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WINTERING AND SUMMER FATTENING OF STEERS IN NORTH CAROLINA.

By F. W. Farley[1] and F. T. Peden, *Animal Husbandry Division, Bureau of Animal Industry*, and R. S. Curtis, *North Carolina Agricultural Experiment Station.*

CONTENTS.

OUTLINE OF THE EXPERIMENTAL WORK.

During the fall of 1913, the Bureau of Animal Industry, United States Department of Agriculture, in cooperation with the North Carolina Agricultural Experiment Station, began a series of beef-cattle experiments on the grazing farm of T. L. Gwyn, near Springdale, Haywood County, N. C. This is in the western part of the State where most of the cattle produced are for beef purposes.

This work has been in progress six years. The first three years' work, reported in United States Department of Agriculture Bulletin No. 628 and in North Carolina Department of Agriculture Bulletin No. 240, comprised the following: (*a*) Wintering steers both in barns and on pastures; (*b*) summer fattening of steers on pasture with and without cottonseed cake; and (*c*) winter fattening of beef cattle. During the second three years the winter fattening and the supplementing of grass with cottonseed cake for summer fattening were discontinued, because these practices were found not generally profitable under western North Carolina conditions. However, the use

[1] Mr. Farley, the senior author of this bulletin, resigned from the department in June, 1919.

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of cottonseed cake to supplement summer pasture had been profitable the first two years, which was before the rapid rise in prices of feeds began. The three years' work here reported dealt with various phases of wintering and summer fattening of steers.

THE REGION AND ITS PROBLEMS.

Most of the land in western North Carolina and the surrounding territory, shaded on the map, figure 1, is extremely rough and mountainous and suited only for grazing. There are thousands of acres of cut-over timberland, recently left by lumbering operations, which are

FIG. 1.—Map showing location of experimental work (heavy black dot) and area (shaded) suitab for similar cattle-feeding operations; also local and principal cattle markets.

practically worthless in their present condition. In many of the mountainous counties only from 5 to 10 per cent of the land can be cultivated, and much of this is mountain and hillsides which should be in grass. The production of stocker and feeder cattle is especially practicable on account of the large areas available for pasture and the relatively small quantity of winter feed necessary for the maintenance and growth of such cattle. The fattening of cattle is much less practicable than the growing of cattle because of the greater quantity of feed necessary. Where feed has to be shipped in by rail, as is usually the case with the concentrates, the distance from the railroad station makes the fattening of cattle prohibitively costly for many farmers.

On account of the relatively small area of land which can be cultivated profitably, the chief problem with most of the cattlemen in this section, as in other range sections, is to keep as many cattle through the winter as can be grazed during the summer. The men who have good pastures suitable for fattening a carload or more of steers nearly always buy their stockers in the fall. They buy part of them from men who keep a large herd of cows to raise stockers, and the rest from small farmers who keep from one to six cows. Nearly all the cattle are roughed through the winter on very light rations. Relatively few are fed on silage. It is expected that they will lose weight rather heavily during the winter, but that they will put it back very cheaply on grass the following summer. They are sold as two-year-olds for feeding purposes, going principally to the blue-grass region of the Virginias and the feed lots of Pennsylvania.

OBJECTS AND PLAN OF THE WORK.

This work was undertaken to determine the following:

1.—The value of pastures in this section for wintering and finishing cattle.

2.—The effects of the different methods of wintering on the gains made on grass the following summer.

3.—A way by which stockmen can winter more cattle than is the case at present.

4.—The relative cost of various methods of keeping steers through the winter.

The work was planned to cover a period of three years to get averages practically free from the effects of variations in seasons, feed, pasture, and cattle. The feeds selected to determine the most economical winter ration were: Mixed hay, corn silage, corn silage with stover and straw, and winter pasture, that had not been grazed the preceding summer. The methods tested as to their possibilities for carrying more cattle through the winter were the use of silage and winter pasture. The steers used were divided into four lots for each of the first two years and five lots for the third year, there being about a carload of cattle in each lot. The lots were as nearly uniform in quality and condition as it was possible to make them. At the close of each of the three winter periods the cattle were carried through the summer on grass. The steers were numbered the same as in the previous winter's work so that the records of each lot of cattle could be followed from one fall until the next fall. As the steers were not given any other feed while they were on summer pasture, all gains can be credited to the pasture on an acreage basis. An outline of the work is given in Table 1. Changes in this general outline made necessary by the giving out of the supply of the various roughages at various times before the end of the winter periods are noted in Table 2.

The following year, in a somewhat similar experiment, the same authors (13) find a loss of 18 per cent of the dry matter, 11 per cent of the albuminoids, and 26.5 per cent of the sugars and starch of the green maize during ensiling.

Two years later Hills (14) reports a repetition of the investigation of the comparative losses in maize silage and maize fodder and gives a more detailed chemical report. He states that he found losses in the total amounts of the different constituents of the maize from harvesting to feeding to be as follows: Dry matter, 20 per cent; crude protein, 12 per cent; crude fiber, 5 per cent; nitrogen-free extract, 30 per cent; ether extract, 16 per cent; and a gain of 3 per cent in crude ash.

