



Towards a satiety map of common foods: Associations between perceived satiety value of 100 foods and their objective and subjective attributes



Nicola J. Buckland^{a,*}, R. James Stubbs^b, Graham Finlayson^a

^a University of Leeds, School of Psychology, Leeds, LS2 9JT England, United Kingdom

^b University of Derby, Psychology, Kedleston Road, Derby, DE22 1GB England, United Kingdom

HIGHLIGHTS

- Consumer perceptions of the satiety value of 100 foods were explored.
- Consumers rated 100 foods for perceived satiety value and subjective attributes.
- Perceived satiety value correlated with objective and subjective attributes.
- Low energy density, low %fat, high fibre, %carbohydrates and cost were important.
- Weight management and frequent consumption were important subjective attributes.

ARTICLE INFO

Article history:

Received 20 March 2015

Received in revised form 4 June 2015

Accepted 1 July 2015

Available online 15 July 2015

Keywords:

Food perceptions

Perceived satiety

Satiety map

Weight management

Food images

ABSTRACT

Hunger is one of the main reasons given by people experiencing problems in managing their weight. Identifying the types and properties of foods that enhance satiety may help consumers improve appetite control and weight management. However the attributes of foods associated with their perceived satiety value have been largely unexamined. The current research examined a range of objective and subjective attributes of foods and sought to map them onto ratings of their perceived satiety value. Participants ($n = 1127$) rated 100 individual food images, through online surveys, based on subjective (e.g. perceived energy content, control over eating, healthiness, palatability) and objective (e.g. actual energy content, macronutrient composition, cost/kcal) attributes. Perceived satiety value was quantified from ratings of how filling each food was judged to be. Results showed that when controlling for perceived total energy content, perceived satiety value was associated with lower energy density ($r = -.74$), lower %fat ($r = -.47$), higher %protein ($r = .31$) and higher cost ($r = .48$). In terms of subjective attributes, perceived satiety value was associated with greater healthiness ($r = .90$), weight management ($r = .91$), frequency of consumption ($r = .58$) and greater control over eating ($r = .76$). Linear regression models indicated that the objective attributes of energy density, %fat, fibre content, %carbohydrate and cost ($R^2 = .69$) and the subjective attribute of utility for weight management and frequency of consumption ($R^2 = .83$) accounted for the most variance in the perceived satiety value of food. These findings may help towards a 'satiety map' of the diet with implications for public health promotion and the development of satiety enhancing foods.

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1. Introduction

The negative health, social and economic consequences stemming from the prevalence of overweight and obesity have led to a focus on the promotion of food intake restriction and dieting behaviour as the primary means to manage body weight. At any one time 1 in 4 women are dieting to lose weight [32]. However, successful weight management is difficult and hunger is one of the main reasons given

for aborted or unsuccessful attempts to diet [38]. As a result, there has been growing interest amongst academics, regulators and the food industry to identify or develop satiety-enhancing foods which facilitate appetite control [1,7,21,23].

Foods differ in their potential to generate satiety and the major nutritional attributes underpinning this process are thought to be energy density and macronutrient composition. Low energy dense foods, such as salads [35] and fruits [16] have been found to induce greater fullness and reduce subsequent food intake compared to isoenergetic high energy dense foods [12,36]. In addition to energy density, laboratory studies have demonstrated a macronutrient hierarchy of food, in which

* Corresponding author.

E-mail address: n.j.buckland@leeds.ac.uk (N.J. Buckland).

proteins are most satiating, followed by carbohydrates then fats [26,39]. Moreover, specific fibres have received special attention [42] due to their pre- and post-absorptive actions with the potential to mediate satiety.

Previous research has sought to standardise objective measures of the satiety value of foods. For example by adjusting changes in subjective appetite for energy content consumed (i.e. Satiety Quotient; [20]) or by measuring food intake in response to a range of food items compared to a control food (i.e. Satiety Index; [26]). In the latter study, Holt et al. [26] measured food intake in response to 38 foods compared to a standard serving of white bread. It was found that protein, fibre and water content were inversely correlated with energy consumed and of all foods examined, boiled potatoes were ranked highest on the satiety index [26]. Such studies investigating objective measures of satiety compare the satiety value of foods per unit of energy by adjusting for energy content [20,22,25,28]. By adjusting for energy content, a standardised score for satiety value can be established which allows foods to be compared across varying energy contents.

Besides the objective nutritional composition of foods, consumer perceptions about the properties of food can strongly influence the extent to which they are not only perceived but also experienced as satiating or satiety-inducing (for a review see [43]). In the short term at least, the satiating capacity of foods can be enhanced if consumers merely perceive foods to have a high satiety value. For instance, a beverage labelled as 'satiating' was found to increase fullness compared to a beverage labelled with 'diet' or a supermarket brand [13].

