International Journal of Obesity (1998) 22, 906–909
 0307–0565/98 $12.00
http://www.stockton-press.co.uk/ijo

Effect of hydrolyzed guar fiber on fasting and postprandial satiety and satiety hormones: A double-blind, placebo-controlled trial during controlled weight loss

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OBJECTIVE: To evaluate the effects of a completely soluble fiber on fasting and postprandial hormone levels, respiratory quotient (RQ) and subjective ratings of satiety during a controlled weight-loss program.
DESIGN: In a five-week prospective, randomized, double-blind study, a 3.3 MJ (800 kcal)/d diet was provided during a two-week wash-in period. Then, during the intervention weeks, separated by a one-week wash-out period, a 3.3 MJ (800 kcal) formula containing either 20 g fiber or placebo daily, was given in a cross-over design and on days 1, 3 and 7 of the intervention weeks (weeks 3 and 5) measurements were taken after an overnight fast.
SUBJECTS: 25 obese but otherwise healthy females (age: 46 ± 6 y, body mass index (BMI): 35 ± 6 kg/m^2) were studied.
MEASUREMENTS: Body weight; hunger/satiety ratings; glucose, insulin, cholecystokinin (CCK) and leptin concentrations; RQ during the intervention weeks.
RESULTS: In the fasting state, the supplement had no effect on any of the measured parameters, including blood concentrations of glucose, insulin, CCK, and leptin, RQ and satiety ratings. In the 2 h postprandial period following the test meal, none of the measured parameters differed significantly from that following the non-fiber-supplemented meal, except for the CCK response. CCK demonstrated an overall higher concentration after the fiber-supplemented meal ($P = 0.007$), even after adjustment for age, weight, height and treatment sequence. The postprandial peak in CCK also occurred earlier (at 15 min *vs* 30 min) after completion of the fiber-supplemented meal.
CONCLUSIONS: The results indicated that a hydrolyzed guar gum fiber supplement produced a heightened postprandial CCK response, but did not alter other satiety hormones or increase satiety ratings, in either the fasting or the postprandial state.

Keywords: Obesity; fiber; guar gum; hormone; satiety; leptin; cholecystokinin; insulin; respiratory quotient

Introduction

Although there are controversial data on the effect of dietary fiber on weight loss,[1] there is some evidence that diets high in soluble and insoluble fibers reduce hunger sensation and subsequent food intake.[2–8] Proposed explanations for the satiating effect of dietary fiber include, taste/texture aversion, intolerance of fiber-containing food,[3] prolonged eating time,[4] increased viscosity[9] and delayed gastric emptying.[10] The recently developed modified guar fiber, a partially hydrolyzed guar gum (PHGG),[11,12] which is entirely soluble and has a low viscosity, offers a unique opportunity to test various effects of soluble fiber in a blinded, placebo-controlled fashion, obviating many of the previously noted confounding effects.

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Received 25 August 1997; revised 23 January 1998, 15 April 1998; accepted 27 April 1998

In a recent study, although not blinded, Pasman *et al*[13] showed that the addition of 20 g PHGG to a 4 MJ (970 kcal) diet during one week, reduced hunger feelings during the day and on the following morning. The intent of the present study was to examine the potential effects of PHGG on satiety and satiety-related hormones in a double-blind, placebo-controlled trial during a low-calorie, weight-loss diet.

Subjects and methods

Subjects

Twenty five pre- and postmenopausal, mildly–markedly obese women from the Greater Birmingham community, were selected. The average age was 46 ± 6 y and the body mass index (BMI) averaged 35 ± 6 kg/m^2 (range 30–50 kg/m^2). None had diabetes or thyroid disease at the time of entry into the study. Informed consent was obtained and the study was approved by the Institutional Review Board of the University of Alabama at Birmingham.

