Kitchen Science Investigators

Kicking Up the Science A Notch In Your After-school Program

Introductions

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Kitchen Science Investigators

Exciting Children about Science and Cooking
Since 2004

• Context: After-school or summer camp learning environment where kids learn science and scientific reasoning skills through cooking
  – Applying science and scientific reasoning to make their food better
  – Relating science to the real world and learners’ interests and goals
• Ages:
  – Middle School
  – 5th – 8th grade children
• Today:
  – Ideas
  – Activities

Who are you?

• Front line afterschool staff
• Program Directors
• Administrators
• Principles

Agenda

• Overview of our approach
  – What is KSI?
  – Why KSI?
  – What it looks like
  – FAQ’s
• Activities
  – How to Sequence: Investigations and Experiments
  – Hands-on practice with science experiments

Our Philosophy

• Our Goal is Helping Children to
  – Connect science to their everyday lives
  – Through connecting cooking activities with science activities
  – To answer practical questions with hands-on experience
• Our approach
  – Learning by doing
  – Hands-on learning activities
  – Authentic context
  – Practicing science
  – Making science visible
  – Modeling science practices
  – Highlighting science in everyday life
• Today: Water-Bottle Kitchen Science
  – Discovering the science behind cooking through water bottle experiments
Why KSI?

• Leveraging cooking to get learners interested in science
• Context for science explorations
  – Leaveners
  – Thickeners
• Kitchen Science Investigators: Investigations and Experiments
  – Cooking
  – Scientific

Frequently Asked Questions

1. Can kids really cook?
2. What does it take?
3. Can kids learn science through cooking?
4. How do you get them to learn science amidst all this activity?

FAQ #1: Can kids really cook?

Answer:
Yes, but
– To varying degrees
  • They are a lot slower and perhaps messier than adults
  • You have to trust them to do it

FAQ #2: What does it take?

Answer:
– Knowing learners’ needs
– Giving them the types of help they need
– Modeling them the types of help they need

Examples:
Provide assistance with
– How to read a recipe
– How to get started
– Cooking procedures
– Measurement
– Working in groups
– Recognizing mistakes they made while cooking

KSI In Action & on CNN

CNN Video
FAQ #3: Can you learn science through cooking?

Answer:
Yes, through cooking you can learn and experience both
– Scientific Reasoning
– Science content/scientific phenomena

FAQ #3: Can they learn science through cooking?

Answer:
– Learning About Scientific Reasoning through Cooking: Investigations, Experiments, & Explorations

Examples:
– Investigations: Sequences of cooking activities, experiments, and explorations to help learners see the scientific mechanism underlying their cooking.
– Experiments: Activities where all materials/ingredients and procedures are held constant except for one varying material/ingredient or procedure
– Exploration: Informal, tinkering, sometimes spontaneous and unplanned

FAQ #4: How do you get them to learn science amidst all this activity?

– Sequencing of activities
  • Driving Questions (e.g., for brownies)
  • Recipes and corresponding science experiments/investigations
    – Cooking
    – Science
    – Exploring underlying mechanisms in their dishes
  • Conversations:
    – Small Group: Doing and analyzing
    – Whole Group: Design, analyze, and draw conclusions

Today’s Activities: Water Bottle Kitchen Science

• Pizza & Yeast-air balloon: Getting started with scientific investigations
• Brownies & Oil and Water Mixers: Getting started with designing experiments
  – Varying amounts of ingredients

How does yeast make pizza and breads rise?

