SDSU Extension

Food Safety Scientist

A Dynamic STEM Educational Adventure

Manipulating pH Level in Food

Department of Dairy & Food Science
College of Agriculture, Food & Environmental Sciences

Acknowledgements:

Curriculum:

Food Safety Scientist: A Dynamic STEM Educational Adventure
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Unit: Manipulating pH Level in Food

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South Dakota State University (SDSU) and New Mexico State University (NMSU) produced this project as part of a Higher Education Challenge Grant "Innovative STEM instruction techniques to increase the number and diversity of students in food safety related majors". SDSU served as the lead institution for the overall project developing the content and curriculum with NMSU leading the digital creation of classroom media, animations and interactive educational technologies. North Dakota State University serves as the outside evaluator of the project. This project was supported by Agriculture and Food Research Initiative Competitive Grant no. 2011-38411-30625 from the USDA National Institute of Food and Agriculture. This project was supported in part by the USDA NIFA grant numbers 2008-38411-19055, NDSU serving as the lead institution with SDSU and NMSU as sub-awardees. Virtual Lab creative presentation © 2010 The NMSU Board of Regents

Food Safety Scientist

A Dynamic STEM Educational Adventure

Real-life situations provide some of the greatest opportunities for students to learn how science impacts their life. Explore the common science and technological concepts in the development of a safe food supply within the classroom through the Food Safety Scientist Curriculum.

Engaging

The Food Safety Scientist Curriculum is intended to enhance the regular classroom curriculum. Educators are encouraged to pick and choose from the various educational tools to engage students in the STEM related field of food safety.

Scientists Needed

Food safety requires the need for scientists in the research laboratory, production practices, regulatory agencies, veterinarians, food product development and processing, meeting the demands of feeding the world, as well as preparing and serving food within the home. Educators in Science, Agriculture, and Family and Consumer Sciences utilize the components of the curriculum to help students explore STEM careers that keep food healthy and safe.

Free Curriculum

The curriculum is entirely free. Educators can access the website, download materials they want to use in their educational setting and change them to meet their needs. Components of the curriculum have been used in formal and informal educational settings as well as with various age levels. For example, the virtual labs of gram staining and using a microscope have been used with middle school students as well as introductory microbiology courses at colleges and universities across the United States.

Curriculum Components

The curriculum enhancement tool Food Safety Scientist includes the following components:

1. Unit Guide to assist teachers in identifying the goals, objectives and standards (Next Generation Science Standards, and Career and Technical Education Classes) for each unit and individual learning experiences.
2. Interactive Virtual Labs that include real-life situations that bring science, technology, engineering and math into the delivery of a safe food supply.
3. Hands-on laboratory experiences that compliment the virtual labs. Providing the opportunity for students to gain real-life experiences and a greater understanding of the applications of STEM for food safety scientists.
4. Exposure to careers related to the agricultural and food safety sciences.
5. Discussion Guides for teachers to empower students to explore the various scientific concepts that are utilized to develop a safe food system.

Contents of Unit

Manipulating pH Level in Food

*Virtual Labs Series: pH of Foods

This unit was created to expose students to a career that has a connection to food safety (inspector and food scientist in research and development). All the units are developed for the teacher to pick and choose what they want to use. The enrichment activities are developed with a format that allows for educators to adapt for their purposes.

Overall Goal:

Increase the number of students that consider food safety and related fields as a career path

Enrichment Activity	Time Allowed	Objectives Applied*	Standards*
Virtual Lab-Sensational Salsa	15 minutes	1,2,3,4,5,6,7	FCS 8, FCS 9, AgP 1.2, AgP 1.3, AgP 3.4, FS 1.2, FS 2.2, MS-ETS1-1, MS-ETS1-2, MS-LS1-5
Mixing it up with Sensational Salsa	50 minutes	1,2,3,4,5,6,7	FCS 8, FCS 9.2,AgP 3.4, FS 2.2, MS-ETS1-1, MS-ETS1-2, MS-LS1-5
Isoelectric Point of Milk: Making Curds and Whey	50 minutes	1,2,3,4,5,6,7	FCS 9.5.7, HS-PS1-3
Measuring pH	30 minutes	1,2,3,4	FCS 9.2.1, FCS 9.5.7, MS-LS1-5
Discussion Guide/Worksheet	45-50 minutes	1,2,3,4	MS-LS1-5

