A Grain of Salt

Figure out just how much salt is in your food

Lesson Plan

Description: Visitors test liquids for salt content using a titration technique. They then test food samples to see how much salt they contain.

Audience: Hands-on activity for families and children ages 8 and up

Length: 30 minutes

Learning Objectives

Visitors learn:

- Many processed foods contain a lot of salt.
- The maximum salt recommended for daily consumption is no more than 2400 mg/day.

Visitors develop skills related to chemistry and science, including:

- Using titration
- Analyzing data
- Communicating and discussing experiment results

Learning Standards

National Science Education Standards

1. Science as Inquiry
   - K-4: Abilities necessary to do scientific inquiry
   - K-4: Understanding about scientific inquiry
   - 5-8: Abilities necessary to do scientific inquiry
   - 5-8: Understanding about scientific inquiry
   - 9-12: Abilities necessary to do scientific inquiry
   - 9-12: Understanding about scientific inquiry

2. Physical Science
   - K-4: Properties of objects and materials
   - 5-8: Properties and changes of properties in matter
   - 9-12: Structure and properties of matter
   - 9-12: Chemical reactions

6. Personal and Social Perspectives
   - K-4: Personal health
   - 5-8: Personal health
   - 9-12: Personal and community health

Background Information

Salt is essential for good health, but too much salt can be harmful. Studies show that people who eat too much salt in their diet have higher chances of developing heart disease. The Food and Drug Administration recommends consuming no more than **2400 mg** of salt per day.

Processed and prepared foods are often very high in salt. People who eat a lot of these foods may be eating much more salt than they realize. This activity helps make visitors aware of how much salt is in common foods, including many family favorites such as canned soup. (Although the amount of salt in processed foods appears on the nutrition label, determining it themselves often makes people aware of salt content and reinforces its importance.)

The salt we eat is a compound made up of one atom of the element sodium (Na) and one atom of the element chlorine (Cl). Its chemical name is *sodium chloride.*

To determine the exact amount of salt in a mixture, chemists find that it is easier to measure the amount of chlorine in the mixture. Because there is one chlorine atom for every salt molecule, if you determine the amount of chlorine, you know the amount salt present. The amount of salt in food is usually measured as milligrams (10^{-3} grams) per serving.

One way to determine the amount of chlorine in a solution takes advantage of the fact that silver nitrate reacts on a one-to-one basis with chlorine ions to form a white solid called a *precipitate*.

Silver nitrate + Sodium chloride → Silver chloride + Sodium nitrate
in solution *in solution* *a white solid* *in solution*

If you add silver nitrate to a solution one drop at a time, the silver will react with the chloride until the chloride is used up. After this point, adding more silver nitrate just adds silver to the solution. To tell when this happens, we add an *indicator* that detects excess silver in solution and changes color to indicate the presence of the silver.

Silver nitrate + Potassium chromate → Silver chromate + Potassium nitrate
in solution *in solution* *a red solid* *in solution*

In this activity, visitors follow a procedure called *titration*. They use a sodium chromate indicator, which turns red in the presence of excess silver. The appearance of the red color signals that all the chlorine has been used up (because it has reacted with the silver). This is called the *endpoint* of the titration.

Analytical chemists almost always do titrations several times (called *replications*), to be sure that they were done correctly. If the results do not agree, it suggests that there may have been a mistake in one of the titrations or that the method may not be reliable. By comparing results with the group we will achieve replication.

EXPECTED RESULTS

Each drop of silver nitrate used in the titration represents approximately 110 mg of sodium per cup. For example, if we use 5 drops of silver nitrate when titrating a soup, this means that there are about 550 mg of sodium per cup of that soup. See the last page for the graphical representation that museum visitors will use when doing the activity.