The director of the New York Experiment Station (15) at Geneva reports investigations extending over a period of three years, during which nine bags of green maize and seven bags of green sorghum were buried in a silo 14 by 15 by 30 feet. The bags weighed 50 pounds each at ensiling and, except for one bag of sorghum, were buried in sets of three, one bag at the center and the other two within a foot of opposite walls of the silo. The combined results of the 16 bags show during ensiling the following changes, which are based on the total amounts of each constituent of the maize ensiled: Losses—water, 3.9 per cent; ash, 0.4 per cent; albuminoids, 18.5 per cent; crude fiber, 9.8 per cent; nitrogen-free extract, 15.1 per cent; albuminoid nitrogen, 18.7 per cent; sugars and starch, 26.6 per cent; and dry matter, 12.6 per cent; grains—crude fat, 45.4 per cent; and amide nitrogen, 3.7 per cent.

Clements and Russell (16) state that they ensiled green maize in a round silo 12 feet in diameter and 17 feet high and examined the silage a few days and also three weeks after ensiling. Their tables show a loss in protein nitrogen and a gain in amide nitrogen, also a slight gain in fiber and in furfurol, and they seem to indicate no trace of sugars remaining even after a few days' ensiling.

Russell (17) gives a summary of the investigations undertaken with maize silage over a period of five years at the South-Eastern Agricultural College, Wye, England. He concludes that the characteristic silage changes are the disappearing of sugar, of some of the less resistant cellulose, and of a part of the protein.

Annett and Russell (18), in a very interesting paper published in the Journal of Agricultural Science in 1908, give a discussion of various phases of silage investigation undertaken at the South-Eastern Agricultural College, Wye, England. They discuss quite thoroughly the losses and changes in the silo. Each year the investigators buried in a 12 by 17 foot round stave silo several sacks of from 10 to 15 kilos of fine-cut corn at different depths, and analyzed the maize when put in and when taken out of the silo.

The maize was cut green. In some seasons the dry matter was as high as 20 per cent and in cold, wet seasons as low as 13 per cent. They find practically no loss in crude fiber, but a very great loss in nitrogen-free extract, from which the sugar is shown by direct test to disappear almost entirely. The pentosans and protein suffer considerably. They state that the bags in the top half of the silo lost an average of 32 per cent of their original content of ether extract and 17 per cent of their soluble ash constituents, while the bags in the lower half gained over the original amounts 6 per cent in ether extract and 2 per cent in soluble ash constituents. They make note of a downward wash of soluble acids and ash. In a table stating an average of all losses and gains in original constituents present in the green material during the ensiling of maize during the seasons of 1904 and 1905, they give the losses as follows: Dry matter 36 per cent; ether extract, 16 per cent; nitrogen-free extract, 55 per cent; fiber, 8 per cent; total nitrogen, 26 per cent; protein nitrogen, 55 per cent; ash, 14 per cent; furfurol, 32 per cent; and gains, non-protein nitrogen, 83 per cent.

Feruglio and Mayer (19) claim to find a loss of only 5 per cent in the food material during the ensiling of maize. They state that this loss falls somewhat on the pure protein and albuminoids, but most strongly on the sugars and pentosans. On the other hand, they find an increase in ether extract and total acidity.

THE EXPERIMENTAL WORK.

The silo used was a cylindrical concrete silo 42 feet high by 14 feet in diameter inside, holding approximately 150 tons, and located at the Dairy Division Experiment Farm, Beltsville, Md. The floor of the silo was 4 feet below the lowest door, and the silo up to this door was water-tight. The work was carried on for two seasons, 1914–15 and 1915–16. During both seasons the silo used was completely filled with corn. The depth of the silage after settling was approximately 38 feet.

MANNER OF PLACING AND REMOVING SAMPLES.

Samples of silage in cheesecloth sacks were buried at various depths and positions in the silo. The silo was divided into 8 levels the first season and 6 levels the second season. The first level was near the bottom of the silo and the last one near the top. The distance between levels was approximately the same. When a level was reached in the regular course of filling the silo a sack of the carefully sampled cut corn was weighed and buried at about the center. At the same time another sample was taken for chemical analysis. The sacks were numbered according to the level at which they were buried.

During the fall and winter the silage was fed out as usual, and whenever a level was reached the sack was removed, placed in a closed can, and immediately sent to the laboratory for analysis.

COLLECTION OF THE JUICE.

The floor of the silo was tapped and a 1-inch pipe conducted the silage juices to a receptacle outside and below the floor level of the silo. During the first season a barrel was used to receive the juice, but this proved unsatisfactory, and during the second season a covered concrete tank was employed. At first daily, later at more extended periods, the juice collected since the previous sampling was thoroughly mixed, and the sample, in an 8-ounce bottle, was immediately sent to the laboratory for analysis.

During the collection of a number of juice samples in the season of 1914–15 hard rains occurred which caused the barrel in which the juice was collected to overflow or diluted its contents, thus destroying the value of the respective samples. Owing to these facts, the results of this season's work on the juice are of value only as preliminary and as indicating the approximate amount of juice lost from the silo and the nitrogen contained therein.

