The Egyptian Journal of Medical Human Genetics (2015) **16**, 135–139

HOSTED BY

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The Egyptian Journal of Medical Human Genetics

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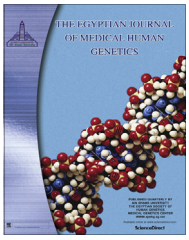

ORIGINAL ARTICLE

The population structure of Ukraine in relation to the phenylthiocarbamide sensitivity

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Received 26 November 2014; accepted 8 December 2014
Available online 6 January 2015

KEYWORDS

Phenylthiocarbamide;
Taste sensitivity;
Tasters/non-tasters for the bitter taste;
Genetic marker;
Population of Ukraine

Abstract *Background:* The taste sensitivity to phenylthiocarbamide (PTC) is one of the classical genetic markers in human studies. PTC is of great interest from the medical point of view since a number of associations of the taster status with human diseases have been found. The aim of our study was to evaluate the population structure of Ukraine in relation to PTC sensitivity.

Methods: The study involved 533 people (78 males and 455 females) aged from 16 to 25 years. The PTC solution in the concentration of 0.13% was prepared according to the method of Harris and Kalmus. The participants of the study analyzed the taste of the filter paper impregnated with PTC. If the trial subjects tasted PTC as "bitter", "very bitter", "bitterish", the phenotype was defined as a taster. If the trial subject did not taste PTC ("no taste", "taste of paper"), he/she was referred to a non-taster.

Results: The structure of the sample of the Ukrainian population studied in relation to the phenotypic and genotypic frequency associated with the phenylthiocarbamide sensitivity has been studied. It has been shown that in the population there are 22% of those who do not feel the taste of phenylthiocarbamide. Among males there are a few more non-tasters than among females, however, the differences are not significant. The frequency of the dominant and recessive allele of the phenylthiocarbamide sensitivity gene in the sample calculated on the basis of the Hardy–Weinberg equation is generally $p_T = 0.55$ and $q_t = 0.45$, respectively.

Conclusions: Frequencies of alleles T and t obtained in the male and female population under research are very close to the frequencies of the same alleles in some populations of India. Data of this study supplement the currently available information in relation to the genetic structure of modern Ukrainian cities.

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Peer review under responsibility of Ain Shams University.

http://dx.doi.org/10.1016/j.ejmhg.2014.12.003

1. Introduction

The ability to detect signals with a different taste and smell is the integral part of adaptation of biological species to the environment. To date, several hundreds of chemoreceptors in the human body have been studied. Despite the fact that taste receptors are much less described than the olfactory ones, the population polymorphism extends increasingly to the taste sensitivity, especially the sensitivity to bitter, with respect to which 25 receptors are known. As for olfactory receptors, there are more than 400, however, the expressed olfactory polymorphism has been studied only with regard to a small number of compounds, particularly, androsterone (musk flavor), isovaleric acid (cheese flavor), *cis*-3-hexen-1-ol (grass flavor) and asparagus metabolites in the urine [1].

The taste sensitivity to phenylthiocarbamide is one of the classical genetic markers in the human studies. Phenylthiocarbamide (PTC) is a synthetic compound, which by the interaction with certain human taste receptors is felt bitter in some individuals (tasters) and tasteless in others (non-tasters). In a number of studies among tasters, the supertasters, who are capable of identifying a bitter taste in extremely low concentrations, are distinguished [2]. Despite the fact that PTC is synthesized in the laboratory and is not found in nature, the ability to sense this substance is highly correlated with the ability to sense other bitter compounds of natural origin, many of which are toxic, such as strychnine, ricin and quinine [3], and some are very useful, such as grapefruit, green tea, broccoli, arugula, cauliflower, and others [4] having in their composition compounds with anticancer activity (citrus flavonoids, polyphenols of green tea and red wine, cruciferous glucosinolates and isoflavones of soy products) [5]. On the other hand, according to some estimates, about 70% of cancers arise from the consumption of certain foods or smoking [6]. At the same time, it is essential to consider that sensitivity of certain compounds with a bitter taste, for example, goitrin, does not correlate with sensitivity to PTC, while they may be contained in the same products [7]. A variety of gustatory senses in the population can significantly affect the eating behavior of a person and, therefore, the state of his/her health; moreover, associations may have a sex specificity. For instance, in one of the studies it was shown that among females, lovers of tea with a bitterish taste, there were more PTC tasters, while among males, who consumed alcohol and preferred bitter coffee and tea, there were more PTC non-tasters [8]. At the same time, the unambiguity of this issue is still missing as in some studies, particularly in Africa, no relationship between the frequency distribution of PTC tasters and non-tasters and food preferences was found [9].

