European Journal of Clinical Nutrition (2002) 56, 368–377
 0954–3007/02 $25.00
www.nature.com/ejcn

ORIGINAL COMMUNICATION

Dose–response effects of a novel fat emulsion (Olibra™) on energy and macronutrient intakes up to 36 h post-consumption

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Objective: To investigate the dose–response effects of a novel fat emulsion (Olibra™) on energy and macronutrient intakes up to 36 h post-consumption in non-overweight subjects.
Design: A single-blind, placebo-controlled, within-subject cross-over design was used.
Setting: Metabolic suite of the University of Ulster, Coleraine.
Subjects: Fifty subjects (30 female, 20 male) from the student and staff population of the University of Ulster, Coleraine.
Interventions: Subjects were given in random order, 7 days apart, a 200 g portion of yoghurt containing a total of 15 g of fat, which varied in quantity of Olibra™ fat (0, 2, 4, 6 g) at 09:00 h. At 13:00 h subjects were given *ad libitum* access to a range of foods. Amounts of food consumed were measured by covert pre- and post-consumption weighing of individual serving dishes. For the remainder of the day and the following 24 h, subjects weighed and recorded all food intakes.
Results: Relative to the control yoghurt, mean energy (7.42 *vs* 5.83, 5.60, 5.24 MJ), fat (97.4 *vs* 74.4, 74.2, 67.5 g; 48.8 *vs* 46.8, 48.9, 47.6% energy), protein (59.1 *vs* 50.0, 44.0, 40.8 g; 13.2 *vs* 13.9, 12.9, 12.8% energy), and carbohydrate (171.5 *vs* 140.9, 130.2, 126.0 g; 38.0 *vs* 39.3, 38.2, 39.6% energy), intakes were progressively reduced with increasing doses of Olibra™ fat in the total group ($P < 0.001$). A similar response was observed in the female group up to 4 g ($P < 0.001$) and in the male group after 2 and 6 g ($P < 0.05$). Energy and macronutrient intakes for the remainder of each study day and over the following 24 h were significantly lower after all dose levels compared to the control ($P < 0.001$).
Conclusion: The results suggest that Olibra™ fat reduced the effect of overeating during an *ad libitum* lunch meal and subsequent food intake up to 36 h post-consumption.
Sponsorship: Scotia Pharmaceuticals Limited.
European Journal of Clinical Nutrition (2002) **56,** 368–377. DOI: 10.1038/sj/ejcn/1601326

Keywords: fat; emulsions; energy intake; satiety

Introduction

Although current research suggests that fat is the least satiating of the macronutrients (Rolls & Hammer, 1995), the issue remains unresolved (Welch *et al*, 1988; de Graaf *et al*, 1992; Blundell *et al*, 1996). It is possible that methodological differences between study designs may have contributed to this controversy (Rolls *et al*, 1988; de Graaf *et al*, 1992). Differences in meal type (Kissileff, 1984), energy density and macronutrient composition (Prentice & Poppitt, 1996; Westerterp-Plantenga *et al*, 1996; Bell *et al*, 1998), duration of time between a preload and a test meal (Rolls *et al*, 1991a; Horn *et al*, 1996; Melanson *et al*, 1999) and characteristics of subject populations (Drewnowski *et al*, 1985; Mela & Sacchetti, 1991) have all been shown to influence the satiating efficiency of fat. Furthermore, different physicochemical properties of fats could influence their satiating properties. These include fatty acid chain length (Bach *et al*, 1996; Stubbs & Harbon, 1996; Van Wymelbeke

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Contributors: **AAB executed the practical work and took overall responsibility for writing the paper. MBEL and RWW are grant holders and assisted in devising the study protocol and writing the paper. AD carried out the statistical analysis. IRR is a grant holder and assisted in writing the paper.**
Received 18 June 2001; revised 29 August 2001; accepted 6 September 2001

et al, 1998), degree of fatty acid unsaturation (Shimomura *et al*, 1990; Lawton *et al*, 1997; Kamphuis *et al*, 2001), degree of emulsification (Welch *et al*, 1985, 1988) and emulsion stability (Armand *et al*, 1992). In this context it has recently been shown that a fat emulsion (Olibra™) formulated from palm oil and oat oil fractions significantly decreased energy and macronutrient intakes in lean, overweight and obese subjects up to 36 h post-consumption (Burns *et al*, 2000, 2001). The aim of the present study is to investigate if the responses to this novel fat emulsion and the subsequent effects of these on food intakes are dose-dependent.

Subjects and methods

Subjects

Fifty subjects (30 females, 20 males) were recruited by poster advertisement from the student and staff population at the University of Ulster. The study protocol was explained in detail to each subject, and the subjects who met the eligibility criteria and agreed to take part gave their written informed consent. Inclusion criteria were: body mass index (BMI) 20–25 kg/m^2, non-smokers, non-vegetarians, non-restrained eaters as assessed by the Dutch Eating Behaviour Questionnaire (Van Strien *et al*, 1986), not taking any prescription medication and non-participants in any previous study using Olibra™ fat. The weight, height and percentage body fat (bioelectrical impedance Bodystat 1500, Bodystat Ltd, Isle of Man, UK) of each subject were measured prior to breakfast on the first study day. The study was approved by the Research Ethical Committee of the University of Ulster.

