We need more silage—2. principles and processes involved

S L. Dilkes
Department of Agriculture
WE NEED MORE SILAGE

2—Principles and Processes Involved

By S. L. DILKES, B.Sc. (Agric.)

ONE of the reasons why silage-making is not as popular as it should be, is that few farmers have a clear understanding of the principles and processes involved in the conversion of green fodder into succulent silage. Without such understanding it is difficult to make good silage economically, so it should be worth while to spend a little time studying the theory of silage-making in order that a product of the highest possible feeding value can be obtained and waste kept to a minimum.

Silage-making is really a process of pickling. This has been a popular method of preserving foods for centuries and—in the case of human foods—it is usually achieved by adding some form of edible acid such as vinegar (a solution of acetic acid) to the food being preserved, to such an extent or concentration that bacterial action is inhibited.

In converting green herbage to silage very similar principles are applied, and indeed this forms the basis of the now well known A.I.V. method of silage making named after Professor A. I. Virtanen, of Sweden, who advocated the addition of mineral acids to the material.

There is, however, a cheaper, and on the whole more satisfactory, method of producing the acidity necessary to preserve green herbage, and that is by the production of an edible acid in the mass itself by the action of certain types of bacteria. These produce small quantities of lactic acid as a by-product of their activities, the process being similar to that which occurs in the souring of milk.

There are, however, other changes which take place that are allied to and largely control the action of these organisms, but to fully understand these we must first consider the fundamentals of plant growth.

PHOTOSYNTHESIS

This is a process whereby plants are able to manufacture food from raw materials drawn from the soil and from the air, using energy from light.

Carbon dioxide from the air is combined with water drawn from soil to produce simple sugary substances such as carbohydrates, and this is followed by further combination with organic material, also absorbed from the soil, to produce more complex substances such as amino acids and proteins.

RESPIRATION

Respiration in plants may be compared with the using up of food materials by animals and human beings, in which the stored food is broken down in digestion, the combustion producing heat which is used to maintain body temperature. Similarly in plants the process, which is the exact reverse of photosynthesis, is one of oxidation whereby the food substances are broken down to produce heat and carbon dioxide.

In the production of heat we have one of the main factors which we can govern to a large extent in the making of silage, by controlling the amount of air (oxygen) present in the ensiled mass.
After herbage has been cut and left exposed to the air, the cells are still alive and breathing. In other words, respiration continues until such time as the cells themselves dry out. This is the case in making hay, where the thin layer dries out rapidly and any heat generated by respiration is quickly dissipated.

If hay is carted and stacked before this stage is reached, however, respiration continues and there will be a rise in temperature, meaning a further loss in easily digestible carbohydrates to give this heat. In addition other undesirable factors may arise, such as mould or spontaneous combustion of the stack. The increasingly popular process of grass-drying endeavours to overcome the initial loss to some extent, but as yet there are many other problems still to be solved.

Crops for silage, on the other hand, are cut while still succulent and containing plenty of sap, and except in the case of very watery crops, or for other reasons yet to be mentioned, they are immediately carted and stacked.

Under these conditions, respiration of the plant cells continues, and if anything speeds up, especially as the temperature rises. This will be dependent on the quantity of air present as controlled by the rate of stacking and treading of the mass.

**BACTERIA**

Constant maceration of the green herbage in cutting, etc., causes some rupture of the cells with a result that the various bacteria present on the leaves commence their activities upon the released sap.

From this sap the bacteria produce lactic, butyric and acetic acids in addition to other organic acids.

Lactic acid is that responsible for the clean souring of milk, being produced from the milk sugar, lactose. Acetic acid is the acid of vinegar, and butyric acid produces the offensive smell of rancid butter.

Of the three, it is to be expected that the lactic acid bacteria are the most desirable of the micro-organisms to be encouraged for good silage, as lactic acid usually constitutes from 0.5% to 2% of the fresh weight of the material. The lactic acid bacteria thrive best in temperatures ranging from about 68 to 113 degrees F. and in a medium having a low concentration of oxygen, or in the absence of air.

Their most important attribute, however, and one that is fortuitous in the ensilage process, is that they are able to withstand a greater concentration of acid than any of the other organisms. In effect, this means that if conditions are such that the lactobacilli can grow rapidly and multiply to bring about the production of lactic acid, the growth of undesirable types of bacteria will be largely inhibited.

The butyric acid bacteria also present on herbage can also multiply in the absence of air at temperatures ranging from 86 to 104 degrees F, which, it can be seen, is also within the range occupied by the lactobacilli. However, if the latter are given a good start with conditions ideal for their rapid multiplication—for example the presence of ample fermentable carbohydrates, etc.—they soon attain a pH of 4.5, at which degree of acidity further growth of the butyric acid bacteria ceases.

Another objectionable feature of the butyric type is the fact that it has the ability to decompose or break down proteins to such substances as ammonia and other compounds of doubtful food value—not to mention the putrefactive odours which accompany the process. This breaking down of proteins differs from the form of predigestion carried out by the enzymes described in the next section and emphasises the importance of restricting the growth of the butyric bacteria in silage making.

**ENZYMES**

Changes other than those brought about by bacteria take place in silage as the result of the activity of plant enzymes present in the sap. Enzymes are chemical substances produced by the plants to assist and stimulate certain complex processes during growth, and they are able to continue to function for some time after the cells which have produced them have ceased to live. These enzymes are able to bring about the breakdown of certain substances contained in the crop in a manner similar to that which occurs in animal digestion.

Proteins in particular are acted upon by certain enzymes and partly converted into more simple substances known as amino acids, the process taking place to a considerable extent in ensilage provided that conditions are suitable.

Enzymes are destroyed at temperatures approaching 80 degrees C. or 176 degrees F. and while the substances produced are neutral and in no way affect the acidity, control of the temperature with a view to allowing them to act may be of some advantage, in that a certain amount of predigestion of proteins takes place in the silo.

The concentration of lactic and acetic acids in good silage would be in the vicinity of 2%, but actually, once a concentration of 1% has been reached and the air is excluded, the material may be effectively preserved for long periods. It is on record that a pit opened after 23 years contained good silage.

The quality of good silage appears to be always directly related to a high concentration of acid. These conditions will continue indefinitely unless either air or water gains access to the silo. In a badly constructed silo, seepage waters may cause much loss by the leaching of soluble materials. If air is permitted to enter the silo it will encourage the growth of moulds, etc., to such an extent that they may attack the lactic acid thereby reducing its concentration and allowing further putrefaction.

(To be concluded.)