



Distribution of Non-tasters for Phenylthiocarbamide and High Sensitivity to Quinine Hydrochloride of the Non-tasters in Japanese

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Abstract

The percentage of non-tasters for phenylthiocarbamide in 915 Japanese students was 9.4%. The thresholds of the edge and back of the tongue to quinine hydrochloride were significantly smaller in the non-tasters than in the tasters. The thresholds of any tongue portions to NaCl, acetic acid or sucrose did not differ between the tasters and the non-tasters. **Chem. Senses** 22: 547–551, 1997.

Introduction

Phenylthiocarbamide (PTC) tastes extremely bitter to most people but is tasteless or only slightly bitter to the remainder. The former are called tasters for PTC and the latter non-tasters for PTC (Fox, 1932; Cohen and Ogdon, 1949; Harris and Kalmus, 1949). The taste insensitivity to PTC is inherited as a Mendelian recessive (Merton, 1958; Kalmus, 1971).

The distribution of non-tasters for PTC differs from race to race. The percentage of non-tasters is 30–40% in European and American Caucasians, 5–15% in the Japanese population and ~5% in the American Indians and Ainu populations (Levine and Anderson, 1932; Rikimaru, 1936; Tsuji, 1957; Ogawa, 1960; Sato and Sata, 1989).

Investigations of the distribution of PTC non-tasters in >900 Japanese subjects have indicated that the percentage of the non-tasters is 12.5% of 1625 subjects in Sapporo (Matsunaga *et al.*, 1954), 13.4% of 1021 subjects in Chiba (Nakajima, 1959), 9.1% of 921 subjects in Osaka and Kyoto

(Fukuoka, 1936) and 11.3% of 1169 subjects in the western districts (Ogawa, 1960). The mean of these values is 11.6%. Ogawa (1960) analysed the percentage of PTC non-tasters in various districts of Japan using relatively smaller samples (187–429 subjects) and reported that the percentage of PTC non-tasters was 5.3% in Sapporo, 4.3% in Tokyo, 7.0% in Hiroshima and 16.5% in Miyazaki. He suggested that the percentage of the non-tasters is smaller in northern and eastern districts than in the western district of Japan. However, this conclusion seems to be invalid because the data mentioned above indicate that a high percentage of PTC non-tasters exist in the northern and eastern districts.

In our previous investigation using 427 dental students the percentage of PTC non-tasters was found to be 5.4% (Sato and Sata, 1989). As suggested by the investigation of Ogawa (1960), it is possible for the distribution of PTC non-tasters to be underestimated when a small number of subjects were investigated.