Study design

This study was conducted over 3 months in the metabolic suite at the University of Ulster. The metabolic suite consists of a food preparation area, which is separate from an independent dining area, where six subjects can eat comfortably. The study design was a randomised, single-blind, placebo-controlled, within-subject cross-over. Each subject was studied on four occasions, on the same day of each week, and with a one-week interval between study days. Each subject came to the metabolic suite at 18:00 h on the evening prior to each study day and consumed (on each occasion) the same evening meal in terms of weight of food, energy and macronutrient composition. Subjects were asked to refrain from moderate-to-heavy exercise on each study day and on the day before and the day after each study day. After the evening meal prior to each study day, subjects were requested to fast from 20:00 h until 08:45 h the following day, when they came to the metabolic suite and consumed a 200 g portion of yoghurt containing varying doses of Olibra™ fat or a control containing only milk fat. After eating the yoghurt, subjects remained in the metabolic suite and were not permitted to consume anything other than uncarbonated water, if required. At 13:00 h subjects were given *ad libitum* access to a range of sweet and savoury foods compatible with the stated food preferences of the subjects. Uncarbonated water was available to drink at meal times. All foods presented at 13:00 h were covertly weighed prior to the meal, and all uneaten food was weighed after the meal when the subjects had left the metabolic suite. Intakes were assessed by difference. After the lunch meal subjects were free to leave the metabolic suite. For the remainder of the day, and up until 21:00 h the following day, subjects were permitted to eat and drink as they wished, but were instructed to keep a weighed record of all food and beverages consumed during this period using a set of weighing scales (Digital Scale, Model 308, Ravencourt Ltd, UK) and a food diary.

Test foods

Test yoghurt. The composition of all yoghurts was matched for energy and macronutrient content (1165 kJ, 6.8 g protein, 15 g fat, 28.8 g carbohydrate per 200 g portion). Depending on the dose, the 15 g of fat comprised a combination of Olibra™ fat emulsion (Scotia LipidTeknik, Stockholm, Sweden) and/or milk fat. The doses of Olibra™ fat emulsion were 5, 10 and 15 g, which corresponded to a content of 2, 4 and 6 g of Olibra™ fat, respectively. The control yoghurt contained 15 g of milk fat (40% fat emulsion). Olibra™ fat is a food ingredient containing fractionated palm oil and fractionated oat oil in the proportions 95:5, dispersed in water to give a total fat content of 42% (w/w). The percentage fatty acid composition of Olibra™ fat compared to milk fat is as follows: palmitic (16:0), 42.1 *vs* 26.8; stearic (18:0), 4.3 *vs* 11.5; other saturates, 2.1 *vs* 25.8; oleic (18:1), 40.1 *vs* 28.7; linoleic (18:2), 10.4 *vs* 1.4; and other unsaturates, 1.0 *vs* 5.8. The yoghurt was supplied by Skane Mejerier, Lunnarp, Sweden.

Lunch meal

The lunch meal was a buffet-style, self-selection meal that allowed *ad libitum* consumption of a variety of foods that varied in macronutrient composition (Table 1). All foods were served in larger than estimated average portions so that choice was not restricted by quantity. Different types of food were served in separate serving dishes so as not to influence food combination choices. Unlimited eating time was given to each subject. Uncarbonated water was available to drink.

Assessment of appetite

Subjects rated their hunger, desire to eat and perceived fullness on visual analogue scales (VAS; in mm) by the pen and paper method. For example, hunger was rated on a 100 mm line preceded by the question 'How hungry do you feel?' and anchored on the left by 'not at all hungry' and on the right by 'as hungry as I have ever felt'. The other anchors for the questions on desire to eat and perceived fullness consisted of the phrases 'very weak…' against 'very strong…', and 'not

Table 1 Nutrient composition (per 100 g) of foods offered to subjects at the lunch meal (4 h post-consumption of yoghurt)

Menu items	*Portion size (g)*	*kJ (kcal)*	*Protein (g)*	*Fat (g)*	*CHO (g)*
Ham, cheese and tomato sandwich	185	900 (215)	8.7	12.6	16.7
Chicken salad sandwich	200	880 (210)	8.7	12.6	16.7
Pizza	220	995 (237)	9.1	11.8	25.2
Sausage rolls	60	1596 (383)	9.9	27.6	25.4
Mushroom soup	300	135 (32)	0.6	1.8	3.4
Crackers	28	1857 (440)	9.5	16.3	68.3
Stilton cheese	15	1701 (411)	22.7	35.5	0.1
Edam cheese	18	1382 (333)	26.0	25.4	0.0
Potato crisps	27	2215 (530)	5.7	34.2	53.3
Apple	120	185 (43)	0.3	0.2	10.8
Orange	160	158 (37)	1.1	0.1	8.5
Banana	160	403 (95)	1.2	0.3	23.2
Fruit yoghurt	250	382 (90)	4.1	0.7	17.9
Swiss roll	27	1812 (433)	5.4	20.5	20.5
Kit kat	22	2098 (500)	7.5	26.0	63.0
Crunchie	17	1945 (465)	4.2	18.3	70.9
Fig rolls	50	1439 (341)	3.5	7.8	64.2

at all…' against 'extremely full…', for each of the questions, respectively. Subjects were instructed to make a single vertical mark at the appropriate point between the two anchors on each scale to indicate their subjective feelings of hunger, desire to eat and perceived fullness, respectively, at defined time points (immediately before and after eating the yoghurt and thereafter at hourly intervals until 21:00 h on all study days). Yoghurts were rated for pleasantness of taste by the subjects using a VAS form 15 min post-consumption of all yoghurts.