*See charts below to identify standards & objectives

Performance Objectives of Students

1. Express an understanding of the monitoring of the food supply for safety and quality.
2. Increase knowledge regarding food microbiology.
3. Students will make inferences and interpretations from knowledge gained regarding the science related to monitoring the safety of the food supply.
4. Students will examine the overall safety of the food supply from the farm to table.
5. Students will describe the various types of safe food handling practices and monitoring of the food supply.
6. Students will identify and give examples of various careers that support the safety of the food supply.
7. Students will evaluate their competency in food safety and related fields.

Standards:

Family and Consumer Sciences

Standard 8: Integrate knowledge, skills, and practices required for careers in food production and services

8.2.1: Determine pathogens found in food and their roles in causing illness

Standard 9: Integrate knowledge, skills, and practices required for careers in food science, dietetics, and nutrition

9.2: Apply risk management procedures for food safety, food testing, and sanitation.

9.2.1: Determine factors that contribute to foodborne illness

9.5: Demonstrate use of current technology in food product development and marketing

9.5.7: Conducting testing for safety of food products, utilizing available technology.

Agriculture

ITA7.1 Illustrate how raw commodities become table-ready food products

AgP 1.2 Discuss how food safety is addressed in the food processing industry

AgP 1.3 Explain how regulatory agencies in the food industry work to protect consumers

AgP 2.1 Translate regulatory procedures as they apply to food processing

AgP 3.4 Process food safely
FS 1.2 Identify industry organizations and their impact on the food industry
FS 2.2 Apply safety and sanitation practices used in the food industry

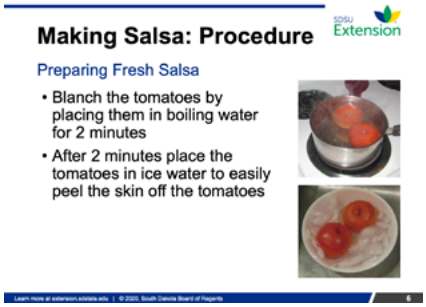
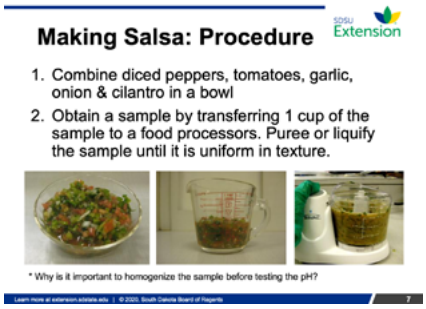
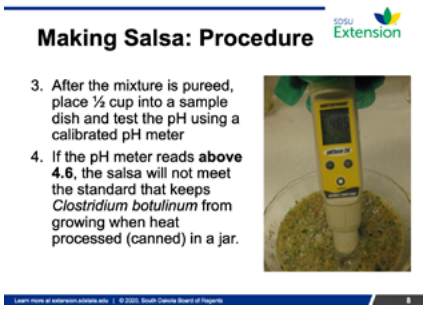
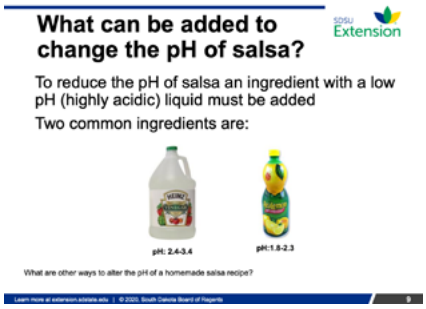
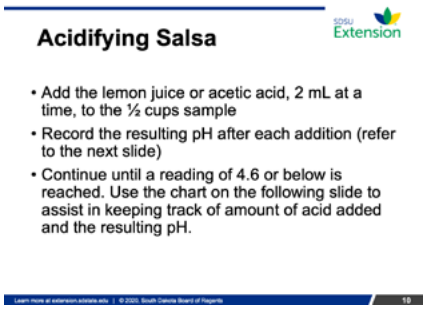
Science (Next Generation Science Standards)

