

**October/November 2016 Teacher's Guide for**

***Expiration Dates: What Do They Mean?***

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# About the Guide

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Articles from past issues of *ChemMatters* and related Teacher’s Guides can be accessed from a DVD that is available from the American Chemical Society for $42. The DVD contains the entire 30-year publication of *ChemMatters* issues, from February 1983 to April 2013, along with all the related Teacher’s Guides since they were first created with the February 1990 issue of *ChemMatters*.

The DVD also includes Article, Title, and Keyword Indexes that cover all issues from February 1983 to April 2013. A search function (similar to a Google search of keywords) is also available on the DVD.

The *ChemMatters* DVD can be purchased by calling 1-800-227-5558. Purchase information can also be found online at <http://tinyurl.com/o37s9x2>.

# Student Questions

**Expiration Dates: What Do They Mean?**

* 1. Why do foods spoil even after they are packaged?
	2. What initiates the chemical reactions that cause food to spoil?
	3. What are unsaturated fatty acids?
	4. Describe the three-step process that occurs when unsaturated fatty acids present in oils are converted to the molecules that are responsible for rancid odors and flavors in foods?
	5. Why do many fruits and vegetables turn brown after they are cut?
	6. Explain what happens during caramelization of sugars.
	7. Does the U.S. government require expiration dates on all packaged food?
	8. What information does an expiration date stamped on food packaging give a consumer?
	9. Compare the three main types of expiration dates?
	10. How can you know when a food is past its prime?
	11. Is food still safe to eat after the expiration date has passed?

# Answers to Student Questions

**(taken from the article)**

**Expiration Dates: What Do They Mean?**

* + 1. **Why do foods spoil even after they are packaged?**

*Foods spoil after they are packaged because “… the molecules that give foods their appetizing flavors, smells, textures, and colors … break down or chemically react with other substances to produce unappealing—or even dangerous—substances.”*

* + 1. **What initiates the chemical reactions that cause food to spoil?**

*The chemical reactions that cause food to spoil are initiated when food molecules are exposed to*

1. *oxygen,*
2. *high temperatures, or*
3. *enzymes in the food.*
	* 1. **What are unsaturated fatty acids?**

*Unsaturated fatty acids are “… long chains of carbon and hydrogen atoms, with one or more double bonds between the carbon atoms.”*

* + 1. **Describe the three-step process that occurs when unsaturated fatty acids present in oils are converted to the molecules that are responsible for rancid odors and flavors in foods?**

*The three steps involved in oils converting to molecules responsible for rancid odors and flavors are:*

1. *the unsaturated fatty acid reacts with a reactive oxygen species, such as the hydroxyl radical (OH●), forming a fatty acid radical,*
2. *the fatty acid radical reacts with oxygen, leading to a molecule called a fatty acid peroxyl radical,*
3. *the fatty acid peroxyl radical reacts with the original fatty acid to produce molecules that are responsible for rancid odors and flavors.*
	* 1. **Why do many fruits and vegetables turn brown after they are cut?**

*Some fruits and vegetables turn brown after they are cut because they contain an enzyme called polyphenol oxidase (PPO) and molecules called phenols. These molecules are kept separate when the fruit in uncut. Cutting the fruit exposes the two molecules to each other and to oxygen in the air. PPO causes the phenols to react with oxygen, producing brown pigments.*

* + 1. **Explain what happens during caramelization of sugars.**

*“Caramelization is the oxidation of sugars, which causes them to break down into simpler sugars and into other compounds.” Some of these compounds are the brown-colored substances of caramelization.*

* + 1. **Does the U.S. government require expiration dates on all packaged food?**

*The U.S. government requires dates on the packaging of baby formula and some kinds of baby food, but it does not require them on other food packaging.*

* + 1. **What information does an expiration date stamped on food packaging give a consumer? What does it *not* tell you?**

*The expiration date stamped on food packaging is primarily used to tell you about the quality of the food. After a given date the food may not taste as good or have all the nutritional value that it had earlier. The expiration date does* **not** *tell if the food is safe to eat.*

