HOW SWEET IT IS!

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Annotation

In this activity, students will explore functional properties of food ingredients by comparing the structures and functions of natural and artificial sweeteners.

Primary Learning Outcomes:

Students will be able to name common sweeteners found in food products.

Students will be able to classify sweeteners as organic compounds.

Students will be able to identify the chemical structures of *sucrose*, *saccharin*, *aspartame*, and *sucralose*.

Students will be able to describe the relationship of chemical structure to the function of ingredients.

Students will be able to explain the importance of ingredient selection to the development of food products.

Assessed GPS:

Not applicable

Duration:

Preparation: 30 minutes
Introduction: 20 minutes
Student Activity: 20 minutes
Conclusion: 15 minutes
Total Class Time: 55 minutes

Materials and Equipment:

For Teacher Preparation:
(Per class of 30 students)

1. 1 Cup sucrose (table sugar)
2. 1 Cup sucralose (Splenda®)
3. 1 Cup saccharin (Sweet’N Low®)
4. 1 Cup aspartame (Equal®)
5. 150, 5-oz. Plastic cups
6. 5 Gallons of drinking water
7. Saltine crackers
8. Napkins

Per Student:

1. *How Sweet It Is!* student handout
2. 5-oz. Cup of Solution A
3. 5-oz. Cup of Solution B
4. 5-oz. Cup of Solution C
5. 5-oz. Cup of Solution D
6. 5-oz. Cup of water
7. 2 Saltine crackers
8. Napkin

Safety:
Because students will be allowed to eat during the activity, precautions should be taken to prevent materials from coming into contact with lab equipment or surfaces. Materials should remain in cups or on clean napkins at all times.

Technology Connection:
Not applicable

Procedures:
Teacher Preparation:
Use the attached template to prepare the *How Sweet It Is!* student handout for each student. To one gallon of drinking water, add one cup of sucrose(table sugar) and mix thoroughly. Label this "Solution A." To a second gallon of drinking water, add one cup of sucralose(Splenda®) and mix thoroughly. Label this "Solution B." To a third gallon of drinking water, add one cup of aspartame (Equal®) and mix thoroughly. Label this "Solution C." To a fourth gallon of drinking water, add one cup of saccharin (Sweet'N Low®) and mix thoroughly. Label this "Solution D." For each student, label 5 cups "A," "B," "C," "D," and "water," respectively. Fill each cup with the appropriate sample.

Estimated Time:
30 minutes

Introduction:
Everything we see, touch, smell, and taste is chemical, whether it is the neon lights at your favorite restaurant, the napkin you place in your lap, the aroma of fresh garlic, or the food that you eat.

During the development of a new food product, each ingredient, *i.e.* chemical, is selected because of its specific function within the food. Sugar sweetens. Vanilla flavors. Flour thickens. Potassium sorbate preserves. The specific function of an ingredient is a result of its chemical structure, and therefore, any changes in the chemical structure alter the function of the ingredient. For example, L-carvone and D-carvone are enantiomers, or isomers whose structures are mirror images of one another. In this case, L-carvone exhibits a spearamint aroma; whereas, D-carvone exhibits a caraway, or rye cracker-like, aroma. Structural changes in ingredients can result indirectly from heating, processing, and storage or can result directly from the efforts of food scientists to manipulate specific functional properties of an ingredient. Therefore, knowledge of the relationship between the structure and function of ingredients is critical to food scientists.

Explain to students that they will be sampling the following: sucrose, saccharin, aspartame, and sucralose. Each of these is an organic compound that is used as a sweetener in food and beverage products. As with any ingredient function, it is the chemical structure of sweeteners that allows them to function as such. Food scientists have determined that a specific arrangement of organic functional groups allows a compound to interact with taste bud receptors to register a sweet sensation. A compound must contain an –OH or –NH group, a basic N or C atom, and a hydrophobic group such as $-CH_3$ in a triangle with specific angles and distances in order to act as a sweetener. Among the more than 50 sweeteners known to food scientists, the natural sugars, such as sucrose and fructose, are the best known.

Sucrose (Figure 1), or common table sugar, is a carbohydrate and is a major source of calories and energy in the human diet. Sucrose is actually a disaccharide that is composed of the two monosaccharides glucose and fructose. Table sugar is refined from sugarcane and sugar beets and is considered the standard when measuring the sweetness of compounds.

