



# Lesson 1

## Sorbet

### Mathematics/Chemistry

#### Lesson

Possible topics include unit conversions, addition/subtraction, multiplication/division, proportions, density, concentration, refractive properties of light

**Time:** 1 or 2 45 min class periods (processing own coconuts will require and additional class period to prep coconut milk)

#### Overview

This curriculum is adaptable over a wide range of math and chemistry skill levels. Examples of learning objectives include conversions from the English systems of measurement to the metric system of measurement, utilizing multiplication, division, fractions, and decimals. Students can also use multiplication and division to determine serving size for each student and yield per coconut of coconut sorbet. If a chemistry lesson is desired, students can calculate the density of an egg and perform the egg test to approximate the percentage of sugar in a given solution. Likewise a refractometer may be used, if available, to determine the exact sugar concentration (Brix). For instance 18 Brix is equivalent to 18 g sugar/100 g. Teachers can engage the students in a discussion of concentration and how this

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term can be explained in terms of moles/liter of dissolved sugar, a situation that involves the use of Avogadro's number ( $6.23 \times 10^{23}$ ) and scientific notation.

Avogadro's number is  $6.022 \times 10^{23}$  and is referred to as 1 mole. The atomic weight of each chemical element is the amount of grams per mole and this number is in the upper right hand corner for each element on the periodic table. For example Carbon is 12, Hydrogen 1, and Oxygen 16. The molecular weight of a molecule is equal to the sum of the atomic weights. Students can then calculate the molecular weight of sucrose ( $C_{12}H_{22}O_{11}$ ), a disaccharide composed of glucose ( $C_6H_{12}O_6$ ) and fructose ( $C_6H_{12}O_6$ ), which are monosaccharides. Most importantly engage the students and have fun!

### HCPS III Mathematics Benchmarks Addressed:

MA.7.3.1 Multiplication and division  
MA.7.1.1 Solve problems using fractions, decimals, and percents  
MA.7.1.2 Identify situations with large numbers that require scientific notation  
MA.7.3.2 Determine the reasonableness of a solution by comparing the answer to an estimate



## NSES standards addressed

Abilities of technological design  
Understandings about science and technology  
Science and technology in society  
Nature of science  
Science as human endeavor  
Motions and Forces

## Background

Do you know what the difference between a sorbet and an ice cream is? Like ice cream, a sorbet is a frozen dessert that is sweet, however unlike ice cream, sorbets do not contain dairy products. You can make a sorbet out of literally any flavor from the garden, however some fruits require more added sugar than others to achieve proper crystal formation, that in turn affects the smoothness of the texture of the sorbet. In order to formulate a smooth sorbet food scientists use a refractometer to measure the sugar concentration with a unit of measure called Brix. One degree Brix is equal to 1 gram of sucrose (sugar) per 100 grams of solution. This represents the strength of the solution as a percentage by mass. In comparison pastry chefs have long used a method called the egg test in making desserts, which can also approximate sugar concentration by density. This lab will help you to formulate a sorbet out of nearly any flavor you can think of, but sugar concentration is important to keep in mind as this can even vary between the same fruit depending on seasonality and ripeness. If the Brix reading (sugar concentration) of the sorbet mix is lower

than 18 the mixture will probably freeze with large ice crystals. If the Brix reading is higher than 20, the mixture may not freeze well or at all.

## Materials

### 1-1/2-Quart hand crank Ice Cream Maker

(any automatic will work but the hand crank may be used in and around your garden, perhaps under your coconut tree even if you do not have an alternative source of power near the garden. Previously frozen inserts work in just 15 minutes, and you do not need to stir continuously, only every 2 minutes to prevent larger ice crystal formation.)

### Fresh fruit:

1 medium aged coconut for every 4 kids, picked fresh or  
6 mangoes for each 4cups  
desired sorbet or  
Ripe apple bananas and/or  
any additional fruit, vegetable,  
spice or herb desired to add to  
these base flavors

Simple syrup and/or corn syrup (1 part sugar, 2 parts water, simmered until the volume is halved) Approximately ¼ cup will be needed for each 2 cups of fruit puree, however some fruit may not require any added sugar ex: bananas and super sweet mangos

Blender (If using apple bananas, mangoes, or young coconuts with spoon meat). Coconut ‘Spoon meat’ is softer and more jelly-like than a mature coconut, and can be scooped out with a spoon



Access to a freezer in advance (so ice cream maker insert is frozen to begin with)  
Serving bowls (may use coconut halves)  
Spoons (may use slices of coconut husks)

Refractometer available at:

<http://www.agriculturesolutions.com/Refractometers/-/Brix-Meters/View-all-products.html>

[http://www.amazon.com/s/ref=nb\\_sb\\_noss?url=search-alias%3Daps&field-keywords=refractometer](http://www.amazon.com/s/ref=nb_sb_noss?url=search-alias%3Daps&field-keywords=refractometer)



2 types of traditional coconut graters, with wooden seat



2 bowls, one to collect water and one to collect meat

\*Option – may substitute canned coconut milk, use regular not light

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\*If processing medium aged to mature coconuts will also need:  
Pick axe, maddock, or o’o bar (for demo, recommended that coconuts are dehusked ahead of time)  
Cheesecloth /strainer (may use a’ a’ a- the cheesecloth like fiber around young coconuts- if washed and cleaned)

Additional options:

Want less sugar? Add ¼ cup fresh poi (from taro) or soft-ripe breadfruit to the coconut milk. Add sugar to only a 16 Brix reading. Add to ice cream maker. How does the texture compare? Don’t have an ice cream maker? Take your sorbet mix and freeze in ice pop molds for a frozen treat.



mango sorbet – ready in 20 minutes

## Step 1

### Directions for Coconut sorbet

As a demo one coconut can be dehusked using the pick end of a maddock, pick axe, or o’o bar and peeled open. This can most easily be done by piercing through each of the three edges closer to the pointed end of the coconut and then peeling off the husk. (Note: peeling of the husk is requires some strength. Alternatively see youtube video for opening coconuts “Hawaiian style”

<http://www.youtube.com/watch?v=FEuhUb4Y1WE>).

