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Research report

Texture and savoury taste influences on food intake in a realistic hot lunch time meal

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ABSTRACT

Background: Previous studies with model foods have shown that softer textures lead to higher eating rates and higher *ad libitum* food intake and higher intensity of salt taste has been shown to result in a lower *ad libitum* food intake. These observations have yet to be replicated in the context of realistic solid hot meal components. *Aim:* The objective of the present study was to assess the effect of texture and taste on the *ad libitum* intake of a realistic hot lunchtime meal. *Methods:* The meals consisted of potatoes, carrots, steak and gravy varied according to a 2 (texture: mashed vs. whole) × 2 (taste: standard taste vs. strong taste) design. The texture dimension referred to mashed potatoes, mashed carrots and pieces of steak vs. whole boiled potatoes, whole boiled carrots and whole steak. The taste was varied by manipulating the taste intensity of the gravy to be either standard or high intensity savoury taste. The current study used a between groups, single course *ad libitum* design whereby subjects were recruited for a one off meal study, during which their food intake was measured. The four groups consisted of about 40 subjects (mashed, standard, $n = 37$; mashed, savoury $n = 39$; whole, standard $n = 40$; and whole, savoury $n = 41$) matched for age (average age = 44.8 ± 5.3), gender (on average 19 males and 20 females), normal BMI (average 22.6 ± 1.7) and dietary restraint score (DEBQ score = 1.74 ± 0.6). *Results:* The results showed that the estimated means of the intake of the two mashed conditions was 563.2 ± 20.3 g and intake of whole meal was 527.5 ± 20.0 g ($p = 0.23$). The texture effect was significant in the higher savoury condition with an average of 91 g less food consumed in the solid-savoury meal than in the mashed–savoury meal. This effect was not replicated in the standard gravy condition, with no significant difference between solid and mashed textures. This was reflected in an interaction effect that was approaching significance ($p = 0.051$). The estimated mean eating rate in the two mashed conditions was 57.0 ± 2.5 g and was significantly higher than the whole meal condition (47.2 ± 2.5 g ($p < 0.05$), with no difference in eating rate between the standard and savoury gravy conditions. *Discussion:* Although interpretation was made difficult by the between groups design and the interaction between taste * texture, the results nonetheless confirm the effect of texture on eating rate and *ad libitum* intake for solid savoury meal components. The impact of taste on *ad libitum* intake of a solid meal remains unclear. We conclude that people consumed more of the meal when the food was simultaneously mashed and savoury. Food texture may be used to produce slower eating rates that result in a reduced overall energy intake within a realistic hot lunchtime meal.

Introduction

The high prevalence of obesity in the industrialised world is partly due to easily available, energy dense and palatable foods, which can be consumed quickly (de Graaf & Kok, 2010; Rolls, 2009, 2010). In a large series of studies, it has been shown that foods that can be ingested quickly (e.g. sugar sweetened beverages) have a low satiating efficiency (for a review see de Graaf, 2011). This is due to oral processing characteristics such as large bite size (Burger, Fisher, & Johnson, 2011; Fisher, Rolls, & Birch, 2003; Spiegel, Kaplan, Tomassini, & Stellar, 1993; Stellar & Shrager, 1985; Weijzen, Smeets, & de Graaf, 2009; Zijlstra, de Wijk, Mars, & de Graaf, 2009), low chewing activity (Li et al., 2011; Smit, Kemsley, Tapp, & Henry, 2011), and a low overall oro-sensory exposure time (Bolhuis, Lakemond, de Wijk, Luning, & de Graaf, 2011b; Zijlstra, Mars, de Wijk, Westerterp-Plantenga, & de Graaf, 2008; Zijlstra et al., 2009). To reverse this trend and slow the rate of calorie intake, smaller bite sizes (Weijzen, Zandstra, Alfieri, & de Graaf, 2008; Weijzen et al., 2009; Zijlstra et al., 2009), more chewing activity (Li et al., 2011; Smit, Kemsley, Tapp, & Henry, 2011), and a longer

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oro-sensory exposure time (Bolhuis et al., 2011b; Zijlstra et al., 2009) can be used to lower *ad libitum* food intake.

The effects of foods with different oral processing characteristics on food intake have mainly been studied in model foods where the texture and/or oral processing characteristics have been altered on purpose (e.g. Zijlstra et al., 2008). The foods used in these studies were not considered as alternatives for each other within the context of a realistic hot meal. Very little has been done on the effect of food texture on intake, within the context of realistic meals that can be consumed in a regular way. The question remains whether or not *ad libitum* intake of a meal with components that have softer textures is higher than the *ad libitum* intake of an equivalent meal with components that have 'harder'/'chewier' textures? This issue is relevant from a nutritional point of view, as hot meals may contribute 30–40% of daily energy intake (e.g. Levitsky & Pacanowski, 2011; Van Rossum, Fransen, Verkaik-Kloosterman, Buurma-Rethans, & Ocke, 2011).

