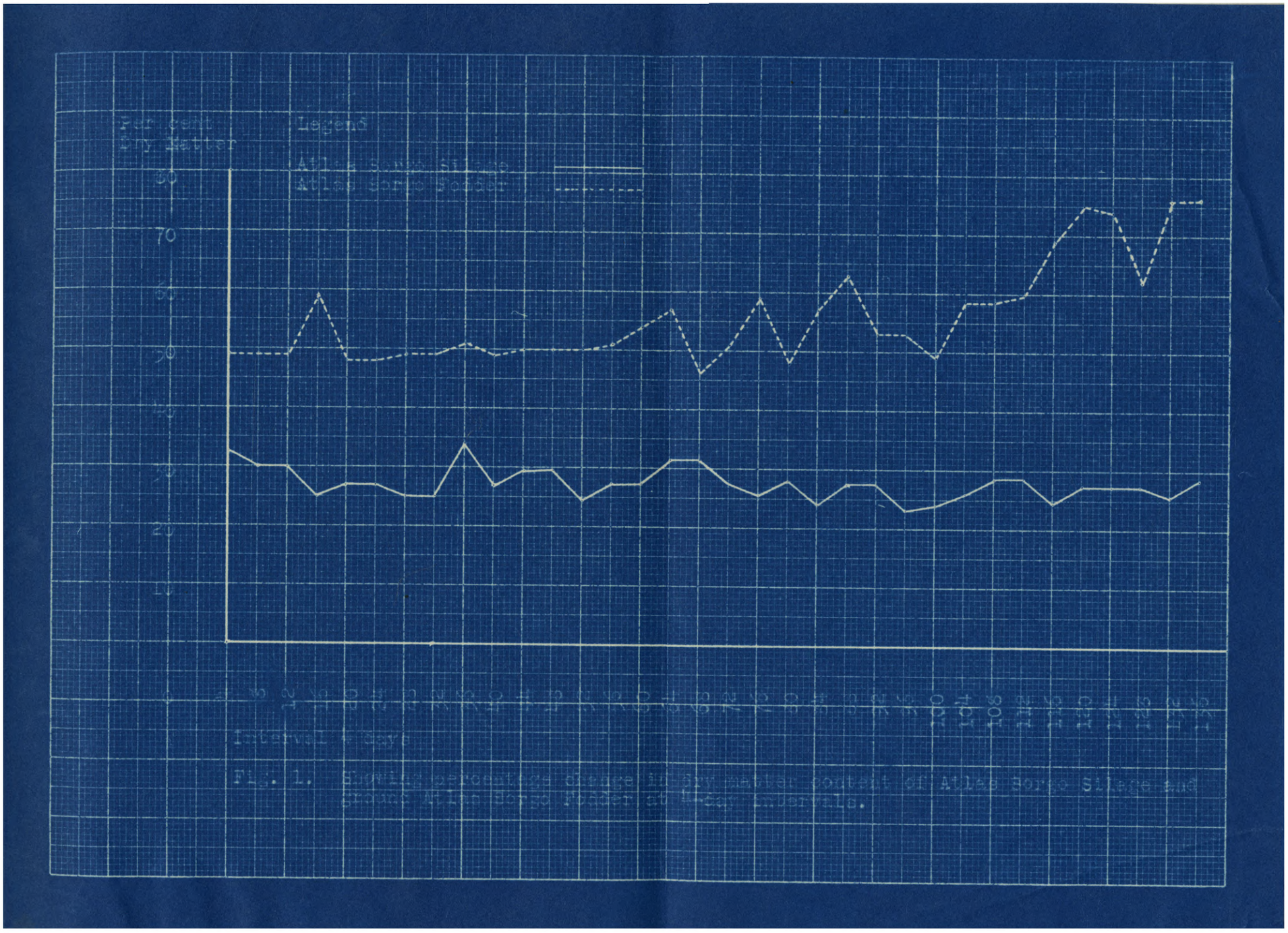

Fig. 1. Monthly percentage change in dry matter content of Atlas Sorgo Sileage and ground Atlas Sorgo Fodder at four intervals.

