

Bitter Taste Perception in a population of BIOL 001 students

Purpose: To characterize phenotypic variation for sensory perception of the bitter tastant in a student population.

Background: Take a moment and reflect upon those foods you absolutely love to eat and those foods you could certainly do without. If you turn to your lab partner, you will probably find that there is at least one difference in food preference that exists between the two of you. Now take a moment and think about why these differences exist. Is it because of texture? Is it because of a previous bad experience? Is it because of flavor?

There are multiple reasons for differences in food preferences and one important contributor is taste perception. In humans, and many other species, certain chemicals in food stimulate taste cells on our tongue, which in turn send messages to a specific region of our brain. The central nervous system then interprets what these messages mean and determines the appropriate response (continue chewing OR spit it out). Collectively, which taste cells and how many taste cells are activated helps to characterize the flavor of food.

Think back to the earlier part of the semester when we discussed cell membranes. Remember that this cell structure is composed of three components, one of which is proteins. Do you remember any of the functions of proteins found in the cell membrane? Well, in taste cells, one important class of proteins is chemoreceptors, which function to detect the specific chemicals in our food. These proteins are embedded in the cell membrane with one part exposed to the outside of the cell and another part facing the inside of the cell. Given a high enough concentration of the specific chemical outside a taste cell, a chemoreceptor will respond and begin relaying a message to the brain.

In humans, there are five different classes of chemoreceptors: sour, salty, sweet, umami, and bitter. Each taste cell is proposed to exhibit only one type of chemoreceptor, but all five categories of chemical receptors are found somewhere on the tongue. Amazingly, scientific data show that there is only one type of receptor for sweet, sour and umami (interacts with monosodium glutamate: MSG), but at least 30 different receptors for bitter. (NOTE: the number of salt receptors is unknown.) Reflecting on the extensive variation in bitter receptors, in the number of taste cells and in the types of taste cells (each containing only one type of chemoreceptor), we can begin to see why individuals perceive foods differently.

In lab today we will focus on phenotypic variation in sensory perception of the bitter tastant in a human population of BIOL 001 students. We will use four (4) different chemicals to help us characterize our population. These chemicals are phenylthiocarbamide (PTC), thiourea, sodium benzoate (a common food preservative) and quinine. As you work through the lab activities, remember that evolution produced this many different bitter receptors in our human population. From an evolutionary perspective, why might this be? You will be challenged to propose an answer to this question.

PTC

In 2003, discovery of a gene on human chromosome 7 helped explain why humans perceive PTC differently. There are several known alleles for the PTC gene, but two of these are most frequent in the human population. This genetic variation creates at least three different phenotypes. You will use PTC taste paper to determine your phenotype. Generally, students who find PTC paper very bitter are considered tasters, while students who find PTC paper without any flavor are considered nontasters. Those students who find PTC paper mildly bitter and unpleasant should be characterized as mild tasters. Using these loose definitions, ~70% of the human population are tasters and 30% are nontasters.

Thiourea

The genetic variation contributing to phenotypic taste perception of this bitter tastant is unknown. A majority of people taste this chemical and can be classified as tasters or mild tasters. Nontasters do not detect any chemical on the paper.

Sodium benzoate

As mentioned earlier, this chemical is often used as a food preservative. Individuals report varied responses to this substance: sweet, salty, bitter, or no taste. By tasting the paper with sodium benzoate you will characterize your taste perception.

Quinine

Presently, the compound exists for two main reasons: one is used as a second-line treatment of malaria and the other is a main component of tonic water. The concentration of quinine used medicinally is significantly higher than that found in tonic water. In addition, all tonic water solutions in the laboratory today will be diluted from the original bottle by at least 50% or one-half. Those who taste quinine in tonic water report a bitter flavor. There is a possibility that some people may not perceive tonic water as bitter and instead just taste the sugar added to the tonic water that masks the bitterness. You will indicate whether or not you taste the bitterness of tonic water in each of the dilutions. If tonic water does not taste bitter to you, then you would answer “no” to all of the dilutions and would be considered a nontaster.

