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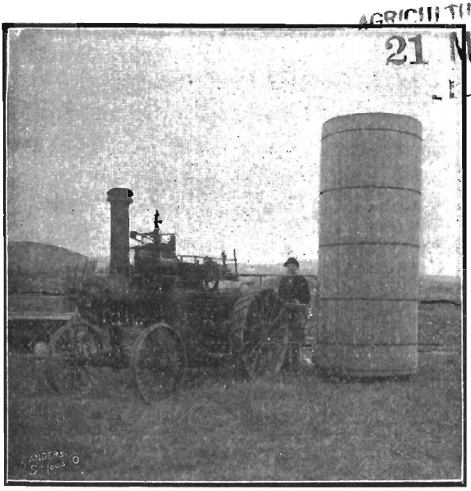

Preliminary Report on Steamed Silage.

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PRELIMINARY REPORT ON STEAMED SILAGE.

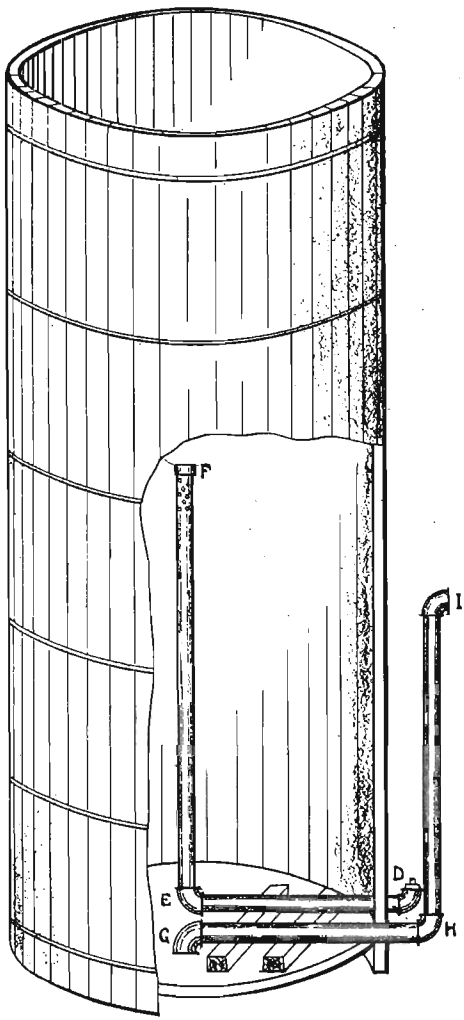
Silage Investigation Undertaken in 1901.

Introductory Comments.—The economic value of silage as a succulent winter food for stock is generally recognized by the farmer and dairyman. Successful animal husbandry, from a pecuniary point of view, depends almost wholly upon the cost of production. With this in mind, the Station has endeavored to discover some method of ensiling the large annual and perennial forage crops which will retain their natural palatability and succulence.

The method commonly employed does not produce these results and is objectionable for two reasons, (1) loss in food elements; (2) the presence of organic acids, the product of chemical or biological changes. The aim of the Station has been to secure an approximately acid-free silage that could be fed in sufficient quantities to supply a complete ration for a beef or dairy animal, or at least furnish the larger portion of the ration, so as to eliminate so far as practicable mill feeds.

In addition to the four silos maintained for work on a practical scale, five smaller ones were constructed for more technical work. This work with silage was also supplemented with extensive experiments conducted by the Departments of Chemistry and Bacteriology, some of which gave moderately good results, but none gave promise of a complete fulfillment of the object sought. During the progress of this work, Hon. Benton Killin, Chairman Station Committee, suggested the use of steam, the result of which is given in this publication. No attempt is made in this bulletin to draw conclusions because the work at this date is simply in the experimental stage. The principle seems correct, although many details remain to be worked out for the practical application of the method to farm conditions. Among these are the following: The amount of piping necessary for a given space in the silo and its proper distribution; steam pressure required; cost of operating; the discovery of an inexpensive method for sealing the silo, if found necessary to do so.

