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

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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.

1. Introduction

The negative health, social and economic consequences stemming from the prevalence of overweight and obesity has 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 (NICE, 2006). However, successful weight management is difficult and hunger is one of the main reasons given for aborted or unsuccessful attempts to diet (Stubbs et al., 2012). 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 (Blundell, 2010; Chambers, McCrickerd, & Yeomans, 2014; Halford & Harrold, 2012; Hetherington et al., 2013).

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 (Roe, Meengs, & Rolls, 2012), and fruits (Flood-Obbagy & Rolls, 2009) have been found to induce greater fullness and reduce subsequent food intake compared to isoenergetic high energy dense foods (Ello-Martin, Roe, Ledikwe, Beach, & Rolls, 2007; Rolls, Roe, Beach, & Kris-Etherton, 2005). In addition to energy density, laboratory studies have demonstrated a macronutrient hierarchy of food, in which proteins are most satiating, followed by carbohydrates then fats (Holt, Miller, Petocz, & Farmakalidis, 1995; Stubbs, vanWyk, Johnstone, & Harbron, 1996). Moreover, specific fibres have received special attention (Wanders et al., 2011) 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; Green & Blundell, 1997) or by measuring food intake in response to a range of food items compared to a control food (i.e. Satiety Index; Holt, Miller & Petocz, 1995). In the latter study, Holt et al. (1995) 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 was inversely correlated with energy consumed and of all foods examined, boiled potatoes were ranked highest on the satiety index (Holt et al., 1995). Such studies investigating objective measures of satiety compare the satiety value of foods per unit of energy by adjusting for energy content (Green & Blundell, 1997; Heaton, 1981; Holt &

Miller, 1995; Kissileff, 1984). 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 Chambers, McCrickerd & Yeomans, 2015). 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 (Fay et al., 2011).

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 (Brunstrom, 2014; Brunstrom, Shakeshaft, & Scott-Samuel, 2008). The same methodology also showed that more familiar foods were rated with increased expected satiety compared to less familiar foods (Brunstrom, Shakeshaft, & Alexander, 2010). High protein foods have also been rated as most satiating and with higher satiety when participants rated images of 2 different sandwiches (De Graaf, 1992). Similar results were reported when participants rated the hunger satisfaction of 22 food names (Oakes, 2006). However, when rating nutritional descriptions of foods (without foods names) participants rated foods high in fat and energy as most satiating (Oakes, 2006). Similarly, Green and Blundell (1996) 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 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 a focus 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. 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 (2013). 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 value; ii) examine which individual objective or subjective attributes of food were associated with perceived satiety value; 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 energy content and frequency of consumption would be most strongly associated with perceived satiety value.

2. Method

2.1. Participants

Participants (n = 1127, 86% female) 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. 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 3,000 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 (2013). 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 (Finglas et al. 2015; Mc Cance & Widdowson, 1992). 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

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

and background. Full details of the database have been described elsewhere (Buckland, Dalton, Stubbs, Hetherington, Blundell & Finlayson, *In press*).

2.3. Perceived satiety value of food

Previous work has shown that consumers associate the terms 'satiating' and 'satiety' with sensations of fullness (Fitzsimons, Varela, Diaz, Linares & Garrido, 2014). Therefore, to ensure 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 food, rather than evaluating the food based on the particular presentation or quantity shown, or their current motivational state.

In the current study, images were composed to maximise recognisability, meaning that the energy, weight and macronutrient content varied between images. Given that energy content impacts satiety, analyses were adjusted to control for perceived energy content (satiety value / perceived energy content).

2.4. Objective attributes: Nutritional components and cost (£/kcal)

For the current study, objective attributes of cost (£/kcal), fibre (per 100g), energy density (kcal/100g); and energy composition from protein, fat and carbohydrate (%kcal) were obtained from Mc Cance and Widdowson (1993) and Finglas et al. (2015).

2.5. Subjective attributes: Perceived nutritional, sensory, and cognitive aspects

Using 7-point scales, participants rated each food based on: perceived energy content; fat content; pleasantness; taste (sweet or savoury); utility for weight management; healthiness; and controllability over eating. Table 1 shows the questions used to assess each subjective attribute. The controllability item was reverse scored. For all attributes, higher scores indicated stronger perceptions of the specified attribute. In addition, participants self-reported the frequency they consumed each food (never, once a year, every few months, once a month, once a week and almost every day).

