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Viscosity Differences Between Various Guar Gums

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Summary. Guar gum from four industrial sources was investigated. The viscosity of two preparations of hydrated guar gum in the form of powdered flour and one granulate flour was measured at 22° and 32 °C and pH 1.0 and pH 4.0. Viscosity measurements on wax-coated guar granules proved impossible but visual assessment indicated an extremely low viscosity in all conditions. These findings were compared with the ability of the equivalent of 5 g guar gum of the various preparations to modify the absorption of a 50 g liquid glucose load. The mean post-prandial blood glucose curve was not significantly different from the control situation after the incorporation of each preparation. Despite the granulate flour attaining a considerably lower viscosity than the powdered flour they were equally effective in significantly reducing the mean post-prandial insulin curve (area under the curve (0–180 min) reduced by 46 and 50% respectively). The wax-coated granules which achieved minimal viscosity caused significantly less reduction of post-prandial insulin levels (area under the curve reduced by 37%). The viscosity of guar gum upon hydration is of importance in assessing the efficacy of a preparation in clinical use.

Key words: Guar gum, viscosity, glucose tolerance

Guar gum has been employed in the dietary treatment of diabetes and shown to improve glucose tolerance [1, 2]. This property has been attributed to the viscosity of the hydrated guar gum which reduces the rate of gastric emptying [3] and possibly the rate of diffusion of nutrients in the gut. Jenkins et al. have shown that when guar gum is hydrolysed with a subsequent reduction in viscosity, its efficacy is greatly diminished [4]. There has, however, been considerable controversy in the literature over the degree of effectiveness of guar gum in various situations [5–11]. During several years of clinical trials we have used preparations of guar gum supplied by three industrial sources and noted marked differences in the ability of these preparations to hydrate. We have, therefore, measured the viscosity of solutions of these preparations under varying conditions and compared their viscosity to their physiological action.

Method

Sources of Guar Gum

Four preparations of guar gum were provided by three industrial companies: a) two powdered guar flour preparations (Boots and Norgine); b) one granulate guar flour preparation (Speywood); c) one preparation of guar coated in liquid paraffin and paraffin wax to form large granules (Norgine).

Measurement of Viscosity

Solutions of each preparation (1 g/100 ml) were made up with either tap water (pH 4.0) or tap water acidified to pH 1.0 with concentrated hydrochloric acid and maintained at 22° and 32 °C. Each solution was prepared by whisking the guar gum vigorously into the water. The point at which the addition began was taken as the start of the hydration time.

Viscosity measurements were made with a Brookfield Synchro-Lectic Viscometer (model RVF-100, spindle no. 4 at 20 rev./min), 2, 5, 10, 20, 30 and 45 or 60 min from the start of hydration. Experiments were carried out in duplicate. Further measurements were made after 28 h hydration on solutions at pH 4.0 maintained at 22 °C.

Clinical Studies

Five healthy volunteers (two males and three females) who were within 10% of their ideal body weight and aged between 22–25 years took part in the study.

Each subject attended on four separate occasions at least a week apart. After an overnight fast they each consumed in two equal portions a minute apart 80 ml Hycal (Beechams) diluted to 250 ml with water. This provided 50 g glucose. On two occasions each portion contained in addition 5 g powdered flour (Norgine) or granulate flour (Speywood) which was whisked into it immediately prior to consumption. During the other session they chewed

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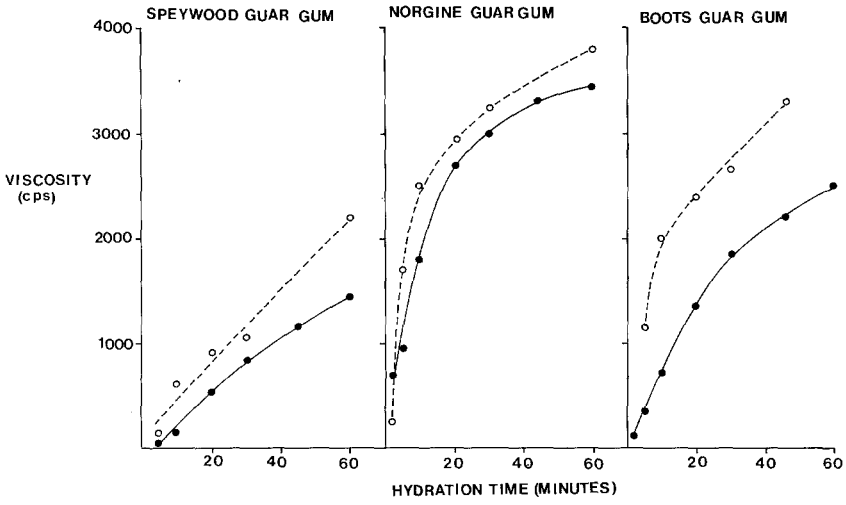