* + 1. **Compare the three main types of expiration dates.**
1. *“Best before” and “Best by” tell you that a food does not have the same quality or does not taste the same after that date. Their nutritional quality may still be alright, but they may not taste as good.*
2. *“Sell by” is an inventory aid for the grocer, so that he removes the item from his inventory after that date. The item should still be good after this date.*
3. *“Use by” is similar to “Best by” in that it indicates the quality of the item but it has been determined by the manufacturer that it is no longer at its peak quality after this date and may taste stale, have less nutritional value, or be less effective as a cooking ingredient.*
	* 1. **How can you know when a food is past its prime?**

*To know if a food is past its prime you generally have to be able to examine the food—look at it, smell it, and possibly taste it. Even then, you may not be able to tell if the food has passed its prime.*

* + 1. **Is food still safe to eat after the expiration date has passed?**

*Usually if food has been store properly and the container is still in good shape, the food will be safe to eat after the expiration date, although this depends on the type of food. If the food is labeled with the “Use by” date, the food may not be safe to eat after this date.*

# Anticipation Guide

Anticipation guides help engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss students’ responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.

**Directions:**  *Before reading*, in the first column, write “A” or “D,” indicating your agreement or disagreement with each statement. As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. At some point, all foods spoil because of chemical changes.
 |
|  |  | 1. The products of the oxidation of vitamin C have the same flavor and nutritional value as vitamin C.
 |
|  |  | 1. Oil becomes rancid when exposed to oxygen in the air.
 |
|  |  | 1. Rancid odors and flavors are produced in a one-step chemical reaction.
 |
|  |  | 1. When apples are uncut, the enzyme that causes browning is separated from compounds that react with oxygen.
 |
|  |  | 1. Caramelization (production of simple sugars) can occur when cooking vegetables.
 |
|  |  | 1. Caramelization is always desirable.
 |
|  |  | 1. Food must be stored properly for expiration dates to have meaning.
 |
|  |  | 1. The FDA regulates expiration dates on food sold in the United States.
 |
|  |  | 1. As a general rule, you should never eat food past its expiration date.
 |

# Reading Strategies

These graphic organizers are provided to help students locate and analyze information from the articles. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher if students are struggling. Encourage students to use their own words and avoid copying entire sentences from the articles. The use of bullets helps them do this. If you use these reading strategies to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

***Teaching Strategies (for entire October/November 2016 issue):***

* Links to **Common Core Standards for Reading**:
	+ ELA-Literacy.RST.9-10.1:Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
	+ ELA-Literacy.RST.9-10.5: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
	+ ELA-Literacy.RST.11-12.1:Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
	+ ELA-Literacy.RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
	+ Links to **Common Core Standards for Writing**:
	+ ELA-Literacy.WHST.9-10.2F: Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
	+ ELA-Literacy.WHST.11-12.1E: Provide a concluding statement or section that follows from or supports the argument presented.
	+ **Vocabulary** and **concepts** that are reinforced in this issue:
	+ Forensic science
	+ Molecular structures
	+ Polar and nonpolar molecules
	+ Wavelengths of light
	+ Chemical reactions
	+ Personal and community health
	+ Heavy metals
	+ Conservation of matter
	+ Consumer choices
	+ Some of the articles in this issue provide opportunities for students to consider how understanding chemistry can help them make informed choices as consumers.
	+ To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles. The Background Information in the *ChemMatters* Teachers Guide has suggestions for further research and activities.
	+ In addition to the writing standards above, consider asking students to debate issues addressed in some of the articles. Standards addressed:
	+ **WHST.9-10.1B** Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and **counterclaims** in a discipline-appropriate form and in a manner that anticipates the audience’s knowledge level and concerns.
	+ **WHST.11-12.1.A** Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

**Directions:** As you read the article, complete the graphic organizer below to describe

|  |  |  |
| --- | --- | --- |
| **Reasons food can go bad** | **How food is affected** | **Chemicals involved** |
| **Oxygen exposure** |  |  |
| **High temperatures** |  |  |
| **Enzymes in food** |  |  |

**Summary:** On the back of this paper, explain in a sentence or two how your new understanding expiration dates will affect your food choices.

