IS IT DONE YET? HEAT TRANSFER IN THE KITCHEN

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Annotation:
In this guided inquiry laboratory exercise, students will examine the methods of heat transfer as applied in common cooking methods as they determine which method of heat transfer is most effective in cooking a skinless, boneless chicken breast filet.

Primary Learning Outcome:
Students will be able to identify common cooking methods as examples of the three types of heat transfer: conduction, convection, and radiation.

Students will describe factors influencing the efficiency of heat transfer.

Additional Learning Outcomes:
Students will relate heat transfer to physical and chemical changes occurring during the cooking process.

Students will relate heat transfer to food safety.

Georgia Performance Standards:
Characteristics of Science
SCSh2. Students will use standard safety practices for all classroom laboratory and field investigations.

SCSh3. Students will identify and investigate problems scientifically.

SCSh4. Students use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.

SCSh5. Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.

SCSh6. Students will communicate scientific investigations and information clearly.

SCSh8. Students will understand important features of the process of scientific inquiry.

Physical Science Content
SPS7. Students will relate transformations and flow of energy within a system.

Physics Content
SP3. Students will evaluate the forms and transformations of energy.

Duration:
Preparation: 30-45 minutes
Introduction: 10 minutes
Lab Exercise: 45 minutes
Conclusion: 30 minutes
Total Class Time: 85 minutes

Materials and Equipment:

1. 2 Single-Burner Electric Stoves
2. Electric Deep Fryer
3. George Foreman Grill
4. Toaster Oven
5. Rotisserie
6. 8" Non-Stick Frying Pan
7. 2-qt. Stockpot
8. 6 Pairs of Tongs
9. 6 Pairs of Oven Mitts
10. 6 Meat Thermometers
11. 6 Kitchen Timers
12. Boneless, Skinless Chicken Breasts
13. Kitchen Knives
14. Cutting Boards
15. Food Scale
16. 32 oz Vegetable Oil
17. Aprons and Goggles

For optional flavor and texture exercise:

1. *Chicken breasts cooked by teacher using each of six cooking methods tested in lab*
2. *Small plates and/or napkins*
3. *Toothpicks*

Safety:
The primary safety concern in this laboratory exercise is the heat produced during cooking. Ensure that students wear dry oven mitts and use caution when handling hot objects. Caution should also be used when cutting chicken as knives are sharp. Do not allow students to eat chicken prepared in the lab. Chicken to be eaten by students should be prepared outside of the lab using food-grade products and cookware.

Technology Connection:
Students should use internet resources to research answers to extension questions.

Procedures:
Teacher Preparation:
The teacher should prepare the chicken breast filets ahead of time. One 5-lb. bag of frozen boneless, skinless chicken breast filets should provide enough chicken for about 20 lab groups. Trim filets to 50 g portions. Make the portions as uniform as possible in terms of size, thickness, and mass.

Introduction:
Ask students to draw on their previous experiences to compile, as a class, a list of possible cooking methods. Discuss with the students the reasons for cooking food (*e.g.* safety, flavor enhancement, etc.). Further, ask them to identify alternatives to cooking (*e.g.* drying, curing, etc.). As a class, classify the possible cooking methods according to the method of heat transfer

(*i.e.* conduction, convection, radiation) involved. This list will likely include the six cooking methods selected for testing. Introduce the six cooking methods that will be tested during the laboratory exercise: stovetop pan-cooking, boiling, electric indoor grilling, deep frying, rotisserie, and broiling in a conventional oven. Inform students that they will design an experiment that uses these cooking methods to determine which method of heat transfer is most effective at cooking a skinless, boneless chicken breast. Lead students in a discussion of the experimental design: including variables, setup, and data collection. The first issue to be addressed in the experimental design is what effective means in terms of the experiment. Inform students, without explanation, that chicken is considered to be fully cooked when it reaches an internal temperature of 170^{o}F. Students will explore the scientific basis for this fact in their extension questions. Ask students to individually develop a hypothesis explaining which method of heat transfer will prove to be most effective and why. Assign one cooking method to each lab group. *NOTE: Even though this is described as a guided inquiry activity, an experimental procedure is provided below. The activity is straightforward enough that students will likely derive a procedure quite similar to the one provided, so it is provided only for planning purposes.*

