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EFFECT OF SENSORILY VARIED FOODSTUFFS ON SENSORY SPECIFIC SATIETY IN YOUNG ADULTS DEPENDING ON THEIR SEX – A SHORT REPORT

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The aim of the study was to assess the effect of sex on the development of sensory specific satiety and energy intake in young people. It was found that *ad libitum* consumption of the tested products (milk chocolate, crackers, grapefruit and apple) caused sensory specific satiety with similar intensity, irrespective of the sex of individuals. Moreover, it was found that the sex had a significant effect ($p<0.001$) on the amount of the consumed meal and energy intake by the tested individuals, with these parameters being higher in men than in women.

INTRODUCTION

It is common knowledge that the consumption of food is connected with the sensation of pleasure. However, the sensation of pleasure accompanying eating does not remain permanent, but decreases in the course of consumption. This phenomenon is termed "sensory specific satiety" and is manifested by the decrease in pleasure, progressing in the course of eating, felt as a result of response to the pleasantness of the currently consumed food, at the simultaneous lack of changes or an increased interest in food with differing sensory properties [Rolls *et al.*, 1981a].

Sensory specific satiety is a result of changes in the response of hypothalamic neurons. In studies on monkeys [Rolls *et al.*, 1986], it was shown that the neuronal response was weakening gradually as a result of the appearance and taste of food which animals were fed *ad libitum*, while neuronal response to sensorily different food remained unchanged. The weakening strength of the signal and reduced neuronal response could also have been responsible for decreased desirability of a given foodstuff during the next meal [Poothullil, 2002].

Sensory specific satiety is found to be strongest within 2 min after the consumption of a meal and it may last as long as several hours [Raynor & Epstein, 2001], while its development and intensity are dependent on sensory properties of consumed foodstuffs [Chung & Vickers, 2007; Guinard & Brun, 1998; Galiński & Gawęcki, 2000; Rolls & Rolls, 1997; Romer *et al.*, 2006; Sørensen *et al.*, 2003; Vickers *et al.*, 1998] and the capacity of the organism to receive stimuli generated by food [Rolls & McDermott, 1991; Rolls, 1999]. The phenomenon of sensory specific satiety results in the consumption of various products during one meal and affects the selection of food at the next meal, thus contributing the nutritionally-balanced diet [Rolls *et al.*, 1981b]. On the other hand, sensory specific satiety is essential in the maintenance of energy balance and offering sensorily varied foodstuffs over a long time period may lead to the development of overweight and obesity [Louis-Sylvestre *et al.*, 1984].

Results of some studies [Okoro *et al.*, 1998; Sato *et al.*, 2002] show that women generally have lower recognition thresholds for basic tastes than men do, and they also exhibit higher responsiveness to electrical stimulation of the tongue [Coats, 1974], which might prove to be of importance for the development of sensory specific satiety. Thus the aim of this study was to assess intensity and duration of sensory specific satiety after consumption of sensorily varied foodstuffs by young people depending on their sex.

MATERIAL AND METHODS

Investigations were conducted on the group of 18 young people, including 9 women (20.8±2.0 years, BMI 23.0±4.7 kg/m^2) and 9 men (21.2±0.8 years, BMI 22.5±3.0 kg/m^2) following the requirements and experimental conditions given by Hetherington and Rolls [Hetherington, 1996; Rolls *et al.*, 1988]. At the beginning of the study the participants, previously asked not to eat anything for at least 3 h before the start of the assessment, evaluated the level of their hunger (satiety) using a 100-mm graphic scale, marked at the left end with "very hungry", and at the right end "very satiated". Next participants defined the pleasantness of foodstuffs with differing sensory properties (milk chocolate, crackers, grapefruit, apple), using a 100-mm graphic scale with margin markings "very unpleasant" and "very pleasant" and consumed one of the tested products *ad libitum*. Moreover, each par-

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ticipant was given "Żywiec Zdrój", mineral water with low mineral contents, to rinse their mouths. Each individual consumed as much food as they wanted (within max. 15 min), with the amount of consumed food being recorded and used to determine the amount of energy intake. Immediately after consumption of the product the subjects were again asked to define their hunger (satiety). At 2, 10, 30, 60 and 90 min after the end of the meal the participants again assessed pleasantness of the tested products. Individual series of tests were recorded on separate charts, preventing in this way the participants from comparing results and being influenced by them. A measure of sensory specific satiety resulted from differences in assessed pleasantness of a given product before and after *ad libitum* consumption of one of the products. The assessment consisted of 4 sessions, during which products eaten *ad libitum* were milk chocolate, crackers, grapefruits and apples.

Results were verified statistically using a one-way and two-way analysis of variance, Student's t-test for paired and unpaired samples, as well as correlation and regression analyses. All calculations were performed using STATISTICA PL v.7.1 software.

