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The role of smell, taste, flavour and texture cues in the identification of vegetables

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ABSTRACT

It has been shown that the identification of many foods including vegetables based on flavour cues is often difficult. The effect of providing texture cues in addition to flavour cues on the identification of foods and the effect of providing taste cues only on the identification of foods have not been studied. The aim of this study was to assess the role of smell, taste, flavour and texture cues in the identification of ten vegetables commonly consumed in The Netherlands (broccoli, cauliflower, French bean, leek, bell pepper, carrot, cucumber, iceberg lettuce, onion and tomato). Subjects ($n = 194$) were randomly assigned to one of four test conditions which differed in the sensory cues available for vegetable identification: taste, smell (orthonasal), flavour (taste and smell) and flavour-texture (taste, smell and texture). Blindfolded subjects were asked to identify the vegetable from a list of 24 vegetables. Identification was the highest in the flavour-texture condition (87.5%). Identification was significantly lower in the flavour condition (62.8%). Identification was the lowest when only taste cues (38.3%) or only smell cues (39.4%) were provided. For four raw vegetables (carrot, cucumber, onion and tomato) providing texture cues in addition to flavour cues did not significantly change identification suggesting that flavour cues were sufficient to identify these vegetables. Identification frequency increased for all vegetables when perceived intensity of the smell, taste or flavour cue increased. We conclude that providing flavour cues (taste and smell) increases identification compared to only taste or only smell cues, combined flavour and texture cues are needed for the identification of many vegetables commonly consumed in The Netherlands.

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1. Introduction

The daily recommended intake of vegetables is met by less than 15% of adults and less than 3% of children in The Netherlands. Median vegetable consumption in The Netherlands is 103–140 g/day for adults and 60–92 g/day for children (Van Rossum, Fransen, Verkaik-Kloosterman, Buurma-Rethans, & Ocke, 2011). These values are far below the recommended daily intake of at least 200 g/day for adults and 150 g/day for children (Gezondheidsraad, 2015). Similar consumption patterns have been observed in other countries (Alexy, Sichert-Hellert, & Kersting, 2002; Bowen, Klose, Syrette, & Noakes, 2009; Dennison, Rockwell, & Baker, 1998).

The dislike for the taste of vegetables, specifically for bitterness, has been suggested to cause low vegetable consumption (Brug, Tak, te Velde, Bere, & De Bourdeaudhuij, 2008; Dinehart, Hayes, Bartoshuk, Lanier, & Duffy, 2006; Drewnowski & Gomez-Carneros, 2000; Tak, te Velde, & Brug, 2008). However, it was recently demonstrated that vegetables display low taste and flavour intensities compared to other foods (Lim & Padmanabhan, 2013; Martin, Visalli, Lange, Schlich, & Issanchou, 2014; Poelman, Delahunty, & de Graaf, 2017; Van Dongen, van den Berg, Vink, Kok, & de Graaf, 2012; Van Stokkom, Teo, Mars, de Graaf, van Kooten, & Stieger, 2016). Van Stokkom et al. (2016) determined the taste intensities of ten vegetables commonly consumed in The Netherlands using a modified Spectrum Method. In the modified Spectrum method, a sensory profiling method, three reference solutions representing fixed intensities for each taste modality are used by trained panellists to evaluate the intensity of each taste (sweetness, sourness, bitterness, umami, saltiness) on an absolute intensity scale. In general, the intensities of all taste modalities for most vegetables were very low. Sweetness was the most intense

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taste, followed by sourness and bitterness. Another study using the Spectrum method found that vegetables had low taste intensities compared to other foods (Poelman et al., 2017). It is therefore likely that other sensory properties such as appearance, smell, flavour and texture, influence acceptance of vegetables.

To assess the influence of sensory cues provided for the identification of foods, Schiffman (1977) studied the effect of combined removal of visual cues by blindfolding and textural cues by pureeing, on identification of 20 commonly consumed foods, including 10 vegetables. The absence of visual and textural cues means that only flavour cues (taste and smell) were provided for the identification of the foods. Identification of foods in young adults (students, 18–22 y) and elderly (67–93 y) was considerably impaired when only flavour cues were provided. Identification by students ranged from 4% to 67% from cabbage to corn. Identification by elderly ranged from 0% to 69% from broccoli to tomato. Students identified most foods better than elderly when flavour cues were provided for identification. These results suggest that visual and texture cues might be important for identification of foods. Schiffman (1977) quantified the identification of foods under one experimental condition only i.e. when flavour cues were provided. The effect of providing texture cues in addition to flavour cues on identification was not investigated by Schiffman (1977), nor anyone else. Smell cues play a role in identification of foods, as shown by previous studies which used sniffing sticks to assess identification of smell and mainly focussed on differences in identification ability between different ages and sexes (Hummel, Kobal, Gudziol, & Mackay-Sim, 2007; Hummel, Sekinger, Wolf, Pauli, & Kobal, 1997; Sorokowska et al., 2015). However, it remains unclear how the influence of smell in identification relates to the influence of other sensory cues. To summarize, currently knowledge is lacking on the contribution of specific sensory cues on the identification of vegetables.

