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The impact of individual variations in taste sensitivity on coffee perceptions and preferences

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HIGHLIGHTS

- Physiological measures underlying taste perception were investigated
- The impact of physiological indices on coffee lixking and consumption was studied
- Fungiform papillae density affects both taste perception and coffee preference
- PROP taste status affects taste perception both in coffee and in standard solutions
- Sugar use depends both on fungiform papillae density and PROP taste status

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ABSTRACT

Despite a few relationships between fungiform papillae (FP) density and 6-n-propylthiouracil (PROP) taster status have been reported for sensory qualities within foods, the impact on preferences remains relatively unclear. The present study investigated responses of FP number and PROP taster groups to different bitter compounds and how these affect coffee perception, consumption and liking. Subjects (Ss) with higher FP numbers (HFP) gave higher liking ratings to coffee samples than those with lower FP numbers (LFP), but only for sweetened coffee. Moreover, HFP Ss added more sugar to the samples than LFP Ss. Significant differences between FP groups were also found for the sourness of the coffee samples, but not for bitterness and astringency. However, HFP Ss rated bitter taste stimuli as stronger than did LFP Ss. While coffee liking was unrelated to PROP status, PROP non-tasters (NTs) added more sugar to the coffee samples than did super-tasters (STs). In addition, STs rated sourness, bitterness and astringency as stronger than NTs, both in coffee and standard solutions. These results confirm that FP density and PROP status play a significant role in taste sensitivity for bitter compounds in general and also demonstrate that sugar use is partly a function of fundamental individual differences in physiology.

1. Introduction

Individual sensitivity to taste and other oral sensations shows considerable variability between individuals, and there is increasing evidence these variations are a significant influence on food preference and consumption [1–6]. Overall taste sensitivity is reflected in two commonly studied physiological measures. The first of these, the density of lingual fungiform papillae (FP) is positively associated with taste intensity [7] because the tongue's taste buds are contained primarily within the FP. Thus, those who have higher numbers of FP are more sensitive to tastes [8–12].

The second measure, the intensity of the compounds phenylthiocarbamide (PTC) and 6-n-propylthiouracil (PROP), is a genetically mediated index of individual variation in oral sensations [13–16]. PROP responsiveness is typically expressed categorically as PROP taster status (PTS), which consists of three groups: PROP super tasters (STs), PROP medium tasters (MTs), and PROP nontasters (NTs) [17]. PROP responsiveness has long been used as general orosensory responsiveness to a variety of stimuli (e.g., [13,18]). PROP tasters rate the intensity of other bitter compounds, including caffeine, quinine, and urea [19–22], as more intense than do NTs, sucrose as sweeter [23,24], sodium chloride as more salty [13], and citric acid as more sour [25]. PTS is also associated with responsiveness to other orosensory stimuli apart from tastes: STs perceive irritation from capsaicin [26,27], cinnamaldehyde [27], ethanol [27–29], and astringency [30–32] with greater intensity than NTs.

PROP intensity and the density of FP are often found to be positively correlated. The most plausible explanation for this is that, while the ability to taste PTC [33] or PROP [29,34] results from the presence of a functional bitterness receptor (TAS2R38), the intensity of all tastes results

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from the spatial summation of number of taste buds stimulated, itself a function of FP density.

Bitterness *per se* is instinctively rejected [35–37] and this is thought to have been crucial to survival via its impact on food choice, specifically the avoidance of bitter toxins [38].

However, sensitivity to bitterness in foods and beverages varies widely among individuals, and some foods are consumed despite the presence of potentially bitter compounds. Both FP density and PROP intensity appear to clearly reflect this variation [39]. A range of bitter foods, including Brussels sprouts, cabbage, broccoli and spinach [40–42], caffeinated coffee [40] and grapefruit juice [43,44], have been reported as more bitter and/or less preferred by PROP tasters than by NTs. Differences between PROP/PTC tasters and NTs have also been found with foods that are sour such as lemon juices, vinegar, and sauerkraut [43]. Some studies have reported relationships between FP density, PROP status and food consumption/preference: Ss who rated the least bitterness intensity of PROP or had lowest numbers of FP reported less burn and disliking of ethanol as well as more frequent consumption of alcoholic beverages [45]; perceived less creamy/sweet sensations of sugar-fat mixtures and their liking was not affected by concentration at high sugar/high fat levels [46]; tasted less bitterness from some vegetables and consumed vegetables most frequently [39]; had significantly higher liking ratings for bread [47].

