

## Original Research

# The Effect of Different Dosages of Guar Gum on Gastric Emptying and Small Intestinal Transit of a Consumed Semisolid Meal

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**Key words:** guar gum, gastric emptying, intestinal transit, satiety, scintigraphy, H<sub>2</sub>-breath test.

**Background:** There is no consensus about the effect of guar gum supplementation on gastrointestinal transit. It has been suggested that guar gum slows gastric emptying and intestinal transit, thus inducing an increased feeling of satiety.

**Objective:** To investigate whether addition of guar gum to a semisolid meal affects gastrointestinal transit.

**Design:** Eight male subjects were randomly studied four times. They consumed a standard semisolid test meal containing either 0 g, 2.5 g, 3.5 g, or 4.5 g of guar gum. The test meals contained 1 mCi <sup>99m</sup>Tc-hepatate for scintigraphy and 5 g lactulose for the H<sub>2</sub>-breath test. Scintigraphic scanning was performed for at least two hours, and gastric half-emptying time (T1/2) was calculated. Breath samples were collected at 15 minute intervals and analyzed for H<sub>2</sub>-enrichment. The orocecal transit time (OCTT) was then determined. A parameter of intestinal transit (PIT) was obtained by subtracting the T1/2 from the OCTT.

**Results:** There were no significant differences (in minutes) between the different tests in both T1/2 (0 g, t = 88.2 ± 11, 2.5 g, t = 83.3 ± 11.9, 3.5 g, t = 83.3 ± 13.6, 4.5 g, t = 72.4 ± 7.2, p = 0.86) and PIT (0 g, t = 149.9 ± 26.6, 2.5 g, t = 145.5 ± 25.6, t = 3.5 g, t = 175.3 ± 17.6, t = 4.5 g, t = 152.6 ± 22.4, p = 0.52).

**Conclusion:** Addition of guar gum to a semisolid meal up to a dosage of 4.5 g does not affect gastrointestinal transit. Other mechanisms than gastrointestinal motility are involved in a possible satiating effect of guar gum supplementation.

## INTRODUCTION

Dietary fiber is an important component of the diet. However, controversy and confusion still exist about the physiological effects of dietary fibers on serum lipids, blood glucose and induction of satiety. It has been suggested that guar gum may play an important role in weight maintenance in obese subjects. It has been established that guar gum can induce an increased feeling of satiety, thus reducing food intake [1]. A possible mechanism for this increased feeling of satiety is a delayed gastrointestinal transit.

The aim of the study was to determine the effect of different dosages of a highly purified guar gum type (Meyprofin M-175)

on the gastric emptying rate and small intestinal transit time of a standardized homogeneous low-caloric semisolid meal, using scintigraphy to measure gastric emptying and the hydrogen breath test to measure the intestinal transit rate. These techniques are regarded as the gold standard.

It is hypothesized that guar gum addition to a semisolid meal will lead to gel forming in the stomach, resulting in a substantial delay of gastric emptying. It is also hypothesized that guar gum will delay the intestinal transit. The data from the current dosage-response study may possibly lead to the establishment of the most optimal guar gum dosage, which can be ingested shortly before a meal or can be added to a meal, with the aim of increasing the delay of gastric emptying and a possible subsequent effect on appetite. The

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establishment of this dosage then could be used in subsequent short- and long-term studies on food intake and weight maintenance.

## METHODS

### Viscosity Measurements

Viscosity of the test meals containing 0 g guar gum and 4.5 g guar gum was measured at 37°C, at different shear rates (0.12, 0.30, 0.74, 1.85, 4.65, 11.7, 29.4, 73.5, 185 and 465 s<sup>-1</sup>) using a 3 cm plate diameter rheometer (Bohlin Vor. Rheometer, Bohlin Rheology AB, Sweden). The guar gum was added to the semisolid meal and homogenization took place by a five-minute shaking, followed by a ten-minute stabilization period. Samples were sheared for at least two minutes before the first reading was taken to ensure stable viscosity readings and temperature equilibration of the sample. The viscosity was measured in upward and subsequent backward order of shear rates. No precautions were taken to avoid sample evaporation.

### Study Design

Four different dosages (control = 0 g, low = 2.5 g, medium = 3.5 g and high = 4.5 g) of modified guar gum (Meyprofin M-175. Rhodia Food Meyhall AG, Kreuzlingen, Switzerland), a highly purified dietary galactomannan fiber, which forms a viscous liquid in approximately five to seven minutes after addition to water, were administered to a semisolid meal in a double blind randomized crossover study design.