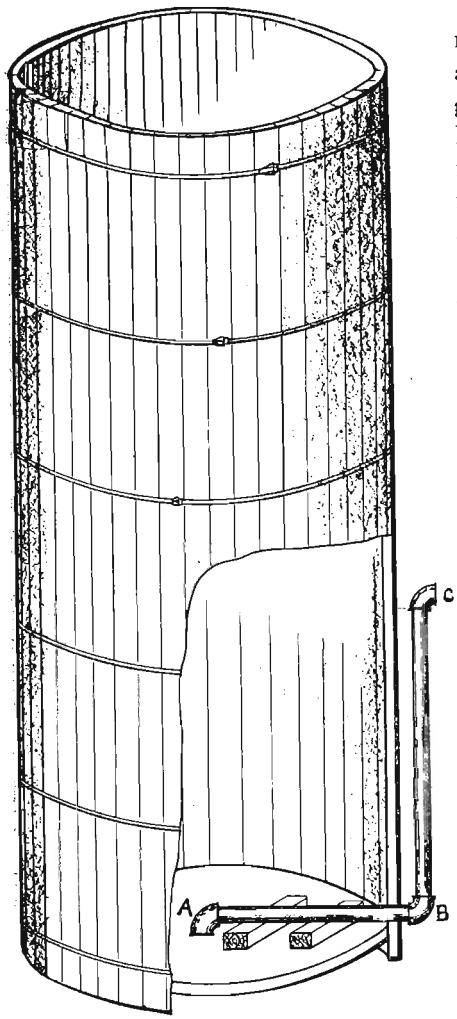
Construction of the Experimental Silos.—The experimental silos were constructed of well seasoned yellow fir, dressed, tongue and groove lumber, $1\frac{5}{8}$ inches thick, $3\frac{1}{2}$ inches wide and 12 feet long. When completed the silos measured approximately 5 feet in diameter and 12 feet deep. They were constructed plain, having no doors, so that the only way of filling and emptying was by way of the top of the silo. Five such silos were constructed; two of them, numbers 1 and 5, were fitted with $1\frac{1}{4}$ inch piping so that they could be steamed after being filled. Silo No. 1 (see accompanying cut*) was fitted with pipes so that steam could be liberated in the silo within 2 inches of the bottom at G and also midway between the bottom and top at F. The upright pipe EF in the silo was covered with a cap at F so as to prevent fodder from falling into the pipe. Ten to 15 holes $\frac{3}{8}$ inch in diameter were drilled in the pipe near the cap at F as outlets for the steam. The elbow at G turns directly down and comes to within about 2 inches of the bottom of the silo. This elbow G prevents material from getting into the pipe GH and serves as an easy outlet for the steam when forcing it into the silo near the bottom.



Silo No. 1.

* The drawings were kindly furnished by Mr. Clyde Phillips.

Silo No. 5 (see accompanying cut) was fitted with 1¼ inch piping so that the steam could be introduced into the silo near the bottom only.



Silo No. 5.

Filling the Silos. — Experimental silos numbers 1, 2, 4 and 5 were filled with very green immature corn fodder. Number 3 was filled with more mature corn fodder. The fodder was cut in the field and hauled immediately to the silos where it was cut with a steam cutter and elevated into the silos. The cutter was set so as to cut ¾ inch long. At the time of filling, the fodder was packed in the silos as tightly as possible, each silo receiving somewhat more than 3 tons of fodder.

Steaming the Silage. — Silo number 1 (see page 188) was filled with cut corn fodder Oct. 11, 1901. The material was well tramped and also tamped as firmly as possible with a piece of 2x4 scantling. The filling was completed at 6 o'clock P. M. Steam connections were made at **D** with pipe delivering steam at **F** six feet from bottom. (See cut page 188) At 7:20 P. M. steam under 20 pounds pressure was turned into the silo. After 6 hours the steam had penetrated the whole upper portion of the silo and was coming out at the top. The steam was then turned off and connections made with the pipe at **I** delivering steam into the bottom of the silo at **G**. As soon as the connections had been made, the steam was again turned on. Early the following morning the steam pressure was

increased to 40 pounds with the steam valve leading to the silo wide open. At 9:30 A. M., Oct. 12 steam was shut off and boiler disconnected. A sterilized cotton plug was tied over the end of the pipe at **I** projecting from the silo. The second pipe projecting from the silo was stopped with an iron plug screwed in at **D** (see cut page 188.)

When steam was shut off the temperature on top of the cut fodder in the silo was 212° Fahr. and one foot below the surface a trifle above this temperature. During the steaming process the fodder shrank from ¼ to ⅓ in bulk so that at the end of the steaming process the material in the silo occupied only ¾ to ⅔ of the space originally occupied by it. There was practically no further settling of the silage after it was steamed.

Silo number 5 was filled with cut corn Oct. 5, 1901, the material being well packed as in silo number 1. After filling the silo, steam connections were made as described on page 189 and at 6:15 P. M., steam was turned in near the bottom of the silo at **A** (see cut page 189). The steam pressure on the whole was higher while steaming this silo than it was with silo number 1. The pressure ranged from 20 to 40 pounds and part of the time as high as 60 pounds. After 6 to 8 hours the steam had penetrated the whole silo from bottom to top. At 8 o'clock next morning the steam was shut off, the boiler disconnected and the end of the pipe at **C** (see cut page 189) projecting from the silo covered with sterilized cotton. During the steaming process the material in this silo shrank about as much as it did in silo number 1 when it was steamed so that at the end of the steaming process the material occupied only ¾ to ⅔ of its original space. This was practically all the shrinkage which the silage underwent up to the time of emptying the silo.

