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Effects of Liquid Preloads with Different Fructose/Fibre Concentrations on Subsequent Food Intake and Ratings of Hunger in Women

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Preloads (250 ml) of 2% or 10% fructose containing 1% soluble fibre and 1% insoluble fibre or 10% fructose with 3% soluble fibre and 1% insoluble were administered 60 min before lunch to 24 healthy women, who were slightly overweight and considerably weight concerned. The fibre consisted of guar gum, partly hydrolysed for the soluble form. The placebo consisted of a solution of sweeteners (cyclamate and saccharin). After the experiment with three preload-types and a placebo, a random subset of 15 subjects returned for an experiment with one preload-type and a placebo, given 30 or 60 min before lunch. Food intake during the subsequent lunch was only significantly different from after the placebo in this subset of 15 subjects after the 10% fructose/3% soluble and 1% insoluble fibre preload after intervals of 30 or 60 min. However, energy intake of preload and meal was significantly higher than energy intake of placebo and meal. At the 30-min delay, eating rate was significantly lower after the preload than after the placebo; also, hunger ratings were lower after intake of a preload and meal than after intake of the placebo + meal, from immediately after lunch until 5 hours later. Energy intake over 24 h was not affected by administration of fructose/fibre or placebo 30 or 60 minutes before lunch in the 24 women.

Introduction

When consumed before a meal, fibre reduces intake and so might aid weight control (Porikos & Hagamen, 1986; Rigaud *et al.*, 1987; Burley *et al.*, 1987). Fructose also reduces food intake but little or nothing is known of dose effects or time course (Rodin, 1990). Mechanisms like deceleration of gastric emptying and release of gut hormones are supposed to act on satiety and food intake, and postponed intake might result in reduced intake (Blundell & Burley, 1987; Rodin, 1990). In this study, liquid preloads containing different concentrations of fructose and fibre were consumed either 30 or 60 min before lunch, and the effects were assessed on food intake and eating rate at lunch, hunger ratings recorded during the 5 h after preload administration, and 24-h food intake.

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METHODS

Subjects

From responses to an article in the local newspaper and in the university newspaper, 50 women were recruited for this experiment. Selection of 24 subjects was according to health status (no high blood pressure, no diabetes mellitus, no other disease), age 24–40), and BMI (23–29). Weight and height in indoor clothes, without shoes, were used to calculate body mass index (BMI = kg/m^2). Subjects completed two questionnaires (Herman & Polivy, 1980; Stunkard & Messick, 1985) to distinguish between restrained ($n = 12$) and unrestrained ($n = 12$) eaters. Subjects with a score of >15 on the Herman-Polivy questionnaire and a score of >9 on the cognitive restraint factor of the Three Factor Eating Questionnaire (the median in our subject population) are defined as restrained eaters (Westerterp-Plantenga *et al.*, 1991). All subjects received a complete written description of the experiment and signed their informed consent. Subjects were told that the preloads were a type of fruit juice, as it looked exactly like a cloudy juice, and that one of them was a placebo.

Experimental Design

All subjects came five times for lunch at the Nutrition Research Centre, at the same time on the same day of the week for five consecutive weeks. The effect of different fructose/fibre preload concentrations on food intake and hunger ratings after 60 min was recorded in the whole group of 24 subjects, while the effect of preload B after 30 and 60 min was recorded in a random subset of 15 subjects. The preloads and placebo were given at random order. The subset of subjects came four more times for lunch, twice receiving preload B and twice the placebo, each once with an interval of 30 min before lunch and once with an interval of 60 min.

Subjects were instructed to have their own standard breakfast at least 3 h before the start of the trial and not to eat anything after breakfast; subjects drank their preload at 1130 or 1200 hrs and got lunch at 1230 hrs. Subjects ate lunch alone in a closed, windowless room, in which table arrangement, lighting and music gave the atmosphere of a restaurant. Eating behaviour was observed using "the universal eating monitor" developed by Kissileff *et al.* (1980), which provides data on amount eaten, eating rate and time spent eating.

