In the present study the sensitivity of the ATP- ^{32}P exchange reaction to DDT and to some related compounds has been compared in systems *in vitro*. A close correspondence has been revealed between the extent of inhibition of ATP- ^{32}P exchange produced by various analogues of DDT and their concentration in the respiratory particles proper. This finding recalls the action of narcotic substances. According to Meyer (1937), the latter exert their physiological effect as a result of their preferred solubilities in the lipids of the cell. It is likely that the pronounced sensitivity of the ATP- ^{32}P exchange reaction and that of the oxidative phosphorylation to DDT and its analogues is merely an expression of the fact that the phosphorylating electron-transport particles are rich in lipids. Various analogues of DDT which have similar partition characteristics, like compounds (I), (II), (III), (VIII) and (X), differ widely in their toxicity toward insect larvae. Compound (VIII) and compound (X) are approximately 1000 times less toxic than DDT. Thus the effect *in vivo* reflects not only the variation in lipid solubilities. One has to conclude either that the effect of DDT on the phosphorylative processes has no physiological significance at all or alternatively that, *in vivo*, unknown factors impede selectively the access of some of the analogues to the respiratory particles.

SUMMARY

1. The effect of 1:1:1-trichloro-2:2-di-(*p*-chlorophenyl)ethane (DDT) and its analogues on the adenosine triphosphate- ^{32}P exchange reaction in mosquito sarcosomes has been compared.

2. All analogues of DDT tested inhibited the exchange reaction by nearly the same extent when their concentration in the particles reached the same level.

3. No correlation was found between the toxicity for mosquito larvae of the compounds tested and their effect *in vitro* on the exchange reaction.

We are indebted to Dr Rachel Galun for the cultivation of the test organisms, and to Mr S. Cohen for valuable help in the synthesis of the DDT analogues.

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Synthesis of Glucosylfructoses by the Action of a Yeast α -Glucosidase

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It has been reported (Herzog, 1913; Isaiev, 1926) that hydrolysis of maltose by yeast maltase is slightly inhibited by D-fructose. Similarly Avigad (1958) in a study of a hybrid yeast α -glucosidase has shown that D-fructose partially inhibited liberation of glucose from suitable α -glucoside substrates (sucrose, methyl α -glucoside or maltose).

It was of interest to inquire whether this inhibitory effect might be due to an ability of D-fructose to combine with the glucon-binding site of the enzyme, as suggested by Gottschalk (1950), or to an ability of fructose to compete with water as an acceptor for transferred α -glucosyl residues. Experiments described below show that the latter

is the case. The structure of several oligosaccharides formed by transglucosylation to carbinol positions in fructose in the presence of a yeast α -glucosidase is described.

MATERIALS AND METHODS

Oligosaccharides. All the materials used were chromatographically pure compounds. They had the physical constants and the phenylosazones as listed in Table 1. Isomaltose and isomaltotriose were isolated from a partial acid hydrolysate of *Leuconostoc mesenteroides* B-512 native dextran (Commercial Solvents Corp., Terre Haute, Ind., U.S.A.) as described by Turvey & Whelan (1957). Maltotriose was isolated from a salivary amylase digest of potato starch according to the procedures of Peat, Whelan & Kroll (1956).

Isomaltulose, maltulose, isomaltotriulose and maltotriulose were prepared by alkaline treatment of corresponding aldose sugars (Hough, Jones & Richards, 1953) as follows: 5 ml. of aq. conc. NH_3 soln. was added to 20 ml. of a 5% (w/v) solution of the aldose. After 24 hr. at 37° the solution was evaporated under reduced pressure at < 30°. The resulting syrup was dissolved in 10 ml. of water, 2 g. of BaCO_3 and 0.5 ml. of bromine were added and the mixture was agitated for 6 hr. at room temperature. After removal of bromine by aeration the solution was neutralized by addition of about 2 ml. of 0.2M- $\text{Ba}(\text{OH})_2$. Ethanol (3 vol.) was added and the mixture was left overnight at 4°. The precipitate was removed by filtration and washed with 50 ml. of aq. 70% (v/v) ethanol. The filtrate was passed through an Amberlite MB1 mixed-bed resin and concentrated under reduced pressure. The concentrate was resolved quantitatively by chromatography on sheets of Whatman no. 3 MM filter paper, and bands of paper containing the desired ketose sugar were eluted with water. The yield of the ketose oligosaccharide was 25–29%.