# Connections to Chemistry Concepts

**(for correlation to course curriculum)**

1. **Chemical Reactions**—Food can lose its freshness and become spoiled through a variety of chemical reactions.
2. **Oxidation and reduction**—Most reactions involved in food decomposition are oxidation-reduction reactions that can be deterred by preventing food from coming in contact with oxygen.
3. **Enzymes**—Enzymes such as polyphenol oxidase in food react best in neutral conditions. Changing the pH or temperature can deter enzymatic browning in foods.
4. **Kinetics**—The rate of chemical reactions is affected by temperature, pH, and surface area, all of which are used to prolong the shelf life of food. Not all foods spoil at the same rate.
5. **Organic chemistry**—The reaction between unsaturated fatty acids and oxygen is responsible for the rancid odors and flavors that are formed in food spoilage.
6. **Polymers**—Plastic wraps are used to keep food in an air-tight environment.
7. **Acids and pH**—In solutions of a certain pH, some molecules in food will oxidize, changing the food’s original health benefits and flavor. The acids in lemon juice or vitamin C can be used to prevent this enzymatic browning in fruits like apples and peaches.

# Possible Student Misconceptions

**(to aid teacher in addressing misconceptions)**

1. **“I thought all food should be thrown out after the date on the packaging. That’s what we do at our house.”** *Dates on packages are suggestions for the time when the food is in its prime. They do not always refer to the safety involved with eating that food. When the packaging was opened and how the item was stored both impact the safety of the food. Food can become unsafe to eat before the expiration date if it has not been stored properly.*
2. **“We don’t throw any food out at our house.”** *That’s great. Some households are very conscientious about food waste, and they may compost leftover, spoiled food or maintain a “slop bucket” of food scraps to feed farm animals. For others, food is scraped off the plate into the garbage disposal which is another source of food waste—unfortunately one that is hard to monitor. Food waste consists of peels removed before using the food and food left uneaten on plates as well as any food that may be tossed out due to being past the expiration date.*
3. **“I never worry about dates on food when I’m shopping. The grocer takes care to remove all the food that’s beyond its expiration date.”** *While most grocers are very good at updating and managing their inventory, some items that are outdated can be overlooked and remain on the shelf past the date on the product.*
4. **“You get food poisoning from eating old food.”** *Food poisoning is caused by eating food that has been contaminated with pathogenic bacteria or its toxins. The microbes that cause food to eventually rot are generally nonpathogenic. Milk that has soured would still be safe to drink, though it might not taste very good. It could also be used in recipes calling for sour milk.*
5. **“As long as hamburgers are cooked, they are safe to eat.”** *Hamburgers should be cooked until the internal temperature is at 160 °F. Hamburgers that are rare usually have not reached this internal temperature and may still harbor live bacteria.*

# Anticipating Student Questions

**(answers to questions students might ask in class)**

1. **“Will I get sick if I eat food that has passed its expiration date?”** *Whether food is safe to eat is different from how fresh it is. If the food has been stored appropriately and its container is still in good condition, it is very likely that the food is safe to eat past the expiration date, and you probably will not get sick from eating it. If food has not been stored or treated safely, then often it can make you sick, sometimes even before the expiration date. Visual examination and smell are two additional ways of checking food to determine if it has gone bad.*
2. **“How long past the expiration date can I safely eat an item?”** *This depends on the item. The expiration date is normally a date designating when the product is nearing the end of its peak condition. An exception is in foods such as hotdogs and unpasteurized milk and cheeses that may harbor Listeria which can grow at refrigerator temperatures. These items it would be best to discard after the “Use by” date.*
3. **“Is it safer to use frozen food rather than canned food?”** *Both methods of preserving food are safe if done correctly. It becomes a matter of taste preference and storage space that often dictates which type of preserved food a person uses. Consumers are encouraged to freeze more food before the date on the label rather than throw it out. Freezing is more convenient and takes less time than canning.*
4. **“I have a can of tomato paste at home whose ends are a bit convex (bowed out). Will this be ok to use to make spaghetti?”** *No. A can that is bulging indicates a gas has been formed inside the can due to anaerobic bacterial activity or food decomposition. Any can that is not in good condition should be discarded. Sometimes cans that are dropped get bent but the food is still good inside. Bent cans, though, must be monitored more closely to make sure the integrity of the can and the food it contains were not compromised.*