Table II - Percentage composition of green feed at time of cutting, of silage, fodder and cottonseed meal at beginning of experiment. (Dry matter basis.)

	Cottonseed Meal	Green Feed at time of cutting	Atlas Sorgo Silage Dec.15,1931	Atlas Sorgo Fodder Dec.15,1931
% Crude Protein	47.475	7.091	6.092	7.143
% True Protein	44.398	6.729	3.998	6.898
% Ether Extract	7.300	3.155	2.653	3.029
% Crude Fiber	8.901	17.733	22.176	22.225
% Ash	6.202	7.077	6.868	7.174
% Nitrogen Free Extract	29.875	64.591	64.012	60.666
% Free Amino Extract	0.0478	0.04392	0.0642	0.0327
% Reducing Sugars	0.4892	4.173	1.437	3.426

During the ensiling process certain chemical, physical and bacterial changes occur, and to these the peculiar odor and flavor of the silage are due. These changes take place at the expense of the nutrients in the ensiled material. Accompanying silage formation, therefore, is a loss of

certain nutrients. Likewise there is a loss of nutrients in the field curing of a plant as fodder.

The earliest recorded studies of losses of elements during the ensiling process were made with corn material very low in dry matter and stored in pits or tub silos.

Jordan (10) states that in the course of three years' work, using a stone basement root cellar as a silo, he found that the loss of organic matter ranged from 5.18 per cent to 11.82 per cent, which appeared to be almost wholly in carbohydrates other than crude fiber. He noted apparent gains in crude fiber in two of the three cases and losses from 0.0 per cent to 0.77 per cent in the crude protein due to ensiling. He bases his calculations on the assumption that there is no loss of ash during ensiling.

Armsby and Caldwell (2) in connection with a comparative feeding experiment, using silage and dry corn fodder, found a loss of 10.76 per cent of the total dry matter ensiled. Their tables show a large loss in ash and albuminoids, a small loss in crude fiber, and a large loss in nitrogen free extract, with a large gain in non-albuminoids and crude fat.

Henry and Woll (8) studied the losses in ensiling green corn. They report twenty-two per cent to twenty-four per cent losses of the total dry matter ensiled. They found the largest losses to be in nitrogen free extract, crude protein and crude fiber. There was a large gain in ether extract of all silos studied. They also found a small gain in ash in one silo and a large loss in another, which is explained as translocation of mineral matter caused by pressure of the upper layers on the lower ones by movement of juices of green fodder or by diffusion.

Woll (31) summarized three years' work, including ten experiments in which the comparative losses in ensiling and field curing green maize were studied. He found that by ensiling there was a loss in total dry matter of 20.5 per cent and in crude protein of the green corn a loss of 20.6 per cent.

Annett and Russell (1), in a very interesting paper published in the Journal of Agricultural Science in 1908, give a discussion of various losses and changes in the silo. In a table giving an average of all losses and gains in the original constituents present in the green material during the ensiling of maize, they give the losses as follows:

Dry matter, 36 per cent; ether extract, 16 per cent; nitrogen free extract, 55 per cent; crude fiber, 3 per cent; protein nitrogen, 55 per cent; total nitrogen, 26 per cent; ash, 14 per cent; and gains, non-protein nitrogen, 83 per cent.

Shaw, Wright and Deysher (24) have shown conclusively that there is a decided downward wash of the juice in the silo, carrying with it soluble food material. They report a loss of 10 per cent of the dry matter, which was apparently due to the fermentation of the carbohydrates and to the carrying away of soluble material by the juice. The reducing sugars and non-reducing sugars almost entirely disappeared, and they show a considerable loss in crude fiber and total nitrogen. They attribute the increase in ether extract to the formation of new ether-soluble bodies.

The causes of the above changes have been ascribed to various factors by different investigators. After studying the fermentation of corn silage, Lamb (11) concluded that the hydrolysis of protein as indicated by amino-nitrogen is primarily due to cell respiration, although later in the fermentation micro-organisms show some activity. Hunter (9) concludes that plant enzymes are

chiefly responsible for the hydrolysis of proteins with the formation of amino-nitrogen while the formation of ammonia nitrogen is due both to enzymes and micro-organisms. It has been shown by Neidig (24) that the products of acid take place at the expense of the sugars due to the action of micro-organisms. Rapsdale and Turner (25) ascribe most of the chemical changes taking place in the silo as being due to bacteria and yeasts. Peterson, et al (25) in a study of the principal changes which take place in the making of silage, ascribe the resulting products to micro-organisms.

