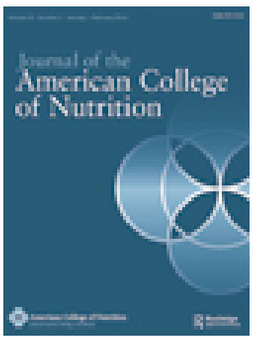

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Original Research

Desire for Sweet Taste Unchanged After Eating: Evidence of a Dessert Mentality?

Kate Harington, MDiet, Rebecca Smeele, MDiet, Fiona Van Loon, MDiet, Jannie Yuan, MDiet, Jillian Joy Haszard, PhD, Amanda Drewer, BSc, Bernard Joseph Venn, PhD

University of Otago, Department of Human Nutrition, Dunedin, NEW ZEALAND (K.H., R.S., F.V.L., J.Y., J.H., B.J.V.); University of Waikato, Department of Psychology, Hamilton, NEW ZEALAND (A.D.)

Key words: sweetness, desire, visual analog scale, appetite, food reward

Background/Objectives: Added sugars provide calories and desirability to foods and beverages. Our aim was to test whether desire for a sweet taste would be better maintained than a desire for other tastes for 3 hours after a test meal.

Methods: Eighty-three young adults ate 2 slices of bread on 2 separate occasions after which they were asked to rate their desire for savory, sweet, fatty, or salty tastes and to specify the number of servings of white rice, pizza, cheese and crackers, sweet biscuits, and pasta they could consume. Desirability was assessed using 100-mm visual analog scales (VAS), with 0 mm representing no desire and 100 mm great desire.

Results: When participants provided a quantitative assessment of the servings of foods that they wanted to eat following the bread meal, desire decreased on average for all foods measured, χ^2 (3) = 2.63, $p = 0.452$. Mean (95% confidence interval [CI]) change in VAS taste desirability 30 minutes after eating declined for salty (14.5 mm [10.5, 18.6]), fatty (11.2 mm [7.1, 15.2]), and savory (24.1 mm [19.7, 28.5]) tastes ($p < 0.001$). Desirability for sweet taste did not differ from baseline (2.4 mm [−2.3, 7.1]), and this level of desire was maintained throughout the 3-hour period.

Conclusions: The data indicate a partial disconnection between appetite and desirability for sweet taste. Physiological and psychosocial reward systems may make it difficult for people to resist sweet tasting foods and beverages. Targeting familial and cultural practices that discourage the consumption of added sugar foods might be useful to combat desire-driven food intake.

INTRODUCTION

The global prevalence of obesity is alarming due to its negative impact on health [1]. Although multifactorial, one dietary component associated with obesity is added sugar intake [2]. Added sugars are defined as caloric sweeteners that are added to foods during processing or preparation or consumed separately [3]. Various guidelines for added sugar intake have been recommended. The North American Institute of Medicine suggests a maximal intake of 25% of energy intake from added sugars and the World Health Organization is proposing an ideal intake of no more than 5% of energy intake from free sugars [4,5].

Twenty-five percent of energy as added sugar is liberal and at the upper end of intake for adults, with the average intake in the United States from 2005 to 2010 estimated to be 13% of energy [6]. Intake as a proportion of energy may be higher in children, with around 20% of dietary energy in a number of European countries coming from total sugars [7]. The advice of the U.S. Department of Health and Human Services is to largely avoid calorically sweetened beverages and to eat less cake, cookies, ice cream, other desserts and candy by "replacing them with foods and beverages that provide substantial amounts of nutrients and relatively few calories (p. 1)" [8]. Undoubtedly, this is sound advice in an obesogenic environment; however, there may be reluctance, including psychosocial and even physiological barriers, preventing people from restricting their sugar intake [9]. Humans have a genetically preprogrammed innate liking of sweet foods dating back

Address correspondence to: Dr. Bernard Venn, University of Otago, Department of Human Nutrition, P.O. Box 56, Dunedin 9054, NEW ZEALAND. E-mail: bernard.venn@otago.ac.nz

Abbreviation: VAS = visual analog scale.