Covering the Steamed Silage.--Just at the end of the steaming process, and while the corn fodder was still very hot, both silos were covered with layers of heavy building paper and then with several inches of sterilized cotton. This covering of paper and cotton was placed directly on top of the corn fodder so that if the fodder settled the cotton covering would settle also. It was thought that by this means these silos might be made more nearly germ proof.

Untreated Corn Silage.—On Oct. 5, 1901 silo number 4 was filled in the ordinary way with cut corn and was given no treatment whatever. This silage was to serve as a check on the steamed silage.

Salted Silage.—The Station Bacteriologist wished to try salting or pickling corn fodder and so silos numbers 2 and 3 were filled with cut corn and salted at the rate of one pound of salt for every 100 pounds of cut corn fodder. Silo number 2 was then saturated with water. Shortly after filling, silo No. 2 sprung a leak and the water drained off carrying with it much of the soluble portion of the silage.

Condition of the Corn Fodder. The corn fodder used in this experimental work was very immature. Ears were just forming when the fodder was cut so that the silage contained little or no corn. Silo number 3 received the best fodder for silage; this fodder being more mature and the ears well formed. The kernels were soft however and not well glazed.

Opening the Silos.—Silo number 5 was opened Dec. 21, 1901. After carefully removing the cotton and paper, the silage was found to be mouldy, a white mould permeating the top layer of silage. After removing the top 12 inches of mouldy silage, the silage was bright and sweet and had the odor of sweet corn when it is being cooked.

Silo number 1 was opened Feb. 3, 1902, and after removing the cotton and paper the condition of the silage was just about the same as that of silo number 5. The top 3 or 4 inches were more or less decomposed and mouldy, the mould extending down about one foot below the surface. After removing the surface foot of silage the remainder of the silage was sweet and bright and had a most pleasant odor, not at all like ordinary silage.

It is doubtful if the layer of cotton served its purpose, since a layer of the silage spoiled. In all probability the silage would not have spoiled or fermented more than it did with no layer of cotton.

The check silo, number 4, was opened Jan. 25, 1902. The top layer was somewhat decomposed and mouldy. After removing the spoiled layer, the silage was bright and looked and smelled like ordinary corn silage, except that it was very immature and contained but little corn—possibly a more musty odor near the top and a more acid odor down in the silo than is usually experienced, probably due to this immature condition of the material when put into the silo.

The top layers of salted silos numbers 2 and 3 were more or less decomposed and musty. After removing the spoiled layers, the rest of the silage had a somewhat briny or pickled odor and of course was very salty to the taste.

Amount of Spoiled Silage.—The following table shows the amount of corn fodder put into each silo, also the amount of waste which had to be thrown out of each silo at the time of opening for feeding purposes:

Silo number	Date of filling	Am't cut corn fodder put in silo	Date of opening silo	Spoiled silage top of silo
1	October 11, 1901	6121 pounds	February 3, 1902	350 pounds
2	October 5, 1901	6140 pounds	February 24, 1902	665 pounds
3	October 2, 1901	6650 pounds	February 12, 1902	640 pounds
4	October 5, 1901	7248 pounds	January 25, 1902	740 pounds
5	October 5, 1901	6491 pounds	December 21, 1901	860 pounds

Discussion of Table.—The large percentage of loss from spoiled silage in these silos was evidently due to the smallness of the silos and the consequent resistance to the settling of the silage by friction from the walls of the silo. The better showing made by the steamed silage in Nos. 1 and 5 was doubtless due to the wilting of the silage from the effects of the heat and to its greater weight per cubic foot, due perhaps to moisture acquired from the condensation of steam.

Feeding the Silage and Results.—Owing to the small quantity of steamed silage no experimental feeding was undertaken to determine its value as compared with silage put up in the ordinary way. The cows ate it with avidity and seemed to do well on it.

The Chemistry of Silage.

A Chemical Study of Silage.—Corn silage, as it usually comes from the silo, has undergone many changes since the time when the green material was put into the silo. One of the best ways of noting changes in silage is to keep track of the acidity. If the acidity of the material increases to any great extent, it is a sure indication that many changes have taken place in the silage in the silo; if the acidity does not increase then but few changes have taken place.

Untreated Silage from Immature Corn.—On Oct. 1, 1900, very immature cut corn fodder was put into a silo in the ordinary way. The acidity of the fresh material was not determined, but from examinations of other fresh samples of cut corn fodder, it probably ranged from .10 to .15 per cent. When the silage was fed the latter part of April and May, 1901, it contained on an average 1.94 per cent acidity calculated as acetic acid. One of the partial samples contained as much as 2.22 per cent acid. This large increase in acidity indicated that the silage had undergone great changes. The follow- table gives these changes:

