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The perceptual properties of the virgin olive oil phenolic oleocanthal are not associated with PROP taster status or dietary intake

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ABSTRACT

Oleocanthal, has been identified as the sole oropharyngeal irritant in virgin olive oil with large individual variation in the perceived intensity of irritation. In this study participants were screened for sensitivity to the oropharyngeal irritation of oleocanthal and bitterness of 6-n-propylthiouracil (PROP), and categorized as hypersensitive (extremely sensitive) or hyposensitive (extremely insensitive). In addition, we determined if a relationship existed between sensitivity to oleocanthal and PROP and dietary intake. Participants ($n = 168$) took part in the initial screening for irritation to oleocanthal (gLMS range 1.70–70.31). From this sample 87 participants also completed a 4-day diet diary and rated the intensity of oropharyngeal irritation of olive oil and the bitterness of PROP using a gLMS scale. There was large variability in the perceived intensity of irritation from olive oil (gLMS range 4.26–57.15) and the perceived bitterness of PROP (gLMS range 0.0–62.52) with no association between PROP sensitivity and oleocanthal irritation ($r = -0.04$, $p = 0.71$). We report no relationship between oleocanthal sensitivity and total energy intake ($r = 0.13$, $p = 0.29$), carbohydrate intake ($r = 0.12$, $p = 0.92$), protein intake ($r = -0.11$, $p = 0.37$), or fat intake ($r = 0.14$, $p = 0.22$). There was no association between PROP sensitivity and total energy intake ($r = -0.08$, $p = 0.46$), carbohydrate intake ($r = 0.12$, $p = 0.31$), protein intake ($r = 0.12$, $p = 0.32$), or fat intake ($r = -0.08$, $p = 0.53$). We did find a significant negative correlation between PROP sensitivity status and the intake of broccoli ($r = -0.24$, $p < 0.05$). In the present study individual variation in sensitivity to the irritation of virgin olive oil or bitterness of PROP was not related to diet with the exception of PROP sensitivity and broccoli intake.

1. Introduction

1.1. Sensory properties of oleocanthal and chemesthesis

Oleocanthal, a phenolic compound contained in virgin olive oil (VOO) produces irritation in the oropharyngeal region. The flavor of VOO is significantly different from other edible oils as it includes flavors such as pungency and irritation from the phenolic fraction along with odors creating a distinct perceptual combination that is reflective of VOO. One of the features of VOO is the localized pungency restricted to the oropharyngeal region and this is elicited by a single compound in VOO, oleocanthal and also the NSAID ibuprofen (Beauchamp et al., 2005; Bennett & Hayes, 2012; Cicerale, Breslin, Beauchamp, & Keast, 2009; Peyrot des Gachons et al., 2011). Both oleocanthal and ibuprofen not only share perceptual characteristics but also pharmacological properties as both compounds are exert anti-inflammatory actions on cyclooxygenase enzymes 1 and 2 (COX 1 and 2) (Beauchamp et al., 2005). In fact oleocanthal is now recognized as a naturally occurring NSAID that has beneficial effects in several models of inflammatory disease (for review see (Parkinson & Keast, 2014)).

1.2. Genetically mediated variation in the perception of compounds in foods

Variability in the perceived sensitivity of irritation of oleocanthal and also bitter taste from compounds in foods have been noted amongst individuals (Cicerale, Breslin, Beauchamp, & Keast, 2009; Cicerale, Lucas, & Keast, 2012; Hayes et al., 2011). The individual variation in perception of bitter taste is presumably a result of individual genetic factors (Bufe et al., 2005; Dinehart, Hayes, Bartoshuk, Lanier, & Duffy, 2006; Duffy et al., 2010; Hayes, Bartoshuk, Kidd, & Duffy, 2008; Hayes et al., 2011). It is logical to assume that this applies to large variation in oleocanthal sensitivity as well, with the discovery that oleocanthal selectively

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activates the human nociceptor, transient receptor potential cation channel, member A1 (TRPA1) in HEK 293 cells (Peyrot des Gachons et al., 2011). Beauchamp and colleagues along with other researchers have investigated the affinity of oleocanthal and ibuprofen with the TRPA-1 channel protein, which responds to chemicals and temperature, and is located in abundance in the upper throat and nose. This explains the localized throat sensation arising from oleocanthal and ibuprofen ingestion (Beauchamp et al., 2005; Peyrot des Gachons et al., 2011). It is therefore also to be expected that the genetic variance in distribution of TRPA1 receptor levels across individuals is reason to why one individual may find the intensity of throat irritation from oleocanthal severe whereas another may find it mild or non-existent (Bennett & Hayes, 2012; Cicerale, Breslin et al., 2009). The extent of difference in throat irritation from VOO warrants further attention. Therefore the objective of the first part of this study is to determine the variation in individual differences of perceived intensity of irritation from oleocanthal.

The aim of the second part of this study is to build on the existing taste status and ingestive behavior literature with a hypothesis that there may be a link between the perceived intensity of irritation to a VOO, the perceived bitterness of PROP and diet.

