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The Degradation of Potato Starch by Pancreatic Amylase

JAKOB BLOM and TORKIL SCHMITH

The Laboratory of the Tuborg Breweries, Copenhagen, Denmark

It is generally assumed that the fermentable sugar formed by the action of pancreatic amylase on starch is maltose. Preliminary investigations (1934) did not agree with this assumption. This work (1940) was carried out to get more information about the enzymic degradation products in general and about the fermentable sugars in particular. For this purpose the action of pancreatic amylase on starch paste was interrupted at different degrees of hydrolysis and the degradation products formed were fermented by *Saccharomyces cerevisiae*. Results calculated from gravimetric, reductometric and polarimetric measurements before and after fermentation are collected in the following table. The difference between fermentable and unfermentable carbohydrates is well defined. Fermentation stops abruptly. The weight of unfermentable carbohydrates decreases during hydrolysis to about 25 % TMG, the rest being dextrins which are attacked very slowly. Similar phenomena are observed with α-β-malt amylases. During hydrolysis the reduction power of the unfermentable components (% TMR) increases, remains constant and, finally, decreases. RM follows a similar curve. The weight of fermentable carbohydrates increases to about 75 %, then remaining constant although the hydrolysis, measured in % TMR, continues. Until a degradation to about 60 % TMR, RM of fermentable carbohydrates is constant = 88. This result indicates that *considerable quantities of fermentable oligosaccharides with a lower reduction power than maltose are formed.*

The degradation products of unfermentable carbohydrates may be a) unfermentable, b) mixtures of fermentable and unfermentable or c) fermentable carbohydrates. Hydrolysis of fermentable carbohydrates can only yield d) fermentable sugars. At every stage of degradation all 4 reactions are possible. The present results indicate that all of them occur, however, more or less dominantly. A detailed study of the table leads to the conclusion that in the course of degradation the processes a), b), c) and d) dominate in the

Table 1. Potato starch paste and pancreatic amylase. Starch paste 3 %, pH = 6.9, 20°, [Cl⁻] = 0.005.

Before fermentation	Unfermentable			Fermentable			
% TMR	% TMG	% TMR	RM	% TMG	% TMR	RM	$[\alpha]_D^{20}$
18.1		4.9			13.2		
26.1	79.7	8.3	10	20.3	17.8	88	
32.7	74.1	9.7	13	25.9	23.0	89	
39.1	67.6	10.3	15	32.4	28.8	89	
48.9	56.0	10.3	18	44.0	38.6	88	
53.7	49.9	10.0	20	50.1	43.7	87	
59.8	43.9	10.3	23	56.1	49.5	88	
64.0	38.8	9.1	23	61.2	54.9	90	
67.9	32.1	7.1	22	67.9	60.8	90	
69.7		5.3			64.4		
71.2	29.9	4.6	15	70.1	66.6	95	154°
71.6	28.6	4.8	17	71.4	66.8	94	151°
81.5	24.6	6.7	27	75.4	74.8	99	138°
82.9	24.8	6.5	26	75.2	76.4	102	141°
86.3	25.3	6.3	25	74.7	80.0	107	141°
91.8	24.3	6.4	26	75.7	85.4	113	134°

% TM = Percentage of theoretically obtainable maltose.
R = Reductometrical determination. Bertrands method.
G = Gravimetrical determination.
RM = Reduction power; maltose = 100.

mentioned sequence. Generally, it can be concluded that the large molecules are hydrolyzed at first — % TMR of unfermentable increases. The chains become shorter — % TMR of unfermentable is constant. Finally the chains become so short that both fractions are fermentable — % TMR of unfermentable decreases. When process c) has practically finished, reaction d) starts. The latter manifests itself as an increase in RM and a decrease in $[\alpha]_D^{20}$ of the fermentable carbohydrates. Also the following investigations on starch degradation (% TMR) as a function of time (fig. 1) indicate that a primary process has practically finished at about 65 % TMR, while a secondary process starts, running 2—3000 times more slowly. A comparison of the table and the diagram leads to the conclusion that the primary very rapid process consists of reaction a), b), c), while the secondary, very slow process, must be reaction d).

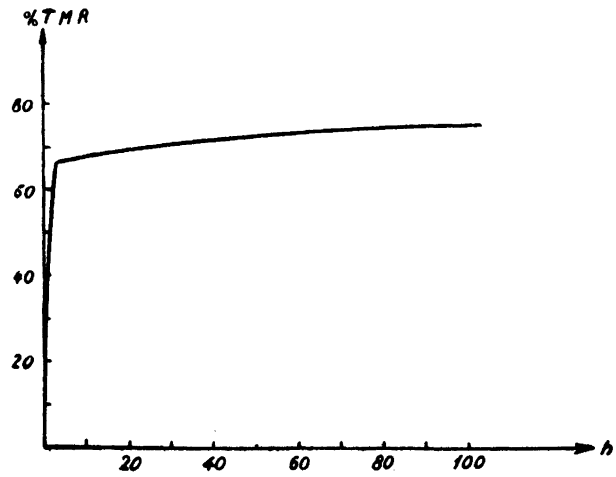

Fig. 1. Degradation of potato starch paste by pancreatic amylase as a function of time. Starch paste 3 %, pH = 7.2, 37°, [Cl⁻] = 0.005.

SUMMARY

Experiments on the degradation of potato starch by pancreatic amylase performed in 1940, however, not published in view of the occupation of our country, offer information on the structure of starch. The main result is that considerable quantities of fermentable oligosaccharides are formed which have a lower reduction power and a higher specific rotation than maltose.

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