It is known that there is a loss of material in the field-curing of corn. Ten stations, however, have conducted research on this subject. The average results of the investigations by Henry and Woll (18), Armsby and Caldwell (2), and Rapsdale and Turner (25) on the comparative losses of materials due to ensiling and field-curing of corn are shown in Table III.

Table III - Average percentage losses of materials due to ensiling and field-curing of corn. As shown by Henry and Woll (8), Armsby and Caldwell (2), and Rapsdale and Turner (25).

	Percentage Losses Due to Ensiling	Percentage Losses Due to Field-Curing
Dry Matter	17.88	20.34
Ash	.057	2.98
Crude Protein	1.66	0.91
Crude Fiber	3.85	5.62
Nitrogen Free Extract	13.49	15.55
Crude Fat	+ 0.54	0.08

Rate of Gain

The experiment started December 15, 1931, P.M., and closed May 3, 1932, A.M., at the end of 140 days. The animals were weighed on three consecutive days at the beginning and end of the experiment and an average of these weights considered as the initial and final weights respectively. Period weights were taken every 14 days. These weights were taken after the morning feeding and before watering. The P.M. feed of the second consecutive day of the initial weighings was considered the beginning

of the experiment and the A.M. feed of the second consecutive day of final weighings was considered the close of the experiment.

In Table IV are given the average initial and final weights, total gains, average daily gains, average daily feed consumed, total feed consumed and feed consumed per one hundred pounds gain.

The rates of gain of the individual animals within a pair were quite similar. At no period during the experiment did all the steers fed silage gain more than did their mates fed the ground fodder. Neither was there a period in which all the steers fed ground fodder gained more than their mates fed silage. In total gains in each pair except pair 3 the steer fed ground fodder gained more than the steer fed silage. The difference in gains in an ordinary feeding trial would be considered significant. In a paired feeding experiment, however, a more critical analysis of the results is possible. While average gains in this experiment indicate that ground fodder has a higher nutrition value than silage, a study of individual gains does not lead to this conclusion since in one of the pairs the steer fed silage gained more than its mate fed ground fodder.

Table IV - Initial and final weights, total gains, average daily gains, average daily rations, feed consumed per 100 pounds gain and total feed consumed for each individual steer.

Pair Number	I		II		III		IV		V	
Steer Number	2	9	16	18	69	54	80	87	4	15
Ration	Silage C.S.M.	Fodder C.S.M.	Silage C.S.M.	Fodder C.S.M.	Silage C.S.M.	Fodder C.S.M.	Silage C.S.M.	Fodder C.S.M.	Silage C.S.M.	Fodder C.S.M.
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Final Weight	818.33	848.33	820.00	856.66	881.66	876.66	866.66	876.66	733.33	826.66
Initial Weight	676.67	676.67	683.33	673.33	671.66	685.00	690.00	683.33	630.00	625.00
Gain	141.66	171.66	136.67	183.33	210.00	191.66	176.66	193.33	103.33	201.66
Average Daily Gain	1.01	1.23	0.98	1.31	1.50	1.37	1.26	1.38	0.74	1.44
Average Daily Ration *										
Roughage	10.62	10.62	10.17	10.17	11.26	11.26	10.31	10.30	9.02	9.01
Cottonseed Meal **	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
Feed Consumed Per 100 Pounds Gain *										
Roughage	1049.2	865.8	1041.7	776.7	750.7	822.7	816.8	745.9	1226.5	625.5
Cottonseed Meal **	143.1	118.1	148.3	110.56	96.5	105.7	114.7	104.8	196.8	100.5
Total Feed Consumed *										
Roughage	1486.3	1486.2	1423.6	1423.9	1576.5	1576.8	1443.0	1442.1	1263.3	1262.5
Cottonseed Meal **	202.7	202.7	202.7	202.7	202.7	202.7	202.7	202.7	202.7	202.7

* Given in pounds dry matter.

