
Phenotype Variations of TAS2R38 Gene and Its Bioecological Significance

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Abstract: People have different feeling skills of the bitterness of compound phenylthiocarbamide (PTC). This trait has been shown to correlate with a number of dietary preferences and thus may have important implications for human health. There are two types of phenotypes in different ethno groups and populations according to this feature: PTC tester and PTC non-tester. Both phenotypes, besides some rare exceptions, are fixed in almost every population. We have studied the phenotypic variants of feeling the PTC bitterness spread in Georgian ethno group for the first time. Basing on the conducted experiments, about $\frac{3}{4}$ of the investigated population turned out to be sensitive towards PTC, and $\frac{1}{4}$ of the population – insensitive. We have analyzed the phenotypic structure of PTC feeling in the people who smoke in the population. The majority of the smokers (70%) turned out to be PTC non-tester and only 30% - PTC tester. It is important to study the phenotypic variants of feelings coded with TAS2R38 gene in the point of view of both – genetic structure of the population and bio-ecology in order to plan different kinds of preventive measures.

Keywords: PTC, Phenotype, Tester, Non-Tester

1. Introduction

In perceiving an environment by a human being, together with the other basic senses (sight, hear, smell, touch), the sense of taste also takes part. Different substances when penetrating into the mouth cavity cause the activation of receptor cells, which results in a specific feeling – sense of taste. The taste is based on the five basic senses (bitter, sweet, sour, salt and umami). The receptors of each category are activated with correspondent adequate irritants. It is important to feel bitter from them since they protect a person from receiving naturally toxic substances which, as a rule, have bitter taste [1]. In addition, differences in genetic variation in taste receptors between ethnic groups may contribute to differences in dietary intake patterns [2].

Feeling bitter of some substances by a person is characterized with polymorphism. Some people cannot feel the bitterness of this substance at all. One of these kinds of substances is phenylthiocarbamide (PTC). This substance cannot be found in the pure nature, though its analogies are

included in the consistencies of some plants (cabbage, rape, broccoli). The taste of such plants is perceived differently by PTC tester and PTC non-tester.

The genetic basis of different feeling of PTC bitterness is TAS2R38 gene, which is localized in the 7th chromosome (7q) of the human being. The ratio of the phenotypes of this gene is an ethno-specific sign and reveals an association with different genetically determined and nonhereditary (ecological) factors. At present, the researchers recognize the bidominal structure of TAS2R38 gene haplotypes. Many researches in different ethnicities and races reveal large variations of phenotypic structure (from 55% to 85%) [3,4]. According to the existed data, PTC insensitive phenotypes are inclined to thyroid-deficient diseases of thyroid [5]. PTC insensitive phenotypes are dominant among the [6], and by the experiment conducted in order to connect with the body mass and food ration of the phenotypes, it was revealed a correlation (72% of the investigated people) between PTC insensitive phenotypes and overweightness of children [7]. Thus, it is important to study the phenotypic variability of the

senses coded with TAS2R38 gene in the point of view of both – genetic structure of population and bio-ecology.

2. Study Area and Methods

We have pursued a research on the PTC bitterness sensitivity in the representatives of Georgian ethnicities of different ages and sexes. The inquired groups were randomly selected.

The research included 183 people. We have studied 115 female and 68 male people.

The research participants were inquired in our survey on the questionnaires drawn up by us. The questionnaire contained the questions on age, physical data (height, weight), blood group and Rhesus factor, undergone infectious diseases, endocrinal system pathologies (goiter, diabetes), smoking, etc.

The research was conducted by means of PTC standard testers, which contained 3.4 mg/kg of compound phenylthiocarbamide.

Basing on the data obtained via PTC testing, the people studied according to the sensitivity of bitterness was divided into PTC-tester and PTC non-tester phenotypes. We made notes of dominant, heterozygous and recessive genotypes with the following symbols: T – symbolically denotes the bitterness sensitivity; t – denotes non-sensitivity. Consequently, TT – is dominant homozygote according to the bitterness sensitivity; Tt – Heterozygote; tt – recessive Heterozygote.

The obtained results have been mathematically processed by a statistical method. We counted the allele concentration of PTC gene and the frequency of its propagation in the population with Hardy-Weinberg’s formula:

$$q^2+2q(1-q)+(1-q),$$

which reflects the distribution of genotypes in a panmictic (freely hybridizable) population. In the formula, q denotes the T allele frequency of PTC gene in the population, and the frequency of the second t allele will be 1-q.

The authenticity of the obtained research results is proved by the formula:

$$M=\frac{p}{n}+\sqrt{p(100-p)/n}$$

Where, P denotes the percentage data, n – the number people studied.