	Water-free Material.		Fresh Material.	
	No. 1849	No. 1936	No. 1849	No. 1936
	Cut corn as put in silo Oct. 1, 1900.	Composite sample corn silage as taken out of silo from April 30 to May 15, 1901. **No treatment**	Cut corn as put in silo Oct. 1, 1900.	Composite sample corn silage as taken out of silo from April 30 to May 15, 1901. **No treatment**
	Per cent.	Per cent.	Per cent.	Per cent.
Ash	5.65	6.19	1.40	1.23
Protein	9.13	10.31	2.27	2 05
Ether extract	2.93	5.83	0.73	1.16
Crude fiber	19.35	21.15	4.80	4.21
Sugars (cane and invert)	17.79	1.40	4.42	0.28
Acids (calculated as acetic)	.....	9.74	.....	1.94
Moisture	.....	.....	75.18	80.09
Dry matter	.....	.....	24.82	19.91

A study of this table shows that the greatest changes were undergone by the carbohydrates. An examination of the water-free material shows that when put in the silo the fodder contained 17.79 per cent sugar (cane and invert), at the time of taking out of the silo 1.40 per cent, or a loss of 92.13 per cent. This loss consisted of cane sugar, dextrose, laevulose, and in all probability small amounts of other carbohydrates. When calculated to the fresh material, we find that when it went into the silo it contained 4.42 per cent total sugar, and that when taken from the silo this amount had decreased to 0.28 per cent. With this large loss of carbohydrates there is a large gain in acidity and apparently small gains in the other component parts of the silage. Since a considerable portion of the carbohydrates during fermentation escapes from the silo in the form of gases, this would increase the percentage composition of the remaining component parts of the silage, even though they had undergone no change.

The following year similar experiments were conducted. Oct. 5, 1901, experimental silo No. 4 was filled with very immature corn fodder. This silo was given no treatment other than that given the ordinary silo. On Jan. 25, 1902, this silo was opened and the feeding of the silage began. The following table gives the changes which the material underwent in the silo:

	Water-free Material.		Fresh Material.	
	No. 2073	No. 2289	No. 2073	No. 2289
	Cut corn as put in silo No. 4, Oct. 5, 1901.	Composite sample corn silage as taken out of silo No. 4 from Jan. 25 to Feb. 3, 1902. No Treatment.	Cut corn as put in silo No. 4, Oct. 5, 1901.	Composite sample corn silage as taken out of silo No. 4 from Jan. 25 to Feb. 3, 1902. No Treatment.
	Per cent.	Per cent.	Per cent.	Per cent.
Ash	6.61	8.49	1.70	1.43
Protein	7.31	8.13	1.88	1.37
Ether extract	3.55	5.89	0.91	0.99
Crude fiber	21.75	25.02	5.58	4.21
Sugars (cane and invert)	17.40	1.22	4.46	0.21
Acids (calculated as acetic)	0.47	10.59	0.12	1.78
Moisture			74.34	83.19
Dry matter			25.66	16.81

An examination of this table shows that when the fodder was cut and put in the silo it contained 0.12 per cent acid calculated as acetic, when taken from the silo this acidity had increased to 1.78 per cent, being very nearly sixteen times the original amount in the fodder. Here again as in last year's work we find that this large gain in acidity is accompanied by a corresponding large loss in carbohydrates. Calculated to a water-free basis, we find that when the fodder was put in the silo it contained 17.40 per cent sugar (cane and invert) and that when taken from the silo this amount had decreased to 1.22 per cent being a loss of 92.99 per cent in sugars. When calculated to the fresh material we find that when it went into the silo it contained 4.46 per cent total sugar and that when taken from the silo this amount had decreased to 0.21 per cent.

It is believed that the silage as it came from the silo contained not even a trace of sugar in any form because after digesting a water extract of the fresh silage for 15 minutes with hydrochloric acid, a careful examination of this digested extract failed to show any reducing sugar present. However, after drying the silage thoroughly at 100 degrees centigrade and grinding to a powder in a Maercker's mill, a careful analysis of the water extract of this fine powder, after digesting with hydrochloric acid, gave 0.21 per cent reducing sugars.

Salted Silage.—In the fall of 1901 another experiment was com-

menced; On Oct. 5, Experimental Silo No. 2 was filled with immature corn fodder. During the filling process the corn fodder was salted from time to time at the rate of one pound of salt to each 100 pounds of corn fodder. After filling, the material in the silo was thoroughly saturated with water. Another Experimental Silo No. 3, was filled on Oct. 6, 1901 with corn fodder which was much more mature, the ears were well formed and the kernels glazed. This silo was also salted at the rate of one pound of salt to each 100 pounds of green corn fodder. No water was added to this silo.