RESULTS AND DISCUSSION

Table 1 presents changes in the assessed pleasantness of the tested products (milk chocolate, crackers, grapefruits and apples) 2 min after their *ad libitum* consumption. As it results from the presented data, consumption of all analysed products caused sensory specific satiety in the participants, irrespective of their sex. In the group of women the highest relative decrease in pleasantness ratings was recorded for crackers (56.3%) after their *ad libitum* consumption, while among men – for grapefruit (48.8%). In turn, the smallest change in the assessed pleasantness of products eaten *ad libitum* was found for apples (43.5%) in women and for crackers (36.4%) in the group of men. In the case of the other tested products, which were not consumed *ad libitum* in a given session, small changes were found in pleasantness ratings. In the group of men an exception was a significant decrease of pleasantness ratings for grapefruit (34.2%; $p<0.05$) after *ad libitum* consumption of apples. The performed statistical analysis did not show any significant effect of the type of the tested product eaten *ad libitum* and the sex of participants on the development and intensity of sensory specific satiety. These results confirm our earlier reports [Galiński *et al.*, 2005], in which it was found that the type of tested product consumed *ad libitum* did not have any significant effect on the intensity of sensory specific satiety. Similarly as in the presented experiment, also Miller *et al.* [2000] found no effect of the sex of participants on the incidence of sensory specific satiety.

The greatest decrease in ratings for products eaten *ad libitum* was recorded 2 min after the end of the meal, while the greater the decrease, the sooner the trend to return to the initial pleasantness level was observed (Figure 1). However, the sensed pleasantness did not reach the level from before consumption in any analysed case.

A significant ($p<0.001$) effect was shown of the type of eaten product and the sex of participants on energy value of the consumed meal, which was significantly higher in the group of men. The highest energy intake was recorded in those sessions, in which products with higher energy density were eaten, *i.e.* milk chocolate (695±299 kcal in women and 1355±659 kcal in men) and crackers (607±368 kcal and 1091±428 kcal, respectively). No significant correlation

TABLE 1. Changes in pleasantness ratings (mean ± SEM) of test products 2 minutes after *ad libitum* intake of several products.

Product consumed *ad libitum*	Sex	Changes in pleasantness ratings (mm)			
		Milk chocolate	Crackers	Grapefruit	Apple
Milk chocolate	Women	$-45\pm11^{a**}$ (-52.9)	1 ± 7^{b} (1.3)	10 ± 8^{b} (17.5)	1 ± 9^{b} (1.8)
	Men	$-37\pm9^{a**}$ (-44.0)	-2 ± 4^{b} (-2.7)	-3 ± 4^{b} (-3.8)	-3 ± 4^{b} (-4.3)
	Significance of sex differences	ns	ns	ns	ns
Crackers	Women	1 ± 3^{b} (1.2)	$-45\pm5^{a***}$ (-56.3)	-1 ± 7^{b} (-1.5)	3 ± 4^{b} (4.4)
	Men	-3 ± 4^{b} (-3.3)	$-28\pm8^{a**}$ (-36.4)	0 ± 7^{b} (0.0)	-9 ± 6^{b} (-11.8)
	Significance of sex differences	ns	ns	ns	ns
Grapefruit	Women	6 ± 3^{b} (7.1)	2 ± 6^{b} (2.5)	$-41\pm11^{a**}$ (-56.9)	-3 ± 2^{b} (-4.1)
	Men	$9\pm4^{b*}$ (10.7)	-5 ± 8^{ab} (-6.7)	$-39\pm11^{a**}$ (-48.8)	-13 ± 8^{a} (-16.9)
	Significance of sex differences	ns	ns	ns	ns
Apple	Women	6 ± 3^{c} (6.7)	6 ± 3^{c} (7.2)	-9 ± 5^{b} (-13.0)	$-30\pm11^{a*}$ (-43.5)
	Men	-2 ± 3^{c} (-2.2)	-3 ± 5^{bc} (-3.6)	$-25\pm8^{ab*}$ (-34.2)	$-35\pm8^{a**}$ (-47.9)
	Significance of sex differences	ns	ns	ns	ns

Change in pleasantness ratings = rating 2 minutes after consumption – initial rating, Significance of changes in pleasantness ratings * – $p<0.05$; ** – $p<0.01$, *** – $p<0.001$. Brackets provide percentage changes in pleasantness scores for test products as compared to the initial rating. Mean values in the same rows denoted with the same letter inscriptions do not differ at $p<0.05$. ns – differences statistically non-significant.