Lab Exercise:
Students should first collect materials appropriate to the assigned cooking method. Every group should have tongs, oven mitts, meat thermometer, and kitchen timer. Each group should then obtain a 50 g sample of boneless, skinless chicken breast and cook the sample following standard cooking practices for the assigned method. Students should use a meat thermometer to measure the initial temperature of their chicken sample. Students will then measure and record meat temperature every thirty seconds to one minute during the cooking process. All temperature readings should be taken from the center of the chicken sample. Each experiment will terminate when the sample temperature reaches 170^{o}F. Upon completion of all cooking, students should observe chicken samples prepared by each of the six cooking methods. Students should record observations of color and texture of each of the chicken samples. *(Optional: Chicken prepared by the teacher prior to class, using each of six cooking methods, is presented to the students for tasting. Students should observe the flavor of each sample and record any differences. Students should rank the six cooking methods according to flavor and texture preferences.)*

Conclusion:
Class data may be compiled on the board. Students should construct a graph to display the cooking times of the various methods and determine the method of heat transfer that resulted in the shortest cooking time. Students should also compile preference rankings for each cooking method and discuss any correlation, or lack thereof, between cooking time and preference ranking. As a class, discuss with students the experimental results of the laboratory exercise. Provide the students with instruction on the laboratory write-up.

Post-laboratory Write-up:
Students should answer the following questions based on the data they collect during the exercise:

1. Identify the method of heat transfer associated with each of the six cooking methods tested.

2. Which method of heat transfer proved to be most effective in this experiment? Why do you believe this was the most effective method?
3. What are some factors that might have influenced the accuracy of our results?
4. To improve this lab, what would you change? Why?

The following extension questions should be answered independently based on student research:

1. Describe the physical and chemical changes that occur in chicken during cooking.
   Sample Answer: The main physical change that occurs while cooking chicken is the rise in temperature of the meat. This occurs because the chicken absorbs heat from the cooking appliance (oven, grill, etc.). We know this is a physical change because it is completely reversible. The chicken will cool to its original temperature if we leave it on the counter or place it in the refrigerator after it is cooked. Water in the meat may also be converted to steam, resulting in the cooked chicken having a smaller mass than when it was raw. The major chemical change that occurs in cooking chicken involves the proteins that make up the majority of muscle tissue. Proteins are large, long polymers made up of chains of amino acids. In living tissue, these chains exist as folded shapes that are held together by chemical bonds. The high heat of the cooking process causes these bonds to break and the proteins to lose their shape. This causes the proteins to coagulate, or intertwine, and the meat to become firm. The color of the meat is also changed by this reaction as it goes from the pink of raw chicken to the white color of fully cooked chicken. This process is very obvious in frying an egg, which is also a high-protein food. Because chemical bonds are broken and this change cannot be reversed, we know that it is a chemical change. Cooking methods that sear the surface of chicken, such as grilling or pan frying, also cause chemical changes. In this case, proteins and fats on the surface of the chicken are partially combusted and react with one another to form new compounds that add flavor to the chicken.
   http://www.ag.auburn.edu/~ckerth/2710/lec%20notes/Sizzle.pdf.