Materials

For each pair of visitors

- 24-well well plate
- Set of chemicals in labeled dropping bottles:
    - 0.2 M (moles/Liter) silver nitrate solution (filled halfway and taped shut)
    - 0.2 M (moles/Liter) potassium chromate indicator solution (filled halfway and taped shut)
    - Distilled water (0 mg salt solution)
    - 2 g of salt dissolved in 225 ml of water
    - Miso soup mix dissolved in directed amount of hot water; be sure to strain before placing in bottle.
    - Chicken noodle soup mix dissolved in directed amount of hot water; be sure to strain before placing in bottle.
    - Light-colored sports drink
    - Pickle juice
    - Chicken-flavored bouillon cube dissolved in water (follow preparation instructions)
    - Macaroni & cheese powder dissolved in water (for a standard box, substitute 1/4 cup of water for the milk)
    - Optional: other food samples to test
- Sheet of white paper
- Toothpicks (to use as stirrers)
- Results sheet
- Pen or pencil
- Laminated graph (found on last page)
- Safety glasses
- Gloves

For the presenter

- 6 g table salt placed in a baggie (representing RDA of 2400 mg of sodium)
- One set of visitors' supplies
- Paper towels
- Tray (to use when disposing of chemicals)

Notes to the Presenter

All solutions should be in labeled dropping bottles. Dropping bottles eliminate cross contamination, spills, and excessive use of reagents.

Silver nitrate will turn black or brown when exposed to air. It will stain skin and clothing. Stains on skin are harmless and will eventually wear off. Stains on clothing are permanent. Visitors should wear gloves to avoid getting silver nitrate on their skin.

Miso soup has about 800 mg of sodium per serving, whereas chicken noodle soup only has about 500 mg of sodium per serving. Even with a very rough titration, it should be clear to visitors which one has more salt.

CAUTION: The experiment uses small quantities of silver nitrate and potassium chromate solutions. Both of these chemicals are poisonous if they are ingested or if they get in eyes. Visitors must wear safety goggles. To limit risk, only provide these chemicals in small dropper bottles, fill the bottles halfway only, and tape the bottles shut.

CAUTION: Always supervise visitors during this activity. Be sure visitors wear safety glasses and don't let them taste any chemicals (even food or drinks).

Set Up

Set up takes approximately 20 minutes. (Set up will take longer the very first time you do the activity.)

1. Set up enough workstations so that visitors can work individually or in pairs. At an eight-foot table, you can comfortably fit 4 pairs of visitors.
2. Decide where you (the presenter) will demonstrate procedures. You may want to set up a demonstration station for yourself at the front of the room, or you may demonstrate the activity's procedures at the head of one of the visitors' tables, using the equipment from one of their workstations.

Program Delivery

Welcome visitors. Explain that they will be working individually or in pairs, and divide them among the workstations.

What do you know about salt? What is it? What is it used for? *Visitor response.*

What is your favorite salty food? Do you think it's good for you? *Visitor response.*

People need to have a little salt in their diets, but most of us get way too much. Studies have shown that too much salt can raise your risk of heart disease, including high blood pressure. So it's important to know how much salt you are eating.

Show the salt in the baggie and state that it is the recommended amount of daily salt intake per day.

Does that seem like very much salt? *Most visitors will say that it doesn't seem like very much at all.*

Do you know how to figure out how much salt is in your food? *Visitor response.*

If you buy it at the grocery store, you can check the label. *Show where sodium content appears on label.*

So, food labels are one way to find out how much salt is in food.

Today we're going to learn another way to measure salt in food. It's a chemistry procedure called *titration*. You might not decide to do this at a restaurant, but it is an interesting way to find out how much salt is in your food!

Before we start, everyone should put one their safety glasses and gloves.

The chemicals we're using today are safe, but you should take special care when you use the silver nitrate. This one turns black when it's exposed to light. If you get it on your clothing or skin, it will stain. The stain will eventually come off your skin, but not out of your clothing.

Safety: Make sure everyone is wearing safety glasses and gloves.

In the first part of this program, we're going to learn how to do a titration, using distilled water (which has no salt in it), and water that has a known amount of salt added to it. *Hold up water and broth.*

Then, once we know how to do the titration, we're going to test whether miso soup or chicken noodle soup has more salt in it.

Which one do you think is healthier or has less salt in it? *Show visitors the packages without showing them the nutrition information.*

Let's find out!

Everyone has one of these, which is called a "well plate". It's sitting on a white piece of paper. That's so you can see the color of the different liquids we're going to put in it.

You also have a sheet of paper and a pen/pencil for recording your results, and a graph to use to find out what your results mean. *Hold up each object.*

I'm going to go through the steps of doing the titration with distilled water. Then, you can try the distilled water and the salt water. When everyone's done, we'll compare results. *Demonstrate the following procedure.*

Titration procedure

1. Place a 24-well plate on a piece of white paper.
2. In the first well, carefully add 10 drops of water.
3. Add one drop of potassium chromate indicator.
4. Stir with a toothpick.
5. Add one-drop silver nitrate solution.
6. Stir with a toothpick.

