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Taste intensities of ten vegetables commonly consumed in the Netherlands

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ABSTRACT

Bitterness has been suggested to be the main reason for the limited palatability of several vegetables. Vegetable acceptance has been associated with preparation method. However, the taste intensity of a variety of vegetables prepared by different methods has not been studied yet. The objective of this study is to assess the intensity of the five basic tastes and fattiness of ten vegetables commonly consumed in the Netherlands prepared by different methods using the modified Spectrum method. Intensities of sweetness, sourness, bitterness, umami, saltiness and fattiness were assessed for ten vegetables (cauliflower, broccoli, leek, carrot, onion, red bell pepper, French beans, tomato, cucumber and iceberg lettuce) by a panel ($n = 9$) trained in a modified Spectrum method. Each vegetable was assessed prepared by different methods (raw, cooked, mashed and as a cold pressed juice). Spectrum based reference solutions were available with fixed reference points at 13.3 mm (R1), 33.3 mm (R2) and 66.7 mm (R3) for each taste modality on a 100 mm line scale. For saltiness, R1 and R3 differed (16.7 mm and 56.7 mm). Mean intensities of all taste modalities and fattiness for all vegetables were mostly below R1 (13.3 mm). Significant differences ($p < 0.05$) within vegetables between preparation methods were found. Sweetness was the most intensive taste, followed by sourness, bitterness, fattiness, umami and saltiness. In conclusion, all ten vegetables prepared by different methods showed low mean intensities of all taste modalities and fattiness. Preparation method affected taste and fattiness intensity and the effect differed by vegetable type.

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1. Introduction

Vegetables are an essential part of a healthy diet, however the majority of Dutch children and adults do not meet the recommended daily intake of vegetables (Van Rossum, De Boer, & Ocke, 2009). Especially for children, taste is an important driver for preference and food choice (Drewnowski, 1989, 2000). Bitterness has been suggested to cause the rejection of many vegetables (Ames, Profet, & Gold, 1990; Drewnowski & Gomez-Carneros, 2000). It has been shown that humans are predispositioned to have an adverse response to bitter and sour tastes, while they prefer sweet and salty tastes (Birch, 1999; Steiner, Glaser, Hawilo, & Berridge, 2001). This aversion of bitterness was probably crucial for survival, because bitter tasting plant-based nutrients are often toxic. However, in small amounts, many of these nutrients, such as glucosinolates, have been suggested to contribute to healthy diets (Drewnowski & Gomez-Carneros, 2000).

Several studies investigated taste profiles of various vegetables using different sensory methodologies. Dinehart, Hayes, Bartoshuk, Lanier, and Duffy (2006) profiled the taste intensities of asparagus, Brussels sprouts and kale using a Labelled Magnitude Scale. They found that bitterness was the most intensive taste and sweetness and saltiness the least intensive tastes for the tested vegetables (Dinehart et al., 2006). van Dongen, van den Berg, Vink, Kok, and de Graaf (2012) determined taste intensities of fifty commonly consumed foods using a modified Spectrum method. Most raw vegetables had a more neutral taste, while vegetable soups were more salty and savoury compared to other foods (van Dongen et al., 2012). Martin, Visalli, Lange, Schlich, and Issanchou (2014) used an in-home modified Spectrum method to evaluate five basic tastes and fat intensities of 68 vegetables. Vegetables were grouped in two clusters based on taste. The first class contained 46% of the vegetables and was more intense in saltiness, umami, sourness and bitterness than average and less intense in sweetness and fattiness than average. The second class contained 19% of the vegetables and was mainly salty (Martin et al., 2014).

Not only taste but also preparation method and nutrient content can influence vegetable acceptability. Studies have shown that children prefer boiled and steamed vegetables over other preparation methods and that vegetables with a medium firm texture are preferred compared to very soft or very firm vegetables (Bongoni, Stieger, Dekker, Steenbekkers, & Verkerk, 2014; Bongoni, Verkerk, Steenbekkers,

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Dekker, & Stieger, 2014; Zeinstra, Koelen, Kok, & de Graaf, 2010). Nutrient content of vegetables can differ depending on the preparation methods used (Bernhardt & Schlich, 2006; Pellegrini et al., 2010). As nutrient content has been linked to taste (Drewnowski & Gomez-Carneros, 2000; Schiffman & Dackis, 1975; van Dongen et al., 2012), it is plausible that preparation method alters taste. Humans prefer high energy dense foods and the low energy density of vegetables might contribute to the limited acceptability of vegetables (Drewnowski, 2003). Preparation method can alter vegetable texture and might influence acceptance by altering perceived energy density (Drewnowski, 2003; Poelman, Delahunty, & de Graaf, 2013; Zeinstra et al., 2010).

To the best of our knowledge, the taste and fattiness intensities of the most commonly consumed vegetables in the Netherlands and the influence of different preparation methods on taste and fattiness intensity has not been studied yet. Altering the preparation method is an easy way for parents to influence sensory properties of vegetables and may help optimize vegetable acceptance by children. The aim of the current study is to describe the taste and fattiness intensity of ten vegetables commonly consumed in the Netherlands using a modified Spectrum method and to investigate the effect of preparation method on taste and fattiness intensity.