Laboratory Procedure:

The first part of the laboratory characterizes your perception of PTC, thiourea and sodium benzoate using taste papers soaked in a small amount of the chemical.

- 1) Rinse your mouth with water prior to starting the experiment.
- 2) Taste the PTC paper and classify your bitter perception as taster, mild taster or nontaster.
Record your result.
- 3) Rinse your mouth with water prior to starting the experiment.
- 4) Taste the thiourea paper and classify your bitter perception as taster, mild taster or nontaster.
Record your result.
- 5) Rinse your mouth with water prior to starting the experiment.
- 6) Taste the sodium benzoate paper and record whether you perceive bitter, salty and/or sweet (taster). You may also taste nothing (nontaster). Record whether you are a taster or nontaster; if you are a taster describe the flavor. Keep in mind that you may taste one or all three of the sensations.

In the second part of the laboratory, you will taste a series of 6 dilutions of tonic water. The dilutions are numbered 1 through 6, and are in random order of concentration. You should taste each sample in order, and record whether you taste the tonic (yes) or it tastes the same as club soda (no). Club soda is simply carbonated water.

1. Use a ruler to mark a line 2 cm from the bottom of two Dixie cups. These fill lines represent approximately 1 oz. Please use both cups for all of the samples.
2. Fill one cup to the line with Dilution 1. Also fill a second Dixie cup with club soda to use as a comparison and pallet cleanser. You will only get one sample of club soda so use it sparingly.
3. Drink Dilution 1 and record if you can taste the tonic water. Repeat with each dilution of tonic water in order from 1 to 6, recording your 'yes' or 'no' response each time.

Laboratory Results

PTC: _____

Thiourea: _____

Sodium Benzoate: _____

If taster, do you taste bitter? _____

If taster, do you taste salty? _____

If taster, do you taste sweet? _____

Tonic Water (quinine) – Does the solution taste bitter, like tonic water?

Dilution 1: _____

Dilution 2: _____

Dilution 3: _____

Dilution 4: _____

Dilution 5: _____

Dilution 6: _____

Threshold for quinine (last dilution you could perceive bitter flavor): _____

Question and Analysis

PTC perception:

What percentage of your classmates is considered a

- a. taster?
- b. mild taster?
- c. nontaster?

Thiourea perception:

What percentage of your classmates is considered a

- a. taster?
- b. mild taster?
- c. nontaster?

Sodium benzoate perception:

What percentage of your classmates is considered a

- a. taster?
- b. nontaster?

Of those tasters, how many perceived the paper to be

- a. salty?
- b. sweet?
- c. bitter?

Analysis of PTC, thiourea and sodium benzoate:

- 1) Of those students who tasted PTC, were they more likely to taste thiourea?
- 2) Of those students who tasted PTC, were they more likely to think sodium benzoate tasted bitter?
- 3) Do you think the same protein that recognizes and binds to the chemical PTC can recognize and bind to thiourea or sodium benzoate? Why or why not?

Determine the threshold for quinine (sample #):

- 1) What percentage of your classmates did not consider tonic water bitter?

- 2) Of those who considered tonic water to taste bitter, what percentage of your classmates determined each of the following dilutions to be the threshold for quinine perception?
 - Dilution 1: _____
 - Dilution 2: _____
 - Dilution 3: _____
 - Dilution 4: _____
 - Dilution 5: _____
 - Dilution 6: _____

- 3) Describe two (2) factors that might explain why there are different thresholds for quinine perception?

General Analysis:

- 1) As a class, generate a list of other factors that could influence how food is perceived. Choose one of these factors and construct a hypothesis that could be tested in a future experiment.

- 2) From an evolutionary perspective, why do you think there is so much variation in the human population for detecting bitter tastants as compared to sweet, umami or sour?