Experiments in Food Science

Activity #3

Effect of Emulsifiers on Process Cheese

A Science Unit for Secondary School Curriculum

Institute of Food Technologists
The Society for Food Science and Technology
TEACHER ACTIVITY GUIDE

Effect of Emulsifiers on Process Cheese

Process cheese is a food made from selected Cheddar cheeses, although Swiss, Limburger, Brick, and other cheeses are sometimes used. Some types of process cheese were prepared as early as 1895, but production in the United States was introduced in 1916 by the Kraft Process, for which a patent was granted.

The manufacture of process cheese requires the use of emulsifying salts. These salts are not correctly named because they do not act as emulsifiers. Rather, their main function is to bind calcium (removing it from the cheese protein, casein) and to control pH (optimum pH range is 5.6–5.8). The most common emulsifying salts are trisodium citrate dihydrate and disodium phosphate dihydrate. The usual organic emulsifiers found in many manufactured food emulsions are not needed for process cheese because casein and casein peptides that are present in the natural cheese act as emulsifiers when they are not bound together by calcium. Upon calcium removal, these casein proteins and peptides are able to move to the oil–water interface and orient themselves so that the fat droplets are stabilized and do not coalesce. As long as the calcium remains bound to the casein in cheese, no emulsion can be formed. Emulsion formation requires heat and mixing to melt the fat, give energy for forming the emulsion, and help distribute the emulsifying salt, protein, and fat components of the cheese so that a smooth, homogeneous mixture is obtained.

PROCESS CHEESE

In making commercial process cheese, selected cheeses are evaluated for flavor, age, acidity, texture, and body. Most cheeses used will be 2–3 months old, but 10% will be 6–12 months old. The selected cheeses are then blended and combined with emulsifiers and heated with agitation to at least 150°F for 30 seconds (most processors cook cheese to 175°F for 2–3 minutes).

The liquid cheese is then either poured into molds for making process cheese loaves or thinly spread on cold, rotating drums for manufacturing process cheese slices. In the case of slices, the cheese is cooled very rapidly, and the process cheese ribbons are automatically sliced and wrapped. In the case of process cheese loaves, the cheese is packaged and cooled.

The amount of emulsifier added can vary from 0.5% to 3%. Process cheese is made commercially in large batches ranging from 250 to 500 kg each.

MATERIALS REQUIRED

Medium Cheddar cheese
Sodium phosphate dibasic (Na₂HPO₄)
Blender, or a cheese grater and bowl
Bunsen burner
Double boiler (or two beakers—one 500 mL, the other 250 mL)
Glass stirring rod
Thermometer
Cheese molds (paper hot cups or Popsicle molds)
Cork borer (or apple corer)
Knife
Cookie sheet
Oven
TEACHING TIPS

1. The experiment is simple, and the students are not likely to have problems. The instructor should pre-run the experiment because texture characteristics are quite dependent on the age of the cheese used. The experiment will not work if a very young (mild) Cheddar cheese or an aged (sharp) Cheddar cheese is used. It is recommended that a medium Cheddar cheese be used.

2. The easiest way to rig the beakers into a double-boiler arrangement is to set the large beaker over the Bunsen burner and use a stand and clamp to suspend the small beaker into the water in the large beaker. If a stand and clamp are not available, a length of wire wrapped around a small beaker just below the lip and hung over the edge of the large beaker will also work.

3. Providing that the same batch of cheese is used, the students should see differences at least between the extremes of the emulsifier additions. The control batch should show separation of the lipid (fat) and curd (solid) fractions. The optimum level of Na₂HPO₄ addition is about 2%.

4. Phosphates also affect the flavor and texture as perceived by the taste testers. It is recommended that the students not taste their product because of the lack of microbiological control and the possibility that the Na₂HPO₄ used is not of food quality.

5. Repeat the process with each of the four treated batches. Stir well during melting to make sure the sodium phosphate is well mixed into the batch. Also be sure to clean the cooking pan or beaker after each batch.