Statistical analysis

Energy (MJ) and macronutrient (g) intakes, and the weight (g) of the food consumed at the *ad libitum* lunch meal, subsequent evening meal and snacks, and intakes for the following 24 h were analysed using Wisp 1.28 C (Tinuviel Software, 2 Penmark Close, Warrington, UK). The data from the total group and the female and male groups separately at 4 h post-consumption were analysed using a general linear mixed effects model. Subjects were treated as random and the fixed effects were treatment, treatment-order, treatment period and 'carry-over'. The treatment effect refers to the energy and macronutrient intakes after the test yoghurts relative to their intake after the control yoghurt. The treatment-order effect compared the intakes of the subjects who received the varying doses of Olibra™ fat in different order (group 1, 0 g; group 2, 2 g; group 3, 4 g; group 4, 6 g). The 'carry-over' term represents the possible effects of treatment in one treatment period carrying over to the next treatment period. Differences in 'carry-over' should not be present because they contaminate the data from the second, third etc treatment periods. Non-significant ($P > 0.05$) 'carry-over' terms were omitted from the model when testing treatment effects. The energy and macronutrient intakes for the remainder of the evening and the following 24 h for the total group of subjects were analysed by a general linear model procedure (Jones & Kenward, 1989). Analyses of energy and macronutrient intakes were performed using the SAS statistical program (SAS Institute Inc., Cary, NC, USA).

The visual analogue ratings were analysed using a mixed procedure model by calculating a mean rating for each 14 h (pre- and post-yoghurt, 10:00–21:00 h) period. Real mean values were used for reporting hunger, desire to eat, fullness and pleasantness of taste ratings. VAS were analysed using the SAS statistical program (SAS Institute Inc., Cary, NC, USA). Results were considered significant at the $P < 0.05$ level.

Results

Subjects

No subjects reported any ill effects or discomfort after consumption of any of the yoghurts. The male subjects were significantly older, taller and had significantly higher BMIs and lower percentage body fat than the female subjects ($P < 0.05$ for each parameter; Table 2).

Table 2 Characteristics of subjects[a]

	Total group (n = *50*)	*Females* (n = *30*)	*Males* (n = *20*)
Age (y)	25.2 ± 3.08	24.0 ± 2.06[b]	26.5 ± 4.11
Height (m)	1.7 ± 0.07	1.63 ± 0.07[b]	1.78 ± 0.07
Weight (kg)	67.2 ± 6.8	58.7 ± 6.14[b]	75.7 ± 7.45
BMI (kg/m^2)	22.9 ± 2.25	22.0 ± 2.38[b]	23.8 ± 2.12
Body fat (%)	22.8 ± 1.67	21.9 ± 1.23[b]	23.8 ± 2.12

[a] $\bar{x} \pm$ s.d.
[b] Significantly different from male subjects ($P < 0.05$).

Energy and macronutrient intakes at the lunch meal

The mean energy and macronutrient intakes, the total weight of food and water consumed 4 h post-consumption of all yoghurts for the total group are presented in Table 3, while the data for female and males groups separately are presented in Table 4. For the total group of subjects and the female and male groups there was no evidence of a treatment-order or 'carry-over' effect at the *ad libitum* meal 4 h post-consumption of the test yoghurts. Thus, non-significant ($P > 0.05$) interaction terms were omitted from the model when testing treatment effects.

Relative to the control conditions, the energy intakes (MJ) in the total group were lower by 21, 25 and 30% after the 2, 4 and 6 g doses, respectively ($P < 0.001$ at each dose level; Table 3). The corresponding macronutrients (g) and weight of food (g) were also significantly lower ($P < 0.001$ at each dose level). Water intakes (ml) at each dose level were not significantly different from the control condition ($P > 0.05$). However, the differences between doses were not significant, with the exception of the 6 g dose where energy ($P < 0.05$), protein ($P < 0.01$) and carbohydrate ($P < 0.05$) intakes were significantly lower compared to the 2 g dose of Olibra™ fat.

In the female group, energy (MJ) and macronutrient intakes (g) and the total weight of food (g) were also significantly lower following consumption of all doses of Olibra™ fat relative to the control condition ($P < 0.05$ at each dose level; Table 4). However, intakes of energy, fat, protein and carbohydrate following the 4 and 6 g doses were broadly similar. Compared to the lowest dose of 2 g of Olibra™ fat, intakes of energy ($P < 0.05$), carbohydrate ($P < 0.05$) and the total weight of food ($P < 0.05$) were significantly lower after the ingestion of the 4 and 6 g doses, and protein ($P < 0.05$) after the 6 g dose. Water intakes (ml) at each dose level were not significantly different from the control condition ($P > 0.05$).

Only at the 2 and 6 g dose levels were energy (MJ) and macronutrients (g) significantly lower in the male subjects relative to the control condition ($P < 0.05$ at each dose level; Table 4). Following the consumption of 4 g of Olibra™ fat, energy (MJ), fat (g), protein (g) and carbohydrate (g) intakes together with the total weight of food (g) were not significantly different from those of the control condition. However, after the 6 g dose there were significantly lower intakes of energy ($P < 0.05$), fat ($P < 0.05$) and protein ($P < 0.05$) compared to the lower dose of 4 g (Table 4). Similarly to the female subjects there was no significant difference in water intakes (ml) at each dose level compared to the control condition ($P > 0.05$).

Energy and macronutrient intakes for the remainder of the evening and the following 24 h

There were no significant differences in energy intakes between the female and male subjects for the remainder of the evening and the following 24 h and therefore results are shown for the total group in Figures 1 and 2. At both times, intakes of energy (MJ) and the corresponding macronutrients (g) were significantly lower ($P < 0.001$) after each dose level compared to the control, but the reductions between dose levels of Olibra™ fat were not significant. A 'carry-over' effect was observed in the self-recorded food intakes. This 'carry-over' effect represents the effects of one treatment period carrying over to the next treatment period. However, as there was a 7 day interval between each study day this 'carry-over' effect is most likely to be a consequence of outliers in the data.