2. Materials and methods

2.1. Subjects

Subjects were selected based on their taste recognition, taste discrimination, concentration and sensory profiling abilities. The trained panel that analysed the taste and fattiness intensity of ten vegetables most commonly consumed in the Netherlands consisted of nine subjects ($n = 9$), two males and seven females (mean age 36.3 ± 13.3 yrs.) with a normal BMI (18.5–25 kg/m^2). All subjects signed an informed consent form and received financial compensation for participation in the study. The study has been approved by the Human Ethics Review Committee of Wageningen University under number NL47315.081.13.

2.1.1. Training and the modified Spectrum method

The panel received intensive training using a modified Spectrum method to evaluate the intensity of sweetness, bitterness, umami, sourness, saltiness and fattiness in food products. Training of the panel consisted of two sessions per week for a period of six months. Each (training) session lasted 60–90 min. Each panellist received a minimum of 63 h of training in total. Panellists were trained using basic tastant solutions, modified commercially available products and commercially available reference products. For each taste modality three reference solutions with fixed intensities on a 100 mm line scale were used during training and product profiling (13.3 mm (R1), 33.3 mm (R2) and 66.7 mm (R3)). For saltiness, the position of R1 and R3 on the 100 mm line scale differed (16.7 mm and 56.7 mm). Reference solutions contained different concentrations of sucrose (sweetness), citric acid (sourness), caffeine (bitterness), monosodium glutamate (MSG) (umami) and sodium chloride (saltiness) dissolved in Evian mineral water (Table 1). After the training with the reference tastant solutions, the panellists were trained in taste and fattiness evaluations of several food products which were modified with varying intensities of sapid taste substances (mashed potato (modified with NaCL and MSG), gelatine dessert (modified with sucrose), agar (modified with caffeine and citric acid) white rice (modified with MSG) and vanilla custard (modified with mascarpone)). This part of the training was completed when group consensus was reached about the taste intensities of the tastant solutions and modified commercially available products. In the next step of the training of the panellists, five reference products for fattiness and additional reference products for each taste modality were discussed and rated. This part of the training was completed when consensus about the taste and fattiness intensities of the commercially available reference products was reached. Based on the training, reference products were placed on the line scale at fixed points. Panellists were trained to recognise the fixed points of the reference solutions and reference products until they were able to accurately assess the references with the corresponding intensities of the fixed points. Training also included special sessions concerning umami, bitterness, fattiness and saltiness-umami discrimination. These additional training sessions included the profiling of taste intensities of (semi) solid foods. Reference solutions and reference products were available during profiling sessions and their position on the line scale was marked. Similar modified Spectrum methods have been used previously (Martin et al., 2014).

Table 1
Modified spectrum method: composition and position of reference solutions and reference foods used on the intensity scale (100 mm).

Taste modality	Position reference solutions	Concentration g/L	References foods	% on scale
Sweetness (Sucrose)	R1 13.3	20	Biscuit	20
	R2 33.3	50	Custard	33
	R3 66.7	100	Cake	50
			Marshmallow	67
			Condensed milk	88
Sourness (Citric acid)	R1 13.3	0.5	Rye bread	15
	R2 33.3	0.8	Butter milk	38
	R3 66.7	1.5	Biogarde (yoghurt)	50
			Pickle	78
			Citric acid	97
Bitterness (Caffeine)	R1 13.3	0.5	Grapefruit juice	57
	R2 33.3	0.8	Dark chocolate	70
	R3 66.7	1.5		
Umami (Monosodium glutamate)	R1 13.3	1.2	Seaweed	28
	R2 33.3	3.0	Surimi	43
	R3 66.7	7.0	Parmesan cheese	69
			Soy sauce	94
Saltiness (Sodium chloride)	R1 16.7	2.0	Cracotte	14
	R2 33.3	3.5	Pringles	48
	R3 56.7	5.0	Old cheese	75
			Soy sauce	94
Fattiness	–		Cracker	9
			Custard	55
			Cream cheese	72
			White chocolate	73
			Butter	97

2.1.2. Panel performance

Panel performance measures (discriminative power, agreement and reproducibility) were monitored regularly during training and profiling sessions and feedback was given when necessary. Feedback was given to the panellists based on their individual ability to reproduce their results, their evaluations of the reference solutions and reference products and their use of the 100 mm rating scale compared to the whole panel. In general, the panel had high reliability and discriminatory power with fair agreement and was able to produce a constant mean with a low standard deviation in repetitive sessions for a particular food item. A detailed description of the panel selection, training and performance will be provided elsewhere.

Sensory profiling took place in a sensory laboratory with individual testing booths at Wageningen University. Panellists were presented with a maximum of ten samples per session. Every session consisted of three randomized replicates per sample and lasted a maximum of 90 min.

2.2. Vegetable selection and preparation

Ten vegetables were selected based on consumption frequency in the Netherlands reported in the Dutch national food consumption survey (Van Rossum et al., 2009): cauliflower, broccoli, leek, carrot,

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