Indiana Soy Sensation Facilitator Guide

Exploring science with soybeans!
# Table of Contents

- Smashing Soybeans ................................................................................. 3
- Separating Protein .............................................................................. 5
- Hydrolyzing Oil .................................................................................. 7
- Soy Plastic .......................................................................................... 8
- Soy Ice in a Bag .................................................................................. 10
- Swirling Science .................................................................................. 13
- Materials by Lesson Plan ..................................................................... 15
- Preparation Notes .............................................................................. 16
- Soy Processing Products and Uses ..................................................... 17
- Glossary of Terms .............................................................................. 18
- Indiana Science Standards ................................................................. 20
- References .......................................................................................... 21
- Donors and Acknowledgments ........................................................... 22
Objective:
Explore what is inside a soybean and understand that soybeans are an important source of both oil and protein.

Materials:
- ½ cup of soybeans
- ½ cup soy flakes soaked overnight
- 1 quart sealable bag
- 1 gallon sealable bag
- Newspaper
- Hammer
- Large glass jar
- Hot water
- Brown paper sack
- Mortar and pestle
- Plastic Cup

Safety Notes:
1. Remind youth to be careful when using a hammer.
2. Use hard surface, not wood floors or tile. (Will dent or crack floor.)
3. Make sure air is eliminated from bags as much as possible.

Procedure:
1. Place soybeans in the sealable bag, remove as much air as possible, and then enclose in another sealable bag.
2. Place bag between sheets of newspaper and insert into a brown paper bag.
3. Find a hard flat surface and use a hammer to break up all the soybeans.
4. Transfer contents of the sealable bag to mortar and pestle and grind.
5. Place pulverized beans into the plastic cup and cover with 3 inches of hot water (100-110 degrees).
6. Stir mixture for three minutes.
7. Examine mixture.
8. Compare the soybeans you crushed with the soy flakes that were soaked overnight.
Smashing Soybeans

What's going on?

When you crush, stir and soak the soybeans, you release the oil from the soybeans and the oil collects on the top of the mixture, because it is less dense than other substances. The soybean meal settles to the bottom of the container, while the middle layer is a solution of water and protein. Soybeans are an important source of both oil and protein. Most industrial soy products and soy foods require soaking, crushing, or both. Look at "Soy Processing Products and Uses" located on the page 16 for a diagram that explains how soybeans are processed and what the process produces.

Seeds for Thought....

1. What challenges did you have with smashing the soybeans with a hammer?
   Soybeans are hard and round; soy hulls are tough.

2. Describe the mixture you have created with the crushed soybeans and water.
   Mixture is a milky white with pieces of beans floating.

3. How is the mixture changing?
   Mixture begins to separate out into layers:
   Top—oil
   Middle—water and protein
   Bottom—soybean meal

4. What are the similarities and differences between the crushed soybeans and soaked soy flakes?
   The crushed soybeans still have the hulls which decreases the ability to extract the oil and milk. The soy flakes have been dehulled and flattened on a roller allowing the oil and milk to be released when hot water is added. The youth should see more separation of layers with the flakes vs. the soybeans they crushed.
Objective:
Experience what happens to the protein in soymilk when it is mixed with an acid.

Materials:
- 1/2 cup Soy Flakes soaked overnight in wide mouth jar.
- 1/2 tsp measuring spoon
- Vinegar
- Small clear tube with cap
- Pipette or eye dropper
- Microwave
- 1 1/2 cups tap water
- Measuring Cup

Safety Notes:
1. Make sure caps are on tubes before inverting to mix.

Procedure:
1. Soak 1/2 cup soy flakes overnight in a wide mouth jar of water (see Preparation Notes).
2. Insert pipette below the top layer of oil to extract protein/water solution from the jar of soybeans soaked overnight.
3. Place 1 tsp. of the protein/water solution into a clear plastic tube.
4. Add 1/2 tsp. of vinegar.
5. Cover with cap and invert to mix.
6. Let the mixture sit for about 10 minutes.

What’s going on?
Two layers form as a result of the acid in the vinegar denaturing (unraveling) the soy protein. When the protein is unraveled, it is no longer soluble. It precipitates out and settles in the bottom of the tube. Explore more about the Soybean Protein Process at www.soya.be.
Seeds for Thought....