Subjective hunger, desire to eat, fullness and pleasantness of yoghurts

The mean ratings for hunger, desire to eat and perceived fullness after all doses of Olibra™ fat over each study day are shown in Figures 3–5. There were no significant differences

Table 3 Energy and macronutrient intakes at 4 h post-consumption of the yoghurts containing increasing doses of Olibra™ fat, for the total group ($n = 50$)[a]

	Olibra™ fat (g)			
	0 (control)	*2*	*4*	*6*
Energy intake (MJ)	7.42 ± 1.89	5.83 ± 1.91[b]	5.60 ± 1.89[b]	5.24 ± 1.91[b,c]
Fat (g)	97.4 ± 2.66	74.4 ± 2.69[b]	74.2 ± 2.66[b]	67.5 ± 2.69[b]
Percentage energy	48.8	46.8	48.9	47.6
Protein (g)	59.1 ± 1.48	50.0 ± 1.49[b]	44.0 ± 1.48[b]	40.8 ± 1.49[b,c]
Percentage energy	13.2	13.9	12.9	12.8
Carbohydrate (g)	171.5 ± 4.78	140.9 ± 4.83[b]	130.2 ± 4.77[b]	126.0 ± 4.83[b,c]
Percentage energy	38.0	39.3	38.2	39.6
Weight of food eaten (g)	770.2 ± 21.8	624.6 ± 22.0[b]	590.2 ± 21.7[b]	594.7 ± 22.0[b]
Water (ml)	415.8 ± 20.8	446.5 ± 19.5[d]	463.6 ± 20.3[d]	420.6 ± 19.5[d]

[a]$\bar{x} \pm$ s.e.m.
[b]Significantly different from control ($P < 0.05$).
[c]Significantly different from 2 g ($P < 0.05$).
[d]Not significantly different from control ($P > 0.05$).

Table 4 Energy and macronutrient intakes at 4 h post-consumption of the yoghurts containing increasing doses of Olibra™ fat, for the female and male subject groups[a]

	Females (n = 30) Olibra™ fat (g)				*Males (n = 20) Olibra™ fat (g)*			
	0 (control)	*2*	*4*	*6*	*0 (control)*	*2*	*4*	*6*
Energy intake (MJ)	6.99 ± 2.18	5.25 ± 2.20[b]	4.59 ± 2.18[b,c]	4.58 ± 2.23[b,c]	8.04 ± 3.45	6.72 ± 3.46[b]	7.17 ± 3.46	6.18 ± 3.44[b,d]
Fat (g)	92.6 ± 3.13	68.0 ± 3.16[b]	62.8 ± 3.13[b]	60.7 ± 3.20[b]	103.7 ± 4.75	84.5 ± 4.77[b]	92.0 ± 4.77	77.2 ± 4.74[b,d]
Percentage energy	49.5	47.7	50.5	48.7	47.8	46.3	47.6	46.4
Protein (g)	54.0 ± 1.78	39.9 ± 1.80[b]	34.4 ± 1.78[b]	34.3 ± 1.81[b,c]	66.7 ± 2.60	57.8 ± 2.61[b]	58.4 ± 2.61	50.5 ± 2.60[b,d]
Percentage energy	12.5	12.4	12.2	12.3	13.6	14.0	13.5	13.4
Carbohydrate (g)	160.7 ± 5.57	127.6 ± 5.63[b]	104.3 ± 5.57[b,c]	109.1 ± 5.69[b,c]	187.7 ± 8.63	162.7 ± 8.65[b]	169.2 ± 8.65	150.7 ± 8.60[b]
Percentage energy	38.0	39.9	37.3	39.0	38.6	39.7	38.9	40.2
Weight of food (g)	718.5 ± 24.1	566.4 ± 24.4[b]	479.8 ± 24.1[b,c]	512.2 ± 24.6[b,c]	843.6 ± 40.7	719.4 ± 40.8[b]	757.6 ± 40.8	713.0 ± 40.6[b]
Water (ml)	330.6 ± 19.3	392.0 ± 20.1[e]	413.3 ± 19.3[e]	354.0 ± 20.1[e]	501.0 ± 22.3	498.5 ± 19.0[e]	514.0 ± 21.2[e]	487.3 ± 18.9[e]

[a]$\bar{x} \pm$ s.e.m.
[b]Significantly different from control ($P < 0.05$).
[c]Significantly different from 2 g ($P < 0.05$).
[d]Significantly different from 4 g ($P < 0.05$).
[e]Not significantly different from control ($P > 0.05$).