2.6. Procedure

In response to recruitment adverts participants clicked on a link to be directed to the online survey (SurveyMonkey Inc., Palo Alto, California, USA, www.surveymonkey.com)]. Informed consent was obtained and participants then indicated their age, gender, self-reported height and weight, time since they last ate and rated hunger on a 7-point scale [“How hungry do you feel right now?” (“1 = “not at all hungry” to 10 “extremely hungery”)]. Participants were then shown an image of the first food item and were asked to name the food, indicate frequency of consumption and rate pleasantness, taste and perceived nutritional content. On a separate page, the image of the food was displayed again and participants rated utility for weight management, controllability over eating, healthiness and perceived satiety value. Next, the second food item appeared on a new page and participants repeated the ratings until 25 food items were completed. The order of presentation of foods was determined randomly for each survey. Once participants had completed ratings for all 25 foods they were prompted to state where they had heard about the survey, indicate their nationality and whether they wished to be part of the prize draw. Each survey took a mean time of 27 minutes (SD: ±10 minutes) to complete. Prior to data collection, full ethics approval for the study was granted by the University of Leeds’ Faculty of Medicine and Health ethics committee (#14-0024, February 2014).

2.7. Data analysis

Data are expressed as mean ± SD unless otherwise stated. Descriptive analyses on perceived satiety value and the subjective attributes of the food database were conducted. If any foods were incorrectly named their corresponding ratings were excluded. To retain as many responses as possible correct generic food descriptions were accepted. If more specific descriptions were given which were incorrect, responses were excluded (for example, if milk chocolate was described as “plain chocolate”). Spelling mistakes (provided the word was decipherable) did not affect inclusion but indecipherable responses were excluded. For participants who did not complete the survey to entirety ratings were included in the analysis up to the point of terminating participation. A series of independent t-tests in which alpha was set at $p<.01$, showed no differences between completers and non-completers for hunger, time since last ate, age, height, weight and BMI [largest t: $t(1114) = 2.40$, $p = ns$].

Associations between objective and subjective food attributes and perceived satiety value were initially explored using bivariate correlations. Bonferonni adjustment was applied to correct for multiple tests (12 correlations per variable), thus alpha was set at $p<0.05$.

To examine whether specific combinations of attributes accounted for greater variation in perceived satiety value, stepwise linear regression was applied in which all the objective and subjective attributes (in separate models) were introduced successively based on descending coefficient sizes.

To check for the presence of statistical outliers that might unduly influence the relationship between variables, the residual statistics were examined. A standardised residual of less than -3 or greater than +3 SD was used to indicate that an observation was a statistical outlier. Furthermore, Cook's Distance scores were also calculated, with a score of greater than 1 taken to indicate that an observation unduly influenced the model. To check for multicollinearity between predictor variables, the variance inflation factor (VIF) and tolerance statistics were calculated. Multicollinearity was assumed if the VIF statistic was greater than 10, and the tolerance value below 0.2 (Tabachnick and Fidell, 2007). For regression analyses, alpha was set at $p < .05$. All statistical analyses were performed using IBM SPSS for windows (Chicago, Illinois, Version 21).

3. Results

3.1. Comparison of foods with the highest and lowest perceived satiety value

Mean scores for the perceived satiety value of individual foods are shown in Table 2. Participants rated broccoli, carrots, cherry tomatoes, fine beans, berry salad, pepper, lettuce, celery, cucumber and salad tomatoes as highest in perceived satiety value. Foods such as sweets, chocolate, crisps, biscuits and pastries received the lowest ratings for satiety value. Independent t-tests were conducted to compare objective and subjective ratings of the 20 food items with highest perceived satiety value to the 20 foods with the lowest satiety value. It was found that foods perceived with the highest satiety value had a lower energy density [$t(38) = 10.02$, $p <.001$], lower percentage fat [$t(38) = 4.25$, $p <.001$] and higher cost [$t(19.06) = 3.67$, $p = .002$] compared to the lowest satiety value foods. Comparisons of the subjective ratings showed the highest satiety foods scored higher in perceived weight management [$t(38) = 32.91$, $p <.001$], healthiness [$t(38) = 28.98$, $p < .001$], controllability [$t(38) = 13.01$, $p <.001$] and were reported with increased consumption [t(38)

= 4.42, p <.001] compared to the lowest satiety foods. There were no significant differences between the highest and lowest satiety value foods for percentage protein [t(21.33) = 2.62, p = ns] or percentage carbohydrate [t(38) = 1.38, p = ns]. Means for subjective attributes are provided in Table 2.

