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Effect of Naturally Occurring Dietary Fibre in Western Foods on Blood Glucose

R. W. Simpson[*], J. McDonald[†], M. Wahlqvist[‡], N. Balazs[**] and M. Dunlop[††]

From the Diabetic Clinic and Departments of Nutrition and Chemical Pathology,
Prince Henry's Hospital, Melbourne, and the Royal Children's Hospital, Melbourne

Abstract: Effect of naturally occurring dietary fibre in Western foods on blood glucose. R. W. Simpson, J. McDonald, M. Wahlqvist, N. Balazs and M. Dunlop, *Aust. N.Z. J. Med.*, 1981, **11**, pp. 484–487.

The aim of this study is to evaluate the short term effect of naturally occurring dietary fibre (mainly cellulose and hemicelluloses) in the Western diet on carbohydrate absorption. Two equicaloric test meals were designed, each containing the same amount and types of absorbable carbohydrate and similar proportions of fat and protein. One meal was composed of salad vegetables and apple and the other of simple sugars and starch added to a gelatine and cream cheese base. Thirteen normals and 12 maturity onset diabetics consumed both test meals and neither group showed any reduction in the post-prandial blood glucose levels or immunoreactive insulin concentrations on the fibre containing meal. Thus naturally occurring dietary fibre in unrefined foods commonly consumed in Australia does not attenuate carbohydrate absorption in short term studies.

Key Words: Natural dietary fibre Blood glucose – Insulin – Diabetes mellitus.

Introduction

A reduction in the amount of dietary fibre (non-absorbable carbohydrate) has been implicated in the etiology of diabetes mellitus.[1] Guar (a gelling, non-absorbable carbohydrate not naturally found in Western foods) given in large amounts (14·5 or 16 g) with absorbable carbohydrate reduces post-prandial blood glucose levels in normal and diabetic subjects.[2,3] Hemicelluloses (e.g. wheat bran) and cellulose, fibres (both non-gelling) more commonly found in Western foods appear to be much less effective than guar when added in similarly large amounts to carbohydrate-containing meals.[4] Recently, the true effectiveness of these non-gelling fibres has been questioned[5,6] and more particularly their effectiveness when present in natural foods generally consumed in Australia has never been clearly demonstrated.

Patients and Methods

Thirteen non-diabetic subjects (6 males, 7 females) and 12 maturity onset diabetics (9 males, 3 females) were studied after giving informed consent. The non-diabetics were aged (mean ± SEM) 30·5 ± 1·3 yrs and 108·2 ± 4·6% ideal body weight (Metropolitan Life Assurance Co.) and the diabetics 62·9 ± 2·9 yrs and 126·0 ± 8·1% ideal body weight.

All subjects were fasted overnight and prior to the study an indwelling cannula was inserted to obtain free flowing blood samples. After collection of two baseline samples 10 min apart, blood was drawn at 15 or 30 min intervals (see results) for glucose and immunoreactive insulin (IRI).

Each subject consumed two meals, one a salad and fruit meal (Table 1) and the other a flummery (Table 2). Each meal was consumed on different mornings over the same time interval. The two meals were equicaloric (435 calories) and designed to contain identical amounts and types of absorbable carbohydrate and similar proportions of protein and fat.[7,8] Blood glucose was estimated in the routine laboratory by a glucose oxidase method. Immunoreactive insulin was assayed in plasma samples stored at −15°C by radioimmunoassay involving ethanol precipitation[9] (sensitivity 3·75 μU/ml, intraassay coefficient of variation at 15 μU/ml 4·7%, and 120 μU/ml 2·7%, MD); samples from both meal studies for each subject were estimated in the same assay. All tests of significance used a 2-tailed Student's paired "t" test and results are expressed as mean ± standard error of mean ($\bar{x}$ ± SEM).

Results

The blood glucose levels after both meals were the same for the first hour in the non-diabetics (Fig. 1a). Between 90 and 180 mins the blood glucose levels following the salad meal were significantly lower at two points, 90 and 150 mins. For the diabetics there was no difference in the blood glucose response to the two meals

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[*] Clinical Assistant, Department of Endocrinology and Consultant Endocrinologist

[†] Dietitian

[‡] Professor of Nutrition and Physician, Diabetic Clinic.