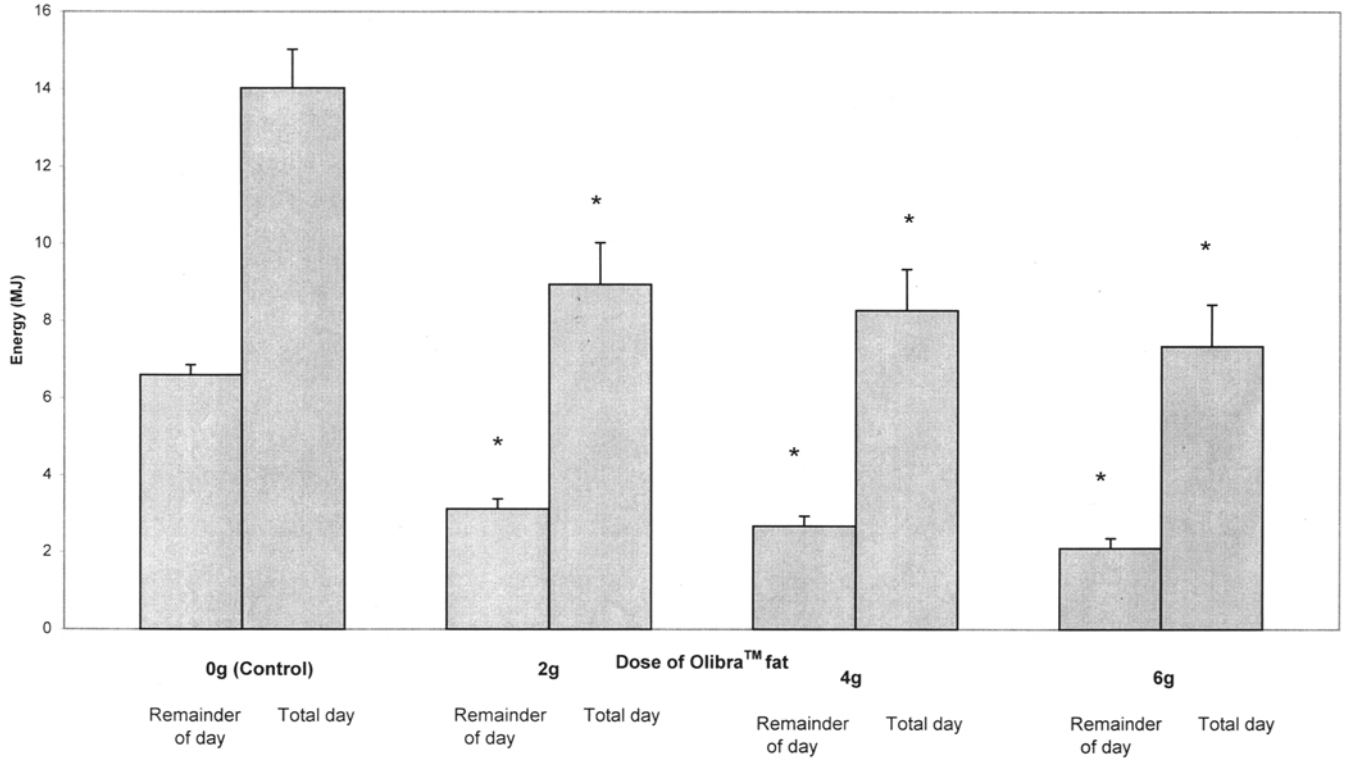

Figure 1 Mean ± s.e.m. energy intakes (MJ) for the remainder of each study day and total intake for the day, for the total group ($n = 50$). *Significantly different from control ($P < 0.05$).

in hunger, desire to eat or perceived fullness between the varying doses of Olibra™ fat and the control yoghurt. No significant differences in the subjectively rated pleasantness of taste of the yoghurts were observed (Table 5).

Discussion

The present study confirms previous observations that yoghurt containing Olibra™ fat significantly reduces energy and macronutrient intakes relative to milk fat