3. Results and Discussions

Despite the fact that the researchers recognize the bidominal structure of TAS2R38 gene haplotypes, many researches reveal large variations (from 55% to 85%) of phenotypic structure in different ethnicities and races [8]. The distribution of phenotypic variants of this gene occurs in a specific way in every population.

183 volunteers of Georgian nationality took part in the experiment. The inquired group included the people of both sexes aged from 18 to 70. According to the obtained results of the experiment, the part of the research objects felt the

universal limited amount (3.4 mg/kg) of PTC that was perceivable for a person in a tester as very bitter, the part of them – as average bitter or slightly bitter, some of them could not feel the PTC bitterness at all. The PTC insensitive people fixed the flavor of paper or could not feel any flavor.

As we can see, according to the bitterness sensitivity rather wide range of research objects were revealed (the people who are being studied). We divided them conditionally into three categories:

- Dominant homozygote (TT) – clearly feels the bitterness of PTC;
- Heterozygote (Tt) – feels the PTC bitterness or slightly feels the bitter.
- Recessive homozygote (tt) – fail to feel PTC bitterness at all. They perceive the flavor of paper or have generally neutral feelings.

On the basis of the conducted experiments, 125 examined people of the studied population (183 people) turned out to belong to PTC tester phenotype, 58 – to PTC non-tester; consequently, the people bearing the PTC sensitive phenotype made up 68% of the research population, and PTC non-sensitive people – 32% of the research population (fig. 1).

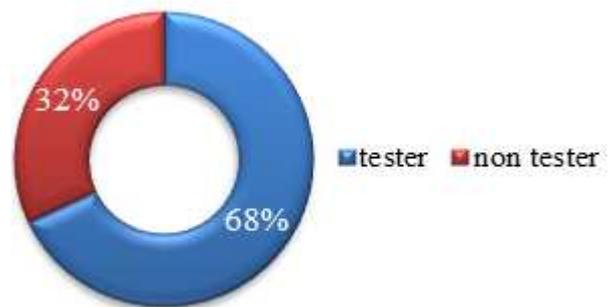


Figure 1. Distribution of PTC tester and PTC non-tester phenotypes in the population.

From this, the recessive t - allele concentration of the coding gene of the bitterness sensitivity in the population equals to:

$$1-q=\sqrt{0,32}=0,57$$

Dominant T – allele concentration in the population equals to:

$$q=1-(1-q)=1-0,56=0,43$$

Knowing the allele concentration enables us to calculate the distribution of the genotype frequency in the research population (fig. 2).

$$TT(q^2)=0,19; Tt(2q(1-q))=0,49; tt(1-q)^2=0,32.$$

The number of female representatives in the research amounted to 115 people. They composed the majority of the research population – 63%.

According to the experimental outcomes, 84 people turned out to be PTC tester, 31 – PTC non-tester. Consequently, the bearers of PTC tester phenotype were 73% of female inquired

group and 27% were the people with PTC non-sensitivity (fig. 3).

Basing on the obtained results we can assume that in the female representatives of Georgian research ethnicities the sensitive phenotype towards the PTC bitterness equals to 73% of the population, insensitive – 27%, T and t allele concentration in the population – 0,48 and 0,52 and the frequency of genotypes of the sign of bitterness sensitivity is represented as following: dominant homozygote (TT) – 0,27; heterozygote (Tt) – 0,5; recessive homozygote (tt) – 0,23. As we can see, in the discussed group the inheritance of the bitterness sensitivity is the classical example of Mendel’s first law. Essentially, the total obtained data coincide with the data obtained in the inquired population.

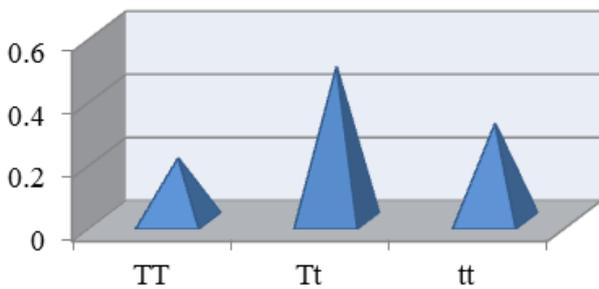


Figure 2. Genotype frequency in the research population.

