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The influence of guar-gum bread on the regulation of diabetes mellitus type II in elderly patients

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1. The effect of a high-fibre bread mixed with guar-gum (75 g/kg flour) on serum glucose, connecting peptide (C-peptide), haemoglobin A1 (HbA1), high-density-lipoprotein–cholesterol (HDL-cholesterol) and triglycerides was examined in fourteen elderly patients with diabetes mellitus type II.

2. The mean daily consumption of guar gum was 8·1 g. Gastrointestinal disorders were not observed.

3. Consumption of guar-gum bread resulted in a significant decrease in C-peptide values on the 1st day and blood glucose values after 3 weeks (both measured 90 min after breakfast). C-peptide values remained low, while an unaccountable 'rebound' phenomenon was seen in the blood glucose values 90 min after breakfast at the end of the study.

4. No significant change was seen in respect to HDL-cholesterol and triglycerides. However, a small significant increase in HbA1 was noted.

Criticism of the use of oral antidiabetic agents by patients with diabetes led to efforts to find other methods of treatment (University Diabetes Program Group, 1970). An example is therapy by dietary fibre as developed by Trowell and Burkitt (Burkitt, 1969; Trowell, 1972, 1974, 1975, 1976, 1978; Trowell & Burkitt, 1977*a*, *b*; Burkitt & Trowell, 1975). Dietary fibre delays the resorption in the small intestine of carbohydrates.

Of all the known dietary fibres, guar gum probably has the greatest effect on slowing the resorption of carbohydrates. Guar gum is extracted from the endosperm of the Indian bean *Cyamopsis tetragonolobus* and is a non-absorbable galactomannan polymer. It is a tasteless, light-brown powder, very viscous in solution and therefore used in the food industry as a solidifying agent. If the retarding effect of guar gum on the resorption of carbohydrates is to be used for the treatment of diabetes, the gum should be presented in a desirable form.

Jenkins *et al.* (1978*b*, 1980) were the first to make an edible product with guar gum in the form of 'crisp bread'. As bread is an important element of the Dutch diet, it is obvious to mix guar gum with bread. In cooperation with the Institute for Cereals, Flour and Bread of TNO, Wageningen, a brown bread of good quality and taste was made in accordance with the directions of Apling & Ellis (1982) (Plate 1). In the present paper the effects of this guar-gum bread on the regulation of diabetes in elderly patients with diabetes mellitus type II are reported.

MATERIALS AND METHODS

With the approval of the Medical Ethical Committee of the Academic Hospital, Maastricht, fourteen patients with diabetes mellitus type II from the Klevarie Clinic voluntarily participated in our research project. The age range of the patients was between 53 and 96 years. Details of the subjects, including medical information, is given in Table 1.

Only patients with blood glucose values between 5 and 20 mmol/l at 90 min after breakfast and after lunch took part in the pilot study. Bread meals were taken in the morning and in the evening. As guar-gum bread contained less energy per unit weight than the control

Table 1. *Details of elderly patients participating in the study*

Sex	Age (years)	Body-wt (kg)		Blood glucose (screening) (mmol/l)		Energy intake (MJ/d)	Drugs (g/d)
		Initial	Final	After breakfast	After lunch		
♀	53	58·2	61·3	11·5	12·1	4·8	Rastinon 1·5
♀	83	60	64	6·8	6·4	4·2	Rastinon 1·0
♀	88	60·5	61·3	8·2	7·8	5·0	Rastinon 1·5
♂	85	72·5	73·8	9·3	9·6	7·0	Rastinon 2·5
♀	77	44	46·5	8·4	7·3	5·7	—
♀	96	71·8	73	7·5	9·5	5·0	Rastinon 1·5
♀	87	57	56	10	8·2	4·8	Rastinon 3 Glucophage 1
♀	68	57·7	58·3	16·8	23·6	5·8	Diamicron 2 × 80 mg Rastinon 2
♀	74	54·3	57·7	12	10·7	7·3	Rastinon 1
♀	71	70·5	71·4	7·8	7·7	4·5	Rastinon 1·5
♂	81	55	53	5·5	5·6	6·1	—
♀	86	51·5	54	8·0	6·8	5·4	—
♀	73	61	60	7·2	11·9	4·4	Rastinon 1·5
♀	65	77·7	74·3	9·9	8·4	5·6	—