### Subjects

Eight healthy, sedentary, non-obese male subjects (age 19.1 ± 0.8 years), recruited from the university, were included in the study. Informed consents were obtained. The study was approved by the Medical Ethics Committee of the Maastricht University. The subjects were studied on four different occasions. All tests were separated at least 72 hours. The subjects were asked to abstain from alcohol, medication and fiber-rich food the day before the study. Additionally the subjects were asked to register dietary intake the evening before the test and to consume exactly the same diet before the other tests. After an overnight fast, at 08:00 am the subjects consumed 200 mL of a standardized semisolid breakfast (Milical Crème®, Laboratoires Diététique et Santé, Revel, France). The subjects arrived at the laboratory at noon for the experiment.

### Test Substances

The different dosages of guar gum were mixed with a standard 203 Kcal semisolid meal (1 sachet of Milical Crème® dissolved in 200 mL water) and labeled with 1 mCi (37 MBq) <sup>99m</sup>Tc-hepatate, as a marker of the semisolid phase. The meal contained 19 g carbohydrates (maltodextrin), 16 g protein, 7.1 g

fat and 1 g electrolytes. The meal itself did not contain a viscous non-digestible fiber. Subsequently 5 g of lactulose (syrup 670 mg/mL, Centrafarm, Etten-Leur, The Netherlands) were mixed with the test meal. The different guar gum dosages resulted in meals with different consistencies. The consistency of the semisolid meal without guar gum was comparable to custard, while the consistency of the semisolid meal with added 4.5 g guar gum was comparable to soft dough, in which a spoon was supported in an upright position. We considered a higher dose of guar gum not suitable for consumption. Immediately after preparation, the meals were consumed within three minutes. A scintigraphic pilot experiment, which we performed, demonstrated that these semisolid meals empty according to a linear function.

### Scintigraphic Technique

The subjects sat in a semi-reclined position with a single-headed rectangular gamma camera equipped with energy collimators positioned in front of the stomach area. Subsequently the test meal was consumed. The images were recorded with a 10% window around a 140 Kev <sup>99m</sup>Tc-peak during a dynamic scanning (180 seconds per image) of at least two hours. If the remaining radioactivity had not been reduced to 50% of the maximum activity, the procedure was continued.

Data were stored on an on-line computer network. The gastric counts were determined for each image in the marked region of interest and corrected for tissue attenuation using a lateral image, down scatter and radioactive decay. Values for relative residual radioactivity (% RRA) for the solid component of the meal, using the activity at time zero (end of meal consumption) as 100%, was calculated at each time point. A linear regression fit was applied in order to calculate the gastric half-emptying time (T1/2) and lag time of the solid component.

### Hydrogen Breath Technique

The consumed meal contained a non-digestible soluble carbohydrate (5 g lactulose) allowing the measurement of orocecal transit time (OCTT) via H<sub>2</sub> measurement in breath. This method is the gold standard for determining the presence of bacterial overgrowth and for measurement of the OCTT. Lactulose itself has an accelerating effect on intestinal transit, which might hypothetically outstrip the effect of guar gum on intestinal transit. To avoid this, we used a small amount of lactulose, which has little effect on intestinal transit. Caride *et al.* [2] observed that if scintigraphy and the hydrogen breath test using lactulose were used simultaneously, similar results were obtained. As soon as the lactulose enters the colon, bacterial fermentation will take place, and H<sub>2</sub>-gas will be produced [3]. At 15 minute intervals after ingestion of the test meal, the subjects breathed for two minutes via a mouthpiece in a mixing chamber. A breath sample was drawn from the mixing chamber using a 140 mL syringe. The H<sub>2</sub>-enrichment of the breath samples (in ppm), due to the colonic fermentation of the

added lactulose, was determined by injecting the breath sample into an exhaled H<sub>2</sub>-monitor (GMI Medical Ltd., Renfrew, Scotland). The OCTT was determined using the time of onset of a sustained increase in breath H<sub>2</sub>, which is the first breath sample that shows a higher breath H<sub>2</sub> than the preceding one, followed by two or more breath samples that show a further increase. Since the OCTT is determined by the processes of both gastric emptying and the rate of intestinal transit, a parameter of intestinal transit (PIT) could be obtained by subtracting the T1/2 obtained from the gastric emptying measurements from the OCTT.