Hunger ratings were completed on 100-mm lines, which were anchored at the ends with "very hungry" and "not hungry at all". Hunger ratings were completed before and after the preload, before and after the lunch, and every hour for 5 h after lunch. Subjects were asked not to eat anything during those 5 h. Moreover, all subjects answered questions on sweetness, taste and palatability of the preloads, on the palatability of the meal, on how comfortable they felt during the meal, and on the date of the first day of the last menstruation.

Seven subjects completed a dietary record of 24-hour energy intake on three normal days, a preload day and a placebo day. Data on the amount of energy and macronutrients (carbohydrate, fat, and protein) ingested were calculated by a computer program based on the Dutch Food Table (Becel).

Foods

The liquid preloads (Table 1) were 250 ml of 2% or 10% fructose containing 1% soluble fibre and 1% insoluble fibre or 10% fructose with 3% soluble fibre and 1%

TABLE 1
Characteristics of the preloads

	Volume (ml)	Energy content (kJ)	Fructose (g)	Fibre (g)	Osmolarity (mosmol)
Preload A	250	500	25	5	911
Preload B	250	500	25	10	971
Preload C[a]	250	210	5	5	355
Placebo[a]	250	0			3
Milkshake	250	1300			not measured

[a]Included sweeteners (see Method).

TABLE 2
Ratings of preloads from: not sweet = 0, very sweet = 100; tasteless = 0, tasty = 100; unpalatable = 0, very palatable = 100

	Sweetness		Taste		Palatability	
	Median	Range	Median	Range	Median	Range
Preload A	68	68–71	74	70–78	76	73–80
Preload B	69	66–72	75	70–80	77	74–80
Preload C	63	60–66	73	67–79	77	75–79
Preload D	63	61–65	71	65–77	75	71–78

insoluble fibre. Fibre consisted of guar gum (insoluble), partly hydrolysed to the soluble form (guaran). Guar gum is the ground endosperm portion of guar seeds, i.e. the seeds of *Cyamopsis tetragonoloba (L.)* or *Cyamopsis psoraloides (D.C.)*. The water-soluble fraction of guar gum, i.e. the purified guar galactomannan, is called guaran. Preload C contained, apart from fibre and fructose, also the sweeteners cyclamate (260 mg/l), saccharin (11 mg/l), aspartame (34 mg/l) and acesufame K (28 mg/l), and the placebo consisted of a solution of sweeteners: cyclamate (380 ml/l) and saccharin (24 mg/l). Osmolarity was measured in triplicate with an Osmomat 030, Gonotec, Berlin, calibrated with water (0 mosmol/kg) and with NaCl (0·9406%; 300 mosmol/kg). The preloads looked like a cloudy fruit juice, and were considered by the subjects as healthy non-flavoured fruit juices. The preloads were tried out beforehand, by offering them to colleagues and subjects at different times of the day, and no differences in sweetness, taste, or palatability were found (Table 2).

A milkshake was offered to create a condition that might show a counterregulation effect in restrained eaters (Herman *et al.*, 1980, 1987): it consisted of 150 ml of whole milk, 25 ml of orange syrup and 75 ml of ice cream.

Lunch always consisted of macaroni with a sauce (pasta, meat, tomato puree, mild red peppers; 483 kJ/100 g; 15·4 g carbohydrate, 2·2 g fat and 5·4 g protein per 100 g). An ample portion (700 g) was given so that subjects could eat *ad libitum*; there was always some food left on the plate.

Data Analysis

Values are given as mean and standard deviation. Statistical analysis for the effects of the preloads on amount eaten, eating rate and on hunger ratings at different times was carried out with a repeated-measures analysis of variance (ANOVA). Amount eaten during the meal, eating rate, hunger ratings and 24-h food intake were compared between each preload and the placebo, for the 30-min as well as for the 60-min interval between preload and lunch. The relationship between hunger ratings before lunch and amount eaten during lunch was assessed by calculating the correlation coefficient. Total amount eaten, total protein, fat and carbohydrate intake in grams over 24 h were compared by means of *t*-tests between the preload day and the placebo day or normal days.

RESULTS

Energy Intake

There were no statistically significant differences between restrained and unrestrained eaters in any of the meal parameters. Therefore the data were combined.