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through our evolutionary ancestry in the form of ripe fruits [10]. This liking has been extended by manufacturers to produce foods containing added sugars, often in combination with fat, that are said to be hyperpalatable [11]. It has been argued that the gratification or comfort experienced from consuming palatable food drives excessive food intake by activating the brain's neurological reward system and overriding satiety signals [12,13]. Consistent with this concept, dessert was still consumed following consumption of regular and supersized restaurant meals despite high visual analog scale (VAS) scores of satisfaction following the main course [14]. Thus, there is evidence of discrepancy between what people record as appetite sensations and what they do, leading to questions regarding methodological problems with VAS [15]. One suggestion to improve the sensitivity of recording of appetite sensations is to use pictures of food [16]. Given the current interest in added sugars and the World Health Organization's recommendation to limit intake, the purpose of this work was to test whether the desire for a sweet taste would be better maintained than a desire for other tastes following the consumption of a bread meal using 2 methods of assessment, VAS and real food models. Our hypotheses were that a liking for sweetness would be maintained following a bread meal and that this desire would be reflected in both VAS and food model methodology.

METHODS

Subjects

Eighty-three healthy male and nonpregnant female nutrition students, of predominantly European ethnicity, without food allergies or chronic and digestive diseases were recruited. The University of Otago Human Ethics Committee approved the study. An information sheet was given to all participants and a signed consent form obtained.

Study Design

Participants were randomly assigned to consumption of bread and to a morning or afternoon start time allowing at least 4-hour fasting before commencement of the tests. The experiment was repeated 2 weeks apart with each participant having the same morning or afternoon start time on each occasion. The tests included consumption of 2 10-mm-thick slices of bread each spread with 5 g margarine. Bread was chosen for the test meal because it is a food that can ordinarily be eaten at breakfast and at lunchtime, and bread has a wide appeal in New Zealand, being the single biggest contributor to energy intake in New Zealand [17]. Bread is also a neutral food in that it is unlikely to generate feelings of extreme like or dislike, factors that have been found to influence feelings of desire [18]. The bread differed between occasions in that one of the breads contained 5 g of added fiber per slice. The mean (SD) weight of the bread was 108 (6.9) and 137 (6.3) g for the non-fiber-added and fiber-added bread, respectively. The greater weight of the fiber bread was due to its higher moisture content. The mean (SD) energy contents of the 2 slices of bread plus margarine were 1570 (82) and 1530 (195) kJ for the non-fiber-added and fiber-added bread, respectively. The effects of the added fiber on postprandial glycemia, energy intake, satiety, palatability, and gastrointestinal well-being have been reported previously [19].

Desire

Desire to eat various foods before and after consumption of the bread was assessed in 2 ways: by presenting food on a plate (food models) and by VAS. For the food models, participants were asked, "How many portions of this product—rounded to the nearest half portion—would you like to eat if that portion was served to you right now?" [16]. Five foods were displayed, each on their own plate, in portion sizes typical of a small serving designed to contain similar amounts of energy among foods. The foods were chosen to nominally represent sweet (plain biscuits), savory (pasta with tomato sauce), salty (pizza), fatty (cheese and crackers), and bland (white rice). There is overlap in that some of the foods have a mixed nutritional composition—for example, fat and salt—but the foods were deemed by a group of 4 trainee dietitians to nominally represent the tastes. A photograph of the foods is shown in Fig. 1.

Desire was also assessed with VAS using 4 questions that have been validated for single meal studies [20]. The questions were, "Would you like to eat something sweet?" "Would you like to eat something salty?" "Would you like to eat something

Fig. 1. Foods presented to participants to quantify the number of servings they desired before and following consumption of a test meal of bread. The foods in order left to right: crackers and cheese; white rice; pasta; pizza; and sweet biscuits.

savory?" and "Would you like to eat something fatty?" Responses were marked on a 100-mm-long horizontal line anchored at either end with *not at all* (0 mm) and *yes, very much* (100 mm). VAS questions were asked at baseline and at 30, 60, 90, 120, 150, 180 minutes following consumption of the bread. Immediately following each of these time points, the food models were placed in front of each participant to allow his or her quantitative assessment to take place.