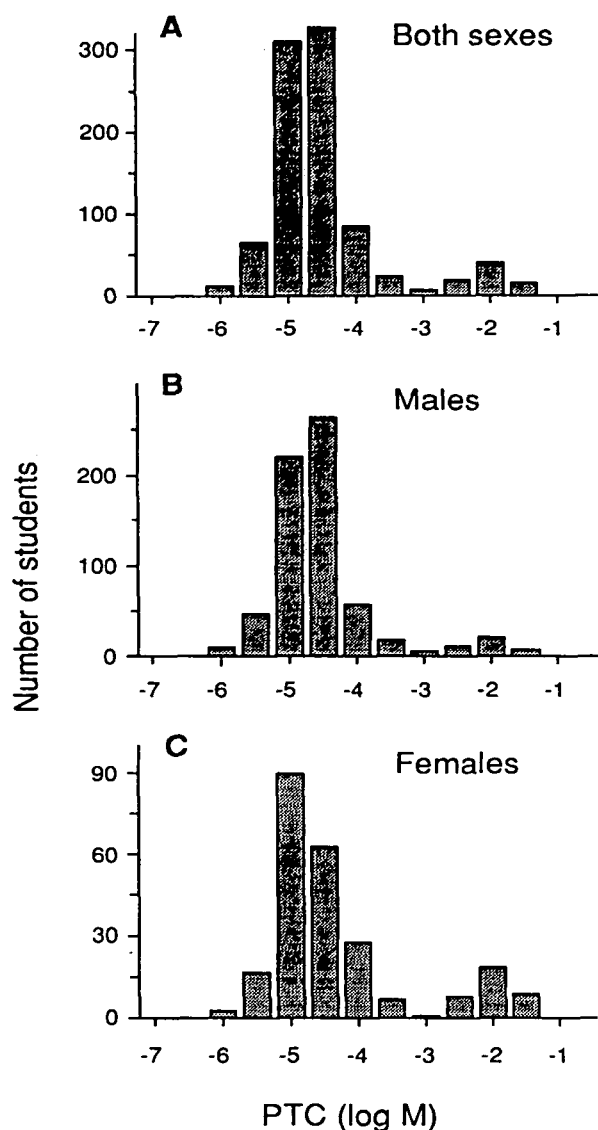


Figure 1 Distribution of bitter thresholds to PTC in Japanese dental students. (A) 915 students of both sexes. (B) 670 male students. (C) 245 female students.

Further, we investigated PTC thresholds of 488 dental students over 8 years from 1989. In this report we have combined the present and previous data to get a reliable percentage of PTC non-tasters. We also investigated a difference in taste thresholds for four basic taste stimuli between PTC non-tasters and tasters.

Methods, results and discussion

A total of 915 dental students (670 males and 245 females) were used as the sample. The measurements of thresholds for PTC were carried out in the Laboratory in Physiology

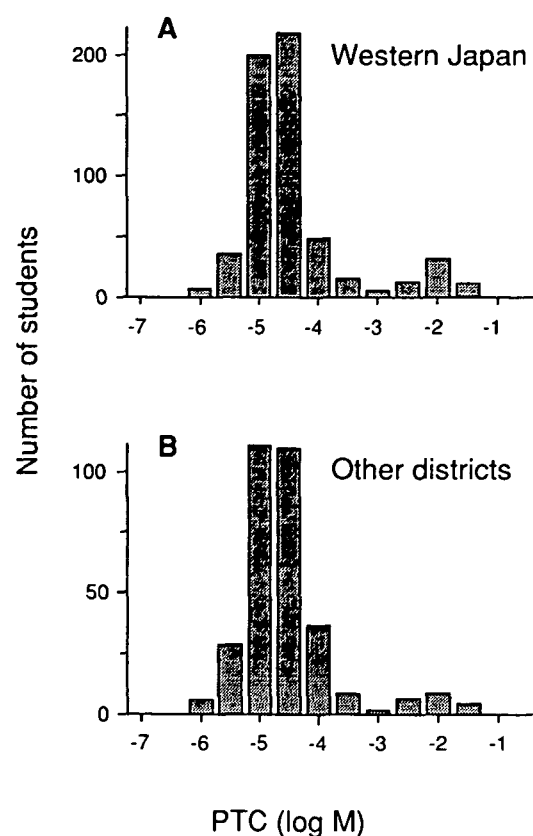


Figure 2 Distribution of bitter thresholds to PTC in Japanese dental students. (A) 590 students from western Japan. (B) 325 students from other districts.

during April and May of 1983–1996 at a room temperature of 22–25°C. All the subjects were in the third grade of the Nagasaki University School of Dentistry. The mean age was 22.6 years, with a range of 20–39 years. Of the sample, 96% were aged 20–29 years and 4% were aged 30–39 years. The dental students in Nagasaki University came from all over Japan. The students from western districts (Chugoku, Shikoku, Kyushu districts) comprised 64% of the sample (590 persons) and those from the other districts (Hokkaido, Tohoku, Kanto, Chubu and Kinki districts) comprised 36% (325 persons).

