TEMPERATURE AND OTHER FACTORS AFFECTING THE QUALITY OF SILAGE.

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INTRODUCTION.

IN 1883 Mr George Fry, F.L.S.[1] described a series of observations which he had made upon silage. From these he drew the conclusion that if the conditions of silage making were such that the temperature exceeded 45° C. sweet brown silage resulted, but that if the temperature failed to rise above 40° C. then sour silage with a rather repulsive odour was produced. These results were obtained in the type of silos then commonly in use, which varied in depth generally between 12 and 18 feet, frequently had a considerable surface area and were filled comparatively slowly.

In 1884 Dr Augustus Voelcker, F.R.S.[2] confirmed Mr Fry's experience with silage in the regulation and maintenance of a proper temperature and mentions 125° F. (51·3° C.) as being the point below which sweet or hay fermentation does not take place. He further stated that sweet silage keeps only a short time on exposure to air, whereas sour silage may keep 6–9 months exposed to air.

In 1886, Dr J. A. Voelcker[3] described the making of sweet silage by ensuring the temperature of fermentation rising to 122° F. = 50° C., "the point which Mr George Fry considers must be reached to get sweet silage."

M. Goffart[4], however, is quoted as follows: "My maize, my green rye, my fodders of every kind have scarcely changed colour after eight or ten months of ensilage." From this it is obvious that the silage of M. Goffart, which had "scarcely changed colour" was very different material from the "sweet brown silage" advocated by Fry.

Babcock and Russell[5] state that "the popular opinion that good silage can only be made with considerable heat is erroneous." Good silage

[1] *Agricultural Gazette*, Aug. 27th, 1883, Nov. 26th, 1883 and April 14th, 1884.
[2] Voelcker. *Journal of the Royal Agricultural Society*, 1884.
[3] Voelcker. *Ibid.* 1886. [4] Silos for British Crops by the sub-editor of the *Field*.
[5] Babcock and Russell. *Wisconsin Agricultural Experiment Station*, 17th and 18th Annual Report, 1900.

was made by them in small retainers at temperatures which did not exceed 80° F. = 27° C.; thus, as the authors say, "disproving Fry's theory, that a temperature of at least 120° F. was essential for good silage."

Many American and other experimenters have obtained similar results, of which may be quoted those of Neidig[1]. In this case the maximum temperature recorded at the centre as distinct from the top surface of the silo was 91° F. = 33° C., and good silage resulted.

When in 1917 the authors began to study silage-making in the American type of tower silo, agricultural opinion in England still retained the distinction between "sweet" and "sour" silage which Fry had enunciated and did not realize the possibilities of other types of silage. For this reason, as well as for the fact that silage produced in the experimental silo at Cambridge varied very greatly not only from year to year, but also in different parts of the same silo, it became apparent that, before reliable feeding experiments with silage could be conducted, it was necessary firstly to define the different types of silage which were capable of being produced, and secondly to define the conditions under which each type could be produced.

The observations in this paper are divided into two parts. The first part concerns those made upon silage produced by a large number of silage growers in the Eastern Counties and elsewhere, from which a few characteristic examples have been described. The second part describes a more accurate series of observations made in the experimental silo at Cambridge.

In the earlier years the late Mr G. Williams co-operated but his untimely death in 1920 prevented him from helping to complete the work.

Qualitative observations made on silage produced by farmers under various conditions.

1. On farms belonging to Mr J. Thistleton Smith, Fakenham, Norfolk.

Mr Thistleton Smith farms light to medium land, upon which the silage crops generally stand well. The crop mixture consists of wheat, oats, and tares, which is allowed to become fairly mature before cutting (the oats being past the milk stage and the tares well seeded). If the crop is succulent it is allowed to wilt a few hours before being ensiled.

[1] Neidig. "Chemical Changes in Silage fermentation." *Iowa Agric. Exp. Station, Research Bulletin*, No. 16.

The resulting silage over a period of years and in several silos has been of a yellowish-brown to brown colour with an acid though quite pleasant smell. The silage has been readily eaten by all classes of stock, which have invariably thriven upon it.

This is much the most common type of silage now being produced in the Eastern Counties of England and appears to be universally produced in tower silos from a mature crop which is reasonably dry when ensiled.