1. What do you see happening in the tube?
   *Youth should note a white precipitate falling out of the mixture. This is the denatured soy protein. The protein becomes insoluble in the solution because vinegar is an acid and makes the soy flakes and water mixture more acidic (lowers the pH). Hydrogen ions in solutions with a lower pH have a greater tendency to interact with other components in the solution which allows measurement with a pH meter or litmus paper (acids will turn indicators red and bases will turn indicator paper blue).*

2. The addition of vinegar denatured the soy and water solution. How could an egg be denatured?
   *When eggs are cooked the transparent "egg white" denatures the proteins and turns them opaque. Heat is used to denature the protein in the egg like the vinegar did to the soy protein.*
Objective:
Identify the process that happens when soybean oil is mixed with a sodium hydroxide agent.

Materials:
- Soybean Oil
- Hot Water
- Liquid Drain Cleanser (Sodium Hydroxide, NaOH)
- Small capping plastic tube
- (2) 1/2 tsp measuring spoon (one specifically for NaOH)

Safety Notes:
1. Liquid drain cleaner is caustic. Use caution when working with this ingredient in the experiment.
2. To prevent cross contamination, once liquid drain cleaner is used, label the measuring spoon so it is used solely for liquid drain cleaner.

Procedure:
1. Pour ½ tsp soybean based oil into small test tube.
2. Heat ½ tsp tap water in microwave.
3. Add ½ tsp of hot water (approximately 110 degrees F).
4. Add ½ tsp of liquid drain cleanser.
5. Cap and invert to mix.

What's going on?
Soap foam will form. This indicates that the NaOH has hydrolyzed (broken-up) the fatty acids in the oil. This is the process that was used to make the first soaps from animal fat. Fatty acids can be washed away more easily after the bonds have been broken.

Seeds for Thought....
1. What do you notice happening in the test tube?
   *Foam is being created due to the sodium hydroxide breaking up the fatty acids in the oil.*

2. Explain how liquid drain cleaner works.
   *It breaks up the fatty acids in the oil so they can be washed down the drain and won't stick to (and plug up) the pipes.*
Objective:
Explore how soybeans can be made into biodegradable products.

Materials:
• Cornstarch
• Soybean Oil
• Sandwich-sized sealable bag
• Food coloring (liquid)
• Microwave
• Water
• Pipette or eye dropper
• Tablespoon measuring spoon

Safety Notes:
1. Caution! The bags and plastic will be HOT after time in microwave.
2. The mixture must be thoroughly mixed or plastic will be chalky.

Procedure:
1. Place 1 Tbs of cornstarch into the plastic bag.
2. Add 2 drops of soybean oil.
3. Add 1 Tbs of water.
4. Close bag and knead it, mixing the contents.
5. Add two drops of food coloring.
6. Seal bag leaving a corner of the bag open to vent the contents.
8. CAUTION: Bag will be hot!
9. Remove the cornstarch and oil mixture and see what shapes you can form.

What’s going on?
The chemistry is that the starch in the cornstarch is binding with the soybean oil, when exposed to heat which forms the plastic. This is considered a bioplastic because it is produced from a biological source.
Seeds for Thought...

1. What products could be made from biodegradable soy plastic?
   Let them use their imaginations...Refer to the chart on page 16 for other items soybeans can aid in producing.

2. Explore Henry Ford's Plastic Car and his contribution to the soybean industry.
   Henry Ford is known for his automobile, but did you know that he once made a car with all the plastic made from soybeans - even the automobile’s exterior? Mr. Ford owned a large research facility. He came to the lab one day with a huge bag of soybeans. He dumped them out on the floor and told the scientists, "You guys are supposed to be smart. You ought to be able to do something with them." In time, the scientists in Ford’s labs made a strong enough plastic for the gearshift knobs, horn buttons, window frames, accelerator pedals, light-switch assemblies and ignition-coil casings. They also fashioned the exterior of an automobile from "soybean plastic." By 1935 Mr. Ford was using one bushel of beans for every car he manufactured. (60 pounds = 1 bushel)

3. This is chemistry at work. How do you think the plastic was formed?
   The starch in the cornstarch binds to the oil when the cornstarch and oil mixture is heated.
Objective:
Explore how a liquid changes to a solid and why.

Materials:
- Soy milk vanilla
- Soy milk chocolate
- Cow's milk (at least 2%)
- Vanilla flavoring
- Sugar
- Ice
- Ice Cream Salt
- Quart size sealable bags
- Gallon size sealable freezer bag
- A hand towel or gloves
- 1/2 cup measuring cup
- 1/2 tsp measuring spoon
- 1 Tbs measuring spoon
- Soy Ice Worksheet (page 12 or page 9 in Student Guide)

Safety Notes:
1. Due to the extreme low temperature of this experiment, use a towel or gloves when shaking the mixture.

