Instructor Notes

You Are What You Eat: Chemical Residues and Consumers

The media frequently reports on harmful effects of pesticides, fertilizers, and other applied chemicals. Should we base our decisions on using these products solely on these reports? The purpose of this activity is to provide participants with a scenario in which they can examine issues, make judgments, and draw conclusions by performing their own experiments and making their own judgments. This is an essential role in environmental health science.

The objective of Part A of this activity is to determine how evidence gained from a simulated test for the presence of pesticide residues can be used to determine risk. Participants will also be able to illustrate the limitations in the testing process and in the interpretations of test results. In Part B, participants research the use of Alar and hold a class debate.

The activity is written for workshop participants and may need modification for classroom use.

Suggested Background Readings

- An Introduction to Toxicology
- The Scientific View of Risk

National Science Education Standards for Grades 5–12

Science as Inquiry

- Abilities Necessary to Do Scientific Inquiry

  Conduct scientific investigations. Students use evidence and apply logic to determine how evidence gained from a simulated test for the presence of pesticide residues can be used to determine the risk encountered by a population of consumers.

  Use mathematics to improve investigations. Students use mathematics to calculate the percentage of contamination found in a sample and use this value to estimate contamination in the entire population.

  Formulate scientific explanations using logic and evidence. Students base their explanations on what they observe during the pesticide residue simulation. As they develop cognitive skills, they differentiate explanation from description, provide causes for effects, and establish relationships based on evidence and logical arguments.

  Communicate and defend a scientific argument. The pesticide residue test encourages students to become competent at communicating experimental methods, following instructions, describing observations, and summarizing and communicating their results

to others. The Alar class debate offers the opportunity for students to explain statistical analyses, speak clearly and logically, construct a reasoned argument, and respond appropriately to critical comments.

- Understanding about Scientific Inquiry
  Scientific explanations must adhere to specific criteria. During the Alar class debate, students learn to be logically consistent, abide by the rules of evidence, be open to question and possible modification, and base explanations on historical and current scientific knowledge.

  Results of scientific inquiry emerge from different types of investigations and public communication among scientists. Students researching the Alar issue recognize that methods and procedures that scientists use to obtain evidence must be clearly reported to enhance opportunities for further investigation.

Science in Personal and Social Perspectives

- Natural and Human-Induced Hazards
  Human-induced hazards present the need for humans to assess potential danger and risk. Students learn that although pesticides and growth-regulating chemicals benefit society in some ways, they also create some risk. Important personal and social decisions are made based on perceptions of these benefits and risks.

Safety

As the instructor, you are expected to provide participants with the necessary safety equipment (including personal protective equipment such as goggles, gloves, aprons, etc.) and appropriate safety instruction to allow them to work safely in the laboratory. Always follow local, state, and school policies. Read and follow all precautions on labels and MSDSs provided by the manufacturer for all chemicals used.

Take appropriate precautions to avoid getting Windex® in the eyes. Handle the undiluted phenolphthalein with care because it can be absorbed through the skin and may cause unpleasant laxative effects.

Materials

For Getting Ready

- 2 containers with lids
- bag of dehydrated black-eyed peas
- paper towels
- rubbing alcohol (70%)
- 0.05 g phenolphthalein
- 500 mL ethanol
- 500 mL distilled water

For the Procedure, Part A

Per group

- well plate with at least 10 wells
- tweezers to handle peas
- stir sticks or craft sticks
- dropper bottle of Windex with ammonia D labeled "Pesticide Testing Solution"

Getting Ready

To prepare the phenolphthalein indicator solution, dissolve 0.05 g phenolphthalein in 500 mL ethanol, then add 500 mL distilled water and mix thoroughly.