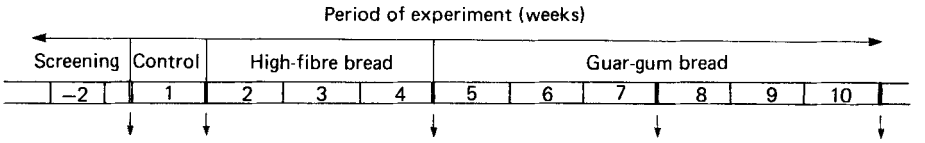

Fig. 1. Scheme of the experimental study of 10 weeks in which the effects of high-fibre bread and guar-gum bread were evaluated *v.* control period. ↓, Blood samples taken.

bread (7730 *v.* 9660 kJ (1840 *v.* 2300 kcal)/kg respectively), the quantity of bread consumed during the guar-gum-bread period was changed in such a way as to keep the energy value of each bread meal per patient constant. The bread meals were consumed in 20 min. The exact daily intake of bread was supervised by the dietician and the nurses of the wards. The midday meals were not changed and therefore did not contain any additional fibre.

During the control period (1 week), normal brown bread was eaten. A period of 3 weeks with high-fibre bread was interposed, followed by a 6-week period with guar-gum bread (see Fig. 1). This regimen allowed adaptation to the difference in taste between normal brown bread and guar-gum bread and, at the same time, assessment of the influence of dietary fibre without guar gum on the regulation of diabetes mellitus.

All bread meals were isoenergetic during the different periods for each patient. The high-fibre bread contained (g/kg) 42 dietary fibre (neutral-detergent fibre (NDF)) and 32 slow-release starch, on a wet weight basis. The latter refers to the difference between total starch (430 g/kg) and 'processed' starch (398 g/kg). Guar-gum bread contained (g/kg) 40 dietary fibre (NDF), 30 slow-release starch and 40 guar gum (guar Kwal; CSAA-M200, Mepro B.V., Zaandam) on a wet weight basis; the guar gum content can also be expressed as 75 g/kg flour.

The following indices were determined: body-weight; blood sugar (glucose quant kit no. 245178, Boehringer) after an overnight fast, 90 min after breakfast and 90 min after the midday meal; connecting peptide (C-peptide), as an indicator of insulin secretion, with a

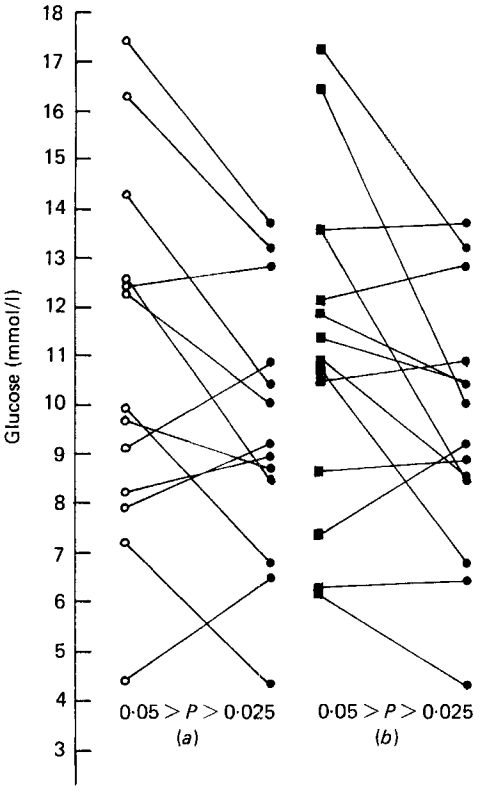

Fig. 2. Blood glucose values 90 min after breakfast measured after 3 weeks on a diet containing guar-gum bread (●) compared (*a*) with the control week (○) and (*b*) with the 1st day on guar-gum bread (■). After 3 weeks on guar-gum bread the blood glucose value decreased significantly ($P < 0{\cdot}05$) when compared with the control week when normal bread was eaten and in comparison with the 1st day of guar-gum bread.