3.2. Associations between perceived satiety value and attributes of food

In terms of the objective attributes included in this study, perceived satiety value was positively associated with percentage protein and cost (£/kcal) and were negatively associated with energy density (kcal/100g) and percentage fat (see Table 3). There were no associations between perceived satiety value, percentage carbohydrate and fibre (per 100g).

For the subjective attributes of food assessed, perceived satiety value was positively associated with healthiness, utility for weight management, controllability over eating and frequency of consumption. There were no associations between perceived satiety value and pleasantness or sweet/savoury taste.

2.8. Do combinations of subjective or objective food attributes better account for perceived satiety value of food?

For the objective attributes, results showed that energy density (β = -.66, p <.001), percentage fat (β = -.38, p < .001), fibre content (β = .34, p < .001), percentage carbohydrate (β = -.24, p = .01) and cost (β = .17, p = .01) were the strongest combination of attributes associated with perceived satiety value [Adjusted R^2= .69, F(5, 94) = 45.13, p < .001]. Foods with the highest satiety value tended to be lower in energy density, percentage fat, percentage carbohydrate and higher in fibre (per 100g), and cost (kcal/g) (see Table 4).

For the subjective attributes, results showed that utility for weight management (β = .85, p <.001) and frequency of consumption (β = .10, p < .05) accounted for most of the variance in perceived satiety value [Adjusted R^2 = .83, F(2, 97) = 247.40, p <.001]. Foods with the highest satiety value tended to be those associated with successful weight management and self-reported to be consumed more frequently (see Table 4).

4. Discussion

The current study explored consumer perceptions of the satiety value of 100 different foods and examined whether these perceptions were associated with a number of objective and subjective attributes of food. Foods with the highest perceived satiety value included broccoli, carrots, tomatoes, fine beans, berry salad, pepper, lettuce, cucumber and rice cakes. Perceived satiety value was associated with a number of objective and subjective attributes including energy density, fibre, percentage protein, percentage carbohydrates, percentage fat, cost, perceived healthiness, utility for weight management, controllability over eating and frequency of consumption. These attributes will be discussed in turn.

It is interesting that the nutritional attribute that foods consumers rated as most satiating i.e. low energy density, corresponds with the established literature from laboratory studies using objectively measured indices of satiety (Rolls, Roe, & Meengs, 2004; Stubbs et al., 1996; Wanders et al., 2011). Low energy density was the strongest correlate of perceived satiety value, followed by high fibre content and low percentage fat. This finding also confirms previous studies that have evaluated the expected satiety value of foods (Brunstrom, 2014) which hold energy density as the most important factor. Gram for gram, low energy dense foods contain less energy (kcal) compared to high energy dense foods. Thus, larger volumes of low energy dense foods can be consumed for equal amounts of energy consumed from high energy dense foods. Larger volumes of food can enhance satiety by increasing gastric distension (de Castro, 2005) and increasing oral transit times and eating rate (de Graaf, 2012). The current study did not ask participants to elaborate on their ratings of satiety value however it would be interesting for future studies to examine perceptions of sensory factors related to oral processing such as chewing (Higgs & Jones, 2013), eating rate and oral residence (de Graaf, 2012).

In addition to energy density, fibre was identified as important for satiety value. This is in line with laboratory studies which highlight the role of specific fibres on satiety (Wanders et al., 2011). Interestingly, no relationship was observed between fibre content (g/100g) and perceived satiety value in the univariate analysis, but there was a strong effect in the final multivariate model. One explanation for this is that fibre is a function of % carbohydrate and both are a function of perceived satiety value but in opposing directions. Therefore fibre is a correlate of perceived satiety value after variance from % carbohydrate is explained. Alternatively, higher fibre foods are lower in ED, higher in CHO, lower in fat and relatively low in protein (with the exception of pulses etc) and one or more of these variables could be responsible for suppressing the effect. However, the current findings do not directly correspond with the macronutrient hierarchy which places protein as most satiating followed by carbohydrates and fat (Stubbs et al., 1996). In the current study, although protein was a significant correlate of perceived satiety value, a high percentage carbohydrate and low percentage fat were most important. This might be due to participants not always being aware of the nutritional components which influence satiety. Indeed, other research has shown that consumers underestimate the role of protein when evaluating the extent a food will impact hunger satisfaction (Oakes, 2006).

