Food Quality and Preference 21 (2010) 655–661

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

Effects of hot spices on energy intake, appetite and sensory specific desires in humans

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ARTICLE INFO

Article history:
Received 17 July 2009
Received in revised form 6 April 2010
Accepted 11 April 2010
Available online 14 April 2010

Keywords:
Chili
Horseradish
Ginger
Mustard
Wasabi
Meal
Humans

ABSTRACT

This study investigated the effect of hot spices on energy intake and appetite. Forty participants received five meals of fixed portion sizes, served with or without five hot spices followed by a buffet. Spices were used in doses perceived as moderately hot, ensuring that the meals were palatable. Food intake (kJ), appetite and liking (before, during, after the meal and after the buffet), mood (before, after the meal and after the buffet) and desire to eat sweet, sour, fatty, salty, bitter and hot foods (after the meal and after the buffet) were measured on 9-point scales. Hot spices did not affect energy intake ($p > 0.05$). Desire for sweet foods was increased by chili (0.6 point, $p < 0.05$) whereas desire to eat salty foods was decreased by mustard (1 point, $p < 0.01$), suggesting that hot spices can induce changes in sensory specific desires. Liking of the meals tended to increase during the buffet when compared to the relatively constant liking of the fixed starter meals, suggesting that traditional sensory specific satiety does not play a large role in determining eating behaviour with complex meals.

1. Introduction

Hot spices like chili peppers, horseradish, ginger, mustard and wasabi are commonly used in many cuisines to stimulate our senses with exotic flavours and burning, heat sensations. Apart from enhancing the pleasure of eating, some of these spices also provide nutritional value and have anti-oxidant as well as antibacterial properties (Habsah et al., 2000; Shin, Masuda, & Naohide, 2004). Capsaicin, the predominant pungent substance in chili peppers, has been shown to increase energy expenditure and decrease appetite in humans in the short term when added in relative high doses (3–30 mg capsaicin) (Lejeune, Kovacs, & Westerterp-Plantenga, 2003; Lim, Suh, & Lee, 1999; Westerterp-Plantenga, Smeets, & Lejeune, 2005; Yoshioka, St-Pierre, Suzuki, & Tremblay, 1998; Yoshioka et al., 1995, 1999). Increased activity of the sympathetic nervous system after ingestion of chili pepper suggests that the reduction in energy intake could be due to the anorectic effect of catecholamines (Yoshioka et al., 1999). Since obesity is now a global problem leading to increased risk of developing lifestyle diseases it is of great interest to explore if hot spices, could be attractive supplements to common weight-loss strategies.

Based on this evidence we wanted to investigate if hot spices in meals suppress energy intake and appetite when used in lower doses (0.4 mg capsaicin) that are perceived as moderately hot, ensuring that the meals are still palatable. Subjects participated in 10 experimental sessions. Five different fixed meals were served as a starter twice, either with or without one of the following hot spices: chili peppers, horseradish, ginger, mustard and wasabi. Next an ad libitum buffet was served to measure energy intake.

2. Methods

2.1. Participants

A homogeneous group of young subjects were recruited from the *University of Copenhagen*. Subject characteristics are summarized in Table 1. The subjects were asked to fill out a questionnaire on health status, meal patterns and food intake to ensure that all subjects were in good health (e.g. no chronic diseases or food allergies) and liked to eat hot spices and pork meat. Height and weight were measured to calculate body mass index (BMI). Subjects were allowed to stick to their normal breakfasts and lunches as long as they ate the same portions and types of food on every test day to have the experiment be as close to daily routines as possible. Eating and drinking, with the exception of water, was not allowed 3 hours prior to a session and smoking was prohibited 1 h before the session. Subjects were asked to abstain from intense physical activity the day before a test.

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doi:10.1016/j.foodqual.2010.04.003

Table 1
Subject characteristics (mean ± standard deviation).

	Men	Women	All
N	17	23	40
Age (years)	25.4 ± 2.6	24 ± 2.2	24.6 ± 2.5
Body weight (kg)	76.1 ± 8.4	63.0 ± 12.1	68.5 ± 12.4
BMI (kg/m^2)	23.3 ± 1.8	21.8 ± 3.0	22.5 ± 7

2.2. Procedure

Each subject participated in a crossover study where ten test meals, corresponding to five different meals with and without five hot spices (±chili pepper, horseradish, ginger, mustard and wasabi) were consumed at dinner time, separated by at least 48 h, for five consecutive weeks. The study took place in surroundings mimicking a canteen dining room with coloured napkins and flowers used to create a realistic canteen atmosphere. Participants were seated at one of four tables and were allowed to talk about everything but their opinions of the food. During each test day all subjects had the same starter meal of fixed portion size but were randomly assigned to a spicy or non-spicy version, which they had to finish completely. Thirty minutes after the fixed starter meal was served, subjects could choose freely from an ad libitum buffet. The ad libitum buffet contained all the food components from the fixed starter meal to mimic second serving of the 'warm dish of the day' in a canteen. Each subject noted their food choices from the buffet in a personal schedule before eating ad libitum until satiation, as instructed. Total food and energy intake of the fixed starter meal and the ad libitum buffet (g, kJ) as well as total water intake (g) were determined. Participants spent 1 h per test and received a bottle of red wine as payment after each session.