Fig. 1. Effect of temperature on the viscosity development during hydration of three guar gum preparations at pH 4.0 ●—●—● 32 °C; ○—○—○ 22 °C

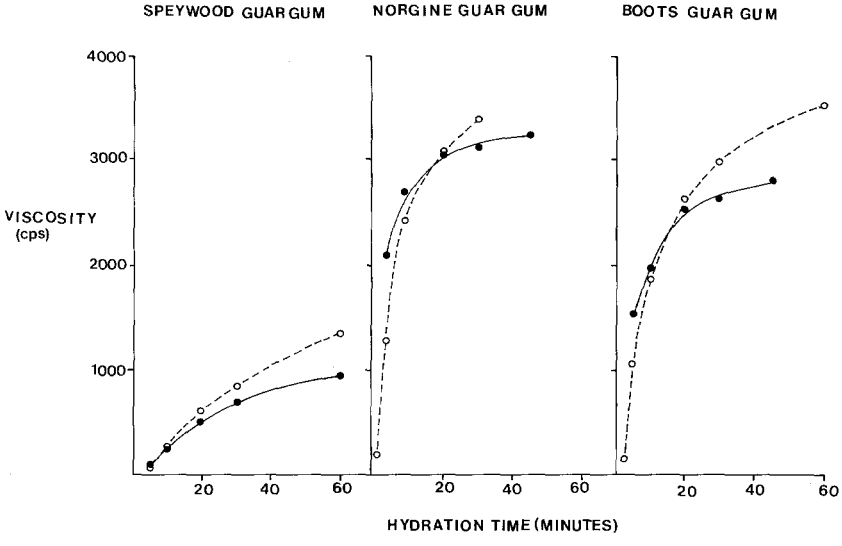

Fig. 2. Effect of temperature on the viscosity development of three guar gum preparations at pH 1.0 ●—●—● 32 °C; ○—○—○ 22 °C

6.25 g wax-coated granules (equivalent to 5 g guar gum) before taking the drink.

Venous blood samples were collected from an indwelling venous cannula (kept patent with 3.8% sodium citrate) in the fasted state and at 20, 40, 60, 80, 100, 120, 150 and 180 min from the start of consumption while the subjects were at rest. The samples were analysed for glucose by a glucose oxidase method [12] and insulin using a double antibody radioimmunoassay technique [13]. Results were compared using Student's t-test for paired data.

The study was approved by the Ethics Committee of St. Luke's Hospital and each subject gave their informed consent.

Results

Viscosity Measurements

It was impossible to obtain reproducible viscosity measurements on the wax-coated Norgine granules, as the granules swelled sightly but did not form a uniform solution. However, visually assessed, the wax-coated granules formed very much less viscous solutions than any of the other preparations.

The effects of pH and temperature on the viscosity of the other guar gums are shown in Figures 1 and 2. The viscosities the various guar solutions attained were dependent on time, temperature and pH. All the preparations were less viscous at the higher temperature. The situation was a complex one, and the extent to which these factors influenced viscosity varied in each individual preparation. On every occasion the Speywood granulate flour was much less viscous during the first hour of hydration then the Boots or Norgine powdered flours. At pH 4.0 and 22 °C their relative differences were still apparent after 28 h (3,100 centipoises (cps), 4,600 cps and 4,700 cps respectively). At both 22° and 32 °C the Speywood product was less viscous at pH 1.0 than at pH 4.0. This is in contrast to the other two flours which were generally more viscous at pH 1.0 at both tempera-