Statistical Analysis

The sample size was sufficient to detect a 10% difference (10 mm) using a 2-sided test at a power level of 0.8 (20% chance of type II error) for VAS [20]. Mixed model linear regressions were undertaken for each taste type (sweet, salty, savory, fatty) to determine the mean change in VAS scores comparing before consumption of the bread to 30 minutes later. In the regression models, time (before or after) was a fixed effect; bread type (fiber-added or non-fiber-added) and time of day (morning or afternoon) were included as covariates; participant id was included as a random effect to account for the repeated experiments. The same method was used for the food models (biscuits, pizza, pasta, and cheese and crackers). Regression coefficients, 95% confidence intervals, and *p*-values were calculated. Changes in appetite were compared among tastes and foods using mixed regression with final appetite ratings as the outcome variable and taste or food categories as the predictor variable; baseline appetite ratings, bread type, and time of day were covariates and id was included as a random effect. A Wald test for differences between tastes or groups was undertaken and, if significant, pairwise comparisons using a Bonferroni adjustment were carried out. The data for white rice contained numerous zero ratings (i.e., no desire at either time point) that could not be quantitatively analyzed.

RESULTS

Of the 83 participants, 80 people consumed both fiber-added and non-fiber-added bread on different days, providing a data set of 160 items of data for each VAS question (sweet, salty, savory, fatty) and desire to eat the foods displayed as food models. The nutritional compositions of the food models are shown in Table 1. As designed, the portions were based on a small serving such that the range in energy content was narrow, resulting in weights that varied considerably among foods.

Table 1. Nutritional Composition of the Real Food Models

Food	Weight (g)	Energy (kJ)	Fat (g)	Carbohydrate (g)	Sugar (g)	Sodium (mg)
Pizza	63	607	4.8	19.4	2.8	200
Biscuits	29	525	5.5	18.8	6.8	90
Crackers /cheese	34	526	7.3	<8.0	<1.0	240
Pasta	130	706	1.2	33.2	4.5	260
White rice	120	674	<1	36.0	<1.0	2

The acute effect on desire assessed using VAS and food models was tested between baseline and 30 minutes for each of the foods (excluding white rice), and the results are shown in Table 2. Bread type (fiber-added or non-fiber-added) was initially included as an interaction term with time in all regressions but was not found to be a significant moderator; therefore, bread type was included as a covariate.

Before consuming the bread, the mean desire for savory taste was higher than that for sweet, salty, or fatty tastes, χ^2 (3) = 169.09, $p < 0.001$. Thirty minutes after eating 2 slices of bread, taste desirability for salty, fatty, and savory foods was markedly reduced ($p < 0.001$), whereas the desire for sweet foods did not differ from baseline ($p = 0.316$). Desire for salty, fatty, and savory tastes diminished over time compared to a sweet taste, χ^2 (3) = 49.52, $p < 0.001$.

The immediate decreases in desire for savory, salty, and fatty tastes 30 minutes after eating the bread, depicted in Fig. 2, were followed by a gradual return of desire over the next 2 to 3 hours. The desire for sweet taste did not acutely decrease after eating the bread and remained relatively constant over the subsequent 3-hour period.

Using the food model data, the desire for pizza at baseline was significantly higher than for all other foods, χ^2 (3) = 121.58, $p < 0.001$. The desire for foods after consumption of the bread decreased on average for all foods measured, χ^2 (3) = 2.63, $p = 0.452$.