METHOD OF ANALYZING SAMPLES.

The bags of silage were taken to the laboratory immediately after removal from the silo. After the weights were taken the contents were mixed and a 1-kilogram charge was taken for the gross-moisture determination. The remainder was pulped in a power meat grinder. The pulp was thoroughly mixed and charges for the various nitrogen determinations immediately taken. The charge for the gross-moisture determination was placed in a steam drying closet and dried at a temperature between 50° and 60° C. to a constant weight. It was then exposed to the air for several days and the final weight taken to represent the air-dry condition. The material was then ground in a power mill to a fine flour suitable for analysis.

The amino nitrogen was determined by the method of Van Slyke and the ammonia nitrogen by the method of Folin and Macallum. The other determinations were made according to the methods of the Association of Official Agricultural Chemists.

RESULTS OF THE ANALYSES.

The results of the experimental work are given in the following tables. Table 1 gives the weight and chemical composition of the corn in each sack as it was buried. Table 2 shows the weights and chemical composition of the contents of the sacks as they were removed from the silo. Table 3 was calculated from the preceding tables and shows the losses or gains in each sack based on the weights ensiled. Tables 4 and 5 give the weights and chemical analyses of the juice.

TABLE 1.—*Summary of analyses of cut corn as placed in bags.*

SEASON 1914–15.

Bag No.	Weight.	Moisture.	Total nitrogen.	Albuminoid nitrogen.	Ether extract.	Crude fiber.	Ash.	Total sugar.	Nonreducing sugar.	Furfurol.
	Grams.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	3,350	68.54	0.451	0.334	0.52	6.15	1.33	4.23	0.39	3.64
2	7,740	67.18	.406	.344	.58	6.29	1.02	3.93	1.83	3.71
3	5,510	67.21	.506	.418	.63	5.65	1.18	4.16	1.03	4.74
4	6,220	66.23	.434	.347	.64	6.17	1.18	3.07	1.30	3.74
5	6,390	69.13	.45	.362	.54	5.89	1.83	3.67	0.71	3.49
6	6,640	74.60	.329	.282	.42	4.55	1.02	3.30	0.09	2.72
7	6,620	69.90	.394	.349	.58	6.17	1.56	2.64	0.68	3.37
8	5,870	72.19	.370	.286	.47	5.92	1.38	2.46	0.72	3.30
Average.	....	69.39	.413	.340	.55	5.84	1.31	3.39	1.28	3.56

SEASON 1915–16.

Bag No.	Weight.	Moisture.	Total nitrogen.	Albuminoid nitrogen.	Ether extract.	Crude fiber.	Ash.	Total sugar.	Nonreducing sugar.	Furfurol.
1	5,615	76.95	0.398	0.326	....	....	1.29	2.97	0.51	2.33
2	4,685	72.02	.434	.339	....	....	1.91	3.57	.68	3.03
3	7,170	76.63	.360	.307	....	....	1.49	2.98	.17	2.47
4	7,180	75.18	.374	.317	....	....	1.31	3.17	.29	2.55
5	7,935	74.80	.416	.325	....	....	1.13	3.23	.28	2.70
6	7,540	73.28	.344	.320	....	....	1.57	3.03	.79	2.75
Average.	....	74.89	.385	.321	....	....	1.42	3.14	.46	2.63

TABLE 2.—*Summary of analyses of silage as removed from bags.*

SEASON 1914–15.

Bag No.	Weight.	Gain (+) or loss (−).	Moisture.	Total nitrogen.	Albuminoid nitrogen.	Ether extract.	Crude fiber.	Ash.	Total sugar.	Nonreducing sugar.	Furfurol.	Amino nitrogen.	Ammonia nitrogen.
	Grams.	*Grams.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Parts per million.*	*Parts per million.*
1	3,800	+250	75.14	0.442	0.154	0.65	5.10	1.22	0.12	None.	2.68	1,530	302
2	8,550	+810	71.02	.427	.168	.59	5.58	1.14	.08	None.	3.24	1,420	264
3	6,400	+890	73.36	.491	.237	.78	4.91	1.13	.13	None.	2.69	1,510	304
4	7,920	+1,700	74.48	.405	.155	.70	4.69	1.16	.15	None.	2.62	1,360	278
5	7,070	+780	77.30	.396	.149	.67	4.40	1.20	.09	None.	2.33	1,440	246
6	6,355	−245	75.32	.349	.106	.64	4.51	1.13	.74	None.	2.44	1,250	257
7	7,655	+1,035	76.83	.331	.110	.70	4.94	1.27	.00	None.	2.45	1,880	305
8	6,560	+690	78.52	.312	.114	.45	4.74	1.25	.17	None.	2.49	1,900	105
Average.		....	75.15	.392	.149	.65	4.87	1.19	.18	....	2.63	1,538.8	257.6

SEASON 1915–16.