The following table shows the changes undergone by the salted silage:

	Water-free Material.			
	No. 2073	No. 2305	No. 2074	No. 2292
	Cut corn as put in silo No. 2, Oct. 5, 1901.	Composite sample corn silage as taken out of silo No. 2 from Feb. 24 to Feb. 28, 1902 **Salted and watered.**	*Cut corn one day after putting in silo No. 3, Oct. 6, 1902.	Composite sample corn silage as taken out of silo No. 3 from Feb. 12 to Feb. 21, 1902 **Salted.**
	Per cent.	Per cent.	Per cent.	Per cent.
Ash	6.61	7.99	7.89	10.45
Protein	7.31	7.13	10.81	9.13
Ether extract	3.55	5.35	3.77	5.96
Crude fiber	21.75	27.28	20.70	19.80
Sugars (cane and invert)	17.40	0.79	11.28	2.24
Acids (calculated as acetic)	0.47	8.16	.....	7.78
	Fresh Material.			
Moisture	74.34	87.26	77.70	79.45
Dry matter	25.66	12.74	22.30	20.55
Ash	1.70	1.02	1.76	2.15
Protein	1.88	0.91	2.41	1.88
Ether extract	0.91	0.68	0.84	1.22
Crude fiber	5.58	3.48	4.62	4.07
Sugars (cane and invert)	4.46	0.10	2.52	0.46
Acids (calculated as acetic)	0.12	1.04	.....	1.60

*Owing to an oversight the composite sample of fodder put in silo No. 3 was not saved. A sample was taken next morning—probably fifteen hours after the silo had been filled. At this time the material in the silo was beginning to heat and much of the sugar had disappeared.

This salted silage underwent rather more changes than were expected. The salt did not seem to prevent to any great extent fermentation and the formation of acids. The sugars had practically all disappeared during the changes taking place in the silos. However, upon drying the silage and grinding and digesting a water extract of this ground silage with acid, a small amount of sub-

stance, namely 0.10 per cent in silo No. 2 and 0.46 per cent in silo No. 3, was found which would reduce Fehling's solution.

By examining the foregoing table we find that the fodder calculated to a water-free basis, when put into silo No. 2, contained 17.40 per cent total reducing sugars and 0.47 per cent acidity calculated as acetic acid. When taken out of the silo the sugars had decreased to 0.79 per cent whilst the acidity had increased from 0.47 per cent to 8.16 per cent. These results when reduced to the fresh material are as follows: when put into the silo the green corn fodder contained 4.46 per cent reducing sugars and 0.12 per cent acid. When taken out of the silo the sugars had decreased to 0.10 per cent and the acidity had increased to 1.04 per cent.

From a practical point of view it would not be advisable to salt the fodder and then saturate it with water, because salt solutions tend to dissolve out some of the valuable parts of the fodder. A considerable proportion of the protein being easily soluble in salt solutions.

Steamed Silage.—The most interesting part of the year's work with silage centered about the silos which had been steamed. The work this last year was purely experimental and the results obtained were far beyond the Station's expectations. The process of filling and steaming the silos is described on pages 189 and 190. The silage coming from the steamed silos was sweet and had undergone very little change since the green fodder was put into them.

The following table shows the changes which have taken place in the steamed silage:

	Water-free Material.			
	No. 2073	No. 2263	No. 2080	No. 2291
	Cut corn as put in silo No. 5, Oct. 5, 1901.	Composite sample corn silage as taken out of silo No. 5 from Dec. 21 to Jan. 16, 1902. **Steamed.**	Cut corn as put in silo No. 1, Oct. 11, 1901.	Composite sample corn silage as taken out of silo No. 1 from Feb. 3 to Feb. 11, 1902. **Steamed.**
	Per cent.	Per cent.	Per cent.	Per cent.
Ash	6.61	6.35	6.08	6.38
Protein	7.31	7.38	8.31	7.56
Ether extract	3.55	3.60	3.21	3.80
Crude fiber	21.75	22.40	17.75	21.18
Sugars (cane and invert)	17.40	17.44	18.14	16.25
Acids (calculated as acetic)	0.47	1.62	0.47	1.63
	Fresh Material.			
Moisture	74.34	81.51	74.34	78.50
Dry matter	25.66	18.49	25.66	21.50
Ash	1.70	1.17	1.56	1.37
Protein	1.88	1.36	2.13	1.62
Ether extract	0.91	0.67	0 82	0.82
Crude fiber	5.58	4.14	4.55	4.55
Sugars (cane and invert)	4.46	3.22	4.65	3.49
Acids (calculated as acetic)	0.12	0.30	0.12	0.35

By carefully examining the analysis of the water-free material in the above table it is seen that of all the silage considered in this bulletin, the steamed silage underwent the fewest changes. The sugars which usually undergo the most change in the silo were not altered to any great extent and were found in approximately their original amounts.

During the changes taking place in the silos the acidity increased somewhat but instead of finding 8 to 10 per cent acid we find only 1.62 per cent. These results when reduced to the fresh material just as it came from the silo show that the steamed silage contained about .30 per cent whilst the ordinary silage contained from 1.78 to 1.94 per cent acid. In other words the ordinary corn silage contained six times as much acidity as the steamed silage.