Another characteristic that has been implicated in earlier meal termination is a higher perceived sensory intensity of food. The effect of sensory intensity on satiation has been shown both for sweet and salty foods (Bolhuis, Lakemond, de Wijk, Luning, & de Graaf, 2011a; Bolhuis et al., 2011b; Weijzen et al., 2008). Higher sensory intensities may lead to lower *ad libitum* food intake through a lower bite size (Bolhuis et al., 2011b) and longer subsequent oro-sensory exposure. One postulated mechanism behind this effect may be that higher taste intensities signal higher macronutrient density (Yarmolinsky, Zuker, & Ryba, 2009). The perceived sweet, savoury and salt intensities of foods have been shown to relate to the sugar and protein content in an array of 45 commonly consumed foods (Viskaal – van Dongen, Kok, & de Graaf, 2011). The impact of taste intensity on *ad libitum* food intake within a solid-savoury hot meal has yet to be shown.

This study sought to assess *ad libitum* intake of meals with equivalent components that varied in texture and taste intensity. We measured the intake of four hot meals containing potatoes, steak, carrots and gravy, which varied along two dimensions in a 2×2 design. One dimension was texture with a 'whole' condition, i.e. boiled potatoes, boiled carrots, and whole steak, and a 'mashed' condition i.e., mashed potatoes, mashed carrots and pieces of steak. The other dimension was perceived taste intensity which was varied through the gravy component, with a standard gravy condition and a higher savoury intensity gravy condition. Based on previously published trends, we hypothesised that the whole condition and the strong savoury taste condition would lead to a lower *ad libitum* intake compared to the mashed condition and the standard taste condition.

Methods

Experimental approach

The current study used a between groups, single course *ad libitum* design whereby subjects were recruited for a one off meal study, during which their intake during a lunchtime meal was measured. Using a between groups design, four groups participated in the 2×2 study design with four different meals that were modified in the texture of the meal components (whole and mashed) and the taste of the gravy (control and high savoury). Every effort was made to recruit four comparable groups of subjects, and each group was served one of the four meals in a single lunchtime session. The between groups design was favoured to avoid the strong likelihood of memory effects that would arise in a full cross-over within subjects design. The study was assessed and approved internally having met the ethical and quality control criteria required for sensory studies of this nature.

Subject recruitment and characteristics

Participants for the study were recruited from the local Lausanne area through the data base of a local market research company. The estimated number of participants for each group was calculated to ensure adequate sensitivity for the between group comparison. A target of 40 participants was set for each of the four test groups and participants had to meet the recruitment criteria outlined. Within each group, participants were gender matched (50% male 50% female), were aged between 35 and 55 years, had a reported body mass index between 18 and 25 kg/m^2, were not currently dieting to gain or lose weight and all were regular participants of a hot lunchtime meal. Table 1 summarises the key characteristics of the four groups of consumer participants, matched for age, gender, BMI and cognitive restraint. All participants did not currently or in the past suffer from an eating disorder. Participants had no specific food related allergies or intolerances (i.e. lactose intolerance) had no specific dietary requirements (i.e. diabetic, coeliac) or specific dislikes towards the foods to be served in the lunchtime meal and they could not be vegetarian, pregnant or breastfeeding at the time of the trial. None of the participants worked in advertising, food marketing or the food industry and they were removed if they had participated in any consumer research in the previous six months. As part of their screening, participants were asked to complete the restraint section of the Dutch eating Behaviour Questionnaire (DEBQ: Van Strien, Frijters, Bergers, & Defares, 1986) to ensure they all had equivalently low levels of dietary restraint. In addition, at the end of the lunchtime session, participants were asked to complete a series of questionnaires to compare the health motivation and attitudes to food across the four study groups. The questionnaires included the Health and Taste Attitudes Questionnaire (Roininen, 1999), Food Involvement Scale (Bell & Marshall, 2003), the Food Choice Questionnaire (Steptoe, Pollard, & Wardle, 1995) and the full version of the Three Factor Eating Questionnaire (Stunkard & Messick, 1985). In each case, the aim was to measure consumer characteristics within each group, and compare across groups to ensure participants in each group had comparable ranges for each measure. The cumulated measures from each questionnaire were not statistically different when compared across the four groups of consumer participants, and this data is not reported in the current paper.

Each group of participants received only one of the four test meals. There were no fasting restrictions for the lunchtime meal and all participants were asked to follow their normal dietary behaviour and to consume their normal breakfast on the day of the lunchtime session. All participants came to the Nestlé Research Centre for their *ad libitum* lunch and all data was collected between 13:00 and 14:00 pm on each test day and data was collected over eight test days across two consecutive weeks. Participants were required to give their informed consent before taking part in the meal session and they were free to withdraw from the study at any stage.

Table 1
Subjects characteristics (mean ± s.d.) of the four meal groups, matched with respect to age, gender, BMI, and restraint score. There were no statistically significant differences in subject's characteristic or liking between the four groups.

	Whole		Mashed	
	Standard	Savoury	Standard	Savoury
N	40	41	37	39
Males/females	21/19	18/23	18/19	19/20
Age	43.5 (5.33)	44.5 (4.97)	45.6 (5.66)	45.7 (5.2)
BMI	23.2 (1.81)	22.5 (1.69)	22.6 (1.57)	22.2 (1.6)
Cognitive restraint	1.8 (0.54)	1.8 (0.58)	1.7 (0.57)	1.6 (0.59)