With the 60-min interval between preload and lunch, food intake at lunch was significantly lower after the milkshake than after the placebo (Table 3), $F(1,23) = 20{\cdot}69$, $p<0{\cdot}001$. With respect to the other preloads, no significant differences between food intake after preload or after placebo was found with the interval of 60 min in the whole group of 24 women. When the energy content of the preload was taken into account, food intake was higher for any preload and meal together compared with placebo and meal (Table 3), overall variation $F(1,23) = 17{\cdot}24$, $p<0{\cdot}01$. Eating rate did not show any significant variation, except at the 30-min interval, where eating rate after a preload was lower than after a placebo ($p<0{\cdot}05$); in particular, food intake was significantly lower after preload B than after the placebo, $F(1,14) = 10{\cdot}89$, $p<0{\cdot}01$, while food intake of the preload B and meal together was higher than of placebo and meal (Table 4), $F(1,14) = 54{\cdot}20$, $p<0{\cdot}001$.

In the subset of 15 subjects, food intake 30 min after the preload appeared to be the same as food intake 60 min after the identical preload, but food intake 30 min after the placebo was lower than food intake 60 min after the placebo, $F(1,14) = 11{\cdot}28$, $p<0{\cdot}01$. Eating rate was significantly higher 30 min after the placebo than 60 min after the placebo ($p<0{\cdot}01$), and in accordance to that, time spent eating was significantly lower (Table 4).

Hunger Ratings

Initial ratings of hunger did not vary significantly within subjects prior to the preload administration, and were set at 100 (Fig. 1). Hunger ratings were lower after the preloads than after the placebo, just after intake of the preload ($p<0{\cdot}0001$), half an hour after preload ($p<0{\cdot}01$), after lunch ($p<0{\cdot}05$), and at 1, 3 and 5 h after the lunch ($p<0{\cdot}05$). These results were similar in the different experiments.

When the delay between preload and lunch was 60 min, a positive relationship between hunger score and amount eaten was found: whole group $F(1,23) = 12{\cdot}72$, $p<0{\cdot}01$; $r = 0{\cdot}605$; subset: $F(1,14) = 12{\cdot}53$, $p<0{\cdot}01$; $r = 0{\cdot}701$. With a delay of 30 min, no relationship between hunger score and amount eaten was found.

TABLE 3

Amount eaten during lunch, duration, eating rate and total energy content of the meal and of the meal+preload at 60 min after preloads (n=24)

	Amount eaten (g)		Duration (min)		Eating rate (g/min)		Energy in meal (kJ)		Energy in meal+preload (kJ)	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Preload A	352·4	143·8	7·9	3·0	46·1	12·1	1706	696	2243**	713
Preload B	342·6	140·4	7·8	2·9	44·1	11·2	1655	678	2193**	696
Preload C	356·2	141·3	8·3	3·4	45·0	12·9	1718	684	1942*	692
Placebo	367·3	126·1	8·5	3·3	45·3	13·3	1775	610	1775	610
Milkshake	298·8**	133·4	7·0**	2·6	43·1	10·4	1443**	644	2733**	644

**$p<0·001$; *$p<0·05$, significance of difference from the placebo.

TABLE 4

Amount eaten during lunch, duration, eating rate and total energy content of the meal and of the meal+preload at 30 and 60 min after the preload (n=15)

	Amount eaten (g)		Duration (min)		Eating rate (g/min)		Energy in meal (kJ)		Energy in meal+preload (kJ)	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
30-min interval										
Preload	308·5**	132·6	6·5*	2·7	47·2[d]	11·7	1490**	640	2037***	674
Placebo	343·9	136·4	6·9	2·9	52·5	12·7	1661	659	1661	659
60-min interval										
Preload	306·5***	115·3	7·3**	2·4	43·1	10·3	1480***	557	2028***	594
Placebo	373·2**	115·3	8·7**	2·7	44·3**	10·3	1803**	557	1803	557

***$p<0·001$; **$p<0·01$; *$p<0·05$, significance of difference of preload from the placebo: Between placebo's, **$p<0·01$ significance of differences between 30-min and 60-min intervals.