MS-ETS1-1- Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions
MS-ETS1-2 – Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem
MS-LS1-5 – Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms
HS-PS1-3- Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles

Slide	Notes
SDSU Extension **Procedure for Acidifying Salsa** Food Safety Scientist Curriculum 	
Lab Safety Protocol SDSU Extension • Lab coat is advised • Wash hands before and after handling raw vegetables – Gloves are advised • Keep long hair tied back away from face • Wear closed toe shoes Learn more at extension.sdstate.edu | © 2020, South Dakota Board of Regents 2	

Salsa & Food Preservation
SDSU Extension
• What is pH?
  • The measure of the acidity of food. It is measured on a scale of 0-14. The lower the pH the higher the acidity.
• The Importance of pH
  • The pH level of homemade salsa is important when preserving the salsa over extended periods of time to prevent the growth of unwanted microorganisms.
Learn more at extension.sdstate.edu | © 2020, South Dakota Board of Regents 3	

What are the Safety Concerns of Heat Processed Salsa? SDSU Extension **The pH of food determines the type of heat processing used** • **Less than 4.6: High Acid Food – processed using a boiling water bath.** • **Greater than 4.6: Low Acid Food – must be processed using a pressure canner** The pH of the combined vegetables in salsa are often **greater than 4.6** • Therefore salsa has acid added to it. It is therefore considered an **acidified food – processed in a boiling water bath.** • Acetic acid (vinegar) or lemon juice are often added to lower the pH well below 4.6 • **If recommended heat processing is not used, the jar of salsa stored on the grocery store shelf, or in your home cupboard, can support the growth of potentially harmful bacterium, *Clostridium botulinum*** Learn more at extension.sdstate.edu | © 2020, South Dakota Board of Regents 4	
Ingredients SDSU Extension • 2 Green Bell Peppers, diced • 1 Jalapeno Pepper*, diced • 2 Ripe Tomatoes, diced • 3 Cloves Garlic, minced • 1 White Onion, diced • ½ bunch Cilantro, chopped • One Can Corn or Black Beans  *If you have an adverse reaction to Jalapeno peppers, or other items in this recipe, do not handle any of the ingredients. Wear gloves when handling Jalapeno peppers. Recipe makes 4 cups of salsa Learn more at extension.sdstate.edu | © 2020, South Dakota Board of Regents 5	

Slide	Notes
	
	Homogenize means to make the entire sample the same. With salsa there are different ingredients added with different pH levels thus it is important for the entire sample to have the same pH and ensure it the pH reading is accurate for the entire sample. Step #2 is optional – heating will help to create a pH that is similar throughout the entire product.
	*Notice in the image the pH reading is above 4.6
	The ingredients! Consider the pH of each ingredient. Do some ingredients have a higher pH level than other? Consider altering the recipe and doing some trial and error testing to further adjust the pH. The acid may still need to be added but in different ratios.
	

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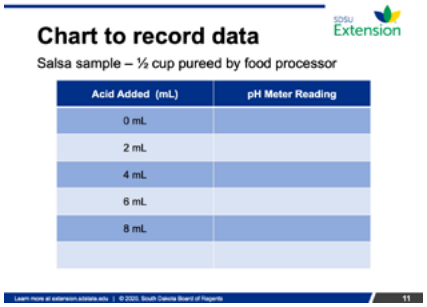
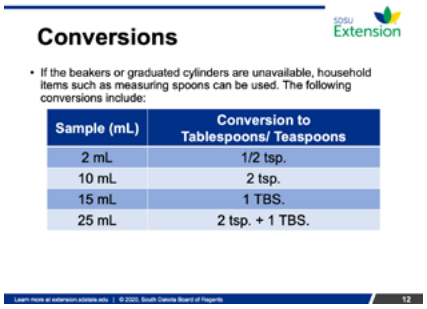
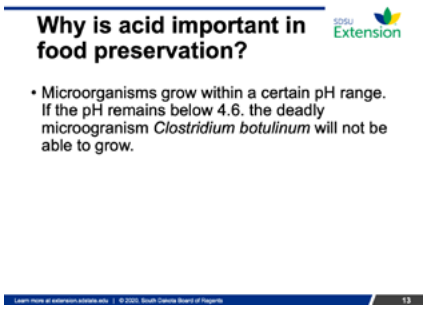
	