RIA-kit (Hoechst) using blood samples taken 90 min after breakfast; haemoglobin A1 (HbA1) with a thiobarbituric acid (TBA) assay according to Postmes *et al.* (1981); high-density-lipoprotein (HDL)–cholesterol by a precipitation method according to Allen *et al.* (1979), followed by HDL determination using the CHOD PAP method by a test comb cholesterol kit (no. 172626, Boehringer); and triglycerides (triglyceride rapid test kit no. 0710865, Roche). Blood samples were taken at the start of the study, on the 1st day of the high-fibre-bread period, on the 1st day of the guar-gum-bread period and after 3 and 6 weeks on guar-gum bread.

Statistical analysis was based on a paired *t* test.

RESULTS

At the end of the study (see Table 1) it appeared that on average most patients had gained 1 kg in weight.

Blood glucose. During the whole period of the study (10 weeks) there were only small variations in the blood glucose values in the samples taken before breakfast. The mean glucose level change for each patient was 1·7 (SD 1·1) mmol/l.

After 3 weeks on guar gum bread, a significant decrease was found in the blood glucose

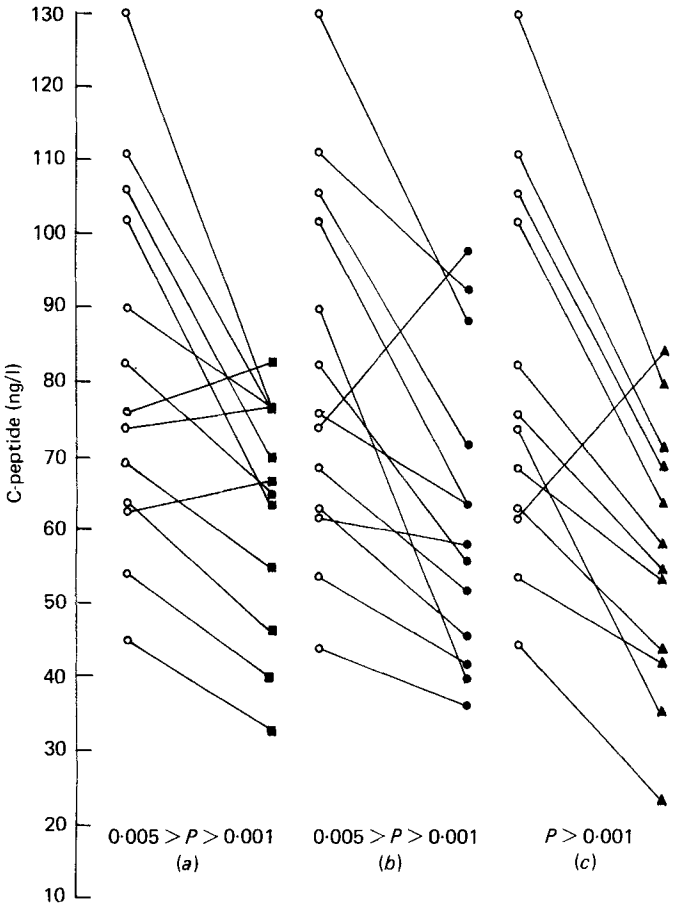

Fig. 3. C-peptide concentrations after consumption of normal brown bread (control) and high-fibre bread containing guar gum. When compared with the control week (○) the C-peptide concentrations (determined 90 min after breakfast) appeared to have decreased significantly (*a*) on the 1st day (■), (*b*) after 3 weeks (●) and (*c*) after 6 weeks on guar-gum bread (▲).

value 90 min after breakfast (Fig. 2(*a*)) compared with the control week (mean −8·6%, $P \leqslant 0{\cdot}05$). The difference between the start of the guar-gum-bread period and the start of the 4th week of the guar-gum-bread period (Fig. 2(*b*)) was also significant (mean −12·1%, $P \leqslant 0{\cdot}05$). The blood glucose value after 3 weeks on guar-gum bread showed a significant difference compared with the high-fibre-bread period (mean −13·8%, $P \leqslant 0{\cdot}005$).

The blood glucose values 90 min after the isoenergetic midday meals (without guar gum) in the various experimental periods were not significantly different.