** All steers fed 1.778 pounds dry matter in cottonseed meal during first 114 days of feeding period. Cottonseed meal was dropped from the ration the last 26 days in order to obtain samples of feces for digestion trial.

"Students" method (28) for analyzing the significance of small groups of observations was applied to determine statistically the significance of the resultant increase in gains of the fodder steers over their silage mates. The average difference between total gains of the fodder steers over their silage mates is 34.6 pounds and the standard deviation of the difference is 51.57. The ratio of the mean difference to the standard deviation, the Z of "Student", is 0.67. With Z = 0.67 and N = 5 the odds are seven to one that the mean difference was due to chance. Odds of thirty to one are ordinarily considered necessary for significance. Therefore, it is impossible to draw the conclusion that the ground fodder was responsible for producing larger gains than silage when fed to steers.

It is very likely that the larger gains of the steers fed fodder was due to the fact that a greater percentage of the grain in the fodder was cracked than in the silage. This is shown in Table I. A fact which tends to contradict this conclusion is that the fodder contained a smaller percentage of grain than did the silage due to losses of grain before feeding.

Amount of Feed Consumed

All steers had good appetites and consumed a normal amount of feed throughout the entire experiment. Pair V, however, due to illness of the steer fed silage, was removed from the experiment. Occasionally an animal fed silage did not clean up, but in no case did the animals fed ground fodder refuse any feed. It was noted throughout the experiment that the amount of feed consumed was not affected by individual feeding and handling, and that in every case the steers fed ground fodder ate their feed with more relish and would have consumed more dry matter than their pair mates fed silage. The results obtained in this experiment may have been due to the high moisture content of the fodder.

"Students" method (28) was again used to determine the significance of the gain derived from 100 pounds of dry matter consumed. The mean difference is 6.98 pounds, the standard deviation is 10.65 pounds, and the ratio of the mean difference to the standard deviation, the Z of "Student", is 0.65. With Z = 0.65 and N = 5, the odds are seven to one that the mean difference was due to chance. Therefore, none of the greater gains, per 100 pounds of

dry matter consumed, made by the steers fed ground fodder may be attributed to the feed.

An interesting observation was made in Pair VI. Although both steers were fed the same amount of dry matter the steer fed silage gained only 103.33 pounds and the steer fed ground fodder gained 201.66 pounds. This shows that steers differ in their ability to use feed. This may have been due to the fact that the steer fed silage was extremely nervous throughout the experiment while his mate, fed ground fodder, became quiet and gentle.

It will be noticed in Table IV that cottonseed meal was fed at the rate of 1.778 pounds of dry matter per steer per day during the first 114 days of the experiment. On the 114th day the cottonseed meal was removed from the rations in order to obtain feces samples for the second digestion trial.

Digestibility of the Feeds

The total consumption of feed gave no indication of the effectiveness with which the nutrients were removed from the digestive tract. For this reason, a digestion trial was run on three pairs of steers. The method used

involved the determination of the ratio of silica naturally present in the feed to the nutrients in the feed and in the feces. A discussion of the advantages and disadvantages of this method and a comparison of this method with other methods of determining coefficients of apparent digestibility have been given by Gallup and Kuhlman (7). The limited value of coefficients of apparent digestibility has been fully discussed by Mitchell (21).

Two separate digestion trials were run; the first, to determine the coefficients of apparent digestibility of the ground fodder and silage when fed with cottonseed meal, the second, to determine the coefficients of apparent digestibility of the silage and ground fodder alone.

With the method used it was unnecessary to remove the steers to metabolism stalls as the feces were collected each evening from the stalls and removed to an electric oven for drying. Composite samples of the feeds were taken daily at time of weighing, placed in half gallon jars, sealed, and stored in a cooler at about 35-38° F. until the end of the trial when a composite was taken for feeding analysis. It was unnecessary to know the water content of the feces, therefore, only a composite sample

of each accumulated dry sample of feces was analyzed.

The period for collection of the feces was 20 days in the first trial and 16 days in the second trial. This length of time was deemed necessary in order to obtain a representative sample of feed and feces. A period of 10 days was used as a preliminary period to the second trial in order to clear the digestive tract of the animals of feed residues containing cottonseed meal. The same three pairs of animals were used in both digestion trials.