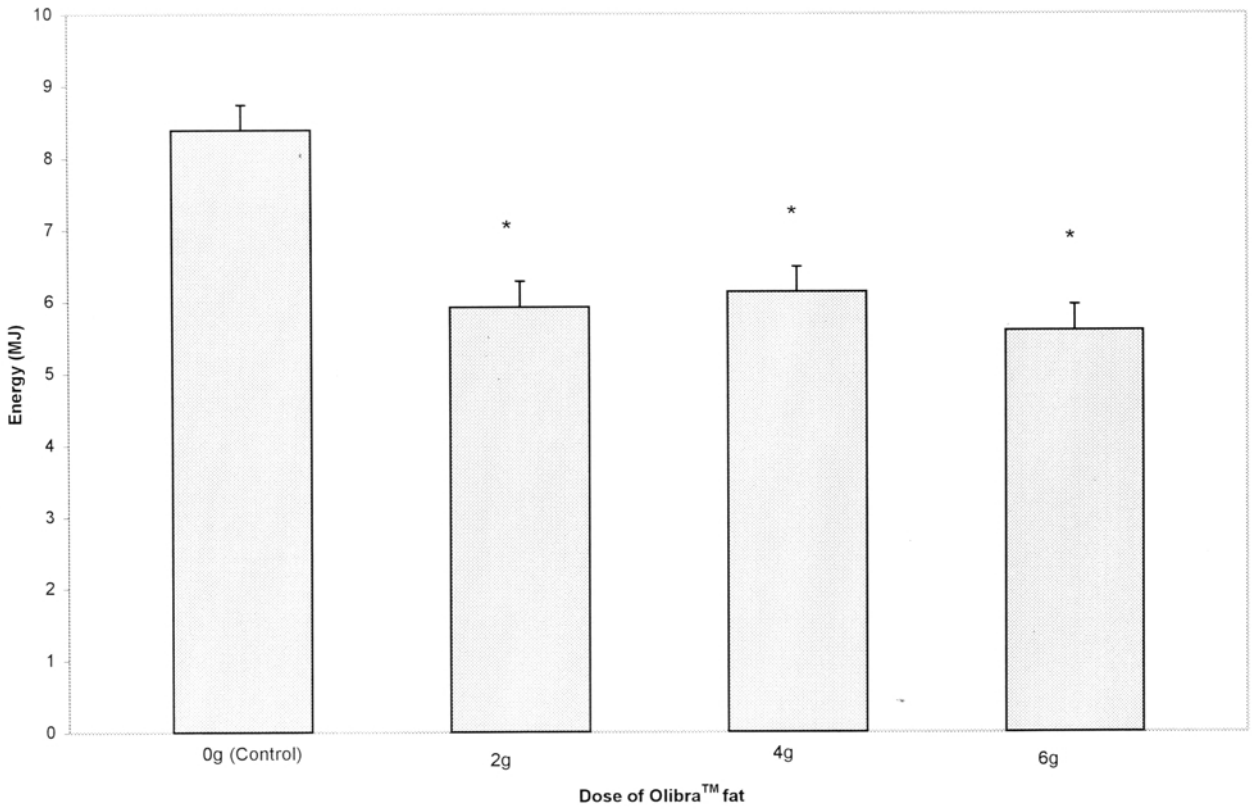

Figure 2 Mean ± s.e.m. energy intakes (MJ) for the following 24 h (post-study day) for the total group ($n = 50$). *Significantly different from control ($P < 0.05$).

(Burns *et al*, 2000, 2001). The present study has also shown that, when using a dose-response paradigm, which is a sensitive test of differences in satiety (Rolls & Hammer, 1995), the effects of Olibra™ fat generally increase with increasing doses. The results suggest that the reductions in food intake were by a non-specific reduction in overall energy intake, given that the percentages of energy from the macronutrients were not significantly different under test and control conditions. However, a greater fat-specific satiety may be expected in the medium-to-long term given that the test yoghurts contained a higher amount of linoleic acid which has been shown to induce fat-specific satiety (Beardshall *et al* 1989; Lawton *et al*, 1997; Kamphuis *et al*, 2001).

In the total group, energy intakes were lower by 21% (1.59 MJ), 25% (1.82 MJ) and 30% (2.18 MJ) after the 2, 4 and 6 g dose levels, respectively, compared to the control condition. Overall this indicates that the minimum dose tested (2 g) gives a significant and substantial lowering of energy intakes, and that although two-fold or three-fold increases in the dose enhanced the responses, these enhancements were not proportional to the dose. This suggests that it may be informative to evaluate response at doses below the minimum 2 g evaluated here. However, there were some interesting differences in response between males and females. While both the male and female group showed significant lowering of energy intakes after the 2 g dose, the response was greater in the females (25%; 1.74 MJ) than in the males (16%; 1.32 MJ). In the female group, the response increased with the 4 g dose (34%; 2.4 MJ) but showed no further increase at the 6 g dose. In contrast the response of the male group was lower after the 4 g dose (11%; 0.87 MJ), but increased further after the 6 g dose (23%; 1.86 MJ). In a previous experiment where a 5 g dose was tested in two separate but similar studies, it was found that males gave very similar reductions in energy intake (10%; 0.89 MJ and 11%; 1.00 MJ), and these are in close agreement with those reported here with the 4 g dose (Burns *et al*, 2000). However, in the previous experiment the females gave somewhat divergent responses to the 5 g dose (22%; 1.48 MJ and 14% 0.95 MJ) and those responses were lower than that observed at the 4 g dose in the present study. This inconsistency is attributed to unexplained experimental variables, such as unaccounted for variations in subject characteristics. However, overall it is apparent that female subjects respond more than males, regardless of dose and there are a number of possible explanations for this. These include gender

