



## Sweetness but not sourness enhancement increases acceptance of cucumber and green capsicum purees in children

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### ABSTRACT

For children it is important to consume enough vegetables to establish healthy dietary patterns. Taste acceptance is an important factor contributing to food choice and consumption. Sweetness and sourness enhancement can increase acceptance of specific foods in children. The aim of this study was to determine the effect of sweetness and sourness enhancement on acceptance of cucumber and green capsicum purees in 5-6-year-old children. Three concentrations of sucrose (2, 5 and 10%) and citric acid (0.05, 0.08 and 0.15%) were added to cucumber and green capsicum purees. Children ( $n = 70$ ,  $5.7 \pm 0.5$  yrs) assessed acceptance of the vegetable purees using a 5-point hedonic facial scale. Sweetness enhancement significantly increased acceptance of cucumber purees (5 and 10% sucrose) and green capsicum purees (2 and 10% sucrose) compared to unmodified purees. Sourness enhancement (0.05, 0.08 and 0.15% citric acid) did not significantly influence acceptance of cucumber and green capsicum purees compared to unmodified purees. Children differed in acceptance of vegetable purees with added sucrose and citric acid. Sweetness likers (cucumber 77.1%, green capsicum 58.6%) accepted sucrose concentrations better than sweetness non-likers in both vegetables. Sourness likers (cucumber 50.0%, green capsicum 44.3%) accepted medium and high concentrations of citric acid better than sourness non-likers in cucumber and all citric acid concentrations in green capsicum. We conclude that enhancement of sweetness increases acceptance of cucumber and green capsicum purees in most children whereas enhancement of sourness is better accepted by only a few children. This study highlights the challenge to get children to better accept vegetables, since only sweetness enhancement improved acceptance while addition of sucrose is undesirable. For a small subset of children enhancing sourness might be an alternative strategy to increase acceptance of vegetables.

### 1. Introduction

Consumption of vegetables by children is below recommended intake in multiple countries even though vegetables are an important part of a healthy diet (Alexy, Sichert-Hellert, & Kersting, 2002; Bowen, Klose, Syrette, & Noakes, 2009; CSIRO, 2008; Dennison, Rockwell, & Baker, 1998; Van Rossum, De Boer, & Ocke, 2009). Children form a key target group to increase vegetable consumption as vegetable consumption at a young age contributes to vegetable consumption later in life (Nicklaus, 2009).

Taste acceptance is an important factor contributing to food consumption, especially in children (Brug, Tak, te Velde, Bere, & de Bourdeaudhuij, 2008; Mennella, Finkbeiner, Lipchock, Hwang, & Reed, 2014). Recent studies showed that vegetables in general have low taste intensities compared to other foods (Poelman, Delahunty, & de Graaf,

2017; Van Stokkom et al., 2016). The low taste intensities of vegetables might contribute to low acceptance. Therefore, taste enhancement might be an effective approach to increase vegetable acceptance.

Several studies investigated the effect of taste enhancement of different taste modalities on food acceptance in children. Liem and de Graaf (2004) showed that enhancing sweetness but not sourness increased preference of orangeade and yoghurt in children. However, some children have a preference for extreme sourness intensities of foods (Liem, Westerbeek, Wolterink, Kok, & de Graaf, 2004). Enhancing sweetness of grapefruit juice, a more bitter food, by adding sucrose reduced initial dislike of grapefruit juice by children. An increased liking was even sustained when later on sucrose was removed (Capaldi & Privitera, 2008). In summary, children's acceptance of specific beverages and foods increased when taste intensities were enhanced and depends on taste modality and type of food.

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Limited research has been conducted to investigate the effect of taste enhancement on children's acceptance of vegetables. Bouhhal, Chabanet, Issanchou, and Nicklaus (2013) demonstrated that enhancing saltiness of green beans by adding sodium chloride increases children's acceptance of green beans. In adults, the effect of taste enhancement of different taste modalities on vegetable acceptance has been investigated more extensively. Sweetness enhancement increased acceptance of broccoli and cauliflower in adults (Capaldi & Privitera, 2008). A recent study by van Stokkom, de Graaf, van Kooten, & Stieger (2018) demonstrated that enhancing sweetness by adding sucrose to cucumber and green capsicum purees increases acceptance of these vegetable purees in adults. A relatively low sweetness enhancement (2% sucrose) was sufficient to increase acceptance of cucumber purees, while for green capsicum purees a higher sweetness enhancement was needed (5% sucrose). Sharafi, Hayes, and Duffy (2013) misted asparagus, Brussels sprouts and kale with solutions containing different concentrations of aspartame, sodium acetate and sodium chloride to determine the effect of sweetness, sourness and saltiness enhancement on bitterness suppression in adults. Aspartame was the most effective bitterness suppressor and increased liking for all vegetables in adults.

