SHORT COMMUNICATION

COMPARISON OF ABSORPTION RATES OF GLUCOSE AND MALTOSE IN MAN IN VIVO

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SUMMARY

1. Using a double-lumen tube perfusion technique in vivo, the absorption rates of glucose from a glucose (200 mmol l^{-1}) and from a maltose (100 mmol l^{-1}) solution were measured in the proximal jejunum of six Zambian African adults.

2. In all of the subjects the rate of glucose absorption from the maltose solution was greater than that from the glucose solution. The difference between the mean rates was approximately 15\% and is significant (P<0.01).

Key words: disaccharide absorption, glucose, maltose.

Polysaccharide, mainly in the form of starch, constitutes the bulk of the diet of most Zambian Africans. It is not clear whether maltose, and sucrose, have a greater rate of disappearance from the lumen than their constituent monosaccharides (McMichael, Webb & Dawson, 1967; MacDonald & Turner, 1968; Matthews, Craft & Crampton, 1968; Cook, 1970). In the present investigation a double-lumen tube perfusion system was used to compare the jejunal absorption rates of glucose from glucose and from maltose in a group of Zambian African adults.

SUBJECTS AND METHODS

The subjects were six Zambian Africans who were in-patients at The University Teaching Hospital, Lusaka; they volunteered to undergo investigation after full explanation through an interpreter. None of them had clinical evidence of malnutrition or of gastro-intestinal disease. Two were men; the mean age was 40 (17–60) years and mean body-weight 53 (44–66) kg. They were from the Bemba, Inamwanga, Chokwe, Kaonde, Soli and Lenje tribes of Zambia (Brelsford, 1965). The mean haemoglobin concentration was 12.0 (7.9–13.7) g 100 ml^{-1}.

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Mean serum protein concentrations were: albumin 3.5 (3.1–4.0), total globulin 4.2 (3.3–5.3), and γ-globulin 2.2 (1.7–3.0) g 100 ml–1. Five of them had stool examinations for parasites, which were normal.

A double-lumen tube (Portex MLT/B, external diameter 4.2 mm) was used and the perfusion technique has been described (Cook, 1971a, 1972b). Radiographs were taken immediately before and after the study and in no case had the proximal end of the 30 cm perfusion segment moved by more than 10 cm distally; the mean position at the beginning of the study was 11 (1–22) cm past the ligament of Treitz.

Perfusion was with a 200 mmol l–1 glucose solution, and a 100 mmol l–1 maltose (Hopkin & Williams, England) solution. Both solutions were rendered iso-osmotic with sodium chloride and they contained 0.50 g 100 ml–1 of polyethylene glycol (PEG), mol. wt. 4000. The maltose solution contained <50 mg of glucose 100 ml–1 by the hexokinase method (see below). In three subjects the glucose solution, and in three the maltose solution was infused first. The two perfusions followed immediately after each other.

Aliquots of all samples were immediately deproteinized (Marks, 1959) and they and the remainder were frozen solid until estimation. Glucose was determined before and after incubation for 90 min at 37°C with a maltase (Sigma M-2125) suspension, by a glucose oxidase method (Boehringer, Mannheim G.m.b.H.). Maltose was hydrolysed during the glucose oxidase reaction; glucose in the samples containing maltose was therefore determined by a hexokinase method (Slein, 1965). Glucose oxidase and hexokinase determinations were also done after exposure of the samples to room temperature (~27°C) for 6 h; in no case was there a detectable difference. Total carbohydrate concentrations in the glucose samples were determined by a copper reduction method using glucose standards (Asatoor & King, 1954). PEG concentrations were estimated by the method of Hydén (1955). Specimens of all perfusion solutions were treated as the test samples. All determinations were made in duplicate.

Correlation of glucose oxidase and copper reduction results on samples obtained during the glucose perfusions was significant \( (r = +0.989; n = 17; y = 1.037x - 0.010) \).

Absorption rates were calculated using standard formulae (Cook, 1971a). For glucose absorption from glucose the SD for the three 10 min collections was 0.014 g min–1 (30 cm of jejunum)–1 \( (n = 6) \); coefficient of variation = 6.1% (Cook, 1972a). For glucose absorption from maltose the corresponding values were 0.009 g min–1 (30 cm of jejunum)–1 \( (n = 6) \), and 3.4%. For net water absorption the SD was 0.42 ml min–1 (30 cm of jejunum)–1 \( (n = 12) \).