Procedure:
1. Mix 1/2 cup soy milk, 1/2 tsp vanilla and 1 Tbs sugar together in a quart size bag. For Chocolate batch, do not use vanilla.
2. Seal the bag tightly, allowing as little air to remain in the bag as possible.
3. Place this bag inside another quart size bag, again leaving as little air inside as possible and sealing well.
4. Put the two bags inside the gallon size bag and fill the large bag with ice. Sprinkle ice cream salt on top. Again, let all the air escape and seal the bag.
5. Wrap the bag in the towel or put gloves on, and shake the bag, making sure the ice surrounds the cream mixture.
6. Shake mixture until frozen.
7. Repeat steps 1-5 with cow's milk and chocolate soy milk. Do not add vanilla to chocolate soy milk batch.
8. Record minutes needed to freeze each type of ice cream.
9. Taste and record information on Soy Ice Worksheet.
**What’s going on?**

**The structure of ice cream - emulsions and foams**

An emulsion is defined as liquid droplets dispersed in another immiscible liquid. A foam is defined as a gas dispersed in a liquid where the gas bubbles are the discrete phase. A foam is likewise unstable and needs a stabilizing agent to form the gas bubble membrane. Ice cream as a solution is both an emulsion and a foam. Also adding structure to the ice cream is the formation of the ice crystals. Water freezes out of a solution in its pure form as ice. In a sugar solution such as ice cream, the initial freezing point of the solution is lower than 32 degrees F due to these dissolved sugars. As ice crystallization begins and water freezes out in its pure form, the concentration of the remaining solution of sugar is increased due to water removal; hence, the freezing point is further lowered. This process, known as freeze concentration, continues to very low temperatures. Thus the structure of ice cream can be described as a partly frozen foam with ice crystals and air bubbles occupying a majority of the space. The tiny fat globules, some of them flocculated and surrounding the air bubbles also form a dispersed phase. Proteins and emulsifiers are in turn surrounding the fat globules.

**What does the salt do?**

Just like we use salt on icy roads in the winter, salt mixed with ice in this case also causes the ice to melt. When salt comes into contact with ice, the freezing point of the ice is lowered. By lowering the temperature at which ice is frozen, we are able to create an environment in which the milk mixture can freeze at a temperature below 32 degrees F into ice cream.

**Seeds for Thought...**

1. Explore time, taste, and texture.
   *These will vary by group... discuss Soy Ice Worksheet.*
2. What other soy products could we eat?
   *Look at www.soystats.com for edible uses of soybeans.*
3. What ways could we alter this experiment?
   *Let the youth discuss options.*
Use the following tables to record information about the Time, Texture, and Taste of each type of Ice Milk being made. Then draw a conclusion based on your experience making Ice Milk from both Soy Milk and Cow’s Milk.

<table>
<thead>
<tr>
<th></th>
<th>Vanilla Soy Milk</th>
<th>Chocolate Soy Milk</th>
<th>Cow’s Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taste</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Objective: 
Explore what happens when surfactants are added to soy milk and explore why surfactants are important.

Materials: 
- 2 disposable plates
- Soy Milk
- Food Coloring (liquid)
- Liquid Dish Soap
- 2 Cotton Swab (Q-tip)
- Lecithin

Safety Notes: 
1. For easier clean up, bring a trash can around to each group and have them slide the plates off into the trash, because the soymilk spills easily off the plate.

Procedure: 
1. Cover the bottom of each plate with soy milk.
2. Place 3 drops of food coloring in the soy milk, in a triangle pattern.
3. Draw a picture of the plate, milk, and food coloring now in the left hand observation boxes below.
4. Predict what will happen when you touch the milk with a Q-tip dipped in soap and lecithin.
5. Write your prediction here:
6. Dip a cotton swab into the soap and then touch the milk in the first plate.
7. Dip a cotton swab into the lecithin and then touch the milk in the second plate.
8. Draw pictures in the boxes provide of what you see happening when the soap and lecithin are added to milk and food coloring. (see next page for results.)
After seeing the results how accurate were your predictions? Describe the difference between your prediction and the results.

*Discuss the differences that were experienced. There will be a variety of difference.*

**What’s going on?**

When the soap is added to the milk, the color will swirl because the water molecules in the milk are separating. Surfactants are used when fats and oils need to be mixed with water and other ingredients. A soybean by-product that is a surfactant is Lecithin. Examine the Soybean Processing, Products and Uses on page 17 to explore where lecithin is produced and used in the Soybean process. Lecithin is found on ingredient labels of chocolate candy because it keeps the candy smooth and creamy. A Surfactant is a wetting agent that will break the surface tension and cohesiveness of water.