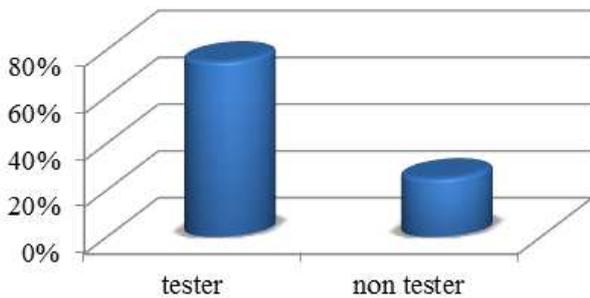


Figure 3. Phenotypic variations according to female the sex.

The male people in the inquired population were represented with 68 males. From this, 41 studied people turned out to be PTC tester, 27 – PTC non-tester. Consequently, the bearers of the PTC sensitive phenotypes made up 60% of the male inquired group; and the PTC non-sensitive people made up 40% (fig. 4).

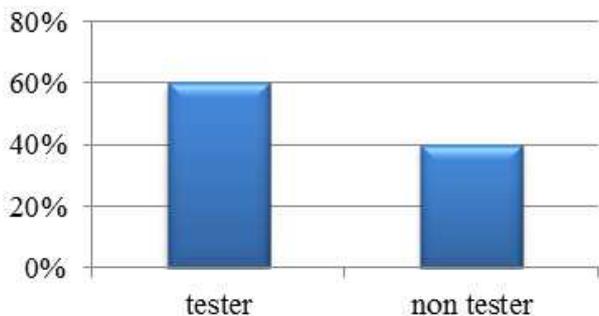


Figure 4. Phenotypic variations according to the male sex.

T and t allele concentration in the inquired group makes up

0,37 and 0,63 consequently, and the frequency of genotypes of bitterness sensitivity is represented as following: dominant homozygote (TT) – 0,13; heterozygote (Tt) – 0,47; recessive homozygote (tt) – 0,4.

Basing on the analyses of the obtained results, we can assume – according to the sexes in Georgian ethnicity, the structure of distributing phenotypic variations of PTC sensitivity is approximately equal. This fact has been corroborated by the equality of the frequency of the homozygotes in the population in almost every discussed cases and it does not change in connection to the sex (fig. 5).

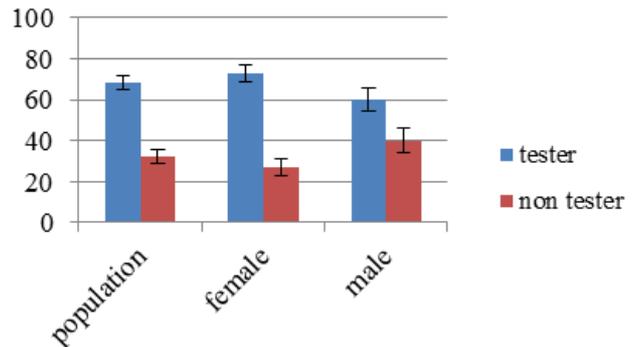


Figure 5. PTC bitterness variations in the inquired population of Georgian ethnicity.

There are rather controversial data in scientific references on the structure of the population of feeling PTC bitterness gene with respect to age. The majority of the authors considers the opinion that the ratio of the phenotypic variations of ethnicities and populations with respect to age is unchanged. The part of them thinks differently; they consider that according to the phenotypic expressions of this gene, varied ration is observed in different populations of different age groups. For instance, according to the current data of the molecular – genetic research on TAS2R16 gene, which was conducted with 941 individuals of 20-106 age groups in Italy, the high bitterness sensitivity was revealed among the aged people (dominant homozygote). These data increase from 35% to 55% in the aged people. The authors suggest that the PTC sensitivity could be one of the presumable markers for longevity [9].

We have studied phenotypic variations according to the ages towards PTC bitterness sensitivity in the randomly selected research populations. We divided the people studied during the analyses into three age categories: from 17 to 30, from 31 to 60 and above 60 age groups.

According to the conducted researches, the tester phenotype towards the PTC bitterness sensitivity made up 69±4,12 of the first study group; and non-tester phenotype – 31±4,12. The recessive t allele concentration in the first age group – 0,55, dominant T-allele – 0,45. The genotype frequency is represented as following: dominant homozygote (TT) – 0,2; heterozygote (Tt) – 0,49; recessive homozygote (tt) – 0,31 (fig. 6a).

In the second age group, the sensitive phenotype towards the PTC bitterness equals to 73% and non-sensitive phenotype –

27%. The concentrations of T and t – alleles in the study group equals to 0,52 and 0,48. The genotype frequency is represented as following: dominant homozygote (TT) – 0,23; heterozygote (Tt) – 0,5; recessive homozygote (tt) – 0,27 (fig. 6b)

In the third age group, 63% of the inquired people turned out to be the bearers of PTC tester phenotype, and 37% - non-tester. Consequently, in the third age group t-allele concentration is 0,61, T – 0,39. The genotype distribution frequency is: TT - 0,15; Tt- 0,48 and tt - 0,37.

