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Research report

Quinine sensitivity influences the acceptance of sea-buckthorn and grapefruit juices in 9- to 11-year-old children ☆

Ditte Hartvig [a,*], Helene Hausner [a], Karin Wendin [a,b,c], Wender L.P. Bredie [a]

[a] Department of Food Science, Section for Sensory and Consumer Science, Faculty of Science, University of Copenhagen, DK-1958 Frederiksberg C, Denmark
[b] SP Technical Research Institute of Sweden, IDEON, SE-22370 Lund, Sweden
[c] Food and Meal Science, Kristianstad University, 291 88 Kristianstad, Sweden

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ABSTRACT

The acceptance of novel foods by children is related to a number of factors, and differences in taste sensitivity may form some specific challenges. High sensitivity might be a barrier to the acceptance of sour/bitter products by children. This study investigated the effect of sensitivity to bitter, sour, sweet, and salty tastes on the acceptance of Nordic juices in 9- to 11-year-old children. A total of 328 children were subjected to two taste sensitivity tests for quinine, citric acid, sucrose, and NaCl. Their acceptance of six juices (carrot, rosehip, sea-buckthorn, lingonberry, grapefruit, and aronia) was measured. Bitter sensitivity was found to be significantly correlated to the intake of the sweet sea-buckthorn and lingonberry juices; the most bitter-sensitive children exhibited the highest intake of these juices. The opposite relationship was found for bitter sensitivity and the intake of the bitter grapefruit juice. Sour, sweet, and salt sensitivities did not affect the intake of any of the juices. Liking scores were not affected by sensitivity. In conclusion, bitter sensitivity appears to influence food intake in children to a greater extent than sour, sweet, or salt sensitivity. Bitter-sensitive children exhibited a reduced intake of grapefruit juice and a higher intake of sucrose-sweetened juices. Thus, bitter sensitivity might be a challenge in the acceptance of certain bitter foods.

Introduction

A number of factors influence the acceptance of novel foods by children. One of these factors is how we perceive food, and this factor serves as an important factor for dietary behaviour because children eat what they like (Birch, 1979). The perception of food is influenced by individual taste sensitivity and children appear to be more guided by their taste sensitivity than adults (Mennella, Pepino, & Reed, 2005). In contrast, adults are more easily able to overcome these genetic influences due to several years of experience.

Bitterness has been widely investigated because humans have an innate aversion to bitter tastes (Steiner, 1974) and because bitterness often constitutes a barrier to healthy eating. The ability of humans to detect extremely low concentrations of bitterness serves as an important evolutionary adaptation for limiting or avoiding the consumption of potentially toxic plant foods (Rozin, 1976). However, in the modern world, bitter taste may impact nutrition and health because many healthy foods, such as fruits and vegetables, contain bitter components. A large number of structurally diverse bitter compounds, including several classes of polyphenols, exist. Polyphenols provide positive and important health benefits by acting as antibacterial and antioxidant agents (D'archivio et al., 2007) and therefore positively impact the human diet.

Large individual differences in bitter perception are a known characteristic in humans (Falconer, 1947; Fischer & Griffin, 1963; Kalmus, 1971). Genetically predisposed differences in bitter taste sensitivity to 6-n-propylthiouracil (PROP) have been investigated in several studies (e.g., Drewnowski, Henderson, & Shore, 1997; Fisher et al., 2012). The bitter sensitivity to the bitter component quinine has been rarely measured. The individual variations in the perception of bitter taste are due to allelic diversity in the TAS2R G-protein coupled receptors. To date, 25 bitter receptors have been discovered (Chandrashekar et al., 2000). Base sequence variations in TAS2R19 have been associated with individual differences in the perception of the bitter taste of quinine (Reed et al., 2010) and with differences in the bitterness perception and liking of grapefruit juice (Hayes et al., 2011).

A number of previous studies have investigated the relationship between taste sensitivity and dietary behaviour, and many of these

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* Corresponding author.
E-mail address: dlhh@food.ku.dk (D. Hartvig).

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studies have attempted to link detection thresholds, identification thresholds, and/or perceived intensity of taste qualities to preferences/liking of foods. Because food contains many structurally diverse taste components, the measurement of only one taste component has a limited ability to predict the ratings of complex foods. However, some previous studies have indicated interesting partial relationships, and others have found no correlations. Fischer, Griffin, England, and Gran (1961) were the first to characterise differences in food preferences by examining quinine sensitivity. These researchers reported that individuals with low thresholds (high sensitivity) for quinine had more food dislikes and aversions than individuals with high thresholds (low sensitivity). Furthermore, quinine has been reported to be a good partial predictor of sucrose intake, i.e., a high quinine intensity rating is associated with high preference and intake of sucrose (Duffy, Peterson, Dinehart, & Bartoshuk, 2003) and the liking of added sugar (Hayes & Duffy, 2008). The effect of taste sensitivity to sweet, sour, and salty tastes on food preference and intake has been less investigated. Mattes (1985) found a slight correlation between sweet sensitivity and the liking or intake of sweet-tasting products. Other researchers found no relationship between sucrose perception and the preference for sucrose in adolescents (Coldwell, Oswald, & Reed, 2009). In addition, a general inverse relationship has been found between the perceived intensities of sourness and the liking or preference of sour-tasting foods in children and adults (Chauhan & Hawrysh, 1988; Kildegaard, Tønning, & Thybo, 2011). Studies on the influence of differences in salt taste sensitivity on food acceptance in school-aged children are not prevalent.