	
	

Lab Report: Acidifying Salsa

Name: _____ Date: _____

Introduction:

What is the purpose of this lab?

_____

_____

_____

_____

What do you hypothesize the results will indicate (or conclude)?

_____

_____

_____

_____

Results:

Acid Added (mL)	pH reading
0	
2 ml	
4 ml	
6 ml	
8 ml	

Continue adding acid until the pH falls below 4.6

From your results, construct a linear graph that shows the relationship between the acid added and the pH readings and draw a trend line showing the results.

Discussion:

Which is the dependent variable and which is the independent variable in this lab exercise?

_____

_____

What observations can be made from the graph?

_____

_____

If this experiment were repeated, what could be done differently? Why?

_____

_____

Interpretation/Conclusion:

Were the results as expected? What can be concluded from this experiment?

_____

_____

_____

_____

Lab Report: Acidifying Salsa (Teacher's Version – Answer Key)

Name: _____ Date: _____

Introduction:

What is the purpose of this lab?

The purpose of the lab is to demonstrate the importance of pH in food products to maintain a safe product and how to manipulate the pH of a salsa recipe.

What do you hypothesize the results will indicate (or conclude)?

Answers Vary. A hypothesis can be made that adding vinegar to the salsa will significantly lower the pH of the salsa as a whole. Another hypothesis may be, the pH of the salsa is below 4.6 without the addition of an acid because of the natural low pH level of the ingredients.

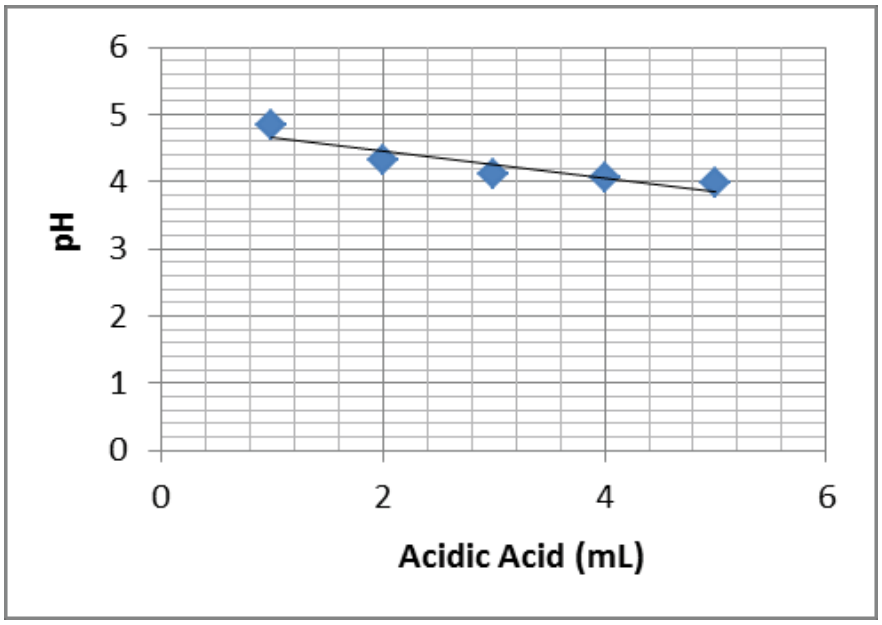
Results:

Acid Added (mL)	pH reading
0	4.83
2 ml	4.31
4 ml	4.10
6 ml	4.05
8 ml	3.97

Continue adding acid until the pH falls below 4.6

Answers may vary depending on pH readings

From your results, construct a linear graph that shows the relationship between the acid added and the pH readings and draw a trend line showing the results.