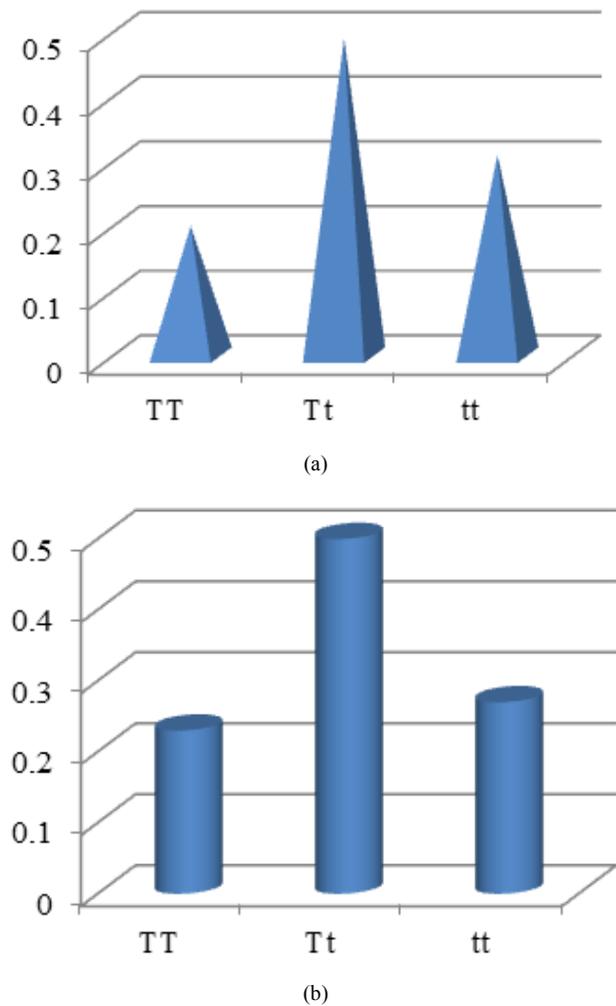


Figure 6. Genotype frequency in the age groups of population: a - first age group; b - second age group.

Towards the PTC sensitivity in the population studied by us, we have analyzed the frequency of phenotypic variants of the PTC bitterness sensitivity in the group addicted to cigarette. According to the experiments carried out in this regard, some phenotypes are associated with different diseases, especially with the high risk of thyroid cancer [10].

Based on the obtained data, in the group of smokers the tester phenotype having the ability of bitterness sensitivity was determined with 30% and 70% turned out to be PTC non-tester phenotype.

As a result of the conducted experiment and on the basis of the obtained results of the analysis of a group of smokers, we

can assume that the majority of the smokers belong to PTC non-tester phenotype, and PTC tester are made up by about the quarter (30%) of the smoker group. As we can see, the phenotypic variations of PTC sensitivity in smokers are clearly different from the phenotypic structure of PTC sensitivity of the studied populations and generally European populations. At the same time, the obtained results coincide with the studies conducted by other authors in the cohorts of cigarette smokers, according to which the PTC non-sensitive phenotypes are fixed not only in the smokers but even in the majorities of their parents. The high percentage of the propagation of PTC non-tester phenotypes has been explained as if these people are less likely to feel the bitter taste of cigarettes. Due to this, the adults who have PTC non-tester phenotypes are more likely to become smokers in the future. Thus, PTC non-sensitive phenotype can be considered as a risk-group predisposed to this harmful habit.

4. Conclusions

On the basis of the research carried out in order to study the phenotypic variations of TAS2R38 gene in the Georgian ethnic group, we have found out that in the studied population the propagation frequency of the individuals having a phenotype with sensitivity towards the PTC bitterness equals to $68 \pm 3,14$, non-sensitive phenotypes – $32 \pm 3,14$. T allele concentration of TAS2R38 gene is 0,43, and t allele concentration – 0,57, consequently. The frequency of genotypes is TT - 0,19; Tt – 0,49; tt – 0,32;

According to a sex, the structure of the distribution of phenotypic variations of PTC sensitivity in the population is approximately equal.

The majority of the smokers in the studied population belong to PTC non-tester phenotype (70%). Consequently, this sign can be considered as a risk-group predisposed to cigarette consumption and during planning, preventive measures, it is recommended to consider the bearing of PTC non-tester phenotype.

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