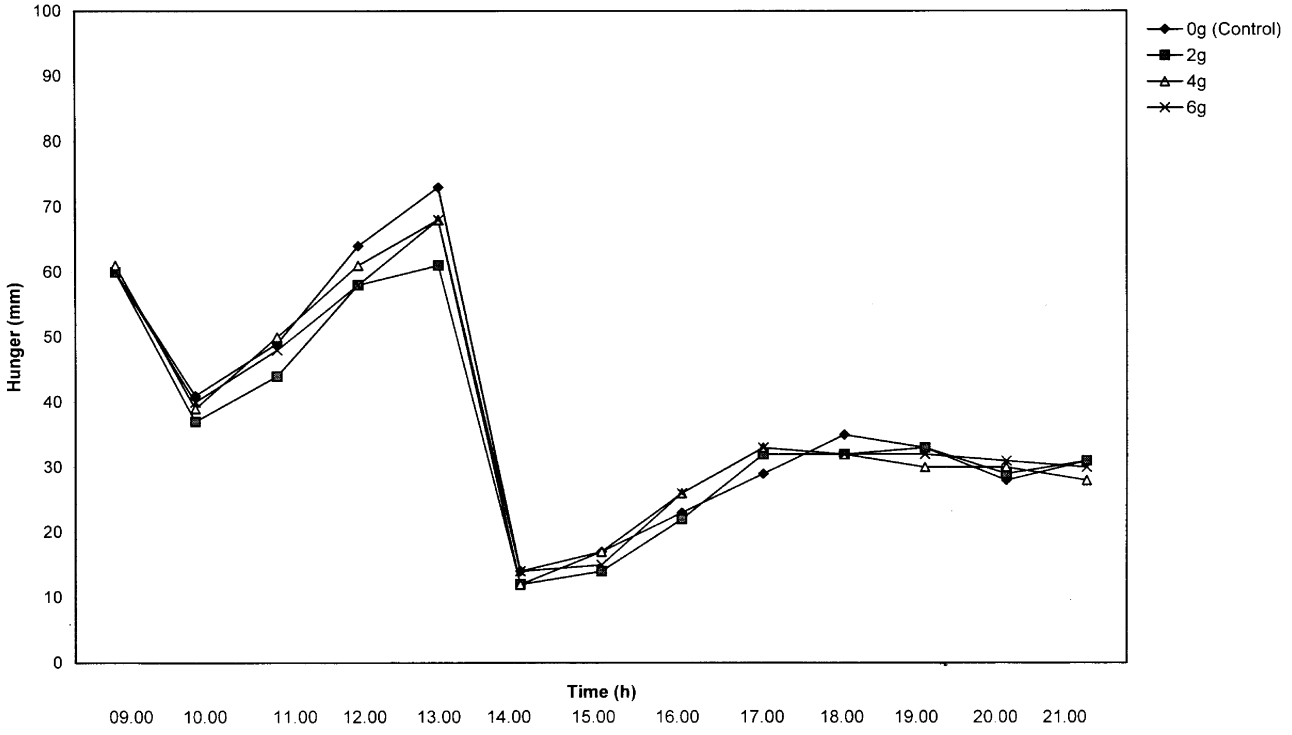

Figure 3 Subjective scores for hunger (mm) from 09:00 h until 21:00 h for the total group ($n = 50$).

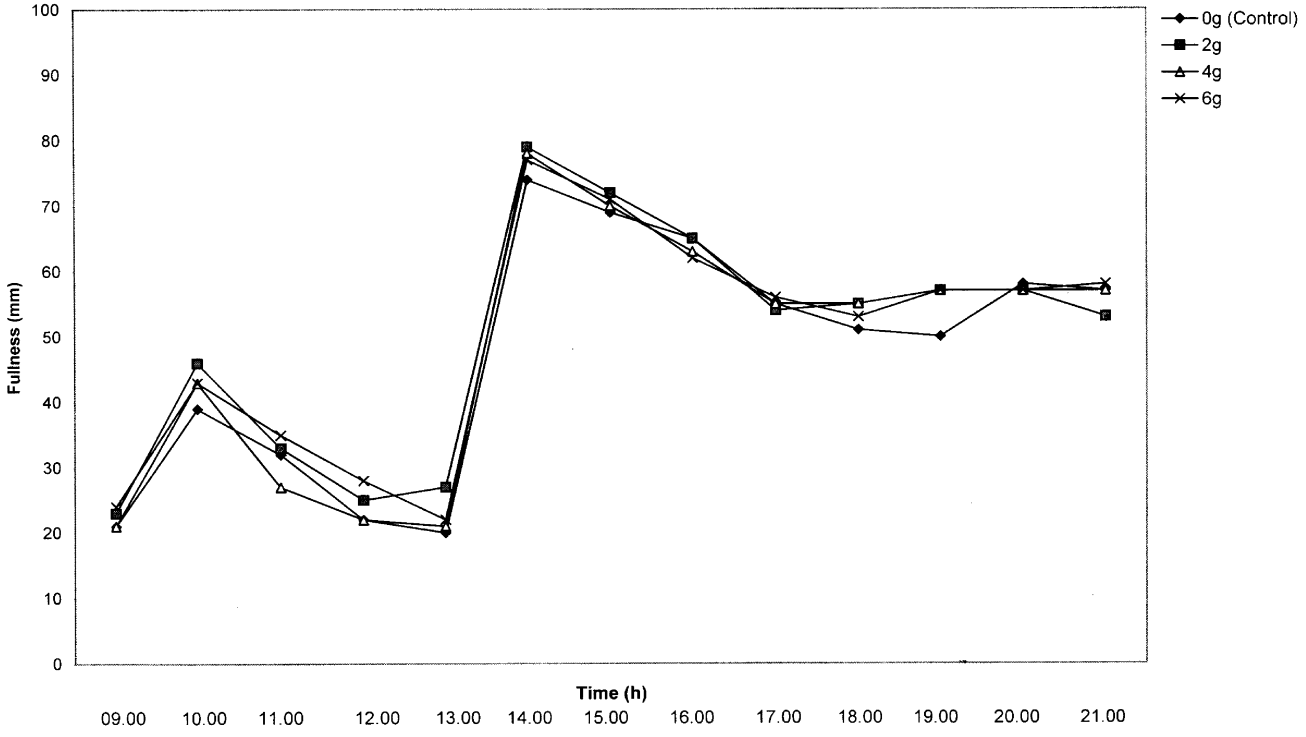

Figure 4 Subjective scores for fullness (mm) from 09:00 h until 21:00 h for the total group ($n = 50$).

