Approved
C. H. Eckel
C. B. Hutchinson

SILAGE INVESTIGATION

by

Albert Lark Darnell, B. S. in Agr.

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SILAGE INVESTIGATION.

INTRODUCTION.

The practice of preserving green feeds in silos dates back about one hundred and thirty years. According¹ to Simonds, it was a common practice in Italy to preserve fresh leaves for cattle, in pits, or in casks, above ground, as early as 1786. Possibly the first article on the preservation of green feeds in silos was written by Johnston, an Englishman, in 1843. The practice of storing green maize in silos was probably begun in 1869, when Adolph Reihlen, a sugar manufacturer of Stuttgart, Germany, stored in a silo, a crop of corn of the large yellow dent variety. The results of his work were published in both German and French in 1870, which led many farmers in France to build silos. A. Goffart, in 1877 wrote, perhaps the first book on "ensilage" which was translated into English and published a few years later in New York.

1. U. S. Dep't. of Agriculture, Bul. No. 32, pp7.

The first silage made in the United States was put up by Manly Miles of Michigan, who built two silos in 1875 and filled them with small grain and hay. From this beginning the silo has spread rapidly; due, first, to the fact that it prevents waste of a portion of the forage that would otherwise be lost, and converts it into palatable food; secondly, it is the most economical method of supplying succulent feed during the winter and the hot dry periods of summer.

At the present time the silo is found on many thousand farms in the United States, especially in dairy regions, and it may be considered a well-established fixture in American farm economy, where stock feeding is practiced.

The first work with silage along experimental lines was probably conducted by Francis Morris of Maryland, in 1876. From this date to the early part of the twentieth century considerable work was carried out. After 1902, little work was done along this line until very recently. At the present time various phases of the subject are under investigation by several experiment stations.

The work at the Missouri Experiment Station

was begun in 1913. The work for that year was conducted by D. G. Magruder. The work for 1914-15 was a continuation of that begun in 1913 and was carried on by O. I. Oshel. The investigations during 1915-16 have been conducted by the present writer and were designed to continue and supplement the investigations of the previous years. The scope of the investigation reported in this thesis may be considered as an attempt to answer the following questions by experimental methods:

1. What are the factors affecting acidity in silage?
 2. What is the percentage loss in the silo as compared with shocking corn in the field?
 3. What are the possibilities of making silage from the legume crops?
 4. What is the percentage loss when shock corn is put in the silo, and is there a normal acidity developed in silage from shock corn?
 5. Is it possible to make silage from the small cereal crops, and from the non-saccharide sorghum?
 6. What are the factors affecting the weight of a cubic foot of silage at different depths?
 7. What is the effect of mould upon the composition of silage?
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LITERATURE.

Ensilage as defined by Webster is the material as it appears while being put into the silo. Immediately after the material is stored it begins to undergo physical, chemical and bacterial changes, that continue for about fourteen days, at which time the material is known as silage. Thus silage formation includes all the physical, chemical and bacterial changes which take place in the silo the first fourteen days after being filled.

At the present time there are two views held as to silage fermentation: one, that it is due to the action of bacteria, the other, that it is due to the intra-molecular respiration of the cells. The former view is supported¹ by several experiment stations: Pernot, Whitcombe and Kinsley of the Oregon Experiment Station, and Esten and Mason of the Storrs Experiment Station, being the strongest supporters.³ Hart, Willaman, Babcock and Russell of the Wisconsin Experiment Station, and E. J. Russell of⁵ the Rothamstead Experiment Station in England, support the latter view. The larger mass of evidence seem to support the intra-molecular theory.

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1. Ore. Exp. Sta. Rpt., 1902, pp. 68-69; Bul. 72.
 2. Storrs Exp. Sta.; Bul. No. 70, 1912, pp. 12-14.
 3. Jour. Amer. Chem. Soc., 34(1912) No. 11, pp. 1619-1625.
 4. Chem. News, 70(1894), pp. 273-275.
 5. Jour. Agr. Sci. 2(1908), No. 4, pp. 395-410.

FACTORS INFLUENCING ACIDITY IN SILAGE.

As a result of work on silage fermentation for
¹
 three years at the Storrs Station, Connecticut, Esten
 and Mason pointed out that there is a thin film of
 juice surrounding each piece of silage which affords
 an ideal media for the growth of sugar fermenting
 yeast and bacteria, which begin to grow as soon as
 the silage enters the silo. The work of the bacteria
 in changing the sugar to acid is continued for a time
 until the lactic acid bacteria cease to work, then the
 yeast completes the fermentation of the remaining sugar.

The alcohol produced is immediately acted on by acetic
 bacteria and changed to acetic acid.

The factors aiding these changes, as pointed
 out by authors, are, proper temperature, lack of air
 in the silage, and symbiosis. Acid bacteria need a
 temperature not lower than 60^o F but grow much better
 at temperatures from 70^o F. to 90^o F. Yeast work better
 at a temperature between 70^o F. and 90^o F.

²

The Illinois Experiment Station reports the

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1. Storrs Expt. Sta. Bul. 70
 2. Ill. Exp. Sta. (1888) Bul. 2.

presence of *Bacterium aceti*, *Bacterium lactis*, and *Spirillum postorianus* in samples of silage. Amounts of acid found in three samples were 1.99%, 2.27%, and 2.44%. Clover silage fifteen days old had .038% acetic acid, .865% lactic acid or a total of .903%. Green wheat silage twenty-eight days old had .338% acetic and 1.20% lactic, or a total of 1.53% acid.

¹ Whitcombe and Kinsley of the Oregon Station found that corn silage, after being steamed in the silo, underwent very little fermentation. However, the fermenting organisms in silage from legume crops seemed to be more resistant against heat, as there was more fermentation in silage from these crops than from corn. The acidity of silage not steamed varied from 1.01% to 1.94% and averaged 1.58%. The acidity of the steamed silage varied from .30% to .88% and averaged .55%

² Short, of Wisconsin, showed that as corn becomes more mature, it contains less water and produces silage with a lower per cent of acid. The higher the per cent of moisture in the silage, greater is the per cent of acid, as shown in the following table:

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1. Ore. Expt. Sta. Bul. 72.
 2. Wis. Exp. Sta., Bul. 19, pp. 20.

Variety of Corn:	Percent of Moisture	Percent of Acid.
Flint	39.85	0.53
Flint	40.89	0.66
Flint	41.20	0.67
Dent	38.13	0.43
Dent	78.00	1.42
Dent	80.00	1.64
Evergreen	77.90	1.31
Evergreen	68.30	0.98
B & W	82.00	1.16
B & W	79.00	0.81
B & W	45.00	0.53
Sheep's Tooth	75.35	1.26

¹ King, of the same Station found that when water was added to the silo while being filled, a high per cent of acid was developed in the silage and there was not as great loss by the action of undesirable ferments.

² Whitcombe confirms King's results. He found that

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1. Wis. Exp. Sta. 10th. Ann. Rpt. pp. 211-227.
 2. Ore. Exp. Sta. Bul. 67. pp. 104.

both corn and legume silage with a low per cent of dry matter had a correspondingly high per cent of acid. However, the silage made from the legumes did not give as good results as did the corn, the tendency being toward a lower per cent of acid when there is an excess of moisture.

¹ Morse, of the New Hampshire Station found that the percentage acidity in silage varied with the variety of corn, for example: The average acidity of silage made from the Leaming variety of corn was .67%, that made from the Mosby Prolific averaged .83%, while that made from the Sanford variety averaged 1.95%. Morse also found that there was a lower per cent of acid at the surface of the silage after standing a few hours than there was six inches below the surface, the percentages being .83% and 1.3% respectively, calculated as acetic acid.

² The Massachusetts Experiment Station reports a high per cent of acid with a correspondingly low per cent of dry matter.

³ Babcock and Russell, of Wisconsin, claim that acid formed in silage is due to the intra-molecular respiration of the plant tissues, hence silage made from

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1. N. H. Exp. Sta. Bul. 96, pp. 115.
 2. Mass. Exp. Sta. Bu. 36, (1890).
 3. Chem. News 70(1894), pp. 273-275.

corn in the milk stage, having more active cell tissue, will develop more acid than that made from more mature corn. They also pointed out that carbon dioxide has something to do with the development of acid, as it kills the plant tissue, thus checking the intra-molecular respiration.

¹
Hart and Willaman, of the same Station are of the opinion that the acidity of silage is caused by anaerobic respiration of the living cells within the tissues, rather than by means of foreign organisms. Their decision was based upon the fact that grinding the silage very fine with a meat grinder liberates more acid than by chopping with a knife.

²
Dox and Neidig, of the Iowa Station conducted an experiment to show the rate of formation of lactic acid in silage. Samples were taken each day for fourteen days. They were taken with a two inch soil auger through holes in the door, after which the holes were carefully sealed. The greatest formation of lactic acid and volatile acids occurred between the first and fourth day. The ratio of lactic to volatile acids as an average of all samples was 1.0 to 0.75. ³ Neidig, a few years later, with other experiments on silage

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1. Jour. Amer. Chem. Soci. 34(1912) No. 11, pp. 1619-1625.
 2. Iowa Exp. Sta. Res. Bul. No. 10.
 3. Iowa Exp. Sta. Res. Bul. No. 16.

showed with three different types of silos the relation between the sugar content of the corn and the acid of the silage made therefrom. He took samples from a silo (as previously described) at frequent intervals for two weeks. He found that from the time of filling, there was a gradual increase in the amount of volatile acids (acetic and propionic) as well as a gradual increase of the non-volatile acid (lactic). There was a trace of butyric and valeric acids in some cases at the beginning, but disappeared in a few days. From the time of filling the silos the sugar decreased in amount until a minimum was reached in about three weeks. In no instance did the reducing sugars disappear completely.

¹
Griffith found with acid silage produced from clover, at temperatures of 32^o C. to 49^o C., the volatile acids were; from very immature forage, 1.19%; from plants just in bloom, 0.38%. The non-volatile acids were respectively, 0.31% and 0.23%. The silage was more acid from immature than from older plants.

²
Kedzie demonstrates with corn cut when in full tassel and in first stage of silk made silage with 1.26% acid. Silage made from corn cut at intervals of one week from the first cutting in August to the last

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1. Chem. News, 70(1894), No. 1828, pp. 273-275.
 2. Mich. Exp. Sta. Bul. 68. (1890) pp. 10.

cutting in September, when the corn was in the glazed stage and some of the older stalks with hard ears, showed a constant decrease in the amount of acid contained, from 1.26% in August to .70% in September. This is (as previously pointed out) due to the greater functional activity of the plant cells in the early stages. During this period the tissues are not only richer in protoplasm but are more active and hence the amount of fermentative changes which take place in the dying of the cells is greater than in those stages where the tissues are much more mature.

¹ Magruder, in his work at this Station, shows that the per cent of acid at the wall and in the center of the silo varies, the difference being 1.8% and 2.1% respectively. He also showed that there is a normal amount of acid developed in silage made from shock corn when water is added in the ratio of 1:1. Where 6.25 pounds of water was added to every twenty pounds of fodder the silage produced had only .76% of acid. With other proportions of water and fodder he found the acid to increase in direct proportion to the water added. In siloing green corn as compared with the more mature

1. Thesis, "Silos and Silage", Univ. Mo. 1914.

corn he obtained the same results reported by various other experiment stations; that is a higher per cent of acid in silage made from immature corn.

¹
Oshel showed that the high per cent of acid in silage made from immature corn is not necessarily due to a high moisture content, but suggests the amount of sugar present. This he showed by siloing crops with different sugar content, in small silos. However, he claimed that all of the acid developed is not due to direct fermentation of sugar, but must be due to some other agent, as shown in the case of alfalfa silage which developed 2.05% of acid, as compared with corn which developed 2.58% acid. He also pointed out that the more air present in silage, the lower the per cent of acid developed.

LOSSES IN SILAGE.

The fermentation of an organic body is always accompanied by a loss of substance, the amount destroyed depending upon the extent of the fermentation. The greater the fermentation, the higher the temperature runs in the silo, and it is a well established fact that silage formation is accompanied by a high temperature. It is easily seen therefore, that under the conditions which

1. Thesis, "Silage Investigations" for the Degree of A.M., Univ. of Mo., 1915.

exist in the silo we must expect a loss of dry matter, and that the higher the temperature in the silo, the greater will be the loss. This loss, as indicated by various experiment stations, ranges from 2% to 31%; none, so far, reporting a smaller loss than 2%.

Early work along this line carried on at the ¹ Wisconsin Experiment Station showed a loss of from 14.7% to 31.81%. ² The Arkansas Station reported a loss of 13.7% to 27.8% in total weight, and results obtained by ³ Armsby showed a loss of 22.9% to 43.48% in total nutrients. All of these results include the loss from mouldy silage as well as what mechanical losses that might have occurred.

⁴ Babcock and Russell point out that there are two kinds of losses in the silo: (1), the unavoidable losses which are due to the formation of water, carbon dioxide, and volatile organic acids which are produced as a result of the intra-molecular respiratory process of the ensiled tissue. As these changes are prolonged in the more active and immature tissues in comparison with the more mature, the losses in the first case are greater. (2), The avoidable losses which are due mainly

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1. Wis. Exp. Sta. Bul. 19, pp. 19.
 2. Ark. Exp. Sta. Rpt. 1890, pp. 5.
 3. Penn. State Col. Rpt. 1890, pp. 67.
 4. Wis. Exp. Sta. Rpt. 1900, pp. 123-141.

to the decomposition of organic matter induced by the development of bacteria and moulds, the growth of which is greatly facilitated by the admission of air, as a result of imperfect construction of the silo.¹ King's results substantiates Russell and Babcock's contentions. He weighed the forage as put in the silos and silage when taken out for three years. That lost by moulding was weighed separate from the good silage. Samples were taken from each load of corn as it was cut and put in the silo, and the average of all these samples was used to represent the contents of that silo. One or more tons of silage was taken from the silo at a time, and samples of from 50 to 80 pounds taken from each of these lots. About 200 grams was taken from this sample for analysis, and 30 pounds weighed into a wire basket for the determination of dry matter.

The first year, 1893, there was put into the silo 63.37 tons of corn, and there was removed from it 57.2 tons of thoroughly good, bright green silage, making a loss of 10.16%. When the spoiled was included in this there was a loss of only 7.35%. The loss in dry matter was 8.10% in the first case, but with the mouldy silage included this was reduced to 4.95%. The results obtained the next year in silo with 67.85 tons were practically

1. Wis. Exp. Sta. Rpt. 1895, pp. 373-378.

the same as those for 1893, with the exception of a little greater loss in dry matter. Thus Mr. King's results show both the avoidable and unavoidable losses in the silo.