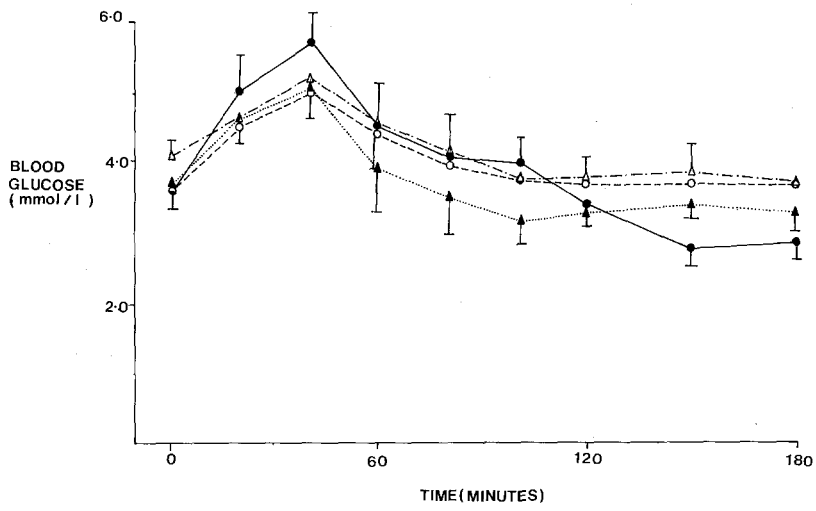

Fig. 3. Effect of three guar gum preparations on mean (±SEM) post-prandial glucose levels following a 50 g liquid glucose load (n = 5). ●—●—● 50 g glucose (control); ▲—▲—▲ 50 g glucose + Norgine wax-coated granules; ○—○—○ 50 g glucose + Speywood granulate flour; △—△—△ 50 g glucose + Norgine powdered flour

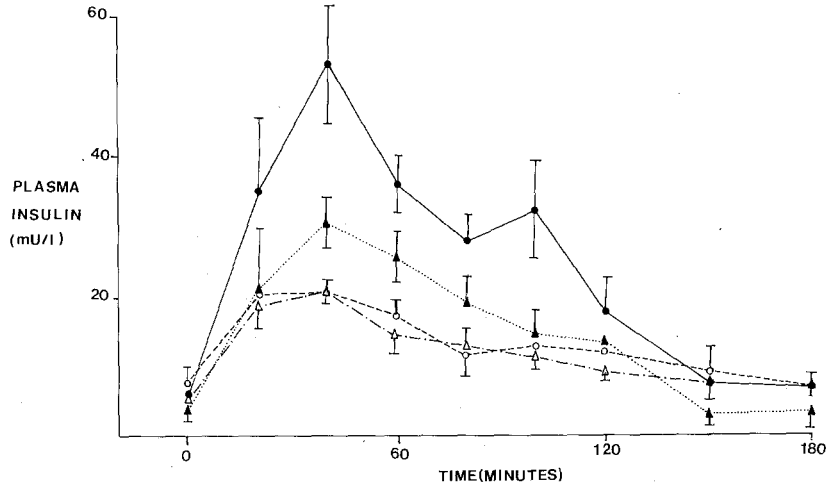

Fig. 4. Effect of three guar gum preparations on mean (±SEM) post-prandial insulin levels following a 50 g liquid glucose load (n = 5). (For symbols see Fig. 3)

tures. The reproducibility of duplicate experiments was 88.5 ± 1.6% (mean ± SEM).

Clinical Studies

Addition of guar to the glucose drink had no statistically significant effect upon mean peak blood glucose levels, although peak post-prandial blood glucose levels when each of the three guar preparations were taken with the glucose load were lower than the control (Fig. 3). In the second part of the experiment (90–180 min) addition of guar had in each case the effect of preventing a fall in blood glucose to below fasting levels, thus 'smoothing' the post-prandial glucose curve compared with the control. The wax-coated granules were least effective in this respect, but there were no statistically significant differences in blood glucose levels between any of the different guar preparations.

In contrast, post-prandial insulin levels (Fig. 4) were significantly reduced by addition of each of three preparations of guar to the glucose load. [Area under the curve 0–180 min significantly smaller with wax coated granules (Norgine) ($p < 0.025$), Norgine powdered flour ($p < 0.01$) and Speywood granulate flour ($p < 0.01$)]. The Norgine and Speywood flours were equally effective in reducing post-prandial insulin levels compared with the control, but the Norgine wax-coated granules were significantly less effective than the other two flours [area under the curve 0–180 min significantly greater with wax-coated granules than with either flour ($p < 0.05$)].

Discussion

Guar gum is a galactomannan derived from the leguminous plant, *Cyamopsis tetragonoloba,* grown in India, Pakistan and the United States. Climatic differences may affect the degree of cross-linking of the galactomannan chains. We suggest this may be partly responsible for the variations in viscosity seen

between the Boots and Norgine guar gum flours. Both these products are in the form of a powdered flour, whereas the Speywood company specially process the flour to produce a granulate which is more readily miscible with water. This processing may provide an explanation for the marked differences in viscosity development between the Speywood granulate flour and the other two flours. The wax-coated guar gum granules (Norgine) hydrated poorly and this is the probable reason for their very much lower viscosity compared with the other guar preparations.