Sugar and Acidity in Fresh Silage.—In all the experimental work with silage, when the material was taken out of the silos for feeding purposes, partial samples were taken for analysis. Determinations were made for acidity and sugar in the water extract of the fresh silage. The following partial analyses of the fresh material will give a fair indication of the condition of the silage as it came from the different experimental silos. It will be noticed that the water extract of the silage contained no sugar except in the two cases where the silage had been steamed. These partial analyses are as follows:

Sugar and acid contained in corn fodder when put in silo.	Large Silo No treatment.		Exp. Silo No. 1. Steamed.		Exp. Silo No. 2. Salted.		Exp. Silo No. 3. Salted.		Exp Silo No. 4. No treatment. Check.		Exp. Silo No. 5. Steamed.	
	Sugar Per cent.	Acid Per cent.	Sugar Per cent.	Acid Per cent.	Sugar Per cent.	Acid Per cent.	Sugar Per cent.	Acid Per cent.	Sugar Per cent	Acid Per cent.	Sugar Per cent.	Acid Per cent
	4.42	------	4.65	0.12	4.46	0.12	------	------	4.46	0.12	4.46	0.1
1st sample silage as taken out of silo	------	2.22	2.49	0.66	None	0.96	None	1.14	None	1.68	2.99	0.36
2d sample	------	1.92	3.26	0.48	None	1.02	None	1.74	None	1.74	3.32	0.27
3d sample	------	1 68	3.29	0.30	None	1.14	Trace	1.38	None	1.80	3.18	0.45
4th sample	------	------	3.72	0.33	None	1.08	None	1.38	None	1.89	3.82	0.30
5th sample	------	------	3.97	0.30	None	1.02	None	1.77	None	1.80	3.49	0.27
6th sample	------	------	3.74	0.24	------	------	None	1.80	None	1.74	3.58	0.24
7th sample	------	------	3.70	0.24	------	------	None	1.80	------	------	3.40	0.27
8th sample	------	------	3.70	0.27	------	------	None	1.80	------	------	4.24	0.36
9th sample	------	------	------	------	------	------	------	------	------	------	4.01	0.21
10th sample	------	------	------	------	------	------	------	------	------	------	3.43	0.30
11th sample	------	------	------	------	------	------	------	------	------	------	4.04	0.30
12th sample	------	------	------	------	------	------	------	------	------	------	3.32	0.27
13th sample	------	------	------	------	------	------	------	------	------	------	------	0.36
14th sample	------	------	------	------	------	------	------	------	------	------	3.68	0.30
15th sample	------	------	------	------	------	------	------	------	------	------	3.16	0.24
16th sample	------	------	------	------	------	------	------	------	------	------	------	0.24

Methods and Table of Analyses of Silage Materials.—The following table gives the complete fodder analysis of the materials used in the corn silage experiments. The methods of analysis used are those adopted by the Association of Official Agricultural Chemists.

A departure was made from the routine method of fodder analysis when the carbohydrates were examined. Under the heading "Carbohydrates" is included all those materials which are capable of hydrolysis. For this determination 2 grams of dry substance were boiled two and one-half hours with 200 cubic centimeters of water and 20 cubic centimeters of hydrochloric acid (specific gravity 1.125) in a flask provided with a reflux condenser; then cooled, neutralized, filtered and the reducing sugars determined in a portion of this filtrate. The reducing sugars thus obtained would include cane and invert sugar, starches, pentosans and such other carbohydrates which undergo hydrolysis and conversion into reducing sugars when boiled with hydrochloric acid. Concerning the nitrogen compounds it is seen that with the chemical and biological changes taking place in the silos the tendency was for the proportion of albuminoid nitrogen to diminish whilst the amide nitrogen increased. The steamed silage contained the least amide nitrogen of any of the samples of silage examined. The amount of ether extract in the untreated silage and also in the salted silage had increased greatly during the time that the material was in the silos, whilst the ether extract in the steamed silage changed but very little. The crude fiber in the silage in one of the salted silos increased greatly because a considerable amount of the soluble portion of the silage leaked out of this silo.

