Food Quality and Preference 49 (2016) 20–32

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

A Sensory-Diet database: A tool to characterise the sensory qualities of diets

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ARTICLE INFO

Article history:
Received 29 May 2015
Received in revised form 20 November 2015
Accepted 23 November 2015
Available online 23 November 2015

Keywords:
Basic tastes
Textures
Diet
Food choice
Food composition
Children

ABSTRACT

This paper describes the development of a Sensory-Diet database for understanding sensory drivers of food choice and how sensory characteristics influence food intake.

Using an Australian children's national nutrition survey, foods were selected as representing the diet based upon frequency, food grouping, nutritional and/or sensory differences. Foods (377) were evaluated by a trained sensory panel for five basic tastes (sweet, sour, bitter, salt and umami), basic textures (hardness, cohesiveness of mass, moistness and fatty mouthfeel) and flavour intensity. A systematic methodology was developed to then assign the sensory values of the tested foods to all foods across the food composition database (3758 foods).

Relationships between dietary sensory characteristics and composition were explored. Principal component analysis found diets were largely explained by a salty–sweet dimension in terms of flavour/taste and by cohesiveness, moistness and fatty mouthfeel in terms of texture. For foods evaluated by the trained sensory panel, significant correlations included those between sugar and sweetness; fat and fatty mouthfeel; sodium and salty and umami taste, and protein with salty taste. Across the diet, these correlations remained strong when applied to the entire food composition database with the exception of sodium and salty taste. In this case the relationship no longer held in more complex foods. The Sensory-Diet tool is the first published method for applying food sensory characteristics to a composition database to facilitate investigation of sensory characteristics, food composition and diet.

1. Introduction

Whilst many factors are known to affect food choice or preference including availability, cost, and socioeconomics (Mela, 2000), there is consensus that sensory characteristics play a pivotal role (Drewnowski, 1995, 1997; Sobal, Bisogni, Devine, & Jastran, 2006) upon food palatability, selection and intake from an early age (Nasser, 2001). It has been hypothesised that a food's sensory properties act as a 'nutrient-sensor,' eliciting expectations about the food and its macronutrient content and in turn affecting the sensory stimulation to eat, food choice and consumption (Johnson & Vickers, 1993; Sorensen, Moller, Flint, Martens, & Raben, 2003; Stubbs, Johnstone, Mazlan, Mbaiwa, & Ferris, 2001; Viskaal van Dongen, van den Berg, Vink, Kok, & de Graaf, 2012). For example, sweetness may suggest a foods' energy and carbohydrate content (Sclafani, 2007), viscosity may reflect energy density (Davidson & Swithers, 2004), savoury taste may indicate protein content, bitterness may signal food toxicity whilst sourness may indicate ripeness (Viskaal van Dongen et al., 2012). Recent evidence suggests humans are capable of estimating the presence of dietary fats, mono- and disaccharides, protein and sodium in foods based purely on their taste properties (Mattes, 2009; Viskaal van Dongen et al., 2012). However, as Davidson and Swithers (2004) suggest, highly processed consumables including sugar-free sweet drinks or low-viscosity foods/drinks that are energy dense may cause discrepancies between sensory perceptions and nutrient composition and affect the ability to anticipate dietary energy and regulate food intake. Similarly, additional taste stimuli (e.g. salts or acids) added to foods' may suppress other tastes (Green, Lim, Osterhoff, Blacher, & Nachtigal, 2010). For example, sweetness contributes greatly to food palatability (Sorensen et al., 2003), but will dominate taste perceptions, suppressing saltiness, bitterness and sourness (Green et al., 2010; Viskaal van Dongen et al., 2012). With higher palatability levels related to larger meal sizes (Sorensen et al., 2003), distortion of nutrient and sensory

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http://dx.doi.org/10.1016/j.foodqual.2015.11.010
0950-3293/

perceptions may in avertedly lead to higher energy intakes and nutrients such as salt or fat. Clearly, there is a need to adopt more rigorous measures of sensory characterisation of dietary intake to better understand the interactions and influence of sensory characteristics on dietary choices and food intake.