Experimental design

During five weeks the subjects underwent a tightly controlled weight-loss diet, with all meals provided by the Department of Nutrition Sciences Metabolic Kitchen. After two weeks on a 3.3 MJ (800 kcal) diet (wash-in period), the subjects were placed on a 3.3 MJ formula diet (Optifast® Drink, Novartis Nutrition Corp., Minneapolis, Minnesota) containing a daily supplement of either 20 g PHGG (Benefiber®, Novartis Nutrition Corp. Minneapolis, Minnesota) or placebo for one week (week 3). After one week of wash-out (identical to the wash-in diet), in a cross-over design, subjects were given the opposite treatment for one week (week 5). The placebo-containing formula was identical to the fiber-containing formula in energy and macronutrient composition (50% carbohydrate, 33% protein, 17% fat, food quotient = 0.89). On the first, third, and seventh day of the intervention weeks (weeks 3 and 5), the subjects underwent measurements of serum glucose, insulin, leptin and plasma cholecystokinen (CCK) concentrations, and hunger/satiety ratings, in the fasting state between 0.600–0.800 h after an overnight fast of at least 10 h. On the seventh day of weeks 3 and 5, serum glucose and insulin, plasma CCK, respiratory quotient (RQ) and hunger/satiety ratings were measured in the fasting state, and at 0, 15, 30, 60 and 120 min after a test meal providing 1331 kJ (320 kcal) of the formula diet, with or without 8 g PHGG. The measurement of time '0 min' refers to the time immediately after consumption of the liquid test meal. Time '0 min' was usually reached within 5 min of the time the subject started to drink the test meal, until she completed it. Consumption generally required 2–4 min. Leptin was not assessed postprandially, since leptin levels appear not to change notably in response to meals.[14,15]

Methods and procedures

Serum glucose was analyzed by the glucose/hexokinase (HK) method (Boehringer Mannheim, Mannheim, Germany) and insulin by a two-site immunoendymometric assay (AIA-PACK IRI, TOSOH, Kyoto, Japan) method. Serum leptin was measured by a radioimmunoassay (RIA), described by Considine *et al.*[16] Leptin values were available only in 19 of the 25 subjects. Plasma CCK samples were collected in C-18 Sep-Pak tubes (Waters Associates, Millford, Massachussetts). Kept frozen, the samples were then analyzed in subject-sets using a bioassay described by Liddle *et al*[17] which is based on the ability of CCK to stimulate amylase release from isolated rat pancreatic acini. RQ measurements were obtained continuously by indirect calorimetry (Sensormetics Deltatrac). After a 30 min assessment of resting RQ, postprandial values were averaged over 9 min around the time points 0, 15, 30, 60 and 120 min. Ratings of hunger-satiety were assessed using a numeric category scale previously described by Haber *et al*[2] and previously used by us in studies of obese subjects.[18] The scale, which includes reference hedonic phrases at points along a numerical spectrum, affords subjects the opportunity to describe their feelings of hunger–satiety anywhere in a numerical range from 0 ('painfully hungry') to 100 ('full to nausea').

Statistical methods

Data analysis was performed using ANCOVA from PROC MIXED of the Statistical Analysis System (SAS). The measured metabolic parameter and hunger/satiety levels were considered to be the independent variables, treatment, time and order were the independent variables. Most of the analyses were done both with and without covariates. Average numbers are displayed as means ± s.d. Besides the arithmetic mean, the geometric mean ($\log_{10}$) was used for glucose, insulin and CCK, in order to reduce the effect of right-skewed values and heterogeneity of variance.