# Activities

**Labs and Demos**

1. **Lab about enzymatic browning:** This is a lab activity that explores the factors affecting the browning of apples—enzymatic browning. Procedure and data table printouts are included. ([www.curriculumsupport.education.nsw.gov.au/secondary/science/assets/aifst/Experiments/apple\_browning.pdf](http://www.curriculumsupport.education.nsw.gov.au/secondary/science/assets/aifst/Experiments/apple_browning.pdf))
2. **Caramelization Lab:** This activity is written for the student to perform at home. The student will need sugar, water, a pan, a candy thermometer, and several spoons. Essentially a solution of sugar is cooked until it caramelizes. Samples of the solution are set aside and the temperature noted for each sample. The student then describes the color, texture, and taste of each sample. You could assign this as a take home lab, or it could be modified to be done in class. If done at school, the students should not be allowed to taste their product unless the lab was done in a kitchen facility with utensils that are used for food. (<http://www.sciencebuddies.org/science-fair-projects/project_ideas/FoodSci_p018.shtml>)
3. **Another Caramelization Experiment** is described by Harold McGee, in an article on the “Curious Cook” Web site. His experiments could be adapted for an interesting classroom demonstration, project, or lab. Recent research shows sugar does not have to melt before it caramelizes. He uses large sugar crystals and heats them in an oven at different temperatures to observe the color transformation. (<http://www.curiouscook.com/site/2012/09/caramelization-new-science-new-possibilities.html>)
4. **Lab explores the difference in bacteria content in pasteurized milk and ultra-high-temperature (UHT) treated milk:** “Blue’s the Clue” is designed to explore pasteurized milk and UHT milk, which have distinctly different expiration date ranges. This lab explores one reason why UHT milk can be stored unopened at room temperature for such a long time. A methylene blue indicator is added to a sample of both milks. As bacteria in the samples multiply the oxygen level decreases. In an oxygen poor environment the methylene blue becomes colorless. The rate at which the blue color disappears from the milk is directly related to the amount of bacteria present. Instructions for this lab can be found in module 3 in the *Science and Our Food Supply* curriculum supplement described below in “Lesson Plans”. The curriculum package can be accessed here: [www.fda.gov/downloads/Food/FoodScienceResearch/ToolsMaterials/UCM430367.pdf](http://www.fda.gov/downloads/Food/FoodScienceResearch/ToolsMaterials/UCM430367.pdf).
5. **The old standard “Blue Bottle Demo” shows the oscillating reaction of methylene blue in an alkaline glucose solution:** This demonstration could be used with the “Blue’s the Clue” lab (#4 above) in Module 3 in the *Science and Our Food Supply* curriculum supplement. Methylene blue is added to an alkaline solution of glucose. Upon setting, the blue color disappears. When the bottle is shaken, the blue color reappears as oxygen is dissolved back into the system. This cycle can be repeated several times before the reaction is depleted. Instructions for this classroom demonstration can be found here: <https://www.flinnsci.com/media/621281/91536.pdf>.

**Media**

1. **Food waste, a Ted Talk video:** “A Recipe for Cutting Food Waste” (14:37) by Peter Lehner addresses several aspects of the food waste problem in the U.S., including misinterpretation of date labels on food. (<https://youtu.be/UwOHpWTRsbE>)
2. **Videos on food waste:** This site provides links to four videos that address the food waste problem.
	1. “Tossed Out” (28:16): a documentary that explores the food waste problem
	2. ”Inside a landfill” (1:56): a description of how communities analyze what is going into their landfills and where it is coming from.
	3. “Studying a family’s food waste” (3:21): One family‘s participation in a food waste study is taped.
	4. “Trash to glass” (2:33): One scientist’s answer to using components found in the waste stream to make glass.

(<http://harvestpublicmedia.org/content/tossed-out>)

1. **Public service announcement on food waste:** This short (1:00) public service announcement, titled “The Extraordinary Life and Time of Strawberry”, concerns preventable food waste. It follows a strawberry from farm to table to dumpster. It would make a good introduction to a discussion on food waste. (<https://www.youtube.com/watch?v=WREXBUZBrS8>)
2. **Video on global food waste:** This short (3:08) video titled “Food Matters: Food Waste How and why 40 percent of our food goes uneaten” addresses the global problem of food waste, including the part that misinterpretation of date labels plays in encouraging waste.