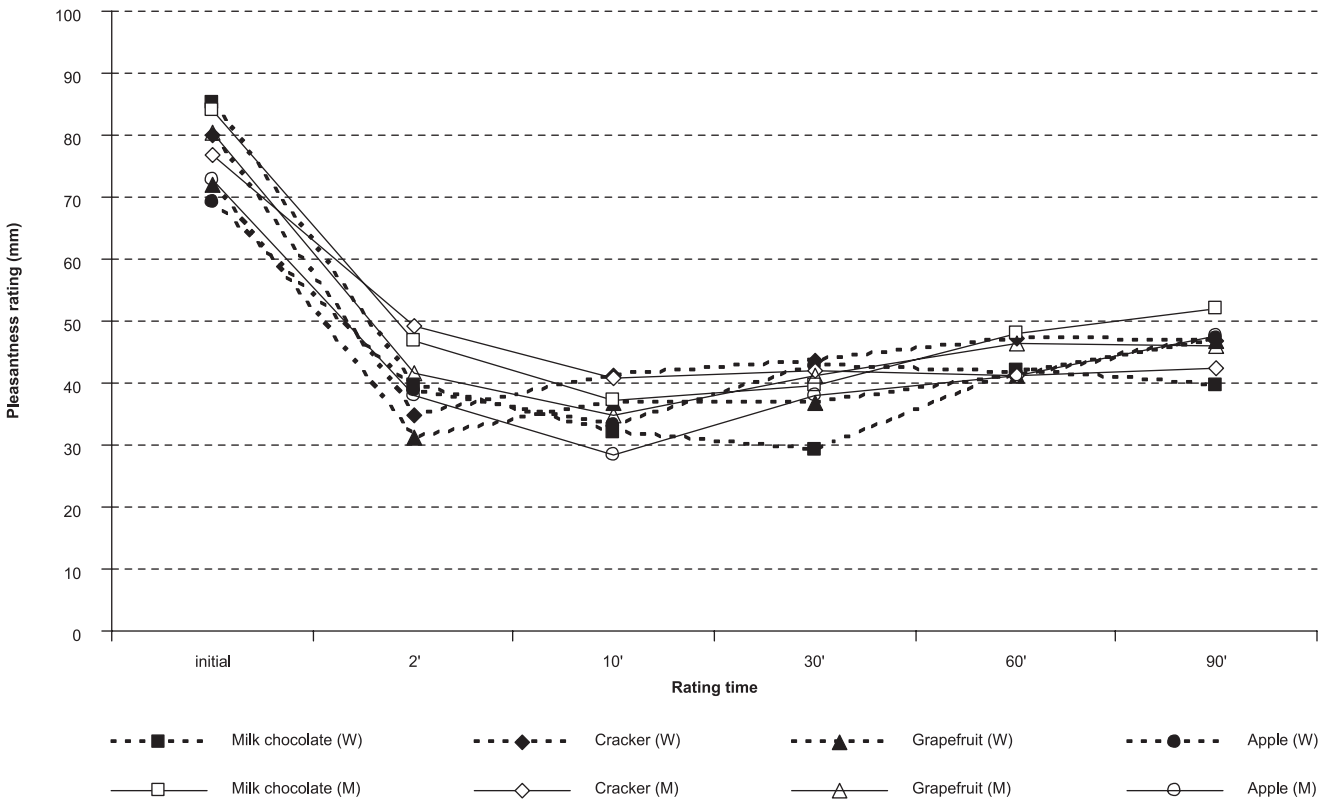

FIGURE 1. Dynamics of changes in pleasantness ratings of test products after their *ad libitum* consumption ((W) – women, (M) – men).

was found between energy value of the consumed meal and a change in the sensation of pleasantness, which may indicate that the generated satiety was sensory specific and the recorded change in product pleasantness did not depend on the amount of energy intake. This confirms the results of earlier studies [Bell *et al.*, 2003; Galiński & Gawęcki, 2000], which demonstrated that energy value of the consumed meal did not have a significant effect on the development of sensory specific satiety. Also the correlation between a change in the level of sensed pleasantness of the product eaten *ad libitum* and the declared satisfaction of hunger turned out to be statistically non-significant, which is another piece of evidence on the sensory specific satiety generated by the analysed products.

CONCLUSIONS

1. *Ad libitum* consumption of milk chocolate, crackers, grapefruits and apples generates sensory specific satiety with comparable intensity and duration, with the phenomenon being independent of the sex of participants of the study.

2. The amount and energy value of consumed foodstuffs are significantly affected by the sex of participants, with higher values of these parameters being found in the group of men.

3. A decrease in pleasantness of products eaten *ad libitum* caused by sensory specific satiety is independent of the amount and energy value of the consumed meal and changes in the subjective assessment of hunger (satiety).

4. The decrease in pleasantness of the tested products was felt most intensively 2 min after their *ad libitum* consumption. The stronger the decrease, the faster the trend to return to the originally sensed pleasantness of the product; however, 90 min after consumption it did not reach the initial level.

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