Bag No.	Weight.	Gain (+) or loss (−).	Moisture.	Total nitrogen.	Albuminoid nitrogen.	Ether extract.	Crude fiber.	Ash.	Total sugar.	Nonreducing sugar.	Furfurol.	Amino nitrogen.	Ammonia nitrogen.
1	5,510	−105	78.80	0.382	0.139	.....	....	1.31	0.09	None.	2.28	1,480	274
2	5,170	+485	78.12	.392	.118	.....	....	1.72	.08	None.	2.37	1,320	252
3	6,210	−960	77.34	.354	.176	.....	....	1.64	.09	None.	2.46	1,040	180
4	6,870	−310	75.58	.379	.139	.....	....	1.23	.40	None.	2.39	1,480	217
5	7,775	−160	76.98	.386	.142	.....	....	1.07	.35	None.	2.16	1.440	256
6	7,350	−190	75.98	.322	.133	.....	....	1.40	.11	None.	2.41	1,120	192
Average.		....	77.02	.368	.142	.....	....	1.37	.20	....	2.34	1,313.3	228.5

TABLE 3.—*Summary of losses and gains, based on weights ensiled.*

SEASON 1914–15.

Bag No.	Green matter.	Moisture.	Dry matter.	Total nitrogen.	Albuminoid nitrogen.	Nonalbuminoid nitrogen.	Ash.	Ether extract.	Crude fiber.	Total sugar.	Furfurol.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	+13.43	+24.36	−10.36	+11.16	−47.69	+179.18	+ 4.05	+41.79	− 5.93	− 96.75	−16.48
2	+10.47	+16.78	− 2.46	+16.18	−46.04	+361.53	+23.45	+12.37	− 2.00	− 97.73	− 3.53
3	+16.15	+26.78	− 5.63	+12.71	−34.15	+235.31	+11.23	+43.82	+ .94	− 96.37	−34.07
4	+27.33	+43.17	− 3.78	+18.82	−43.13	+265.94	+25.17	+39.26	− 3.21	− 93.76	−10.80
5	+10.64	+23.73	−18.64	− 2.64	−54.47	+210.56	−27.45	+37.26	−17.35	− 97.31	−26.13
6	− 4.29	− 3.37	− 7.00	+ 1.52	−64.01	+394.75	+ 6.03	+45.82	− 5.13	− 78.54	−14.14
7	+15.63	+27.10	−10.99	− 2.86	−63.55	+467.94	− 5.86	+39.56	− 7.42	−100.00	−15.93
8	+11.75	+21.55	−13.69	− 5.76	−55.45	+163.41	+ 1.23	+ 6.99	−10.52	− 92.31	−15.67
Average of 4 top bags[1]	+ 8.31	+16.71	−12.74	− 2.46	−59.41	+277.24	− 8.96	+33.31	−10.29	− 91.65	−18.24
Average of 4 bottom bags[1]	+16.87	+27.43	− 4.70	+15.19	−42.18	+264.33	+17.61	+31.92	− 2.26	− 96.35	−15.60
Average of all bags	+12.35	+21.61	− 8.66	+ 6.49	−50.76	+270.36	+ 2.07	+32.59	− 6.34	− 94.14	−17.07

SEASON 1915–16.

Bag No.	Green matter.	Moisture.	Dry matter.	Total nitrogen.	Albuminoid nitrogen.	Nonalbuminoid nitrogen.	Ash.	Ether extract.	Crude fiber.	Total sugar.	Furfurol.
1	− 1.87	+ 0.49	− 9.75	− 5.82	−58.16	+231.16	− 0.35	....	....	−97.00	− 3.98
2	+10.35	+19.70	−13.71	− .33	−61.59	+136.96	− .63	....	....	−97.49	−13.68
3	−13.39	−12.59	−16.01	−14.84	−50.34	+190.90	− 4.67	....	....	−97.37	−13.73
4	− 4.32	− 3.81	− 5.86	− 3.04	−58.04	+302.96	−10.16	....	....	−87.91	−10.32
5	− 2.02	+ .84	−10.49	− 9.08	−57.19	+162.72	− 7.22	....	....	−89.38	−21.62
6	− 2.52	+ 1.07	−12.37	− 8.75	−59.47	+667.40	−13.07	....	....	−96.45	−14.57
Average of 3 top bags[1]	− 2.91	− .57	− 9.72	− 7.09	−58.21	+276.14	−10.43	....	....	−91.18	−15.78
Average of 3 bottom bags[1]	− 3.32	− .04	−13.41	− 7.59	−56.08	+184.70	− 2.16	....	....	−97.32	−10.88
Average of all bags	− 3.09	− .34	−11.29	− 7.31	−57.27	+231.79	− 6.54	....	....	−93.90	−13.68

[1] These averages are based on weights obtained rather than on the percentages of the different compounds in each bag as shown in this table.