[**] Deputy Director, Department of Chemical Pathology

[††] Research Fellow, Royal Children's Hospital

Correspondence: Dr R. W. Simpson,
Medical Research Centre,
Prince Henry's Hospital
Melbourne, Victoria 3004

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TABLE 1
Carbohydrate, protein and fat content of salad and fruit meal

		Glucose	Fructose	Sucrose	Starch	Lactose	Total Abs. CHO*	Fibre	Protein	Fat
Apple	100 g	1·50	6·00	3·00	0·10	—	10·6	2·0	0·3	0·30
Lettuce	40 g	0·20	0·24	0·04	TR	—	0·5	0·6	0·5	0·10
Tomato	110 g	1·21	1·32	0·11	TR	—	2·6	1·7	1·1	0·30
Celery	30 g	0·15	0·12	0·09	0·03	—	0·4	0·5	0·3	0·03
Cucumber	30 g	0·24	0·27	0·03	0·00	—	0·5	0·1	0·2	0·03
Peas	28 g	0·03	0·02	0·22	0·92	—	1·2	3·4	1·5	0·11
Carrot	60 g	0·48	0·48	2·28	0·00	—	3·2	1·7	0·5	0·12
W.M Bread	42 g	0·90	—	—	16·70	—	17·6	3·6	3·4	1·01
Glucose	15 g	15·00	—	—	—	—	15·0	—	—	—
Potato	45 g	0·08	0·04	0·04	8·70	—	8·9	0·4	0·9	0·05
Butter	7·5 g	—	—	—	—	—	TR	—	TR	6·09
Cream	20 g	—	—	—	—	0·6	0·6	—	0·4	7·60
Egg white	28 g	—	—	—	—	—	TR	—	2·9	0·06
Vanilla essence	5 g	—	—	—	—		—	—		—
TOTAL		19·79	8·54	5·81	26·45	0·6	61·2	14·0†	12·0	15·80
% Calories (total calories = 435)							56·3		11·0	32·70

*Total absorbable carbohydrate.
†Approx. 8 g cellulose + hemicellulose, 1 g lignin, 5 g other non-cellulosic polysaccharides.[10]

TABLE 2
Carbohydrate, protein and fat content of flummery meal

		Glucose	Fructose	Sucrose	Starch	Lactose	Total Abs. CHO	Fibre	Protein	Fat
Glucose	19·79 g	19·8	—	—	—	—	19·8	—	—	—
Fructose	8·54 g		8·5	—	—		8·5	—	—	—
Sucrose	5·81 g		—	5·8	—		5·8	—	—	—
Lactose	0·60 g		—	—	—	0·6	0·6	—	—	—
Starch (cornflour)	26·45 g		—	—	26·5		26·5	—	—	—
Gelatine	9·00 g		—	—	—	—	—	—	7·7	—
Cream cheese	50·00 g		—	—	—	—	TR	—	4·6	15·9
Vanilla essence	5·00 g	—	—	—	—	—		—	—	—
TOTAL		19·8	8·5	5·8	26·5	0·6	61·2	0	12·3	15·9
% Calories (total calories = 435)							56·3		11·0	32·7

(Fig. 1b). The area under the blood glucose curve did not differ between the two meals for either subject group.

The IRI levels for both non-diabetics and diabetics did not differ significantly between the two meals at any point (Figs 2a and 2b). The area under the IRI curve (expressed as area divided by time in hours) of non-diabetic salad meal was significantly less than that for the flummery (44·3 ± 3·5 mU/l salad meal, 51·0 ± 3·3 mU/l flummery, $P < 0{\cdot}05$). The corresponding areas for diabetics, 62·2 ± 6·0 mU/l (salad) and 67·9 ± 7·1 mU/l (flummery) do not differ significantly.

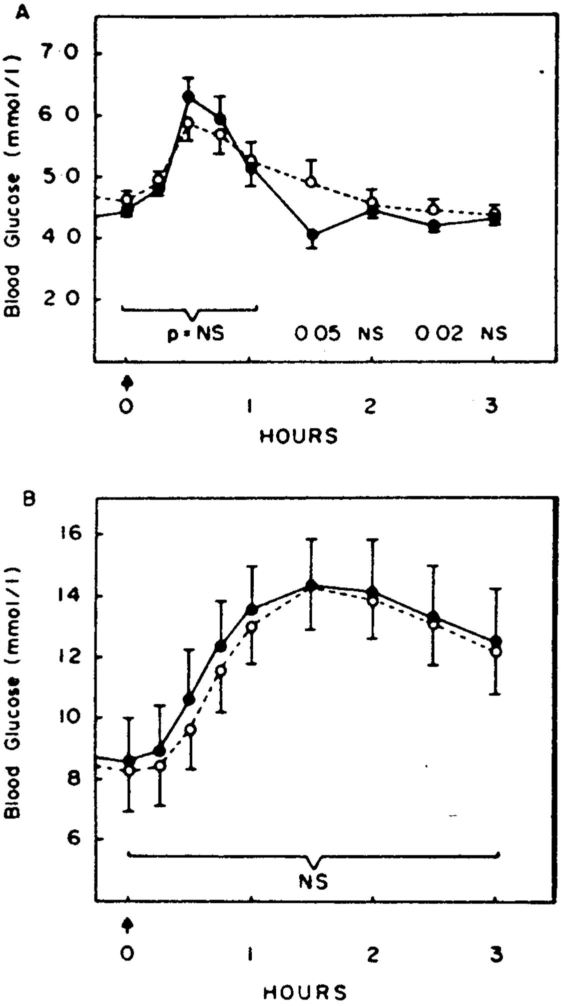

FIGURE 1. Blood glucose response to each meal. Non diabetic (A); diabetic (B); •——• salad and fruit meal; O-----O flummery.