¹ King again in 1900 conducted an experiment with silage in small glass jars to determine the effect of air on the loss in weight of silage. In both tests that he run, there was a greater loss in the jars containing a large amount of air than in those with a very small amount, or none; the percentages being 3.68% and 1.27% respectively. ² In another experiment he siloed in pint mason fruit jars, field peas, just passed the blooming stage, cowpeas with young peas, first cutting of alfalfa, oats just beginning to head, and corn just coming into roasting ears. In 108 days the alfalfa silage lost 3.01%, field pea silage lost 2.40%, cowpea silage lost .91%, oat silage lost 2.3% and the corn silage lost 4.93% of dry matter.

³ An experiment is reported by the Geneva, New York, Experiment Station, which consisted in burying sacks of silage in a silo at different depths at the time of filling. It was found that with thirteen different sacks there was an average loss of 12.6% dry matter, 26.6% sugar and starch, 15.1% of nitrogen-free

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1. Wis. Exp. Sta. Rpt. 1900, pp. 189-196.
 2. Wis. Exp. Sta. Rpt. 1901, pp. 200-209.
 3. N. Y. State Exp. Sta. 11th. Ann. Rpt. pp. 162.

extract, 9.8% of crude fiber, 18.5% of albuminoids, .4% of ash, and 3.9% of water. There was an apparent increase of 45.4% of crude fat, which was doubtless due to the fact that in the fermentation in the silo a larger percentage is rendered soluable in ether and this ether extract was termed crude fat in this experiment. It is also pointed out that the greatest loss in the silo is in the dry matter as claimed by ¹ Cooke. Cooke siloed corn in the glazed stage, using a small tank three feet high and about two feet in diameter, and found a loss of 2.67% of water and 14.67% of dry matter. The loss in dry matter fell almost entirely on the nitrogen-free extract. The acid was not determined. Cooke does not claim the above results are typical of all silos and sights as an example some tests made the year previous which showed the amount of water lost was from six to seven times as much as the dry matter. In each of the cases of the previous year the contents had heated considerably, while in the case of the small tank almost no heat was developed. It is natural to suppose that high temperature tends to drive off a large proportional amount of water.

² The Kansas Experiment Station in siloing different crops for a period of six years shows an average loss of 12.3% by weight in silage. They filled

1. Vt. Exp. Sta. Rpt. 1889, pp. 96.

2. Kan. Exp. Sta., Bul. 48, pp. 33-40.

three silos of varying capacity from 33 tons in the case of the smallest to about 100 tons in the largest. These silos were filled in the usual manner each year with either corn, sorghum, or Kaffir corn. The corn was cut as near the hard dough stage as possible and the sorghum was mature. Uniting and averaging the results for the six year period, they found that 77.2% of the total was good feed, 10.5% was rotten, and 12.3% lost.

¹ Kalngin and Parashchuck point out with an experiment in siloing red clover, cabbage, and fodder carrots, that close packing of the material in the silo aided their preservation, the structure of the fodder being maintained and an agreeable odor being produced. The loss of organic substance was reduced, except that the decomposition of proteids was considerably increased. Close packing also caused an increase in the formation of free organic acids. Loose packing on the other hand was not favorable, the fodder becoming covered with moulds and acquiring a disagreeable odor and the loss of organic substance increasing except in the case of proteids. They also showed that the addition of carbon bisulphid to the silo greatly diminished the loss of all organic nutritive substances, especially when the fodder was loosely packed, and it arrested in a considerable

1. Zap. Novo-Alexandri Inst. Selsk. Khoz. i Lyesov., 1899, pp. 39.

measure the development of free organic acids.

¹
Kellner points out that silage made from green maize, when taken out of the silo, or pit, at the end of 120 days had lost 17.5% of organic matter, 22.3% of crude protein, 41.7% of pure protein, 21.1% crude fiber, and 17.5% of nitrogen-free extract. Beet tops and leaves after being in a pit silo for 140 days showed a loss of 49% of dry matter, 63% of crude protein, 74% of pure protein, 33% crude fiber, 43% nitrogen-free extract and 67% of mineral substances. According to other observations made by Kellner, sliced beet roots ensiled for seven months in a wooden lined pit silo lost 22% of organic and in an unwallled silo there was 35% loss. Potatoes lost in sixteen months 19-36%, mangels 32%, and beet leaves 31%, the loss increasing with the length of storage period. However, it was shown by Mr. Kellner in other experiments that the great loss in the above was greatly reduced when a water-tight silo was in the place of the very poorly constructed ones used in the first experiment.

²
Tangi and Weiser demonstrated that when green alfalfa was siloed for eight months it lost 33.3% in total weight. The outer layers of silage were more or less mouldy and in some cases it was charred.

1. Landw. Vers. Stat. pp. 105-114.

2. Landw. Vers. Stat., 74 (1911), No. 3-5, pp. 263-342.

The results before and after siloing are shown in the following table for both green alfalfa and corn stover:

Analysis	H ₂ O	Percent Protein		Fat	Fiber	N.	F.E.	Energy Value Cal. in 100 Gr's	Ash
		Crude	Pure						
Alfalfa When Put in Silo	13	14.55	12.05	3.38	20.65	42.67		390.1	
Alfalfa When Taken Out of Silo	48	10.62	7.2	1.63	10.31	24.98		235.6	
Corn Stover When Put in Silo	15	5.57	4.89	1.41	27.53	44.25			6.24
Corn Stover When Taken Out of silo.	65	2.51	1.48	0.95	11.64	17.1			2.8

In metabolism experiments with wethers showed a loss in digestibility of all constituents of the alfalfa silage as seen in the following table:

	%	%	%	%	%
	Crude	Pure			
Trial.	Protein.	Protein.	Fat.	Fiber.	N. F. E.
Before Siloing:	74.5	71.7	52.8	42.1	63.9
After Siloing:	48.0	29.8	44.9	38.2	52.7

The stover silage was made in an iron-concrete silo. As noted in the first table there was not as great loss in nutriment as in the case of the alfalfa, and this loss was off-set by the increased palatability of the stover.

¹ Smith reports an average loss of 8.32% in total weight for four silos. The greatest loss was noted in silage made from immature corn, the loss decreasing with the maturity of the corn. ² Morse claims that this loss is due to the immature corn having a larger amount of sugar than the more mature corn. He shows that the greatest loss comes in the sugar of the plant, and in the case of mature corn this sugar has been converted into starch which is changed but

1. Mich. Exp. Sta. Bul. 191, pp. 165.

2. N. H. Exp. Sta. Bul. 92, pp. 59-62.

very little in the silo. Smith's figure of 8.32% loss includes the loss from mouldy silage.¹ Cooke reports a loss of only 3% but he does not include the loss from mould.² Penny, shows in his results a loss of 6.0% which agrees quite closely with the above results. He claims that the greatest loss is in the sugar and is brought about more rapidly with a high temperature.

On comparing the composition of silage with that of the maize from which it was formed,³ Russell of the Rothamstead Experiment Station, England, found that the fiber was practically unaltered in amount. He confirmed his observations by microscopical examinations of sections of maize and of the silage afterwards produced. He found that the epidermal cells had undergone no change in the silo beyond a certain amount of shrinkage; even the stomata were intact. Similarly the vascular bundles were intact. He showed that nitrogen-free extract suffered most, and a direct test showed that the sugar disappeared almost entirely. The less resistant cellulose showed a decrease in amount. The protein suffered considerably, though not as much as the nitrogen-free extract. His table is as follows:

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1. Colo. Exp. Sta. Bul. 57, (1902) pp. 15.
 2. Del. Sta. Rpt. 1903, pp. 40-41.
 3. Jour. Agri. Sci. 2(1908), pp. 387.

Mean Loss In The Silo.

	Dry Mat- ter.	Ether Ex- tract	N.E.F.	Fiber	Tot- al N.	Pro- tein N.	Non- Pro. N.	Ash	Furfur- ol.
Put in	100	100	100	100	100	100	100	100	100
Taken out	64	84	45	92	74	45	183	86	68
Loss	36	16	55	8	26	55		14	32
Gain							83		

¹ Magruder reports a loss of from .31 to 5.86% in green corn silage, and a loss of from 2.49% to 6.66% in silage made from shock corn. ² Oshel reports a loss of 3.37% by weight in silage made from peas and oats, 2.46% in that made from corn, an average of 4.48% in that made from soy beans, 4.83% in partially dried corn silage, and 7.5% in silage made from corn fodder.

The figures reported by Magruder and Oshel do not include the loss from mouldy silage.

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1. Thesis, "Silos & Silage", for the degree of A. M. Univ., Mo., 1914.
 2. Thesis, "Silage Investigations", for the degree of A.M. Univ., Mo., 1915.

LEGUMES FOR SILAGE.

Heretofore the legume crops have not been considered very good for silage purposes, but recently it has been shown that there are conditions under which they may prove satisfactory. At the present time there is much experimental work being done with these crops for silage purposes.

¹
Alfalfa:- At the Colorado Experiment Station some tests were made on a small scale to show what losses might be expected in making silage of alfalfa. One test was made with the alfalfa placed in the silo as cut in the field, and the other with the alfalfa cut to quarter inch pieces. The whole alfalfa showed a spoiled layer three inches thick on top and an inch layer around the sides nearly all the way down. The silage of the bottom and middle was excellent and was greedily eaten by the cows and calves. Its loss in total weight was 10.7%, but its loss in feeding value was probably a little larger.

On the day after filling the silo with the cut alfalfa it was covered with two thickness of building paper and one of boards, and weighted with stones to about fifty-five pounds per square foot. When covered

1. Colo. Exp. Sta. Bul. 57, pp. 10.

the silage was hotter than the hand could bear. Two days later the temperature had fallen to 83⁰ F. and in two days more it had fallen to that of the air. The silage shrunk and settled a great deal. When put in, it contained 33.0% of dry matter. On opening, the silo showed two inches of spoiled silage on top and half an inch on the sides. The spoiled silage was 7.3% of the total weight. The loss in dry matter was approximately 10%.

At the Kansas Experiment Station alfalfa has been ensiled fairly successfully. ¹ Professor Reed in writing on this subject says that alfalfa makes good silage but the silage will not keep but a few months in a good condition. ² Professor Stone of the Cornell University reports practically the same results as the Kansas Station. He obtained satisfactory results from siloing one hundred tons of alfalfa. The silage was fed out during the summer and was eaten fairly well. Some that remained in the silo and was covered with corn in September came out the following spring in a less satisfactory condition. The practice was not considered sufficiently successful to warrant its continuance. The results of various experiments indicated good returns from alfalfa silage if it is fed within a few months.

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1. Correspondence.
 2. Correspondence.

Digestion experiments with sheep on alfalfa hay and alfalfa silage were carried on by Professor True of the Nevada Experiment Station to determine their relative values. The hay was from the first cutting of alfalfa and the silage from the second cutting. The digestability of the two feeds is shown in the following table:

	%	%	%	%	%	%	%
Feeds	D.M.	Pro.	Fat	Fiber	tract	Ash	
Alfalfa Hay	57.52	60.07	37.77	54.39	67.59	32.26	
Alfalfa Silage	46.47	52.14	78.46	38.67	45.53	43.52	

On comparing the two it can be seen that the alfalfa hay is more digestable.

Magruder buried two sacks of alfalfa in a large silo. The alfalfa was cut the usual length for silage with a silage cutter. To one of the sacks he added sugar by sprinkling over the alfalfa.

Both sacks when removed from the silo were in excellent condition, the silage having the appearance

1. Nevada Exp. Sta., Bul. 72, pp. 37-40.

2. Thesis, "Silos & Silage", for the degree of A. M., Univ. Mo., 1914.

of green alfalfa. The sugar had no effect on the amount of acid developed as it was at first supposed.

¹ Oshel put the second cutting of alfalfa, the most of it being in bloom, into a small experimental silo. The silage made therefrom had 2.05% of acid and was in excellent condition when taken out of the silo, although it seemed quite dry. It seemed to mould very easily, as there was considerably more mouldy silage on top than there would have been with ordinary silage crops.

² Some experiments at Piacenza, with the second cutting of alfalfa showed that this crop could be siloed to good advantage. The silage to which lactic acid ferment was added gave better results than that with no culture.

³ Four small silos (one ton each) were filled at the Nebraska Station in 1914, one with alfalfa and three with alfalfa and cane mixed in different proportions. Eleven months after filling, the silos were opened and the silage in all, except one containing alfalfa alone, was in perfect condition. It was found that a mixture composed of two parts of alfalfa and one of cane made silage of an excellent quality, it having 1.3% acid and 62.13% of moisture.

⁴ Clover:- Clark demonstrated that the second crop of

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1. Thesis, "Silage Investigations", for the degree of A. M., Univ. Mo., 1915.
 2. Milch Zentr., 43, pp. 15.
 3. Neb. Exp. Sta. Press Bu. 46.
 4. Mont. Exp. Sta., Bul. 94.

of clover made into silage during September and October after being frozen, kept well until May and June the following year, but becomes dark in color, strong in odor, and was not relished by dairy cows after the weather became warm, although they relished it and had a keen appetite for it during the winter months. As an of three experiments of two periods each, he pointed out that the clover silage was more economical as a feed for dairy cattle. On clover hay the cost of producing one hundred pounds of milk was 73.9 cents, and of one pound of butter fat 17.9 cents, while on clover silage the cost of producing one hundred pounds of milk was 73.4 cents, and of one pound of butter fat 17.8 cents.

However, in milk production 2.33 pounds of clover silage was required to equal one pound of clover hay. The value of clover silage according to the experiments reported, ranges from \$2.36 to \$2.76 per ton.

With experiments at the Oregon Experiment Station,¹ it was clearly demonstrated that clover cut at the proper stage of ripeness and put into a properly constructed silo would make good silage.² Short points out that clover cut on a bright day and allowed to lay in the sunlight for four or five hours before putting in the silo

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1. Ore. Exp. Sta. Bul. 67, pp. 105.
 2. Wis. Exp. Sta. Bul. 67, pp. 27.

made excellent silage with very little acid content.

¹

Whitcombe's results agree quite closely with Short's. He points out that as good results were obtained with clover when siloed without being cut as there were when it was run through a cutter.

²

Cowpeas:- Oshel did not obtain good results in siloing cowpeas. The hay was necessarily cut very immature. The silage developed only .4% of acid, was very wet, and had a somewhat disagreeable odor and taste. The silage in the bottom had an excess of moisture. Regardless of the disagreeable odor and taste, the cows seemed to relish it very much. ³ On the other hand, Professor Stone says he has had good results in siloing cowpea hay, it producing excellent silage.

⁴

Soule and Fain tried growing cowpeas with a crop of corn and sorghum for the silo. They thought that the cowpeas would raise the protein in this mixture so it would make nearly a balanced ration. They found that the cowpeas greatly improved the quality of silage, but did not grow "rank" enough to raise the protein in the mixture to any appreciable extent.