## Statistics

Data of the gastrointestinal transit measurements are presented as mean  $\pm$  SD. The differences in T1/2 and PIT between the trials were evaluated using Friedman's nonparametric test. All analyses were performed using the SPSS 7.5 for Windows statistical package. Values of  $p < 0.05$  were accepted as statistically significant. The data of the viscosity measurements are presented as a graph with logarithmic axes.

## RESULTS

### Viscosity Measurements

The results of the viscosity measurements are displayed in Fig. 1. The figure demonstrates that addition of 4.5 g guar gum resulted in approximately a tenfold increase in the viscosity of the test meal. At the highest shear rate (465 s<sup>-1</sup>) the viscosity of the meal without guar gum was 0.08 Pa.s and with 4.5 g guar gum it was 0.22 Pa.s.

### Gastrointestinal Transit Measurements

All the subjects showed full compliance to the study. All the gastric emptying measurements showed a linear relationship in time. Friedman's nonparametric analyses showed no significant

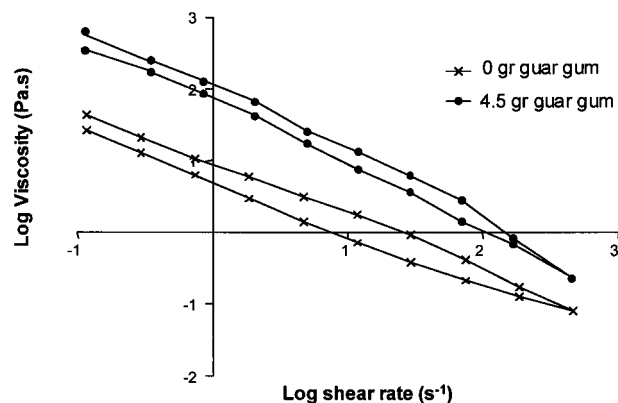


Fig. 1. Viscosity plots of the semi-solid meal and the semi-solid meal with added 4.5 g guar gum.

differences between the different dosages of guar gum in the T1/2 (0 g,  $t = 88.2 \text{ min} \pm 11 \text{ min}$ , 2.5 g,  $t = 83.3 \text{ min} \pm 11.9 \text{ min}$ , 3.5 g,  $t = 83.3 \text{ min} \pm 13.6 \text{ min}$ , 4.5 g,  $t = 72.4 \text{ min} \pm 7.2 \text{ min}$ ,  $p = 0.86$ ) as displayed in Fig. 2. The PIT also failed to demonstrate differences between the different guar gum dosages (0 g,  $t = 149.9 \text{ min} \pm 26.6 \text{ min}$ , 2.5 g,  $t = 145.5 \text{ min} \pm 25.6 \text{ min}$ ,  $t = 3.5 \text{ g}$ ,  $t = 175.3 \text{ min} \pm 17.6 \text{ min}$ ,  $t = 4.5 \text{ g}$ ,  $t = 152.6 \text{ min} \pm 22.4 \text{ min}$ ,  $p = 0.52$ ), as displayed in Fig. 3.

## DISCUSSION

Gastric distension is assumed to be an important signal of satiety [4]. Guar gum is assumed to be able to induce a delayed gastric emptying by forming a gel in the stomach, leading to a prolonged gastric distension, which results in prolonged satiety signals from the stomach. However, the relationship between guar gum and gastric emptying is not clear yet. Various gastric emptying studies, in which guar gum was added to test meals, have been carried out and show different results [5,6–20]. These discrepancies may be explained by the different methods that are used to measure gastric emptying. In some studies only the gastric emptying of the liquid phase was measured, using the paracetamol absorption method [10,12,20]. This was sometimes done after consumption of a solid/liquid meal and means that no information about the gastric emptying of the solid phase is available. It is well known that liquids, solids and fats show different gastric emptying kinetics; liquids empty according to an exponential function, and solids and fats empty according to a linear function. Moreover, the gastric emptying rate is dependent on the volume, temperature and caloric contents of both the liquid and solid phase. Unusual methods such as <sup>24</sup>Na- absorption or sampling of gastric contents using a nasogastric tube have also been used to measure gastric emptying [16]. In other studies the common scintigraphy technique was used [6–8,14,17–20]. In addition, different types (purified vs. non-purified) and dosages of guar gum have been used, leading to different viscosities and textures of the meals. Finally, there were differences in the type of meal (liquid [5,8,11,15–17,19], liquid/solid [7,9,10,12,13] or semisolid [14],

