## AUDIENCE

Middle School/ High School

## TIME FRAME

200 minutes (4 x 50 minutes periods)

## OBJECTIVES

After completing this module, students will be able to:

1. Explain the chemistry, including structure and properties, of the pectin molecule.
2. Describe the action's mechanism of the hydrolysis of pectin.
3. Define a colloid, emulsion and emulsifier.
4. Mention some common emulsifiers used in the food industry and cosmetics.
5. Internalize that pectin as an emulsifying agent can be added to two immiscible liquids to stabilize them to each other when mixed. Example: water and oil.
6. Identify pectin applications in the food, personal care, and pharmaceutical industries.
7. Understand the potential benefits of agricultural residues as a source of pectin.
8. Perform pectin extraction under the teacher's supervision.
9. Prepare an edible product using pectin as thickener.

## NEXT GENERATION SCIENCE STANDARDS

1. **Structure and Function- From Molecules to Organisms**
    a. **MS-LS1-1:** Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
    b. **MS-LS1-2:** Develop and use model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
    c. **HS-LS1-3:** Plan and conduct an investigation to provide evidence those feedback mechanisms maintain homeostasis.
2. **Ecosystems: Interactions, Energy, and Dynamics**
    a. **MS-LS2-1:** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
    b. **MS-LS2-3:** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
    c. **MS-LS2-5:** Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
    d. **HS-LS2-4:** Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
3. **Matter and its Interactions**

a. **MS-PS1-1:** Develop models to describe the atomic composition of simple molecules and extended structures.
b. **MS-PS1-2:** Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
c. **MS-PS1-4:** Develop a model that predicts and describes changes in particle motion, temperature, and state of pure substance when thermal energy is added or removed.
d. **MS-PS1-5:** Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

4. **Energy**
   a. **HS-PS3-3:** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
   b. **HS-PS3-4:** Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
5. **Earth and Human Activity**
   a. **MS-ESS3-4:** Construct an argument supported by evidence for how increases in human population and per- capita consumption of natural resources impact Earth's systems.
   b. **HS-ESS3-1:** Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
   c. **HS-ESS3-4:** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

## INTRODUCTION

Pectin is a polysaccharide (long chain of sugars bonded together) mainly composed of galacturonic acid (specifically 1-4 α-D-galacturonic acid) that is found in the cell wall and intercellular tissue of some fruits and vegetables (Gamma et al., 2004). It is extensively used in the food industry as a gelling agent, thickener, stabilizer emulsifier, and edible coating (Egbekun, et al., 1998). Also, pectin has been recently investigated for other applications in the medicinal and pharmaceutical field in the manufacturing of hygiene products such as shampoos and liquid soaps, and for acne treatment (Sandarani, 2017).

Pectins are classify according to their degree of methylation (DM) in two types: high methoxy pectin (DM>50) and low methoxy pectin (DM<50). High methoxy pectins can form gels in mediums with pH ranges from 2.0-3.5 under high concentrations of sugars (≥55% of total weight), while low methoxy pectins can form gels over a larger pH range (2.0- 6.0) in the

presence of a divalent ion such as calcium, with no need of high concentrations of sugars (Kliemann et al., 2009).

The extraction (or recovery) of pectin is a crucial phase in the food, medical and pharmaceutical industries (Sandarani, 2017). Pectin is extracted at high temperatures by hydrolysis (breakdown of a chemical compound when in contact with water) by various methods such as the conventional, microwave- assisted, ultrasonic and enzymatic, being conventional and microwave- assisted the most used (Kute et al., 2015). Both methods consist of two phases; pectin is hydrolyzed using acidic water and later precipitated using ethanol (Garna et al., 2004). However, using microwaves have shown potential in terms of saving time and energy (Kute et al., 2015) and can lead to a considerable increase in the yield and quality of extracted pectin (Routray, 2012).

**DAY 1:** Introduction to Pectin: Structure and Properties

**DEMONSTRATION:** Science of Canning: Pectin (YouTube Video)

*Methodology:*

The teacher will discuss what is pectin, its chemical structure, types, properties and uses.

*Assessment:*

Discussion questions will be included in the test.

**DAY 2:** Pectin Extraction

**EXPERIMENT:** Microwave- Assisted Pectin Extraction

*Materials:*

| | | | |
|---|---|---|---|
| 250mL Volumetric Flask with Screw Cap | Green Plantains | Centrifuge | Labels |
| 500mL Büchner Flask with Funnel | Knife | Blender | Sharpie |
| 100mL Graduated Cylinder | Acetic Acid | Oven/ Dehydrator | Lab Coat |
| 250mL Beaker | Isopropyl Alcohol | Microwave Oven | Lab Goggles |
| 5 x 50mL Centrifuge Tubes | Oven Mold | Stir Plate | Gloves |
| 250mL Storage Bottle with Cap | Magnet/ Stir | Scale | Lab Notebook |
| Scoopula | Small | Vacuum Pump | Pencil |
| Crucible | Polyethylene Bag | Filter Paper | |
| | pH meter | | |

*Methodology:*

Previous the day of the experiment:

1. Wash the plantains in running water for 3 minutes.
2. Using a knife, remove the plantains peel.
3. Cut the peel in little squares (~1in. x 1in.) and place it in an oven mold.
4. Set the oven at 150°F (65°C). Place the oven mold with the plantain peel pieces in it. Let it dry overnight (~12 hours). Remove from the oven an let it cool down for few minutes.
5. Using a blender, mill the dried plantains peels (do not leave it for too long) and store them in a re- sealable polyethylene bag.