Activities
• Cooking Activity:
  – Pizza
• Science Activity:
  – Yeast Air Balloons

Science Learning Goals
• Exploration
  – To highlight the relationship between cooking and science
  – To foster use of the 5 senses in collecting data and asking questions
• Focus: Biological leavening
  – To support understanding of how yeast works
The importance of Leveling the Field of Pizza Experiences

Children’s various knowledge of the Pizza Making Process
- Many have experienced eating pizza
- Most have seen a pizza made
- Some may have made pizza at home
- Others may know that pizza dough is made with yeast
- Some may know that yeast makes the dough rise

Our solution:
Hands-on cooking activity were everyone shares the experience of making pizza and working with yeast

While the dough is resting
Science Activity: Yeast-Air Balloon Exploration

Children know that pizza rises
But, why and how does the crust rise?
Opportunity to spark curiosity with a Science Exploration

Science Activity: Yeast-Air Balloons

Supplies:
- Ingredients: Yeast, water, and sugar
- 20 oz water bottles
- Large latex balloons

Activity tasks
- Practice making predictions and hypotheses based on their prior knowledge and their experiences doing the cooking activity:
- Construct several water bottles to figure out what is necessary to make the balloon inflate

Doing the Yeast-Air Balloon Activity

Break up into groups of at most 5 people.
Use the Activity instructions
And materials on the table to complete the activity.

After the Completion of the Science Activity

Children will have noticed
- that their timers have gone off and
- that it is time to finish making their pizzas

Yeast Air Balloon water bottles
- Remain in participants work area while they prepare their pizzas
- And they keep an eye on the progress of their bottles
In the mean time

Since we don’t have a pizza to prepare,
• We are going to jump to the next activity and let the water bottles do their thing.
• But keep an eye out for changes in our water bottles.

What makes some brownies cakie and others fudgy?

Activities
• Cooking Activity:
  – Brownies
• Water-Bottle Kitchen Science Activity:
  – Oil and Water Mixers

Learning Goals
• Experiment
  – Designing Experiments by varying the amount of an ingredient

• Science Focus: Structural leavening
  – Mixtures
  – The role of eggs in brownies
    • Egg protein
    • Eggs as emulsifiers

Designing Experiments

Cover Story
• Different people like different types of brownies
  – Cakie and Fudgie
  – But we need to know what ingredient makes the brownies different
  – We heard it has something to do with eggs

Designed Experiment
• Make 4 batches of brownies
  – 1 egg, 2 egg, 3 egg, and 4 egg brownies
• Each group makes a different batch of brownies

Cooking Activity: Making Pizza from Scratch

While the Brownies are baking

Children’s Knowledge
• Kids know they varied the amount of eggs in each batch
• they may think that at least one variation will come out cakie and at least one variation will come out fudgie

Gap in Children’s Knowledge
• Why varying the amount of eggs makes them come out differently
• The role eggs play in making the brownies

Opportunity to design an experiment to make the science visible

Water-Bottle Kitchen Science Activity: Oil and Water Mixers

Activity tasks
• Do an experiment that mirrors the Brownies Cooking Experiment
  – This time each group makes water bottles to mirror the cooking experiment

• Practice making predictions and hypotheses

• Construct several water bottles to figure out what makes some brownies cakie and others fudgy
Doing the Oil and Water Mixers Activity

Break up into groups of at most 5 people.
Use the Activity instructions
And materials on the table to complete the activity.

The oil and water mixed for a short period of time then separated back out

Conclusion: Oil and Water don’t mix

What happened when you combined
Oil + Water = ??????

The oil and water mixed for a short period of time then separated back out

Conclusion: Oil and Water don’t mix

What happened when you combined
Oil + Water + 1 Egg= ??????

The oil and water mixed for a short period of time then separated back out.

But there is a small band of oil and water mixed and a little foam

Conclusion: 1 Egg doesn’t mix the Oil and Water

What happened when you combined
Oil + Water + 2 Egg= ??????

The oil and water mixed and hasn’t separated back out. It is hard to distinguish between the eggs, oil, and the water. There is a small band of foam.

Conclusion: 2 Egg are just enough to mix oil and water and not enough to produce a large amount of foam.

What happened when you combined
Oil + Water + 3 Egg= ??????

The oil and water mixed and hasn’t separated back out. It is hard to distinguish between the eggs, oil, and the water. There is a larger band of foam. The color is uniform.

Conclusion: 3 Eggs are enough to mix oil and water and the additional egg is enough to produce a large amount of foam which traps air.