C-peptide. All C-peptide measurements were made on blood samples taken 90 min after breakfast. The consumption of the high-fibre bread did not lead to changes in the C-peptide value compared with that of the control week. The use of guar-gum bread, on the other hand, resulted in a significant decrease in the C-peptide value compared with that of the control week (Fig. 3(*a*, *b*, *c*) on the 1st day and after 3 and 6 weeks on the guar gum bread. Mean values were −19·8, −21·9 and −27·8% respectively. The corresponding values for the high-fibre-bread period were −22·8, −24·7 and −28·1%. Remarkably, the maximum decrease was achieved on the 1st day of the guar-gum-bread period. Prolonged consumption

of guar-gum bread did not lead to a further decrease in the C-peptide value. No correlation was found between the decrease in C-peptide and the quantity of guar gum consumed daily, nor in relation to the daily energy intake. The average daily consumption of guar gum was 8·1 (SD 1·8, range 5–12) g.

HbA1. During the whole study the HbA1 values appeared to increase rather than decrease. Statistical analysis showed a significant increase during the high-fibre- and guar-gum-bread periods in relation to the control week, varying from +7·8 to +28·4%. At the end of the study, however, there was a decrease in comparison with the value after 3 weeks on the guar-gum bread (mean −5·53%). With respect to the entire guar-gum period, the HbA1 value remained constant.

HDL–cholesterol and triglycerides. Values remained constant.

DISCUSSION

In order to obtain a decrease in blood glucose, guar gum must be well mixed with the food (Jenkins *et al.* 1979). It must be in a palatable form to promote faithful application of the therapy and a ready-made product has to be available, e.g. in the form of a 'crisp bread' (Jenkins *et al.* 1978*b*, 1980) or bread (Ellis *et al.* 1981; Apling & Ellis, 1982). Our experience shows that the treatment of diabetes mellitus entirely depends on the faithfulness in the application of the therapy. According to Ellis *et al.* (1981), there is apparently a dose-effect relation between the quantity of guar gum and the blood-glucose diminishing effect. In a preliminary study we found that bread containing 75 g guar gum/kg was accepted (*n* 20). The average hedonic score was 3 on a scale ranging from 0 to 5. This is comparable to the bread prepared by Ellis *et al.* (1981). Bread containing 100 g guar gum/kg flour appeared to be unacceptable. In our study, bread containing 75 g guar gum/kg flour was accepted by all the patients during the 6 week study. Moreover, no one suffered from any gastrointestinal trouble.

The effect of guar-gum bread, brown bread and white bread on the levels of glucose, C-peptide and insulin was investigated in healthy persons by Pikaar *et al.* (1984). In their study breakfast was standardized: the starch component was fixed while the quantity and type of dietary fibre was varied. Lunch contained various kinds of starch. Various combinations of breakfast and lunch allowed the study of the effect of breakfast and lunch on a number of selected indices with a small number of persons and within a short period of time. Guar-gum bread appeared to have the greatest influence on the peak concentration and 'area under the curve' of blood glucose, C-peptide and insulin. Only with guar-gum bread did a 'second meal' effect appear.

Our investigation is similar to that of Pikaar *et al.* (1984). However, there is a difference: in elderly patients frequent blood sampling is a practical problem, therefore only a limited number of measuring points were used, which rendered it impossible to plot curves. In addition, nothing can be said about the 'second meal' effect, as lunch was not standardized.

The blood glucose values (determined before breakfast) showed no change during the guar-gum-bread period, although supper also contained bread with guar gum. This contradicts the findings of Ray *et al.* (1983). The blood glucose at 90 min after breakfast showed a significant decrease after 3 weeks on the guar-gum bread, which was not maintained, as after 6 weeks there was no further difference compared with that of the control week (rebound phenomenon?). After lunch there was no significant decrease in the blood glucose value. As reported previously these meals were isoenergetic but not standardized as to composition.

The influence of guar-gum bread on the C-peptide values is remarkable (Fig. 3(*a*, *b*, *c*)). The maximum decrease was achieved after the first breakfast with guar-gum bread and in

the course of the experiment the C-peptide values stabilized. Contrary to the findings of Ellis *et al.* (1981) we found no relation between the quantity of guar-gum consumed and the decrease in the C-peptide values when 5–12 g guar were consumed daily. Another remarkable fact is that the decrease in the C-peptide values occurred on the very 1st day of the guar-gum bread period, while the blood glucose value, determined 90 min after breakfast, decreased significantly only after 3 weeks. This could indicate an uncoupling between blood glucose and C-peptide. The same phenomenon occurred after 6 weeks on guar-gum bread: blood glucose 90 min after breakfast increased to a value not significantly different from that of the control week, while the C-peptide remained low. In this small group of patients, three out of thirteen showed a striking increase in C-peptide values while on guar-gum bread (Fig. 3). However, at the end of the study, only one patient had elevated C-peptide values compared with the control week. We therefore investigated different factors that might explain these results, especially to characterize possible 'non-responders'. Blood glucose, daily energy intake, total dietary fibre consumption, drugs, weight gain or daily guar gum intake could not be used to predict the individual's response to guar-gum bread. Hence, we have started a study with a greater number of patients and over a longer period, during which this problem will be investigated thoroughly again.