2. In two silos belonging to Mr F. W. D. Robinson, Beccles, Suffolk, 1919–1920.

The crops in this case were oats and tares grown upon light land. They were cut in a medium condition of maturity, the oats being in milk and the tare pods full-grown in length but with immature seeds. The crops were ensiled immediately after cutting. The resulting silage possessed a green colour with a smell which was neither "sweet" nor "sour"; it can best be described as "fresh" and "fruity." Stock ate it greedily and throve upon it.

It would seem highly probable that M. Goffart's "crops of every kind which had scarcely changed colour after 8 or 10 months of ensilage" must have been of this character.

3. On Mr Arnold Oliver's farm at Bures in Suffolk.

In two successive years 1919 and 1920 the silos were filled with oat and tare crops cut in a medium condition of maturity, and under conditions very similar to those prevailing in Mr Robinson's silos.

In each case the crop was ensiled immediately after cutting and produced a green silage with the same "fruity" smell observed with Mr Robinson's silage. In 1920 a maximum thermometer was inserted about the middle of the silo and this recorded 30° C.

4. On General Adlercron's farm at Culverthorpe, near Grantham.

In 1920 the silo was filled during September and October from a late-sown oat and tare crop which was badly laid. The crop had grown to a great length and was semi-rotten close to the ground. Much rain fell during the ensiling process. The resulting silage was dark brown almost black in colour and possessed the most objectionably sour pungent smell. So tenaciously did this smell cling to anything touching it that the writer, who had occasion to handle some, was unable to get the taint from his hands for 36 hours. This silage was eaten by cattle but without relish.

It is satisfactory to record that in the season 1921–22 beautiful silage has been produced on this farm by ensiling under conditions similar to those adopted by Mr J. Thistleton Smith.

5. Silage made by Capt. Nicoll of Alresford in 1920.

The crop was slightly overmature when cut, but not badly laid; during the greater part of the filling the crop was allowed to wilt after cutting and frequently got very wet with rain, but during the last two days of filling the crop was ensiled directly after cutting.

The top part coinciding with the dry period of filling of the silo produced very good silage upon which the cattle throve, but the bottom coinciding with the wet period of filling was poor silage and the cattle fell away whilst feeding upon it.

In 1921, the silo was filled throughout with freshly cut material and the product was excellent: green in colour with the characteristic "fruity" smell.

6. Silage made from immature crops on Mr Alfred Amos' farm at Wye, Kent.

Maize was grown for several years in succession from 1899 to 1904 and ensiled in a tower silo, but the variety grown—American Horse Tooth—failed to ripen sufficiently for ideal silage purposes, rarely getting beyond the flowering stage. Under these conditions the silage was invariably "sour" with a pungent clinging smell. The cattle ate it, but not greedily and did not thrive greatly upon it.

In 1921, a crop of winter oats which had grown very rankly and was likely to be badly laid before harvest was cut off between May 8th and 10th when a foot to 15 inches high, and put into a clamp silo after wilting for 24 hours. The crop was of course very immature. The resulting silage was of a greenish olive colour with a most objectionable smell, similar to that described in General Adlercron's silage. The silage was fed to dairy cows in late summer, being scattered on the grass during the severest part of the drought in that year. The cows did not eat it greedily until the smell had partially blown away, but after lying in the sun for an hour the silage was readily eaten. The cows kept in good condition, milked well and no taint was noticeable in the milk.

7. Silage made in a stave silo in Sussex in 1920.

The crop consisted of oats and tares in which a large proportion of charlock was growing. This was allowed to become very mature before cutting, so that the charlock had set seeds, which were almost ripe, and produced stems which were hard and woody. The crop after cutting was allowed to wilt 24 to 48 hours and was consequently very dry when ensiled. This fact combined with the woody character of the charlock stems prevented the chaffed crop being adequately packed by trampling, so that much air was included.

When the silo was opened numerous tiny patches of mould were found throughout the whole depth of the silo and of necessity became mingled with the rest when thrown down for feeding. This silage was very dark brown almost black in colour, possessed a strong smell of ammonia and was musty. Cattle, when fed upon it, only ate it under compulsion unless they were able to pick out pieces uncontaminated with mould.

SILAGE AT CAMBRIDGE, 1917–1921.