Leucrose (Stodola, Sharpe & Koepsell, 1956) and 1- β -D-glucosylfructose (Pacsu, Wilson & Graf, 1939) were samples kindly donated by Dr F. H. Stodola and Professor E. Pacsu respectively. Uniformly labelled [^{14}C]fructose was obtained from The Radiochemical Centre, Amersham, Bucks.

Other sugars were commercial A.R. preparations.

Yeasts. Haploid-yeast strain 12836 of genotype MA MG su m α z (Hestrin & Lindegren, 1952) was kindly provided by Professor C. C. Lindegren. This strain and the *Torulopsis glabrata* cells were grown with mild aeration. Medium and conditions of growth were as described by Hestrin & Lindegren (1950). The harvested washed haploid cells were dried in a stream of air at 35°.

Enzymes. The α -glucosidase was extracted from the dried yeast cells by incubating them for 3 hr. in 0.05M- NaHCO_3 soln. at 37°. This enzyme solution was found to be free from β -fructofuranosidase activity (Hestrin & Lindegren, 1952; Avigad, 1958).

The yeast invertase used was a concentrate supplied by British Drug Houses Ltd.

Chromatographic methods. Whatman no. 1 filter paper was used. The solvent systems were: I, butanol-ethanol-water (5:2:2, by vol.); II, butanol-pyridine-water (5:3:2, by vol.). The developing time was 72 hr. in descending and 8 hr. in circular chromatography.

The spray reagents used to obtain typically coloured spots

with different sugars were: *p*-anisidine-HCl (Hough, Jones & Wadman, 1950) and aniline-diphenylamine-phosphoric acid (Schwimmer & Bevenue, 1956), as general sprays for revealing reducing sugars and for β -fructofuranoside in non-reducing sugars; urea-phosphoric acid (Wise, Dimler, Davis & Rist, 1955) for the detection of ketoses; alkaline aq. triphenyltetrazolium chloride (Wallenfels, 1950) for the detection of free reducing groups (cf. Feingold, Avigad & Hestrin, 1956).

Paper electrophoresis was conducted on Whatman no. 3 MM filter paper in 0.1M-sodium borate buffer, pH 10.0, at 20 v/cm., 25 ma during about 4 hr.

Quantitative determinations. Total hexose was determined by the anthrone reagent (Yemm & Willis, 1954); reducing sugar was determined cuprimetrically (Nelson, 1944), fructose with resorcinol (Roe, Epstein & Goldstein, 1949) and formaldehyde by the chromotropic acid method (O'Dea & Gibbons, 1953). Aldose was determined by a modification of the iodometric method of Macleod & Robison (1929) for use on a micro-scale.

RESULTS

Inhibitory effect of fructose on hydrolysis of α -glucosides

D-Fructose added to a reaction mixture containing α -glucosidase and a suitable α -glucoside as substrate caused a decrease in the rate at which free glucose was liberated (Table 2). The inhibition effected by fructose was of a non-competitive type (Fig. 1). Chromatographic analysis showed in such reaction mixtures the presence of a reducing ketose-containing product slightly lagging in mobility in relation to sucrose. In a paper chromatogram this product gave a spot which coalesced with that of sucrose and therefore it was difficult to distinguish it in samples containing sucrose as the initial substrate. With [^{14}C]fructose as inhibitor of hydrolysis, analyses of a radioautograph showed the product (tentatively regarded as 'glucosylfructose') to be the sole [^{14}C]oligosaccharide that was formed, except for a trace of radioactive product sometimes found at the level of a trisaccharide. No [^{14}C]-sucrose was found. Quantitative determinations clearly showed (Table 2) that the deficit in the liberation of glucose when fructose is present is nearly fully compensated by an amount of glucose transferred to fructose with formation of 'glucosylfructose'.

A small amount of the 'glucosylfructose' is also formed in systems in which sucrose was the only sugar added. This can be ascribed to liberation of fructose in the course of hydrolysis. Prolonged incubation of the enzymic reaction mixtures brings about the hydrolysis of both the initial substrates and the transfer products formed. Trace amounts of transfer products other than the 'glucosylfructose' were also detected in these reaction systems. The properties of these products and their assigned identities are given in Table 1.

