SOME FACTORS AFFECTING SILAGE FERMENTATION

II. *Influence of degree of laceration and of the bacterial flora from the grass*

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SUMMARY

It was shown by laboratory-scale ensiling experiments that crushing is advantageous to the course of fermentation only after a certain degree of laceration has been exceeded. Owing to the interaction of the microflora no correlation could be established in these experiments between the sugar content of the grass and the quality of the silages.

The effect of the number of lactic acid bacteria initially present appeared to be more important in mown grass than in minced grass silages.

It is emphasized that soil contamination and high temperatures should be avoided in crushed grass silages.

The tendency of crushed grass silages to exhibit high acetic acid figures is dicussed.

For some years experiments have been conducted on the effect which crushing has on silage quality. Good quality silages were obtained with the Vicon experimental wringing machine (KAPPELLE and LENIGER). Observations in practice showed, however, that this method might fail under certain unknown conditions.

It was concluded from laboratory experiments previously described that crushing accelerates the initial growth rate of the lactic acid bacteria and that successful fermentation largely depends on the liberation of sugars by laceration and low silage temperatures (WIERINGA, 1959).

The introduction of four new types of harvesters in 1958 raised the question whether these machines differed in crushing power. To answer this question a method was evolved for measuring the degree of laceration (WIERINGA, 1958).

In addition to carrying out a number of laceration tests, an attempt was made to establish a correlation between the degree of laceration and the silage quality.

METHODS

Grass was lacerated by the Albion Hurricane and Taarup harvesters, by the Vicon wringing machine and by a Bauknecht 1 h.p. electrical meat-mincer. The latter, provided with a stationary carving knife, served as a standard crushing machine. When fitted with a rotating knife and a cutting plate (No. 13) the same machine was used for mincing grass.

Press juice from untreated, lacerated and minced grass was obtained by means of a hydraulic press (operating at an oil pressure of 400 atms). The degree of laceration (L) was calculated from the equation:

$$L = \frac{P_l - P_o}{P_m - P_o} \times 100\,\%$$

in which P_o = press juice in ml/kg mown grass
P_l = „ „ „ ml/kg lacerated grass
P_m = „ „ „ ml/kg minced grass.

Silages were made in one- or two-litre preserving jars and incubated for 2 months at 25° C. Silages were only stored at 30° C in trial No. 9. Fermentable soluble sugars were determined by means of a biological method with Streptobacterium plantarum as the test organism, the production of acid being an index of the amount of fermentable sugar. This method will be published in detail elsewhere.

Strains of lactic acid bacteria isolated from grass silages were used to inoculate grass. These strains were identified according to Bergey's Manual.

Results

The experiments on the crushing power of the harvesters showed that the degree of laceration largely depends on the driving speed of the mobile machines and the number of rotations of the power take-off (Wieringa, 1958). Running on a low gear always gave better crushing than running on second or third gear. The degree of laceration is probably also influenced by the air velocity in the harvester. Investigations on this subject are being continued.

It was concluded that the wringing machine gave substantially better laceration than the harvesters and that the laboratory machine occupied an intermediate position. But the differences were small, and as mentioned above, the effect of the tractor on the crushing power is very important. Hence at this stage of the research it would be premature to associate laceration figures

Table 1 Chemical composition of the grass before ensiling.

Exp. no.	% of fresh	% of dry matter			
	dry matter	crude protein	crude fibre	ash	fermentable soluble sugars
1	23.1	22.6	24.4	10.5	8.3
3	16.1	24.3	—	—	8.1
4	19.2	16.0	—	—	13.0
5	15.0	16.7	26.3	11.3	10.1
6	27.0	15.6	23.0	8.4	18.2
7	14.6	18.0	30.0	9.3	6.6
8	11.4	16.8	29.8	10.0	7.3
9	16.4	17.4	26.2	9.1	8.8

with any of the types of machine which were tested. Simultaneously with the laceration tests carried out from May to July, nine ensiling experiments were conducted with untreated, crushed and minced grass. Silages were made in duplicate.

The chemical data of the grass are given in Table 1. In Fig. 1 the butyric acid figures of the silages are plotted against the degree of laceration. In experiment No. 7 butyric acid-free silages were obtained from the untreated grass. In experiments 1 and 4 crushing did not result in a better silage quality; in experiment No. 1 total mincing was needed to prevent the production of butyric acid.

In the other experiments (Nos. 2, 3, 5, 6, 8, 9) a connection could be established between the degree of laceration and butyric acid production. In experiment 3 chopping (L = 10%) gave a poor quality silage, whereas crushing (L = 40%) led to a butyric acid-free silage. Experiment 5 also gives a clear

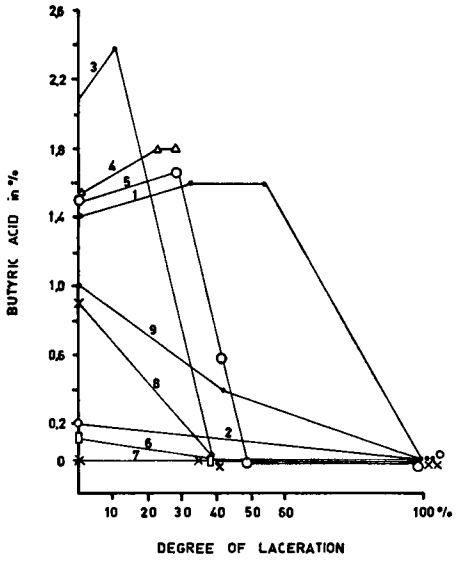

FIG. 1 EFFECT OF LACERATION ON THE PRODUCTION OF BUTYRIC ACID IN GRASS SILAGES.

picture of the effect of the degree of laceration on silage quality, a laceration L = 0%, 26%, 42% and 50% resulting in 1.4%, 1.7%, 0.6% and 0.0% butyric acid.