The day before you do Part A, determine the number of peas you will need by providing at least 10 peas per group. Be sure to add some extra peas to the total in case of loss or damage. To rehydrate the peas, place about half of them in a container (with a lid), add enough phenolphthalein solution to cover the peas, and seal the container. This will be the "pesticide" group. Allow the peas to soak overnight. To test whether the rehydrated peas have absorbed the phenolphthalein, place a treated pea in a plastic cup and add a drop or two of Windex. You should see a pink color develop. If the pink color does not develop, allow the peas to soak longer. Before using the treated peas in class, rinse them well in tap water, place them on a paper towel, and blot dry.

The remainder of the peas should be soaked in rubbing alcohol in a sealed container overnight, then rinsed and blotted dry with a paper towel.

Seal the containers while the peas soak because both solutions evaporate quickly.

When ready for class, mix the two pea groups together so the sample becomes random; each set of 10 peas will vary slightly in the number of positive results.

Procedure Notes and Outcomes

For Part A: Pesticide Residue Testing

The three solutions needed for Part A—rubbing alcohol, Windex, and phenolphthalein—were chosen based on their availability. The "pesticide" (represented by phenolphthalein) internalizes due to the way it is spread, which is why one trial involves crushed peas. Thus, if a reaction is observed with a crushed pea where none was observed with the whole pea, that is acceptable. Sample data are shown on the next page. After doing the experiment, have participants answer questions 1–6. Many of the questions do not have concrete right or wrong answers, but typical answers based on the sample data are provided here.

For Part B: To Spray or Not to Spray? That Is the Question

The second part of this activity deals with Alar, a growth-regulating chemical sprayed on apples. In 1989, the Natural Resources Defense Council issued a report claiming that Alar was a potent cancer-causing agent. However, critics of that report pointed out that experimental rats had been fed Alar at concentrations equal to a human drinking 19,000 quarts of Alar-tainted apple juice per day. (See "An Introduction to Toxicology" background for a discussion of Alar.)

Divide the class into two groups. The first group's position is that Alar in any amount is unacceptable. The second group's position is that while Alar has been acknowledged to be a weak carcinogen, there are far worse dangers with our food.

Conduct a class debate in which each group presents their assigned position. To express their positions, participants must obtain information to substantiate their claims. After the debate, have participants answer question 7 based on all the information presented.

Sample Data

Observation Table			
Well	Pea Only	Pea + Solution	Crushed Pea + Solution
1	No visible pesticide residue	no color change	no color change
2	No visible pesticide residue	no color change	no color change
3	No visible pesticide residue	pink	pink
4	No visible pesticide residue	no color change	no color change
5	No visible pesticide residue	no color change	no color change
6	No visible pesticide residue	no color change	pink
7	No visible pesticide residue	pink	pink
8	No visible pesticide residue	no color change	no color change
9	No visible pesticide residue	no color change	no color change
10	No visible pesticide residue	pink	pink

Plausible Answers to Questions

1. Were you able to determine which peas had pesticide residue just by looking at them? Why or why not?
   No; the residue was invisible.

2. What changes, if any, did you observe when you added the pesticide testing solution to the peas? Based on your observations, which peas do you believe contain trace amounts of pesticides?
   The peas that contained pesticide residue turned pink. No color changes occurred in the uncontaminated peas.

3. How many peas exhibited a positive test for pesticide, both in your group and in the class?
   The sample data shows that four peas were contaminated. Class results will vary.

4. How could you mathematically calculate the percentage of contamination found in your sample group? How could you mathematically calculate the percentage of contamination found within the class sample? Show your calculations and label the answers.
   The following equation can be used to calculate the percentage of contamination:

$$\frac{\text{number of peas testing positive for pesticides}}{\text{total number of peas}} \times 100\% = \text{percentage of contamination}$$

5. Why may these percentages differ from one another?
   Group data will vary, but overall class data should average out to approximately 50% contamination.

6. What contamination level (percent) do you feel would make the peas unsafe to eat? What were some of the issues you considered when making this decision? What other information would you like to have had when making your decision? What other questions would you have asked?
   Answers will vary, but participants should consider the median level of the pesticide among the contaminated peas, quantity of peas per meal, frequency of meals with these peas, and that this is a systemic pesticide. Participants should also consider what is known and not known about the contaminant. For example, does the contaminant cause adverse side effects like cancer, and what are the particular risks for children and the unborn?