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1. Ore. Exp. Sta. Rpt. 1904, pp. 28-29.
 2. Thesis, "Silage Investigations", for the degree of A. M., Univ. Mo., 1915.
 3. Personal correspondence.
 4. Tenn. Sta. Bul. Vol. 17, No. 1, pp. 17-19.

¹

The Illinois Experiment Station reports the digestibility of cowpea silage to be as follows: dry matter, 60%, ash, 32%, protein, 49%, fat, 82%, fiber, 63%, and carbohydrate extract, 68%.

²

Soybeans:- Soule and Fain in some trials at the Tennessee Experiment Station with soybeans alone as silage, obtained good results. They claim, however, that this crop is too expensive for silage purposes in comparison with its feeding value. ³ Woods and Bartlett claim that soy bean plants alone do not make good silage, but make excellent silage when mixed with corn. They mixed corn and beans in the proportion of about fourteen parts of corn to nine parts of beans. The silage kept perfectly, and when fed out was nearly as green as when it was put in the silo. The animals ate it with great relish, and sheep preferred it to corn silage. They showed that eight tons of soybean fodder had about the same amount of protein as twelve tons of corn, in the milk stage, ready for the silo, but it had only a little more dry matter than eight tons of corn.

⁴

Haward reports a loss of 43% in a silo filled with a mixture of corn and soja beans. At the time of opening the silo there was only a loss of eight per cent

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1. Ill. Exp. Sta. Bul. 43, pp. 190.
 2. Tenn. Exp. Sta., Bul. Vol. 17, No. 1, pp. 17-19.
 3. Me. Exp. Sta. Bul. 106, pp. 118.
 4. Md. Exp. Sta. Ann. Rpt. 1891, pp. 349.

but upon exposure to the air the soja beans acquired a certain musty smell, and the cows refused to eat it.

¹
The Hatch Experiment Station reports the digestibility of soybeans silage as follows: protein, 55%, crude fiber, 43%, nitrogen-free extract, 61%, and ether extract 49%.

SHOCK CORN SILAGE.

²
Armsby and Caldwell of the Pennsylvania Station in a series of experiments in which they compared the method of putting corn in the silo with shocking it in the field, show that out of every hundred pounds of dry matter in the original crop, there was a loss of 10.75 pounds by fermentation in the silo (not including the loss by moulding), and 21 pounds by field curing. This seems to agree quite closely with an average from other stations in which they report a loss of 17.75 pounds in siloing and 21.3 pounds in field curing from every one hundred pounds. In the above experiment, the silage lost about two-fifths as much protein as the fodder, but over one-fourth of its albuminoids were converted into the less valuable albuminoids. The fodder lost more fiber and ash than the silage, and the losses of nitrogen-free extract were about in proportion to the

1. Mass. Hatch Exp. Sta. 9th. Ann. Rpt. pp. 165
2. Penn. Exp. Sta. Rpt. 1889, pp. 113.

losses of dry matter. In all cases, good results were obtained in siloing shock corn when water was added in the ration of 1:1.

¹
In other experiments Armsby and Caldwell found that the corn silage was very nearly as digestible as the fresh fodder. The shock corn was considerably less digestible than either the fresh fodder or the silage.

²
Woll of the Wisconsin Station, as the result of three year's investigations, reports an average loss of dry matter in shocked fodder corn of 20.33%, and of protein 15.55%. At the same time he found the losses in the silo with Indian corn of the same variety and in the same stage of growth to be 20.5% of dry matter and 20.6% crude protein. In 1890, Mr. Woll conducted another experiment along this line by cutting every other row of corn in the field and putting it in the silo, the rest to be cut and shocked in the field. He used the weight of that put in the silo (129,014 pounds) as the weight of corn shocked in the field. In this experiment he reports a loss of 10.3% of dry matter and 12.5% of protein during the siloing period. In the other half of the corn shocked and left in the field the greater portion of the winter, he found a loss of 28.3% of dry matter and 34.8% of protein. He claims this to be a better average than his results previously reported.

1. Penn. Exp. Sta. Rpt. 1890, pp. 44.
2. Wis. Exp. Sta. Rpt. 1890, pp. 227; 1891, pp. 229.

¹ King of this Station found that when corn fodder contained from 30% to 35% of dry matter when put in the silo, made as good silage as the less mature corn. He clearly demonstrated that the fodder should not contain more than 35% of dry matter when put in the silo, if so, water should be added to reduce it. ² Voorhees and Lane, experimenting with shock corn for silage obtained practically the same results as King. They found that when water was added in sufficient quantity to raise the moisture content of the fodder to 75% they got good results. They further demonstrated that when a large amount of water was required, that it could not be added in sufficient amount while the silo was being filled, but would have to be sprinkled over the surface from day to day after the filling was finished. The chemical analysis of this shocked corn before and after putting in the silo showed that a marked change took place during the time it was stacked in the field., which resulted in an increase in ether extract and fiber, and a decrease in protein, ash, and nitrogen-free extract. A comparison of the composition of the dry matter of the green forage and of the silage showed that the change in the proportion of fiber and nitrogen-free extract, though a slight increase was noted in the ether extract.

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1. Wis. Exp. Sta. Bul. 59.
 2. N. J. Exp. Sta. Bul. 122.

In feeding these two feeds with the same kind and amount of concentrates to milch cows, these men obtained considerably better results from the silage.

¹ Kedzie, with corn fodder containing from 13% to 30% of dry matter, made silage of a quality corresponding to the per cent of dry matter. Silage made from forage containing only 13% of dry matter made a silage with a very disagreeable odor and taste, and had a high acid content. The quality of the silage increased with the per cent of dry matter until the dry matter reached about 35%. At this point the silage showed a tendency to mould very rapidly.

² The Delaware Experiment Station reports good results obtained by putting shocked corn in the silo in the proportion of .75 parts of water to one part of fodder. The fodder contained 53.3% of dry matter when it was taken from the shock. The fermentation taking place in this silage seemed to be as near those of green corn silage as possible.

³ Beach, of the Vermont Station, reports similar results to those from the Delaware Station. The fodder contained 60% of dry matter when taken from the shock. Enough water was added to bring it to 25% and the silage produced was excellent. He agrees with Voorhees and Lane, that all of this water cannot be added at the time of filling.

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1. Mich. Exp. Sta., Bul. 68, pp. 10.
 2. Del. Exp. Sta. Rpt. 1903, pp. 38.
 3. Vt. Exp. Sta. Bul. 170.

¹ Magruder found that when water was added to corn fodder in the ratio of 1:1, it produced excellent silage.

² Oshel reports the same results. He further points out that small cans filled with fodder, with water added in the proportion of 1:1 and kept at about 64⁰ F. for forty-one days produced no fermentation.

SILAGE FROM OTHER CROPS.

³ Minkler, of the New Jersey Station, with some trials with oats and Canada peas, concluded that when it is impossible to store sufficient corn for summer use, oats and peas make a splendid silage and that it is more economical to ensile the oats and peas rather than cut green and feed daily as green forage.

⁴ Mr. H. O. Daniels of Middleton, Connecticut, in relating his experience with siloing oats and alfalfa, says that until he discovered the fact that oats and alfalfa made excellent silage, he was losing a great profit from his dairy herd every year, but since he started to siloing his oats and alfalfa, he has changed the loss to profit. He says that he always obtained excellent results in siloing these two crops.

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1. Thesis, "Silos & Silage", for the degree of A.M., Univ. Mo. 1914
 2. Thesis, "Silage Investigations", for degree of A.M., Univ. Mo., 1915.
 3. N. J. Exp. Sta. Rpt. 1911, pp. 51.
 4. Mass. Bd. Agr. 1911, pp. 52.

1

The California Experiment Station reports the dry matter in one hundred pounds of oat silage to be 28.0 pounds and the digestible nutrients in one hundred pounds to be 1.5 pounds of protein, 14.8 pounds of carbohydrates, and .9 pounds of fat.

2

Rye:- Churchill, of the Oklahoma Station, points out that the best quality silage can never be made from plants having a hollow stem; rye is therefore not good for this purpose. He claims that the yield of rye is too small to permit of its use profitably for silage. No reports could be found concerning experimental work with rye for silage.

Sudan Grass:- Sudan grass is suited admirably for use as a silage crop, since it makes a large yield and is very palatable in the green state, as well as when cured for hay. Enormous yields are secured under irrigation, because the growth is so rapid and the recovery from cutting so prompt. A small area in the South where the rain-fall is adequate can be made to support a goodly number of animals by this method.

No trials of Sudan grass as silage have as yet been carried out, but judging from its palatability and its sugar content, it would be excellent for this purpose, especially in mixtures with legumes. Its use for silage will no doubt be very limited, owing to the ease

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1. Cal. Exp. Sta. Bul. 132, pp. 8.
 2. Okla. Exp. Sta. Circ. 34(1914) pp. 14.

of making it into hay, and the fact that there is but little waste in feeding it.

¹
The Oklahoma Experiment Station reports the analysis of Sudan grass to be as follows: water 7.2%, ash, 5.6%, protein, 7.9% , fiber, 31.56%, nitrogen-free extract, 45% and fat, 2.25%.

WEIGHT OF SILAGE PER CUBIC FOOT.

²
Professor F. E. Emery mentions having filled several silos to a depth of fourteen feet where the mean weight was less than 26 pounds per cubic foot. He cites another silo 31.5 feet deep, filled with King Philip corn, where the silage weighed in, averaged only 34 pounds per cubic foot, but which settled so as to average 41.8 pounds, supposing no loss to occurred. ³ The New York Experiment Station reports, with two silos after being filled two days, averaged when full, 25.9 and 25.7 pounds per cubic food, but settled in two and one-half days so as to average 32 pounds. ⁴ Two silos filled at the Kansas Station

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1. Okla. Exp. Sta. Bul. 103, pp. 12.
 2. N.C. Exp. Sta. Bul. 80.
 3. N. Y. Exp. Sta. 7th. Ann. Rpt. pp. 324-331.
 4. Kan. Exp. Sta. Rpt. 1889, pp. 58.

so as to be 20 feet deep, two days after filling had an average weight of 34 pounds per cubic foot. A round silo¹ at Whitewater, Wisconsin, 22.75 feet in diameter and 34 feet deep when filled, settled to 27 feet and weighed on an average of 44.6 pounds per cubic foot. The silage in this case was made of part flint and part dent corn, both being well glazed, and a little dry when put in the silo.² The Missouri Station reports a silo 16x22 feet and 16 feet deep to hold eighty-five tons of silage, thus making the mean weight per cubic foot 30 pounds.

In a silo 15 x 13.83 feet and 22 feet deep, filled with clover,³ Lawes and Gilbert report a mean weight per cubic foot of 53.6 pounds.

⁴King of the Wisconsin Station, assuming the mean weight of well glazed corn silage, cut in slowly, to a depth of twenty-seven feet, to be 42 pounds per cubic foot, the upper thirteen feet to average 26 pounds and 45 pounds as the weight of a cubic foot thirteen feet below the surface. He, further assuming that below this thirteen foot level the weight per cubic foot increased uniformly until 63 pounds was reached, which was the maximum weight. From this he computed the weight of a cubic foot of silage at different depths in the silo. As shown in his table, he obtained the maximum weight

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1. Wis. Exp. Sta. 8th. Ann. Rpt. pp.242.
 2. Mo. Exp. Sta. Bul. 7, pp. 4.
 3. Rothamstead Memoirs Vol. 4, pp. 9-11.
 4. Wis. Exp. Sta. Rpt. 1891.

at a depth of twenty-three feet in the silage and below this depth he considered the weight uniform for succeeding depths. He further points out that from the facts in the table, that the storage capacity of silos increase more rapidly than the depth until the weight has become great enough to compress the silage to its maximum limits, and that beyond this the capacity increases directly as the depth.

¹
King afterwards published a table in which he has calculated the weight of a cubic foot of silage at different depths, beginning with a depth of one foot and going to a depth of thirty-six feet. This table was computed for well matured corn silage, and also includes the mean weight at different depths two days after filling.

1. Wis. Exp. Sta. Rpt. 1893, pp. 207.

WEIGHT OF SILAGE AT DIFFERENT DEPTHS.*

Depth	Wt. of Silage	Mean Wt. of Silage	Depth	Wt. of Silage	Mean Wt. of Silage	Depth	Wt. of Silage	Mean Wt. of Silage
at Dif- ferent Depths	Per Cu. Ft.	Per Cu. Ft.	at Dif- ferent Depths	Per Cu. Ft.	Per Cu. Ft.	at dif- ferent Depths	per Cu. Ft.	per Cu. Ft.
1	18.7	18.7	13	37.3	28.3	25	51.7	36.5
2	20.4	19.6	14	38.7	29.1	26	52.7	37.2
3	22.1	20.6	15	40.0	29.8	27	53.6	37.8
4	23.7	21.2	16	41.3	30.5	28	54.6	38.4
5	25.4	22.1	17	42.6	31.2	29	55.5	39.0
6	27.0	22.9	18	43.8	31.9	30	56.4	39.6
7	28.5	23.8	19	45.0	32.6	31	57.2	40.1
8	30.1	24.5	20	46.2	33.3	32	58.0	40.7
9	31.6	25.3	21	47.4	33.9	33	58.8	41.2
10	33.1	26.1	22	48.5	34.6	34	59.6	41.8
11	34.5	26.8	23	49.6	35.3	35	60.3	42.3
12	35.9	27.6	24	50.6	35.9	36	61.0	42.8

*King's last table.

¹
 Professor Shelton of the Kansas Experiment Station, by the means of a dynamometer, took the lateral pressure of silage at different depths while the silo was being filled. He reported the pressure as ranging from fifteen pounds per square foot at a depth of three feet in the silo, to fifty-six pounds at a depth of twenty feet, which proved to be the maximum pressure. ² King reported the results of an experiment to determine the lateral pressure in the silo by means of a pressure plate. In general the figures reported are much larger than those reported from Kansas. King claims that the pressure after a depth of three feet is reached, increases at a rate of nearly eleven pounds for each foot of depth, until settling is complete. To show that there is no lateral pressure after settling is complete, Mr. ³ King sights the burning of two silos in which settling was complete. The silage stood in the natural form of the silo after the walls were burned. ⁴ Cooke of the Colorado Station divided an experimental silo into three layers with boards to separate the layers, and rods extending from the boards to the surface so that the amount of settling could be recorded. When the weights and top were removed it was noticed in a short time that the

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1. Kas. Exp. Sta. Rpt. 1888, pp. 98.
 2. Wis. Exp. Sta. Rpt. 1891, pp. 249.
 3. Wis. Exp. Sta. Rpt. 1894, pp. 289.
 4. Colo. Exp. Sta. Bul. 57, pp. 15-17.

top layer had expanded, or raised two and one-half inches. This was the expansion of the whole mass. The first and third layers expanded one inch each, and the middle, one-half inch.