**Seeds for Thought….**

1. What happens when the soap and lecithin are added to the milk and food coloring?
   *The color begins to swirl and will re-swirl after the mixture relaxes.*

2. Why does this happen?
   *The water molecules in the milk are separating.*
Materials by Lesson Plan

Smashing Soybeans
- 1/2 cup of Soybeans
- 1/2 cup Soy flakes soaked overnight
- 1 quart sealable bag
- 1 gallon sealable bag
- Newspaper
- Hammer
- Large glass jar
- Hot water
- Brown paper sack
- Mortar and pestle
- Plastic Cups

Separating Protein
- Protein/water solution from the soaked soy flakes (1/2 cup)
- Vinegar
- Small clear tube with cap
- Pipette or eye dropper
- 1/2 tsp measuring spoon
- Microwave
- Wide mouth jar
- 1 1/2 cups tap water
- Measuring cup

Hydrolyzing Oil
- Soybean Oil
- Hot Water
- Liquid Drain Cleanser
- Small capping plastic tube
- (2) 1/2 tsp measuring spoons (one to be used only for NaOH)

Soy Plastic
- Cornstarch
- Soybean Oil
- Sandwich-size sealable bag
- Food coloring (liquid)
- Microwave
- Water
- 1 Tbs measuring spoon
- Pipette or Eye dropper

Soy Ice in a Bag
- Soy milk vanilla
- Soy milk chocolate
- Cow’s milk (at least 2%)
- Vanilla flavoring
- Sugar
- Ice
- Ice Cream Salt
- 6 quart size sealable bags
- 3 gallon size sealable freezer bag
- A hand towel or gloves
- 1/2 cup measuring cup
- 1/2 tsp measuring spoon
- 1 Tbs measuring spoon
- Soy Ice Worksheet

Swirling Science
- 1 disposable plate
- Soy Milk
- Food Coloring (liquid)
- Liquid Dish Soap
- Cotton swab (Q-tip)
Preparation Notes

The activities listed below will need either preparation or additional supplies not provided in the Soy Sensation Kit.

**Smashing Soybeans**
- Identify hot water source
- 1 hammer per group
- Brown paper bag

**Separating Protein**
- Prepare soaked soybean flakes the night before the experiment.
  Place 1/2 cup of Soy Flakes in wide mouth jar. Microwave 1 1/2 cups of water on high for 2 minutes. Pour water on top of soy flakes, cap and rapidly mix for 3 minutes. Let stand overnight to get layer separation. Be careful not to tip jar or layers will re-mix.
  - Wide mouth jar
  - Make sure microwave oven is available.

**Soy Plastic**
- Identify water source.
- Make sure microwave oven is available.

**Soy Ice in a Bag**
- Ice
- *Cow's Milk* (at least 2%; whole milk is better)
- Towels or Oven mitts for each group

**Swirling Science**
- 1 disposable plate per group
- Liquid Dish Soap
- 1 cotton swab per group
- Lecithin (available at health food stores)

More of the following items will make working in the classroom easier, because limited supplies were included in kit.
- Measuring Cups
- Mortar and Pestle
- Measuring Spoons
- Food Coloring
Soybean Processing, Products, and Uses
Acid—Any of various water-soluble compounds having a sour taste and capable of turning litmus red and reacting with a base to form a salt.

Base—Any of various water-soluble compounds capable of turning litmus blue and reacting with an acid to form a salt and water; bases include oxides and hydroxides of metals and ammonia.

Biodegradable—Capable of being decomposed by e.g. bacteria; a biodegradable detergent.

Biological—Pertaining to biology or to life and living things.

Bioplastic—Plastic produced from a biological source.

Caustic—of a substance, especially a strong acid; capable of destroying or eating away by chemical action.

Cohesiveness—The property of being cohesive and sticky.

Denature—modify the tertiary structure of (a protein or nucleic acid) so as to reduce or destroy its characteristic biological activity.

Dispersed phase—(of colloids) a substance in the colloidal state.

Emulsifier—A surface-active agent that promotes the formation of an emulsion.

Emulsion—An essentially permanent suspension of one fluid within another immiscible one.

Flocculated—Cause to become a fluffy or lumpy aggregate.

Foam—A mass of small bubbles formed in or on a liquid.

Hydrolyzed—A chemical process in which a molecule is cleaved into two parts by the addition of a molecule of water.

