ELSEVIER

Appetite 46 (2006) 263–269

Appetite

www.elsevier.com/locate/appet

Research Report

Sensitivity to allyl isothiocyanate, dimethyl trisulfide, sinigrin, and cooked cauliflower consumption

Erwan Engel [a,*], Nathalie Martin [b], Sylvie Issanchou [c]

[a] *Equipe Typicité Aromatique et Authentification, Unité de Recherche sur la Qualité des Produits Animaux, Institut National de la Recherche Agronomique, 63122 Saint-Genès-Champanelle, France*

[b] *Unité Mixte de Recherches, INRA-INAPG en Génie et Microbiologie des Procédés Alimentaires, Institut National Agronomique Paris-Grignon, 78850 Thiverval-Grignon, France*

[c] *Unité Mixte de Recherche, INRA-ENESAD FLAVIC, Institut National de la Recherche Agronomique, 17, rue Sully, BP 86510, 21065 Dijon Cedex, France*

Received 1 August 2005; received in revised form 29 December 2005; accepted 11 January 2006

Abstract

The consumption of cauliflower consumers has been related to the olfactory and gustatory sensitivities to potentially objectionable flavor compounds in this vegetable. Based on the ascending concentration series method of limits, a first experiment was designed to develop rapid tests dedicated to estimate individuals' olfactory thresholds for allyl isothiocyanate (AITC) and dimethyl trisulfide (DMTS) and gustatory thresholds for sinigrin (SIN). The best compromise between rapidity and reliability was obtained with two replications of a four-alternative forced choice (AFC) at six ascending concentrations (6×2×4-AFC) for both AITC and DMTS, and with a 6×1×4-AFC for SIN. In a second experiment, sensitivity to SIN, AITC and DMTS was determined on 267 participants divided into three cauliflower consumer target groups: non-, medium- or high consumers. The non-consumers were significantly more sensitive to SIN and AITC than were the medium and high consumers. No effect of consumer's sensitivity to DMTS was observed.

Keywords: Olfacto-gustatory sensitivity; Bitterness; Volatile sulfur compounds; Food consumption; Cruciferous vegetable

Introduction

Cruciferous vegetables are among the major dietary sources of potentially chemo-protective agents against cancer. Their consumption has been reported to reduce cancer risks (Steinmetz & Potter, 1996). Despite their health benefit, a number of people do not eat them and their undesirable taste is often quoted as the main cause of non-consumption. For example, in a survey conducted in France by CERAFEL in 1999[1] including 212 consumers, 'taste' was the main reason quoted spontaneously by the non-consumers of cauliflower (16% of the sample) for rejecting this vegetable.

Even if it is possible that consumers do not only refer to gustation when they use the word 'taste', bitterness has been considered by many authors as the main cause of cruciferous vegetable rejection (Drewnowski & Gomez-Carneros, 2000; Jerzsa-Latta, Krondl, & Coleman, 1990; van Doorn et al., 1998). This is certainly due to its negative hedonic connotation and to the fact that it is widely speculated that the dislike of bitterness provides an important adaptative safeguard throughout human evolution by reducing the intake of potentially dangerous products (Rozin & Vollmecke, 1986). Moreover, it has been assumed that a higher sensitivity to bitterness induces a higher rate of rejection (Drewnowski & Gomez-Carneros, 2000; Fischer, Griffin, England, & Garn, 1961; Glanville & Kaplan, 1965). Since, the sensitivity to the bitterness of phenylthiocarbamide (PTC) and 6-*n*-propylthiouracil (PROP) is determined genetically, and since the bitter compounds that occur naturally in cruciferous vegetables have the same N–C=S group as PTC and PROP, many authors investigated the possible relationship between PTC or PROP sensitivity and acceptance for cruciferous vegetables (Anliker, Bartoshuk, Ferris, & Hooks, 1991; Dinehart, Hayes, Bartoshuk, Lanier, & Duffy, 2006; Drewnowski, Henderson, Hann, Berg, & Ruffin,

* Corresponding author.
E-mail address: erwan.engel@clermont.inra.fr (E. Engel).

[1] For further information regarding the CERAFEL survey, you may contact the Comité Economique Régional Agricole en Fruits et Légumes, 8 Rue Marcellin Berthelot, ZI de Zerivin, 29600 St Martin des Champs, France. Tel.: +33 2 9862 1155; http://www.cerafel.com/; e-mail: contact@cerafel.fr

0195-6663/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.appet.2006.01.007

2000; Duffy & Bartoshuk, 2000; Jerzsa-Latta et al., 1990; Mattes & Labov, 1989; Niewind, Krondl, & Shrott, 1988; Turnbull & Matisoo-Smith, 2002; Yackinous & Guinard, 2002). However, it is noteworthy that conflicting results were reported about the impact of PTC/PROP sensitivity on the acceptance of cruciferous vegetables. An alternative strategy consists in assessing directly the sensitivity of consumers to the compounds, which are responsible for the bitterness of the food studied. Such an approach seems relevant as several authors (e.g. Montmayeur & Matsunami, 2002) have revealed the existence of different mechanisms of bitter taste perception in humans. Successfully used on bitter beverages like coffee and beers (Mattes, 1994; Tanimura & Mates, 1993), this approach depends on the challenging identification of the bitter-active substances of the food studied. In a previous work, we have identified the bitter glucosinolate sinigrin as the main bitter-principle of cooked cauliflower (Engel, Baty, le Corre, Souchon, & Martin, 2002a).