The following formula suggested by Mr. L. J. Mentsch of San Francisco, for round concrete grain elevators, which are similar to silos, may be use to get the pressure per square foot in a silo. Mr. Linting says that with little allowance, this formula can be applied to silos when you have the angle of repose, which is larger than grain. Formula:-"Assume the weight of grain equals 50 pounds per cubic foot, and the angle of repose equals 29° . Then by common theory of earth pressure, the pressure per lineal foot on a wall h feet high equals $7.7h^2$, and the pressure per square foot at h below the surface equals $15.4h$. This pressure in a bin of the diameter s in feet increases. However, only until h equals $s \cot. 29^{\circ}$ equals $1.8s$. Below this depth the friction against the sides equals the additional weight of the grain, and no matter how deep the bin, the pressure never exceeds 15.4 times $1.8s$ equals $27.75s$, a fact fully demonstrected by practical experience."

²Magruder points that the weight per cubic

1. Correspondence.

2. Thesis, "Silos & Silage", for the degree of A. M. , Univ. Mo., 1914.

foot of silage varies with the amount of moisture and the amount of grain.¹ Oshel showed that the silage reached a limit of compressability at about nine to twelve feet, and below this point the increased pressure did not force out any more air. The weights per cubic foot in different silos showed a great variation and the author concludes that the weights undoubtedly are affected by other factors other than the amount of water present.

MOULD IN SILAGE.

² During 1909 Buchanan made an examination of moulds occurring on silage. On cultures he isolated a number of moulds, among them several species of *Penicillium*, *Aspirgillus*, *Mucor*, and in one instance, *Monascus*. In the sample of silage used, the *Monascus* was practically the only mould found, which was carefully studied.

Several species of *Monascus* have been described, but the specimen studied in the above test seemed to correspond in all essential characters with *M. purpureus*. The author thinks that this is the typical fungus present in mouldy silage which is reported to have killed horses, but its pathological properties have not as yet been determined.

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1. Thesis, "Silage Investigations", for the degree of A. M., Univ. Mo., 1915.
 2. Mycologia, 2(1910) No. 3, pp. 99-108.

Professor S. A. Ivanov points out that when some of the moulds common in silage are grown on different cultures, produce varied results. In one series of experiments, Professor Ivanov grew *Penicillium glaucum* and an unknown brown mould on flour obtained from Hungarian and Zhelanni oats. When the mould was grown on the Hungarian oats, which had a low nitrogen content, nitrogen was assimilated from the air. In the moulding of Zhelanni oats, with a high nitrogen content, a decrease was noted in the total nitrogen. In general, the total nitrogen of the albuminoid substance decreased during the period of molding.

EXPERIMENTAL METHODS.

Description of Silos Used:- The silos used in this experiment were as follows:

North concrete silo.

South concrete silo.

Six experimental silos.

The North and South concrete silos are situated at the dairy barn on the University farm. They are of the monolithic type, thirty-three feet high and sixteen feet in diameter, with concrete floors and set five feet in the ground.

The North concrete silo was filled September 22 to 24, with corn in the dent stage. It was cut $\frac{3}{4}$ inch and well tramped into the silo. On September 23 and 24 water was added to the silage by running a small stream into the blower while the corn was being cut. Feeding was begun from this silo a short time after filling was complete.

The South concrete silo was filled September 26 to 29, with corn, the most of which had not passed the glaze stage. The corn was cut $\frac{3}{4}$ inch and well tramped into the silo. No water was added. After filling was complete, the surface was covered with tarred paper,

then a layer of cowpeas cut fine was put on top of this paper.

Six circular water tanks, six feet high and three feet in diameter, and made of two-inch cypress were used as experimental silos. These silos are provided with tops of a size to fit tightly, but still to settle with the silage. The experimental silos were placed in the loft of the dairy barn for protection from the cold. They are designated as experimental silos No. 1, No. 2, etc.

Each time an experimental silo was filled a wire screen which would fit loosely in the silo was placed so that one or more feet of silage was above the screen when filling was completed. The weights of the amount of silage both below and above this screen were taken when put in and again when removed. The object in using this screen was to make it possible to distinguish between the loss of nutrients due to the fermentation of the silage and the loss on top that occurs from exposure to the air.

Taking Samples:- As the material was being weighed into the silo, a sample of about fifty grams was taken from each tub in which the silage was weighed and placed

in a container which was taken to the laboratory. This composite sample was thoroughly mixed and one portion was taken for moisture determination and chemical analysis. The other portion was again mixed and a sample taken and preserved for sugar determination. As the silos were being emptied the same plan of taking samples was followed, except the second sample taken was used for an acidity test, which was run immediately.

Moisture Determination:- A sub sample taken as described above was weighed into a wire basket and placed in an electric drying oven, and dried until it was certain that the moisture content was the same, or below, that of the atmosphere. It was removed from the oven, weighed and placed in a mouse tight case until its weight was constant. This last weight was taken as the air dry weight of the sample. The samples were then preserved in half gallon fruit jars for chemical analysis.

Acidity Test:- The sub samples for the acidity test were taken as described above, and the test made immediately. Each sample was run through a small meat cutter to chop the silage up fine, and then thoroughly mixed and a one hundred gram portion taken for the acidity test. This portion was washed with five hundred c.c. of distilled water and the washings titrated against a standard

alkali until the last washing titrated the same as the blank which had been run on the distilled water. Five washings were usually required; twenty four hours or longer intervening between washings. Each washing was decanted into a suction filter, and the filtrate made up to 500 c.c. A 10 c.c. portion was taken and diluted with 100 c. c. of distilled water and titrated immediately. An average molecular weight of 80 was used for the mixture of acids in making the calculations.

Chemical Analysis:- All of the chemical analyses were made by the department of Agriculture Chemistry of the University, under the direction of Dr. P. F. Trowbridge. The methods used were those adopted by the American Association of Official Agricultural Chemists, for feed stuff analysis, with some slight modifications.

Sugar Determination:-The determination of sugar was also made by the department of Agricultural Chemistry. The gravimetric method for invert sugars, using Soxhlet's modification of Fehling's solution, was used for this determination.

Method of Taking Weights:- The weight of silage per cubic foot at different depths in the silo was taken by means of an apparatus devised by Reed of the Kansas

Experiment Station. This is an iron frame which can be driven into the silage to enclose a cubic foot. This frame is a foot square on the outside and eighteen inches high. The upper six inches of the frame are braced for strength and to this upper part sharp pointed rods are welded, one on each corner and one in the middle of each side. The silage was cut around the outside of the frame with a hay knife and taken out of the frame to a depth of one foot and weighed for the weight of a cubic foot at that depth. The weights were taken as the silage was fed out.

PLATE I.

"Kansas Apparatus"

FACTORS INFLUENCING ACIDITY.

Object.

The object of this experiment was to determine:

1. The relation of the sugar content of the forage when cut to the acidity of the silage produced.
2. The amount of acid normally developed in different kinds of silage.
3. The relation between the moisture and acidity of the silage.
4. The effect of mould upon the acidity.

Plan of Experiment.

The silos used in this experiment were the North Concrete Silo, the South Concrete Silo and six experimental silos.

(1). Relation of Sugar to Acidity:- Sugar determinations were made of samples taken from near the wall and near the center of the South Concrete silo at the time of filling. Acidity tests were made of samples from the same place when the silo was emptied.

Corn in nearly all stages, from the milk stage in August to the hard dent stage in October was put into experimental silos. Sugar determination was made on a sample of corn from each silo at filling time, and an acid test was made on all silage when the silos were emptied.

(2) Kind of Silage:- Moisture and acidity tests were made of green corn silage, shock corn silage, alfalfa silage, pea and oat silage, and Sudan grass silage. Sugar determination was also made of the green corn and shock corn before it was put into the silo.

(3) Relation between Moisture and Acidity:- The data on this factor is considered in other parts of this experiment. However, it will be taken up under a separate heading in the discussion of data.

(4) Effect of Mould on Acidity:- Three samples of 500 grams each were taken from the North Concrete Silo.

Sample No. 1, was tested immediately for acid.

Sample No. 2, was set in a mouse-tight case at about 80° F. and allowed to mold for three days, and then tested for acid.

Sample No. 3, was set under the same conditions as No. 2 and allowed to mold for six days and then the acid determined.

DISCUSSION OF DATA.

Relation of Sugar to Acidity:- When this experiment was begun it was thought that the amount of acid in silage is in direct proportion to the amount of sugar in the forage when cut. It was supposed that the maturity of the corn and the proportion of the grain

to fodder had some effect on the amount of sugar in the forage and consequently the amount of acid in the silage. Table 1 gives data on corn forage as put into the silo and on the silage as taken out.

Table 1.

Corn as put into silo			Silage as taken out of silo.				
Stage of maturity	Air-dry matter	Sugar	No. days in silo	Condition of silage	Air-dry matter	Sugar	Acid
	%	%			%	%	%
Late milk	31.3	3.399	63	Good	27.6	0.36	2.72
Late dough	40.5	2.223	82	Good	41.1	0.00	2.16
Late dough	44.5	3.028	62	Excellent	40.0	0.00	2.40
Hard dent	45.0	1.685	71	Molded Slightly	41.9	0.00	2.05
Dough, from center silo	31.2	3.297	165	Good	28.9	0.00	2.12
Dough, from wall silo	35.1	3.257	165	Good	32.0	0.00	2.10
*Immature corn, shock	88.9	4.018	55	Considerable mould	39.0	0.33	1.88
*Mature corn, shock	81.3	3.601	61	Molded Slightly	53.0	0.66	1.00

*Water was added to this corn in the ratio 1:1 when the silos were being filled.

In the investigations of silage up to the present time, not so much attention has been given to the sugar con-

tent of the forage from which silage is made. According to many chemical tests the sugar in corn is mostly dextrose, the most easily fermented sugar. The sugar in corn averages from three to four per cent. as shown in Table 1. Previous investigators along this line claim that all of the sugar in the forage is converted into acid in the silo during the fermentation process, either by bacteria or by yeasts. They claim further that the per cent. of acid in silage is almost equivalent to the per cent. of sugar that was present in the fresh forage. It will be noticed in Table 1 that this is not the case when the analyses are based upon the amount of fresh material. It is interesting here to note in Table 1 that in some cases all of the sugar was not converted into acid; the silage containing the smallest amount of moisture having the largest per cent. of sugar.

The moisture content of the forage and of the silage being such a variable factor, a table has been compiled, basing the calculations on the per cent. of air-dry matter, of which the sugar is a part. Table 2 shows the relation between the sugar content of the forage and the acid content of the silage made therefrom and is based on the air-dry substance.

1. Found in review of literature, in this thesis.

Table 2.

6

Corn as put in silo		Silage as taken out of silo		
Stage of maturity	Sugar	Sugar	Acid.	
	%	%	%	
Late milk	10.86	1.33	9.85	
Late dough	5.49	0.00	5.25	
Late dough	7.03	0.00	6.00	
Hard dent	3.74	0.00	4.89	
Dough from center of silo	10.57	0.00	7.33	
Dough from wall of silo	9.28	0.00	6.56	
Shock corn from immature corn	4.52	0.87	4.82	
Shock corn from mature corn	4.43	1.26	1.88	

It will be noticed from this table that, in general, there is a definite relation between the sugar content of the forage and the acid content of the silage made therefrom. There was considerable mould in the silage made from the mature shock corn. This may account for the low per cent. of acid in the silage.

There being a definite relation between the sugar content of the forage and the per cent. of acid in the silage, we can conclude that this factor is the cause of the slight variation in the per cent. of acid developed at the wall and in the center of the silo, as there is a higher per cent. of sugar in the center, than at the wall of the silo.

Kind of Silage:- Moisture and acidity tests were made of different kinds of silage. Table 3 shows that the nature of the silage crop affects the per cent. of acid in the silage. The crop containing the greatest amount of soluble carbohydrates has the highest per cent. of acid.

Table 3.

Silo No.	Kind of Silage	Acid %	Air-dry matter %	Days after filling.
4	:First cutting alfalfa, without drying	: 0.75	: 18.5	: 131
6	:First cutting alfalfa, dried 6 hr's.	: 1.35	: 47.5	: 131
5	:Very immature peas and oats	: 0.87	: 12.2	: 104
2	:Mature peas & oats	: 0.63	: 19.8	: 90
1	:Sudan grass	: 1.62	: 25.2	: 44
3	:Corn in late milk stage	: 2.72	: 27.6	: 95
4	:Corn in early dent stage	: 2.40	: 40.0	: 63
1	:Corn in hard dent stage	: 2.05	: 41.9	: 72
1	:Shock corn from immature corn*	: 1.88	: 39.0	: 48
2	:Shock corn from mature corn*	: 1.00	: 53.0	: 48

*Water was added to this corn when put into the silo in the ratio of 1:1.

These data further support the theory of intramolecular respiration of the plant cell tissue, for from

many chemical analyses we know that there is a small amount of soluble carbohydrates in the legumes. Table 3 shows that some of the legumes developed as much acid as some of the corn. These results agree quite closely with those shown in Table 13 of Oshel's thesis, as follows.

Table 13.

Silo No.	Kind of silage.	Acid %	Air-dry matter %	Days after filling.
2	Corn	2.58	26.59	134
3	Soy beans	0.68	26.60	57
4	Soy beans	1.00	25.75	158
5	Dry corn*	1.74	42.08	70
6	Cowpeas	0.40	15.52	69
7	Corn fodder	0.89	39.91	41
A	Oats and peas	1.82	33.05	42
B	Alfalfa	2.05	47.77	53

*Allowed to dry in field until badly in need of water to make normal silage.

Relation Between Moisture and Acidity:- The relation of moisture to acidity is discussed in other parts of this experiment. It might be well to state here that although the acid of the silage seems to bear some relation to the per cent. of moisture in silage, it does not

bear a direct relation to any one constituent, but seems to be affected by several factors.

Effect of Mould on Acidity:- From a sample of about thirty-three pounds of silage taken from the center of the North Concrete silo, three samples were taken and treated as described in the plan of this experiment. About four inches of silage was removed from the surface before the sample was taken. This precaution was made because the silage in this silo was a little dry and was found to have molded slightly, to a depth of about three inches after standing a few hours.

Table 4 shows the effect of mould on the acidity of silage. Sample A served as a check sample, sample B was allowed to mold three days and sample C was allowed to mold six days.

Table 4.