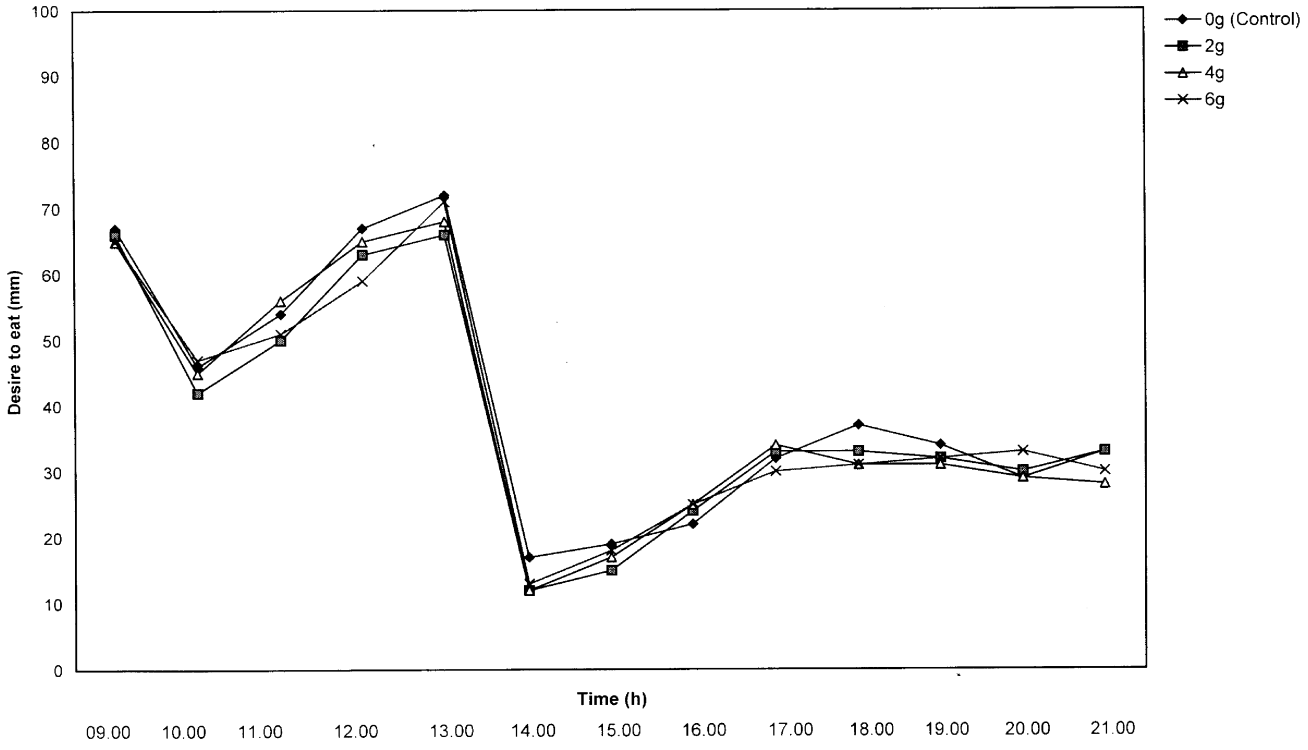

Figure 5 Subjective scores for desire to eat (mm) from 09:00 h until 21:00 h for the total group ($n = 50$).

Table 5 Subjective scores of perceived pleasantness of taste of all doses of Olibra™ fat for the total group and for the female and male groups[a]

Olibra™ fat (g)	*Total group (n = 50)*	*Females (n = 30)*	*Males (n = 20)*
0 (control)	73.8[b]	82.0[b]	65.6[b]
2	76.3[b]	80.1[b]	72.6[b]
4	70.1[b]	69.8[b]	70.5[b]
6	70.9[b]	72.3[b]	69.6[b]

[a]Mean.
Same superscript letter indicates no significant difference ($P > 0.05$).

differences in food intake and selection (Rolls *et al*, 1991b) or that, as a result of their lower body weight, the females received higher doses of Olibra™ fat per kg body weight. This latter explanation seems plausible, since in this experiment, at each dose level, the females received 28% more Olibra™ fat than the males on a per kg body weight basis. In the present study it is not possible to make any comparisons between females and males where the doses are similar on a per kg body weight basis. However, a comparison can be made with data from the earlier report where the doses for females were 82 mg Olibra™ fat per kg body weight in both studies, and energy intakes were lower by 22 and 14% (1.48 and 0.95 MJ; Burns *et al*, 2000). These responses are similar to that found for males in the present study at the 6 g dose level, where the energy intake was lower by 23% (1.86 MJ), and the dose was 79 mg Olibra™ fat per kg body weight.

Under control conditions the energy intake (14.0 MJ) for the total group on the first study day was 40% higher than energy intake (8.4 MJ) on the second day. The validity of the observed intakes at lunch on day one suggests that the high energy intakes during this study day are probably a consequence of over-eating. The wide range of foods on offer at the buffet lunch may have undermined normal physiological satiety signals. On the other hand, it is possible that the energy intake on the second study day could reflect not only under-eating as a compensatory response to over-eating on day one but also under-reporting of this lower food intake. The data from the self-reported food diaries of energy and macronutrient intakes for the remainder of the study day, and also over the following day, suggest that the suppression of food intake under test conditions continued over this period, with the greatest difference observed after 6 g of Olibra™ fat. The 'carry-over' effect observed in the self-recorded food intakes was most likely a consequence of the number of outliers in the data. These outlying data may be a result of the mis-reporting of food intakes, since self-reported food intakes are well recognised to be susceptible to under-reporting (Livingstone *et al*, 1990; Black *et al*, 1993).

It has been suggested that the observed lowering in energy and macronutrient intakes following the consumption of Olibra™ fat was a result of the 'ileal-brake' mechanism (Burns *et al*, 2000, 2001), ie the inhibition of upper gastrointestinal functions elicited by the presence of unabsorbed nutrients in the ileum (Zhao *et al*, 2000). The 'ileal-brake' appears to be related to the release of one or more peptide hormones from the distal intestine. This study has not tested for metabolic effects after the consumption of Olibra™ fat. However, as the 'ileal-brake' has been shown to be dose-dependent (Pironi *et al*, 1993), this is compatible with the present results, given that when dose levels of Olibra™ fat increased, energy and macronutrient intakes were further lowered. Thus, it may be that Olibra™ is acting through an increased and prolonged release of peptides such as peptide YY (Pironi *et al*, 1993), cholecystokinin (Lieverse *et al*, 1994; Smith & Gibbs, 1994), glucagon-like peptide-1 (Naslund *et al*, 1998; Giralt & Vergara, 1999), or enterostatin (Erlanson-Albertson & York, 1997; Lin *et al*, 1997) which are known to influence satiety through the 'ileal-brake'.

In conclusion, this study has shown that the effects of Olibra™ increase with increasing doses but results are not consistent across gender or dose levels and further work is required to establish if the maximum effective dose is dependent upon body weight.

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