TABLE 4.—*Summary of analyses of juice; season 1914–15.*

Sample No.	Weight.	Specific gravity.	Acidity.[1]	Total nitrogen.	Albuminoid nitrogen.	Nonalbuminoid nitrogen.	Total nitrogen calculated as protein.
	Pounds.		*C. c.*	*Per cent.*	*Per cent.*	*Per cent.*	*Pounds.*
1	57	1.008	0.59	0.0432	0.0176	0.0256	0.1539
2	81	1.022	17.29	.138	....	....	.6966
3	84	1.030	24.54	.190	....	....	.9997
4	126	1.034	29.12	.234	.0211	.2129	1.834
5	127	1.036	30.80	.232	....	....	1.842
6	128	1.039	32.70	.254	....	....	2.035
7	108	1.040	32.66	.269	....	....	1.814
8	94.75	1.040	33.14	.278	.0314	.2466	1.700
9	61	1.040	33.64	.283	.0295	.2535	1.080
10	52.5	1.040	32.45	.290	.0295	.2605	.9399
11	29.25	1.041	33.85	.291	.0259	.2651	.5323
12	59	1.042	33.83	.296	.0259	.2701	1.091
13	58.25	1.042	33.08	.288	.0281	.2599	1.048
14	28.25	1.042	32.83	.292	.0251	.2669	.517
15	25	1.042	32.83	.297	.0258	.2792	.465
16	28.5	1.041	29.69	.282	.0226	.2594	.502
17	14.25	1.046	32.95	.320	.0306	.2894	.295
18	18	1.047	32.45	.328	.0306	.2974	.369
19	151.75	1.018	16.17	.126	.0131	.1129	1.200
20	131	1.022	20.14	.163	.0176	.1454	1.336
21	50.0	1.026	23.06	.187	.0178	.1692	.585
22	38.5	1.028	24.03	.202	.0168	.1852	.485
23	31.5	1.029	24.50	.208	.0191	.1889	.410
24	42.5	1.029	25.45	.214	.0202	.1938	.570
25	22.5	1.031	26.88	.230	.019	.211	.324
26	73.25	1.022	21.14	.174	.017	.151	.7984
27	176.25	1.013	13.31	.099	.013	.086	1.0928
28	77.25	1.009	8.83	.075	.006	.069	.3631
29	36.50	1.026	26.11	.195	.015	.180	.4453
30	140.00	1.014	12.53	.109	.010	.099	.9520
31	31.00	1.034	30.99	.269	.022	.247	.5208
32	127.00	1.008	7.82	.060	.005	.055	.4826
33	149.25	1.015	15.03	.119	.007	.112	1.1045
34	90.00	1.023	23.12	.195	.012	.183	.1098
35	8.00	1.026	19.83	.187	.015	.172	.0936
36	23.00	1.009	7.06	.064	.005	.059	.0920

[1] The figures in this column represent the number of cubic centimeters of normal alkali required to neutralize the acid in 100 grams of the juice.

Total weight of juice, 2,579 pounds. Total weight of nitrogen calculated as protein, 28.88 pounds.

TABLE 5.—*Summary of analyses of juice; season 1915–16.*

Sample No.	Number of days represented.	Weight.	Specific gravity.	Acidity.[1]	Total nitrogen.	Albuminoid nitrogen.	Ammonia nitrogen.	Amino nitrogen.	Total nitrogen calculated as protein.
		Pounds.		*C. c.*	*Per cent.*	*Per cent.*	*Parts per million.*	*Parts per million.*	*Pounds.*
1..........	1	40	1.027	22.8	0.139	0.0384	174.2	710.1	0.3480
2..........	1	81	1.029	24.4	.168	.0384	183.1	850.9	.8505
3..........	1	142.5	1.030	21.4	.184	.0384	171.7	854.5	1.6388
4..........	1	166	1.029	....	.195	....	....	....	2.0252
5..........	1	498.5	1.029	21.4	.208	.0352	193.7	1,073	6.4805
6..........	1	655.5	1.029	21.4	.211	.0368	190.4	1,073	8.6526
7..........	2	1,046	1.029	21.4	.227	.0320	205.4	1,133	14.8532
8..........	1	650	1.030	29.0	.240	.0400	215.7	1,119	9.7500
9..........	1	413	1.030	29.0	.245	.0496	224.6	1,159	6.3189
10..........	1	290.7	1.030	28.5	.246	.0304	229.2	1,203	4.4775
11..........	1	237.5	1.030	29.0	.245	.0416	240.3	1,220	3.6338
12..........	1	169.5	1.030	28.5	.254	.0400	232.4	1,214	2.6951
13..........	2	313	1.030	28.1	.251	.0464	233.4	1,240	4.9141
14..........	1	160	1.030	28.3	.250	.0368	243.0	1,246	2.4960
15..........	2	250	1.0295	28.3	.258	.0464	248.5	1,317	4.0250
16..........	3	429	1.029	27.2	.251	.0464	249.8	1,285	6.7353
17..........	5	424	1.030	28.0	.258	.0336	255.1	1,263	6.8264
18..........	4	262.5	1.030	29.7	.266	.0384	295.6	1,392	4.3575
19..........	5	340	1.030	30.5	.262	.0352	301.7	1,401	5.6580
20..........	3	172.3	1.030	31.8	.251	.0432	309.6	1,462	2.7033
21..........	6	257	1.032	34.1	.277	.0384	316.8	1,498	4.4461
22..........	2	147	1.032	34.6	.262	.0384	317.9	1,503	2.4108
23..........	6	254	1.035	36.3	.291	.0336	334.7	1,539	4.6228
24..........	4	171.5	1.034	36.8	.290	.0384	332.4	1,517	3.1042
25..........	7	205	1.035	36.8	.280	.0144	329.4	1,558	3.5875
26..........	4	107	1.035	37.0	.285	.0128	356.3	1,663	1.9046
27..........	4	107	1.036	37.5	.288	.01536	374.4	1,717	1.9260
28..........	3	106	1.036	37.8	.290	.0144	371.2	1,757	1.9186
29..........	8	177	1.040	38.6	.298	.0160	387.7	1,771	3.2922
30..........	8	115	1.040	39.5	.302	.0144	394.5	1,762	2.1735
31..........	12	124	1.040	39.3	.306	.0144	438.3	1,959	2.3684
32..........	9	89	1.040	38.6	.304	.0112	416.0	1,941	3.5910
33..........	8	68	1.042	38.5	.315	.0118	429.5	1,986	1.3396
34..........	9	65	1.046	39.3	.320	.01328	441.6	2,139	1.3000
35..........	13	89	1.041	35.3	.299	.01200	415.4	1,979	1.6643
36..........	10	58	1.045	36.2	.315	.01280	416.4	1,972	1.1426
37..........	20	90	1.045	34.1	.322	.0182	429.6	1,962	1.8090
38..........	22	880	1.045	32.0	.323	.0211	448.7	1,962	1.6160
39..........	14	49	1.042	28.2	.299	.0216	416.8	1,967	.9163
40..........	15	51	1.039	26.7	.274	.0151	397.1	1,657	.8721
41..........	21	64.5	1.040	24.2	.275	.0189	395.9	1,759	1.1094
42..........	30	122	1.037	28.3	.267	.0195	419.8	1,505	2.0374
43..........	34	157.5	1.030	26.6	.219	.0158	369.3	1,318	2.1578
Average..........		....	1.0345	31.17	.263	.0283	317.9	1,472.9	....