(<https://nrdc.org/stories/food-matters-food-waste>)

1. **Video on food safety rules:** For a fun video (3:27) that introduces the four rules of food safety, visit the kitchen of Martie Duncan, where she prepares food for her family and friends to eat while watching the Super Bowl. (<https://www.foodsafety.gov/keep/events/superbowl/index.html>)
2. **Foodkeeper App:** The Foodkeeper app can be downloaded to phones or tablets for quick information on food storage recommendations and other food safety tips. It would be a good tool to use while shopping or consulting safe storage methods once home. Information on this app with access to a sample can be found here: [www.fmi.org/industry-topics/consumer-affairs/food-keeper-food-storage-database](http://www.fmi.org/industry-topics/consumer-affairs/food-keeper-food-storage-database).
3. **Video on solutions to food waste:** “Shrinking America’s Food Waste Mountain” is a video (2:36) that addresses current congressional efforts and goals for attacking the problem of food waste. Included are two statements from Senator Blumenthal about the role congress is taking. (<http://www.usatoday.com/videos/news/nation/2016/08/11/88553718/>)
4. **PowerPoint presentation with audio:** (12:15) This PowerPoint presentation developed by the CDC presents information about food safety: [www.cdc.gov/winnablebattles/101/FoodSafety/index.html](http://www.cdc.gov/winnablebattles/101/FoodSafety/index.html).
5. **Video on oxidative rancidity experiments**: (5:31) A food scientist performs several experiments showing environmental effects on oxidation in oils. He concludes with promoting food science as a fun career. (<https://www.youtube.com/watch?v=1jhMw7Y9DI0>)
6. **YouTube video comparing oxidative and hydrolytic rancidity:** This blackboard lecture uses chemical formulas to illustrate the reactions of oxidative and hydrolytic rancidity. (1:16) (<https://www.youtube.com/watch?v=UHbrnwRN-hc>)

**Lessons and Lesson Plans**

1. **“Science and our Food Supply”**, developed by the National Science Teachers Association (NSTA) and FDA, is a supplemental curriculum consisting of 5 modules complete with lesson plans, classroom activities and inquiry labs designed for high school classrooms. There is a 45 minute video, *Dr. X and the Quest for Food Safety*, which is divided into 5 modules. Most of the 7 labs in the curriculum involve working with bacteria and require the use of petri dishes. In Module 3, The “Blue’s the Clue” lab uses methylene blue in samples of pasteurized milk and UHT (ultra-high temperature) milk to monitor resistance to bacterial growth to see which milk still contains bacteria. There is also an “Irradiation Web Quest” that would make a good classroom activity if technology is available. In Module 4, the 4 C’s of food safety are introduced and the corresponding labs deal with an investigation for each “C”. Module 5 concludes with an “Outbreak Investigation Case Study”. The assessment piece for the unit is a game patterned after “Who Wants to be a Millionaire” but is titled “Lose a Million Bacteria”. ([www.fda.gov/downloads/Food/FoodScienceResearch/ToolsMaterials/UCM430367.pdf](http://www.fda.gov/downloads/Food/FoodScienceResearch/ToolsMaterials/UCM430367.pdf))

(The video *Dr. X and the Quest for Food Safety* can be found here: <http://www.fda.gov/Food/FoodScienceResearch/ToolsMaterials/ucm182117.htm>)

1. **“Food Recovery and its Role in Climate Change”** is the focus of the lessons that can be found at the “Rock and Wrap it Up” website. There are two sets of lesson plans that present food recovery as it relates to poverty and to climate change. The first set of lesson plans concentrate on food recovery and the second set of plans relate to climate change. One of the activities is a mock United Nations meeting about climate change. In the first module, students are introduced to the Whole Earth Calculator, where they can turn pounds of recovered food into meals or into carbon dioxide that is not being generated at a landfill. Short videos and slide shows are available in the lesson plans. <http://rockandwrapitup.org/whole-earth-calculator-with-lesson-plans/>

**Projects and Extension Activities**

1. Students could be assigned to find date labels on food at home and report back how many different types of labels they found—“Use by”, “Best by”, “Sell by”, and even the new “Use or Freeze by”. They could record what foods carried the different labels. For foods they encounter that have passed the expiration date students could research the safe shelf life of the item using the Foodkeeper App that can be found here: <https://www.foodsafety.gov/keep/foodkeeperapp/index.html>.
2. **Food Rescue** **Network**: Students can get involved in creating solutions to the food waste problem at their school. They may choose to work on this as a club activity or personal or class project. The “Food Rescue” website provides students with sample letters, emails, and a protocol for starting a food rescue program. Lots of resources are available to give the students guidance. The program is based out of Indiana but has participating schools from other states. (<http://foodrescue.net/>)
3. **U.S. Food Waste Challenge:** At this site you can enroll students to participate in the U.S. Food Waste Challenge, a program issued by the USDA that challenges students to tackle the food waste problem in their schools. The class fills out and submits online a short form indicating the activities they want to undertake to reduce food waste at their school. ([www.usda.gov/oce/foodwaste/join.htm](http://www.usda.gov/oce/foodwaste/join.htm))