If the action of guar gum is to delay gastric emptying by virtue of its ability to hydrate in the stomach then one might expect the differences in rates of viscosity development and maximum viscosity attained to mimic its physiological effectiveness [3]. We compared the effect of incorporating into a liquid glucose load a) Norgine powdered guar flour, which was the most viscous at pH 1.0 and 32 °C (similar to conditions in the stomach), b) Speywood granulate guar flour, which not only had a lower viscosity but whose viscosity was adversely affected by acid conditions, and c) Norgine wax-coated guar granules, the least viscous preparation. All three guar products were effective in slowing down glucose absorption in a liquid test meal situation as shown by reduction in mean post-prandial insulin levels compared with the control. However, whilst the least viscous wax-coated granule preparation was the least effective, the two guar flours were equally effective in spite of widely different viscosities. It therefore appears that following a liquid test meal a low-threshold viscosity attainment is sufficient for the observed effects. However, guar has been shown to be less effective when incorporated into solid test meals [14] where conditions are not as favourable for the attainment of maximum viscosity. In this situation, differences in viscosity between guar preparations might become more important. We have shown that the wax-coated guar granules were ineffective when given as a pre-meal medication to a solid mixed meal in both healthy volunteers and maturity onset diabetics (Tredger, O'Connor and Morgan, unpublished observations). It is also possible that the mode of action of guar gum is not solely by virtue of its viscosity. Other possible modes of action could include:

1. creation of an effective barrier between nutrients and absorptive sites;
2. interference with the active transport mechanism by 'mopping up' Na^+ ions;
3. altered release of gastrointestinal hormones with a concurrent increase in insulin sensitivity.

This latter hypothesis has some foundation. Morgan et al. have found that GIP secretion is modified by guar [2] and reduced 24-h urinary 3-hydroxybutyrate outputs were found in diabetics on guar supplemented diets [15], indicating a probable reduction in fat metabolism.

We believe that guar gum would be a useful adjunct to the conventional treatment of diabetes and that it can be successfully incorporated into the dietary regimen. However, further studies are necessary to establish the characteristics of guar gum which are critical to its activity in physiological conditions. In the meantime, to prevent further confusion, the source and type of guar gum used should be specified in all reports of clinical trials.

References

1. Jenkins DJA, Goff DV, Leeds AR, Alberti KGMM, Wolever TMS, Gassull MA, Hockaday TDR (1976) Unabsorbable carbohydrates and diabetes: decreased post-prandial hypoglycaemia. Lancet 2: 172–174
2. Morgan LM, Goulder TJ, Tsiolakis D, Marks V, Alberti KGMM (1979) The effect of unabsorbable carbohydrates on gut hormones. Diabetologia 17: 85–89
3. Holt S, Heading RC, Carter DC, Prescott LF, Tothill P (1979) Effect of gel fibre on gastric emptying and absorption of glucose and paracetamol. Lancet 1: 636–639
4. Jenkin DJA, Leeds AR, Gassull MA (1977) Viscosity and the action of unavailable carbohydrate in reducing post-prandial glucose and insulin levels. Proc Nutr Soc 36: 44A
5. Wolever TMS, Taylor R, Goff DV (1978) Guar: viscosity and efficacy. Lancet 2: 1381
6. Williams DRR, James WPT (1979) Fibre and diabetes. Lancet 1: 271–272
7. Jenkins DJA, Nineham R, Craddock C, Craig-McFeely P, Donaldson K, Leigh T, Snook J (1979) Fibre and diabetes. Lancet 1: 434–435
8. Wolever TMS, Taylor R, Goff DV, Aherne J (1979) Fibre and diabetes. Lancet 1: 435
9. Goulder TJ (1979) Guar and diabetes. Lancet 1: 612
10. Williams DRR, James WPT (1979) Guar and diabetes. Lancet 1: 612
11. Dewar J, Garcia-Webb P, Shenfield GM (1979) Guar and diabetes. Lancet 1: 612–613
12. Morley G, Dawson A, Marks V (1968) Manual and autoanalyser methods for measuring blood glucose using guaicum and glucose oxidase. Ann Clin Biochem 5: 42–45
13. Samols E, Bilkus DA (1964) A comparison of insulin radioimmunoassays. Proc Soc Exp Biol Med 115: 79–84
14. Wolever TMS, Jenkins DJA, Nineham R, Alberti KGMM (1979) Guar gum and reduction of post-prandial glycaemia: effect of incorporation into solid food, liquid food and both. Br J Nutr 41: 505–510
15. Jenkins DJA, Wolever TMS, Nineham R, Goff DV, Haisman P, Charnock P, Taylor RH, Hockaday TDR (1979) Dietary fibre and ketone bodies: reduced urinary 3-hydroxybutyrate excretion in diabetics on guar. Br Med J 2: 1555

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