In addition to these nutritional attributes, the current study supports previous findings by revealing an association between perceived satiety value and cost. The results showed that foods perceived with the highest satiety value tended to be more costly. This corresponds to a recent examination of food costs based on the UK Department of Health's Eatwell Plate which showed that the healthiest foods were more costly compared to less healthy foods (Morris, Hulme, Clarke, Edwards, & Cade, 2014). Other research shows that nutrient rich foods are more expensive (Drewnowski, 2010). Thus, not only healthy or nutrient rich foods, but from the consumers' perspective, those which have the most potential for satiety tend to be more expensive.

The current findings also contribute to previous research by identifying a number of subjective attributes associated with perceived satiety value. Participants rated utility for weight management as the main characteristic of foods perceived with the highest satiety value. This result is interesting as previous research exploring perceptions about the healthiness (or weight management utility) of food on food intake is mixed. In line with the current findings, Buckland et al. (2013) found that a low energy dense, high volume salad preload was perceived to be useful for weight management and reduced objectively measured subsequent food intake compared to an equi-caloric high energy dense preload. In contrast, other studies have reported that consumption of foods perceived to be healthy increased food intake (e.g. Provencher, Polivy & Herman, 2009). These discrepant results may be due to the types of foods that have been under investigation. Studies which find that healthy or weight management foods increased food intake have tended to use high energy dense foods (e.g. cookies) labelled with healthy messages (Provencher et al. 2009). In contrast, this study, along with previous research (Buckland et al. 2013; Rolls et al. 2004) shows that foods with a low energy density are perceived to be compatible with weight management and have a higher perceived satiety value.

Participants also reported how frequently they consumed each food item and in line with previous research, higher perceived satiety value was associated with more frequent consumption (Brunstrom, 2014; Irvine et al., 2013; Brunstrom et al. 2010). This positive association is likely to stem from learned associations between perceived characteristics of food and their (post)ingestive consequences.

Additionally, foods perceived to be satiating were rated as those which promote control over eating rather than encouraging overconsumption. The benefits of satiety to the consumer have been reviewed elsewhere (Hetherington et al. 2014) and the current research provides support for the development of satiety-enhancing foods to be integrated in to weight management programs to facilitate compliance and enjoyment (Hetherington et al. 2014). Currently, more research is needed to substantiate the use of satiety enhancing foods to effectively improve appetite control in individuals attempting weight management. The results from the current research can be used to target specific attributes or compose specific diets for objective verification of satiety value using laboratory methods.

There are a number of limitations to acknowledge in the current research. Firstly, the findings are only illustrative of associations between food attributes and ratings of perceived satiety value; therefore it cannot be assumed that these perceptions will necessarily correspond to objective indices of satiety as measured in the laboratory. Subsequent work is needed to verify that the foods or combinations of food attributes identified by this approach are valid for the application to actual eating situations. This is especially important as the current study is based on images of foods and exposure to actual food may elicit different perceptions of subjective attributes and satiety value. Secondly, the current study developed a scale to assess perceived satiety value and currently participants' interpretation of the scale is unclear. For example, it is unknown whether participants considered "filling" to mean a reduction in hunger or rated food's satiety value in terms of hedonic hunger (for a review of homeostatic and hedonic hunger see Lowe & Butryn, 2007). The results do imply some validity for this scale, as satiety value was associated with nutritional (e.g. energy density and fibre) and perceptual attributes (e.g. frequency of consumption) known to be important for satiety. However, subsequent uses of the scale should provide instructions to participants to interpret the scale in terms of homeostatic hunger. Thirdly, although the current methodology allows a relatively high number of foods to be rated with large sample sizes, there are time constraints which limit the number of questions and the types of responses which can be collected for each food. Therefore, in future work it may be important to consider the findings in parallel with qualitative approaches, such as interviews which can obtain more in-depth information about a constrained set of foods (Furst, Connors, Bisogni, Sobal, & Falk, 1996; Furst, Connors, Sobal, Bisogni, & Falk, 2000). Finally it is unclear whether demographic or behavioural factors between individuals might affect ratings of perceived satiety. Previously we have shown how the subjective attributes of food associated with successful weight management are different in active dieters and non-dieters (Buckland et al. *In Press*). Therefore, it would be interesting to explore for example, whether individuals with a tendency to overeat and prone to weight gain have any distortion in their perception of the satiety value of food that might cause them to select high energy over low energy foods.