Table 1. Physical constants of formed oligosaccharides and reference compounds

Reference sugars	R_{glucose}		M_{glucose}^*	$[\alpha]_D^{25}$ (water)	Phenylsazone		Comparative literature values
	Solvent I	Solvent II			m.p.	$[\alpha]_D^{25}$ (pyridine-ethanol; 2:3, by vol.)†	
Sucrose	0.78	0.71	0.20	+67°	—	—	—
Maltose	0.64	0.45	0.36	+130	204–206°	+81°	Bates (1942); Peat, Roberts & Whelan (1952)
Isomaltose	0.54	0.41	0.66	+122	174–176	+42	Jeanes, Wilham, Jones, Tsuchiya & Rist (1953); Thompson & Wolfson (1954)
Turanose	0.84	0.74	0.73	+75	202–204	+33	Peat <i>et al.</i> (1952); Pazur & Budovich (1956)
Leucrose	0.68	0.50	0.67	–8	186–188	—	Stodola, Sharpe & Koepsell (1956)
Maltulose	0.71	0.58	0.63	+57	202–204	+78	Peat <i>et al.</i> (1952); Hough, Jones & Richards (1953); Corbett & Kenner (1954); Yasumura (1954); White, Eddy, Petty & Hoban (1958)
Isomaltulose	0.68	0.53	0.59†	+95	173–175	+44	Weidenhagen & Lorenz (1957)
1-β-Glucosylfructose	0.66	0.48	0.68†	–59	—	—	Pacau, Wilson & Graf (1939)
Isomaltotriose	0.26	0.18	0.81	+144	—	—	Jeanes <i>et al.</i> (1953); Wolfson & Thompson (1957)
Maltotriose	0.32	0.23	0.32	+156	—	—	Peat, Whelan & Kroll (1956)
Isomaltotriulose	0.37	0.26	0.31	+120	—	—	—
Maltotriulose	0.42	0.34	0.35	+80	—	—	—
Products of transglucosylation:							
a	0.64	0.48	0.70	+49§	—	—	Suggested identity: 1-α-Glucosylfructose
b	0.68	0.52	0.60	+94	174–176	+40	Isomaltulose
c	0.72	0.58	0.62	+60	201–203	—	Maltulose
d	0.54	0.40	0.67	+120	172–173	+42	Isomaltose
e	0.35	0.25	0.31	+118	—	—	Isomaltotriulose
f	0.26	0.18	0.80	+146	—	—	Isomaltotriose

* Index of migration in paper ionophoresis (Foster, 1953).
† Concentrations were between 0.7 and 1.0%.
‡ Comparative values for 6-β- and 1-β-fructosylfructose were 0.59 and 0.70 respectively (cf. Feingold, Avigad & Hestrin, 1956).
§ Yasumura (1954) described an unidentified glucosylfructose (AII) which may be identical with compound a.

Table 2. *Transfer of glucosyl from α -glucoside to fructose by an α -glucosidase of MA MG su mz yeast grown on different sugars*

Reaction mixture (0.2 ml.) consisted of 0.06M-sodium phosphate buffer, pH 6.8, 0.2M- α -glucoside as substrate and 0.1 ml. of enzyme. In a parallel series, 0.2M-[14 C]-fructose (0.12 μ C/ μ mole) was included. After incubation for 60 min. at 37°, reaction mixtures were inactivated by heating for 2 min. at 96°. Samples were removed, for determination of increase in aldose content by the iodometric method. Samples (10 μ l.) from systems containing [14 C] sugars were applied to sheets of Whatman no. 3MM filter paper for chromatographic separation. Radioautographs (6 days' contact with an X-ray-sensitive film) enabled the location of areas corresponding in mobility to a disaccharide sugar (R_{sucrose} 0.86 in solvent 1) identified as glucosylfructose. These areas were cut from the chromatograms and extracted with 2 ml. of hot water. The eluents were dried and their radioactivity was measured in a Geiger-Müller counter with a thin end-window. Values indicate μ moles of product/ml. of reaction mixture.