What happened when you combined
Oil + Water + 4 Egg= ??????

The oil and water mixed and hasn’t separated back out. It is hard to distinguish between the eggs, oil, and the water. There is a larger band of foam. The color is uniform.

Conclusion: 4 Eggs are enough to mix oil and water and the additional egg is enough to produce a large amount of foam which traps air.
What they should notice about their bottles

**Sight:**
- General Composition of mixtures – 2-3 different bands
  - Bottom: water & eggs
  - Middle: egg, oil, and water mixture
  - Top: There is foam in the bottle
- Height of mixture
  - Increases as you increase the amount of eggs
- Height of foam
  - Amount of eggs
- Color of mixtures
  - Goes from darkly colored to lighter colored as the amount of eggs increase

We learned four things from the Water Bottle experiment

1. Oil and water do not mix
2. One egg doesn’t mix the oil and water
3. Two – four eggs mix the oil and water
4. When we shake the egg, water, and oil mixture it produces a foam.
5. More foam with more eggs
6. The height of the mixture increase as we add more eggs

Side Notes

Opportunities to design more experiments
- Controlling the amount of shakes everyone can do so that they are as close as possible to one another

Troubleshooting
- If you are having trouble seeing the bands you can use food coloring in the water bottles which will help make the distinctions between bands clearer

Based on what they noticed with their water bottles

- Get them to make predictions about how the brownies will turn out
- Also have them make hypotheses about what will be the best fudgy or cakie brownies and make sure they provide reasons based on the science experiment
  - Caveat: They are likely to pick their own brownies despite their preference for a specific type of brownies.

What caused the oil and water to mix and stay together?

Possible Answers:
- How much a person shook the bottle
- The eggs

The Science You’ll Need to know to Explain How Eggs Work

- **Scope:**
  - Enough to explain the scientific phenomena by which eggs are able to make brownies fudgy and cakie
  - Enough to connect what happened in the water bottles to the brownies
Science Behind Eggs

Eggs are made up of protein, water, and fat. The protein in eggs mixes together oily and water-based substances.

Egg Proteins are Emulsifier

- Egg proteins have two sides:
  - One side that loves water and water-based substances
  - One side that fears water (likes oil-based substances)

Egg Proteins are Emulsifier

Each side of the protein attaches to either a water molecule or an oil molecule and forms a lattice-like structure. This lattice-like structure traps other ingredients and air in the structure, holding everything together.

Other Emulsifiers in Our Every Lives

Try doing the Oil and Water Mixers with other emulsifiers:
1. Soap (think about how dishes detergent cleans dishes)
2. Mayonnaise (oil and water emulsified by eggs)
3. Mustard
4. Eggs in salad dressing (look at the labels for ranch and Caesar dressings)
5. Soy Lecithin in Baked goods and many manufactured products
6. Lecithin in Homogenized Milk

Lecithin is a protein that naturally occurs in milk and soy.

Connecting the Science to the Cooking

Mapping the Science Activity to the Cooking Activity

- Water = chocolate
- Oil = butter

- We use the same amount of water (chocolate) and oil (butter) to create this experiment as a parallel to the cooking experiment to help them make connections easier.

What role do you think the eggs played in making the recipes different?
Role of Eggs in the Brownies

Egg protein play two crucial roles in making our Brownies spectacular
1. The egg protein help the oil from the butter stay mixed with the watery/liquid nature of the chocolate
2. Egg protein also trap air.
   a) The trapped air expands in the heat of the oven
   b) The egg proteins harden in the heat of the oven and provide structure along with the protein in flour to help the brownies retain their risen shape

How Many Eggs do we need to make Cakie & Fudgie Brownies?

