THE CHEMICAL CHANGES AND PRODUCTS RESULTING FROM FERMENTATIONS

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INTRODUCTION.

THE majority of the chemical changes which are the result of fermentation occur in two large classes of compounds—the carbohydrates and the albumins. These are the materials used by young plants and animals as food-stuffs; as such, however, they cannot be assimilated, but must first undergo the changes which will be described in the following pages, in order that they may be made assimilable and really serviceable as food-stuffs.

The changes, so far as they are known, generally consist in a splitting up of a complex molecule into simpler ones, but, at present, only in a few cases can the stages in the transformation be followed. The reverse changes, or synthetic processes, no doubt, also take place both in plants and animals, and they consist in the building up of a complex molecule from simpler ones; at the present time, however, we have no knowledge as to how they are produced, but during the last few years experimental

synthetic fermentation processes with the ferments maltase (Hill, Emmerling), lipase (Kastle and Loevenhart, Hanriot), lactase, and emulsin (Fischer and Armstrong), have been carried out in the laboratory, and it is very possible that processes of this kind take place in nature on similar lines.

All these changes are brought about either directly or indirectly by means of living organisms. In the latter case the change is caused by a soluble ferment, or enzyme, which is secreted by the organism, and which can be employed in the laboratory as a reagent; similar changes to those which occur in nature can thus be produced, and the different products which result at the various stages of the process can be obtained. In the former case, so far as is at present known, these changes are produced by the living organism as the result of its metabolism, though, in all probability, an enzyme is secreted, not excreted, which produces these metabolic changes in the interior of their constituting cells. The researches of recent times upon this subject have made this supposition very probable; for example, a soluble ferment, or enzyme, has been extracted by Buchner from yeast, which can cause the alcoholic fermentation of saccharine liquids—a change which until then had been regarded solely as the result of the life of the yeast-cells.

The chemical changes which occur as results of fermentation are generally brought about by hydrolysis; but oxidation, as well as reduction, also takes place. All enzymes, as pointed out by Schönbein, are capable of decomposing hydrogen peroxide with the evolution of oxygen, and of producing a blue colouration with guaiacum tincture,

beer yeasts only being exceptions with regard to the latter test. It has lately been shown that the blue colouration produced in guaiacum tincture is due to the action of a separate enzyme, belonging to the class of oxydases, and Loew has still more recently made experiments showing that the power of decomposing hydrogen peroxide is due to the action of another separate enzyme of general occurrence, termed by him catalase.

The changes which the carbohydrates undergo are by far the most important, on account of the fact that the products obtained from them have been the substances upon which most investigation and research have been expended, and many of them are of commercial importance, *e.g.* the production of alcohol from starch. It will, therefore, be more advantageous to describe firstly the changes which these undergo.

The carbohydrates are generally divided into four classes: (1) the Polysaccharides; (2) the Trisaccharides, or Saccharotrioses; (3) the Disaccharides, or Saccharobioses; (4) the Monosaccharides, or Monoses.

To the monosaccharides, the glucosides, most of which are derivatives of glucose, are very closely allied, and the chemical changes which these undergo as the result of fermentation are best considered before those which take place in the monosaccharides, especially glucose, and which result in the formation of products other than alcohol, *e.g.* the production of lactic acid. Hydrolytic changes also occur in the fats and oils, and in urea, and these are best reviewed before the changes caused by oxidation, the most important of which is the production of acetic acid from alcohol; we shall then come to