6. Remove each batch from the molds. Using the cork borer or apple corer, cut a cylindrical sample from the middle of each batch. Observe and record any differences in the appearance of the interior of the process cheese samples.

7. Trim each sample cylinder to about 2 cm high. Set the five samples on end on a cookie sheet and place them in a moderate oven (about 350°F). Examine them periodically (about every minute) and note the differences in melting.

STUDENT EXPERIMENTAL PROCEDURE

1. Your instructor will provide you with about 500 g of medium Cheddar cheese.

2. Cut the cheese into small pieces (about 1-cm cubes) and grind them in the blender at low speed. If you don't have a blender, grate the cheese into a bowl. Divide the ground or grated cheese into five batches of approximately 100 g each.

3. To four batches, add 0.5 g, 1 g, 2 g, and 4 g of sodium phosphate, respectively. This will make the percentage of sodium phosphate in each of the samples approximately 0.5%, 1%, 2%, and 4%, respectively.

4. Heat the untreated batch of cheese in the double boiler to 150°F. If you don't have a double boiler, ask your teacher to show you how to rig a double boiler arrangement with the beakers. Stir the samples with a glass stirring rod, not with a glass thermometer. When the batch is melted, pour it into a mold and set it aside to cool.

5. Repeat the process with each of the four treated batches. Stir well during melting to make sure the sodium phosphate is well mixed into the batch. Also be sure to clean the cooking pan or beaker after each batch.

6. Remove each batch from the molds. Using the cork borer or apple corer, cut a cylindrical sample from the middle of each batch. Observe and record any differences in the appearance of the interior of the process cheese samples.

7. Trim each sample cylinder to about 2 cm high. Set the five samples on end on a cookie sheet and place them in a moderate oven (about 350°F). Examine them periodically (about every minute) and note the differences in melting.

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characteristics—speed of melting and appearance after melting. The total time in the oven should be 10–15 minutes.

8. Note the texture and melting characteristics in the table provided.

**Caution:** Unless the sodium phosphate is of food quality, do not taste the process cheese samples.

**QUESTIONS & ANSWERS**

The answers to the following questions will vary depending on the age and texture of the cheese used.

1. What is the purpose of using sodium phosphate in process cheese?
   *Ans. The purpose of using disodium phosphate in process cheese is to chelate or bind the calcium so that casein can be released for emulsion formation. The* phosphate also *helps control pH in the final product.*

2. Which of the reheated cheeses melted quickest?
   *Ans. Batches prepared with low levels of Na$_2$HPO$_4$ will melt the most quickly.*

3. Which of the cheese samples melted with no curd showing? Which with the most?
   *Ans. The 4% and probably the 2% levels should melt without curd showing. The lower levels do not contain enough Na$_2$HPO$_4$ to completely emulsify the entire sample. The untreated (control) sample should show the most curd and fat separation.*

4. Which level of Na$_2$HPO$_4$ would be the best to use in making process cheese?
   *Ans. The batches containing 1% or 2% Na$_2$HPO$_4$ should have the best melting characteristics and are the ones used commercially. Since the maximum legal limit for emulsifiers is 3%, the 4% batch in this experiment would not be legal.*
## DATA TABLE

<table>
<thead>
<tr>
<th>Amount of sodium phosphate</th>
<th>During heating</th>
<th>After coring</th>
<th>During reheating</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (control sample)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5%</td>
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<td>1%</td>
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<td>2%</td>
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<tr>
<td>4%</td>
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</tbody>
</table>

### EXPERIMENTAL PROCEDURE

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2. Cut the cheese into small pieces (about 1 cm cubes) and grind cheese in the blender at low speed. If you do not have a blender, grate the cheese into a bowl. Divide the ground or grated cheese into four batches of approximately 125 g each.

3. To four batches, add 0.5 g, 1 g, 2 g, and 4 g of sodium phosphate, respectively. This will make...