To date, several studies have explored the properties of foods which consumers rate with the highest satiety value. Using an 'expected satiety' paradigm, in which participants matched portion sizes for expected satiation to a reference food, Brunstrom and colleagues showed that participants perceived low energy dense foods to be more satiating compared to high energy dense foods [2,4]. The same methodology also showed that more familiar foods were rated with increased expected satiety compared to less familiar foods [3]. High protein foods have also been rated as most satiating and with higher satiety when participants rated images of two different sandwiches [10]. Similar results were reported when participants rated the hunger satisfaction of 22 food names [33]. However, when rating nutritional descriptions of foods (without food names) participants rated foods high in fat and energy as most satiating [33]. Similarly, Green and Blundell [19] found that participants rated the taste of a high fat sweet food as more filling compared to a high fat savoury food, a high carbohydrate sweet food and a high carbohydrate savoury food. Thus, participants might not always be aware of the perceptual attributes they use for selecting high satiety foods. Importantly too, such studies have tended to be limited in terms of the number of foods under investigation and have mostly focused on exploring objective nutritional attributes only.

However, consumers also have considerable contextual and experiential knowledge of the value of specific foods for appetite. Therefore, the subjective attributes (e.g. taste, palatability) and other associated cognitions (e.g. healthiness, utility for weight management) related to satiety may also be important. Additionally, unlike studies investigating objective satiety values, research on perceptions about satiety value do not account for energy content and as such the satiety value of foods per unit of energy cannot be compared across foods.

Understanding the factors that influence how consumers perceive the satiety value of foods (per unit of energy) could be important to enable consumers to select a healthier diet conducive to weight management, or to inform the development of satiety-enhancing foods. Therefore, the current study aimed to explore multiple objective and subjective nutritional attributes within an array of common foods that varied in energy density, macronutrient composition and food groups in relation to their perceived satiety value (per unit of perceived energy). Objective nutritional information was obtained for an array of 100 standardised, high-quality, photographic images of different foods sampled from across food groups according to the UK Department of

Health's Eatwell Plate [41]. These images were also rated on a range of subjective attributes in a large sample of consumers.

The specific objectives were to: i) identify and compare foods with the highest and lowest perceived satiety values; ii) examine which individual objective or subjective attributes of food were associated with perceived satiety value; and iii) test which combination of objective or subjective attributes best accounted for perceived satiety value. It was hypothesised that the actual energy density, fat, protein and fibre content, and subjective ratings of frequency of consumption would be most strongly associated with perceived satiety value.

2. Method

2.1. Participants

Participants (n = 1127, 86% females) were recruited through email distribution lists (44%, n = 494), online forums and classified adverts (19%, n = 210), social network sites (2.5%, n = 28) and word of mouth (1.5% n = 1) (33% did not indicate recruitment origin). Of the sample, 31% were students, 39% were employed either full- or part-time, 5% were stay at home parents and 2% were unemployed (23% did not specify). Participants completed a subset of food image ratings from the total database which was distributed over 4 online surveys (survey 1, n = 347; survey 2, n = 327; survey 3, n = 213 and survey 4, n = 240).¹ Participants were aged 18–76 years (M: 32.21, SD: 12.23 years) and BMI calculated from self-reported height and weight ranged from 18.5 to 39.5 (M: 24.61, SD: 4.42). Out of all participants who entered the study, 69% completed the entire survey. Upon completion of the survey, participants were entered in to a prize draw to win £100 shopping vouchers.

2.2. Food images

Using food composition databases and supermarket inventories of over 300 food items, a final list of 100 foods was selected to ensure representation across different food groups [fruits, vegetables, starchy, dairy, non-dairy protein (including meat, fish, nuts, eggs and pulses), high fat and high sugar] according to the UK Department of Health's Eatwell Plate [41]. This formed a database of standardised photographic images. The database comprised of snack and meal appropriate foods, with approximately similar distribution of predominantly sweet or savoury tasting, high or low energy items. Foods were photographed without packaging and no other branding visible. All food items in the database were photographed in the laboratory according to standardised operating procedures. Foods were catalogued with nutritional information which was sourced from the product manufacturers' nutritional information and the UK Composition of Foods Database [14, 30]. Cost information was sourced from one of the largest supermarkets in the UK (<http://www.sainsburys.co.uk> accessed January to May 2014). All images were matched for lighting conditions, image composition and background. Full details of the database have been described elsewhere [5].

2.3. Perceived satiety value of food

Previous work has shown that consumers associate the terms 'satiating' and 'satiety' with sensations of fullness [15]. Therefore, to ensure that the construct of 'satiety value' was understandable to participants, they were asked to rate each food according to the prompt: "Generally, how filling do you consider this food to be?" Responses ranged from "1 = not at all filling" to "7 = extremely filling". The term 'generally' was explained in the survey to encourage participants to rate the food shown in terms of their general experience with the

¹ When taking into account attrition and invalid responses, each food received ratings from 141 to 331 participants.

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