Vegetables and other core food groups: A comparison of key flavour and texture properties

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ABSTRACT

Vegetables are the food category least liked by children. This research investigated the sensory properties of vegetables vis-a-vis other core foods that comprise children's diets, to determine to what degree low acceptance of vegetables can be attributed to sensory properties. Vegetables ($n = 34$) were compared to fruit ($n = 26$), dairy ($n = 28$), meat/fish ($n = 28$) and grains ($n = 38$); these foods were representative of the diet of Australian children and profiled by a trained sensory panel on 10 key taste and texture attributes as part of a larger study (Lease, Hendrie, Poelman, Delahunty, & Cox, 2016). Mean intensities were analysed using ANOVA.

Vegetables were more *bitter* in *taste* than the other food categories and amongst the *hardest*. They were the lowest, or amongst the lowest, in all other flavour properties. Other core food categories had sensory properties known to be drivers of food liking: *sweet* and *sour* for fruit, *sour, salty* and *fatty* for dairy, *salty, umami* and *fatty* for meat/fish, and *salty* for grains. No food category other than vegetables had a *bitter taste*, a known driver of dislike.

This research shows that vegetables, relative to other food groups, have sensory properties that are known to predispose to low acceptance based on innate likes and dislikes or preferences acquired within the first few months of life. High *hardness* of vegetables implicates a slow eating rate, which is generally beneficial from a public health perspective, but may make it difficult to meet recommended vegetable intake. To increase children's acceptance and intake for vegetables, either vegetable sensory properties can be modified, or children's acceptance for vegetables can be modified through sensory learning strategies.

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1. Introduction

Children's consumption of foods is largely driven by hedonics (Birch, 1999; Brug, Tak, te Velde, Bere, & De Bourdeaudhuij, 2008; Köster & Mojet, 2006). Vegetables are the category of foods least liked by children, and other core food groups such as fruit, dairy, meat and grains are more readily accepted (Caporale, Policastro, Tuorila, & Monteleone, 2009; Hill, Wardle, & Cooke, 2009; Nicklaus, Boggio, & Issanchou, 2005; Wardle, Sanderson, Gibson, & Rapoport, 2001). As a consequence children in most Western countries do not meet the recommended vegetable intake (Casagrande, Wang, Anderson, & Gary, 2007; CSIRO, 2008; Kim et al., 2014; Yngve et al., 2005).

Children's low acceptance of vegetables has been largely ascribed to their bitter taste and lack of sweet taste (Drewnowski & Gomez-Carneros, 2000; Zeinstra, Koelen, Kok, & de Graaf, 2007), as well as a strong flavour (Baxter & Schroder, 1997; Baxter, Schröder, & Bower, 1999; Zeinstra, Koelen, Kok, & de Graaf, 2009). In addition, energy density in vegetables has been related to vegetable acceptance (Gibson & Wardle, 2003), which can be explained by sensory learning through association from positive post-ingestive feedback.

There is ample evidence from nutrition composition databases that vegetables are relatively low in energy density compared to most foods; in fact, this low-energy density combined with their high nutrient density is one of the reasons their intake is promoted (Rolls, Drewnowski, & Ledikwe, 2005; Spill, Birch, Roe, & Rolls, 2011). In contrast, scientific evidence on how the sensory properties of vegetables compare to those of other foods commonly consumed is currently largely lacking. This comparison is important, with consideration that individual foods and food groups are chosen from the selection available to form diet.

Recent research has started to investigate the sensory properties of overall diets, in an attempt to better understand the role

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that sensory characteristics play in food intake regulation. A French group used an in-home method of sensory analysis to profile foods that comprise the diet of French adults (Martin, Visalli, Lange, Schlich, & Issanchou, 2014). A total of 590 foods were profiled for basic tastes and fatty sensation. Six food classes were identified on the basis of their sensory properties. A large proportion of vegetables pertained to the group of foods with relatively more intense, salty, umami, sour and bitter taste, 19% of vegetables pertained to a class with high saltiness, and 6% of all vegetables pertained to a class characterised by high bitterness.

Ten key flavour and texture properties of the diets of Australian children have recently been characterised and added to a nutritional composition database (Lease, Hendrie, Poelman, Delahunty, & Cox, 2016). In this research, a total of 377 foods from all food categories were profiled by a trained sensory panel on five basic tastes, flavour intensity as well as four texture attributes. These profiles were then systematically applied to all foods in a nutritional composition database, and sensory/nutrient relationships were explored. No analyses of specific food categories were reported.

The current study builds onto the research by Lease et al. (2016) by focusing on the sensory data and further analysing it, specifically by comparing the vegetable component vis-a-vis other core food categories. The aim of this research was to compare the flavour and texture properties of vegetables with those of other core food groups representative of the overall diet of Australian children. This research will help to determine which sensory properties are responsible for low acceptance of vegetables in children.

2. Methods

2.1. Samples

This research compared the sensory properties of vegetable items to the sensory properties of other core food groups representative of the diet of Australian children, using data collected as part of a wider study (Lease et al., 2016).