Discussion:

Which is the dependent variable and which is the independent variable in this lab exercise?

In an experiment, the independent variable is the variable that is varied or manipulated by the researcher, and the dependent variable is the response that is measured

Dependent: pH (effect)

Independent: Amount of Acid Added (cause)

What observations can be made from the graph?

The graph shows the more acid added to the salsa the lower the pH level. A conclusion can be drawn: as long as the acid is increased the pH of the salsa will continue to decrease.

If this experiment were repeated, what could be done differently? Why?

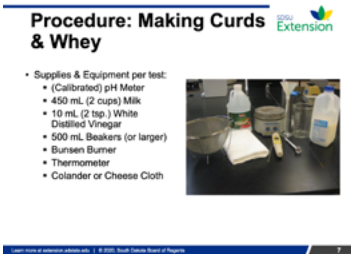
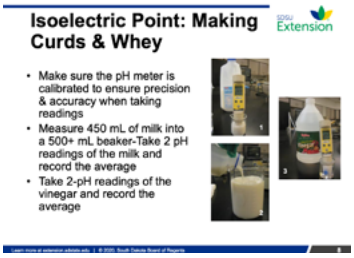
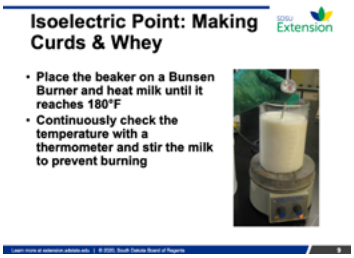
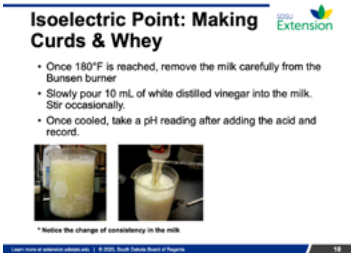
Answers vary depending on how the procedure was done. Additional changes could include: make sure the pH meter was calibrated correctly, changing the type of acid that was used, using a different recipe for the salsa, where the sample was taken from, was the sample completely homogenized, and was the salsa completely mixed with the acid prior to taking the pH reading?

Interpretation/Conclusion:

Were the results as expected? What can be concluded from this experiment?

Answers vary depending on hypothesis. A conclusion could be something along the lines of the more acid added to the salsa the lower the pH and the decreased growth of microorganisms thus preventing the growth of harmful toxins.

Slide	Notes
SDSU Extension **Procedure for Isoelectric Point of Milk: Making Curds & Whey** Hands-on module for identifying the isoelectric point of milk and understanding pH. Food Safety Scientist Curriculum 	
pH: Food & Microogranisms SDSU Extension Pathogenic Bacteria grow well at a pH of **4.6-7.5** • Meat & Milk have a pH of **5.5-6.8** making them an excellent growth media for foodborne pathogens • Fruits: **3.9-4.5** • Vegetables: **3.8-6.0** • Pathogens grow slowly with a pH **BELOW 4.6** & can be minimized even more with a pH of **4.2** • Increasing acidity has been used for centuries to preserve foods and is still used today.	
Lab Safety Protocol SDSU Extension • Lab coat is advised • Keep long hair tied back away from face • Wear closed toe shoes	
Properties of Milk SDSU Extension **Milk is a Colloid** • Colloid: A mixture of liquid and tiny particles that do not settle (unlike orange juice). Examples of Colloids: Glue, Cream, & Paint • When Milk is heated, the proteins denature and with the addition of the acid the milk will begin to separate (coagulate) into solid particles (curds) and the remaining liquid is known as whey. • **Cheese** is made from the curds (milk protein & casein) of milk either left unripened or through curing, another food preservation method ▪ Examples of unripened cheese: cottage, ricotta, cream cheese ▪ Examples of cured cheese: Cheddar, parmesan, jack, mozzarella, provolone	
Properties of Milk Continued SDSU Extension **Milk has a pH between 6.5-6.7** • The pH is controlled by a buffer system of three components: ▪ Phosphate, Citrate, & Carbonate • When vinegar is added to lower the pH of the milk it **inactivates the buffer system** ▪ pH can decrease – reach isoelectric point ▪ Formation of curds	
Isoelectric Point in Milk SDSU Extension • **Isoelectric Point: When a molecule carries neither a positive or negative charge** • In milk, the isoelectric point indicates when the protein, casein, no longer has a positive or negative charge • The isoelectric point for casein is pH value of 4.6. Once 4.6 is reached, the casein protein will separate from the liquid and clump together.	

