



## Better-liked foods can produce more satiety

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### ABSTRACT

Food liking influences hunger and fullness, however, the direction of this influence has remained unclear due to the difficulty in capturing the complexity of hunger and fullness feelings and the subjective nature of evaluating food liking. The objective of this study was to investigate the impact of food liking on feelings of hunger and fullness utilizing the 5-Factor Satiety Questionnaire. Thirty participants attended two breakfast sessions one week apart in which they evaluated hunger and fullness feelings produced by two equal-caloric smoothies that differed only in that one contained a bittering agent to lower liking. Levels of the bittering agent were determined from a screening procedure and were panelist specific. Evaluations were made at 0 min, 60 min, 120 min, and 180 min after consumption. Food intake from a snack offered three hours after breakfast was covertly recorded. The more palatable control smoothie provided significantly greater mental fullness factor sensations over the three-hour testing period than the bitter smoothie. Physical fullness factor ratings were initially higher for the bitter smoothie than the control smoothie, but dropped to a nearly equal level two hours after consumption. Mental and physical hunger factor sensations were nearly equal between the two smoothies over the three hour testing period. Subjects consumed on average 77 more calories from the snack following the bitter smoothie in comparison to the control. These findings suggest that if people eat a food they greatly enjoy, instead of eating a less-well-liked version, they will experience more pleasure, satisfaction, and satiety.

## 1. Introduction

### 1.1. Definitions and importance

Satiety has been traditionally defined as the feeling of fullness and/or inhibition of hunger sensations after a meal resulting from the ingestion of food (Blundell, 1991; Green, Delargy, Joanes, & Blundell, 1997; Sorensen, Moller, Flint, Martens, & Raben, 2003). However, definitions of satiety have evolved over the years, leading to two functionally different terms. Satiation has been defined as the ‘within meal satiety’ (Green et al., 1997; Sorensen et al., 2003). Satiation refers to the process that occurs during a meal and leads to the termination of the meal. Satiety, on the other hand, is solely viewed as ‘between-meal satiety’ and is most commonly defined as the state of inhibition from further eating from the end of one meal to the next eating episode (Green et al., 1997; Sorensen et al., 2003). Sensory-specific satiety is an independent but related term representing the changing hedonic response to the sensory properties of a food as it is consumed (Rolls, 1986). Because appetite measures of satiety and satiation are not good proxies for energy intake at a next meal (Holt et al., 2016), energy

intake must be measured directly.

If foods and/or the manner in which they are prepared, served and consumed provide more satiety per calorie, consumers’ overall calorie intake might be reduced without sacrificing feelings of satiety and satisfaction. Such strategies may have use in the prevention or management of obesity. We need to know more about what factors make a food satiating, and how to screen foods for their ability to satiate.

### 1.2. The influence of food liking on intake, satiety and satiation

People eat more of foods they like more. Several studies (Bellisle & Le Magnen, 1980; Bellisle, Lucas, Amrani, & Le Magnen, 1984; Guy-Grand, Lehnert, Doassans, & Bellisle, 1994; Spiegel, Shrager, & Stellar, 1989) have demonstrated the sensitivity of the microstructure of *ad libitum* meals to liking manipulations and provided early insight into liking’s effect on intake. In the majority of these studies, caloric content was not matched among test foods because the focus of the research was not on the impact of food liking on satiety.

The studies that have more clearly measured the effect of liking on satiety-related feelings have shown inconsistencies in the direction of

Abbreviations: LAM, labeled affective magnitude; JAR, just about right; Glm, general labeled magnitude; ANOVA, analysis(es) of variance; BMI, body mass index; M, mean; FDA, Food and Drug Administration; CFR, Code of Federal Regulations; MSG, monosodium glutamate

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**Table 1**  
Smoothie ingredients and formula for a single serving.

Smoothie recipe ingredient	Amount per single serving (grams)	Company information
Mountain High® Low-fat All Natural Plain Yoghurt	78	Mountain High, Englewood, CO
Kirkland Signature® Frozen Strawberries	156	Costco Wholesale Corporation, Seattle, WA
Wymann's of Maine® Fresh Frozen Wild Blueberries	59	Jasper Wyman and Son, Milbride, Maine
Land'O Lakes® 2% Milk	101	Land'O Lakes, Arden Hills, MN
Sucrose solution (250 g water and 435 g Crystal® Sugar brought to boil for 1 min to dissolve)	36	Kandiyohi Premium Water, Minneapolis, MN
†Virginia Dare® Natural Flavor for Tonic*	0.0–0.688	United Sugar Corporation, Minneapolis, MN Virginia Dare, Brooklyn, NY

\* Provided as a gift from Virginia Dare.

the influence. Rogers & Schutz, 1992 and Bobroff & Kissileff, 1986 both observed that increased liking increased feelings of satiety or satiation. Hill, Magson, & Blundell, 1984 and Holt and Delargy (1999) observed that increased liking decreased feelings of satiety or satiation. Still other researchers found the effect of palatability to have no difference on hunger and fullness ratings (Yeomans, 1996; Yeomans & Symes, 1999).