The aim of this study is to assess the role of smell, taste, flavour and texture cues in the identification of ten vegetables commonly consumed in The Netherlands. We hypothesize that each of the sensory cues contributes differently to the identification of vegetables and that identification depends on the preparation method and type of vegetable.

2. Materials & methods

2.1. Subjects

Adults were recruited through social media, flyers and a list of individuals available at the Division of Human Nutrition, Wageningen University. Inclusion criteria comprised a good general health, understanding of the Dutch language and aged between 18 and 65 years. Subjects with allergies or intolerances to vegetables were excluded from participation, as well as subjects experiencing problems with chewing, swallowing, tasting or smelling. Pregnant or breast-feeding women were excluded from the study. Subjects were asked not to wear perfume and not to eat or drink (except water) 1 h prior to the test session. Subjects received financial compensation for participation in the study. One subject was removed from the dataset since the nose clip fell off multiple times in the taste condition. In total 194 subjects were included in the study (147 females, 47 males, 37.8 ± 16.6 y). Ethical approval was not required for the study according to the Medical Research Ethics Committee of Wageningen University. The study was registered under number 16/02.

2.2. Study design

Subjects (n = 194) were randomly assigned to one of four test conditions using a between subjects design: smell (n = 48), taste (n = 49), flavour (n = 48) and flavour-texture (n = 49). Subjects were blindfolded in all four test conditions and asked to identify ten vegetables from a list of 24 vegetables in each of the conditions. In the smell condition, subjects sniffed non-pureed vegetables (identification based on orthonasal smell cues). In the taste condition, subjects tasted pureed vegetables while wearing a nose clip to eliminate smell cues (identification based on taste cues). In the flavour condition, subjects tasted pureed vegetables without a nose clip (identification based on orthonasal and retronasal smell and taste cues). In the flavour condition, subjects did not sniff the vegetables before tasting. In the flavour-texture condition, subjects tasted non-pureed vegetables (identification based on smell, taste, texture and auditory cues).

2.3. Vegetable selection and preparation

The ten vegetables most frequently consumed in the Netherlands were selected for the study (Van Rossum et al., 2011): broccoli (*Brassica oleracea* var. *Italica*, variety Ironman), cauliflower (*Brassica oleracea* var. *botrytis*, variety Easytop), French bean (*Phaseolus vulgaris*, variety unknown), leek (*Allium ampeloprasum* L., variety Harston), bell pepper (*Capsicum annuum,* variety Davos), carrot (*Daucus carota,* variety Evora), cucumber (*Cucumis sativus,* variety Proloog), iceberg lettuce (*Lactuca sativa* L., variety unknown), onion (*Allium cepa* L., variety Alfa) and tomato (*Solanum lycopersicum* L., variety Arvento). Fresh vegetables were bought at a local supermarket and stored at 4 °C for a maximum of three days. Some vegetables were boiled and offered warm, other vegetables were offered raw, depending of the more common way to consume the vegetable (Borgdorff-Rozeboom, 2013). Broccoli, cauliflower, French bean and leek were boiled before preparation of the purees or one-bite portions. Cooking times (time in boiling water) and vegetable/water ratio were for broccoli and cauliflower 8 min, 212/500 g, French bean 10 min, 224/500 g and leek 8 min, 238/500 g. Bell pepper, carrot, cucumber, onion and tomato were prepared at the start of the test day and stored at 7 °C during the test day. Vegetable purees were prepared by pureeing vegetables with a hand blender until a homogenous, smooth consistency was obtained (±30 s/200 g). Carrots were first chopped using a food processor and pureed afterwards. Broccoli, cauliflower, French bean and leek samples were stored in bowls in a water bath at 60 °C after preparation for a max of 3.5 h. Therefore, preparation of these vegetables was performed twice a day, as well as preparation of lettuce. Serving temperature of the boiled vegetables was 50 ± 5 °C. Raw vegetables were served at room temperature. Vegetables were presented to the blindfolded subjects by the researcher either as one-bite portions (smell and texture conditions) or as a puree (taste and flavour conditions). Sample size was ~10 g. All vegetable samples were offered in non-transparent plastic containers (50 ml) covered with a lid. In the smell condition, blindfolded subjects were asked to identify the vegetable by sniffing two one-bite portions from the foam container. In the taste and flavour conditions, blindfolded subjects received ~10 g of vegetable puree from the researcher on a spoon. In the flavour-texture condition, blindfolded subjects received a one-bite portion from the researcher on either a fork or a spoon, depending on the vegetable.

2.4. Test procedure

Participation in the study consisted of one test session of approximately 45 min at the University of Applied Sciences Inholland Delft or Wageningen University. Upon arrival at the test

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