STUDENT ACTIVITY GUIDE

EFFECT OF HEAT & pH ON COLOR & TEXTURE OF GREEN VEGETABLES

*Taken from IFT Experiments in Food Science Series*

The *cell* is the basic structural unit of all plant tissues. These cells are surrounded by cell walls that provide an elastic support for retaining the contents of the cell. The cell also has a cell membrane layer, which is located just inside the cell wall and which controls the passage of liquids into and out of the cell. The cell is filled with a jelly-like substance, termed the *cytoplasm*, which is composed of protein, sugars, salts, and other substances dispersed in water. Mature cells also contain *vacuoles*, which are separate compartments filled with a fluid, cell sap, and are composed of dissolved sugars, salts, organic acids, pigments, and other materials. Also located within the cytoplasm are separate inclusion bodies, called *plastids*, which contain the pigment *chlorophyll*. These plastids are only about 4-10 nanometers (nm) in diameter.

Green vegetables contain the green pigment *chlorophyll*, which plays a key role in transferring light energy to chemical energy during the growth and development of the plant by the process of photosynthesis. Examples of such green vegetables include spinach, peas, beans, cabbage, lettuce and celery. The chemical structure of chlorophyll and the two chemically altered forms of importance to this experiment are shown below:

![Chemical structures of chlorophyll, chlorophyllin, and phytohemin](image.png)

**VEGETABLE PROCESSING**

It is necessary to process green vegetables to preserve them as a year-round food source. The most common commercial method of preservation is thermal processing, or canning. For this process, the vegetables are cleaned, trimmed, cut, packed into cans, sealed, and heated to sufficiently high temperatures (on the order of 240°F) to destroy microorganisms that cause spoilage and disease. However, such heat treatments also produce a number of undesirable chemical and textural changes in the vegetables. The textural changes are due to partial destruction of the cell wall and cell membrane. Heat treatments also cause chemical alteration of the chlorophyll, resulting in a processed vegetable with less green color.

It is important for the food processor to control the pH of the water added to the vegetables prior to canning. The degree of acidity or alkalinity of a solution is usually measured in terms of the pH scale. A neutral solution (which contains equal
concentrations of acid and alkali) has a pH value of 7, acidic solutions have pH values below 7, and alkaline solutions have pH values above 7. The lower the pH value, the stronger the acid concentration. The higher the pH value above 7, the stronger the alkali concentration. Most processes require that the pH be near neutral (about 6-7) to minimize the above adverse chemical reactions that cause loss of texture and color acceptability of the canned green vegetable.

MATERIALS REQUIRED

Fresh or frozen green beans, cut into 1-inch lengths
Dilute HCl solution (0.01N HCl)
Dilute NaOH solution (0.01N NaOH)
Distilled water or tap water
Bunsen burner
Timer or wall clock
250-mL beakers with watch glasses
100-mL graduated cylinders
Weighing balance
Twelve 15-cm-diameter filter paper discs
Stirring rods or magnetic stirrer
Heat-resistant gloves or tongs
Spatula or table fork
Litmus paper strips or pH-indicating paper
Marking pen

EXPERIMENTAL PROCEDURE

In this experiment, you will investigate the effect of heat and pH on the color and texture of green beans. The pH of the solutions will be adjusted to alkaline and acidic conditions, but the heating time and all other conditions will be held constant.

1. Label four beakers, cylinders, and filter paper discs as follows:
   0.01N HCl
   0.01N NaOH
   Heated control (distilled or tap water)
   Unheated control (distilled or tap water)

2. Weigh about 20 g of green beans into each of the four beakers.

3. Add 100 mL of the above solutions or water to the labeled beakers.

4. Cover the beakers with a watch glass. Stir occasionally with a glass rod or continuously with a magnetic stirrer at a slow speed.
5. Heat each of the beakers except the unheated control to maintain a slow boil (simmer) for exactly 15 minutes. **Do not heat the unheated control.**

6. Observe and record changes in the appearance of the beans and the solutions in each beaker during the heating treatment.

7. Allow the beakers to cool and then drain the solutions into their correspondingly labeled graduated cylinders. Drain the unheated control beaker into its graduated cylinder.

8. Pour the drained beans onto the correspondingly labeled filter paper discs.

9. Determine and record the pH of each cooking solution and the water in the unheated control in the table provided.

10. Observe and record the color characteristic and the color intensity for each drained solution.

11. Observe the changes in texture (firmness) of each of the green beans by crushing or cutting them with your spatula or table fork. Record these data also.

**QUESTIONS**

1. What is the temperature of water used for heating the beans in your experiment? How does this temperature compare with that used for commercial processing of vegetables.

2. Which of your solutions were near neutral? Acidic? Alkaline?

3. Which pH solution provided the best color and texture retention in the heated beans?

4. Which pH solution provided the poorest color retention in the heated beans?
5. What pigment is responsible for the observed changes in color of the cooked vegetables?

6. What reaction is responsible for loss of texture (firmness) in cooked green beans?

**DATA TABLE**

<table>
<thead>
<tr>
<th>Color and Texture</th>
<th>Color</th>
<th>Drained solution</th>
<th>Drained beans</th>
<th>Bean texture (0-10 Scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Characteristic color</td>
<td>Intensity (0-10 scale)</td>
<td>Characteristic color</td>
</tr>
<tr>
<td>Treatment</td>
<td>pH</td>
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<tr>
<td>Unheated control</td>
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<tr>
<td>Heated control</td>
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<tr>
<td>Acetic acid</td>
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<tr>
<td>Sodium bicarbonate</td>
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