2. Why does chicken need to be cooked to an internal temperature of 170^{o}F?
   Sample Answer: Because chicken, and other meats, are protein rich and of animal origin, they carry an increased risk of food-borne illness. Bacteria found in living animals may still be present in raw meat products. The proteins in meat are important food sources for bacteria and can sustain their growth. The most important concern in chicken is Salmonella bacteria. Salmonella cause severe diarrhea, fever, and abdominal cramps in people lasting four to seven days. Salmonella and other food-borne bacteria cannot live at high temperatures. Therefore, cooking chicken to an internal temperature of 170^{o} F ensures that the cooked food is free from disease-causing bacteria. Related weblinks:http://www.cfsan.fda.gov/~dms/fttmeat.html;
   http://www.cfsan.fda.gov/~dms/fttextra.html#heat;
   http://www.cdc.gov/ncidod/dbmd/diseaseinfo/salmonellosis_g.htm;
   http://www.cfsan.fda.gov/~dms/ftt-411.html.

3. Describe how each of the three methods of heat transfer can be involved in cooking foods on a backyard barbeque grill.

There are two basic methods of grilling on a barbeque grill. In direct cooking, food is placed directly above the heat source (e.g. the coals on a charcoal grill), and cooked at a high temperature for a short period of time (up to 30 minutes). In indirect cooking, the food is placed away from the heat source in the grill. For example, food may be placed in the center of a charcoal grill while the coals are placed at the edges of the grill. This food is cooked at a lower temperature for a longer period of time. In each of these methods, heat is transferred from the hot grill grate to the food through conduction resulting in the grill marks that we associate with grilled foods. In the direct grilling method, the primary method of heat transfer is radiation from the heat source to the food. In the indirect grilling method, the primary method of heat transfer is convection as heat is transferred from the heat source to the food through movement of air within the closed grill. Related weblinks:
http://www.weberbbq.com/bbq/pub/recipe/grilling101/directindirect.aspx; http://www.barbecuen.com/heat.htm.

Assessment:

Students should be assessed based on their laboratory write-ups. Assessment should be based on process skills demonstrated during the laboratory exercise, reproducibility of experimental procedures (*i.e.* could you recreate their experiments based only on their lab notes), and quality of post-laboratory write-up and interpretations. In answering post-laboratory discussion questions, students should demonstrate an understanding of the methods of heat transfer as applied in common cooking methods. They should also demonstrate an understanding of the role of heat transfer in food safety and of the chemical and physical changes occurring during the cooking of chicken.

IS IT DONE YET? HEAT TRANSFER IN THE KITCHEN. *Student Handout*

Introduction:
We all know that we get energy from food, but have you ever stopped to think that before we eat most foods, we have to add energy to them in the form of heat. That's right, the key to cooking, baking, frying, *etc.* is energy, or heat, transfer.

Cooking, baking, and frying are only few of the many cooking methods that people use everyday. Each of these methods relies on one or more of the three methods of heat transfer (*i.e.* conduction, convection, and radiation) to produce the desired results.

In this activity you will design an experiment that compares several cooking methods in order to determine which method of heat transfer is most effective at cooking a skinless, boneless chicken breast.

Terms:
Define the following.

- Conduction

- Convection

- Radiation

Purpose:
To determine which method of heat transfer is most effective in cooking a skinless, boneless chicken breast.

Materials:

1. Assigned cooking appliance
2. Tongs
3. Oven mitts
4. Meat thermometer
5. Kitchen timer
6. 50g Portion of a boneless, skinless chicken breast
7. Apron and Goggles

Procedure:
In your laboratory notebook, describe the procedure developed with your class. Describe the variables, setup, and data collection procedures.

Results and Analysis:

1. Identify the method of heat transfer associated with each of the six cooking methods tested.
2. Which cooking method proved to be most effective in this experiment? Why do you believe this was the most effective method?
3. What are some factors that might have influenced the accuracy of our results?
4. To improve this lab, what would you change? Why?

Discussion & Conclusions:

1. Describe the physical and chemical changes that occur in chicken during cooking.
2. Why does chicken need to be cooked to an internal temperature of 170^{o}F?
3. Describe how each of the three methods of heat transfer can be involved in cooking foods on a backyard barbeque grill.