		Enzyme from cells grown on methyl- α -glucoside			Enzyme from cells grown on maltose		
		Substrate					
Added fructose	Product	Sucrose	Methyl α -glucoside	Maltose	Sucrose	Methyl α -glucoside	Maltose
Without	Free glucose	40.0	37.1	0	32.0	3.5	56.4
With	Free glucose	33.2	32.5	0	27.0	3.0	44.8
	Glucosylfructose	5.4	6.2	0	5.7	0.8	8.8

Fig. 1. Inhibition by D-fructose of hydrolysis of sucrose by the yeast α -glucosidase. Reaction mixture contained α -glucosidase extracted from cells grown on methyl α -glucoside and variable concentrations of sucrose and fructose in 0.06M-sodium phosphate buffer, pH 6.8. After incubation for 30 min. at 37° the amount of liberated glucose was determined iodometrically. S , Sucrose concentration (M); v , μ moles of glucose/ml. $\circ$, Sucrose alone; $\bullet$, with 0.2M-fructose; $\square$, with 0.4M-fructose.

Synthesis and isolation of the transglucosylation products

100 ml. of 0.05 M-sodium phosphate buffer, pH 6.6, containing 17.1 g. of sucrose and 18.0 g. of fructose, was incubated for 24 hr. at 30° under toluene with

50 ml. of extract prepared from 10 g. of dry hybrid yeast strain 12836 cells previously grown on methyl α -glucoside. After inactivation by heating for 3 min. in a boiling-water bath, the solution was cooled and brought to pH 4.5 by addition of acetic acid. Invertase concentrate (5 ml.) was added and the solution incubated for 24 hr. at room temperature. This treatment caused total hydrolysis of residual sucrose without the accumulation of any transfructosylation products. To remove free hexose, the solution was treated with 15 g. of freshly packed *Torulopsis glabrata* cells for 10 hr. with shaking at 30°. Cells were removed by centrifuging and the solution was concentrated to a syrup, which on chromatographic examination was found to be free of hexoses and sucrose. The concentrate was loaded on a 25 cm. $\times$ 3 cm. Darco G-60-Celite 535 column (Whistler & Durso, 1950) and washed with 4 l. of 1% (v/v) ethanol (fraction I). Ethanol (5%, v/v; 2 l.) yielded fraction II; fraction I was resolved on a 5 cm. $\times$ 40 cm. cellulose column (Whatman cellulose powder, standard grade) with 1.5 l. of butanol-ethanol-water (5:1:1, by vol.) as the irrigant. The column contents was extruded and segments at 4–10 cm. and 10–25 cm. from the top surface of the packed column were extracted with hot 20% (v/v) ethanol. The eluents were concentrated and the oligosaccharides were further purified by quantitative band chromatography on sheets of Whatman no. 3MM filter paper. Yields: 132 mg. of compound *a*; 1370 mg. of *b* (Table 1).

Fraction II contained four oligosaccharides which were separated quantitatively by paper chromatography to yield 49 mg. of *c*, 60 mg. of *d*, 37 mg. of *e* and 12 mg. of *f* (Table 1).

Observation on some properties of the isolated oligosaccharides

Compounds *a*, *b*, *c* and *e* were ketose-containing compounds which on hydrolysis by acid (0.5N-H₂SO₄, 2 hr. at 96°) or by yeast α -glucosidase gave fructose and glucose as sole products of reaction. After reduction of these compounds with sodium borohydride (Abdel-Ahker, Hamilton & Smith, 1951) glucose was found to be the only reducing hexose formed from the reduced compounds on hydrolysis, thus indicating that the fructose moiety is the terminal reducing group in these oligosaccharides. The molar ratio fructose:total hexose was 1:2 for compounds *a*, *b* and *c* and 1:3 for *e*. The molar ratio of reducing aldose:total reducing hexose in the hydrolysates was 1:2 for *a*, *b* and *c* and 2:3 for *e*. Chromatographic examination after partial hydrolysis of *e* (0.1N-H₂SO₄ for 1 hr. at 96°, then neutralization with BaCO₃) showed the presence of spots corresponding in mobility to glucose, fructose, isomaltose and isomaltulose.

Compounds *d* and *f* were aldoses which yielded only glucose on hydrolysis by acid or by the α -glucosidase of the haploid yeast.

Values of optical rotation, chromatographic and electrophoretic mobilities of the reference sugars and of the transfer products studied are reported in Table 1. It should be mentioned that the different colour reactions given by the various sugars when tested with spray reagents were highly characteristic. The more outstanding reactions were as follows: a red was afforded with the urea-phosphoric acid reagent by leucrose but by none of the isolated oligosaccharides. With aniline-diphenylamine reagent the compound *a* gave a cherry colour which was given too by 1- β -glucosylfructose

but by no other α -glucosylfructoses tested. Maltulose stained deep violet with this reagent whereas isomaltulose yielded an olive-yellow. Among all the tested oligosaccharides compound *a* and 1- β -glucosylfructose alone did not reduce the alkaline aq. triphenyltetrazolium chloride reagent (cf. Feingold *et al.* 1956).