It is also possible that besides bitterness, pungent and/or sulfurous odor and flavor can be responsible for the consumers' rejection of some cruciferous vegetables. As underlined by Drewnowski (1990), the small interest shown for the effect of olfactory sensitivity on food acceptance is quite surprising. Indeed, it is widely recognized that olfaction plays an important role in flavor perception (Solbu, Jellestad, & Straetkvern, 1990; Weiler et al., 2000). Also, it has been demonstrated that the sensitivity to odorants varies widely between individuals. Indeed, as for sensitivity to PTC/PROP, it has been shown that there is a bimodal distribution of thresholds for specific odorants (e.g. Amoore & Forrester, 1976; Amoore, Forrester, & Buttery, 1975; Amoore, Forrester, & Pelosi, 1975; Amoore, Pelosi, & Forrester, 1977). Thus, when volatile compounds are identified in a food product as responsible for specific and unpleasant odors, it could be relevant to study the relationship between sensitivity to these particular odorants and rate of rejection of this food product. This approach was used to study the relationship between sensitivity to trimethylamine and the rejection of fish (Solbu et al., 1990), and to show the influence of differences in sensitivity to androstenone on the acceptance of boar meat (Weiler et al., 2000). Regarding cooked cauliflower, the 'mustard-like' allyl isothiocyanate (AITC) and the 'sulfur/cooked cauliflower-like' dimethyl trisulphide (DMTS) were identified as potential determinants of consumer behavior (Engel, Nicklaus, Salles, & Le Quéré, 2002b).

Many procedures have been developed to evaluate olfactory and gustatory detection thresholds for clinical and research purposes. In a study of the test–retest reliability of different olfactory tests, the highest reliability for threshold measurements was observed for the 'single staircase' method (Doty, McKeown, Lee, & Shapman, 1995). However, the duration and the cost of this method are incompatible with the constraints imposed by consumer tests. An alternative to this method is the 'forced-choice ascending concentration series method of limits' which has been widely used under different formats (ASTM, 1991; Cain & Gent, 1991; Doty et al., 1995; Hummel, Sekinger, Wolf, Pauli, & Kobal, 1997). Two parameters can have a great impact on the reliability of the results: the *n*-value of the *n*-alternative forced choice (*n*-AFC) test and the number of *n*-AFC tests at each concentration studied. We have chosen to use a 4-AFC. Although they have the same statistical power, 1×4-AFC was preferred to 2×2-AFC used by other authors (Cain & Gent, 1991; Doty et al., 1995) since the former reduces the risk of adaptation in comparison with the latter. We have also chosen to use three replicates of the 4-AFC at a given concentration and we investigated the possibility to reduce the length of the test by comparing the results obtained with this format with the results that would have been obtained with reduced formats, i.e. with two or one replicates of the 4-AFC per concentration.

The first aim of this paper was to validate a rapid method to estimate consumers' sensitivity to sinigrin (SIN), allyl isothiocyanate (AITC) and dimethyl trisulphide (DMTS) (Experiment 1). Using the same method, Doty et al. (1995) obtained different test–retest reliability coefficients for the detection thresholds for different odorants. This suggests that the validity and the format of the test depends on the compound studied. Thus, the validation of a rapid method was performed for each compound. The second objective was to examine whether there is a link between consumption of cauliflower by consumers and their sensitivity to these compounds (Experiment 2).

Materials and methods

Participants

Experiment 1

Twenty-four volunteers, 15 females and 9 males, whose age ranged from 23 to 55 years (average 33 years) participated in this experiment dedicated to develop a rapid test to assess olfactory–gustatory sensitivity to different compounds. They were students and permanent staff recruited from the Thiverval-Grignon INRA research center. These subjects were familiar with sensory tests and none of them had shown any particular olfactory or gustatory dysfunction. The participants were unaware of the nature of the stimuli and the objectives of the experiment. During the sessions, none of the 24 participants declared suffering from cold, allergic reaction or identified adverse conditions that could have affected the normal functioning of the respiratory tract.

Experiment 2

Two hundred and sixty-seven participants (119 men and 148 women between 16 and 69 years of age) were recruited in the town of Quimper (France) for participating in this experiment dedicated to study the relationships existing between cauliflower consumption and sensitivity to potentially behavioral flavor-active compounds. Participants were initially screened by phone for cooked cauliflower consumption. They were asked to answer questions regarding their frequency of consumption for a wide spectrum of foods (bitter foods and beverages) including cooked cauliflower. Allergy to mustard was a criterion of rejection. Three pre-groups of 89 consumers