PTC (Wako, Tokyo, Japan) was dissolved into deionized water (Milli-Q system, Millipore, MA). The concentrations (M) of PTC were changed by 0.5 log steps: 10^{-6} , 3×10^{-6} , 10^{-5} , 3×10^{-5} , 10^{-4} , 3×10^{-4} , 10^{-3} , 3×10^{-3} , 10^{-2} and 3×10^{-2} . These solutions were prepared within 1 week prior to the investigations.

Before PTC threshold tests the purpose and procedure of the investigations were explained to all students. Measurements of recognition thresholds for PTC were carried out according to the up–down or staircase procedure

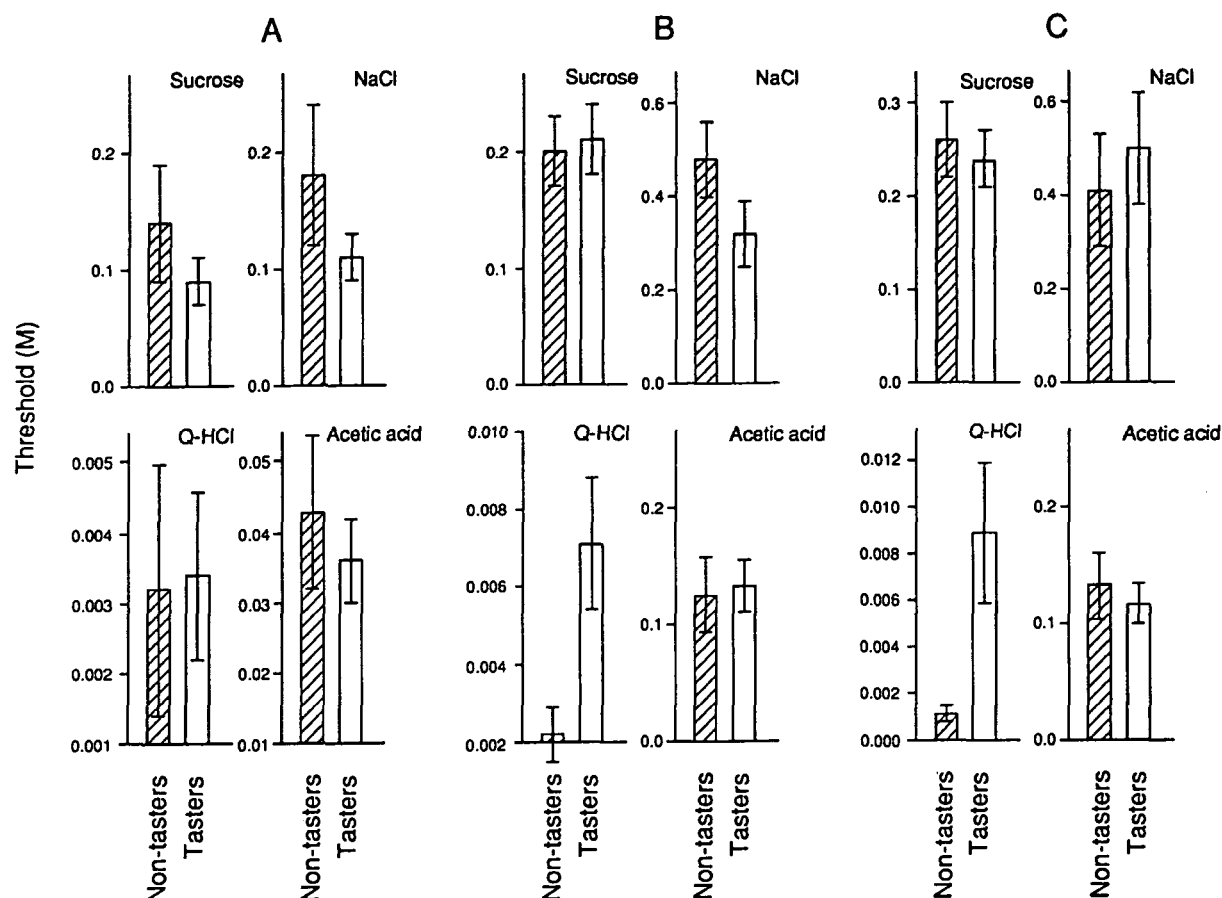


Figure 3 Taste thresholds of the tip, edge and back of the tongue to four basic stimuli. (A) Tip. (B) Edge. (C) Back of the tongue. Taste stimuli: sucrose, NaCl, Q-HCl and acetic acid. The thresholds for four stimuli were obtained from 35 tasters and 19 non-tasters for PTC. Vertical bars are SEM.