The silo has been partially or completely filled each of the five years during the period, and in addition a silage stack was made in 1918. Careful records were kept of the crop as ensiled and of the silage as taken out. In many cases moisture content has been recorded by means of weighed samples enclosed in wire netting sample-bags.

Temperature has been recorded by two methods. In the first a hollow iron gas-pipe was driven into the silage after the silo had been filled. A thermometer was then lowered to different levels in the silage, allowed to remain till it had taken up the temperature of the surrounding silage, quickly pulled out and the temperature read off. Readings were made at different depths at daily or longer intervals. The length of the gas pipe was never more than 8 ft. It is obvious, therefore, that the temperatures of the surface 8 ft. only could be ascertained by this plan. The method is open to the further criticism, that the silage is constantly settling; if, therefore, the tube is driven in 8 ft. from the surface one day and the silage settles, the tip of the tube is no longer 8 ft. from the surface. In the observations recorded the tube was driven in to the full depth after trampling the silage at the time of the first reading and was not driven in further as the silage settled. The temperature readings on subsequent days were therefore taken at depths which corresponded approximately with the same layers of silage as those from which the temperature was taken on the first day.

In the second method maximum thermometers were buried in the silo at more or less regular intervals as the filling of the silo proceeded. These were carefully corked within short lengths of iron gas pipe to prevent breakage, and placed just beneath sample bags put in at the same time. The thermometers were recovered as the silage was used and the maximum temperatures recorded.

In 1917 the silo was filled with a crop of oats and tares cut when fairly mature, the oats being well in milk and the tares with full-grown pods and the seeds beginning to dent the pods. The crop, which was

lodged but not badly laid, was cut on July 16th and 17th in dull weather, a quarter of an inch of rain fell on each of July 17th and 18th and interfered with the commencement of filling on the latter day. Filling had to be stopped on July 19th, when the silage cutter broke down.

The percentage of moisture in the green crop as filled to the silo varied from 70·3 per cent. at the bottom when the crop though wilted contained some added rainwater, to only 64·6 per cent. at the top when the crop was wilted and dry.

The following table gives a record of the daily temperature readings on the centigrade scale for ten days after filling, and subsequently at longer intervals of time.

Table I. 1917 *crop.*

Date	Temperature at 6 ins. ° C.	Temperature at 2 ft. ° C.	Temperature at 5 ft. ° C.
July 20	26	—	—
,, 21	49	33	27
,, 22	60	34	29·5
,, 23	65·5	35·5	32
,, 24	63	40	33
,, 25	65 5	46·6	34·5
,, 26	62·5	47	35
,, 27	64·5	49·5	35
,, 29	63·5	48	36·5
,, 30	—	49·5	36·5
Aug. 2	—	49·5	36·5
,, 5	—	—	37
Oct. 1	—	—	31·5
,, 23	—	—	27
Nov. 3	—	—	26·5
,, 15	—	—	24·5

Except on July 20th, when the reading was made at 9 a.m., the thermometer readings were taken at or near 5 p.m. After July 29th in the case of the 6 ins. depth and August 5th in the case of the 2 ft. depth, readings ceased to be taken because it was impossible to ascertain the corresponding depth, and moreover temperature changes were only those due to cooling.

When the silo was opened on November 12th and subsequent days it was found that the level at which the 6 in. temperatures had been taken consisted of spoilt mouldy material from which much of the moisture had been driven out by the heat. The range of temperature therefore of 60° to 65° corresponded with moulding of the silage.

The silage taken from the 2 ft. depth, where the temperature rose to 49° C., had a uniform dark brown colour with a characteristic "sweet" pleasant smell similar to that of an overheated hay stack, and was evidently comparable to the "sweet" silage described by Fry in earlier days.

The silage taken from the 5 ft. depth, where the maximum temperature did not exceed 37·5° C., was of a much paler brown colour with a strong, somewhat acid, flavour, similar to that described in Mr J. Thistleton Smith's silos.

Two feet from the bottom of the silo where doubtless the temperature of fermentation was lower though records were not obtained, the colour was still brown but the smell was much more pungent and very unpleasant, and similar to that described in General Adlercron's silo. The smell was most tenacious and when handled tainted the hands so that even washing with soap and water failed to remove the unpleasant smell for several hours. This silage in contrast with the previous two types was not relished by stock.