We found only four studies that investigated the impact of consuming fixed amounts of a more-liked and a less-liked test food on energy intake at the next meal.

Warwick, Hall, Pappas, and Schiffman (1993) and Karalus (2011) found participants felt less hungry after the more-liked meal but consumed the same amount at a subsequent eating episode; Rogers and Blundell (1990) found that participants felt more hungry after the more-liked meal but consumed the same amount at a subsequent eating episode. De Graaf, De Jong, and Lambers (1999) observed no difference in satiety-related ratings or in the amount consumed at a subsequent eating episode.

### 1.3. Objectives

Our objectives were to investigate the impact of food liking on satiety, satiation, and subsequent calorie consumption. Our study differed from preceding studies in that we altered liking for each individual participant based on their liking ratings in a pre-test, and that we used the 5-Factor Satiety Questionnaire (Karus, 2011; Karalus & Vickers, 2016), which better measures the variety and complexity of the sensations contributing to the feelings of satiety and satiation. We hypothesized that we would observe the same trends observed by Karalus (2011): the decreased liking would decrease mental fullness, but have no effect on physical fullness or physical hunger.

## 2. Material and methods

### 2.1. Overview

To control for liking differences among participants and to determine what level of the bittering agent subjects would receive in the main part of the study, we held a preliminary screening session. In this session, participants were presented with five smoothie samples differing in the concentration of a bittering agent and asked to evaluate their liking. Using these data, we determined what level of the bittering agent each person would receive in their bitter (less-liked) smoothie to decrease their liking by approximately 20% of the liking scale length. In the main part of the study, participants came in for two breakfast sessions (one week apart) in which they consumed the control and bitter smoothies for breakfast, evaluated hunger and fullness feelings before, during, and after consumption, and were given an *ad libitum* snack tray three hours after breakfast.

### 2.2. Experiment I – preliminary session to determine participant response to bittering agent

#### 2.2.1. Participants

Forty-seven participants were recruited from a database of students and staff on the Saint Paul campus who had previously indicated an interest in participation in studies for the Sensory Center in the Food Science and Nutrition Department. We recruited 47 participants for this part of the test to be sure we would have at least 21 participants for the second experiment. We had determined that to achieve a power of at least 0.95 for detecting a difference of 10% in scale length in the second experiment we would need a minimum of 21 participants Lenth (2006–9). A recruitment questionnaire was used to screen respondents to make sure they had no food allergies, were native English speakers, and had no medical conditions that restricted their diet in any way (including diabetes, depression, eating disorders, or celiac disease). Participants had to be breakfast eaters and like and be willing to consume fruit smoothies as a meal. They could not be on any sort of medically supervised diet, and they had to indicate that they considered themselves food secure. They indicated their dieting status by selecting one of the following responses: I am currently working on losing weight; I am currently working on gaining weight; I am actively working on maintaining my current weight; or I am not currently involved in any weight management effort. Participants received a cash payment after this initial session. The protocol was approved by the University of Minnesota Institutional Review Board, and all participants gave their informed consent prior to their inclusion in the study.

#### 2.2.2. Products

Strawberry-blueberry yogurt smoothies were prepared for testing according to a standard formulation (Table 1). The five samples differed in the amount of added tonic flavor (0, 0.04, 0.08, 0.12, and 0.16% w/w) (Table 1). Samples were stored and served at 40 °F. Each participant received approximately 30 ml of each smoothie in lidded 60 ml plastic soufflé cups coded with random 3-digit codes.

#### 2.2.3. Experimental procedure

The study was conducted in tasting booths at the University of Minnesota Sensory Center facilities in McNeal Hall (St. Paul, Minnesota, USA). Samples were served to participants balanced for order and carryover effects (Williams, 1949). Participants were asked to taste the smoothies and rate their overall liking of each. They made liking ratings on 120-point labeled affective magnitude (LAM) scales. (See Section 2.3.3 for a more detailed description of the scale points).

#### 2.2.4. Data analysis

To determine the concentration of tonic flavor required to drop the liking rating of the control by about 20% of the scale length, we used the following procedure for each participant separately: distances from the greatest imaginable disliking end of the LAM scales were measured. A plot of tonic flavor concentration vs. overall liking rating was made for each panelist. Using polynomial regression, a trend line was fit for each plot. Each panelist's liking rating given to the control was

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