The HbA1 value reflects the mean blood glucose value during the last 2–3 months. A period of 6 weeks is rather short to eliminate variations in the HbA1 levels resulting from the previous period. Nevertheless, in our test the HbA1 value showed a significant increase which could perhaps partly be explained by the increase in the blood glucose during the high-fibre-bread period. It is strange, however, that the HbA1 value did not decrease when the blood glucose decreased significantly after 3 weeks on guar-gum bread.

Information on the effect of dietary fibre on lipids is rather contradictory. Some authors reported a decrease (Heaton & Pomare, 1974; Albrink *et al.* 1976; Najemnik *et al.* 1984) while others found no change (Bremer *et al.* 1975; Connel *et al.* 1975). The results of the present study indicate no effect on the HDL–cholesterol and triglyceride values when 5–12 g guar gum was consumed daily for 6 weeks.

The effect of dietary fibre is explained in the literature in various ways: delayed emptying of the stomach (Holt *et al.* 1979; Ray *et al.* 1983); increased viscosity in the small intestines, resulting in delayed diffusion through the unstirred layer of the food (Gassull *et al.* 1976; Jenkins *et al.* 1978*a*); diminished gastric inhibitory polypeptide (GIP) secretion (Morgan *et al.* 1979); increased sensitivity to insulin (Anderson, 1980; Pedersen *et al.* 1982; Hjollund *et al.* 1983); and decreased glucagon secretion (Miranda & Horwitz, 1978; Munoz *et al.* 1979).

Our short-term study shows that a guar-gum-flour mixture can be made into a palatable bread with an evident effect on blood glucose and C-peptide values. Guar-gum bread is an acceptable way to slow the resorption of carbohydrates. Further investigations should comprise a long-term study with particular reference to entero-hormonal patterns.

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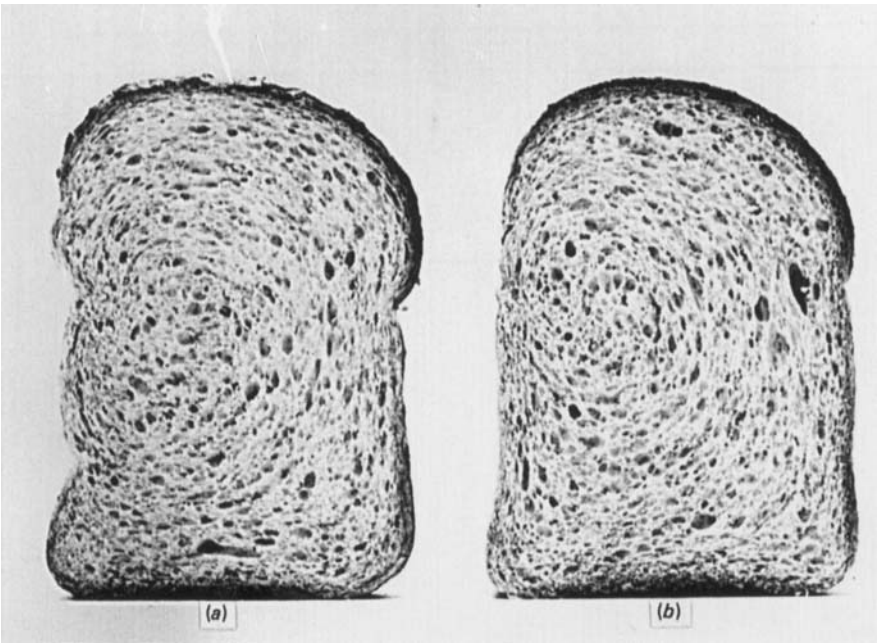

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EXPLANATION OF PLATE

Plate 1. (*a*) A normal high-fibre bread and (*b*) a high-fibre bread containing guar gum.

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