Slide	Notes
	
	
	
	
	Caseins give the milk its white appearance as it absorbs all the color except white. Another contributor to the white color of milk is the cream or fat in the milk.

Lab Report: Isoelectric Point of Milk – Making Curds & Whey

Name: _____ Date: _____

Introduction:

What is the purpose of this lab?

_____

_____

_____

What do you hypothesize the results will indicate (or conclude)?

_____

_____

_____

Results:

pH of Milk:

pH of Vinegar:

pH of Milk & Vinegar combined (whey):

Discussion:

1. Was there a significant change in the pH of the milk after to adding the vinegar? Why?

_____

_____

_____

2. What physical properties changed after the acid was added? Please describe.

_____

_____

_____

_____

3. Why did the color of the milk change when the casein was removed?

_____

_____

_____

4. If this experiment were repeated, what could be done differently? Why?

_____

_____

_____

Interpretation/Conclusion:

Were the results as expected? What can be concluded from this experiment?

_____

_____

_____

_____

Lab Report: Isoelectric Point of Milk – Making Curds & Whey (Teacher's Version – Answer Key)

Name: _____ Date: _____

Introduction:

What is the purpose of this lab?

The purpose of the making curds and whey lab is to understand how lowering the pH of acid affects the physical and chemical properties of milk. The lab also identifies the isoelectric point of the protein, casein, in milk.

What do you hypothesize the results will indicate (or conclude)?

Adding acid to the milk will lower the pH of the milk and cause the protein to separate and form curds

Results:

pH of Milk: 6.4 – 6.8

pH of Vinegar: 2.4 – 3.4

pH of Milk & Vinegar combined (whey): Varies; typically falls between 3 – 5

Discussion:

1. Was there a significant change in the pH of the milk after to adding the vinegar? Why?

After adding the vinegar to the milk, the pH will drop well below 6. Vinegar has a low pH and when combined with a low acid substance such as milk it will overall lower the pH of the milk.

2. What physical properties changed after the acid was added? Please describe.

Milk is made up of a several components including water, fat, and protein. When vinegar is added to milk it substantially lowers the pH, sours the milk, and the negative charge of the casein proteins in the milk will become neutralized and instead of pushing each other apart they will clump together into white clusters, the liquid (whey) will take on a greenish opaque color.

3. Why did the color of the milk change when the casein was removed?

Casein plays a role in the white color of milk. The fat globules and the casein micelles are large enough to reflect light and produce a white color when the light enters the milk. When the casein is removed from the milk, the liquid portion of the milk (whey) loses its white color.

4. If this experiment were repeated, what could be done differently? Why?

Trying different temperatures to determine if it will affect how much of the casein is removed from the milk. Different types of milk (1%, 2%, whole milk, skim, goat milk) will have an effect on the appearance of the curds and the whey as the casein is removed.

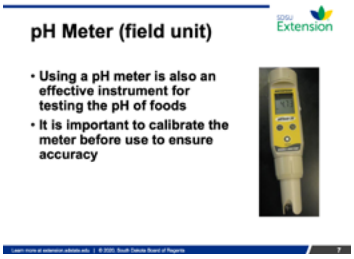
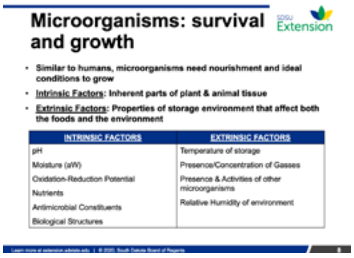
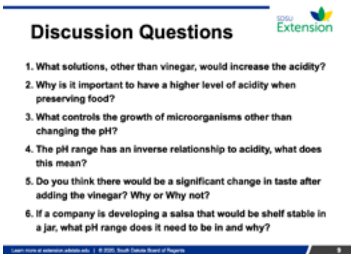
Interpretation/Conclusion:

Were the results as expected? What can be concluded from this experiment?