Immiscible—Incapable of mixing.

Insoluble—Incapable of being dissolved in a particular liquid.
Lecithin—A yellow phospholipid essential for the metabolism of fats; found in egg yolk and in many plant and animal cells; used commercially as an emulsifier.

Metabolism—The organic processes (in a cell or organism) that are necessary for life.

pH—p(otential of) H(ydrogen); the logarithm of the reciprocal of hydrogen-ion concentration in gram atoms per liter; provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (where 7 is neutral and greater than 7 is acidic and less than 7 is basic).

Phospholipids—any of various compounds composed of fatty acids and phosphoric acid and a nitrogenous base; an important constituent of membranes.

Precipitate—An insoluble substance separated from a solution in a concrete state by the action of some reagent added to the solution, or of some force.

Protein—any of a large group of nitrogenous organic compounds that are essential constituents of living cells; consist of polymers of amino acids; essential in the diet of animals for growth and for repair of tissues; can be obtained from meat and eggs and milk and legumes.

Sodium Hydroxide—A strongly alkaline caustic used in manufacturing soap, paper, aluminum and various sodium compounds.

Solution—Mixture of two or more substances, constituting a phase in which the composition can vary within wide limits.

Soybean—A leguminous plant, Glycine max, originally of SE Asia, cultivated for its seeds, which are used as replacement for animal protein in certain foods, and as flour, oil, tofu, soy sauce, etc.

Stabilizing Agent—a chemical which tends to inhibit the reaction between two or more other chemicals.

Surfactant—A substance that, when added to a liquid, affects the physical properties of the liquid surface, e.g. increasing its wetting properties or assisting the formulation of emulsified liquids.

Surface tension—A phenomenon peculiar to the surface of liquids, in which the surface molecules seem to have a greater cohesion for one another than do the molecules in the body of the liquid, so that surface acts like a stretched elastic film.
Indiana Science Standards

The following standards are the science standards that are met by this curriculum per grade level. A review of Indiana Science Standards maybe required if individual lessons are used. The Indiana Science Standards maybe found at http://www.indianastandards.org. Select subject area and search by grade. Work with classroom teacher to explore other subject area standards that this curriculum meets.

**Kindergarten**
K.1, K.2

**First Grade**
1.1, 1.2, 1.5

**Second Grade**
2.1, 2.4, 2.5

**Third Grade**
3.1, 3.2, 3.5

**Fourth Grade**
4.1, 4.2, 4.5

**Fifth Grade**
5.1, 5.2, 5.5

**Sixth Grade**
6.1, 6.2, 6.3, 6.5

**Seventh Grade**
7.1, 7.2, 7.5

There are Indiana Science Standards that this curriculum will meet for grades 8th through 12th, however, more scientific processes and procedures will need to be added to the current concepts. Science teachers in these grades will be able to help enhance curriculum to fit Indiana Science Standards.
We gratefully acknowledge the contributions of the following programs and materials that were utilized to adapt ideas and concepts that aided in the development of Indiana 4-H Soy Sensation.

*Color Swirls, Soybeans are Everywhere, Ohio Soybean Council, Worthington, Ohio, 2007.*


*Hydrolyzing Oil, Cool Beans...It’s SOYence, Ohio Soybean Council, Worthington, Ohio, 1997.*

*Plant Plastic, Operation Thistle: Seeds of Despair, Junior Master Gardener, College Station, Texas.*

*Separating Proteins, Cool Beans...It’s SOYence, Ohio Soybean Council, Worthington, Ohio, 1997.*

*Smashing Soybeans, Cool Beans...It’s SOYence, Ohio Soybean Council, Worthington, Ohio, 1997.*
This program was made possible by:

ADM Soy Processing
2191 W. Co. Rd. 0 NS
Frankfort, IN 46041
(765)-654-4411

ADM Grain Company
2906 S. 930 W.
Frankfort, IN 46041
(765)-523-3286

Lesson Plans Compiled by:
Stephanie DeCamp
Clinton County 4-H Youth Development Educator
Purdue Extension Service
Drs. Brady, Carroll, McKee, and Orvis
Dept. of Youth Development and Ag Education

It is the policy of the Purdue University Cooperative Extension Service that all persons have equal opportunity and access to its educational programs, services, activities, and facilities without regard to race, religion, color, sex, age, national origin or ancestry, marital status, parental status, sexual orientation, disability or status as a veteran. Purdue University is an Affirmative Action institution.

This material may be available in alternative formats.