7. Add silver nitrate solution one drop at a time until the mixture turns reddish-orange, counting each drop as you add it.
8. As you add the silver nitrate, an orange or red color may appear that will disappear as you stir the mixture. Be sure to stir after each drop is added.
9. Add silver nitrate until the red color does not disappear when the mixture is stirred.
10. When that happens, record the number of drops you added to well. That's known as the *endpoint.*

Repeat procedure using salt water.

How many drops did it take to get to the endpoint with the water? *Responses may vary.*

Most of you found that it took one drop.

How about the salty water? *Responses may vary.*

It sounds like for most of you, it took around 7 or 8 drops.

There are lots of us doing this activity so we each only needed to do it once, because we can compare results. But if we were chemists doing it alone, we'd do each one (the plain water and the salt water) three times, to be sure we got the same answer each time.

Now let's look up our results on the graph, and see what they mean. *Show how to use the graph.*

Looking up results on the graph

Take the average of all the endpoints (number of drops needed to get to red) in the group.

Look at the graph (drops vs. amount salt) to see how much salt is in a cup of liquid. *For every drop of silver nitrate needed to get to red there are 110 mg of sodium in a cup of the liquid.*

How much salt is in one cup of the plain tap water? *None, or a negligible amount.*

How much salt is in one cup of the salt water? *800 mg*

The recommended daily amount of salt per day is 2400 mg.

So we could drink three cups of salt water in a day, if we didn't eat anything else with salt. Does anyone here drink salt water? No? So, let's test some foods that you might eat!

Testing foods

You can use the same procedures to test these real foods. *Indicate foods.*

First, you'll do the titration, to see how many drops it takes before the indicator turns permanently red.

Have visitors compare the two soups first. Then, if they wish, they can test and compare other foods.

Then, you'll look up your results on the graph, to see how much salt is in one cup of the food.

If you like, you can do the titration more than once, to be sure your results are accurate. You can also compare your results to the nutritional information on the package! (Remember that if you do that, you'll have to take the serving size into account.)

Visitors experiment. When a majority has finished the miso soup and chicken soup, compare results.

Before we go, let's compare results. Which food had the most salt? The least? *Miso soup had the most.*

Does this make you think differently about some of your food choices? *Responses will vary.*

If you'd like you can stick around and keep experimenting!

Clean Up

CAUTION: DO NOT DUMP THE LIQUIDS FROM THE WELL PLATES DOWN THE SINK!
The precipitates should not enter the water supply.

To dispose of the contents of the well plates:

1. Layer a pile of paper towels onto the tray.
2. Dump over the well plate, and knock it onto the pile of paper towels on the tray. You need to get the precipitates out of the well plate and onto the paper towels.
3. Dispose of the paper towels in the trash.
4. After dumping the contents out, the well plates can be rinsed in the sink with water and wiped out with a paper towel.

Tips and Troubleshooting

With younger visitors, it's easier to have them compare the number of drops, rather than use the graph.

For each drop of silver nitrate used there are 110 mg of sodium in a cup of the test solution.

Credits
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Calculations used to determine graph

Salt = NaCl = sodium chloride 58.43 g/mol
Na = sodium 22.98 g/mol
Cl = chlorine 35.45 g/mol

Recommended daily allowance: 2400 mg sodium = 2.4 g sodium

Our silver solution has 0.2 Moles of silver nitrate in 1 L of water.

There is 0.05 mL (.00005 L) in 1 drop of solution (20 drops = 1 mL). So there are 0.00001 moles of silver nitrate in 1 drop of the solution.