On the day of the experiment:

1. Clean and dry the laboratory equipment you will need previous the experiment.
2. Using a pH meter, prepare an acidic solution (pH ~2.0) by slowly adding acetic acid into 150mL of distilled water. Make sure you mix the solution very well after each addition. Once the pH reading stabilizes, record it in your lab notebook. Label the solution with proper nomenclature.
3. Using a scale, weight 4.0g of dried plantain peel and place them in the 250mL Volumetric Flaks. Record the measurements in your lab notebook. Close the flask with the screw cap.
4. Using a 100mL Graduated Cylinder, measure 100mL of the acidic solution (pH ~2.0) and add it to the 250mL Volumetric Flask. Mix well with the dried plantain peel.
5. Set the microwave oven at 400 watts. Place the 250mL Volumetric Flask in it for 2 minutes without the screw cap. Remove the flask from the microwave oven.
6. Using a 500mL Büchner Flask with Funnel and Filter Paper, filter the content within the 250mL Volumetric Flask using a Vacuum Pump (Filtration method can be substituted by using a filter stand assembly, funnel and pantyhose).
7. Discard the plantain peel on top of the filter and measure the filtrate (liquid phase) using a 100mL Graduated Cylinder. Record the measurements in your lab notebook.
8. Transfer the filtrate into a 250mL Beaker. Using a ratio of 1:1, add Isopropyl Alcohol to the same 250mL Beaker. A flocculant particulate should start to come out of the solution.
9. Transfer and divide the mixture into 4 x 50mL Centrifuge Tubes and spin them down at 10,000 rpm x 5 minutes.
10. Discard the supernatant in the 250mL Beaker labeled as “waste” and transfer the pellet to a crucible.
11. Set the oven at 150°F (65°C) overnight (~12 hours). Remove it from the oven a let it cool down for few minutes.
12. Using a scale, weight the dried pectin and record the measurements in the lab notebook. Calculate the yield %.

13. Label and Store the dried pectin in a 50mL Centrifuge Tube.

*Assessment*

Students will be assessed by completing a laboratory report which will include the objective of the lab, a brief introduction, materials and procedure, and a brief conclusion. Discussion questions will be included in a test, similar to the pre and post test ones. I*n- process* data collection is crucial for the understanding of the process.

**DAY 3:** Sources of Pectin and its Applications in the Food Industry- Part I

**EXPERIMENT:** Low- fat Mayonnaise Using Pectin as a Fat Substitute

*Materials:*

- 1 x Fresh Egg
- 200mL Canola/ Vegetable Oil
- 1 pack Commercial Pectin Powder
- Calcium Solution
- Mustard
- White Vinegar
- Lemon Juice
- Sugar
- Salt
- Deep Bowl
- 2 x Storage Containers with Cap
- Hand Mixer
- Measuring Cup
- Measuring Spoons

*Methodology:*

1. Clean and dry the laboratory equipment you will need previous the experiment.
2. Prepare a calcium solution by mixing 1 teaspoon of calcium into 1 cup of distilled water. Mix well, label and store it in the refrigerator within a closed container.
3. In a deep bowl, mix 1 egg, ½ teaspoon of mustard, ¼ teaspoon of salt, ½ teaspoon of sugar, 4 teaspoons of vinegar and 1 teaspoons of lemon juice using a hand mixer for 30 seconds.
4. Very slowly, add 200mL of Canola/ Vegetable Oil to the mixture while mixing with the hand mixer. Do not stop mixing until you have added all the oil content.
5. Add 1 teaspoon of pectin powder to the mixture and ½ teaspoon of calcium solution. Continue mixing until the mixture thickens.
6. Transfer to a container with cap (preferable glass) and store it in the refrigerator for 8 hours prior consumption.

*Assessment:*

Students will complete a pre and post- test to have a better understanding of their knowledge on the topic before and after the activity. (See supplementary materials section)

Students will be assessed by completing a lab report which will include the objective of the lab, a brief introduction, materials and procedure, and a brief conclusion. Discussion questions will be included in a test, similar to the pre and post test ones.

**DAY 4:** Sources of Pectin and its Applications in the Food Industry- Part II

**EXPERIMENT:** Jam Making Using Pectin as a Gelling Agent

*Materials:*

- 1 x whole fruit
- 1 pack Commercial Pectin Powder
- Calcium Solution
- Sugar
- Distilled Water
- Cooking Pot
- Metal Spoon
- Metal Knife
- Measuring Spoon
- 1 x storage glass container
- Kitchen Glove
- Hot Plate

*Methodology:*

1. Clean and dry the laboratory equipment you will need previous the experiment.
2. Prepare a calcium solution by mixing 1 teaspoon of calcium into 1 cup of distilled water. Mix well, label and store it in the refrigerator within a closed container.
3. Plug in the hot plate and turn it on to the max temperature.
4. Add water to the cooking pot until the bottom is completely covered by water and place on the hot plate.
5. Using a knife, carefully cut the whole fruit in chunks and add them to the cooking pot.
6. Add 2 teaspoons of sugar into the cooking pot. Mix well and let it boil.
7. Add 2 teaspoons of pectin powder and 1 teaspoon of calcium solution into the mixture. Continue mixing until the mixture thickens.
8. Transfer the jam to a glass container with cap and store it in the refrigerator for 4 hours prior consumption.

*Assessment:*

Students will be assessed by completing a laboratory report which will include the objective of the lab, a brief introduction, materials and procedure, and a brief conclusion. Discussion questions will be included in a test, similar to the pre and post test ones.

## SUPPLEMENTARY MATERIALS

*Pre and Post Test:*

1. Explain the difference between a solution vs. emulsion and provide an example of each one of them.
2. Mention three common emulsifiers (thickness agent) and the industry they are used in.
3. Compare and contrast jelly, jam and preserve.
4. What emulsifiers are shown in mayonnaise and marmalade?
5. What type of chemical is pectin and where is it found?

## REFERENCES


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