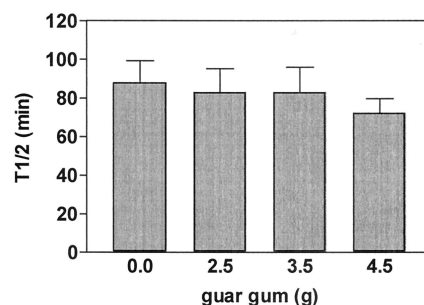
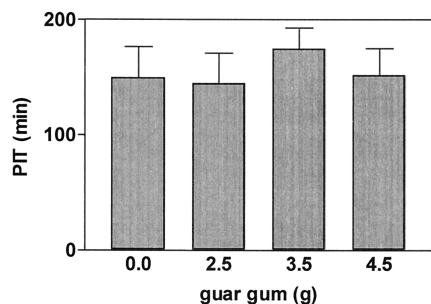


Fig. 2. The effect of different dosages of guar gum on the gastric emptying rate (mean  $\pm$  SD,  $n = 8$ ,  $p = 0.86$ ).



**Fig. 3.** The effect of different dosages of guar gum on the parameter of intestinal transit (PIT) (mean  $\pm$  SD,  $n = 8$ ,  $p = 0.52$ ).

high fat [18,20]) and the quantity of the meals, which were consumed.

The results of the present study clearly indicated that addition of guar gum in dosages ranging from 0 to 4.5 g/200 mL semisolid low-caloric meal led to a large increase in meal viscosity, but has no effect on either the gastric emptying rate or the rate of small intestinal transit. These results suggest that other physiological processes are involved in a possible satiating effect of guar gum. It is useful to distinguish different processes involved in satiety [21]: 1) sensory processes, 2) cognitive processes (these processes will not be discussed in this paper), 3) post-ingestive processes (these include a number of possible actions, including gastric distension, the rate of gastric emptying, small bowel transit, colonic transit, the release of gastrointestinal peptides and hormones and the stimulation of specific nutrient receptors along the gastrointestinal tract) and 4) post-absorptive mechanisms (these include mechanisms arising from the effect of metabolism of glucose, fatty acids and amino acids after small intestinal absorption).

Since addition of guar gum does not result in a change of post-ingestive processes, such as a prolongation of gastric distension due to a decreased gastric emptying rate, or a delay in the rate of intestinal transit, a possible satiating effect of guar gum is not the result of a delayed gastrointestinal transit. However, it might be possible that guar gum addition to a meal induces a prolonged feeling of satiety resulting from the increased viscosity of the meal, leading to a lower intestinal uptake rate of nutrients, which leads to a prolonged exposure of intestinal chemo-receptors to nutrients. The postprandial plasma glucose peak is lower after a meal with guar gum, compared to a meal without guar gum [22]. This is most probably due to a decreased rate of glucose absorption because of an impaired transport of glucose in the lumen. It is likely, however, that this impaired diffusion rate will lead to a prolonged period of intestinal glucose uptake and consequently a prolonged influence on blood glucose and insulin levels. In this respect, it is logical to assume that the monitoring of blood glucose levels by receptors in the brain or in the liver plays a role in controlling appetite.

The combination of gastric emptying measurements with OCTT measurement provides a complete insight in the effect of guar gum on the process of gastrointestinal transit. The hydrogen breath test is a commonly used method to measure small intestinal transit in gastroenterological practice. The method is reliable since every individual has a colonic flora. There are situations in which false-negative or false-positive results can be obtained such as after antibiotic therapy which eradicates the colonic flora or if subjects are suffering from bacterial overgrowth. However, this was not the case in this study since we only included healthy volunteers.

Measurement of the OCTT alone does not provide information about the rate of intestinal transit, since the influence of the gastric emptying component is unknown. Therefore we propose the calculation of a parameter of intestinal transit (PIT) by subtracting the T1/2 from the OCTT. This parameter gives information about the intestinal transit itself, because a correction is made for the gastric emptying component.

In summary, it is concluded that addition of guar gum to a semisolid, low energetic meal, up to a dosage of 4.5 g/200 mL, has no effect on either the gastric emptying rate or the rate of intestinal transit. These results indicate that mechanisms other than gastrointestinal motility and transit might be involved in the satiating effect of guar gum supplementation, as has been observed in other studies. Therefore, it is proposed that further research on the effects of the modified guar gum used in the present study should focus on a combination of postprandial satiety ratings with continuous blood glucose measurements and plasma insulin and GI peptide-and hormone measurements.

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