Oxidation of the oligosaccharides with periodate

The method was that of Hough, Woods & Perry (1957). To 6–8 μ moles of sugar dissolved in 3.8 ml. of water, 1 ml. of a fresh solution of 1% (w/v) sodium borohydride was added. After 4 hr. 0.2 ml. of 1.5N-H₂SO₄ was added and 1 ml. samples were taken into 1.4 ml. of water for oxidation at pH 3.6, and a separate series of second 1 ml. samples was taken into 1.4 ml. of 0.25M-sodium phosphate buffer, pH 8.0. A solution (1.6 ml.) containing 15 μ moles of *p*-hydroxybenzaldehyde and 100 μ moles of sodium metaperiodate was added to each tube. After 2 hr. in the dark, the formaldehyde contents of samples were estimated colorimetrically. Reducing sugars were also oxidized by the same procedure but without prior reduction by borohydride. The results showing the amount of formaldehyde formed during oxidation are presented in Table 3.

Phenylosazones of the oligosaccharides

The oligosaccharide [100 mg., except for disaccharides *c* and *d* (20 mg.)], 200 mg. of phenylhydrazine-HCl and 300 mg. of sodium acetate in 2 ml. of water were heated for 45 min. at 96°. The crystals appearing after cooling were washed with cold water and twice recrystallized from methanol-water. Yields were 27–30%. Disaccharide *a* did not yield a phenylosazone under these conditions. For properties of the osazones obtained see Table 1.

Table 3. Formaldehyde yields afforded by oxidation of oligosaccharides with metaperiodate at different pH values with or without prior reduction by borohydride

Values indicate moles of formaldehyde liberated per mole of carbohydrate. Numbers in parentheses give the expected theoretical values.

Sugar	Without reduction of sugar (oxidation at pH 8.0)	With prior reduction of sugar	
		Oxidation at pH 3.6	Oxidation at pH 8.0
Maltose	2.10 (2)	1.94 (2)	2.85 (3)
Maltulose	—	1.84 (2)	2.86 (3)
Isomaltose	0.00 (0)	0.97 (1)	1.08 (1)
Isomaltulose	0.88 (1)	0.95 (1)	0.92 (1)
Maltotriose	2.70 (3)	1.98 (2)	3.72 (4)
Isomaltotriose	0.00 (0)	0.94 (1)	1.02 (1)
1- β -Glucosylfructose	0.77 (1)	0.95 (1)	0.97 (1)
Transfer products isolated:			
<i>a</i>	0.71	0.91	1.09
<i>b</i>	0.90	1.04	1.00
<i>c</i>	—	1.86	2.68
<i>d</i>	0.00	0.92	1.06
<i>e</i>	—	0.92	0.96

Oxidation of phenylosazones by periodate. The osazone (26mg.) was dissolved in 5 ml. of aq. 66% (v/v) ethanol and 0.25 ml. of a solution containing 42.8 mg. of sodium metaperiodate was added (one-fifth of these amounts was used for compounds *c* and *d*). The osazones prepared from isomaltose, isomaltulose, melibiose and disaccharides *b* and *d* yielded a precipitate of orange needles of mesoxy-aldehyde-phenylosazone which was washed with ethanol and dried; yields were 77–83%; m.p. 198–200° (Chargaff & Magasanik, 1947; Stodola *et al.* 1956). The osazones prepared from maltose, maltulose, turanose and disaccharide *c* did not yield this product even after incubation with the oxidant for several hours.

DISCUSSION

The observation that the inhibition exerted by fructose on the enzymic hydrolysis of α -glucosides is of a non-competitive type for the α -glucoside substrate (Fig. 1), and the finding that the deficit in the amount of free glucose liberated in the presence of fructose can be accounted for by the appearance of transfer products, lead obviously to the conclusion that the inhibitory effect of fructose on glucose liberation does not involve any decrease in the rate of α -glucoside cleavage but is due to competition of fructose with water for glucosyl units transferred by the enzyme.