Sample No.	Days of Molding	Air-dry matter %	Moisture %	Acid %
185A	None	34.3	65.7	1.87
185B	Three	34.1	65.9	0.23
185C	Six	37.2	62.8	0.15

The above table shows that the mould reduces the acidity in silage in direct proportion to the length

of time it is allowed to mold, or in direct proportion to the amount of mould developed.

It was not possible during the experiment to isolate and grow on culture the moulds in the silage, but it is assumed that there are several different species of moulds which develop in silage on exposure to air.

The question of what becomes of the acid when it is acted upon by these organisms is of considerable importance, but it was not possible to make a study of it in connection with this experiment.

LOSSES IN THE SILO.

Object.

The object of this experiment is to determine:

1. The unavoidable losses in the silo, brought about by fermentation.
2. The comparative losses in field curing and siloing corn.

In this experiment both loss in total weight and total nutrients are considered.

Plan of Experiment.

In this experiment, the data was collected from twelve experimental silos and two oil-cloth sacks. The sacks were buried at different depths in the North Concrete silo at the time of filling.

(1) Losses by Fermentation:- Each time an experimental silo was filled a record was kept of the amount of ensilage put into the silo below the screen--a wire screen was placed in each silo, near the top, and enough forage put on top of it to prevent any loss from mould below the screen. The silage was carefully weighed out of each silo. Complete analyses were made of the forage when put in the silo, and again of the silage when taken out.

When the North Concrete Silo was about half full a sack containing 25.5 pounds of corn ensilage was buried

in the center of the silo, when it was about three-fourths full another sack containing 25 pounds was buried. Samples were taken of each sack and complete analysis made of them. When the sacks were uncovered they were carefully weighed, samples taken and analysed.

(2) Field Curing vs. Siloing:- From a pile of about $3\frac{1}{2}$ tons of corn, cut September 22, 1915, at the beginning of the dent stage, from the same field, eight lots of 800 pounds each were made, by adding one or two stalks at a time to each lot until the total weight was 800 pounds per lot. These lots were designated as lots No. 1, 2, 3, etc.

Lots No. 1 and 2 were brought in immediately, run through silage cutter, sampled, and lot No. 1 weighed into silo No. 5, and lot No. 2 weighed into silo No. 6. These silos were used as a check on the other six lots in the series.

Lots No. 3 to 8 inclusive, were shocked in the field and a rat proof fence build around them.

Lots No. 3 and 4 were brought to the barn December 15, carefully weighed, run through cutter, and again weighed together into silo No. 5 after the silage from lot No. 1 had been removed. Water at 38°F . was added in the ratio of 1:1.

Lot No. 7 was brought in at the time Nos. 3 and 4 were put in the silo. It was carefully weighed and fed out, on frozen ground to cattle. The refuse was gathered as thoroughly as possible and weighed.

Lots No. 5 and 6 were brought to the barn February 14, 1916, carefully weighed, run through cutter, then weighed together into silo No. 6 after silage from Lot No. 2 was removed from the silo. Water at 60°F. was added in the ratio of 1:1. This silo was emptied April 15.

Lot No. 8 was brought in at the time Nos. 5 and 6 were put in the silo. It was weighed and fed out to cattle in the same manner as Lot No. 7. The refuse was gathered and weighed.

Each time a silo was filled, and again when it was emptied a sample was taken and analysed,

Discussion of Data.

Losses by Fermentation:- The data collected on this subject were obtained from twelve experimental silos, on one of which the data are not complete. Data collected from silage in the two oil-cloth sacks, which were buried in the North Concrete Silo are also considered. As each silo was filled one or more times during the experiment the sample number of the silage will be used as the num-

ber of the silo.

The analyses of the silage from the twelve silos and from the two oil-cloth sacks is shown in Table 5. The data in this table are based upon the weight and the analyses of the air-dry matter below the screen.

Table 5.

Silo No.	Sample No.	Descriptive.	Percentage Composition of fresh Material.					
			H ₂ O	Pro.	Fat	C.F.	Ash	N.F.E.
1	146	Immature rye	74.81	4.05	0.86	8.74	2.18	8.69
	155	Silage	83.39	1.73	0.79	6.68	1.88	5.22
3	147	Mature rye	73.91	3.09	0.84	9.32	1.97	10.36
	157	Silage	81.06	1.67	0.74	8.21	1.72	6.32
1	156	Sudan grass	76.38	2.21	0.45	8.10	2.32	10.19
	170	Silage	75.95	1.93	1.04	8.41	2.28	10.07
4	151	1st. cutting alfalfa.	78.77	4.56	0.48	6.44	2.44	6.59
	161	Silage	83.17	2.66	1.20	5.73	2.49	4.33
6	152	1st. cutting alfalfa*	59.25	10.90	1.15	15.39	5.84	5.73
	163	Silage	51.20	10.40	2.52	13.37	4.99	15.85
3	159	Corn in milk stage	69.85	2.50	0.71	6.31	1.34	18.90
	181	Silage	74.07	2.33	1.28	5.60	1.36	14.99
4	165	Corn, early dent stage	57.47	2.98	1.17	9.81	2.16	25.94
	184	Silage	62.12	3.19	1.49	7.55	1.96	23.19

*This alfalfa was allowed to dry in the sun for six hours.

Table 5 Cont'd.

Silo No.	Sample No.	Descriptive.	Percentage Composition of fresh Material.					
			H ₂ O	Pro.	Fat	C.F.	Ash	N.F.E.
5	164A	Corn, late dent stage	61.69	3.04	1.37	5.45	1.55	26.42
	192	Silage	61.04	2.98	1.57	7.89	1.89	24.17
6	164B	Corn, late dent stage	61.69	3.04	1.37	5.45	1.55	26.42
	211	Silage	60.73	2.79	1.17	8.95	2.09	23.82
Sack 1	167	Corn, late dent stage	59.05	2.44	1.09	8.04	1.70	27.30
	200	Silage	61.46	2.44	1.16	7.80	2.03	24.71
Sack 2	168	Corn, late dent stage	53.97	3.47	1.35	7.99	2.39	30.29
	188	Silage	59.60	2.82	1.29	7.96	0.29	27.60
5	193	Shock corn	18.35	5.49	1.90	14.48	3.23	55.29
	213	Silage	56.75	2.79	0.89	10.37	2.38	26.39
5	67	Shock corn	56.59	4.68	1.26	9.20	2.46	25.06
	78	Silage	59.10	4.48	1.73	8.09	2.10	23.79
1	87	Silage	77.21	2.76	0.90	5.63	1.72	11.33
2	88	Silage	75.31	2.76	1.59	5.48	1.79	12.63

1. Water was added in the proportion of 1:1.
2. Water was added in the proportion of 1 of water to 8.8 of fodder.
3. From a silo in which the silage was not packed at all so that mould would develop.
4. From a silo in which the silage was well packed. Check on No. 87.

From the analyses of the forage as put into the silo and of the silage removed, we can see that there is a decrease in the amount of all the constituents, except that of fat. The analyses show that in most cases there is a slight increase in the amount of fat during the process of silage formation. However, this increase may not be due to the breaking down of protein, as is sometimes suspected, but is probably due to the changing of some fats, insoluble in ether, to a soluble form. The fat reported in these analyses is the total ether-soluble matter.

In some cases there was a very great reduction in the amount of protein during silage formation. This reduction was in direct proportion to the extent of fermentation. It will be noticed from the table that the higher the per cent. of moisture in the forage, when put into the silo, the greater was the loss in protein, and the more rapid the fermentation, as shown by the condition of the silage when the silos were emptied. For example: On comparing silage from silos Nos. 4 and 6, in which the first cutting of alfalfa was put, it will be noticed that in silo No. 4 there was a reduction of about 40% in the amount of protein during

silage formation, whereas in silo No. 6, there is practically no change in the amount of protein. The alfalfa put into silo No. 6 was the same as that put into silo No. 4; but it was allowed to dry so as to reduce the amount of moisture from 78.77% to 59.25%. These results are more clearly shown in Table 6. This table gives the percentage losses occurring in the silo during silage formation. These data are based upon the total weight of the material below the screen in each silo.

Table No. 6.

Silo:Sample:		Description	No.days:Total		Percentage Loss in Silo.					
No. :	No. :		in silo:	wt. :	Water :	Protein:	Fat :	C.F. :	Ash :	N.F. E.
1 :	155 :	Immature rye	100 :	6.06 :	3.04 :	60.37 :	14.90 :	29.24 :	20.28 :	44.30 :
3 :	157 :	Mature rye	115 :	17.08 :	9.04 :	54.57 :	27.39 :	26.90 :	27.71 :	49.36 :
1 :	170 :	Sudan seed, dough stage	43 :	11.94 :	12.44 :	22.92 :	50.75 :	8.55 :	13.35 :	12.94 :
4 :	161 :	1st cutting alfalfa	128 :	10.69 :	+ 5.11 :	41.24 :	50.42 :	58.16 :	+ 6.01 :	34.03 :
6 :	163 :	Partly dried alfalfa	128 :	6.48 :	19.19 :	10.72 :	51.45 :	18.63 :	20.05 :	+ 60.37 :
3 :	181 :	Corn in milk stage	64 :	7.89 :	2.35 :	14.13 :	40.13 :	18.19 :	6.60 :	36.83 :
4 :	184 :	Corn in early dent stage	62 :	0.00 :	+ 7.48 :	6.65 :	21.45 :	23.06 :	9.26 :	11.06 :
5 :	192 :	Corn in late dent stage	82 :	4.09 :	5.10 :	6.04 :	+ 8.85 :	28.05 :	+ 14.40 :	12.27 :
6 :	211 :	Corn in late dent stage	142 :	1.48 :	3.01 :	9.60 :	15.60 :	54.70 :	+ 24.90 :	11.20 :
* 1 :	200 :	Corn in late dent stage	102 :	1.76 :	+ 1.62 :	1.60 :	+ 4.80 :	4.41 :	+ 12.79 :	11.20 :
* 2 :	188 :	Corn in late dent stage	76 :	1.20 :	+ 8.35 :	19.72 :	5.93 :	1.50 :	88.08 :	10.03 :
5 :	213 :	Shock corn silage	64 :	4.08 :	+ 77.80 :	15.60 :	21.80 :	6.20 :	+ 22.70 :	20.60 :
5 :	78 :	Shock corn silage	70 :	4.83 :	+ 0.61 :	9.04 :	+ 25.00 :	16.20 :	18.70 :	9.64 :
Average for Rye&Sudan grass silage			:	11.69 :	8.70 :	45.95 :	+ 29.61 :	21.56 :	20.44 :	33.30 :
Average for Alfalfa Silage.			:	5.79 :	14.08 :	25.98 :	55.93 :	39.89 :	14.04 :	+ 26.34 :
Average for Corn Silage.			:	3.19 :	+ 21.04 :	3.25 :	+ 5.60 :	28.11 :	11.70 :	15.35 :
Average for all Samples.			:	6.89 :	+ 9.65 :	27.59 :	+ 30.38 :	2.61 :	15.39 :	22.31 :

*Silage in Sack.

It will be noticed in Table 6 that there was a loss in total weight, from 0.00% to 17.08%, the average being 6.89%. Silo 161 shows a gain of 0.69% in total weight, which is due to the water settling from the layer of silage above the screen. There is a gain in water in some of the silos while in the others there is a considerable loss in moisture. The reason for this gain is given above; the loss is accounted for by the fact that some of the silos leaked. There was an average gain of 9.65% in moisture in all of the silos.

There was a loss of from 1.60% to 60.37% in the amount of protein, the average loss being 27.59%. It will be noticed that there was a gain of 6.65% in Silo 184. The silage from this silo was in excellent condition, making the best silage of any corn in the experiment. The corn was in exactly the proper condition for siloing when cut. The gain in protein content in this silo was due to the fact that there was not as great fermentation and breaking down of the protein into amino acids as there was in Silo 181. This silo shows a loss in the amount of protein, but about 50% greater gain in fat or ether-extract than in Silo 184. In every case where the fermentation in the silo was about normal, there was a gain in

ether-extract during silage formation, the average gain being 30.38%. This gain was probably due to the breaking down of protein into amino acids. Where there was an excessive fermentation, as indicated by the character of the silage when removed, there was a loss in ether-extract, due to the further breaking down of the amino acids into fatty acids and ammonia. The fatty acids were further broken down into gases which were given off. Although it is probable that the gain in the ether-extract was due to the above causes, it is possible that some of the ether-insoluble fats were converted into ether-soluble fats during the process of silage formation.

There was a loss of from 1.50% to 58.16% of crude fiber in the silos, the average being 2.61%. This loss is due to the breaking down of the pentosans into a more soluble form. It will be noticed that Silos 192 and 211 show an increase in crude fiber, which is accounted for in the fact that there was considerable mould in these two silos.

The data on ash show a loss of from 6.60% to 88.08%, the average being 15.39%. This constituent varied with the condition of the sample, depending upon the amount of foreign material in the sample. This variation was very great, as shown in some cases where

there was even a gain in ash.

The loss in nitrogen-free extract varied with the loss of the other constituents, the loss increasing as the loss in nitrogenous substance decreased. The loss of nitrogen-free extract varied from 9.64% to 49.36% and averaged 22.31%.

It will be noticed from the average of the different kinds of silage, that the greatest loss was in the silage made from the small cereal crops. The loss in total weight was 11.69% for the silage made from the small cereals, 5.79% for the legume silage, and 3.19% for the corn silage. This difference was due to the fact that the corn did not have as great a loss in moisture during the siloing period as the cereals and legumes.

From the data in Tables 4 and 5 we can conclude that when the forage of the small cereal and the legume crops have about 37% of air-dry matter at the time of siloing, good silage can be made from them. Corn forage should not contain quite as much air-dry matter at the time of siloing as the legume and small cereal crops.

Field Curing vs. Silo Curing:- In considering the relative value of these two methods of preserving the crop, it must be remembered that it is impossible to preserve any crop by any method now known without some loss. It was hoped in the beginning to have more data than those

which are presented in the consideration of this experiment, but it was impossible to secure all of the analyses in time to present them in this paper. A composite sample of Shocks 1 and 2 was used as the analysis of all of the corn shocked in the field. This analysis, and the analysis of each shock as it was taken from the field, is shown in the following table.

Table 7.

Shock :	Percentage Composition of Fresh Material.						
No. :	H ₂ O :	N :	Pro. :	Fat :	C.F. :	Ash :	N. F. E.
1 & 2 :	61.69 :	0.48 :	3.03 :	1.36 :	5.44 :	1.54 :	26.42
3 & 4 :	18.38 :	0.87 :	5.49 :	1.90 :	14.84 :	3.22 :	55.25
5 & 6 :	44.29 :	0.62 :	3.91 :	1.12 :	11.82 :	2.69 :	35.53
7 :	18.38 :	0.87 :	5.49 :	1.90 :	14.84 :	3.22 :	55.29
8 :	44.29 :	0.62 :	3.91 :	1.12 :	11.82 :	2.69 :	35.53

As stated in the plan of this experiment, Shocks 1 and 2 were put in Silos 5 and 6 respectively. Shocks 3, 4, and 7 stood in the field 75 days; Shocks 5, 6 and 8 stood in the field 134 days.