Answers vary depending on hypothesis. The conclusion should be something along the lines of pH being able to manipulate the physical and chemical properties of milk. Changing the pH of milk causes milk to curdle and the casein protein to reach its isoelectric point and separate from the liquid component. Changing the pH of milk is also a contributor in making cheese, a milk bi-product.

Slide	Notes
	
Equipment • 1 Dozen Hard Boiled Eggs • 7-Sampling Cups • Water • Quick Test pH Strips • Mixing Bowl • Whisk • Measuring Cups • Writing Utensil	
Preparing Samples 1. Remove the egg yolks from the *hard boiled* eggs and break down using a mortar & pestle or a whisk. 2. Add 1 cup of water to yolks and whisk together until a slurry is formed. 	
Procedure Prepare the samples as shown above and label each one 	
Conversions If beakers or funnels are unavailable, household items such as measuring spoons can be used. The following conversions include:	
Using pH Test Strips 1. Cut 7-pH test strips 8 cm long for each sample including the standard 2. Dip each strip in the sample and remove immediately 3. Compare the color of the strip to the standard included with the strip dispenser. 	

Metric Units	Conversion to Tablespoons/ Teaspoons
5 mL	1 tsp.
10 mL	2 tsp.
15 mL	1 TBS.
25 mL	2 tsp. + 1 TBS.

Slide	Notes
	
	
	1. Lemon Juice, Lime Juice any liquid with a pH between 2-3 2. A low pH or high acidity slows and prevents the growth of microorganisms that could lead to spoilage or potential toxins that could cause illness 3. Water activity (moisture), temperature, nutrients, gases in the environment (i.e. oxygen) and time 4. This means when the pH is low the acidity is high and when the pH is high the acidity is low 5. Answers will vary. It depends upon the amount added, the ingredients in the food product, and personal taste preferences 6. 4.6 or below, as that is the standard to prevent the growth of C. botulinium a primary concern for canning foods.

Lab Report: Measuring and Manipulating the pH level of Egg Yolks

Name: _____ Date: _____

Introduction:

What is the purpose of this lab?

_____

_____

What do you hypothesize the results will indicate (or conclude)?

_____

_____

Results:

Sample	Water (mL)	Vinegar (mL)	pH strip color	pH reading	pH Meter reading
Yolk Slurry Standard	0	0	Orange		
1	2	0			
2	4	0			
3	6	0			
4	0	2			
5	0	4			
6	0	6			

Discussion:

Which substance, the water or vinegar, had an effect on the pH of the sample? Why is that?

_____

_____

_____

If this experiment were repeated, what could be done differently? Why?

_____

Interpretation/Conclusion:

Were the results as expected? What can be concluded from this experiment?

_____

_____

_____

_____

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_____

_____

Lab Report: Measuring and Manipulating the pH level of Egg Yolks (Teacher's Version – Answer Key)

Name: _____ Date: _____

Introduction:

What is the purpose of this lab?

The purpose of the acidified egg lab is to examine the effects an acid and a neutral solvent have on a low acid food by using different laboratory techniques to test the pH. And, to become familiar with using a pH meter.

What do you hypothesize the results will indicate (or conclude)?

Answers may vary. The acid (vinegar) will significantly lower the pH as more acid is added, and the water will have little to no effect on the pH of the egg slurry

Results:

Sample	Water (mL)	Vinegar (mL)	pH strip color	pH reading	pH Meter reading
Yolk Slurry Standard	0	0	Orange		6-6.5
1	2	0			
2	4	0			
3	6	0			
4	0	2			
5	0	4			
6	0	6			

*The pH strips should go from an orange to a dark green color as more vinegar is added.
*The pH reading should continuously decrease with the addition of vinegar and may vary depending on the slurry solution.
*The water has no effect on the pH and it shouldn't change with the addition of more water. The strips will maintain the same color.