The average daily rations of the steers used in the first digestion trial are shown in Table V.

Table V - Average daily rations of steers during first digestion trial (Dry matter basis).

Steer Number	AVERAGE DAILY RATION		
	Silage	Cottonseed Meal	Fodder
2	11.178	1.778	....
9	....	1.778	11.300
69	11.700	1.778	....
54	....	1.778	11.880
80	11.178	1.778	....
87	....	1.778	11.300

The percentage composition of feeds used in the first digestion trial are shown in Table VI. Table VIII gives the percentage composition of the feces of the steers used in the first digestion trial. The coefficients of apparent digestibility calculated from Tables V, VI and VIII are summarized in Table X. The figures indicate that there was little difference in the thoroughness with which various animals digested their feed, and that no significant difference occurred in the digestibility of the ground fodder and silage when fed with cottonseed meal.

The same animals were used in the second digestion trial where no cottonseed meal was included in the rations. Table XI gives the average daily dry matter consumption of the steers during the second digestion trial.

Table VI - Percentage composition of feeds used in first digestion trial. (Dry Matter Basis.)

Feed	% Crude Protein	% True Protein	% Ether Extract	% Crude Fiber	% Ash	% Nitrogen Free Extract	% Free Amino Nitrogen	% Reducing Sugars	% Sand Silica	% Sand	% Silica
Atlas Sorgo Silage	5.62	3.85	2.48	22.00	6.86	63.02	0.078	1.05	3.72	1.71	2.00
Atlas Sorgo Fodder	7.15	6.88	3.02	22.12	7.20	60.50	0.040	3.86	4.28	2.15	2.12
Cottonseed Meal	47.57	44.57	7.27	8.87	6.21	30.06	0.049	0.492	0.07	0.04	0.03

Table VII - Percentage composition of feeds used in second digestion trial. (Dry Matter Basis.)

Atlas Sorgo Silage	6.53	4.39	2.70	22.43	6.86	61.66	0.084	0.97	3.95	1.66	2.29
Atlas Sorgo Fodder	7.35	6.12	3.08	21.45	7.70	60.40	0.039	3.93	4.68	2.32	2.36

Table VIII - Percentage composition of feces of steers used in first digestion trial. (Dry matter basis.)

Steer Number	% Crude Protein	% True Protein	% Ether Extract	% Crude Fiber	% Ash	% Nitrogen Free Extract	% Sand and Silica	% Sand	% Silica
2	10.71	9.79	2.11	20.24	20.42	46.50	15.13	8.64	6.49
9	11.97	10.79	1.36	20.17	27.30	39.28	20.68	12.68	7.99
69	10.82	10.63	1.94	23.35	16.51	47.46	11.60	5.14	6.45
54	12.14	10.63	1.66	24.68	18.37	43.24	13.02	6.82	6.19
80	10.90	9.64	2.13	22.26	20.00	44.69	14.22	7.83	6.39
87	11.22	10.36	1.56	23.11	21.78	42.31	16.37	9.03	7.24

Table IX - Percentage composition of feces of steers used in second digestion trial. (Dry matter basis.)

2	7.81	6.86	2.16	24.12	17.85	48.03	14.19	7.79	6.39
9	9.59	7.95	1.57	23.33	18.89	46.61	14.77	8.64	6.13
69	8.22	7.17	2.22	23.23	17.02	49.09	12.82	6.54	6.27
54	9.88	8.02	1.78	26.21	15.75	46.36	12.07	6.33	5.74
80	8.40	7.27	1.95	24.02	19.45	46.15	15.40	9.49	5.91
87	9.39	8.64	1.90	23.92	18.42	46.35	14.63	8.53	6.09

Table X - Coefficients of apparent digestibility.
Trial 1. Silage and fodder fed with cottonseed meal.