It will be noticed from the analyses that there was an increase in all of the constituents, except that of fat, during the time the corn was in the shocks. This does

not necessarily mean a total increase in the constituents, as the analyses were made on the basis of the fresh material, and were greatly affected by the per cent. of air-dry substance when the samples were taken. This fact is shown more clearly in the following table. It shows the per cent. lost in Shocks 1 and 2 which were put in silos, as compared to the loss in the shocks in the field for the same length of time.

Table 8.

Comparative Loss in Field Curing and Siloing
Corn.

Shock No.	Percentage Loss							
	Total Weight	H ₂ O	D.M.	Pro.	Fat	C. F.	Ash	N. F. E.
1	4.09	5.10	4.94	6.04	+8.85	+28.05	+14.40	12.27
2	1.48	3.01	1.15	9.60	15.60	+54.7	+24.9	11.12
3 & 4	53.9	87.0	4.43	16.6	35.7	20.10	4.03	3.66
5 & 6	60.2	71.7	43.3	48.6	66.8	13.73	30.79	46.50
7	54.7	86.5	6.00	18.1	37.3	+18.8	5.78	53.00
8	57.1	69.2	39.1	44.7	64.7	6.90	25.30	42.30
Av. of 1 & 2	2.78	4.05	3.04	7.82	6.75	+41.39	+19.65	11.69
Av. of 3, 4, 5, & 6.	57.0	79.35	23.86	32.6	51.25	16.91	17.36	25.08

The loss of nutrients in Shocks 1 and 2, which were put in Silos 5 and 6 after cutting, has been discussed under Table 6. It will be noticed that the data in Table 8 show a loss by field curing about 87% greater than that incurred by putting the corn in the silo. The greatest losses were in the amount of protein and of fat, two of the most important constituents of feed stuffs. It will be remembered, however, that Shocks 5 and 6 stood in the field 134 days, or 49 days longer than Shocks 3 and 4. These 49 days were in December and January, and February, when we have the most severe weather. Referring to Table 8 again, it will be noticed that the greatest loss in nutrients occurred during this period. Table 9 shows the comparative loss of putting shock corn in the silo after standing shocked in the field from September until December--a period of 74 days, with leaving corn in the field until February, or 49 days longer.

Table 9.

*Comparative Loss in Siloing Shock Corn
and Leaving it in the Field.

Shock No.	Total Weight	H ₂ O	D M	Pro.	Fat	C. F.	Ash	N.F.	E.
3 & 4	4.08	77.8	48.9	15.6	21.8	16.2	22.7	20.6	
5 & 6	8.23	53.4	37.3	38.5	46.0	36.9	27.8	44.5	
Diff- erance	38.1	31.4	23.7	33.8	54.7	56.0	18.3	53.7	

*Shocks 3 and 4 were in the silo 60 days. Shocks 5 and 6 were in the field during the same period.

In the calculation of the data in the above table, the average weight of Shocks 3 and 4 was taken as the average weight of Shocks 5 and 6 when Shocks 3 and 4 were put in the silo on December 15th.

In consideration of data in Table 9, it will be noticed that there was a much greater loss of nutrients in shock corn left in the field than in the shock corn put in the silo. It will be further noticed, however, that there was a greater loss, of the total dry matter in the silo, but this varies with the amount of moisture, as shown in the table. Shocks 5 and 6 gained only 31.4% as much moisture as did Shocks 3 and 4 in the silo. The great gain of moisture in the silo is of course due to water added at the time of filling.

As pointed out in the discussion under Table 8, there was a greater loss in shock corn during the three winter months than there was in the first months after it was shocked in the field. Table 10 shows this comparative loss in Shocks 5 and 6.

Table 10.

Percentage Loss in Shock Corn from Sept. 22 to
Dec. 15, and from Dec. 15 to Feb. 15.

Period	Comparative Loss, Per Cent.							
	Total:	Wt.	D M	Pro.	Fat	C. F.	Ash	N. F. E.
Sept. 22 to Dec. 15.	53.9	4.43	16.6	35.7	20.1	4.03	3.66	
Dec. 15 to Feb. 15	8.23	37.30	38.5	46.0	36.9	27.8	44.5	
Silo from Dec. 15 to Feb. 15.	4.08	48.90	15.6	21.8	16.2	22.7	20.6	

It is shown by the data of the above table that there was about 65.0% greater loss in total nutrients during the second than in the first period. The last line of Table 10 shows that there would have been but a very small loss in nutrients if the two shocks had been put in the silo December 15.

From data obtained by feeding Shock 7 to cows in the barn-lot, December 15, we have further evidence of the advisability of putting shock corn in the silo. When Shock 7 was fed to cows it was found that there was a loss of 20.0% in total weight; that is 20 pounds out of every 100 of shock corn fed was refused. This loss increased with an increase in the length of time the corn remained in the field. Shock 8 was taken from the

field in February and it was found that there was a loss of 32.0% when fed to the cows. The data in Table 9 show that there was a loss in nutrients and from this fact, shown by data obtained from feeding Shocks 7 and 8 to cattle, we can see that the palatability of the fodder decreases in proportion to the time it remains in the field. From these data we feel safe in concluding that it is more profitable to put shock corn into the silo in the fall of the year than to leave it in the field through the winter months.

LEGUMES FOR SILAGE.

Object.

In recent years there has been considerable attention given to the legume crops for silage purposes. The object of this experiment is to determine in part the conditions under which alfalfa, and pea and oat crops can be siloed.

Plan of Experiment.

Experimental silos were filled as follows:

- No. 4, filled May 13, 1915 with first cutting of alfalfa.
- No. 6, filled May 13, 1915, with the first cutting of alfalfa, but was allowed to lay in the direct sunlight six hours before putting in the silo.
- No. 5, filled June 9, 1915, with immature peas and oats.
- No. 2, filled July 2, 1915, with mature peas, and oats in the dough stage.

A record was kept of the amount put into each silo, and of the amount of silage weighed out. Samples were taken and analysed, both at the time of filling the silos, and again when they were emptied.

Discussion of Data.

Alfalfa:- Experimental Silos 4 and 6 were filled with the first cutting of alfalfa, as shown in the plan of this experiment. The forage was cut in $\frac{3}{4}$ inch lengths and thoroughly tramped into the silos.

When these silos were emptied, 128 days later it was found that the silage in No. 4 had settled to one-half its original volume while the silage in No. 6 had settled to only four-fifths its original volume--the latter is the normal shrinkage in the experimental silos. The silage from No. 4 had a very disagreeable odor and appeared to be very badly decomposed. The cows refused to eat this silage. The silage in No. 6 was in good condition, though it was a little dry, as shown in Table 11, column 3. From all indications this alfalfa made better silage than any of the legumes. The cows ate this silage very greedily.

Table 11 shows the composition of alfalfa put into, and of the silage removed from Silos 4 and 6.

Table 11.

Silo No.	Description of sample.	Percentage Composition of Fresh Material						
		H ₂ O	N	Pro	Fat	C.F	Ash	N. F.E.
4	As put in	78.77	0.72	4.55	0.47	6.43	2.44	6.58
	As removed	83.17	0.42	2.65	1.20	5.72	2.49	4.32
6	As put in	59.25	1.74	10.90	1.14	15.39	5.83	5.72
	As removed	51.20	1.66	10.40	2.52	13.37	4.99	15.85

*Allowed to dry in the sun for six hours before putting into silo.

Table 11 shows a decrease in the percentage composition of alfalfa when made into silage. The greater loss is in the silage having the higher per cent. of moisture. It will be noticed from this table that there is a slight increase in the per cent. of fat. This was brought about by the hydrolysis of some of the volatile acids into fats. These results are shown more clearly in Table 12, which gives the total weight of the material weighed into the silo, the amount weighed out, the loss in pounds and the percentage loss.

Table 12.

	Silo No. 4				Silo No. 6			
	Amt.	Amt.			Amt.	Amt.		
Composition:	put in:	removed:	Loss:	Loss:	put in:	removed:	Loss:	Loss
	lbs.:	lbs.:	lbs.:	%	lbs.:	lbs.:	lbs.:	%
Total wt.	710.00:	715.00	+5.0	+0.69	540.00:	505.00	35.0	6.48
Water	559.00:	594.60	+35.4	+5.11	220.90:	258.50	+37.0	+14.50
Dry matter:	150.80:	120.40	30.4	20.10	319.10:	246.50	76.6	24.00
Nitrogen	5.17:	3.03	2.14	41.39	9.42:	8.40	1.02	10.82
Protein	32.34:	18.19	13.34	41.24	58.86:	52.52	6.34	10.77
Fat	3.40:	8.59	+5.19	+6.40	6.18:	12.73	+6.55	+51.45
Crude Fiber:	97.84:	40.93	56.91	58.16	83.12:	67.53	15.59	18.63
Ash	17.13:	18.44	+1.11	+6.01	31.52:	25.20	6.32	20.05
N. F. E.	46.77:	30.95	15.72	34.03	30.91:	80.04	+49.13	+61.37

The above table shows that on an average the loss in total nutrients was considerably more in silo No. 4 than in silo No. 6. However, the greatest loss in both silos was in protein. It will also be noticed that there was a loss of 34.03% of nitrogen-free substance in silo No. 6. There was only 0.75% acid developed in silo No. 4 while the silage in No. 6 had 1.35% acid.

From these data we can conclude that the best results in siloing alfalfa are obtained when the forage

contains about 65% moisture at the time it is put into the silo.

Peas and Oats:- Experimental silo No. 5 was filled with very immature oats and Canada field peas. The oats and peas were taken from a field that was sown at the rate of three parts oats to two parts of peas. The forage was cut in $\frac{3}{4}$ inch lengths and thoroughly packed into the silo. It contained only 14.18% of dry matter when put in the silo and 11.64% when taken out. When this silo was opened after 104 days, it had settled to nearly one-half its original volume. The silage had a very strong, disagreeable odor and contained only 0.87% of acid. The cows refused to eat this silage. There was a loss of 22.09% in total weight and about 33.0% in dry matter in the silo.

Silo No. 2 was filled with peas and oats more mature than the material put into silo No. 5. Some of the peas were mature and the vines were very woody. The oats were in the dough stage. This forage was taken from a field which was sown at the rate of three parts of peas to two parts of oats. It had 19.96% of dry matter when put into the silo and 18.16% when taken out. There was a light rain on the forage when the silo was being filled.

When the silo was opened after 89 days, the silage had settled to about two-thirds of its original volume.

There was a considerable amount of water in the bottom of the silo and the silage had a very strong pungent odor. It contained only 0.63% acid. However, there was a loss of only 15.7% in weight and 19.0% in air-dry matter. The cows ate this silage but did not seem to relish it.

SHOCK CORN SILAGE.

Object.

Previous work along this line indicates that fairly good silage can be made from shock corn fodder, when water, from 60°F. to 70°F. is added in sufficient quantity, and the silo filled slowly.

The object of this experiment is to determine:

1. The loss of nutrients in silage made from shock corn.
2. The relation of the sugar content of the forage to the acidity of the silage.

Plan of Experiment.

On September 24, 1915, corn, in the dough stage was cut and shocked in the field. This shock was brought to the barn December 17, run through silage cutter and put in experimental silo No. 1.

September 22 corn, in the soft dent stage was cut and shocked in the field. The shocks were brought to the barn December 15, run through cutter and put in experimental silo No. 5.

September 23, corn in the hard dent stage, was cut and shocked in the field. This shock was brought to the

barn December 17, run through cutter and put in experimental silo No. 2.

When these silos were being filled water at 60°F. was added to both of them in the ratio of 1:1. Samples were taken of some of the forage, after being run through the cutter, when the shocks were put up in the field, and analysed. Samples were again taken when the shocks were put in the silos and when the silage was removed, and analysed. All of these silos were emptied February 12, 1916.

Discussion of Data.

Silo No. 1 was opened 55 days after being filled. It sustained a loss of only 0.14% in total weight but showed a loss of 59.4% in dry matter. The silage showed an excess of mould near the top of the silo. There was a loss of silage below the screen of about eighty pounds, due to mould. However, this loss was not included in the calculation of the losses given above. The silage was very dry; which accounts for the development of the mould in it. The great loss in silage, caused by mould near the top of the silage was due to the settling of the water in the silo. It was found that the corn fodder would not take up the water as fast as the silo was filled, and there was an excess

moisture in the silage near the bottom of the silo. Although the silage was a little dry and contained considerable mould, it was otherwise similar to silage made from green corn.

Silo No. 2 was opened 55 days after filling. The silage in this silo sustained a loss of only .016% in total weight but there was a loss of 36.9% in dry-matter. Although the silage appeared to be normal in every respect to silage made from green corn, it had developed considerable mould around the top. There was a loss 120 pounds of silage from mould, near the top, This was due to the water settling in the silage, leaving the top very dry.

Silo No. 5 was opened 64 days after it was filled. The silage was in practically the same condition as that removed from Silos 1 and 2. There was a loss of 129.5 pounds of silage near the top of the silo, caused by mould. However, this moldy silage was included in the calculations of the losses in the silo, and a portion of the moldy silage was taken as a part of the sample which was analysed. With the exception of the loss from mould near the top of the silo the silage appeared to be normal in every respect to silage made from green corn. In Table 13 the amount of fresh material, and of each constituent weighed into silo

No. 5 are given, and also the amount weighed out, the loss in pounds, and the percentage loss.

It was hoped in the beginning to have more data on this subject, but it is not yet available.

Table 13 .

Losses in Silo No. 5 in 1914*
and 1915.

1915	Total : :wt.	Dry : matter	: Pro.	: Fat	: C. F.	: Ash.	: N. F. E.
Put in	:697.5	:311.7	:22.09	:7.64	:59.60	:12.97	:222.4
Removed	:669.0	:289.3	:18.64	:5.97	:69.30	:15.92	:176.5
Loss Lbs	28.5	22.4	3.45	1.67	+9.70	+2.95	45.8
Loss %	4.08	7.16	15.6	21.8	+16.2	+22.7	20.6
1914	:4.83	:10.3	:9.0	:+25.0	:16.2	:18.7	:9.64

*Same silo used in another experiment in 1914.

It will be noticed from this table that the average loss in silage made from shock corn was about the same as the loss in silage made from green corn. There was an increase in crude fiber and ash in the silo in 1915. This was due to the development of a large amount of mould in this silo.