Results

No significant subject differences between treatment-sequence groups existed at baseline (Table 1). The average rate of weight loss during the test period was 0.6 kg/week. During and after supplementation for one week, with partially hydrolyzed guar gum compared to placebo, no differences were found in fasting values of satiety, glucose, insulin, CCK, leptin and RQ (Table 2). In addition, there was no significant fiber effect on 2 h postprandial responses of insulin, glucose, RQ and satiety. The absence of an effect of fiber on fasting and postprandial parameters, remained non-significant after adjustment for age, height, baseline weight, weight change and treatment sequence. However, as shown in Table 2, the fiber-containing meal did cause overall increases in CCK concentrations expressed as $\log_{10}$ during the 2 h postprandial period ($P = 0.007$). This difference remained significant after adjustment for age, height, baseline weight, weight change and treatment sequence. The CCK peak occurred earlier (at 15 min) after the supplemented meal than after the control meal (peak at 30 min).

Table 1 Baseline characteristics of 25 obese females

Parameter	*Group A*[a] *(mean ± s.d.)*	*Group B*[b] *(mean ± s.d.)*	*P value*
Age (y)	46 ± 9	45 ± 8	NS
Weight (kg)	94.0 ± 12.2	90.0 ± 14.1	NS
Body mass index (kg/m^2)	35.4 ± 5.3	34.5 ± 6.0	NS

[a]Group A received fiber supplementation during the third week and placebo during the fifth week.
[b]Group B received fiber supplementation during the fifth week and placebo during the third week.
NS = not statistically significant.

Table 2 Mean (s.d.) values for fasting leptin, and fasting and postprandial satiety, glucose, insulin, cholecystokinin (CCK) and respiratory quotient (RQ)

Treatment	*Time*	*Satiety* [a]	*Glucose (mg/dL)*	*Log_{10} Glucose (mg/dL)*	*Insulin (uU/mL)*	*Log_{10} Insulin (uU/mL)*	*CCK (pmol/L)*	*Log_{10} (CCK + 0.1) (pmol/L)*	*Leptin (ng/mL)*	*RQ*
Fiber	Fasting	46.5 ± 17.2	93.1 ± 10.3	1.97 ± 0.05	14.3 ± 11.9	1.05 ± 0.31	1.80 ± 1.86	0.12 ± 0.42	23.0 ± 15.5	0.78 ± 0.06
	0 min[b]	64.6 ± 18.3	92.8 ± 12.7	1.96 ± 0.06	25.9 ± 31.1	1.17 ± 0.47	4.51 ± 3.58	0.45 ± 0.55	—	0.78 ± 0.06
	15 min	63.0 ± 15.1	102.7 ± 18.9	2.01 ± 0.07	77.7 ± 72.4	1.76 ± 0.35	4.45 ± 2.59	0.60 ± 0.24*	—	0.80 ± 0.07
	30 min	61.3 ± 13.9	104.0 ± 22.2	2.01 ± 0.09	90.2 ± 73.2	1.84 ± 0.32	4.39 ± 4.22	0.46 ± 0.49	—	0.82 ± 0.06
	60 min	62.1 ± 13.5	99.3 ± 22.8	1.99 ± 0.11	51.2 ± 45.4	1.59 ± 0.32	4.27 ± 3.14	0.51 ± 0.41	—	0.85 ± 0.07
	120 min	56.9 ± 16.8	100.6 ± 17.3	2.00 ± 0.08	30.3 ± 23.8	1.36 ± 0.33	3.96 ± 3.93	0.38 ± 0.54	—	0.84 ± 0.07
Placebo	Fasting	44.3 ± 21.0	90.6 ± 10.9	1.95 ± 0.06	13.4 ± 12.7	1.01 ± 0.31	2.13 ± 2.97	0.02 ± 0.58	22.7 ± 19.2	0.78 ± 0.06
	0 min[b]	65.0 ± 18.4	91.0 ± 10.7	1.96 ± 0.05	19.8 ± 18.1	1.10 ± 0.46	3.31 ± 3.03	0.33 ± 0.50	—	0.78 ± 0.05
	15 min	60.8 ± 14.7	99.7 ± 16.0	1.99 ± 0.07	64.5 ± 40.4	1.72 ± 0.33	3.34 ± 3.58	0.32 ± 0.50	—	0.81 ± 0.05
	30 min	61.4 ± 14.2	101.0 ± 17.3	2.00 ± 0.08	82.2 ± 41.1	1.86 ± 0.25	4.89 ± 4.88	0.53 ± 0.38	—	0.82 ± 0.05
	60 min	60.1 ± 13.2	102.4 ± 19.2	2.00 ± 0.08	55.9 ± 50.4	1.62 ± 0.34	3.68 ± 3.50	0.34 ± 0.55	—	0.85 ± 0.05
	120 min	54.3 ± 14.3	99.2 ± 12.1	1.99 ± 0.05	26.5 ± 18.6	1.35 ± 0.25	3.66 ± 3.59	0.37 ± 0.48	—	0.83 ± 0.07