Despite these limitations, the current research has implications for early-stage identification and development of satiety-enhancing foods and food components. While there are extensive nutritional databases for the composition of foods there is no equivalent reference for the role of foods in satiety. This platform could be used to develop a 'satiety map' characterising foods based on their perceived satiety value. Of course, objective measures will be needed to validate this approach. However, the current study represents a small preliminary step towards such a system with the future potential to map nutritional, sensory and cognitive attributes of foods onto consumer perceptions, experience and understanding of their satiety value as a reference for consumers, industry and public health bodies.

References

Blundell, J. (2010). Making claims: functional foods for managing appetite and weight. *Nature Reviews Endocrinology, 6*(1), 53-56.

Brunstrom, J. M. (2014). Mind over platter: pre-meal planning and the control of meal size in humans. *International Journal of Obesity, 38*, S9-S12.

Brunstrom, J. M., Shakeshaft, N. G., & Alexander, E. (2010). Familiarity changes expectations about fullness. *Appetite, 54*(3), 587-590.

Brunstrom, J. M., Shakeshaft, N. G., & Scott-Samuel, N. E. (2008). Measuring 'expected satiety' in a range of common foods using a method of constant stimuli. *Appetite, 51*(3), 604-614.

Buckland, N.J., Dalton, M., Stubbs, R.J., Hetherington, M.M., Blundell, J.E. & Finlayson, G. (*In Press*). *Food Quality & Preference.*

Chambers, L., McCrickerd, K., & Yeomans, M. R. (2014). Optimising foods for satiety. *Trends in food science & Technology, 41*, 1-12.

De Castro, J.M. (2005). Stomach filling may mediate the influence of dietary energy density on the food intake of free-living humans. *Physiology & Behavior*, 86, 32 – 45.

De Graaf, C. (2012). Texture and satiation: The role of oro-sensory exposure time. *Physiology & Behavior, 107*(4), 496-501.

De Graaf, C., Stafleu, A., Staal, P. & Wijne, M. (1992). Beliefs about the satiating effect of bread with spread varying in macronutrient content. Appetite, 18, 121-128.

Drewnowski, A. (2010). The cost of US foods as related to their nutritive value. *American Journal of Clinical Nutrition, 92*(5), 1181-1188.

Ello-Martin, J. A., Roe, L. S., Ledikwe, J. H., Beach, A. M., & Rolls, B. J. (2007). Dietary energy density in the treatment of obesity: a year-long trial comparing 2 weight-loss diets. *American Journal of Clinical Nutrition, 85*(6), 1465-1477.

Fay, S. h., Hinton, E. C., Rogers, P. J., & Brunstrom, J. M. (2011). Product labelling can confer sustained increases in expected and actual satiety. *Appetite, 57*, 577.

Finglas, P.M., Roe, M.A., Pinchen, H.M., Berry, R., Church, S.M., Dodhiam S.K., Farron-Wilson, M. & Swan, G. (2015). Mc Cance & Widdowson's The Composition of Foods, Seventh summary edition. Cambridge: Royal Society of Chemistry.

Fizsimons, C., What is satiating? Consumer perceptions of satiating foods and expected satiety of protein-based meals. *Food Research International*, 62, 551 – 560.

Flood-Obbagy, J. E., & Rolls, B. J. (2009). The effect of fruit in different forms on energy intake and satiety at a meal. *Appetite, 52*(2), 416-422.

Furst, T., Connors, M., Bisogni, C. A., Sobal, J., & Falk, L. W. (1996). Food choice: A conceptual model of the process. *Appetite, 26*(3), 247-265.

Furst, T., Connors, M., Sobal, J., Bisogni, C., & Falk, L. W. (2000). Food classifications: Levels and categories. *Ecology of Food and Nutrition, 39*(5), 331-355.

Green, S. M., & Blundell, J. E. (1996). Subjective and objective indices of the satiating effect of foods. Can people predict how filling a food will be? *European Journal of Clinical Nutrition, 50*(12), 798-806.

Green, S. M., & Blundell, J. E. (1997). A satiety quotient: A formulation to assess the satiating effect of food. Appetite, 29(3), 291 – 304.

Halford, J. C. G., & Harrold, J. A. (2012). Satiety-enhancing products for appetite control: science and regulation of functional foods for weight management. *Proceedings of the Nutrition Society, 71*(2), 350-362.