DISCUSSION

The main finding of this study was that after eating 2 slices of bread, the desire for salty, fatty, and savory tastes diminished, whereas the desire for sweet was maintained. There is a well-established relationship whereby the pleasantness of the taste of a food eaten to fullness declines more than the pleasantness of an untasted property [21]. Our participants were provided with a set amount of food as opposed to eating as much as they wanted, but the concept of sensory-specific desirability was maintained. In contrast to our data, a decline in desire to eat sweet food was found after participants had consumed sandwiches *ad libitum* [22]. However, the 2 data sets are not necessarily inconsistent, because Guinard and Brun [22] assessed desire 2 minutes and 20 minutes after the meal and in the short term, our participants also showed a small dip in ratings (Fig. 2). However, the magnitude of the drop and the shape of the desire plot for sweet taste over a period of 3 hours markedly differed compared to the desire for salty, savory, and fatty foods. Consistent with our data [23], when compared over

Table 2. Change in Taste and Food Desirability from Premeal to 30 Minutes after Eating Bread Assessed Using Visual Analog Scales and Food Models ($n = 80$)[a]

Taste/Food	Baseline Mean (SD)	30-Minute Mean (SD)	Mean Change[b] (95% Confidence Interval)	*P* over Time	*P* among Scores[c]
VAS scores (mm)					
Sweet	48.8 (28.8)	46.4 (28.7)	−2.4 (−7.1, 2.3)	0.316	—
Salty	49.5 (27.1)	34.9 (25.9)	−14.5 (−18.6, −10.5)	<0.001	<0.001
Savoury	71.8 (21.9)	47.7 (28.2)	−24.1 (−28.5, −19.7)	<0.001	0.002
Fatty	42.5 (28.7)	31.3 (26.9)	−11.2 (−15.2, −7.1)	<0.001	<0.001
Food models (serves)					
Biscuits	1.5 (1.2)	1.0 (1.0)	−0.44 (−0.60, −0.27)	<0.001	—
Pizza	2.7 (1.9)	1.6 (1.8)	−1.03 (−1.23, −0.82)	<0.001	—
Pasta	1.7 (1.4)	1.1 (1.2)	−0.65 (−0.84, −0.45)	<0.001	—
Cheese and crackers	1.6 (1.0)	1.0 (1.0)	−0.63 (−0.78, −0.49)	<0.001	—

[a]$n = 80$ with duplicate data for each participant consuming fiber-enriched and non-fiber-enriched bread on different days.
[b]A mixed model for taste or food desirability with participant modeled as a random effect and adjusted for bread type and time of day (morning or afternoon).
[c]Using sweet as the reference.

a similar timeframe, wanting between meals was maintained for chocolate mousse, waffles, and orange juice and declined for most non-sweet foods [24].

A decrease in the desired number of servings of food represented by the food models was noted following consumption of the bread. Biscuits represented sweetness and we had hypothesized that the desire for biscuits would have been better maintained than the desire for other non-sweet foods, but this was not the case. Hence, the VAS and food model data appear to be contradictory with respect to measuring desire for a sweet taste. Whether there is a contradiction requires further work because food models introduce food selection and liking into the study design, factors that may impact the results. For example, although people desire sweet-tasting food, they may not like biscuits. If this were the case, VAS and food model data would indicate different aspects of desire. Potentially, the use of a different sweet food could have produced a different result. In a comparison of VAS and food picture methodology, food liking was controlled by allowing participants to preselect preferred foods from a set list [16]. Under these experimental conditions, food pictures were found to be more sensitive than VAS to intervention and the ratio of savory to sweet portions postmeal initially favored sweet foods [16].