(Cornsweet, 1962; Bartoshuk, 1978). Before starting the test a subject held 20 ml of deionized water in the mouth and rinsed the oral cavity. The subject then held 20 ml of a 10^{-6} M PTC solution in the mouth and immediately stimulated the whole taste receptor area on the tongue and soft palate by moving the mouth. If the subject could not discern a bitter taste, the PTC concentration was increased. However, before testing the next concentration, the mouth was fully rinsed with water. If the subject indicated a bitter sensation, the PTC concentration was decreased at the next trial. Furthermore, if the subject failed to indicate the stimulus quality, the concentration was increased.

Recognition thresholds of the tip, edge and back of the tongue for the four basic taste stimuli were measured in 54 students consisting of 35 PTC tasters and 19 PTC non-tasters. The edge and back of the tongue were the middle part of the outer edges and the region of vallate papillae respectively. A filter paper disk of 6 mm in diameter, which was soaked in a taste solution, was put on each portion of the tongue and the recognition threshold was determined.

Taste solutions tested were (in M) NaCl, 0.01, 0.03, 0.1, 0.3, 1.0 and 2.0; sucrose, 0.003, 0.01, 0.03, 0.1, 0.3 and 0.5; quinine hydrochloride (Q-HCl), 0.00003, 0.0001, 0.0003, 0.001, 0.003, 0.01 and 0.03; and acetic acid, 0.001, 0.003, 0.01, 0.03, 0.1 and 0.3. All solutions were prepared in deionized water. The taste recognition thresholds were determined with the up-down procedure as mentioned above.

As shown in Figure 1, recognition thresholds for PTC in 915 students of both sexes (A), 670 male students (B) and 245 female students (C) showed a bimodal distribution. The subjects who showed a threshold of 10^{-3} M or more perceived very low bitterness at the suprathreshold concentrations of PTC, so they were regarded as non-tasters for PTC. The PTC thresholds for all students of both sexes were $3.5 \pm 0.2 \times 10^{-5}$ M (mean \pm SEM) for 829 tasters and $1.1 \pm 0.1 \times 10^{-2}$ M for 86 non-tasters. The thresholds of 670 males were $3.5 \pm 0.2 \times 10^{-5}$ M for 621 tasters and $1.0 \pm 0.1 \times 10^{-2}$ M for 49 non-tasters. The thresholds of 245 females were $3.7 \pm 0.4 \times 10^{-5}$ M for 208 tasters and $1.3 \pm 0.2 \times 10^{-2}$ M for 37

non-tasters. In either sex there was a significant difference between PTC thresholds for tasters and non-tasters (*t*-test, $P < 0.001$).

Figure 2 shows PTC thresholds of students from western districts (A) and the other districts (B). PTC thresholds of 590 students from western districts were $3.5 \pm 0.2 \times 10^{-5}$ M for 527 tasters and $1.2 \pm 0.1 \times 10^{-2}$ M for 63 non-tasters. PTC thresholds of 325 students from the other districts were $3.6 \pm 0.3 \times 10^{-5}$ M for 302 tasters and $1.1 \pm 0.2 \times 10^{-2}$ M for 23 non-tasters.

Eighty-six of the 915 students of both sexes tested were non-tasters for PTC. The percentage of the non-tasters was 9.4% in both sexes, 7.3% in males and 15.1% in females. In males the number of tasters and non-tasters was 621 and 49, respectively, while in females the number of tasters and non-tasters was 208 and 37. The chi-square test for independence with a 2×2 contingency table indicates that the percentage of the non-tasters is significantly higher in females than in males ($P < 0.01$).