[1] The figures in this column represent the number of cubic centimeters of normal alkali required to neutralize the acids in 100 grams of the juice.

Total weight of juice, 9,494.5 pounds. Total weight of nitrogen calculated as protein, 150.75 pounds.

DISCUSSION OF RESULTS.

The investigation was conducted under all the difficulties inherent in practical farm conditions. The silo was not in any sense an experimental silo. The burial and removal of the bags took place during the regular course of filling the silo and feeding out the silage. In the season of 1914–15 the filling extended over a period of 17 days and the feeding out took nearly 3 months from the first bag to the last. In the season of 1915–16 the filling took only 8 days but the feeding out extended over a period of nearly 7 months. In the former season the corn was considered somewhat overmature and for a few minutes during each day's run water was added through the distributer. In the latter season the corn was considered less mature than is desirable for the best quality of silage.

TEMPERATURE AND COLOR CHANGES.

The changes that occur in corn during fermentation in the silo have been the subject of much study by numerous investigators, both in this country and in Europe. First, there is a more or less rapid rise in temperature of the silage mass, the degree of which depends somewhat upon the temperature of the outside air and more perhaps upon the state of maturity of the corn and the degree of fineness to which it is cut. This is followed by a gradual decline in temperature of the silage and a change of color from the green of the fresh-cut corn to a greenish-brown. These changes in physical appearance are accompanied by a copious evolution of carbon dioxid and the formation of volatile and nonvolatile acids, which have been shown to consist largely of acetic and lactic acids. The sugars both of the reducing and nonreducing type which are present in green corn disappear almost completely during the fermentation process. A large part of the albuminoid nitrogen disappears, and there is a great increase in the amount of nonprotein nitrogen, some of which appears as amino acids.

The causes which produce these profound changes have been the subject of considerable dispute, some writers taking the ground that bacterial action is entirely responsible, others that bacteria have little if anything to do with them, and still others contend that the changes are due in part to bacterial and in part to enzymatic action.

DOWNWASH OF SOLUBLE MATERIAL.

The results of the chemical analyses as given in the tables show many evidences of a downwash of soluble material, the upper part of the silo losing and the lower part gaining. In 1914–15 about 2,600 pounds of juice were collected, and in 1915–16 about 10,000 pounds. Doubtless had this juice not been allowed to escape, the analytical results for the bags in the lower part of the silo would have shown a greater loading up with soluble constituents, or at least smaller losses. Especially is it believed that this would have been true in 1915–16 when the loss in juice rose to almost 5 tons. A difficulty in controlling conditions is the impossibility of removing the bags simultaneously so that they would all have been in the silo the same length of time. This factor might be quite important in the 1915–16 work, when from 1 to nearly 3 months elapsed between the recovery of several of the bags.

The tables showing losses and gains of green matter and of moisture during ensiling show by comparison the marked effect of adding water when filling the silo. Indeed, the tendency of certain soluble constituents to wash downward in the silo, which was probably obscured the second season by the excessive outflow of juice, may have been enhanced the first season by the addition of water to the corn at ensiling.