7. Many people believe organic food is the answer to living a healthy lifestyle, as chemical pesticides and fertilizers are not used in growing these fruits and vegetables. What is your response to this view, and why do you feel that way?
   Answers will vary. Participants should be aware that standards for organically grown food have only recently been established. A good resource is the National Organic Program website at http://www.ams.usda.gov/nop.

Activity Instructions

You Are What You Eat: Chemical Residues and Consumers

In Part A, you and your team members play the role of a special investigation committee employed by a consumer safety advocacy association to look into pesticide residues that are found on common food products. You will be testing peas for the presence of a systemic pesticide, one that must be contained in the water of an irrigation system instead of being sprayed or dusted. When watered, the pea plants absorb the pesticide through the root system, so it is more evenly distributed. The pesticides must be applied according to state regulations that provide for a period of time between the date of the last application and the date of harvest. These strict regulations are in place to make sure the pesticide breaks down into less toxic forms, making the peas safe for marketing, drying, or further processing. You are to test this particular shipment of peas by adding test solution to the rehydrated peas. This testing procedure is destructive to the product and relies on statistical methods. Your job is to determine how evidence gained from this test for the presence of simulated pesticide residues can be used to determine the risk encountered by a population of consumers.

In Part B, you investigate Alar and debate the risks and benefits of its use.

Safety

In a laboratory setting, you are ultimately responsible for your own safety and for the safety of those around you. It is your responsibility to specifically follow the standard operating procedures (SOPs) which apply to you, including all local, state, and national guidelines on safe handling, storage, and disposal of all chemicals and equipment you may use in the labs. This includes determining and using the appropriate personal protective equipment (e.g., goggles, gloves, apron). If you are at any time unsure about an SOP or other regulation, check with the course instructor.

Procedure

Part A: Pesticide Residue Testing

1. Label the wells 1–10 with the marker.
2. Use tweezers to place one pea in each well. Observe the overall appearance of the pea and write its description in the appropriate space in Table 1.
3. Add 10–20 drops of "Pesticide Testing Solution" to each pea. Inspect the peas closely and record your observations in the table.

4. Mash the pea in the first well with your stir stick, add 10 more drops of the "Pesticide Testing Solution", and mix well. Record your observations and repeat this procedure with the remaining nine peas. Make sure you wipe off the stick after stirring each well (or use a new stick each time).
5. Answer questions 1–6.

Table 1: Observation Table

Well	Pea Only	Pea + Solution	Crushed Pea + Solution
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Part B: To Spray or Not to Spray? That Is the Question!

Is your food safe to eat? How much contamination of food products is reasonable, if any at all? You will be assigned a position to debate regarding the use of Alar on apple crops. Use the library, search the Internet, write federal agencies, contact hospitals, talk to scientific lab research teams, or use any other reliable resources to find out about Alar and its history so that you can express an intelligent argument for your position. After hearing all sides of the issue, answer question 7.

Questions

1. Were you able to determine which peas had pesticide residue just by looking at them? Why or why not?
2. What changes, if any, did you observe when you added the pesticide testing solution to the peas? Based on your observations, which peas do you believe contain trace amounts of pesticides?
3. How many peas exhibited a positive test for pesticide, both in your group and in the class?

4. How could you mathematically calculate the percentage of contamination found in your sample group? How could you mathematically calculate the percentage of contamination found within the class sample? Show your calculations and label the answers.
5. Why may these percentages differ from one another?
6. What contamination level (percent) do you feel would make the peas unsafe to eat? What were some of the issues you considered when making this decision? What other information would you like to have had when making your decision? What other questions would you have asked?
7. Many people believe organic food is the answer to living a healthy lifestyle, as chemical pesticides and fertilizers are not used in growing these fruits and vegetables. What is your response to this view, and why do you feel that way?