Relation of Sugar to Acidity:- The corn used for Silo No. 1 contained 4.08% of sugar when shocked in the field,

4.01% when put into the silo, and the silage contained 0.33% of sugar when it was removed from the silo. The silage developed 1.88% of acid.

The corn for silo No. 2 contained 3.6% sugar when shocked in the field, 3.6% when put into the silo, and the silage had 0.66% of sugar when taken from the silo. This silage developed only 1.00% acid.

The above data were based on the weight of the fresh corn as put into, and of the silage removed from each silo. Calculations based upon the per cent. of air-dry matter in each silo were also made. When put on this basis the per cent. of sugar in the corn had the same relation to the acid in the silage as was shown in the calculations based on the fresh material.

From these data we can see that the higher the sugar content of green corn, when shocked in the field, the greater is the amount of acid developed in the silage. Although these data show that there is a direct relation between the sugar content of the green forage and the acid content of the silage made therefrom, we would not feel safe in drawing any definite conclusions from these results. As pointed out under the discussion of data under "The Effect of Mould on Silage", mould greatly reduces the acid in silage. The silage from Silos 1 and 2 contained considerable mould, and was therefore the probable cause of the low per cent. of acid in the silage.

OTHER CROPS FOR SILAGE.

Object.

The possibility of growing rye to be followed by another crop makes it important to know if this crop can be put into the silo with success. The interest in Sudan grass, makes it advisable to try it as a silage crop. There-fore, the object of this experiment is to determine under what conditions these two crops can be siloed.

Plan of Experiment.

In this experiment three experimental silos were used. Two were filled with rye and one with Sudan grass.

April 27, 1915, silo No. 1 was filled with immature rye, just beginning to head out, after being run through a silage cutter.

May 5, Silo No. 3 was filled with rye from the same field. It was in the bloom stage, the stems beginning to get woody.

August 17, silo No. 1 was filled with Sudan grass after the rye silage had been removed. The Sudan grass when cut was about seven feet high, the stems a

little woody, and the grain in the dough stage. It was run through a silage cutter and put in the silo in the usual way.

Records were kept of the amount put in each silo and of the amount of silage weighed out. Samples were taken and analysed, both at the time of filling the silos and again when they were emptied. The amount of acid was also determined in a sample from each silo when the silage was removed.

Discussion of Data.

All of the crops were cut in 6/8 inch lengths and put into the silos as soon as possible after it was brought in from the field. When the silos were opened it was found that the volume of silage in each silo containing rye had decreased to about one-half its original volume. This was due to the rye having a hollow stem, necessarily incorporating considerable air at the time of filling, which was pressed out during the period of silage formation.

Rye:- The rye silage was removed from silo No. 1, 98 days after being filled. It had a good straw color and a typical silage taste; the odor, however,

was very disagreeable, The cows ate the silage greedily.

The silage from silo No. 3 was removed after being in the silo 105 days. It was in good condition, but the cows did not seem to relish it, as much as they did the silage made from the less mature rye. Acidity tests were not made on any of the rye silage. Table 14 gives the composition of rye put into, and of the silage removed from Silos 1 and 3.

Table 14.

		Percentage Composition of Fresh Material						
Silo No.	Description of samples	H ₂ O	N	Pro.	Fat	C.F.	Ash	N.F.E.
1	Rye as put in	74.81	0.649	4.05	0.861	6.74	2.18	8.69
	Silage removed	83.39	0.278	1.73	0.755	6.68	1.88	5.22
3	Rye as put in	73.91	0.495	3.09	0.448	9.32	1.97	10.36
	Silage removed	81.06	0.268	1.67	0.742	8.21	1.71	6.32

The average percentage decrease of all constituents during the process of silage formation was about the same in both silos. With the exception of crude fiber and nitrogen-free extract, all of the constituents were lower in silo No. 3 than in silo No. 1.

Table 15 gives the weight of the fresh material and of the total constituents weighed into Silos 1 and 3, the amount weighed out, and the per cent. loss in each .

Table 15.

	Silo No. 1			Silo No. 3.		
	Amt. put in	Amt. removed.	Loss	Amt. put in	Amt. removed	Loss
Fresh material	lbs.	lbs.	%	lbs.	lbs.	%
Fresh material	717.00	663.50	6.06	603.00	500.00	17.08
Water	536.30	553.20	+ 3.04	445.60	405.30	9.04
Dry matter	180.70	110.30	38.90	157.40	94.70	39.10
Nitrogen	4.65	1.84	60.43	2.98	1.34	55.03
Protein	29.08	11.52	60.37	18.65	8.37	54.57
Fat	6.17	5.27	14.90	5.11	3.71	27.39
Crude fiber	62.71	44.36	29.24	56.19	41.05	26.94
Ash	15.68	12.50	20.28	11.87	8.58	27.71
N.F. E	62.31	34.69	44.30	62.49	31.64	49.36

With the exception of nitrogen and protein, there was a much greater loss of nutrients in silo No. 3 than in silo No. 1. It will be noticed that in Table 15 there was not an increase in the amount of fat, or ether-extract, in rye silage. Other experiments reported in this thesis

show that in nearly every case with corn silage, and silage made from legume hays that there was an increase in the amount of fat during silage formation. This was probably due to the breaking down of some of the volatile fats into alcohol which was acted upon by the yeasts, normal to silage, and converted into acetic acid. The acetic acid is further broken down into gases which are liberated.

Sudan Grass:- Silo No. 1, containing Sudan grass silage was opened 43 days after it was filled. As previously stated, the silage had settled considerably, but not as much as the silage made from rye. The silage was free from mould and contained 1.62% acid. It had a good silage odor and the cows ate it greedily, in fact, they seemed to prefer it to corn silage.

Table 16 gives the composition of Sudan grass and of the silage made therefrom.

Table 16.

Percentage Composition of Fresh Material.								
Silo No.	Description of sample.	H ₂ O	N	Pro	Fat	C.F.	Ash	N.F.E
1	As put in	76.38	0.354	2.21	0.452	8.09	2.31	10.18
	As removed.	75.95	0.310	1.93	1.043	8.40	2.28	10.07

It will be noticed from the above table that there seems to be about a normal reduction in the per cent. of all the constituents.

Table 17 gives the weight of the fresh material and constituents put into the silo, the amount removed, and the percentage loss in silo No.1.

Table 17.

Silo:	total								
No. :	wt.	H ₂ O	D.M.	Pro.	Fat	C.F.	Ash	N.F.E.	
1 :Put in	:653.00:	498.70:	154.3:	14.44:	2.95:	52.86:	15.13:	66.52	
1 :Removed	:575.00:	436.70:	138.3:	11.13:	5.99:	48.34:	13.11:	57.91	
1 :Loss, lbs:	78.00:	62.00:	16.3:	3.31:	3.04:	4.52:	2.02:	8.61	
1 :Loss, % :	11.94:	12.44:	10.3:	22.92:	50.70:	8.55:	13.35:	12.94	

There was a normal loss in all of the constituents, except that of fat, which showed an increase of 50.7%. This increase was due to either the conversion of some of the volatile acids into fats, or the conversion of some of the ether-insoluble substances into an ether-soluble form.

WEIGHT OF SILAGE PER CUBIC FOOT.

Object.

The results so far obtained at this*Experiment Station show wide variation in the weight of silage per cubic foot. It is not clear as yet what factors are responsible for this wide variation, but it is believed that the following are the most important ones.

1. The amount of moisture in the silage, which is influenced (1) by the maturity of the corn when cut and (2) by the water added, if any, at the time of filling the silo.
2. The pressure in the silo, which is influenced (1) by the packing done at the time of filling and (2) by the depth of the silage at which a cubic foot is taken.
3. The proportion of grain to fodder which is thought to be influenced (1) by the proportional yield of ears to stalks, and (2) by the manner of distribution of material in the silo when it is being filled.
4. The fineness of cutting.

The first two factors have been investigated by other experiment stations, as well as by the Missouri Experiment Station during the last two years.

*Magruder's Thesis for the degree of A.M. 1914. Oshel's Thesis for the degree of A.M., 1915.

The object of the experiment now reported is to study:-

1. The effect of the proportion of grain to fodder on the weight of a cubic foot of silage.
2. The relation of the fineness of cutting to the weight of a cubic foot of silage.
3. To obtain more data on capacity in general.

Plan of Experiment.

Four baskets, six feet in diameter and five feet deep were made with one inch mesh poultry netting. The netting was doubled in each case so as to strengthen the baskets, and also to prevent the leaking out of any silage. In order to keep the baskets from interfering with the silage settling, it was thought best not to place any braces in the rim of the baskets. These baskets were designated as basket Nos. 1, 2, 3, and 4. The silos used in this experiment were the North and South Concrete Silos.

The North Concrete Silo was filled, as previously stated, September 22 to 24, with corn in the dent stage, cut $\frac{3}{4}$ inch in length. The South Concrete Silo was filled September 26 to 29, with corn in the dough stage, cut $\frac{3}{4}$ inch in length.

(1) Proportion of Grain to Fodder:- When the North Concrete Silo was about one-third full, two baskets were put in.

Basket No. 1 was filled with corn cut $\frac{3}{4}$ inch after the ears had been removed.

Basket No. 2 was filled with corn cut $\frac{3}{4}$ inch to which the ears from No. 1 had been added.

(2) Fineness of Cutting:- When the silo was about two-thirds full, basket Nos. 3 and 4 were put in.

Basket No. 3 was filled with corn cut 1 inch in length.

Basket No. 4 was filled with corn cut $1\frac{1}{2}$ inch in length.

When these baskets were uncovered, about six inches of silage was removed from each and a cubic foot of silage carefully taken and weighed. A cubic foot was also taken from the silo at the same level with the baskets, to be used as a check.

Capacity in General:- To obtain further data along this line, weights per cubic foot were taken at different depths in the North and South Concrete Silos as the silage was fed out. The weights were taken as illustrated in the following Figure.

Figure 1.

Thus an imaginary cross, East and West, and North and South was considered in the silo and five cubic feet taken along each line; Cubic foot No. 1 being at the West and South sides respectively. The third cubic foot being exactly in the center of the silo, served as the point of intersection of the cross. Samples were taken of cubic feet Nos. 1 and 2 each, time, and air-dry determination made.

Discussion of Data.

Proportion of Grain to Fodder:- Baskets Nos. 1 and 2 were uncovered January 15, 1916, after being in the silo 108 days. The baskets were crushed down, so that the total depth of the baskets had decreased from five feet, when put in the silo, to two and one-half

when taken out. The silage in both baskets appeared to be normal to that in the silo but there was a wide variation in the weight per cubic foot, as shown in table No. 18.

Table 18.

Material	Basket No.	Wt. per cu. ft. fresh	Per cent air dry matter	Wt. per cu. ft. air dry.
Corn with ears removed	1	32.00	25.60	8.19
Corn with ears added from No. 1	2	40.50	43.50	17.61
Normal silage from silo.	silo	36.00	41.10	14.79

The weight of a cubic foot in Basket No. 1, that was filled with corn from which the ears had been removed weighed 32.00 pounds, and a cubic foot from Basket No. 2 that was filled with corn to which ears from No. 1 had been added weighed 40.50 pounds. A cubic foot from the silo at the same level weighed 36.00 pounds.

By removing the ears from the corn put in Basket No. 1 it reduced the weight of a cubic foot of the silage made, 11.1 per cent from the normal weight of silage at that depth in the silo. By adding the ears from No. 1 to No. 2 it increased the weight 18.5 per cent. above the

normal weight. These results are far more striking when we make the calculations on the basis of the air-dry matter. In this case there would be a reduction of 44.6 per cent in the case where the ears were removed and an increase of 16 per cent where the ears were added.

Fineness of Cutting:- Baskets Nos. 3 and 4 were uncovered December 19, 1915, after being in the silo 88 days. These baskets were crushed from five feet at the time of putting in the silo to three feet at the time of being uncovered. The silage in the baskets seemed to be normal in every respect to that of the silo, as shown in table No. 19.

Table 19.

Material	Basket No.	Wt. per cu. ft. fresh.	Percent of air-dry matter	Wt. per cubic ft. air dry.
Corn cut $1\frac{1}{2}$ inches.	3	36.50	30.80	11.24
Corn cut $\frac{3}{4}$ inch	4	36.50	40.40	14.74
Normal to silo cut $\frac{3}{4}$ "	silo:	36.50	40.40	14.74

A cubic foot of silage from basket No. 3 in which the corn was cut one and one-half inches, weighed 36.50 pounds, fresh, and 11.24 pounds air dry. A cubic foot from basket No. 4, in which the corn was cut three-fourths inch, which is the same as that of the silo, weighed 36.50 pounds, fresh, and 14.74 pounds air dry. Although the weight of each cubic foot is the same in fresh substance there is a great difference in the weight per cubic foot air dry.

Assuming the weight of a cubic foot of silage to be equal to that of a cubic foot of water, the per cent of air in each cubic foot was calculated to be the same. Thus we can conclude that the greatest varying constituent of a cubic foot of silage, is the moisture.

Capacity in General:- The most of these data were taken from the North Concrete Silo, in which the silage was a little dry for normal silage. The weight per cubic foot at different depths at the wall and in the center, the per cent of air dry matter and the weight per cubic foot, air dry are given in table No. 20.

The distance from the top of the silage, before opening, to the surface of the silage at the point where the weight was taken is given as the depth from the surface of the silage.

Table 20.

Depth from top of silage.		Pounds per cu. ft. fresh.		Per cent of air dry matter		Pounds per cu. ft. air dry.	
Feet	Inches	Wall	Center	Wall	Center	Wall	Center
2	2	22.5	27.0	27.8	34.0	6.25	9.18
5	2	23.5	28.5	36.4	34.9	8.55	9.94
6*	6	20.0	28.0	39.0	35.0	7.80	9.80
9	4	23.0	30.25	38.0	28.0	8.74	8.47
13	1	29.0	44.0	38.8	20.5	11.25	9.02
20	1	29.5	32.5	40.5	40.8	11.94	13.26
25	8	32.0	36.5	40.0	39.0	12.80	14.23
28	5	36.0	40.0	39.8	38.5	14.32	15.40
Average.		26.93	33.34	37.53	33.71	11.10	11.23
Percentage difference between the highest and lowest weight.		40.2%	32.5%	31.2%		56.3%	40.3%

*These cubic feet were taken in a layer of cowpea silage.

In table No. 20 giving the average of all weights it will be noticed that there is a wide variation between the weight of a cubic foot of the silage, fresh, at the wall and at the center of the silo. However, when the weight of air dry matter per cubic foot is considered it

will be noticed that there is a difference of only .13 pounds. Again in the case of the fresh material it will be noticed that the weight per cubic foot varied in proportion to the per cent of moisture. The air-dry matter shows a gradual increase in weight per cubic foot, both at the wall and in the center of the silo, from the beginning at two feet, two inches from the top to the last cubic foot, twenty-eight feet, five inches from the top.