In the season of 1914–15 the change in amount of green matter varies from a loss of 4.29 per cent in the weight of bag No. 6 to a gain of 27.33 per cent in the weight of bag No. 4. The average gain for all bags is 12.35 per cent. The gain for the bags in the upper half averages 8.31 per cent and for the lower half, 16.87 per cent. That the apparent gain in green matter is only a gain in water which more than offsets any loss in dry matter is shown by a comparison, bag by bag, of the figures for gain in green matter and moisture.

In the season of 1915–16, when the corn was somewhat immature and no water was added while filling the silo, there is a loss in green matter in 5 of the 6 bags. The average loss is 3.09 per cent per bag, and the slightly greater loss in the lower than in the upper half probably is due to the large loss of juice that took place. The change in the amount of moisture present, less than 1 per cent, is comparatively unimportant, though it should be noted that the 2 lower bags register gains.

LOSS OF DRY MATTER.

The greatest loss in dry matter in any bag in 1914–15 is but 18.64 per cent, while the average loss for all the bags is 8.66 per cent. The apparent downwash of the soluble dry matter is illustrated very well that season by a comparison of the losses. The bags in the upper and lower halves show, respectively, 12.74 per cent and 4.70 per cent losses in dry matter.

In the season of 1915–16 the figures do not, on their face, bear out this transfusion, there being an increase in loss from 9.72 per cent in the upper half to 13.71 per cent in the lower half. This apparent reversal of the results of the previous season may be and probably is due to the very much larger outflow of juice. The loss in any individual bag does not run as high as in the previous season, but the average percentage loss of dry matter as ensiled is nearly 3 per cent more, being 11.29 per cent.

TOTAL NITROGEN.

The figures for total nitrogen in 1914–15 show a gain in 5 out of 8 bags, while in 1915–16 they show a loss in every bag. The figures for the first season show very plainly that there must have been a downwash of nitrogenous material, for while there is a loss of 2.46 per cent in the bags from the top half of the silo, there is a gain of 15.19 per cent over the total nitrogen ensiled in the bags representing the lower half. The fact that this gain in the lower bags raises the average total nitrogen in all the bags may be accounted for by irregularities in the downwash by which more nitrogenous material was washed into the lower bags than was washed out of the upper ones.

In 1915–16 the average figures for total nitrogen show a loss of 7.31 per cent, with almost exactly the same losses for the upper and lower bags. If it were not for the unaccountably high loss of nitrogen in bag No. 3, the losses for the bags in the lower half would be less than those in the upper half. However, even considering the figure for bag No. 3 as normal, the large loss of nitrogen in the juice would supply a reason why the average figures for total nitrogen show no differences between the bottom and top halves of the silo. The average losses in total nitrogen in all bags for both seasons are very moderate when compared with the results of other investigators.

The smallest loss in albuminoid nitrogen for either season is 34.15 per cent, the largest 64.01 per cent, which also occurs in the same season. The average total loss for 1914–15 is 50.76 per cent and for 1915–16 57.27 per cent. The slightly greater loss in albuminoid nitrogen in the latter season may or may not be due to the less mature condition of the corn when ensiled.

The nonalbuminoid nitrogen is, of course, very small in amount in the corn when ensiled, but increases several times its own weight during ensiling in both seasons. The increase is 270.36 per cent the first season and 231.79 per cent the second season.

ASH.

The figures for loss or gain in ash for both seasons show very plainly the transfusion from the upper half to the lower half of the silo. In 1914–15, 2 of the 4 upper bags gained slightly and the other 2 lost strongly, while all 4 bottom bags gained strongly and consistently. The average for the top bags shows a loss of 8.96 per cent and for the bottom bags a gain of 17.61 per cent. The total average gain of 2.07 per cent may be explained in the same way as the gain in total nitrogen. The figures for 1915–16, while showing losses throughout, show plainly that less ash is lost from the bottom bags than from the top bags. The loss for the top bags was 10.43 per cent and for the bottom bags only 2.16 per cent, which latter would probably have been a gain had no juice escaped.

SUGARS.

The sugars, as has been shown by previous investigators, are the source of much of the actual weight loss of dry matter during ensiling. In both years the nonreducing sugars entirely disappeared and only about 6 per cent of the reducing sugars was left. The loss is slightly greater in the lower bags than in the upper. This is probably due to the fact that fermentation has had a longer time to act on the sugars that remain after the first period of rapid action has taken place.

FURFUROL.

The furfurol-yielding bodies show a loss in both seasons, in 1914–15, 17.07 per cent; in 1915–16, 13.68 per cent. Like the albuminoids they show a smaller loss in the lower than in the upper bags.

ETHER EXTRACT AND CRUDE FIBER.

The ether extract and crude fiber were determined only for the season 1914–15. The former shows an average gain for all bags of 32.59 per cent, this gain being slightly greater in the upper four bags than in the lower four. This consistent increase, which is quite in harmony with the results of previous investigators, is, no doubt, due to the formation of new ether-soluble bodies during the fermentation process.