Steer Number	Ration	Dry Matter	Crude Protein	True Protein	Ether Extract	Crude Fiber	Nitrogen Free Extract
2	Silage Cottonseed Meal	73.95	74.90	72.14	82.06	73.28	78.79
9	Fodder Cottonseed Meal	76.98	78.19	79.32	91.24	77.14	83.78
69	Silage Cottonseed Meal	73.04	76.64	68.70	83.11	68.99	78.16
54	Fodder Cottonseed Meal	70.14	70.69	73.05	86.14	64.38	77.13
80	Silage Cottonseed Meal	72.95	74.05	72.34	81.58	70.14	79.29
87	Fodder Cottonseed Meal	70.94	77.42	79.09	88.90	71.09	80.72
Average of three	Silage Steers	73.31	75.20	71.06	82.25	70.78	78.75
Average of three	Fodder Steers	72.69	73.29	77.15	88.76	70.87	80.54

Table XII - Coefficients of apparent digestibility.
Trial 2. Silage and fodder fed alone.

2	Silage	64.15	57.32	44.03	71.42	61.52	72.13
9	Fodder	61.90	50.00	50.00	80.42	58.15	70.29
69	Silage	63.89	52.49	40.33	69.98	62.17	70.93
54	Fodder	63.77	44.21	45.41	76.17	49.25	69.11
80	Silage	60.98	50.20	35.84	71.93	58.56	71.00
87	Fodder	61.36	50.33	45.42	76.13	56.87	70.31
Average of three	Fodder Steers	62.35	48.18	46.94	77.57	54.75	70.00
Average of three	Silage Steers	62.94	53.33	40.06	71.11	60.73	71.00

Table XI - Average daily consumption of feed during second digestion trial (Dry matter basis).

Steer Number	AVERAGE DAILY RATION	
	Silage	Fodder
2	12.956	....
9	....	13.078
69	13.478	....
54	....	13.658
80	12.956	....
87	....	13.078

Table VI gives the percentage composition of the feeds used in the second digestion trial. The percentage composition of the feces collected during the second digestion trial are shown in Table IX. A summarization of the coefficients of apparent digestibility for the second trial appear in Table XII. These coefficients were computed from Tables VII, IX and XI. The coefficients seem to indicate that no difference exists between the digestibility of ground fodder and silage when fed alone. The only distinct variation was the higher coefficient for crude fiber absorption in the case of silage which probably is due in part to individual differences in the ability of animals to digest feed.

When the coefficients of apparent digestibility of the cottonseed meal were calculated indirectly from the data herein reported impossible coefficients appeared. The average coefficients of apparent digestibility of the cottonseed meal when fed with silage were as follows: Crude protein, 91.28 per cent; true protein, 88.13 per cent; ether extract, 112.29 per cent; crude fiber, 230.08 per cent; and nitrogen free extract, 189.60 per cent; and when fed with ground fodder: Crude protein, 99.97 per cent; true protein 118.23 per cent; ether extract, 117.34 per cent; crude fiber, 299.78 per cent; and nitrogen free extract, 214.07 per cent.

Mitchell (19) explains such coefficients as follows: "More attention should be given to the frequent existence of an 'association digestibility' among feeds and its significance. When impossible coefficients are obtained in the indirect determination of the digestibility of a feed, the common reaction seems to be that the digestion trial is in error and that its results should be corrected. However, such results are not necessarily due to faulty technic; they more probably indicate the existence of mutual effects of one feed on the digestibility of the other, a situation that should not be slighted nor obscured.

It signifies that the digestibility of mixtures of feeds cannot be computed from the digestibility of single feeds, but must be determined experimentally. The case is exactly analogous to the supplementary effect in nutrition of the proteins of one feed upon those of another, precluding any accurate estimate of the protein values of a ration from the protein values of the constituent feeds. Where such associations or supplementary effects are appreciable, the experimental results obtained are as important and significant as the results obtained upon individual feeds."

The cottonseed meal appeared to have a slightly greater associative effect when fed with ground fodder than when fed with silage. The effect was most noticeable in the case of the digestibility of the fiber.

The writer fully recognizes the fact that the coefficients of digestibility, herein reported, are only significant when the same combinations of feeds are fed under the same conditions. They do, however, tend to show that the digestibility of the plant material was not significantly increased by the ensiling process as has commonly been the opinion.