In the light of later experience, it seems probable that the chief factor contributing to this condition was the rainfall upon July 17th and 18th, causing a certain amount of decomposition of the green crop in the field, and resulting in some rainwater being conveyed to the silo with this part of the crop.

In 1918 the silo was filled at the bottom with rye and tares and with oats and tares at the top; both crops were autumn sown. The rye and tares stood well whereas the oat and tare crop was somewhat but not badly laid. Cutting commenced on July 1st when the rye was rather old, the grain being full-grown but soft and the glumes dry; the tare seeds were denting the pods which were well developed; the oats were forward in milk. The crop was cut 24 to 48 hours in advance of filling. This continued from July 2nd to July 5th, when the silo was full. It was left over the week-end to settle and refilled on July 8th with oats and tares cut the same day. During the whole period of filling the weather was beautifully sunny and no rain fell.

The following table gives a record of temperatures taken at or about 5 p.m. each day at first at daily and later at longer intervals.

Table II. 1918 *crop*.

Date	Temperature at 1 ft. ° C.	Temperature at 4 ft. ° C.	Temperature at 8 ft. ° C.
July 9	37	32	45
,, 10	41	34	42·5
,, 11	47	34·5	41
,, 12	47·5	35	40
,, 13	47	35·5	39·75
,, 14	47·5	35·5	39·5
,, 16	49	36·25	38·75
,, 18	46·5	35·75	38
,, 21	45·75	35·5	37·5

The silo was opened on November 10th when it was found that the silage at 1 ft. deep, the level of the first set of temperature readings, was of dark brown colour with a "sweet" pleasant smell in every way similar to that immediately below the top of the silo in the previous year although this part of the silo was filled with freshly cut crop. The maximum temperature recorded at this depth was 49° C. and the silage contained 72 per cent. of moisture when taken out. It is in fact almost invariably the case when a silo is filled with oats and tares or some similar crop that, after the mouldy surface is removed, a shallow layer of "sweet" silage is found; this, however, in most cases rapidly gives place to silage of different character.

At 4 ft. deep, where the temperature did not exceed 36·25° C., the character of the silage was of paler brown colour and had a pleasant smelling though acid flavour.

At 8 ft. deep the temperature records are higher than at 4 ft., and starting at the comparatively high figure of 45° C. on July 9th fall continuously to July 21st. The explanation of this apparent paradox is that the 8 ft. level dipped just below the top layer put into the silo on July 5th. This being easily accessible to air from July 5th to July 8th, during the interval of the filling of the silo, fermented readily and so reached a high temperature before the silo was refilled on the latter day. It is quite probable indeed that 45° C. was not the true maximum, for some cooling may have occurred before the thermometer was inserted on July 9th. The silage at this depth was similar to that at the 1 ft. level in that it was "sweet" with a dark brown colour, but the crop having been cut a couple of days before filling the silage was much drier.

In this same silo five sample bags were put at regular intervals during filling, and below each bag a maximum thermometer was placed. Table III gives in the first column the number of the bag, in the second the condition of the crop when ensiled, in the third the percentage of moisture in the green crop, in the fourth the maximum temperature, in the fifth the percentage of moisture in the silage, and in the last column the type of silage produced.

Table III. 1919 *crop.*

No. of bag	Material	% of moisture green crop	Maximum temp. ° C.	% of moisture silage	Type of silage
5	Oats and tares, no wilting	71·7	47·5	71·6	Sweet dark brown
4	,, ,, wilted 4 hrs.	71·5	37	75·6	Acid light ,,
3	,, ,, ,, 24 ,,	65·2	35	69·1	,, ,,
2	,, ,, ,, 48 ,,	66·6	31	69·6	,, ,,
1	Rye and tares, ,, 24 ,,	65·4	30	69·8	,, ,,

Taking bag 5 first, because this was nearest to the top, and consequently taken out first, it was found to be situated within 1 ft. of the surface and so corresponded with the conditions discussed in relation to the silage 1 ft. deep in Table II. The sample contained a fair amount of moisture, nearly 72 per cent., and reached a maximum temperature of 47°·5 C. The silage produced was characteristically "sweet" with pleasant smell and dark brown colour.