1 egg – isn’t enough to hold the oil (butter) and the water (chocolate) together
1 egg brownies are hard, oily, and grainy. Not very edible or appetizing.
Since the oil and water are not held together by the 1 egg,
• the water evaporates while the brownies cook and
• The brownies become oily because the butter (oil) is less dense (lighter) than the other ingredients and it separates from the rest of the ingredients.
• Which leaves the sugar to crystallize and make the brownies grainy

2 egg – is just enough to hold the oil (butter) and the water (chocolate) together. They do not produce much foam when shaken in our experiment.
2 egg brownies do not rise that much and are dense, dark, fudgy, and sweet.
Since the 2 eggs are just enough to hold the butter (oil) and chocolate (water) together, the 2 eggs are not able to play their second role of making the brownies rise.

3 egg – is enough to hold the oil (butter) and the water (chocolate) together and they produce a a good amount of foam.
3 egg brownies are lighter and rise a lot more than the 2 egg brownies
Since we only need 2 eggs to hold the oil and water together, the third eggs is able to trap air and make the brownies rise.

4 egg – is enough to hold the oil (butter) and the water (chocolate) together and they produce a a good amount of foam.
4 egg brownies are lighter and rise a lot more than the 3 egg brownies
Since we only need 2 eggs to hold the oil and water together, the third and fourth eggs are able to trap air and make the brownies rise.

Science and Cooking Lessons
• Eggs make foods rise.
  – As you increase the amount of eggs you increase the height of the baked product
  – Thus, brownies made with less eggs (e.g., 1 & 2 egg brownies) are more dense and darker than brownies made with more eggs (e.g., 3 & 4 egg brownies).
  – Brownies made with more eggs (e.g., 3 & 4 egg brownies) are more airy (i.e., have more holes made from air bubbles) and have a lighter texture than brownies made with less eggs (e.g., 1 & 2 egg brownies).
Science and Cooking Lessons

- Sweetness of Brownies
  - As you increase the amount of eggs, you increase the amount of batter in the brownies.
  - Thus, since the sugar in the recipe has not changed, the sugar has to be distributed throughout the more brownie batter.
  - So when you take a bite out of the brownies made with more eggs (e.g., 3 egg brownies) they are less sweet than the brownies with less eggs (e.g., 2 egg brownies).
  - Thus, if you want sweet cakie brownies you may need to add more sugar.

The Science of How Egg Proteins Work to Make Foods Rise

Egg Proteins

- Some Egg Proteins are suspended in water in Egg Whites
  - The proteins are shaped in Coils or Complex wads of coils
  - Because the proteins are separate, there is room for light to pass between them
  - That's why egg whites clear when they are uncooked

Beating Eggs Incorporates Air in the mixture and uncoils the proteins

Denatured Proteins

- When egg whites are heated, or exposed to air or acid
  - The bonds across their springs break and the proteins unwind
  - Proteins straighten out with bonds sticking out to the sides
  - Called Denatured Proteins

Coagulation

- Denatured proteins with bonds sticking out run into one another
  - They link together and form bonds with each other
  - They also can form a lattice-like structure
Heating the eggs hardens the egg proteins and trapped air. The heat also makes the air expand stretching the egg protein structure.

Revisiting Our Yeast-air balloons

We left off with the children
• completing the construction of the yeast air balloons bottles and
• returning back to the cooking activity to finish preparing their pizza.

While the pizza dough is in the oven
• Children are cleaning up
• They should have noticed by now that their balloon is inflating
• Some may notice that their balloons haven’t inflated at all

Opportunity for Discussion

Use your KSI Investigative 5 Senses Technique

What happened when you combined
Yeast + Water + Sugar = ??????

• Sight?
• Smell?
• Taste?
• Touch?
• Hearing?

Hint: Look at your 5 senses chart, pictures, and the yeast-air balloon

What they should notice about their bottles

• Sight:
  – Balloon inflated
  – There is foam in the bottle
• Smell:
  – Like bread
  – Funky
• Touch/Feel
  – warm
• Taste (n/a)
  – Bitter
  – Like rotten grapes
• Sound (n/a)

What do you think made the balloon inflate?