Next poke holes in the “mouth” (large hole) of the coconut and turn upside down over a bowl or container to capture the liquid and then crack open the nut. You can easily split the nut in two halves by finding the “nose” (ridge) which runs between the two eyes Now find the middle and hit with a rock. This Sloss, Watters, School Garden Curriculum

is the softest part of the coconut and can be opened in two neat halves in one strike with a little practice.

Each pair of students should then have one half of a coconut with the meat still intact with the shell. Each student should grate his/her own coconut half using a coconut grater (traditionally opihi shells were used to scrape away the coconut meat) over a container. When all of the meat is collected in a single bowl, the meat should then be placed inside of a cheesecloth (traditionally the a’ a’ around the coconut palm was used) and squeezed over the bowl with all of the coconut water. The cheesecloth may be dipped in the liquid to help with the extraction of the coconut cream. Note this will work best when the cheesecloth is not overloaded with grated coconut and help to extract more of the liquid from the meat.

When the liquid has been extracted from the meat remove the grated coconut and cheesecloth and reserve for later use. You now will have a bowl of coconut milk and you may want to let the students have a taste and see what they think. How does this compare to coconut milk from a can? Measure the volume of coconut milk; this is your fruit base mix. Take an initial Brix reading on the refractometer and record your results. Alternatively or in conjunction, float a cleaned, fresh, raw egg in the coconut milk. Did it sink? Float? Or just right with a nickel sized portion exposed through the surface of the liquid? Add sugar solution accordingly.



Option: For young coconuts with spoon meat, simply add meat and juice into a highspeed blender. Add sweetener accordingly.

## Directions for Sorbet from any other flavor

To make a fruit base mix from another fruit, simply puree the prepared edible portion. Take an initial Brix reading and/or perform the egg test. Note: if you are using ripe bananas you will not need to add sugar. This may be true for ripe mangoes in season as well, take a Brix reading to find out.

### Step 2 Adding sweeteners

A chilled simple syrup solution (1 part sugar, 2 parts water, simmered until half the volume of water is remaining) should be added to the coconut milk along with any extra ingredients or flavors desired ex: fruit puree, vanilla beans, cocoa powder, etc. (Note: corn syrup, coconut nectar, or agave nectar may be used to replace the simple syrup solution). With an initial Brix reading of about 4.5, 2 cups of coconut milk will require about ¼ cup of simple syrup or combination of the above sweeteners to achieve an 18-20 Brix reading. However, add the sugar in increments and either take the Brix reading or perform the egg test each time until you achieve the right sugar concentration.

**If 1 cup of your simple syrup solution contains 200g sugar, how much do you need to add to achieve an 18 Brix**

**reading?** Remember a Brix of 18 is 18g sugar/100g solution. Assume a density of 1 g/ml. Measure the Brix of your fruit base and record your results. Add less simple syrup than you think you need to achieve a Brix of 18. Test the Brix again. Add until you have reached a reading of 18-20 on the Brix scale. Record the final reading and the amount of sweetener added. You should be able to do this from the nutrition facts label. If you made simple syrup, there are 200g of sugar in one cup. When either the egg passes the float test or the Brix reading is an 18-20 your mix is ready to prepare into a sorbet.

### Step 3 Add to the Ice cream maker

Remove your pre-frozen sorbet insert from the freezer and add your sorbet mix. Proceed according to the manufactures instructions for making ice cream. This should take about 15 minutes to make. A hand crank ice cream maker with pre-frozen insert can be used to make sorbet in the garden with out electricity.



Egg test with nickel sized portion exposed at the top. This coconut-poi mix is ready for the ice cream maker!



Name \_\_\_\_\_

Date \_\_\_\_\_

### Sorbet Observation Log

Fruit type	Mass fruit base mix (g)	Initial Brix reading	G sugar/100g sweetener (obtain from nutrient label)	Sweetener added (g)	Final Brix reading

### Egg test

What is the mass of the egg (g)?

What is the volume of the egg (ml)?

What is the density of the egg (g/ml)?

Did the egg float or sink?

How much sugar (g) did you add for the egg to float?

What was the Brix reading when the egg floated?

Is your egg fresh?

Scientists devised a system to measure the mass that uses a very large number of an element so that we may work in a reasonable unit, ie grams. This very large number is known as avogadros number and is  $6.022 \times 10^{23}$  and is referred to as 1 mole. This is the number in the upper right hand corner for each element on the periodic table and referred to as the molecular weight. Often we use approximations, for example Carbon would be 12, Hydrogen 1, and Oxygen 16.



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Calculate the molecular weight of one mole ( $6.022 \times 10^{23}$  molecules) of Sucrose ( $C_{12}H_{22}O_{11}$ ) using the above approximations. Show your work.

How many moles is in one gram of sucrose?

How many grams of sugar are in 2 cups (app 454 grams) of a 4.5 Brix solution?

If you wanted an 18 Brix solution, how many grams of sugar would you need to add to the solution? (Hint: and 18 Brix solution has 18g sugar/100g solution)

How was the consistency of your sorbet?

How did it taste?