It has been shown (Avigad, 1958) that D-glucose and maltose act as competitive inhibitors of the hydrolyses of α -glucosides by the hybrid yeast α -glucosidase and these aldoses are but poor acceptors for the α -glucosyl units transferred by the enzyme. In addition, no exchange reaction could be shown between [^{14}C]glucose and an α -[^{12}C]glucoside serving as substrate, when incubated together with this α -glucosidase. These results, at least in respect of the α -glucosidase studied, do not support the suggestion that fructose inhibits the hydrolysis because it can attach itself to the enzyme in the same manner as does D-glucose or maltose (Gottschalk, 1950).

The hybrid-yeast α -glucosidase used in the present study should be regarded as having variable substrate specificity, the latter being a property subject to alterations which are controlled both by the genotype and the nature of the growth sugar (Avigad, 1958). It was found (Table 2) that fructose was able to serve as an acceptor for the transferred glucosyl group in diverse enzyme systems obtained from cells grown on different inducers and possessing a different substrate specificity. This transglucosylation in the different cases, which resulted in the formation of the same products and in the same quantitative relationship to the amount of substrate cleaved, is consistent with the

concept that the specificity of transfer to fructose is a constant property of the enzyme and that a single α -glucosidase is present though the substrate specificity can vary.

The hydrolysis of sucrose by the hybrid-yeast α -glucosidase reflects a series of reactions affording a rather complicated picture. The liberated glucose serves as a competitive inhibitor of sucrose hydrolysis whereas it serves only as a poor acceptor for glucosyl units and cannot interchange with the α -glucosyl moiety of sucrose. In addition, the liberated fructose serves as an acceptor for α -glucosyl units removed from the sucrose molecule.

The values of optical rotation, chromatographic and electrophoretic mobility, the characteristics of the phenylosazones formed, the periodate oxidation studies and other analytical data obtained prove unambiguously that the identity of the isolated oligosaccharides is as follows: compound *a*, 1- α -glucosylfructose; *b*, 6- α -glucosylfructose (isomaltulose); *c*, 4- α -glucosylfructose (maltulose); *d*, 6- α -glucosylglucose (isomaltose); *e*, 6⁰- α -glucosylisomaltulose (isomaltotriulose); *f*, 6²- α -glucosylisomaltose (isomaltotriose).

Other transfer products, probably at the level of tri- and tetra-saccharides, were also observed in the chromatographic examination of the reaction-mixture concentrates but they could not be studied owing to their presence in barely detectable amounts.

Isomaltulose was the product isolated in largest quantities. 1- α -Glucosylfructose was obtained in quantities of about one-tenth that of isomaltulose, whereas maltulose was found only in minute amounts. Isomaltotriulose was probably formed by transglucosylation to isomaltulose. Isomaltose and isomaltotriose were probably formed when the glucose liberated served as the initial acceptor. The primary alcoholic groups of D-fructose served preferentially as acceptors in this transfer system; C-6 of fructose exhibited the highest acceptor activity, i.e. the sugar was probably in the furanose form.

Preferential transfer of α -glucosyl units to primary alcoholic groups in aldose acceptors is known to occur in many systems of α -glucosidases from moulds (cf. review by Edelman, 1956) or from *Schizosaccharomyces pombe* (Shibasaki & Aso, 1954). In comparison it should be mentioned that Yasumura (1954) described maltulose and turanose as products of transglucosylation to fructose catalyzed by brewer's-yeast extract acting on sucrose. Weidenhagen & Lorenz (1957) have isolated a bacterium which formed isomaltulose ('palatinose') after contact with sucrose, and Stodola, Sharpe & Koepsell (1954) mention isomaltulose as one of the products formed in small quantities by the action of dextranucrase on

sucrose. It might also prove interesting to study the acceptor specificity of fructose in other known systems of α -glucosidases like that of aphids (which can transfer α -glucosyl to C-3 of fructose in the sucrose molecule with the formation of melezitose; Bacon & Dickinson, 1957) and that of honey α -glucosucrase (White & Maher, 1953).

SUMMARY

1. The inhibitory effect of D-fructose on hydrolysis of α -glucosides by α -glucosidase of a hybrid yeast is non-competitive for the α -glucoside. The fructose competes with water for the α -glucosyl units transferred by the enzyme.

2. Products of transglucosylation to fructose were isolated and characterized. Isomaltulose was the main component found whereas 1- α -glucosylfructose was obtained in smaller amounts. Small quantities of maltulose, isomaltose, isomaltotriose and isomaltotriulose were also isolated. Properties of the hitherto unknown 1- α -glucosylfructose are described.

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