A full description of how the 377 foods that comprise the overall diet were selected is provided in Lease et al. (2016). In brief, foods were selected on the basis of their frequency of consumption by children, using food intake data from the 2007 Australian National Children's Nutrition and Physical Activity Survey (ANCNPAS). This survey collected food intake data for 1 day from 4487 Australian children aged 2–16 years old using a 24-h recall method. In general, foods with the highest consumption frequency within a minor food category of the AUSNUT 2007 (Food Standards Australia New Zealand, 2008) food composition database were selected for sensory profiling. The AUSNUT database is a hierarchical system, whereby each food, beverage and supplement in the database is classified into 23 major food groups, and then further categorised in sub-major groups and minor food groups.

"Vegetable products and dishes" is one of the major food groups in the AUSNUT database, The food group consists of 9 sub-major food groups primarily based on taxonomy of vegetables, and 19 minor food groups, primarily based on either vegetable type or preparation/processing method. As part of the 377 food items profiled by the sensory panel (Lease et al., 2016), a total of 47 items pertained to the major food group "Vegetable Products and Dishes". The following exclusions were applied: 1) Potatoes and starchy tubers (e.g. pumpkin, sweet potato). These items (n = 10) were excluded as although they are considered vegetables in the Australian context, they are not in most countries and in international guidelines (World Health Organisation., 2015), 2) Three vegetable items consumed only as an ingredient in a dish due to high level of processing (tomato paste, canned tomato) or intense flavour (garlic). The 34 items included covered a substantial part of intake by Australian children, i.e. 81% (measured as frequency of

consumption) and 83% (in terms of volume (in g)) of the consumption of the group of vegetables they represented. Vegetable cooking times were selected using information from previous studies in which information was collected about preparation practices that parents use to prepare vegetables for their children, and children's acceptance of vegetables in relation to preparation (Poelman & Delahunty, 2011; Poelman, Delahunty, & de Graaf, 2013, 2015; Poelman, Delahunty, Gilbert, & Forde, 2009). Vegetable sensory quality is variable in the supply chain, as it is influenced by genetic background (e.g. cultivars), environmental conditions (e.g. growing region, seasonality) and management practices (e.g. storage conditions). For the current study, fresh produce was sourced fresh from two local supermarkets (Woolworths and Coles) within two days prior to evaluation, and was all Australian grown (see also Table 1).

The vegetable category was compared to four other core food categories: fruit, dairy, meat/fish and grains. To select the foods pertaining to each of the categories the following process was used: 1) Foods were considered for which a sensory profile was obtained from the following AUSNUT categories (Food Standards Australia New Zealand, 2008): Fruit – "16 Fruit Products and Dishes"; Dairy – "19 Milk products and dishes"; Meat/fish – "15 Fish and Seafood Products and Dishes" and 18 "Meat, poultry, and game products and dishes"; Grains – "12 Cereals and Cereal Products". The fruit category does not include fruit juices, and the category of dairy products does not include dairy spreads (Food Standards Australia New Zealand, 2008). 2) Products within these categories that were not core foods but occasional foods according to the Australian Guide for Healthy Eating were excluded (Anonymous, 2015) (examples of excluded items are processed meats like salami, and ice cream), 3) Dishes within the categories were excluded (examples of excluded items are apple crumble pie and "Beef, stir fry, chow mein (beef & noodles), Chinese restaurant style"). The Fruit category (n = 26) consisted of mainly fresh fruit (e.g. apple, banana) and a small number of dried fruit and fruit canned in non-sweetened juice. The Dairy category (n = 28) consisted of milks (differing in fat content), goat's milk, yoghurts (differing in fat content and addition or not of flavourings) and cheeses (hard and soft cheeses, differing in type and fat content). The Meat/fish category (n = 28) included meat and fish of different animal origin (e.g. beef, chicken, salmon) and varied in preparation type (e.g. roasting, grilling, frying). The Grains category (n = 38), included breads differing in flour type (e.g. white, mixed grain, rye), ingredients added (e.g. dried fruit, fibre) and preparation (untoasted/toasted), other bread variants (e.g. bread rolls, pita bread), unsweetened muffin, pasta, rice, wheat noodles, tortilla, porridge and breakfast cereals differing in ingredients (e.g. corn, wheat bran, rice) and processing type (e.g. extruded).

2.2. Sensory evaluation

For a full description of the sensory evaluation methodology, the reader is referred to Lease et al. (2016). In brief, a trained sensory panel used a Spectrum® inspired method to collect sensory intensity scores across 10 key sensory attributes. The attributes were the five basic tastes (sweet, salty, sour, bitter and umami), overall flavour impact and four texture attributes; hardness, moistness, cohesiveness of mass and fatty mouthfeel. Attributes were rated on unstructured 100 mm line scales, using Compusense® five sensory data acquisition software (version 4.6, 2004; Compusense Inc., Guelph, Ontario, Canada).

2.3. Data analysis

Analyses were conducted using SPSS (IBM, SPSS Statistics, v20.0.0, 2011) and Unscrambler (Camo, v.9.1, 2004). A p value of 0.05 was used as a criterion for statistical significance.