The conclusion seems warranted that the effect of crushing does not start until after a certain level has been exceeded. Fig. 1 shows that each grass specimen has its own level. Laceration at a degree above this level will result in a suppression of butyric acid fermentation.

It is worth noting that there is increased butyric acid production when the degree of crushing is insufficient. This phenomenon will not be encountered in farm-scale experiments in which the temperature in the untreated silage is close to the optimum temperature of the butyric acid bacteria, and the temperature of the crushed grass will remain lower.

As the preceding paper showed sugars are liberated immediately from the bruised grass cells, resulting in an accelerated production of lactic acid. Is was therefore expected that there would be a correlation between the sugar content of the grass and the effect of crushing on silage quality. Remarkably enough no such correlation could be established (compare Fig. 1 with Table 1).

Evidently some other factor also influenced the growth rate of the lactic acid bacteria in these experiments. An explanation of these contradictory results may be found in the following results of two investigations into the influence of initial bacterial flora on the course of the fermentation.

Experiments Nos. 1 and 2 (Fig. 1) are duplicates, the only difference being that in experiment No. 2 the grass was inoculated with a strain of Strb. casei (about 10^6 viable cells/g grass). In the other experiment (No. 9) three different strains of lactic acid bacteria were used in the same concentration. The results are listed in Table 2. The figures for pH butyric acid, lactic acid and ammonia fraction show that crushing or mincing has a distinct effect on the fermentation of the non-inoculated grass (cf. experiment 9, Fig. 1).

Inoculation of mown or crushed grass with streptobacteria resulted in a

Table 2 Influence of crushing and bacterial flora on silage fermentation.

Treatment		Number of silages	pH	In % of fresh			NH_3-N in % of total N
degree of laceration	inoculation			butyric acid	acetic acid	lactic acid	
0	0	2	4.6	0.9	0.3	0.9	23.0
40	0	2	4.2	0.4	0.4	1.3	10.0
100	0	1	4.2	0.0	0.7	1.5	7.5
0	Bb. breve	2	5.0	0.9	0.3	0.5	18.0
40	,, ,,	2	4.5	0.4	0.4	1.0	12.0
100	,, ,,	1	4.2	0.0	0.6	1.0	7.5
0	Strb.plant.	2	4.1	0.2	0.2	1.4	9.0
40	,, ,,	2	4.0	0.1	0.3	1.6	6.0
100	,, ,,	1	3.9	0.0	0.2	1.1	5.0
0	Strb.casei	2	4.1	0.4	0.2	1.5	10.5
40	,, ,,	2	3.9	0.1	0.2	1.8	8.0
100	,, ,,	1	3.7	0.0	0.2	1.6	5.5

better preservation as compared to the non-inoculated silages. The effect of the addition of Bb.breve was negligible.

According to experiments previously described (WIERINGA, 1958) it may be assumed that the butyric acid in the mown grass silages with streptobacteria was produced during the first few days after ensiling. This indicated that sugars are only occluded in the mown grass during the first two or three days, and that after this time the lactic acid production is so accelerated by inoculation that there is no further clostridia development.

These two experiments show that the course of fermentation greatly depends on the number of lactic acid bacteria initially present. This is in good agreement with STIRLING (1951, 1953) and NILSSON and NILSSON (1956) who stated that lactobacilli only occur in very small numbers on fresh grass. In experiments Nos. 1 and 9 the number of lactic acid bacteria initially present was not determined, but in view of the effect of inoculation this number may be assumed to be low. Despite this, the abundance of free available sugars in the same grass immediately after mincing evidently accelerated the multiplication of these few bacteria to such an extent that no inoculum was needed.

Hence it must be concluded that the effect on the course of the fermentation of the microflora initially present decreases with increasing laceration. In this connection it should be emphasized that soil contamination has a harmful effect on the microflora in the herbage. One drawback of this method of laceration is that large amounts of soil may be picked up by the harvesters.

Returning to the data given in Table 2, it can be seen that inoculation with Bb.breve did not improve silage quality. It is particularly interesting to compare the acetic acid figures from the silages with Bb.breve or without inoculation. It is well known that hetero-fermentative lactic acid bacteria are capable of producing considerable amounts of acetic acid. The high acetic acid figures from the minced non-inoculated grass show that heterofermentatives played an important part in the fermentation.

High acetic acid figures often occur in silages made from crushed grass.

The question as to whether there is any connection between crushing and the development of the betabacteria will be a subject of further research.

References

KAPPELLE, D. and H. A. LENIGER : *Landb.voorl.* 14 (1957) 93–100.
NILSSON, G. and P. E. NILSSON : *Arch. f. Mikrobiologie* 24 (1956) 412.
STIRLING, A. : *Proc. Soc. Appl. Bact.* 16, 1 (1953) 27.
WIERINGA, G. W. : *Neth. J. Agr. Sci.* 6, 3 (1958) 204.
– –: *Landb.mech.* 9 (9) (1958) 459.
– –: *Neth. J. Agr. Sci.* 7, 2 (1959) (in print.).