The number of tasters and non-tasters in the western district were 527 and 63 respectively, while in the other district there were 302 and 23 respectively. The chi-square test for independence between the two pairs indicates that the percentage of PTC non-tasters did not differ between western and other districts of Japan ($P > 0.01$).

We compared thresholds for four basic taste stimuli between tasters and non-tasters. Figure 3 illustrates thresholds of the tip (A), edge (B) and back (C) of the tongue to four basic stimuli in the tasters and non-tasters. There was no statistical difference between thresholds in the tasters and non-tasters when any portions of the tongue were stimulated with sucrose, NaCl and acetic acid (*t*-test, $P > 0.05$). However, the Q-HCl threshold of the edge and back of the PTC non-taster's tongue was much smaller than that of the PTC taster's tongue (*t*-test, $P < 0.001$). Figure 4 clearly shows the difference in distribution of Q-HCl thresholds between PTC tasters and non-tasters. Stimulation of the tip of the tongue with Q-HCl did not cause any change in threshold between tasters and non-tasters (*t*-test, $P > 0.05$). These results suggest that taste cells in the edge and back of the tongue in PTC non-tasters are very sensitive

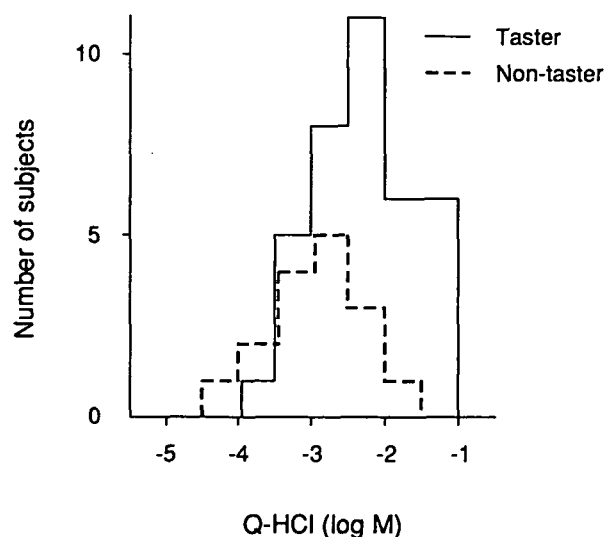


Figure 4 Distribution of thresholds for Q-HCl in PTC tasters and non-tasters. The edge of the tongue was stimulated for 37 tasters and 16 non-tasters. The mean thresholds of tasters and non-tasters were 0.0071 ± 0.0017 M ($n = 37$) and 0.0022 ± 0.0007 M ($n = 16$) respectively.

to Q-HCl, possibly because they have a large number of Q-HCl binding receptors. However, the thresholds for NaCl, acetic acid and sucrose in all parts of the tongue were the same in the tasters and the non-tasters. It has been reported that the sensitivity to Q-HCl or Q-H₂SO₄ of non-tasters for PTC or related substances is similar to (Hall *et al.*, 1975) or lower than (Fischer *et al.*, 1961) that of the tasters. However, these results came from whole mouth stimulation. If the back or side of the tongue is selectively stimulated with bitter substances, the high sensitivity of the non-tasters to quinine can be seen.

The physiological meaning of high sensitivity for Q-HCl in PTC non-tasters is not clear. There exist supertasters who have lower threshold and supersensitivity to a taste substance (Bartoshuk *et al.*, 1994). If PTC non-tasters who have a low threshold for Q-HCl in the edge and back regions of the tongue are highly sensitive to superthreshold concentrations of Q-HCl, the PTC non-tasters are supertasters to only Q-HCl of the four basic tastes. The PTC non-tasters who have little or no mRNA making PTC binding receptor proteins have possibly a larger amount of mRNAs making other bitter substance binding proteins.

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