The crude fiber shows an average loss of 6.34 per cent of its weight at ensiling. Like the albuminoids and furfurol it shows a smaller loss in the lower than in the upper bags. The lower bags lost an average of 2.26 per cent, while the upper bags lost an average of 10.29 per cent.

COLLECTION AND ANALYSIS OF JUICE.

The total amount of juice collected during the season of 1914–15 was only about one-quarter as much as that collected in the following season. This is doubtless attributable to the condition of the corn at ensiling, which in the former season had become so mature that water had to be added, and in the latter season was rather too immature.

An inspection of the table giving the analyses of the juice for 1915–16 shows that the amount of the solids, as indicated by the specific gravity, the acidity, and the nonalbuminoid nitrogen, seems to follow the same general curve. There appears to be a gradual rise during the first part of the period of juice collection, followed by a gradual fall. The only exception seems to be the albuminoid nitrogen, which, while showing a slight tendency to follow the specific gravity curve, in amount shows a gradual but continuous decrease from the first sample taken to the last. In percentage it decreases from over one-fourth of the total nitrogen to less than one-nineteenth.

AMMONIA NITROGEN AND AMINO NITROGEN.

In the season of 1914–15 the bags contained an average of 257 parts per million of ammonia nitrogen and 1,540 parts per million of amino nitrogen. In the season of 1915–16 the bags contained an average of 228 parts per million of ammonia nitrogen and 1,313 parts per million of amino nitrogen. By calculation it is found that in both seasons the ratio of ammonia nitrogen to amino nitrogen is slightly greater in the bags in the lower half than in those in the upper half of the silo. This is only what would be expected when it is considered that the ammonia nitrogen is a decomposition product of the amino bodies and the longer stay in the silo gives more time for such decomposition to take place.

The amounts of amino and of ammonia nitrogen, expressed in parts per million, do not follow parallel curves, although there is a general rise and fall throughout the whole period of juice collection. The proportionate increase in the amount of amino nitrogen is greater, as is also the later decrease. The ammonia nitrogen in the first sample is nearly one-fourth as much as the amino nitrogen, but as the amount of amino nitrogen increases much more rapidly than the ammonia nitrogen it drops in the fifth sample to less than one-fifth. The proportion remains at one-fifth, or below, up to the sixteenth sample and then slightly rises to the thirty-sixth sample. Here the amount of ammonia nitrogen decreases slowly and the amount of amino nitrogen decreases rapidly; consequently, the proportion of ammonia nitrogen to amino nitrogen in the last two samples is raised to over one-fourth.

The specific gravity ranges from 1.027 to 1.046 and the acidity from an amount requiring 21.4 cubic centimeters to an amount requiring 39.5 cubic centimeters normal alkali for 100 grams of juice. The total nitrogen varies from 0.139 per cent to 0.323 per cent, and the albuminoid nitrogen from 0.0112 per cent to 0.0496 per cent.

The ammonia nitrogen ranges from 171.7 to 448.7 parts per million and the amino nitrogen from 710 to 2.139 parts per million.

It will be seen from the tables that the greater part of the nitrogen present in the juice escaping from the silo is in the form of soluble nonalbuminoid nitrogen compounds. Although the actual food value of such compounds is still somewhat a matter of controversy, yet it may be a matter of interest, from a practical standpoint, to observe the possible loss of food material caused by the escape of juice these two years. If the total nitrogen of the 2,579 pounds of juice collected in 1914–15 is expressed as pure protein, we have a loss of 28.89 pounds, which represents the protein in about 1,500 pounds of average silage. Expressing in the same way the results for the season of 1915–16, we have a loss of 150.75 pounds in the 9,494.5 pounds of juice collected, representing the protein in about 7,500 pounds of average silage.

On a technical basis the results of the two seasons' study of silage juice may furnish some explanation for the large variations in the losses of soluble silage constituents which are occasionally reported by investigators. It shows how a large amount of juice, carrying with it much soluble food material, may sink to the bottom of the silo or easily be lost through cracks or through an earthen floor.

CONCLUSIONS.

The two years' work furnishes evidence of a downwash of the juice in the silo, carrying with it soluble-food materials, so that the silage in the lower part of the silo may gain in food material at the expense of the upper part.

There was an average loss for all the bags of nearly 10 per cent of the dry matter, which apparently is due largely to the fermentation of the carbohydrates and to the carrying away of soluble material by the juice. The reducing and nonreducing sugars almost entirely disappeared. There was a considerable loss in crude fiber and in the furfurol-yielding bodies.

There was a loss in total nitrogen. It is probable, however, that this loss is due largely, if not entirely, to the nitrogenous compounds which escaped in the juice. The albuminoid nitrogen suffered a loss of over 50 per cent, while the nonalbuminoid forms increased several times their own weight.

There was a gain in ether extract, which is probably due to the formation of new ether-soluble bodies.

The juice which was collected the second season amounted to nearly 10,000 pounds. This juice averaged 0.263 per cent total nitrogen, 0.0283 per cent albuminoid nitrogen, and 317.9 parts ammonia nitrogen and 1,472.9 parts amino nitrogen per million.

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