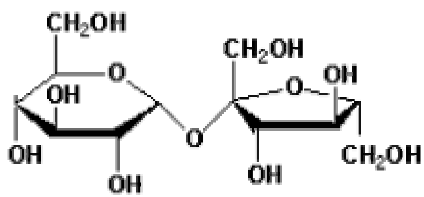

Figure 1: Sucrose

Because of the interest in low-calorie and low-sugar foods that has developed over the last few decades, interest has grown in using low-calorie or no-calorie sweeteners. These sweeteners, such as saccharin, cyclamate, aspartame, and sucralose, are either not metabolized or are so intensely sweet that very small quantities can be used.

Saccharin (Figure 2), the world's oldest low-calorie sweetener, was discovered accidentally in 1879 when a researcher at Johns Hopkins University spilled the compound on his hand and later noticed his hand to have sweet taste. Saccharin is a heterocyclic compound that is derived from toluene or methyl anthranilate and is 300 times sweeter than sucrose. It is not metabolized by the body, and although there has been much controversy concerning its health effects, saccharin has been shown to be a safe alternative to sugar. Today, saccharin is sold as a tabletop sweetener under the trade name Sweet'N Low® and is used in such products as baked goods, gum, candy, and salad dressings.

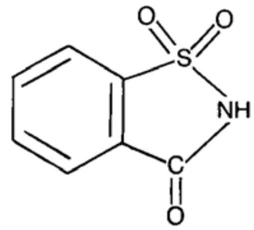

Figure 2: Saccharin

Similar to saccharin, aspartame (Figure 3) was accidentally discovered in 1956 and reached its peak popularity in the 1980s as a result of interest in diet fads. Aspartame is a dipeptide consisting of aspartyl and phenylalanine and is metabolized by the body. Although the amino acids comprising aspartame are nutritional and caloric, it is considered to be a low-calorie sweetener because its intense sweetness—it is 200 times sweeter than sucrose—allows it to be used in very small quantities. Aspartame is unstable during heating, and therefore, cannot be used as a sugar substitute in cooked products. Aspartame is known by the trade names Equal®, when sold at the supermarket, and NutraSweet®, when used by food manufacturers.

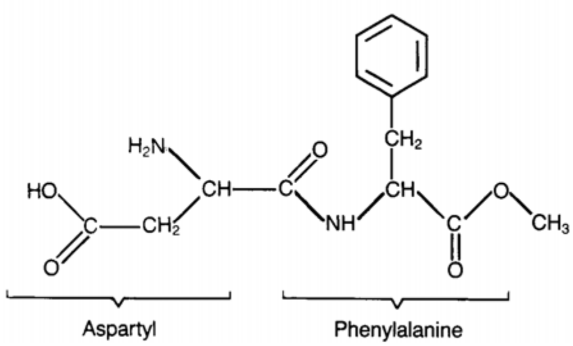

Figure 3: Aspartame

Sucralose is the newest artificial sweetener to enter the market and is known by the trade name Splenda®. Sucralose is made through a process that converts sugar to a non-caloric, non-carbohydrate sweetener by replacing three –OH groups on the sugar molecule with three Cl atoms. The result is a stable compound, 600 times sweeter than sucrose, that is not metabolized by the body and is stable at high temperatures. Aside from its use in manufactured products and as a tabletop sweetener, Splenda® is sold as a sucrose-sucralose blend for baking, as sugar can have important functions in the texture and appearance of baked foods.

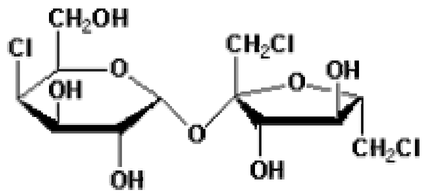

Figure 4: Sucralose

Estimated Time:
20 minutes

<u>Activity:</u>
Provide each student with the materials listed above. Ask students to sample the solutions and rank the relative sweetness intensities according to the instructions given on the *How Sweet It Is!* student handout.   Before sampling each solution, students should use the water and crackers to cleanse their palate.

Estimated Time:
20 minutes

<u>Conclusion:</u>
On the board, note the consensus of student rankings. Confirm the correct rankings and discuss any differences observed by the students. Have students individually answer the post-lab and discussion questions found on the *How Sweet It Is!* student handout.

Estimated Time:
15 minutes

Assessment:
Assessment should be based on completion of the *How Sweet It Is!* student handout.