2.3. Appetite, mood, liking and sensory specific desires

All ratings were scored on 9-point category scales. Appetite was scored before the fixed starter meal, every 3 min during the starter meal and again after the buffet. *Hunger, fullness and satiety* were scored from 'not at all' to 'very', *wanting to eat more* from 'very weak' to 'very strong' and *prospective food consumption* from 'nothing at all' to 'a very large portion'. Liking was scored from 'not at all' to 'very much' every third minute during the fixed starter meal and at meal termination. Physical *well-being* was scored from 'very unwell' to 'very well', *mood* was scored from 'very bad' to 'very good', whereas *level of satisfaction, relaxation, stress* and *exhaustion* were scored from 'not at all' to 'very'. Participants scored their desires (Mela, 2006) to eat sour, sweet, fat, bitter, salty and hot foods after the fixed starter meal and again after the buffet ranging from 'not at all' to 'very much'. The sensory properties of the meals were scored from 'not at all' to 'very much' sour, sweet, fatty, bitter, salty and hot after the fixed starter meal.

2.4. Meals

The fixed starter meals consisted of varying amounts of meat, vegetables/fruits, salads and dressings depending on the composition of the meal (see Appendix 1). The meals were designed to meet the expectation of a meal (meat, a staple, salad and dressing), include sour, sweet, bitter, salty, fat and crunchy foods and be perceived moderately hot.

Based on the assumption that dinner contributes 25–35% of total daily energy intake (Nordic Council, 2004) the fixed starter meals provided less than 2350 kJ (equal to approx. 25% of daily energy need for an average sedentary woman of 18–30 years of age) to ensure that all subjects would eat from the ad libitum buffet. The energy content of the meals was calculated from the nutrition information on the foods or from a standard Den Lille levnedsmiddeltabel (2003). 0.6 g chili pepper (0.3 g dried powder ~0.375 mg capsaicin and 0.3 g fresh finely grinded), 20 g fresh ginger (coarsely grinded and squeezed ginger) and 19.2 g mustard (50% Dijon and 50% coarsely mustard paste) were added to the dressings and placed on the meat whereas 10 g of fresh coarsely grinded horseradish were added to the salad and 4 g of wasabi paste was added to the rice. The amount of hot spices used was determined from the recommended servings of the product and from tasting tests performed to reach a hotness of 7 on the 9-point scale, which was regarded as moderately hot.

2.5. Data analysis

Repeated analysis of the appetite scores was performed by linear mixed models (proc mixed) in SAS (SAS Institute, Inc., Cary, NC, USA) using session and subjects as random effects, treatment, gender and time as fixed factors whereas BMI, age, baseline appetite and liking were covariates in the model. Proc mixed analysis on total energy and food intake (kJ and g) were evaluated for significant effects of gender and treatment as well as BMI, age and baseline energy and food intake (kJ and g) using session and subjects as random effects. Similar mixed models were made for desires to eat and mood scores. Significance was set at a p-value of <0.05. Tukey–Kramer post hoc tests were used for pairwise comparisons across treatments producing adjusted p-values (adj p). Comparisons were made between the spicy and non-spicy versions of the same meal so that meal 1 *without* chili was compared to meal 1 *with* chili, meal 2 *without* horseradish compared to meal 2 *with* horseradish, etc. Trends in scores of appetite, mood, energy intake, desires and sensory properties of the foods were analyzed using principal component analysis (PCA) with Latentix software (LatentiX™ 2006, Latent5, Denmark).

3. Results

Adding spices to the meals had only minor effects on total energy intake (kJ) and no effect on total food intake (g) (Table 2), water intake, hunger and satiety (data not shown). However, adding wasabi to meal 5 significantly increased prospective food consumption ($p = 0.03$).

Adding spices to the meals had no effect on mood, relaxation, exhaustion and satisfaction. Adding ginger (pairwise comparison, meal 3 ± ginger: $p = 0.005$) and wasabi (pairwise comparison, meal 5 ± wasabi: $p = 0.05$) seemed to reduce well-being (Table 2).

Chili increased the desire to eat sweet foods in meal 1 ($p = 0.041$; adj $p = 0.99$) whereas mustard decreased the desire for salty foods in meal 4 ($p < 0.003$; adj $p = 0.71$) and all spices, except ginger, significantly reduced the desire for hot foods (treatment $*$ desire $p < 0.0001$, pairwise comparison ± spices $p < 0.02$; adj $p < 0.99$). All effects can be found in Table 2. Desires for sour, bitter and fatty foods were not affected by adding spices to the meals (data not shown). Adding spices (chili, mustard and wasabi) to the meals ($p < 0.0001$; adj $p = 0.01$) significantly reduced the overall desire to eat after the fixed starter meal ($p < 0.01$; adj $p < 0.51$) whereas no effect of adding spices was found after the buffet (data not shown).

All meals except meal 5 with wasabi were liked by the subjects (Fig. 1a). Mustard significantly increased liking of meal 4 during the fixed starter meal (treatment $*$ time: $p < 0.0001$) whereas none of the other spices affected liking. All the spiced meals were perceived to be significantly hotter than the non-spiced meals, but the meals spiced with horseradish, ginger and mustard were perceived to be less hot than aimed for (Fig. 1b). Pairwise comparison