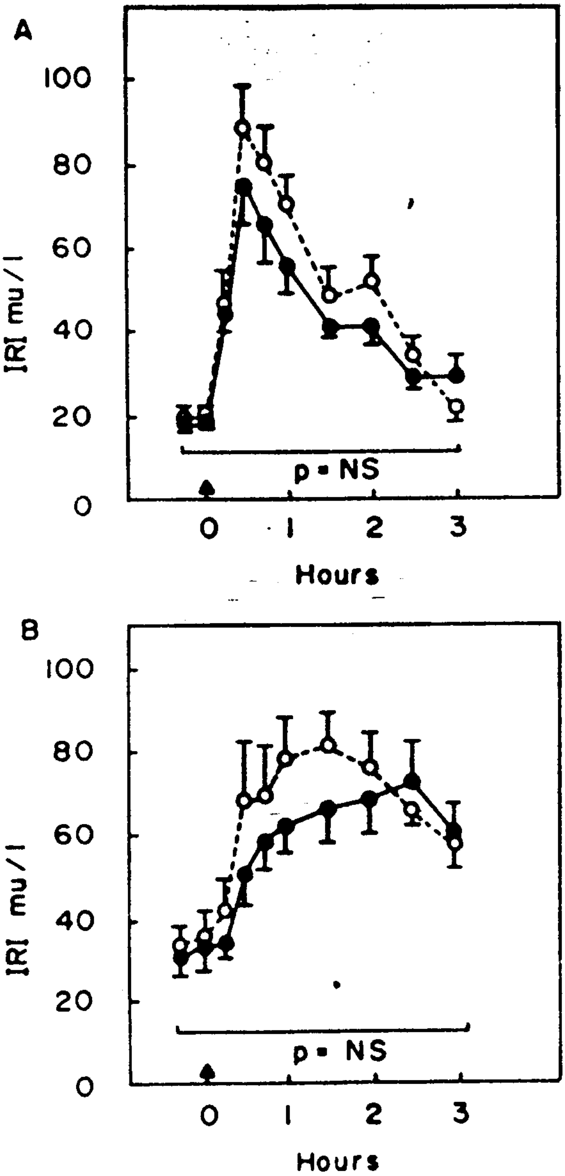

FIGURE 2. Immunoreactive insulin response to each meal. Non diabetic (A); diabetic (B); •——• salad and fruit meal; O-----O flummery.

Discussion

In short term studies the gelling and viscous non-absorbable carbohydrates have been shown to delay carbohydrate absorption from the gut and thus attenuate the post-prandial blood glucose response. The gelling fibre most intensively studied, guar, is derived from the Indian cluster bean and is therefore exotic to the Western diet. In addition, guar in a refined form is an unpalatable substance and not readily acceptable to most patients.

The more usual fibres in the Western diet are cellulose and hemicelluloses which are derived from unrefined cereal foods, salad and tuberous vegetables and many fruits. These are not gelling nor viscous fibres and, as the present acute study shows, do not affect carbohydrate absorption in their natural state and in the amounts normally found in unrefined foods. This is consistent with observations where bran has been added to absorbable carbohydrate containing test meals and found to be relatively ineffective in reducing the blood glucose response.[4, 11] The ability of guar to attenuate the postpandrial response is reduced after hydrolysis has rendered this fibre less viscous.[4]

Recently it has been shown that the physical form of rice starch (ground vs. unground) influences the rate of carbohydrate absorption.[6] In the present study, approximately 17 g of the absorbable carbohydrate hydrolysed to glucose during digestion was intracellular ("unground") and therefore had the potential to show the physical effect of cellular compartmentalisation. Perhaps the remainder of the free absorbable carbohydrate swamped this effect. In addition, O'Dea and co-workers[6] did not find any effect of the non-absorbable carbohydrate derived from rice (predominantly hemicelluloses) on carbohydrate absorption.

A lower blood glucose level in normals on the salad diet during the last 90 mins of the study was an unexpected finding. This contrasts with an earlier study where dietary fibre added to absorbable carbohydrate (protein and fat free) meals appeared to attenuate postprandial hypoglycaemia in patients after gastric surgery (dumping).[12] However, dietary protein and fat also markedly delay gastric emptying[13] and perhaps modify the effect of fibre.

The small reduction in the IRI area in normals after the salad, without a corresponding change in the blood glucose response, just reaches statistical significance and may represent an epiphenomenon. However, several previous studies[14, 15] have observed reduced insulin responses in the presence of dietary fibre without concomitant changes in the blood glucose and have attributed this to altered insulin sensitivity.

It is concluded that the important dietary fibres in the Western diet (mainly cellulose and hemicelluloses) in naturally occurring amounts do not have any significant short term effect on blood glucose levels in either normal or diabetic subjects.

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