The universality of some bitter foods/beverages suggests however that their consumption is not limited to bitter insensitive individuals. Coffee, for example, that is one of the world's most consumed beverages despite the presence of caffeine and other bitter compounds. Such preferences are almost certainly the results of flavor-flavor and/or flavor-consequence conditioning via the stimulatory impact of caffeine and the addition of sugar or milk [48–50].

Nevertheless, how these preferences might also be shaped by individual physiological differences remains poorly understood. Moreover, some physiological indices can be determinants of learned preferences. For example, Yeomans et al. [51] demonstrated that PROP taster status, together with the intrinsic pleasantness of the taste of saccharin (sweet liker status), influenced the pleasantness of an odor paired with the saccharin in solution.

Even in high coffee consuming cultures such as Italy there are clear sensory variations in the coffees that are produced and consumed, and there is also potential for modification of bitterness using the addition of sweeteners. The aim of this study was to investigate physiological measures underlying taste perception and how these influence perception, consumption of, and liking for coffee.

2. Methods

2.1. Product selection

2.1.1. Subjects

As part of a pilot experiment to select suitable coffee samples for use in the main study, eight subjects (Ss), six females and two males, aged from 20 to 38 years, and regular coffee consumers, were recruited in the Florence area. The Ss had no history of disorders in oral perception. They were paid for their participation in the study. Written informed consent was obtained from each subject after the description of the experiment.

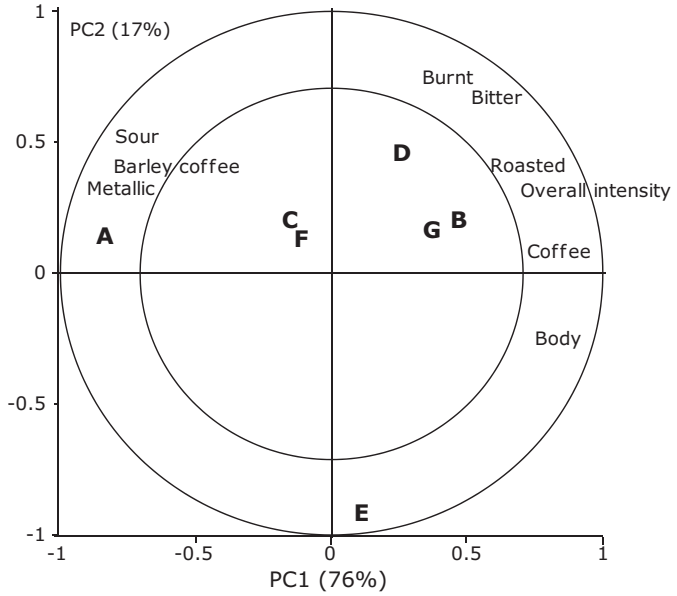
2.1.2. Samples

Seven espresso coffees varying in roasting degree (light, medium, dark) and caffeine content (<0.05–2%) were evaluated (Fig. 1). Coffee samples (25 g) were prepared with an espresso machine using coffee capsules.

2.1.3. Descriptive analysis (DA)

Ss participated in five sessions for training and term generation. Specifically, they were trained to recognize and rate the perceived intensity of the following qualities: sweetness, sourness, bitterness, and astringency using the following standard solutions - sucrose: 8.00, 12.00, 18.00 g/l; citric acid: 0.25, 0.38, 0.50 g/l; quinine monohydrochloride dihydrate 0.025, 0.037, 0.050 g/l; aluminium potassium sulphate: 0.3, 0.6, 0.9 g/l. During training sessions, Ss were asked to rate the intensity of the standard solutions on a 9-point category scale (1="extremely weak"; 5="moderate"; 9="extremely strong").

An evaluation sheet consisting of 22 ratings was defined. In each of the five sessions, four or five samples were evaluated. Each sample was evaluated 3 times. Samples (25 g) were presented in a closed 80 cc plastic cup identified by a three digit code. Sample presentation was balanced across subjects within each session. For each sample, assessors were asked to rate the intensity of odor descriptors perceived by nose (aroma) first. Then they were asked to wait 3 minutes, take a sip of the sample and rate the intensity of odors perceived retronasally, taste and mouthfeel attributes. After each sample, subjects



Sample	Roasting degree	Caffeine (%)
A	Light	0.8-0.9
B	Dark	0.8-0.9
C	Medium	1.50
D	Dark	1.50
E	Medium	<0.05
F	Medium	0.8-0.9
G	Dark	about 2

Fig. 1. Correlation loading plot from Principal Component Analysis on panel averages of each significant attribute describing sample sensory properties. For each sample roasting degree of coffee beans and caffeine content (%) of coffee powder are reported in the table.