I. THE SELECTIVE FERMENTATION OF GLUCOSE AND FRUCTOSE BY BREWER'S YEAST.

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HOPKINS [1928] has published a paper concerning the selective fermentation of a mixture containing equal quantities of glucose and fructose. This paper gives valuable information on the fermentation phenomena of solutions containing those two sugars. In the present note we shall deal only with that part of this interesting paper, which treats of the ratio of the fermentation rates of the two sugars present.

The ratio of the two specific rates was calculated by Hopkins by means of the formula:

$$\frac{k_g}{k_f} = \frac{1/t \ln a_g/(a_g - x_g)}{1/t \ln a_f/(a_f - x_f)} = \frac{\ln a_g - \ln (a_g - x_g)}{\ln a_f - \ln (a_f - x_f)} = K,$$

where a_g is the initial concentration of glucose, a_f the initial concentration of fructose, $(a_g - x_g)$ the concentration of glucose at time t , $(a_f - x_f)$ the concentration of fructose at time t .

The constant K which, as it appears from this formula, is the quotient of k_g and k_f , i.e. of the constants of the fermentation reactions of glucose and fructose, assuming that they are monomolecular reactions, varies from 1.68 to 1.88, its mean value being 1.78. The value of this constant does not appear to vary much beyond the limits of experimental errors.

It is interesting to note that we have found the same value for this constant by an entirely different way, which we described in a paper [1927] which has escaped the attention of Hopkins. Studying the influence of animal charcoal on fermentation by yeast and the application of charcoal in the polarimetric analysis of fermented solutions of sugars we observed the fact that the (negative) rotation of a solution containing equal quantities of glucose and fructose increases up to a maximum, and decreases continually beyond that maximum.

This maximum of laevo-rotation is a very important point, as it throws some light upon the ratio of the disappearance rates of the two sugars from the solution. At the moment of the maximum rotation the ratio of the fermentation rates of the two sugars is given by the ratio of their specific rotations, i.e. by the quotient $93.0/52.5 = 1.78$.

For each 1.78 mol. of glucose, 1 mol. of fructose disappears. In fact, if the glucose fermented at a faster rate than is given by this ratio, the rotation could not decrease after that moment of maximum; if, on the other hand, it fermented at a slower rate, it could not possibly increase before that moment, as the observed rotation is but the sum of the negative and positive rotations of the fructose and the glucose respectively in the solution.

In the paper quoted we stressed the fact that the ratio of the disappearing sugars in the solution was 1 : 1.78, *i.e.* this figure gives the ratio of fermentation rates of sugars at the moment at which the curve reaches its maximum. The fact that this figure coincides to the second decimal with Hopkins's mean value of the constant K must be regarded as accidental.

The constants k_g and k_f of the fermentation reactions are the quotients of the reaction rates and the quantity of substance left in the solution at the time t . The constant K is in consequence

$$K = \frac{k_g}{k_f} = \frac{c_g/q_g}{c_f/q_f} = 1.78,$$

where c_g and c_f are the fermentation rates of glucose and fructose respectively, and q_g and q_f the respective quantities of glucose and fructose left in the solution at the time t .

If $q_g = q_f$, *i.e.* if we have a solution of equal quantities of glucose and fructose, K will be

$$K = \frac{c_g}{c_f} 1.78,$$

i.e. glucose will ferment 1.78 times faster than fructose.

By means of this formula, the ratio of the fermentation rates of glucose and fructose may be calculated for any concentration of the two sugars. The figure 1.78, which we found as quotient of the specific deviations of fructose and glucose, is but the extreme case of Hopkins's general formulation.

For a solution containing glucose and fructose in proportion of 1.78 : 1 the ratio of the rates of fermentation, all other things being equal, will be 3.1 : 1,

as
$$\frac{c_g/1.78}{c_f/1} = 1.78, \text{ where } c_f = 1.$$

Of course, this is true only for the conditions under which Hopkins's equation $K = \frac{k_g}{k_f} = 1.78$ also holds.

REFERENCES.

- Hopkins (1928). *Biochem. J.* **22**, 1145.
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