These figures agree quite closely with those obtained by Oshel in the South Concrete Silo, which are shown in table No. 19 of his thesis.

In range of variations in weights the difference is greater in the weight of air dry matter in a cubic foot than in a cubic foot of the fresh material. Although this great difference is evident, the variation in weight of the air dry substance in a cubic foot is much more constant than that of the fresh material.

Table No. 21 gives the weight per cubic foot at different depths in the North Concrete Silo. These weights were taken as illustrated in Fig. No. 1 and contains part of the data in table No. 3.

Taking weights as indicated in figure No. 1, the following data were collected.

Table 21.

Distance from top of silage:		Weight per cu.ft from West to East along line through center of silo					Wt. per cubic ft. from South to North along line thro center of silo.				
Feet:	Inch:	1st.	2nd.	3rd.	4th.	5th.	1st.	2nd.	3rd.	4th.	5th.
5	2	23.5	25.0	28.0	29.0	32.0	23.5	24.5	28.5	25.0	23.5
6*	6	20.0	24.0	27.0	28.0	34.0	34.0	34.0	27.0	34.0	35.5
9	4	23.0	33.2	30.2	22.2	27.5	23.2	30.2	30.2	22.7	27.7
13	1	29.0	41.0	44.0	40.0	31.5	33.0	40.0	44.0	40.0	35.0
20	1	29.5	29.0	32.5	32.5	31.5	32.0	29.5	32.5	34.0	30.7
25	8	32.0	34.5	36.5	34.0	32.0	32.5	34.0	36.5	34.0	32.0
28	5	36.0	38.0	40.0	38.0	37.0	36.0	38.5	40.0	38.0	36.0

*These cubic feet were taken in a layer of cowpea silage.

It will be noticed that there is a great variation in the weight of a cubic foot taken two inches of the wall and one taken in the center of the silo. Although there is a variation between weights taken near the wall and at the center, as a whole there is a constant difference in weight of about six pounds between the wall and the center. Referring again to table No. 3 we find that the variation in the weight of a cubic foot in terms of air dry matter varies only .13 pounds. Thus we can conclude that in filling a silo, where a distributor is used, the lighter and

coarser part of the material is blown out toward the wall of the silo. This is shown in table No. 4. It will be noticed from this table that near the top, or five feet two inches from the surface of the silage, the weight per cubic foot increases from 23.5 pounds at the West wall of the silo to 32 pounds per cubic foot at the East wall. This is accounted for in the fact that the distributor being very short when the silo is nearly full the material has to be blown over the silo, and necessarily the heavy grain falls first. The distributor entered the silo in this case on the East side.

The mean average of all cubic feet in table No. 3 shows the average weight of a cubic foot in the North Concrete Silo to be 30.13 pounds, while the mean average of all cubic feet in table No. 4, taken from the same silo, shows the average weight of a cubic foot to be 32.25 pounds.

A study of our data in connection with the table on the capacity of silos compiled by King of the Wisconsin Experiment Station, raises the question as to the accuracy of his figures for the weight of a cubic foot of silage at different depths. Our conclusion is that King's figures are too high due probably to the

practice at that time of putting in corn much less mature than is done at present. The more mature corn gives a lower water content. As pointed out elsewhere in this experiment the air dry weight per cubic foot of silage is considerably more constant than the fresh weight. Table No. 5 is based upon the air dry weight per cubic foot, rather than weights of fresh silage.

Method of Compiling Table.

Referring to table No. 20 and taking the average of the figures in the first line of columns 3 and 4 as the average dry matter test, and an average of the figures in the first line of columns 5 and 6, same table, as the weight of a cubic foot of silage, on dry matter basis, two feet, two inches from the top of the silage, it was calculated that for each foot of depth, the air dry matter increases .27 pounds, and for each per cent of dry matter the total dry matter increases .21 pounds.

Description of Table.

In this table the first column gives the depth from the top of the silage, the second and succeeding columns gives the weight per cubic foot of silage, in

terms of air dry matter, when the per cent of air dry substance is as indicated at the top of each column. The weight of fresh material is readily calculated from the air dry figure by dividing the air dry weight by the per cent of air dry substance.

Table 22.

Depth in silo:	25%	26%	27%	28%	29%	30%	31%
2	6.45	6.66	6.87	7.08	7.29	7.50	7.71
3	6.72	6.93	7.14	7.35	7.56	7.77	7.98
4	6.99	7.20	7.41	7.62	7.83	8.04	8.25
5	7.26	7.47	7.68	7.89	8.10	8.31	8.52
6	7.53	7.74	7.95	8.16	8.37	8.58	8.79
7	7.80	8.01	8.22	8.43	8.64	8.85	9.06
8	8.07	8.28	8.49	8.70	8.91	9.12	9.33
9	8.34	8.55	8.76	8.97	9.18	9.39	9.60
10	8.61	8.82	9.03	9.24	9.45	9.66	9.87
11	8.88	9.09	9.30	9.51	9.72	9.93	10.14
12	9.15	9.36	9.57	9.78	9.99	10.20	10.41
13	9.42	9.63	9.84	10.05	10.26	10.47	10.68
14	9.69	9.90	10.12	10.33	10.54	10.75	10.96
15	9.96	10.17	10.38	10.59	10.80	11.01	11.22
16	10.23	10.44	10.65	10.86	11.07	11.28	11.49
17	10.50	10.71	10.92	11.13	11.34	11.65	11.81
18	10.77	10.98	11.19	11.40	11.61	11.82	12.03
19	11.04	11.25	11.46	11.67	11.88	12.09	12.30
20	11.31	11.52	11.73	11.94	12.15	12.36	12.57
21	11.58	11.79	12.00	12.21	12.42	12.63	12.84
22	11.85	12.06	12.27	12.48	12.69	12.90	13.11
23	12.12	12.33	12.54	12.75	12.96	13.17	13.38
24	12.39	12.61	12.82	13.03	13.24	13.45	13.66
25	12.66	12.87	13.08	13.29	13.50	13.71	13.92
26	12.93	13.14	13.35	13.56	13.77	13.98	14.19
27	13.20	13.41	13.62	13.83	14.04	14.25	14.46
28	13.47	13.68	13.89	14.10	14.31	14.52	14.73
29	13.74	13.95	14.16	14.37	14.58	14.79	15.00
30	14.01	14.22	14.43	14.64	14.85	15.06	15.27
31	14.28	14.49	14.70	14.91	15.12	15.33	15.54
32	14.55	14.76	14.97	15.18	15.39	15.60	15.81
33	14.82	15.03	15.26	15.47	15.68	15.89	16.10
34	15.09	15.30	15.51	15.72	15.93	16.14	16.35
35	15.36	15.57	15.78	15.99	16.20	16.40	16.61
36	15.63	15.84	16.05	16.26	16.47	16.68	16.89

These figures are compiled for a silo 16 feet in diameter and it was calculated that for every foot over or under 16 feet a correction of .162 pounds should be made. It should be added if the silo is larger and subtracted if smaller. This correction should be made before using the figure in the table.

INFLUENCE OF MOULD ON COMPOSITION OF SILAGE.

Object.

The object of this experiment is to determine:

1. The effect of mould on the acidity of silage.
2. The effect of mould upon the composition of silage.

Plan of Experiment.

In this experiment in addition to the two experimental silos used a sample of 35 pounds of silage was taken from the North Concrete Silo. This sample was divided into three sub samples of 5000 grams each.

Sub sample No. 1 was tested immediately for acid and complete analysis made. This sample served as a check on the other two.

Sub sample No. 2 was set in a mouse tight case at about 80°F. and allowed to mold for three days, and then tested for acid and complete analysis run.

Sub sample No. 3 was set under the same conditions as No. 2 and allowed to mold for six days, at which time it was tested for acid and complete analysis made.

Corn taken from the same field and at the same stage of maturity was put into two experimental silos. The corn was thrown loose into silo No. 1 and no weights applied so as to allow the development of mould freely. The corn was thoroughly packed into silo No. 2 and 1500 pounds of weight applied to press out all the air possible. This silo was used as a check on silo No. 1.

Discussion of Data.

The two samples of 5000 grams each, taken from the large silo, showed considerable development of mould after standing two days. At the end of three days, when the first sample was tested for acid, it was found that nearly every piece of silage was covered with white mould, and the acid had been reduced from 1.87% to 0.23%. At the end of six days, when the second sample was tested for acid, it was found that the mould had begun to cake the silage. It had a very musty odor, and the color had changed from a dark straw shade to black. The acid had been reduced from 1.87% to 0.15%.

When the two silos were open, 120 days after being filled, the silage in No. 1 had settled to nearly one half its original volume and had developed only 1.89% acid while the silage in silo No. 2 had developed 2.58%

of acid. The silage in No. 1 had considerable mould, and came from the silo in cakes. It was estimated that about 50% of it was unfit for feeding purposes. The mould permeated the entire mass of silage, thus showing the presence of air throughout the silo. The silage in silo No. 2 was in excellent condition, having a good silage odor, and a normal amount of acid. Silo No. 2 showed a loss of only 2.5% in total weight, while silo No. 1 showed a loss of 13.9%. Table 23 shows the composition of three samples taken from the large silo, and of a sample taken from each of the experimental silos.

Table 23

Sample No.	Description of sample	Percentage Composition					
		H ₂ O	Pro.	Fat	C.F.	Ash	N.F.E.
185A	Normal silage	67.92	2.77	0.99	6.19	1.67	20.0
185B	Molded 3 days	68.57	2.74	0.82	5.32	1.69	20.4
185C	Molded 6 days	65.50	2.77	0.82	7.80	1.96	20.7
88	From silo No. 2	75.30	2.75	1.59	5.47	1.79	12.6
87	From silo No. 1	77.21	2.76	0.90	5.63	1.72	11.3

As indicated by the analysis there was a slight decrease in the constituents for the first three days,

during which the silage was allowed to mold. After this period there was a slight increase. The nitrogen and protein came back to normal, while the crude fiber, ash, and nitrogen-free extract went above the normal, or check sample, 185A. The fat did not reach the normal amount again, but it was greater than the amount present in the silage which was allowed to mold only three days. On the average there was very little change in the composition, and the writer is of the opinion that the extent of the change in composition is in proportion to the length of time the silage is allowed to mold. This is shown in a comparison of Sample 87 and 88. It will be noticed that there was a great reduction in the amount of fat and nitrogen-free extract in Sample 87. However, the other constituents were affected very little.

Although there were very slight changes in the composition of the silage during the molding periods, the following table shows that there was a decrease in all constituents for a few days and then a slight increase in the amount of crude fiber and ash.

Table 24.

Sample No.	Total wt.	H ₂ O	Dry matter	Pro.	Fat	C. F.	Ash	N. F. E.
	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.	Gms.
185A	5000	3396	1604	138.7	49.6	309.6	83.5	1000
185B	4646	3185	1461	127.4	38.0	247.3	67.0	948
185C	4374	2864	1510	119.3	35.8	341.4	85.9	117

These results agree very closely with the losses in some of the experimental silos, in which silage molded considerably. There was an increase in crude fiber in every case where the silage molded in the silo.

From these data it seems safe to conclude that:

(1) Although moldy silage is not very good as a feed, the composition is not affected within a reasonable length of time. (2) Mould reduces the acidity of silage in direct proportion to the amount of mould developed. (3) Mould reduces, for a short period, the amount of each constituent in the silage without materially altering the composition of the silage. There is an increase in crude fiber in moldy silage after a few days.

CONCLUSIONS.

At the beginning of this paper, several leading questions were asked. The conclusions are given in the form of answers to these questions.

Factors Influencing Acidity.

1. The per cent of acid developed in silage is affected by the following factors: (1) By the nature of the silage crop; the one which contains the greatest amount of soluble carbohydrates has the highest per cent of acid. (2) By the per cent of moisture in the silage; the normal amount of acid being developed in silage containing from 65% to 75% moisture. (3) By the per cent of sugar in the silage crop when cut; the one having the greatest amount of sugar when cut, develops the highest per cent of acid.

2. Although the per cent of acid in silage is affected by the above three factors, the acid does not bear a direct relation to any one factor.

Losses in The Silo.

3. The losses occurring in the silo are in direct proportion to the extent of fermentation in the silage.

4. There is a greater loss by field-curing of corn than by putting the green corn into the silo.

5. There is a greater loss in corn shocked in the field during December, January, and February than corn shocked in the field during October, November, and December.

6. There is a greater loss by feeding shock corn directly to cows than by siloing the corn and then feeding it.

7. The palatability of shock corn decreases in direct proportion to the length of time it is allowed to remain in the field.

Legumes for Silage.

8. Good silage can be made from alfalfa containing from 60% to 65% of moisture when put into the silo; therefore green alfalfa should be allowed to dry in the sun three to six hours before being put into the silo.

9. Good silage can be made from mature or immature peas and oats, if they contain about 60% of moisture when put into the silo. Under ordinary conditions peas and oats contain from 70% to 85% of moisture when freshly cut.

10. Where it is impossible to cure alfalfa on account of rainy weather, it is advisable to put it into the silo, after allowing it to dry out somewhat.

Shock Corn Silage.

11. Good silage can be made from shock corn when water is added in the ratio of 1:1 and the silo filled very slowly.

12. There is no greater loss in silage made from shock corn than in silage made from green corn.

13. All of the sugar in shock corn is not completely reduced during silage formation.

14. There is a normal amount of acid developed in silage made from shock corn.

Other Crops for Silage.

15. From the data available it is believed that good silage can be made from rye containing about 65% of moisture when put into the silo. Immature rye contains from 70% to 85% of moisture when cut.

16. Good silage can be made from Sudan grass containing from 65% to 70% of moisture when put into the silo; therefore it is necessary to allow it to dry after cutting so as to lose from 10% to 20% of moisture before it is put into the silo.

17. Silage made from Sudan grass develops a normal amount of acid.

Weight of Silage Per Cubic Foot.

18. The weight of a cubic foot of silage at different depths in the silo is affected by several factors, three of which are: (1) The per cent of moisture in the silage. (2) The pressure in the silo. (3) The proportion of grain to fodder.

19. The weight of a cubic foot of silage in the center of the silo, at different depths, is correspondingly higher than a cubic foot at the wall.

20. The air-dry weight of a cubic foot of silage is more constant than the weight of the fresh material.

21. The average weight of a cubic foot of air-dry material at the same level in the silo increases in direct proportion to the depth at which it is taken.

Influence of Mould on Composition of Silage.

22. Mould reduces, for a short period, the amount of each constituent in corn silage, after which there is an increase in the amount of crude fiber.

23. Mould reduces the acidity in silage in direct proportion to the length of time the silage is allowed to mold.

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