Geneticists offered different types of inheritance for the PTC sensitivity, including both single-locus and double-locus models [10]. Most family studies indicated the monogenic nature of the sensitivity to PTC. It was considered that the ability to sense the compound was controlled by a dominant allele, and the inability by a recessive allele of the autosomal gene, respectively. The molecular genetic nature of PTC was determined later when describing the gene of the sensitivity receptor to a bitter taste *h*TAS2R38 [11]. Moreover, it was found that the threshold values of the sensitivity to PTC and a related compound with a bitter taste propylthiouracil are highly correlated with each other [12]. Molecular studies of the mutant gene variants *h*TAS2R38 revealed the presence of three basic single-nucleotide substitutions that encode three different amino acids (*C145G*/*P49A*, *C785T*/*A262V* and *A886G*/*I296V*) [13]. At the moment the obvious nature of inheritance of the sensitivity to PTC allows to use this trait as learning applications. One can show students in real life examples the mechanism of the PTC sensitivity inheritance and to solve genetic problems during the classes in genetics [14].

The ability to sense PTC is not unique for *Homo sapiens* species. The experiments conducted on animals kept in the zoo environment showed that among chimpanzees, orangutans, gibbons and gorillas PTC tasters and non-tasters were also found [3]. PTC, which is close to rodenticide strychnine by the acute toxicity in mice, often acts as an object of various studies of eating behavior [15]. In animal models studied the compounds close to PTC, such as propylthiouracil, which, however, did not show the relationship with the sensitivity to ethanol in mice were also studied [16].

PTC is of great interest from the medical point of view since a number of associations of the taster status with human diseases have been found. In this connection, the sensitivity to PTC detected in the young age may be a predictor of a number of pathological conditions, including genetically determined (multifactorial) ones, which development in individuals in the risk group can be prevented by optimally selected environmental factors. Cheapness and availability of this type of testing appear to be attractive diagnostically. The following examples illustrate the diversity of associations of the sensitivity to PTC. In particular, in early studies the inhibitory activity of PTC in relation to the thyroid gland was found [17], and subsequently the toxic effect of the compound on the thyroid gland and a higher frequency of its pathologies, including goiter in non-tasters were observed. In particular, among non-tasters there were more individuals with pathology of the thyroid gland (68%) compared to tasters (32%) [8]. In one of the studies it was shown that the frequency of PTC non-tasters among individuals with idiopathic and symptomatic epilepsy was higher (35.5% and 32.5%, respectively) than in the control (20%) [18]. In another study non-tasters were more frequently found among patients with schizophrenia and their first degree relatives [19–20] although, according to other authors, this relationship was not confirmed [21]. A higher threshold of the sensitivity of secondary school students to PTC and sucrose was associated with a higher risk of dental caries [22]. Among adult non-tasters an increased inclination to obesity was reported, in particular, the odds ratio among PTC non-tasters to have BMI $\geqslant 25\ kg/m^2$ was 2.51 times more than among PTC tasters [23]. Among children with obesity there were 72% of non-tasters, while among children with the normal weight – only 28% [24]. At the same time non-tasters compared to tasters were less susceptible to malaria [25], and they had less high level of anxiety [26]. The relationship of the sensitivity to PTC and rheumatoid arthritis was studied, but it was not detected [27].

In Ukraine similar studies were carried out restrictedly in the western region of the country among the secondary school students of the Khmelnitsky region (Kamenetz-Podolsk) [26]. Data obtained in this population may not reflect the pattern of distribution of the sensitivity to PTC in Ukraine because different populations of Ukraine differ significantly in the genetic and demographic structure as it has been shown many times in our previous studies [28–32]. Actually, the frequencies