Hetherington, M. M., Cunningham, K., Dye, L., Gibson, E. L., Gregersen, N. T., Halford, J. C. G., et al. (2013). Potential benefits of satiety to the consumer: scientific considerations. *Nutrition Research Reviews, 26*(1), 22-38.

Higgs, S., & Jones, A. (2013). Prolonged chewing at lunch decreases later snack intake. *Appetite, 62*, 91-95.

Holt, S. H. A., Miller, J. B. (1995). Increased insulin responses to ingested foods are associated with lessened satiety. *Appetite*, 24(1), 43-54.

Holt, S. H. A., Miller, J. C. B., Petocz, P., & Farmakalidis, E. (1995). A satiety index of common foods. *European Journal of Clinical Nutrition, 49*(9), 675-690.

Irvine, M. A., Brunstrom, J. M., Gee, P., & Rogers, P. J. (2013). Increased familiarity with eating a food to fullness underlies increased expected satiety. *Appetite, 61*, 13-18.

Kissileff, H.R. (1984). The satiating efficiency of foods. *Physiology & Behavior,* 32(2), 319-332.

Mc Cance, R. A., & Widdowson, E. M. (1992). (Fifth edition ed.). Cambridge: Royal Society of Chemistry. Ministry of Agriculture, Fisheries and Food.

Morris, M. A., Hulme, C., Clarke, G. P., Edwards, K. L., & Cade, J. E. (2014). What is the cost of a healthy diet? Using diet data from the UK Women's Cohort Study. *Journal of Epidemiology and Community Health, 68*(11), 1043-1049.

NICE (2006). Obesity: The prevention, identification, assessment and management of overweight and obesity in adults and children. London: National Institute for Health and Clinical Excellence National Collaborating Centre for Primary Care.

Oakes, M. E. (2006). Filling yet fattening: Stereotypical beliefs about the weight gain potential and satiation of foods. *Appetite, 46*(2), 224-233.

Provencher, V., Polivy, J., & Herman, C.P. (2009). Perceived healthiness of food. If it's healthy, you can eat more! *Appetite*, 52 (2), 340-344.

Roe, L. S., Meengs, J. S., & Rolls, B. J. (2012). Salad and satiety. The effect of timing of salad consumption on meal energy intake. *Appetite, 58*(1), 242-248.

Rolls, B. J., Roe, L. S., Beach, A. M., & Kris-Etherton, P. V. M. (2005). Provision of foods differing in energy density affects long-term weight loss. *Obesity Research, 13*(6), 1052-1060.

Rolls, B. J., Roe, L. S., & Meengs, J. S. (2004). Salad and satiety: Energy density and portion size of a first-course salad affect energy intake at lunch. *Journal of the American Dietetic Association, 104*(10), 1570-1576.

Shide, D. J., & Rolls, B. J. (1995). Information about the fat-content of preloads influences energy-intake in healthy women. *Journal of the American Dietetic Association, 95*(9), 993-998.

Stubbs, J., Brogelli, D., Pallister, C., Avery, A., McConnon, A., & Lavin, J. (2012). Behavioural and motivational factors associated with weight loss and maintenance in a commercial weight management programme. *The Open Obesity Journal, 4*, 35 - 43.

Stubbs, R. J., vanWyk, M. C. W., Johnstone, A. M., & Harbron, C. G. (1996). Breakfasts high in protein, fat or carbohydrate: Effect on within-day appetite and energy balance. *European Journal of Clinical Nutrition, 50*(7), 409-417.

Tabachnick, B.G. & Fidell, L.S. (2007). Using multivariate statistics. Fifth Edition, Boston: Pearson Education, Inc.

UK Department of Health, the eatwell plate (2013): http://www.nhs.uk/livewell/goodfood/pages/eatwell-plate.aspx

Vadiveloo, M., Morwitz, V., & Chandon, P. (2013). The interplay of health claims and taste importance on food consumption and self-reported satiety. *Appetite, 71*, 349-356.

Wanders, A. J., van den Borne, J. J. G. C., de Graaf, C., Hulshof, T., Jonathan, M. C., Kristensen, M., et al. (2011). Effects of dietary fibre on subjective appetite, energy intake and body weight: a systematic review of randomized controlled trials. *Obesity Reviews, 12*(9), 724-739.

Wooley, O. W., Wooley, S. C., & Dunham, R. B. (1972). Calories and sweet taste - effects on sucrose preference in obese and nonobese. *Physiology & Behavior, 9*(5), 765-768.