It was noted in the physical appearance of the feces that the feces from steers fed silage contained more whole grains than did those of steers fed ground fodder. The percentage of grain, on a dry matter basis, voided whole are given in Table XIII.

Table XIII - Per cent whole grain voided in feces. (Dry matter basis.)

Steer Number	Ration	% Whole Grain of Dry Matter in Feces
2	Silage	48.97
9	Fodder	20.15
69	Silage	51.76
54	Fodder	22.47
80	Silage	49.23
87	Fodder	21.23
Average of 3 silage steers		49.98
Average of 3 fodder steers		21.28

This is readily explained by the fact that the silage contained more whole grains per gram of dry matter than did the ground fodder as is shown in Table I. The effect that the increased fineness of the fodder may have had upon the

digestibility and gains produced is undeterminable. It is known, however, that the grinding of feed, especially grain, does increase its digestibility.

In determining the coefficient of apparent digestibility by the method herein used, it was found that the ratio of total sand and silica to dry matter in the feed and feces could not be used because there was more sand voided in the feces than could be accounted for in the feed eaten. This may be explained as follows: First, when steers are turned into a lot they often eat a small amount of soil; second, the sand content of the feeds vary from day to day; and third, due to heaviness of the sand it tends to settle out into blind extremities of the paunch of ruminants and may be voided in large quantities at one time and in smaller quantities at another time, thus causing a variation in the sand content of the feces.

It was recognized that in this study several variables may have effected the results. The effect of the increased fineness of the fodder could have been eliminated by grinding it to the same fineness modulus as the silage. The difference in the amount of whole and cracked grain in the fodder and silage might have been controlled by using fodder and silage with the heads removed and adding to

each ration an equal amount of grain ground to a similar fineness. However, with the facilities at hand at the time the experiment was begun it was impossible to control these variables.

SUMMARY

1. Twelve Hereford yearling steers, allotted in pairs on a basis of feeder grade, weight, temperament, and probable outcome, were studied for changes in weight, ability to utilize feed, and ability to digest feed, as affected by differences in rations supplied them. Both members of each pair received the same amount of dry matter by weight. One steer of each pair received his dry matter in the form of Atlas Sorgo silage and cottonseed meal and the other one received his dry matter in the form of ground Atlas Sorgo fodder and cottonseed meal. The steers were fed individually twice daily. Pair V was dropped from the experiment due to illness of the steer fed silage.

2. Moisture determinations of the feeds were made at four day intervals and the dry matter rations computed therefrom.

3. Changes in body weight of all steers were noted every fourteen days.

4. Chemical analyses of composite samples of the feeds were made.

5. The digestibility of the dry matter in silage and ground fodder, when fed with and without cottonseed meal, was determined indirectly by calculations which were made possible by chemically determining the ratio of silica to dry matter in the feed and feces.

6. In body weight, the steers fed ground fodder increased 34.6 pounds more per steer than did the steers fed silage.

7. In gain in body weight per 100 pounds of dry matter consumed, the steers fed ground fodder increased 6.978 pounds more than the steers fed silage.

8. The advantages held by the fodder steers over the silage steers in rate and economy of gain were treated statistically and found to be insignificant.

9. The average coefficient of apparent digestibility of the dry matter in silage when fed with cottonseed meal was 73.32 and of the ground fodder when fed with cottonseed meal was 72.69.

10. Coefficients of apparent digestibility of the dry matter of the silage and ground fodder were 62.94 and 62.35 respectively.

11. The silage contained 3.77 per cent more grain than did the ground fodder on a dry matter basis. The ground fodder had a fineness modulus of 3.517 and the silage of 4.683.

12. The silage contained 2.815 per cent less reducing sugar, 1.537 per cent less crude protein, 3.035 per cent less true protein, 0.0379 per cent more free amino nitrogen, and 2.52 per cent more nitrogen free extract than did the ground fodder on a dry matter basis.

CONCLUSIONS

1. The dry matter of the ground Atlas Sorgo fodder and Atlas Sorgo silage used in this test were found to have approximately the same nutritive value when fed with cottonseed meal as a wintering ration for yearling steers.

2. No significant differences were noted in the apparent digestibility of the dry matter in the ground fodder and silage when fed with or without cottonseed meal.

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