WATER-FREE MATERIAL.	No. 1849	No. 2073	No. 2074	No. 2080	Composite Sample of Corn Silage as taken out of Silo.					
	Cut corn as put in large Silo Oct. 1, 1900.	Cut corn as put in Silos No. 2, No. 4, No. 5, Oct. 5. 1901.	Cut corn sampled one day after putting in Silo No. 3 Oct. 5, 1901.	Cut corn as put in Silo No. 1 Oct. 11, 1901.	No. 1936	No. 2289	No. 2291	No. 2263	No. 2292	No. 2305
					Large Silo. Apr. 30 to May 15, 1901. **Not Treated.**	Silo No. 4 Jan. 25 to Feb. 3, 1902. **Not Treated.**	Silo No. 1 Feb. 3 to Feb. 11, 1902. **Steamed.**	Silo No. 5 Dec. 21 to Jan. 16, 1902. **Steamed.**	Silo No. 3 Feb. 12 to Feb. 21, 1902. **Salted.**	Silo No. 2 Feb. 24 to Feb. 28, 1902. **Salted and Watered.**
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Ash	5.65	6.61	7.89	6.08	6.19	8.49	6.38	6.35	10.45	7.99
Albuminoid Nitrogen x 6.25	6.50	6.13	9.32	7.62	6.89	5.53	6.69	5.98	5.67	4.24
Amide Nitrogen x 6.25	2.63	1.18	1.49	0.69	3.42	2.60	0.87	1.40	3.46	2.89
Total Protein (total N x 6.25)	9.13	7.31	10.81	8.31	10.31	8.13	7.56	7.38	9.13	7.13
Ether Extract	2.93	3.55	3.77	3.21	5.83	5.89	3.80	3.60	5.96	5.35
Crude Fiber	19.35	21.75	20.70	17.75	21.15	25.02	21.18	22.40	19.80	27.28
Nitrogen-free Extract	62.94	60.78	56.83	64.65	56.52	52 47	61.08	60.27	54.66	52.25
Sugars (cane and invert)	17.79	17.40	11.28	18.14	1.40	1.22	16.25	17.44	2.24	0.79
Carbohydrates (calculated as reducing sugar formed by Hydrolysis)	48.86	44.17	41.51	53.06	38.81	31 55	48.56	43.67	34.52	34.34
Acids (calculated as acetic)	.....	0.47	.....	0.47	9.74	10.59	1.63	1.62	7.78	8.16
FRESH MATERIAL.										
Moisture	75.18	74.34	77.70	74.34	80 09	83 19	78.50	81.51	79.45	87.26
Dry Matter	24.82	25.66	22.30	25.66	19.91	16.81	21.50	18.49	20.55	12.74
Ash	1.40	1.70	1.76	1.56	1.23	1 43	1.37	1.17	2.15	1.02
Albuminoid Nitrogen x 6.25	1.61	1.57	2.08	1.95	1.37	0.93	1.43	1.10	1.17	0 54
Amide Nitrogen x 6.25	0.66	0.31	0.33	0.18	0 68	0.44	0.19	0.26	0.71	0.37
Total Protein (total N x 6.25)	2.27	1.88	2.41	2.13	2.05	1.37	1.62	1.36	1.88	0.91
Ether Extract	0.73	0.91	0.84	0.82	1.16	0.99	0 82	0.67	1.22	0.68
Crude Fiber	4.80	5.58	4.62	4.55	4.21	4.21	4.55	4 14	4.07	3.48
Nitrogen-free Extract	15.62	15.59	12.67	16.60	11.26	8.81	13.14	11.15	11.23	6.65
Sugars (cane and invert)	4.42	4.46	2.52	4.65	0.28	0.21	3.49	3.22	0.46	0.10
Carbohydrates (calculated as reducing sugar formed by Hydrolysis)	12.13	11.33	9.26	13.62	7.73	5.30	10.44	8.07	7.09	4.37
Acids (calculated as acetic)	.....	0.12	.....	0.12	1.94	1.78	0 35	0.30	1.60	1.04

Silage Work—Summer of 1902.

Present Status of the Work.—Since the work last year, which is discussed in this bulletin, was purely experimental, no attempt will be made to draw conclusions. During the present season the Station is carrying out several experiments and is steaming a number of large and small silos.

Two silos filled in June 1902 were piped as follows: One nine feet in diameter and twenty-two feet deep was supplied with a four-foot-square of one inch pipe placed about eight inches from the floor upon blocks in the center of the silo. This pipe was perforated on the under side with one-fourth inch holes about four inches apart. To this was attached a supply pipe passing through the walls of the silo and barn. On the outside of the barn a vertical pipe of five feet was attached and a horizontal pipe twelve feet long connected this to the boiler of the farm traction engine. On June 10th, this silo was filled with whole clover. After the silo was filled steam was turned on and continued for fourteen hours with a pressure fluctuating from twenty-five to forty pounds. At the end of this time the contents of the silo, consisting of 11.86 tons, were thoroughly heated. The following day the silo was filled up again and the steaming renewed.

Another silo ten feet in diameter and twenty-two feet deep, was similarly piped except in addition to the square, an individual vertical pipe extending up fourteen feet and perforated with several one-fourth inch holes near the top was placed in the center of the silo. After partially filling this silo on June 12th and 13th with cut clover, steam was turned on in the square of pipe at the bottom of the silo for sixteen hours. On June 14th, the silo was filled up again and steam turned on in the vertical pipe for about forty hours. This last steaming was not satisfactory as the heat appeared to be unevenly distributed throughout the material put in at the last filling. This silo contained 36.46 tons and required from one to one and one-half cords 4 ft. fir wood to steam it. No attempt was made to seal these silos but the surface was kept thoroughly compact by tramping for a short while each day for a week.