The silage in bag 4, which reached a maximum temperature of 37° C., had an acid though pleasant smell. It was situated not far below the level where the break in filling the silo occurred and doubtless for this reason the temperature is above those in samples Nos. 3, 2 and 1.

The silage in bags 3, 2 and 1 was in each case produced from a crop which had been considerably wilted in dry weather and contained only about 65 per cent. of moisture when ensiled. The maximum temperatures were respectively 35° C., 31° C. and 30° C., and in each case a yellowish brown silage resulted with an acid, typically silage, smell. This was pleasant and by no means tenacious like the smell of the silage from the bottom of the silo in the previous year. These samples seem to be typical of silage produced in tower silos from fairly mature crops which are allowed to wilt under dry weather conditions before being ensiled. The silage is not "sweet" in the sense of the earlier writers and neither is it "sour" enough to be unpleasant. It is readily eaten by stock which thrive well upon it.

In 1918 a silage stack was also made from a crop of spring-sown oats and tares. This was cut on July 20th, allowed to wilt for 24 hours, and built into a circular stack 12 ft. in diameter. The stack heated greatly, the maximum temperature in the bottom half of the stack—ascertained by the use of the same hollow gas pipe with thermometer previously described, but thrust horizontally into the stack—proved to be 58° C., whilst that of the top half rose to as much as 75° C. The whole of the stack was composed of sweet silage, for the most part dark brown, but in some places, where the heat was greatest, almost black in colour.

This silage was readily eaten by cattle, but the losses in fermentation only, as ascertained from two sample bags, amounted to 19 and 21 per cent. of the dry weight respectively. So great a loss indicates that silage made at such high temperatures is uneconomical.

In 1919 the silo was filled with a spring-sown oat and tare mixture. Cutting commenced on August 4th and was completed on August 5th. Filling was carried out on August 5th, 6th, 7th and 8th. The crop was

fairly well developed, the oats just passing out of the milk stage and the tares with full-grown pods and half-grown seeds. The crop stood up fairly well, but a slight shower of rain, amounting only to ·04 in., fell on the crop on the evening of August 4th after the first day's cutting. The rest of the filling period was fine though dull.

In consequence of the rain on August 4th, the fodder in bags 1 to 5, Table IV, was slightly wetted by rain after cutting, but with the exception of bags 1 and 2, was dry again before ensiling.

Table IV. 1919 *crop.*

No. of bag	Material	% of moisture green crop	Maximum temp. ° C.	% of moisture silage	Type of silage
7	Oats and tares, wilted 3 days	57·3	46	60·6	Sweet dark brown
6	,, ,, ,, 2 ,,	67·1	30	71·1	Acid light ,,
5	,, ,, ,, 3 ,,	65·7	30	71·6	,, ,, ,,
4	,, ,, ,, 2 ,,	69·7	34·5	73·6	,, ,, ,,
3	,, ,, ,, 2 ,,	70·1	31	73·8	,, ,, ,,
2	Oats and tares, wilted 1 day, but wet with rain	72·6	30·5	75·7	Sour dark ,,
1	Oats and tares, not wilted, wet with rain	79·8	24	83·4	,, ,, ,,

Table IV is compiled in exactly the same way as Table III.

When the silo was opened it was again found that the topmost bag, No. 7, near the surface, contained "sweet" dark brown silage and this was associated with a maximum temperature of fermentation, taken just below the bag, of 46° C. It is probable that the maximum temperature within the bag would have been a few degrees above this point.

Bag 6, which had been cut in dry weather and allowed to wilt two days before ensiling reached a maximum temperature of 30° C. and contained typical light brown acid silage with a pleasant smell.

Bags 5, 4 and 3 which had been slightly wetted with rain after cutting and then left long enough to dry off the rainwater before ensiling, produced silage very similar to that in bag 6.

Bag 2, which contained a small amount of rainwater when ensiled, contained a slightly unpleasantly sour silage and bag 1, which was next to the floor of the silo and was very wet when ensiled, contained the characteristic unpleasantly sour pungent brown silage. The thermometer indicated that the maximum temperature in this case was only 24° C., due partly to proximity to the floor of the silo and partly to the exclusion of air from the wet material containing as it did 80 per cent. of moisture. It must also be recorded that in the season 1919 the drain in the floor of the silo was intentionally closed so that no drainage was possible. This may have contributed to the souring of the bottom silage.