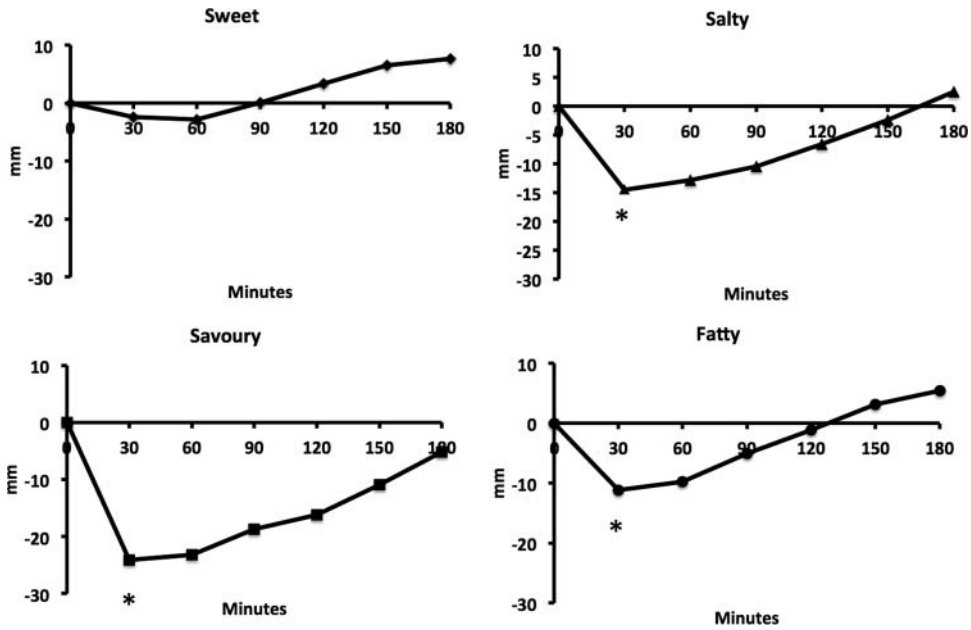

Fig. 2. VAS plots of change in taste desirability from baseline ($n = 80$ with duplicate measures). Mixed model linear regression was used to determine the mean change in VAS scores comparing before consumption of bread to 30 minutes later. In the models, time (before or after) was a fixed effect; bread type (fiber-added or non-fiber-added) and time of day (morning or afternoon) were included as covariates, and participant id was included as a random effect to account for the repeated experiments.

A desire for sweetness can span the life course, with infants being able to taste the sweetness of human and commercial milk [25]. During weaning, the majority of complementary foods manufactured in the United Kingdom are sweet [26], and throughout childhood, caregivers may use dessert as a reward [27,28]. Indeed, food culture at home, in restaurants, and at take-away outlets in many parts of the world is predicated on a main course followed by something sweet, with evidence that such practices contribute to an obesogenic environment [29–31]. This maintenance of desire for a sweet taste may be problematic in terms of energy intake. When participants were offered a sweet course for lunch, consumed either before or after a meal, the tendency was for participants to consume more calories when the sweet course was served last, an effect attributed to "habit and desire to finish the meal with something sweet (p. 146)" [32]. In longitudinal studies, sweets and desserts have been associated with long-term weight gain [33]. Our data are consistent with this potential for positive energy balance in that our participants showed no change in sweet desire, regardless of fullness or emptiness, suggesting that there may be a disconnect between a desire for sweet foods and satiety. Mechanistically, biological triggers for sweetness are activated by a range of appetizing energy-dense foods whose images induce neural rewards with the potential to override satiety cues [34–37]. If indeed we have become habituated to eating something sweet after a meal and our physiology and reward systems encourage that practice, there are strategies to restrain an excess of sugar energy intake. Because portion sizes have increased over the decades [38], reducing portion sizes and sharing of dessert would be practical ways to control intake. The U.S. government encourages fruit as a dessert [39], with the exchange of fat and added-sugar foods for fruit being associated with a lower risk of childhood obesity [40].

A limitation of the work may be that the participants were students of human nutrition and that with their knowledge and interest they might differ in their outlook on food compared to the general public. However, with sugars being negatively implicated in health outcomes [41], the students' knowledge could plausibly have predisposed them to sugar avoidance rather than to the maintenance of desire for sweet foods. Strengths of our work are a large sample, repeated measures, and the use of validated VAS methodology complemented by real food models.

CONCLUSIONS

The desire for sweet taste assessed in a fasted state was maintained after consumption of a small bread meal. We hypothesize that our want for sweet foods is disconnected from our appetite because of habituation from childhood coupled with physiological rewards in brain activity. How generalizable our findings are is questionable; parental practices and food culture differ around the world such that the concept of "a dessert mentality" may vary both within and between populations.

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