Possible Answers:
• The yeast
• The sugar
• The steam from the warm water
Side note: Opportunity for More Exploration

Exploration Activity

• Construct various water bottles to test out their ideas
  – Water-bottles with only yeast, or sugar, or warm water
  – Water-bottles with a combination of the ingredients
    • Water and sugar
    • Sugar and yeast
    • Water and yeast
  – What they should notice is that none of these inflates their balloon like the combination of yeast, sugar, and water

Connecting what they see to a scientific phenomena

• Sight:
  – Balloon inflated
  – There is foam in the bottle
• Smell:
  – Like bread
  – Funky
• Touch/Feel
  – warm
• Taste (n/a)
  – Bitter
    – Like rotten grapes
• Sound (n/a)

The Science You’ll Need to know

• Scope:
  – Enough to explain the scientific phenomena by which yeast is able to make the balloon inflate and to pizza dough rise
  – Enough to connect what happened in the water bottle to what happened with their pizza dough

Simple Explanation of Yeast

Yeast + water + sugar + time

= more yeast + alcohol + CO₂

5 Senses Evidence

more yeast = Sight: Foam in the water bottle
alcohol = Taste: It taste kind of bitter like rotten grapes
SMell: strong smell
CO₂ = Sight: Balloon blown up

Mixed with flour we get Tasty, fluffy, Pizza Dough

Which one of these makes the dough rise?

More Detailed Explanation of How Yeast Works

• Yeast is a living creature, it is a fungus
• The yeast in the jar and packages are “in hibernation” they are dried
• Yeast needs the water to “wake it up”
• Yeast uses the sugar as food
  – Yeast “eats” the sugar and produces
    • CO₂ - Carbon Dioxide
      – The CO₂ - Carbon Dioxide blows up the balloon
    • Alcohol – smell we associate with breads made with yeast
    • More yeast – the foam in the bottle
CO₂ - Carbon Dioxide

- Is an odorless, colorless, tasteless gas
- As people, we breath out CO₂ as a waste product of our breathing in air (Oxygen and other gases)
- What is a Gas?
  - Is water a gas?
  - Is butter a gas?
  - Can you name a gas?

Gases

- Make things rise
- They make up the air we breath
- They are formless
  - That means they take on the form of their container
- Sometimes they are
  - Colorless
  - Tasteless
  - Invisible
  - And odorless

So Gases are tricky

If they are really that tricky how do you know if they are there or not?

You have to trap it like we did with the Balloons

How do you think we trapped it in our recipe?

The Dough

The dough acts like a balloon and traps the CO₂ air bubbles that the yeast creates.
 Connecting the science and the cooking

Thus, while the dough rests the yeast is producing CO₂ air bubbles (like in our water bottles) and making the dough rise (like our balloon on our water-bottles).

Connecting the science and the cooking

While the dough bakes in the oven, the CO₂ air bubbles created by the yeast expand (get bigger) and stretch the dough making it rise (making the dough even bigger).

Air Bubbles in our Pizza Dough

There are two types of air bubbles in our dough

(1) The yeast makes CO₂ gas from “eating” (metabolizing) the sugar in the dough. The CO₂ gas gets trapped in air bubbles already in the dough, as well as creating there own air bubbles. These air bubbles get trapped in the dough and make it rise.

These air bubbles vary in size and some may be as large as a golf ball.

Air Bubbles in our Pizza Dough

There are two types of air bubbles in our dough

(2) Air bubbles created from Mixing and Kneading push air into the pizza dough and get trapped

Yeast FAQs

- Yeast is a living creature (a single-celled fungus that reproduces itself)
  - Yeast, like people, needs oxygen, to eat and metabolize food, and produces carbon dioxide

- Why do we need warm water?
  - The yeast is in hibernation when we purchase it from the store thus they need warm water to wake them up
  - It doesn’t wake up to just any temperature
  - Nor can it survive if the temperature is too hot

- Why do we need sugar?
  - Sugar is the food that yeast eats
    - When yeast “eats” (metabolizes) sugar it produces 3 things
      - Carbon dioxide
      - More yeast
      - Alcohol

- Inflated balloon and risen pizza crust:
  - Comes from the Carbon Dioxide that is produced when the yeast “eats” (metabolizes) the sugar

- The foam in the bottle and why we need to let the dough rest before we roll it out
  - Comes from the extra yeast that is produced/created during the process of the

Yeast belongs to a family of ingredients that “Makes Things Rise”

The family of ingredients that “make things rise” are called Leaveners.