[a]Subjective rating on a scale ranging from 0–100 (see text).
[b]0 time refers to the time immediately after consumption of the liquid test meal, which generally took 2–4 min to consume.
$P < 0.01$, *vs* placebo.

Discussion

The form of soluble fiber used in this study (PHGG), was one which has no viscosity or bulking effect in the gastrointestinal tract and which can be added without the subject's conscious awareness, enabling a completely blinded, placebo-control condition. This is important since, in general, the postprandial satiety measurements are most likely to be affected by the visual aspect of a high-fiber meal (that is, a larger volume of food) or by bulking of the fiber (that is, longer chewing time and possibly delayed gastric emptying). Although the study was performed during a weight-loss period, weight should not have confounded the results, since the study was conducted in a cross-over design and since analyses were adjusted for body weight changes. The results indicate that this form of fiber does not affect appetite during calorie restriction and is therefore not likely to have an impact on the rate of weight loss, as suggested by the data of Pasman *et al*[19] in a long-term study. It is possible that the amount of fiber used (that is, 20 g/d) may have been too small, although this amount is comparable to the amount of fiber recommended for average daily intake of healthy individuals. In another study, the same amount was used and the fasting satiety was increased, reflecting a carry-over effect from the previous day or an adaptation to the seven days of supplementation, which was not seen in our study.[13] Hill *et al*[20] suggest that analog and category scales are of comparable value, although no subjective appetite rating scale is likely to be ideal. Difficulty of interpretation of available hunger-satiety scales, may have decreased the possibility of our detecting a treatment effect. Furthermore, Meier *et al*[21] found that PHGG prolonged colon transit time, but did not delay orocecal transit time. This lack of effect on gastric emptying may be another explanation for our failure to demonstrate a significant satiating effect of fiber.

Assuming that the log transformation, undertaken in order to de-emphasize the effects of a few large values, is the more representative result, an intriguing finding in this study was that the postprandial CCK response was increased by the addition of PHGG to the liquid meal, despite the fact that it was not associated with a greater sense of postprandial satiety. A previous study suggested that CCK can be triggered by the ingestion of PHGG,[21] but the mechanism and role of CCK release is not yet clear. Even without a measurable impact on appetite, higher circulating CCK levels may be of benefit in the treatment of obesity, by way of their known role in preventing gallstone-formation during weight loss.[17,22]

Conclusion

In summary, previously available soluble fiber preparations confer visual, bulking and viscosity effects, which preclude double-blind testing. Use in this study of a partially hydrolyzed guar gum, that is entirely soluble, enables double-blind comparison of all soluble-fiber properties, except for viscosity. The results suggest that soluble fiber enhances the postprandial CCK response, but has no clinically relevant effect on fasting or postprandial hunger-satiety ratings among obese individuals. Soluble fiber is therefore unlikely to play a critical role in weight control.

Acknowledgements
We thank Dr Rodger Liddle and his laboratory for CCK analyses and Ms Lisa Hughes for dietetic assistance. The study was supported by a grant from the Swiss National Fond. Optifast® and the test products were provided by Novartis Nutrition Corp., Minneapolis.

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