The outside vertical and horizontal pipes may be used for steaming a number of silos but should be detached from the pipe leading into the silo while hot. This pipe must be immediately plugged with

cotton so as to exclude germs that might enter with air going in to fill partial vacuums produced by the cooling of the silage.

On June 21, 1902 Experimental Silo No. 5 (see page 189) was filled with cut clover more mature than was put in the large silo June 14. It required 5855 pounds of cut clover to fill it. This silo was steamed for twelve hours commencing at 11:40 A. M. June 21. During the steaming process the clover settled nearly six feet.

The Station has planned to fill Experimental Silo No. 1 (see page 188) with still riper cut clover and steam immediately after filling by forcing steam in, both at the bottom and afterward at the center of the silo. The Station will also fill one of the large silos nine feet in diameter and twenty-two feet deep with cut vetch. This silo will be thoroughly steamed as soon as filled.

Later in the season three or four more silos will be filled with cut corn and steamed. It is hoped that in this way the Station will be able to demonstrate the success or failure of the Oregon method of ensiling crops.

Steaming Immediately After Putting Material in the Silo is Essential.—Since green materials when cut and packed tightly undergo chemical or biological changes very quickly, it is necessary that the materials be steamed as soon as possible after ensiling. Last October corn fodder put into a silo untreated sustained a loss of one-fifth or twenty per cent in sugar content during the first twelve hours in the silo.

Conclusions.—At the present writing no conclusions will be drawn as the Station has but scanty data upon which to found them. The Station believes that it is working in the right direction but at the present time feels warranted only in giving a report of progress concerning steamed silage.

LIST OF BULLETINS

(In print) published by the Oregon Agricultural Experiment Station to July, 1902.

Circular No. 1—Dairying in Oregon ..... Shaw, French and Kent
No. 6, 1890—Chemistry, Zoölogy ..... Washburn
No. 7, 1890—Small Fruits and Vegetables ..... Coote
No. 8, 1891—Varieties of Wheat and Flax ..... French
No. 10, 1891—Entomology ..... Washburn
No. 28, 1894—Pig Feeding, continued ..... French
No. 29, 1894—Horticulture, Pruning, etc. ..... Coote
No. 30, 1894—Potatoes and Roots, continued ..... French
No. 31, 1894—Codlin Moth, Hop Louse ..... Washburn
No. 32, 1894—Five Farmers' Foes ..... Craig
No. 33, 1894—Tent Caterpillar ..... Washburn
No. 34, 1895—Fruits and Vegetables ..... Coote
No. 35, 1895—Pig Feeding, continued ..... French
No. 36, 1895—Composition and Use of Fertilizers ..... Shaw
No. 37, 1895—Experiments in Cattle Feeding ..... French
No. 38, 1895—Fruit Pests ..... Washburn
No. 39, 1895—Grasses, Chemistry ..... Shaw
No. 40, 1896—Prunes, Apples and Pears ..... Hedrick
No. 42, 1896—Feeding Sheaf Wheat ..... French
No. 43, 1897—Flax Culture ..... French
No. 44, 1897—Review of Oregon Sugar Beets ..... Shaw
No. 47, 1897—Cheat and Clover ..... Shaw and French
No. 48, 1898—Spraying ..... Cordley
No. 50, 1898—The Fertility of Oregon Soils ..... Shaw
No. 51, 1898—Marketing Fruit ..... Craig
No. 52, 1898—Nut Culture ..... Coote
No. 53, 1898—Sugar Beets ..... Shaw
No. 54, 1898—Flax, Hemp, Dairy, etc. ..... French and Kent
No. 55, 1898—Chemistry of Cherries ..... Shaw
No. 57, 1899—Brown Rot ..... Cordley
No. 58, 1899—Rose Culture in Oregon ..... Coote
No. 59, 1899—Sugar Beet Experimeuts of 1898 ..... Shaw
No. 60, 1900—Apple Tree Anthracnose ..... Cordley
No. 61, 1900—The Oregon Prune ..... Shaw
No. 62, 1900—Miscellaneous Investigations ..... Shaw
No. 63, 1900—Prevention of Smut on Oats—Preliminary Bulletin ..... Pernot
No. 64, 1901—Investigation of Diseases in Poultry ..... Pernot
Circular Bulletin concerning Acid Soils in Oregon—1900 ..... Knisely
No 65, 1901—Creameries and Cheese Factories of Western Oregon ..... Kent
No. 66, 1901—The Grape in Oregon ..... Lake
No. 67, 1901—The Silo and Silage ..... Withycombe
No. 68, 1902—Birds of Oregon ..... Woodcock
No. 69, 1902—The Codling Moth and Late Spraying in Oregon ..... Cordley
No. 70, 1902—Testing Milk and Cream ..... Kent
No. 71, 1902—Stagnant Water Germs in Milk ..... Pernot
No. 72, 1902—Preliminary Report on Steamed Silage ..... Withycombe and Knisely

Copies will be sent to applicants so long as the supply lasts.

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