2. Materials and methods

2.1. Subjects

Participants ($n = 168$, aged 18–70, male $n = 46$ and females $n = 122$) were recruited from Deakin University and surrounding suburbs in Melbourne Australia. Flyers were distributed via letterbox drop and were also placed at various locations around Deakin University. Demographic information was also collected, including gender, age, height and weight. Body mass index (BMI, kg/m^2) was calculated from the height and weight measurements. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Deakin University Human Research Ethics Committee and all participants provided written informed consent prior to participation.

2.2. Taste assays

Participants were asked to refrain from eating or drinking anything for at least 1 h prior to the session. On the day of testing subjects attended the sensory laboratory at Deakin University. Subjects were trained in the use of the general Labeled Magnitude Scale (gLMS) (Bartoshuk et al., 2004; Green et al., 1996). The gLMS is a labeled scale of perceived sensation intensity used to derive ratio level data similar to magnitude estimation data and it contains descriptors ranging from barely detectable = 1.5, weak = 6, moderate = 17, strong = 35, very strong = 52 and the strongest imaginable sensation of any kind = 100. Only the descriptors are visible to the subject while the researcher receives numerical data from the scale. Subjects were familiarized with the scale and given hypothetical examples corresponding to each descriptor on the scale. For example subjects rated with the gLMS the intensity of the following remembered or imaginary taste sensations: The warmth of lukewarm water, the coolness of an ice cold beverage, the bitterness of celery, the sourness of lemon, the burning sensation of consuming a hot whole chili and others. If participants rated stimuli in the wrong region of the scale during training they were directed to the region on the scale where the sensation should occur and further hypothetical examples given until the subject fully understood scale usage. Emphasis was given to the fact that the strongest imaginable sensation is representative of the strongest and most intense sensation imaginable, including pain. Subjects then completed an intensity rating for oropharyngeal sensitivity to a virgin olive oil determined to be highly irritating by the investigators, and as a control irritant subjects were asked to rate the intensity of mouth irritation elicited by CO_2 in soda water. All procedures were conducted in computerized, partitioned sensory booths in the [Redacted for blind review], using Compusense Five Software Version 5.2 (Compusense Inc., Ontario, Canada).

2.3. Oil sample

High-performance liquid chromatography (HPLC) analysis was used to quantify the concentration of oleocanthal in the oil sample (oil was supplied by Modern Olives Laboratory Service, Lara. Victoria. 2012 harvest) using methodology developed by Impellizzeri and Lin and modified by Cicerale and colleagues (Cicerale, Breslin et al., 2009; Impellizzeri & Lin, 2006).

2.4. Taste sensitivity to oleocanthal

The method for the oleocanthal taste assay was developed by Beauchamp et al. (2005), and modified accordingly by Cicerale, Conlan, Barnett, Sinclair, and Keast (2009). Subjects rinsed their mouths with filtered water (8 μm particulate filter with an activated charcoal filter, Dura®) at least 3 times over a 2-min period before commencement of testing. Each subject sampled and rated (using the gLMS) VOO for oleocanthal irritation and soda water for CO_2 irritation in the oropharynx in duplicate. In the session, 2 VOO and 2 soda water samples were presented in a randomized order with an interstimulus interval of 1 min between samples. Subjects were given 5 ml aliquots of VOO containing oleocanthal (62 mg/kg) and asked to place the oil in their mouths and tilt their head back to allow the oil to drizzle down the back of their throat. Subjects were asked to keep the oil at the back of the throat for ~5 s, then swallow the sample in 2 stages, and rate the peak intensity of irritation after 20 s on the gLMS scale. The irritation induced by CO_2 in soda water was used as a control.

2.5. Taste sensitivity to PROP

Filter papers containing the compound PROP were prepared in accordance to the methods adapted from Zhao, Kirkmeyer, and Tepper (2003). Filter paper disks (1.5×1.5 cm^2) were prepared and submerged in a 50 mM/L PROP solution. The paper discs were then oven dried and wrapped individually in plastic film. Subjects were given a paper disc containing PROP and asked to place the paper on their tongue for 5 s. Subjects were then asked to rate the perceived intensity on the gLMS scale.

2.6. Dietary intake and anthropometry

Data from the 4-day food diary included quantity brand of food, time meal was eaten, and preparation and cooking method. Subjects were asked to, where possible, weigh the foods they consumed (subjects used their own scales), use standard metric measuring cups, or common serving sizes. Dietary intake analysis was conducted using Foodworks nutritional software (Xyris, Brisbane, Australia, 2007). Daily total energy, carbohydrate, protein, and fat intake was established to assess a possible association between taste sensitivity and dietary intake. Intake of specific vegetables (spinach, broccoli, cabbage, cauliflower) was assessed to determine if there was an association between PROP sensitivity and intake of these vegetables. These vegetables are of interest as previous studies suggest an association between cruciferous vegetables and PROP sensitivity. Olive and olive oil intake was also established to determine if there was a relationship between oleocanthal