Yet so far, efforts to understand the role that sensory characteristics of food play in food selection across the whole diet have been minimal. A major methodological limitation of many studies (Alexy et al., 2010; Cox, Hendrie, & Carty, 2015; Salbe, DelParigi, Pratley, Drewnowski, & Tataranni, 2004) is the use of test solutions or 'model foods,' with varying sensory concentrations, to measure taste perceptions (Pepino, Finkbeiner, Beauchamp, & Mennella, 2010; Simchen, Koebnick, Hoyer, Issanchou, & Zunft, 2006; Stewart et al., 2010). Whilst providing experimental control, such methodologies don't reflect real food choices nor are they representative of the whole diet (Rozin & Tuorila, 1993). Research aimed at understanding sensory characteristics of whole diets is rare. An early attempt (Cox, Perry, Moore, Vallis, & Mela, 1999) focusing on weight status, saw consumers classify their own dietary intakes into predominant taste and textural characteristics. However, consumers were minimally trained and the subjective, simplistic attempt at identifying predominant tastes, was limiting. More recently, Viskaal van Dongen et al., 2012 characterised 50 foods using the Spectrum® method to correlate taste intensities and macronutrient composition. The challenge faced by researchers is trying to test the infinite number of foods available and consumed as part of a whole diet. A first attempt to develop a database characterising the sensory and nutritional properties of a diet using diet record analysis software (Diet Cruncher PLUS, University of Otago, NZ) was undertaken by Delahunty, Heath, & Ferguson, 2006). Undertaking descriptive sensory profiling of basic tastes and overall flavour intensity, using a Spectrum®-like method, 263 foods from diet records of New Zealand infants and toddlers were characterised. More recently, Martin, Visalli, Lange, Schlich, and Issanchou (2014) created a food-taste database ($n = 590$ foods) using an in-home profile method of foods consumed by training consumers using "a Spectrum® inspired" sensory methodology for the basic tastes and fat intensity perception. The strength of this work was the breadth of products tested. The authors suggest that linking the sensory database to food compositional databases can provide opportunities to understand the connection between taste and sensory modalities and dietary health outcomes. However the in-home profiling method used made it impossible to control the exact nature of the foods evaluated by the panellists and resulted in higher variability than would have been obtained using conventional laboratory based profiling methods. Similarly, this method characterised only the taste dimensions of the sensory experience neglecting the impact of texture on the sensory experience.

Applying texture variables including hardness, cohesiveness of mass, moistness and fatty mouth feel (Szczesniak, 2002), as well as the basic taste sensory perceptions and intensity of flavour to dietary intakes may lead to a clearer understanding of the effects texture and taste properties have on dietary intake. Whilst all sensory perceptions of food contribute to the eating experience, food texture has been found to contribute to feelings of satiety and guide expectations and experiences about the effect food has on appetite (Chambers, McCrickerd, & Yeomans, 2015). Early work by Munoz and Civille (1987) highlighted the importance of primary textures such as hardness with recent experiments demonstrating that increased hardness leads to decreased eating rates, bite size and energy intakes and increased chewing (Bolhuis et al., 2014; Zijlstra, Mars, de Wijk, Westerterp-Plantenga, & de Graaf, 2008) and satiety (Chambers et al., 2015; Zhu, Hsu, & Hollis, 2013). With a greater motility rate through the gut than solid foods, evidence suggests energy consumed in liquid form has weaker effects on satiety, creating disconnections between sense and reward and may result in excess intake and weight gain (Almiron-Roig et al., 2013; Chambers et al., 2015). There is a need to adopt more rigorous measures of sensory characterisation of dietary intake to better understand whether sensory characteristics of diet influence food intake, nutrient status and health outcomes (Cox et al., 2015).

The work by Delahunty et al., 2006, was used to develop the methodology reported in the current paper. We aimed to further develop and validate the methodology used and extend the application to encompass a wider range of sensory attributes, notably texture attributes and flavour intensity. The sensory profiling of foods was undertaken by a trained panel to control the exact nature of the foods being profiled and the sensory profile data were added to a nutritional composition database to broaden the 'whole-of-diet' concept beyond previous work.

1.1. Study aims and objectives

The current study aims to create a Sensory-Diet database to characterise the sensory qualities of individuals' diets. The steps involved in augmenting an existing food composition database (containing nutrient information) with the sensory profiling of foods are described. Specifically we aim to:

- Describe a method to identify important foods for sensory characterisation utilising population nutrition survey data.
- Describe the sensory profile data collected including the evaluation methods.
- Describe the method used to augment the sensory profile data with the nutrient composition database.

The Sensory Diet database, described below, can be used to examine associations between the sensory characteristics and nutrient properties of food. It also has potential to describe the sensory profile of dietary patterns within sub-groups of the population (eg, by gender, age or weight status).

2. Methods

This study utilised food intake data from the 2007 Australian National Children's Nutrition and Physical Activity Survey (ANCNPAS). Survey details and methodology have been reported elsewhere (CSIRO, 2008). Briefly, the survey was conducted on a representative sample of 4487 Australian children aged 2–16 years, using the three pass 24-h recall protocol (Hendrie & Bowen, 2009), resulting in a list of all foods and beverages consumed within a 24-h period on the day prior to interviewing. Underpinning the dietary survey is the AUSNUT 2007 (Food Standards Australia New Zealand., 2007) food composition database, a hierarchical system of classification whereby each food, beverage or supplement is classified into 23 major (two-digit) food groups, 122 sub-major (three-digit) food groups and 536 minor (five-digit) food groups. Within each minor food group, individual foods/beverages are assigned an eight-digit code and are grouped according to biological origin or major ingredient. Table 1 shows examples of this hierarchical classification structure for grouping foods and beverages.

2.1. Selecting foods for sensory testing

2.1.1. Selection from a national dietary survey and nutrient composition database

In the 2007 ANCNPAS, consumption of 4226 individual foods were reported during dietary recall. In the current study, six minor food groupings were excluded from sensory testing because they