Referrences:

- Gilman, V. 1988. *Artificial Sweeteners: No-calorie sugar substitutes provide options for enjoying the sweet life.*. Chemical and Engineering News. 82(25): 43.
- Emsley, J. 1988. *Artificial Sweeteners*. ChemMatters. February: 4-8..
- http://www.saccharin.org/
- http://www.sweetnlow.com/
- http://www.splenda.com/

Name:

Date:

Class Period:

HOW SWEET IT IS!
Student Handout

Introduction:
Sucrose (Figure 1), or common table sugar, is a carbohydrate and is a major source of calories and energy in the human diet. Because of the interest in low-calorie and low-sugar foods that has developed over the last few decades, interest has grown in using low-calorie or no-calorie sweeteners. These sweeteners, such as saccharin (Figure 2), aspartame (Figure 3), and sucralose (Figure 4), are either not metabolized or are so intensely sweet that very small quantities can be used.

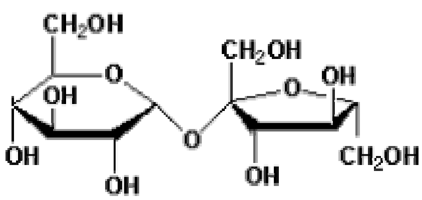

Figure 1: Sucrose

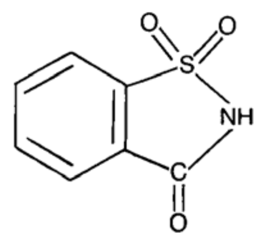

Figure 2: Saccharin

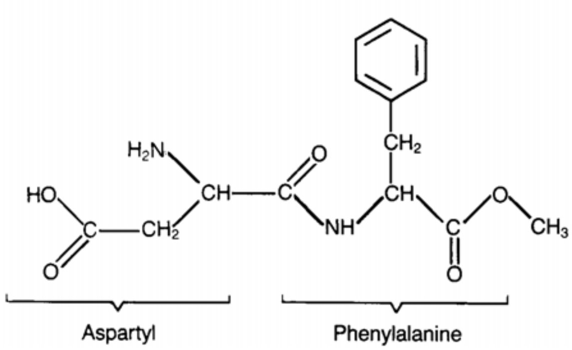

Figure 3: Aspartame

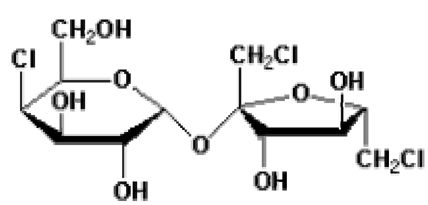

Figure 4: Sucralose

Table sugar is refined from sugarcane and sugar beets and is considered the standard when measuring the sweetness of compounds. Compared to sucrose, artificial sweeteners exhibit much more intense sweetness. Table 1 lists the relative sweetness of sucrose, aspartame, saccharin, and sucralose.

Table 1: Relative Sweetness

Sweetener	Relative Sweetness (by mass)
Sucrose	1
Aspartame	200
Saccharin	300
Sucralose	600

Purpose:
To identify the common food sweeteners sucrose (table sugar), saccharin (Sweet'N Low®), aspartame (Equal®), and sucralose (Splenda®) by comparing sweetness intensity rankings of solutions of each compound to known relative sweetness values.

Materials:

1. 4 Sweetener solutions (A, B, C, and D)
2. Cup of water
3. Saltine crackers
4. Napkin

Intensity Ranking:
Sample each of the four solutions from left to right. Rank, from least intense (1) to most intense (4), the sweetness of each solution.

Sample	Sweetness Intensity Rank	Comments
A	___________	____________________________
B	___________	____________________________
C	___________	____________________________
D	___________	____________________________

Post-Lab Questions:

1. Identify solutions A, B, C, and D as sucrose, saccharin, aspartame, or sucrose by comparing your sweetness intensity rankings to the relative sweetness values given in Table 1.
2. Other than sweetness intensity, what differences did you detect among the samples?

Discussion Questions:

1. List three characteristics of an ideal artificial sweetener. For each characteristic listed, explain its importance.
2. Aspartame is unstable to heat, and therefore cannot be used in cooking applications. Sucralose is stable at high temperatures. However, for baking applications, Splenda® is sold as a sucrose-sucralose blend. Identify two functions, other than sweetening, that sucrose might have in baked food products.
3. In the United States, all products containing aspartame, by law, must display a warning for individuals with phenylketonuria (PKU), a rare genetic disorder. How does aspartame affect individuals with PKU?