The rate of glucose production (by hydrolysis) during the maltose infusions was similarly calculated; the concentration of unhydrolysed maltose was obtained by subtracting the hexokinase from the glucose oxidase result.

RESULTS

No symptoms were reported. Fig. 1 summarizes data for glucose absorption rates. In all subjects the absorption rate was higher from the maltose solution; the difference between the means is significant \( (t = 5.65; 5 \text{ degrees of freedom}; P < 0.01, \text{paired } t\text{-test}) \). The subject with the highest absorption rates had the highest serum albumin and lowest total and γ-globulin concentrations. Fig. 1 also shows the mean net water absorption rates; the difference between them is not significant \( (t = 1.20; 5 \text{ degrees of freedom}; P > 0.10, \text{paired } t\text{-test}) \).

In all of the subjects the rate of glucose production from maltose exceeded its absorption.
Glucose and maltose absorption in man

Fig. 1. Glucose absorption rates (a) [g min⁻¹ (30 cm of jejunum)⁻¹] from the glucose (●) and maltose (▲) solutions. The means ± 1 SEM are shown. The difference between the means is significant. The means ± 1 SEM are also shown for net water absorption rates (b) [ml min⁻¹ (30 cm of jejunum)⁻¹] from the glucose (●) and maltose (▲) solutions. The difference between the means is not significant.

rate. The mean rate of glucose production was 0.35 g min⁻¹ (30 cm of jejunum)⁻¹ (SEM = 0.01). The difference between mean production and absorption rates is significant (t = 11.40; 5 degrees of freedom; P < 0.001, paired t-test).

DISCUSSION

This study shows that glucose was absorbed at a significantly greater rate from a 100 mmol l⁻¹ maltose solution than from a 200 mmol l⁻¹ glucose solution.

Gray & Santiago (1966) showed that in ten normal subjects the mean rate of glucose absorption was 10% higher from a maltose (80 mmol l⁻¹) than from a glucose (160 mmol l⁻¹) solution; that difference was not, however, significant. McMichael et al. (1967) similarly demonstrated that glucose absorption rates from glucose and maltose solutions (0.5–10.0 g 100 ml⁻¹) were comparable. Using oral ‘tolerance’, Matthews et al. (1968) showed in nine healthy subjects that after 90 g of glucose per 70 kg body weight, or its equivalent as maltose, blood-sugar curves were very similar. Comparing sucrose with its constituent monosaccharides in man, Gray & Ingelfinger (1966) and Cook (1970) were unable to detect differences between the rates of absorption and blood monosaccharide responses, respectively. On the contrary, MacDonald & Turner (1968) using oral ‘tolerance’ showed in eighteen healthy subjects that the mean area under the blood fructose curve was 30–40% greater after sucrose compared with its monosaccharides; the difference was significant. In the rat, Dahlqvist & Thomson (1963a, b) found no difference between absorption rates of maltose and sucrose and their respective monosaccharides. The reason for these widely differing results is unknown. The sugar concentrations used in the present study were relatively high when the Kₜ for a 30 cm segment of jejunum is taken into account (Cook, 1971b). Zambian Africans live largely on starch and it is possible that this could account for differences from European subjects; genetic or other acquired bases could also be responsible.

After hydrolysis of maltose in the brush-border of the enterocyte, a high glucose concentration must be produced in the vicinity. Glucose absorption is a saturable process in Zambian
Africans (Cook, 1971b). With 200 mmol glucose \(l^{-1}\) the kinetic curve has not yet reached a plateau and after maltose hydrolysis the higher local glucose concentration would be expected to lead to a greater absorption rate; the remainder of the glucose (from hydrolysis) would diffuse back to the lumen. The present results are consistent with that hypothesis.

The study does not exclude the possibility of separate transfer mechanisms for mono- and di-saccharides, as for amino acids and dipeptides (Cook, 1973; Matthews, 1971), nor the possibility that some intact maltose may enter the enterocyte.

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**REFERENCES**