# References

**(non-Web-based information sources)**

**The references below can be found on the
*ChemMatters* 30-year DVD, which includes all articles
published from the magazine’s inception in October 1983 through April 2013, all available Teacher’s Guides, beginning February 1990, and 12 *ChemMatters* videos. The DVD is available from the American Chemical Society for $42 (or $135 for a site/school license) at this site:** [**http://ww.acs.org/chemmatters**](http://www.acs.org/chemmatters)**. Click on the “Teacher’s Guide” tab directly under the *ChemMattersonline* logo and, on the new page, click on “Get the past 30 Years of *ChemMatters* on DVD!” (the icon on the right of the screen).**

**Selected articles and the complete set of
Teacher’s Guides for all issues from the past three
years are available free online at the same Web site, above. Click on the “Issues” tab just below the logo, *“ChemMattersonline”*.**

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 Tinnesand, M. The Big Reveal: What’s Behind Nutrition Labels? *ChemMatters,* 2012, *30* (4) pp 6–8. This article discusses nutrition labels on food and explains the different tests that are run to establish the values present on the labels. This might be used to tie into the testing of foods that needs to be done to determine how the nutrient value of the food changes with time.

 Husband, T. Two Is Better Than One. *ChemMatters,* 2012, *30* (4), pp 9–11. This article specifically addresses the Maillard reaction in non-enzymatic browning. It would make a nice supplement to the article if food chemistry is discussed.

Warmflash, D. Double, Double Oil and Trouble. *ChemMatters,* 2015, *33* (4), pp 16–17. This article is about fats in the diet. Saturated and unsaturated fats are discussed. This could be used to enhance the discussion of the rancidification reaction mentioned in the Wetterschneider date labels article.

Porterfield, A. Antioxidants Go the Extra Mile. *ChemMatters,* 2016, *34* (2), pp 14–15. The article contains extra information on flavonoids and some other polyphenol compounds in foods. Oxidation and reduction reactions are covered more in depth

 The April 2016 Teacher’s Guide that accompanies the Porterfield article above provides considerable chemistry background material about polyphenolic compounds and oxidation. There is a Vitamin C lab that could be used here also.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 McGee, H. *The Curious Cook;* North Point Press: San Francisco, 1990; pp 56–73. In chapter 8, titled *The Green and the Brown,* Harold McGee discusses enzymatic browning. He relays his quest for the perfect green color in salads, guacamole, and pesto. He approaches the problem with the tools of a scientist using all the parts of the scientific method that students are taught. His experiments could be used for inquiry in the classroom. This book is out of print but if you can find a copy of it, it is an excellent resource for explaining the chemistry of food.

# Web Sites for Additional Information

**(Web-based information sources)**

**Expiration date labels**

 This site contains more information on date labels, as well as time lines for how long specific foods should be kept after they are purchased. It also contains food safety tips.

([www.webmd.com/a-to-z-guides/features/do-food-expiration-dates-matter](http://www.webmd.com/a-to-z-guides/features/do-food-expiration-dates-matter))

This site also contains more information on date labels, as well as lists for how long certain foods can be kept after they are purchased, if students want to look up specific food items. ([www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/food-labeling/food-product-dating/](http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/food-labeling/food-product-dating/))

This is a short article concerning food labels and how they can be interpreted. It underscores the need for the general population to understand the meaning of the labels so they do not dispose of food that is still safe to eat. ([www.consumerreports.org/cro/magazine/2015/10/is-expired-food-safe-to-eat/index.htm](http://www.consumerreports.org/cro/magazine/2015/10/is-expired-food-safe-to-eat/index.htm))

**Food safety**

This site can be used for finding additional information about the most recent food recalls, the Foodkeeper App, safety guidelines, and food poisoning information: [www.FoodSafety.gov](http://www.foodsafety.gov).