Discussion:

Which substance, the water or vinegar, had an effect on the pH of the sample? Why is that?

Vinegar has a much lower pH value (higher acidity) than egg yolks, therefore when added to the solution, it will bring the overall pH level down, closer to that of vinegar. Water, has a pH of 7, which is neutral. This could eventually lead to a very "slight" increase in pH of the egg yolk slurry.

If this experiment were repeated, what could be done differently? Why?

Answers will vary. Possible answers: Add different amounts of vinegar; use a different acid.

Interpretation/Conclusion:

Were the results as expected? What can be concluded from this experiment?

Answers vary depending on hypothesis. The interpretation/conclusion may include some of the following statements:

- The addition of vinegar lowered the pH of the egg slurry.
- The vinegar had a much greater affect on the pH than the water.
- Water has a neutral pH – therefore it does not change the pH of the egg yolk sample (if anything, it could cause a very slight increase in pH).
- The decrease in pH did not decrease in a direct ratio with the addition of the vinegar. The slope of the line was curved downward, instead of straight.

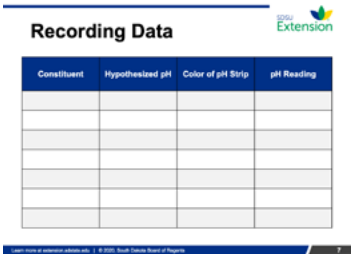
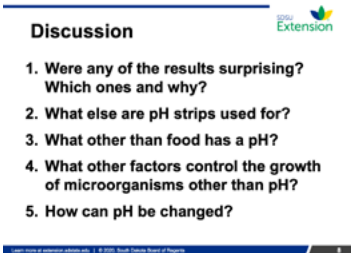
Slide	Notes
SDSU Extension **Procedure for Testing the pH of Various Foods** Hands-on module Food Safety Scientist Curriculum  	
Purpose of the Lab **What is pH?** The acidity of food is measured on a scale of 0-14. The lower the pH the higher the acidity **Why is pH important in food?** pH is a factor in food that contributes to the growth of microorganisms – yeast, mold, fungi and bacteria. Foods with a higher pH are more susceptible to microbial growth as opposed to highly acidic foods.	
Materials • pH paper • Sample Cups • pH meter (optional) • Buffers (for calibration) • Constituents with different pH levels 	
Constituents with Different pH Levels • pH can be tested with household items. If using pH test strips, consider examples that produce a noticeable color change.	

Constituent	pH
Liquid Drain Cleaner	14
Bleach	13
Soapy Water	12
Window Cleaner	11
Ammonia Cleaner	10
Baking Soda + Water	8
Club Soda	7
Raw Egg	7
Water	7
Milk	6

Constituent	pH
Canola Oil	6
Mouth Wash	5
Hand Soap	5
Hand Sanitizing Gel	4
Spaghetti Sauce	3
Apple Cider	3
Lemon Juice	2

Procedure 1. Pour different constituents into sample cups 2. Cut 8 cm strips of the pH paper 3. Dip the end of each strip into a sample 4. The strip will immediately change color in accordance to the pH 5. Compare the pH strip with the color guide to determine the pH 

Procedure
• If supplies are available, use a calibrated pH meter to test the constituents.
• Compare the pH strips with the pH meter reading.
  • Which method is more accurate? Why?
  • Which method is more likely used in a food safety laboratory? Why?
 

Slide	Notes
	
	1. Answers will vary. 2. Swimming pools, food processing, drinking water, soil testing, formulation of medicines, medical tests, and others 3. Soil, blood, saliva, chemicals, medicine, and others 4. Food nutrients, gases in the air, temperature, time, moisture (water activity), 5. Adding other constituents or ingredients.