Table V. 1920 *crop.*

No. of bag	Material	% of moisture green crop	Maximum temp. ° C.	% of moisture silage	Type of silage
7	Oats and tares, no wilting	69·6	35·5	71·5	Acid light brown
6	Oats, tares and beans, wilted 6 hours	68·1	31·5	70	Acid yellow-brown
5	Oats, tares and peas, wilted 6 hours	66	32·5	70·4	Acid yellow-brown
4	Oats and tares, wilted 24 hrs.	70	33	69·7	Acid light brown
3	,, ,, ,, 48 ,,	64·8	36·2	62·8	,, ,,
2	Oats and tares, cut 6 days before filling. Soaked with rain	72·5	31·3	72·9	"Sour" dark brown
1	,, ,, ,,	69·1	30·5	71·8	,, ,,

In 1920 the silo was filled with a crop of autumn sown oats and tares, except for two small quantities of material which contained in addition peas and beans respectively. The crop was well advanced when cut, the oats being just past the milk stage, the tare pods full grown in length, with seeds denting the pods. The pea seeds were full-grown in size though still soft, and the bean seeds were not quite full-grown. Cutting commenced on July 3rd, but much rain fell during the next five days, so that filling was impossible till July 9th. The following Table VI gives the rainfall for the period.

Table VI. *Rainfall* 1920.

July	4	0·14 in.	July	8	0·44 in.	July	12 nil
,,	5	0·56 ,,	,,	9	nil	,,	13 nil
,,	6	0·54 ,,	,,	10	0·04 ,,	,,	14 0·05 in.
,,	7	0·10 ,,	,,	11	0·05 ,,	,,	15 nil

Bag No. 7, which was situated 2 ft. 6 in. below the surface of the silage, was made from the oat and tare crop; this had been ensiled shortly after cutting. The temperature of fermentation was considerable, 35°·5 C., owing to its proximity to the surface and consequent access of air. This silage had a pleasant acid smell and was much relished by the stock.

Bags Nos. 6 and 5, containing beans and peas respectively, mixed with the oats and tares were in each case wilted only six hours, but the crops were dry and fairly mature before cutting, so that their moisture content as filled was low, 68·1 per cent. and 66 per cent. respectively. In each case good silage resulted characterised by a pale yellow-brown colour with a pleasant acid smell; this was greatly relished by the stock, the pea, oat and tare silage being particularly good.

The silage in bag No. 4 was cut on July 12th and allowed to wilt 24 hours; that in bag No. 3 was cut on July 10th, wetted with slight

showers on that day and the morning of July 11th, but the afternoon was dry and sunny so that the crop when ensiled on July 12th was free from rainwater. Each of these produced light brown silage with an acid but not unpleasant smell. None the less it was not so good as that in Nos. 5 and 6.

Bags Nos. 2, and 1 contained material which had been cut on July 3rd, but owing to very wet weather remained in the field till July 9th before ensiling. A certain amount of decomposition occurred in the field, and the crop was ensiled whilst it still contained some rainwater, the total moisture contents being 72·5 per cent. and 69·1 per cent. respectively. The silage from these bags was of the characteristically unpleasant "sour" variety, previously described; it possessed a dark brown colour and a pungent smell which clung to hands or clothes brought into contact with it; the maximum temperatures recorded with these samples amounted only to 30° C. to 31° C. Experimental cattle, when fed upon it, failed to thrive well.

Table VII. 1921 *crop.*

No. of bag	Material	% of moisture green crop	Maximum temp ° C.	% of moisture silage	Type of silage
2	Oats and tares, wilted 6 hrs.	67·4	34·5	70·6	Green and "fruity"
1	,, ,, not wilted	76·5	24·5	69·7	,, ,,

In 1921 the crop was ensiled in perfect weather, warm and dry, except that on the night previous to the first day's cutting ·06 in. of rain fell, so that the material in bag 1 contained a small amount of rainwater. The crop was not very mature, the tares being in full flower and the oats just in milk. Wilting throughout the filling was reduced to a minimum, the crop being cut only a short time before ensiling. Both bags, and in fact the whole of the silage, was of excellent quality. The silage had an olive colour with a tint of green throughout, though in some parts the green was more pronounced than in others. The smell was entirely different from that previously obtained; it had no suggestion of sourness, although it was made from sappy and rather immature material, nor had it any pungent odour, but it possessed a kind of "fruity" smell suggestive of pear drops and combined with this the smell of freshly cut lawn grass. When fed to stock it was ravenously eaten and under experimental conditions has given excellent feeding results[1].