To Leaven means to lift.

So When you lift something it rises.
How does yeast make pizza and breads rise?

Answer:
Yeast is activated by warm water.
Then "eats" (metabolizes) the sugar
Then produces
Carbon dioxide which makes air bubbles in the pizza dough.
The dough traps these air bubbles and begins to expand as the yeast produces more and more carbon dioxide gas.
The air bubbles that expands the size of the air bubbles in the dough.
the air bubbles created both by the yeast and by the processes of mixing and kneading the dough expand in the oven making the dough rise. The heat from the oven hardens the dough which makes the pizza dough retain its risen shape.

Activity Facilitation

• Recovering from mistakes
  – Water temperature
    • Too cold yeast isn’t activated, add hot water to activate them
    • Too hot yeast is dead, try again with new yeast
  – Think on the fly
    • Be sure to model your reasoning by talking through your thought processes aloud when solving problems for the kids
• Assisting struggling children and groups, by letting them retain control while you coach

Let’s Talk About It…

• During your experiments and investigation, what resources and facilitation did you have or did you not have that you thought you needed (or that your students would need) to really be successful at cooking and exploring science?

Let’s Talk About It: Resources

• Time: Cooking and corresponding activities need to be sequenced as close as possible (i.e., same day, same week)
• Learners need resources for scientific thought
  – To help them focus on the science at hand
    • Remembering overarching questions
    • Purpose and procedures of experiments
    • Making observations of what they are seeing during activities
      – Cameras
      – Pen and paper

Let’s Talk About It: Facilitation

• Help learners may need
  – Prompting for scientific observation and thought
  – On the fly explanations, experiments, and explorations to help them understand the science that is going on behind the cooking
  – Improvising – it’s a lot of things to remember, you’re bound to forget something. So it’s important to be able to work around those mistakes.
    • Your mistakes
    • Their mistakes
Your Questions about implementation?

Different Ways of Implementing KSI

Next Steps: Where you can go from here

• Activity adaptations and concerns
  – Introductory activities: getting the kids used to making observations and thinking scientifically about their food
  – Choice Days: once they’ve explored a set of leaveners give them a chance to re-try recipes or create new ones

Next Steps: Choice Days

• Retry: re-make a dish they’ve already made, but use the science they’ve learned to make it better
  – E.g., Deep dish pizza
• Creating new dishes: find dishes that use the leaveners we’ve looked at in significant ways
  – E.g., cakes, muffins (egg, baking soda, baking powder combinations)

Back To Our Frequently Asked Questions

• Can kids really cook?
• What does it take?
• How do you get them to learn science amidst all this activity?
• Can it really work?

Quotes: KSI Participant

Malaysia, 6th Grade

And in KSI, you really know you’re doing something. People really know you’re doing something. And it’s more learning, I can learn more easy… they can see you doing stuff and studying and learning and talking about it. Like, when you talk about it like you *know something* about it, they can tell you did something.
Quotes: KSI Parent

But, after the program, after being involved in the program and understanding a little bit more in her mind, opening up to how Chemistry fits into the science classroom, I think that um, sparked a light inside her mind where she said, 'Man, I can go a lot - I can do a whole lot with science, and I could do a whole lot more with understanding now.'

Quotes: Science Teacher

So it [KSI] had an experiment twist to it, and she could come back to the classroom and say, 'Okay, this is how we, the recipe and the procedure are, almost the same.' So she's been exposed to that. And so, that would give her an opportunity to, show leadership, make a connection between the different types of equipment that we use in the science classroom and then the same equipment that they use in KSI.

Need Help Implementing KSI in your After School

Please speak with us about opportunities for Research Partnerships

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