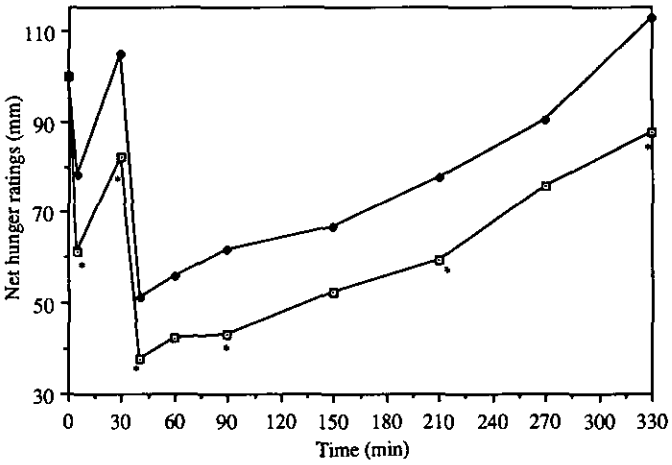

FIGURE 1. Hunger ratings from before preload until 5 h after the lunch ($n=15$): ⊡, preload; ◆, placebo, *significant difference from placebo (see text).

All preloads and the lunch were palatable (median 76, range 71–80 on 100-mm lines), and subjects felt comfortable during the meal (median 82, range 75–88 on 100-mm lines).

There was no effect of the menstrual cycle on food intake and hunger ratings.

Dietary Records

There was no significant variation in 24-h energy intake estimated from dietary records among the three situations, of three identical normal days, a day with a preload 30 min before lunch and a day with a placebo 30 min before lunch (7053 ± 2699, 7542 ± 2782, 7496 ± 2699 respectively). No significant variation among macronutrient compositions appeared either.

DISCUSSION

Although, compared to the placebo, the subjects ate significantly less after the most concentrated fructose and fibre in the experiment with the interval of 30 min before lunch and seemed to eat less after each of the fructose–fibre preloads in the experiment with the preload–lunch interval of 60 min, energy intake from preload and meal was larger than that from placebo and meal. Similarly, all subjects ate less after the milkshake than after a placebo, but the energy intake of milkshake and meal was significantly larger than of placebo and meal. We may conclude that a preload with a certain energy and fibre content may affect shortly subsequent consumption, but the energy content of the preload has to be sufficiently low not to destroy the effect on longer-term intakes. In the case of the concentrated preload a reduction of energy intake during the meal of 210 kJ was induced by a preload of 500 kJ. However, a preload of 500 kJ with less fibre and a 210-kJ preload reduced intake by 69 kJ and 57 kJ, respectively. Apparently the amounts of preload energy and fibre need to be relatively too large to be substantially effective.

The reduction in energy intake during the meals may be due to osmolarity, fibre content and fructose content of the preloads. Drinks with a high osmolarity slow down stomach emptying (Beckers *et al.*, 1990). Fibre has two main effects in the foregut: prolonged gastric emptying time and retarded absorption of nutrients (Eastwood & Morris, 1992). Fibre can postpone food intake for 6 h; this is suggested to be due to postabsorptive effects of actions of fibre (Blundell & Burley, 1987; Burley & Blundell, 1990).

The concentrated preload B reduced hunger ratings at 30 min (and during the 5 h following lunch) but not at 60 min. On the other hand, a correlation between hunger ratings before lunch and amount eaten during lunch was observed with the interval of 60 min but not with the interval of 30 min. Positive correlations of ratings with intake have been found by others (Rolls *et al.*, 1988, 1992; Weber *et al.*, 1988) but Spiegel *et al.* (1989) and Wardle (1987) found that hunger ratings are sensitive to factors such as deprivation and differences in the energy content of a preload, but did not relate to total intake. The differences among observations may partly be attributable to differences in interval between preload and subsequent food intake. There was no difference in eating rate between the preload and placebo situations with the interval of 60 min, but at 30 min eating rate was significantly lower after preload than after placebo. This was also shown by Kissileff *et al.* (1984) who found a reduction in the initial eating rate with different preloads.

Thus, a fructose/fibre preload has stronger effects at 30 min than at 60 min before lunch. However, there were no differences in 24-h energy intake between a normal day, a day with a fibre preload before lunch, or a day with a placebo before lunch.

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