Food Quality and Preference 63 (2018) 73–79

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

Reduced taste responsiveness and increased food neophobia characterize obese adults

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ARTICLE INFO

Keywords:
PROP
Fungiform papillae
BMI
Overweight
Sensory perception
Eating behavior

ABSTRACT

The aim of the present study was to investigate the relationship between two well-established markers of taste perception, 6-n-propylthiouracil (PROP) responsiveness and fungiform papillae number, in obese and healthy-weight subjects. The association between taste responsiveness and food neophobia attitude was evaluated to understand if these variables are linked to nutritional status of subjects.

Forty healthy-weight (Body Mass Index: 22.67 ± 0.43 kg/m^2) and forty-five obese (Body Mass Index: 37.57 ± 0.77 kg/m^2) subjects were involved. PROP responsiveness and fungiform papillae number were positively correlated to each other in both groups of subjects (healthy-weight: $r = 0.67$, $p < 0.001$; obese: $r = 0.83$, $p < 0.001$). PROP responsiveness ratings and fungiform papillae number were significantly negatively correlated with food neophobia scores in both group of subjects ($p < 0.01$). Subjects characterized as significantly less sensitive and more neophobics had a higher Body Mass Index. Especially, obese men showed significant lower taste responsiveness ($p < 0.05$) and higher food neophobia scores ($p < 0.05$) compared to obese women and healthy-weight subjects, both sexes.

The nutritional status of the subjects seems to be linked to taste responsiveness and food neophobic attitude. These data suggest that, between several factors which could play a role in the control of body weight, understand how sensory perception affects eating behavior could give important information to study variables which may determine food habits.

1. Introduction

Sensory perception varies widely across individuals but the link to actual eating behaviour, nutrition and health is not that clear (Tepper, 2008). Possible explanations for this great individual variability are environmental factors (Köster, 2009) as well as genetic background (Bajec & Pickering, 2008). One of the most studied genetic sources of individual variation is the ability to taste the bitter compound 6-n-propylthiouracil (PROP) (e.g. Duffy, 2007; Tepper, 2008; Tepper et al., 2009; Yackinous & Guinard, 2001). Previous studies reported that PROP responsiveness is associated with sensitivity to a variety of oro-sensory stimuli. Super-tasters (i.e., subjects highly responsive to PROP) perceive saltiness, sweetness, and sour more intensely than medium and non-tasters (i.e., subjects less responsive to PROP) (Duffy, Peterson, Dinehart, & Bartoshuk, 2003; Hayes & Duffy, 2007; Prescott, Soo, Campbell, & Roberts, 2004). These differences in taste responsiveness have a remarkable effect on food acceptance, with for example, non-tasters more likely to be sweet likers while super-tasters more likely to be sweet dislikers (Yeomans, Tepper, Rietzschel, & Prescott, 2007).

PROP responsiveness is also related to anthropometric, physiological and behavioral measurements but literature data are controversial. Different studies showed an inverse association between PROP responsiveness and Body Mass Index (BMI) (Burd, Senerat, Chambers, & Keller, 2013; Goldstein, Daun, & Tepper, 2005; Tepper & Ullrich, 2002) whereas others did not (Bajec & Pickering, 2010; Borazon, Villarino, Magbuhat, & Sabandal, 2012; Villarino, Fernandez, Alday, & Cubelo, 2009). Moreover, a wide range of literature suggests that PROP responsiveness is positively related to density of lingual fungiform papillae which are structures containing taste buds. Subjects with a higher number of fungiform papillae are more sensitive to tastes (Bartoshuk, 2000; Delwiche, Buletic, & Breslin, 2001; Hayes, Bartoshuk, Kidd, & Duffy, 2008; Masi, Dinnella, Monteleone, & Prescott, 2015). However, there are also recent findings not supporting the association between PROP responsiveness and fungiform papillae (Fischer et al., 2013; Garneau et al., 2014; Webb, Bolhuis, Cicerale, Hayes, & Keast, 2015).

Previous research led by our group (Bertoli et al., 2014; Proserpio, Laureati, Bertoli, Battezzati, & Pagliarini, 2016) showed that over-

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http://dx.doi.org/10.1016/j.foodqual.2017.08.001
Received 14 February 2017; Received in revised form 11 August 2017; Accepted 12 August 2017
Available online 12 August 2017

Table 1
Participants' characteristics (data are reported as mean values ± SEM).

	Healthy-weight (n = 40)		Obese (n = 45)	
	Women (n = 21)	Men (n = 19)	Women (n = 25)	Men (n = 20)
Age (years)	40.38 ± 1.37	41.84 ± 2.74	43.46 ± 2.05	52.40 ± 2.05
BMI (kg/m^2)	21.59 ± 0.53	22.86 ± 0.60	36.46 ± 0.86	38.95 ± 1.32

weight and obese subjects have a reduced taste sensitivity that might increase food desire, thus leading to excessive energy intake and weight gain. A recent neuroimaging study seems to support this hypothesis showing that gustatory stimulation induced differential fMRI brain activation patterns in obese compared to healthy subjects (Szalay et al., 2012).