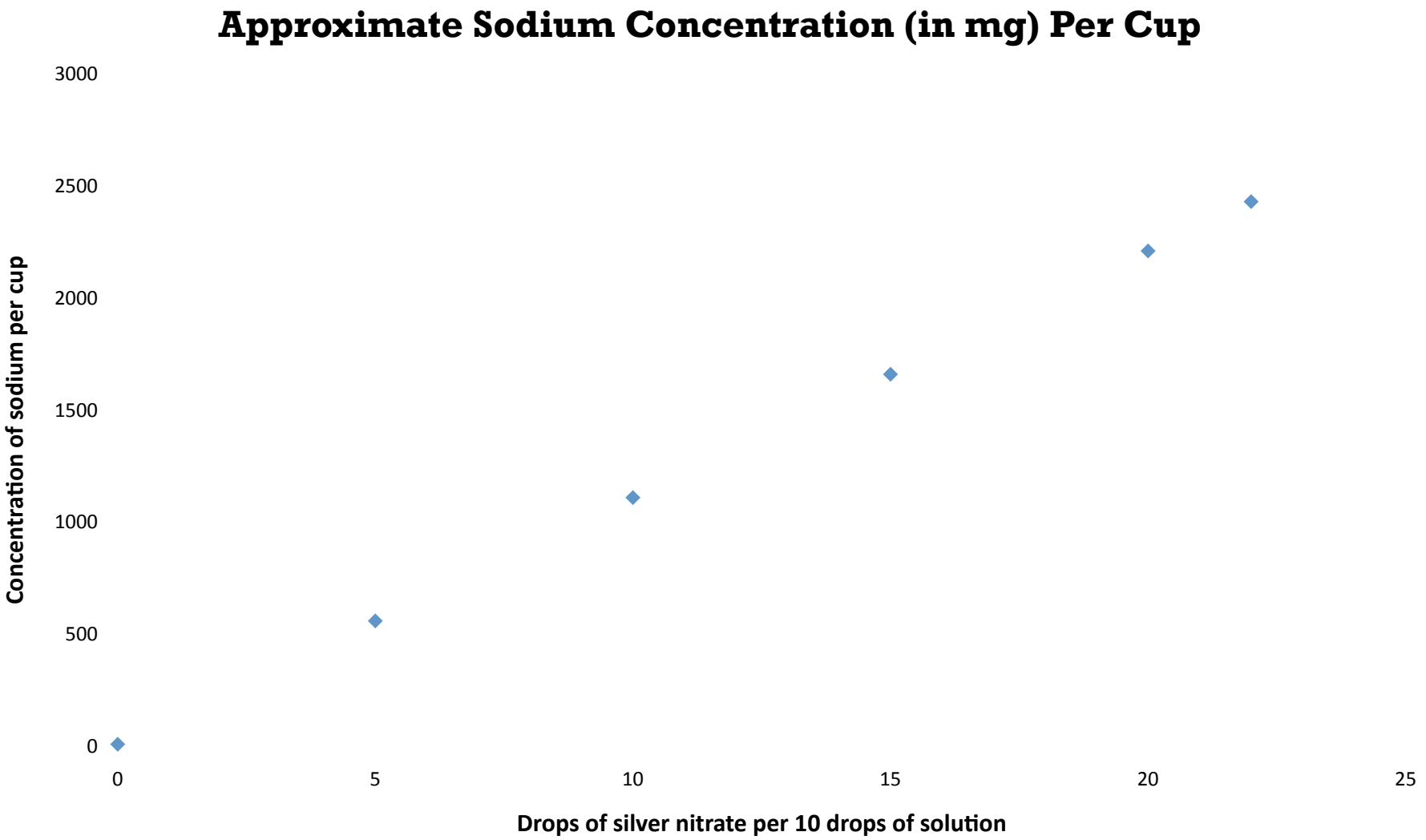
Each atom of silver nitrate reacts with one atom of chlorine. So 1 drop of silver nitrate solution reacts with 0.00001 moles of chlorine. When the chlorine is used up, the color will change.

Sodium chloride has one atom of sodium for every atom of chlorine, so if 1 drop of silver nitrate is used it means there are 0.00001 Moles of sodium.

The molecular weight of sodium is 22.98 g/mole. So 0.00001 moles of sodium has a weight of 0.0002298 g. or 0.2298 mg.

In the well there are 10 drops of salt solution. So, in the well there is 0.0005 Liters of solution. So if there are 0.2298 mg of sodium in 10 drops of salt solution there are
(0.2298mg/10drop)(1drop/0. 00005Liters)(0.24L/1cup) = 110mg of sodium in one cup of salt solution

If 1 drop of silver nitrate (0.0005 L) reacts with all the chlorine in the 10 drops in the well, there are 110 mg of sodium in a 1 cup serving of the solution.


Approximate Sodium Concentration (in mg) Per Cup
3000
2500
2000
1500
1000
500
0
Concentration of sodium per cup
0
5
10
15
20
25
Drops of silver nitrate per 10 drops of solution