It is to be remarked when such freshly cut material containing large quantities of moisture is ensiled that much juice may be expressed and

[1] The results of this feeding experiment will be published shortly.

lost from wooden silos. The juice may run to waste and after putrefaction produce unpleasant smells in the yard or it may be given to cattle or pigs as a liquid.

CONCLUSIONS.

1. Many different types of silage may be produced from the same crop according to the conditions of ensiling; the characteristics of the resulting silage varying not only in physical and chemical but also in feeding properties.

2. The following types of silage have been differentiated and some of the conditions of their production ascertained.

(*a*) "Sweet" dark brown silage. This type of silage is produced when the temperature of fermentation rises above 45°–50° C.; it has not been produced below 45° C. It is frequently produced in stack silage to which air has ready access, but not generally in tower silos except in a shallow layer 6 in. to 2 ft. thick just below the mouldy surface to which air has ready access. This silage has a dark brown colour varying in intensity according to the temperature of fermentation and a sweet pleasant smell resembling that of heated hay. It is readily eaten by stock, but has generally lost a considerable proportion of its food value through excessive heating.

(*b*) Acid light-brown or yellow-brown silage is produced in tower silos from crops which are moderately mature when cut and allowed to wilt for varying periods according to the initial dryness until the moisture content of the crop approximates 70 per cent. The maximum temperature of fermentation is generally between 30° and 37° C.

This silage has a yellowish brown to brown colour with an acid though pleasant smell probably largely due to acetic acid, the yellowish types being generally the more pleasant.

This type of silage is eaten greedily by stock, which thrive upon it and is to be commended.

(*c*) Green "fruity" silage is produced in tower silos from crops which are cut in the earlier stages of maturity, from the time of full flower till the seeds are half formed. The crop must also be ensiled soon after cutting. The temperature of fermentation is low and may vary from 22° C. to 34° C. This type has a green to olive green colour with a smell that is neither "sweet" nor "sour," but can best be described as "fresh" and "fruity." It is greedily eaten by stock, which thrive greatly upon it, and Woodman[1] has recently shown that its digestible properties are very high.

Green silage suffers from one practical disadvantage; large quantities

[1] Woodman. This *Journal*, **12**, Part II, April 1922.

of juice are liable to drain away from the silage and carry with them soluble food material, which if allowed to accumulate in the yard undergoes fermentation and produces a smelly mass of putrid material. If, however, the juice is collected cattle and pigs readily drink it. This problem is receiving further study.

(*d*) Sour silage is produced under at least two different sets of conditions. It may be produced from an immature and succulent crop, or it may be produced from a crop which has been cut and then saturated by rain before ensiling, especially when the crop has become laid and partially rotten at the base before cutting.

Sour silage has a dark brown or olive brown colour with a pungent and most unpleasant smell possibly due to butyric acid. Cattle will eat this, but not readily and do not generally thrive upon it.

(*e*) Musty silage. One case only of this type had been recorded, in which an over-ripe crop containing much charlock was allowed to wilt and become over-dry before ensiling. A number of tiny mouldy centres were produced in which ammonia was generated.

This silage has a dark brown almost black colour and has a musty ammoniacal smell. Stock refused to eat it or ate it only under compulsion.

3. The classification of silages given above is admittedly superficial, but it may serve to pave the way for the chemist, the plant physiologist or perhaps the bacteriologist to produce similar types of silage under well defined conditions and so make the distinctions more absolute. For the successful practice of ensilage in this country it is fundamental that the conditions by which each type of silage may be produced should be accurately known.

4. In the past persons conducting feeding experiments in this country have rarely attempted to define the type of silage used, and conflicting results have been obtained. When it is further noted that the quality of silage at different parts of a silo may be, and frequently is, fundamentally different, it is of the utmost importance that these facts should be recorded in future feeding experiments.

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