Significant correlations in intensity ratings between four stimuli (quinine, citric acid, sucrose, and NaCl) have been found (Lim, Urban, & Green, 2008). Additional research on how sensitivity to these taste components is related and whether taste sensitivity affects food intake and liking in children would be valuable.

Familiarity serves as an important factor in children's acceptance of food because it has been found that children prefer foods that they are familiar with. Familiarity accounted for approximately 30% of the variance in children's preferences for fruits, which is a percentage similar to that obtained for sweetness (Birch, 1979). Therefore, it is important to consider familiarity when measuring acceptance in children.

The New Nordic diet (NND) has been defined in the OPUS project titled "Optimal well-being, development, and health of school children through a New Nordic diet". The concept of the NND is to include more locally produced health-beneficial products e.g., berries and vegetables, into the diet (Mithril et al., 2012). Some of these berries and vegetables are more dominant in bitter and sour tastes than what the children are used to. Because bitter taste is the primary reason why people, particularly children, avoid vegetables and fruits (Rozin & Vollmerck, 1986), the novelty and sensory properties of the new Nordic foods are likely to be the major barriers for the introduction of these NND components into the children's diet.

This study investigates whether children's taste sensitivity to quinine, citric acid, sucrose, and NaCl affects their acceptance of novel fruit juices, primarily those made from berries and vegetables that are characteristically found in the Nordic countries. Furthermore, we want to investigate whether sensitivity to these four taste components is related. Our first hypothesis is that taste sensitivity partly influences acceptance of these juices. We expect bitter sensitivity to be oppositely correlated to the acceptance of bitter- and sour-tasting juices and that bitter-sensitive children will exhibit the highest intake of juices that are dominantly sweet. Our second hypothesis is that taste sensitivity to quinine, citric acid, sucrose, and NaCl is related. To test these hypotheses, taste threshold tests were performed for quinine, citric acid, sucrose, and NaCl. The acceptance of six novel fruit juices, which are characterised as dominant in bitter, sour, or sweet taste, was subsequently measured in 9- to 11-year-old children based on intake and reported liking.

Methods

Experimental design

The study was conducted in two different parts: a taste sensitivity test and an acceptance test. The taste sensitivity test was performed twice (with an interval of approximately 3 days) on the four basic tastes: bitter, sour, sweet, and salty. During the acceptance test, all of the participating children evaluated their acceptance of six juices (two per day over a course of three days, see Fig. 1).

Participants

A total of 328 school children aged 9–11 years participated in the study. They were recruited from five schools in the outskirts of Copenhagen, Denmark. Written parental consent was obtained for all of the participating children. The data were collected during winter 2011/2012. The study was approved by the Research Ethics Committee of Copenhagen (H-1-2010-023).

Taste sensitivity solutions

The participants were presented with six different concentrations of bitter (quinine hydrochloride, Sigma–Aldrich, Germany) solutions and five concentrations of sour (citric acid, Sigma–Aldrich, Germany), sweet (sucrose, Sigma–Aldrich, Germany), and salty (sodium chloride, Sigma–Aldrich, Germany) solutions. The concentrations of the different tasting solutions are shown in Table 1.

The concentrations of the test solutions were selected based on data from a large study on taste sensitivity performed with 8900 Danish school children (Allesen-Holm, Frøst, & Bredie, 2009), the International ISO standard concentrations used for the sensory test panel (ISO 3972, 1991E), and pilot test results from a study performed on taste sensitivity in 86 school children (unpublished data).

All of the samples were prepared the day prior to testing, stored at 4 °C, and brought to room temperature before use. The solutions were served in white plastic cups with a lid (29-ml Solo cups, Saebekompagniet, Denmark). Each test solution was marked with a letter from A to U such that the children could keep track of the samples.

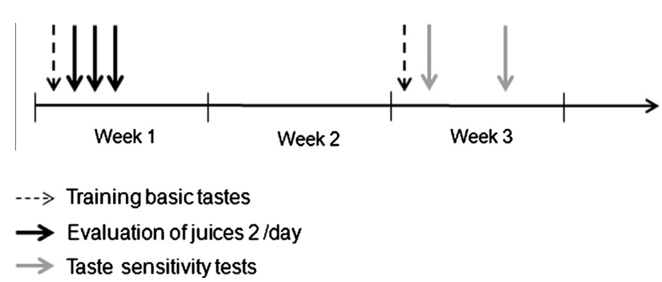

Fig. 1. Experimental design. Two training sessions were performed prior to the sensitivity testing. The acceptance of the juices was evaluated (two juices per day over a three-day period) during week 1, and the two sensitivity tests were performed during week 3 with an interval of approximately 3 days.