In our studies taste sensitivity was measured through the 3-Alternative Forced Choice (3AFC; ASTM E679-04, 2011, a robust and reliable procedure, which is, however, difficult to apply in an ambulatory context involving obese subjects undergoing a weight-loss therapy. Faster and easier approaches, such as the count of the fungiform papillae and PROP responsiveness, would be more appropriate in this context, due to their simpler, but reliable, procedures (Rankin, Godinot, Christensen, Tepper, & Kirkmeyer, 2004; Zhao, Kirkmeyer, & Tepper, 2003). Indeed, taste response to PROP, as well as the density of fungiform papillae, are well-studied markers of genetic variation in taste and oral sensation perception (e.g. Bajec & Pickering, 2010; Bartoshuk, Duffy, & Miller, 1994; Duffy et al., 2010; Feeney & Hayes, 2014; Miller & Reedy, 1990; Tepper, 2008; Tepper, Banni, Melis, Crnjar, & Tomassini Barbarossa, 2014; Zuniga, Chen, & Phillips, 1997). Moreover, the fungiform papillae number, which is not a reported measure, could be helpful in order to avoid biased report ratings.

Besides individual variation in taste responsiveness, food neophobia (literally the fear of novel food) is another aspect to be considered as it plays an important role in shaping food preference and rejection (Pliner & Hobden, 1992). This behavior has been largely studied in omnivores, including humans but its association with taste perception and nutritional status is under debate. Knaapila et al. (2011) reported a weak correlation between food neophobia scores and BMI in young women but not in men. Other authors observed that BMI is higher in food neophobics than in food neophilics (Finistrella et al., 2012; Knaapila et al., 2015).

In a previous study, we hypothesized that obese adults may have a higher neophobic attitude than healthy controls but, unexpectedly, we did not find significant differences (Proserpio et al., 2016). This maybe was due to the deliberately or unwittingly biased report ratings that obese subjects gave about their eating behaviour (Klesges, Hanson, Eck, & Durff, 1988). It is well recognized that obese subjects have the tendency, either intentional or as a form of self-deception, to answer to dietary and eating behaviour questions as expected by the interviewer (Heitmann, 1996).

In this context, among all the several factors which could play a role in the control of body weight, the relation between taste perception and food neophobia is still under investigation.

The aim of the present study was to compare taste perception in obese and healthy-weight subjects using two well-established markers of taste responsiveness, i.e. PROP responsiveness and fungiform papillae number. The relationship between these two markers was also investigated, since we hypothesized that if these two measurements are related, one of these methods could be preferred to investigate taste responsiveness when the 3AFC or similar procedures are not easy to be performed (i.e. ambulatory context). Finally, due to the lack of agreement in the literature, the association between taste responsiveness and food neophobia attitude was evaluated in order to understand if these variables are linked to the nutritional status of the subjects. Gender has been also considered due to its role on BMI and food neophobia attitude (Monteleone et al., 2017).

2. Materials and methods

2.1. Subjects

Eighty-five adults completed the study. Forty-five obese subjects were recruited among patients admitted to the Department of Medical Sciences and Rehabilitation before starting their weight loss treatment (IRCCS Istituto Auxologico Italiano). Forty healthy-weight subjects were recruited among employees of the Faculty of Agriculture and Food Sciences of the University of Milan. Sample size was chosen assuming a standardized effect size around 0.70, $\alpha = 0.05$ and $\beta = 0.20$, which gives approximately 35 subjects for each BMI group. All subjects were invited to a screening session, around 9:00 am, to assess the anthropometric measurements by collecting body weight (to the nearest 0.1 kg) and standing height (to the nearest 0.1 cm) using the same calibrated scale on a telescopic vertical steel stadiometer (SECA 220; Germany), with subjects dressed only in underwear. BMI was calculated accordingly [weight (kg)/height (m^2)]. Subjects with BMI higher than 30 were classified as obese, while subjects with BMI between 18 and 25 were classified as healthy-weight. Participants' characteristics are presented in Table 1.

The exclusion criteria were: aged > 65 years, experienced ageusia, pharmacological therapy that could modify taste perception, smokers and diabetics. All subjects were invited to take part to one session before lunch from 12.00 to 13.00, and were assessed for their taste responsiveness in pre-prandial condition. Subjects were also asked to complete a questionnaire concerning food neophobia. This study was approved by the Ethic Committee of the IRCCS Istituto Auxologico Italiano and written informed consent was obtained from all subjects after full explanation of the study. This study was conducted according to the guidelines laid down in the Declaration of Helsinki.

2.2. Taste responsiveness assessment

2.2.1. PROP responsiveness

PROP responsiveness was established using PROP-impregnated filter paper according to the procedure described by Bartoshuk et al. (2003). 3 cm^2 filter papers (Whatman) were soaked in a saturated aqueous PROP (6-n-propyl-2-thiouracil, Sigma-Aldrich, Spa, Milano) solution heated to near boiling temperature. Papers were air dried and stored at room temperature in small glassine envelopes for a maximum of 24 h. Each paper contained around 1.6 mg PROP. PROP crystallizes into the filter paper making it a convenient vehicle to deliver a measured amount of material into the mouth. Comparing the average perceived bitterness of PROP papers with those of PROP solutions, PROP paper falls between the perceived bitterness of 0.001 and 0.0032 M PROP (Bartoshuk et al., 2003). Using paper filter has the advantage of being easy to administer to subjects in ambulatory conditions and it has been used rather than solutions since it is equally valid and shows high test-retest reliability (Rankin et al., 2004; Zhao et al., 2003).

Prior to the test, subjects practiced the general version of the Labeled Magnitude Scale (gLMS; Green, Shaffer, & Gilmore, 1993; Green et al., 1996) by rating a list of remembered or imagined oral