Taste perception and discriminatory abilities for taste often differ within children and between children and adults (De Graaf & Zandstra, 1999; James, Laing, & Oram, 1997), which might contribute to differences in acceptance. Children can prefer higher intensities of sweetness than adults in a variety of foods (Hoffman, Salgado, Dresler, Faller, & Bartlett, 2016). De Graaf and Zandstra (1999) demonstrated that children prefer higher sucrose concentrations in water and in lemonade than adults. Mennella et al. (2014) also showed that children prefer higher concentrations of sucrose in water than adults. In another study, children preferred higher sucrose concentrations in pudding compared to their mothers (Mennella, Finkbeiner, & Reed, 2012). Children might also prefer higher sourness than adults. Liem and Mennella (2003) showed that 35% of children preferred high levels of sourness in gelatin gels while for adults this was not the case. Vegetables such as cucumber and green capsicum do not have an inherent sour taste or might not have a flavour that is congruent with sourness. However, sour seasonings such as vinaigrettes or dressings are commonly used for the preparation of many vegetables (Martin, Visalli, Lange, Schlich, & Issanchou, 2014). Therefore, enhancing sourness of vegetables such as cucumber and green capsicum might increase acceptance in children.

To the best of our knowledge, the effect of sweetness and sourness enhancement on children's acceptance of cucumber and green capsicum has not been studied yet. The aim of this study was to investigate the effect of sweetness and sourness enhancement on acceptance of cucumber and green capsicum purees in 5-6-year-old children. We hypothesize that both sweetness and sourness enhancement increases acceptance for cucumber and green capsicum purees in children, but that sweetness enhancement has a stronger effect in most children than sourness enhancement. Additionally, we hypothesize that the higher the sucrose concentration, the larger the influence on acceptance. Knowledge about the effect of taste enhancements on acceptance of vegetables by children might help devise strategies to increase children's vegetable consumption.

## 2. Methods

### 2.1. Participants

A dedicated recruitment agency for consumer trials located in the Sydney metropolitan area (Australia) was used for the recruitment. Children aged 5 and 6 years were selected. Children were included if they were generally in good health and had consumed the target vegetables (cucumber and capsicum) at least once before participating in the study. Children were excluded when they had a strong dislike for either target vegetable, had any known food allergies or dietary intolerances or had any problems with chewing or swallowing (parental

reported). In total,  $n = 72$  children participated in the study. Two children refused most samples and were therefore excluded from data analysis. One child refused all capsicum purees. For the remaining children refusals were rare.  $N = 70$  children were included in the data analysis for cucumber purees and  $n = 69$  children for capsicum purees. The CSIRO Human Research Committee granted ethical approval for the study registered under number #25/2016. Participants received financial compensation for participation.

### 2.2. Vegetable purees

The study included cucumber (*Cucumis sativus*, variety Telegraph) and green bell capsicum, hereafter referred to as green capsicum (*Capsicum annuum*). Selection of vegetables was based on three criteria: first, one vegetable should display a relatively neutral taste profile whereas the other vegetable should display a slight bitter taste. In previous studies cucumber displayed a neutral taste profile while green capsicum was characterized by higher bitterness intensity compared to other vegetables (Poelman et al., 2017; Van Stokkom et al., 2016). Secondly, both vegetables should be commonly consumed in Australia (CSIRO, 2008). Thirdly, both vegetables should be consumable cold and without further preparation.

Vegetable purees were prepared at CSIRO in Sydney, North Ryde, Australia. Vegetables were collected in bulk to eliminate between batch variation. Vegetables were rinsed, cut in pieces and pureed with a mixer (NutriBullet, LLC. Los Angeles, United States). Three concentrations of sucrose (2, 5 and 10% w/w) and three concentrations of citric acid (0.05, 0.08 and 0.15% w/w) were added to the vegetable purees and are referred to as low, medium and high tastant concentrations. Tastant concentrations were based on reference solutions used in the modified Spectrum Method. In the modified Spectrum Method, three reference solutions with fixed intensities for each tastant are used to evaluate the intensity of the basic tastes (sweetness, sourness, bitterness, umami and saltiness) on an absolute scale (Martin et al., 2014). Using these concentrations ensured that purees had low, medium and high intensities. Tastants were mixed into the vegetable purees with a hand mixer until complete dissolution. Purees were poured into plastic food freezer bags. Samples were frozen immediately after production and stored at  $-20^{\circ}\text{C}$ . On each test day, one bag per sample was defrosted at  $4^{\circ}\text{C}$ . One hour prior to each session, the defrosted samples were removed from the refrigerator and kept at room temperature so that vegetable purees reached room temperature before the start of the session.

Cucumber and green capsicum purees used in this study were the same as vegetable purees used previously (van Stokkom et al., 2018). In the previous study, adult consumers ( $n = 66$ ,  $35.8 \pm 17.7$  yrs) rated the intensity of sweetness and sourness of vegetable purees using a 100 mm line scale. Sweetness and sourness intensities of vegetable purees assessed by adults increased significantly ( $p < 0.01$ ) with increasing tastant concentration (sucrose and citric acid). Sweetness intensity increased from unmodified (14 for cucumber; 14 for green capsicum) to low (35; 41), medium (71; 69) and high (84; 86) sucrose concentrations. Sourness intensity increased from unmodified (15 for cucumber; 28 for green capsicum) to low (40; 31), medium (55; 43) and high (76; 70) citric acid concentrations. All taste intensities significantly differed between vegetable purees with the exception of unmodified and low citric acid concentration for green capsicum.

### 2.3. Procedure

The acceptance test had a within subject design. Session typically took less than 30 min, only very few sessions lasted up to 45 min. Sessions were performed at the research facilities of CSIRO in Sydney, North Ryde, Australia. Each session included no more than four children. Sessions started with oral instructions after which the parent signed the informed consent form and children gave their assent by colouring in a happy smiley face. If children did not want to participate,

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