 This is an index to several articles that cover food safety. It would be a good site to give students who have additional questions about the foods they eat. (<http://www.consumerreports.org/cro/health/food-safety-and-sustainability-guide/index.htm>)

Education materials including an activity book on safe food handling and a crossword puzzle as a recap activity can be found here. They are geared to middle school or upper elementary but may be able to be adapted. Facts sheets and additional information on food product dating can also be found on this site. (<http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education>)

This site is good for infographics about food safety that you can print off and display in your room: <https://www.cdc.gov/vitalsigns/FoodSafety/infographic.html>.

**Food safety and the “5-second rule”**

The report of the research concerning the reality of the “5-second rule”, as conducted by food scientists at Rutgers University, can be found in its entirety in this article accepted by *Applied and Environmental Microbiology* in September 2016 for publication. This would be good for students to read and note the experimental design and to learn how research is reported. ([http://aem.asm.org/content/early/2016/08/15/AEM.0183816.full.pdf+html?ijkey=FLERGaGuAW0EM&keytype=ref&siteid=asmjournals](http://aem.asm.org/content/early/2016/08/15/AEM.0183816.full.pdf%2Bhtml?ijkey=FLERGaGuAW0EM&keytype=ref&siteid=asmjournals))

 A short article about the Rutgers research and its findings is reported in the September 12, 2016 issue of *Food Safety Magazine*. The link to this article is [www.foodsafetymagazine.com/news/the-5-second-rule-is-bogus-say-rutgers-researchers](http://www.foodsafetymagazine.com/news/the-5-second-rule-is-bogus-say-rutgers-researchers).

**Food poisoning**

“The Burger that Shattered Her Life”, an article from a 2009 issue of *The New York Times*, is a gripping, real life example of the devastating effects of food poisoning. A young dance instructor was sickened with a virulent strain of *E.coli* that was eventually traced to a package of hamburger patties purchased at Sam’s Club. The young girl suffered seizures and was left a paraplegic after her battle with food poisoning. This story could be used as a hook to get students to respect safe food handling procedures.

(<http://www.nytimes.com/2009/10/04/health/04meat.html?pagewanted=1&_r=1>)

*The Bad Bug Book* is a handbook of bacteria and other organisms that cause foodborne illness. A different organism is featured in each chapter. It would be a good resource for that student who wanted to learn more about the organisms that cause food poisoning. ([www.fda.gov/downloads/Food/FoodborneillnessContaminants/UCM297627.pdf](http://www.fda.gov/downloads/Food/FoodborneillnessContaminants/UCM297627.pdf))

This is site especially for teens where students can find out everything they may want to know about food poisoning. You can also select Spanish text if you have a high population of English Language Learners in your class.

([www.kidshealth.org/en/teens/food-poisoning.html?WT.ac=t-ra](http://www.kidshealth.org/en/teens/food-poisoning.html?WT.ac=t-ra))

**Food waste**

 **Food waste and labels**

This would be a good site to visit for best storage practices of specific foods. Students who wanted to check on how to store their favorite food would find it by using the site’s search function. ([www.stilltasty.com](http://www.stilltasty.com))

If you would like to read the full NRDC report on dating labels and food waste, it can be found here: <https://nrdc.org/sites/default/files/dating-game-report.pdf>. A short synopsis of the report can be found here: <https://www.nrdc.org/resources/dating-game-how-confusing-food-date-labels-lead-food-waste-america>.

 This is the NRDC home site for food waste issues. It is a good place to find out all that the NRDC is doing concerning this issue. There are also links to other sites with information on this issue. (<https://nrdc.org/issues/food-waste>)

 **Food waste reduction**

This site provides statistics on the amount of food that is wasted each year. It is also the site of the public service video titled, “Life of Strawberry”. ([www**.**SaveTheFood.com](http://www.savethefood.com)**)**

A June 25, 2016 article in *U.S.A. Today* about a small town in Japan that has established the goal of zero waste by 2020 can be found at this site. By contrast, the U.S. goal is to reduce waste by 50% by 2030. Students can read how this Japanese town is reaching their goal. (<http://www.usatoday.com/story/news/world/2016/06/24/shikoku-town-basks-limelight-moves-toward-zero-waste-target/86174300/>)

If you would like your students to read more about food waste from a news source, this would be a good article to assign. It is about the amount of foods Americans throw out each year. (<https://www.washingtonpost.com/news/wonk/wp/2014/09/23/americans-throw-out-more-food-than-plastic-paper-metal-or-glass/>)

**Food waste and labeling legislation**

This is a May 2016 press release from the NRDC that updates the status of food waste legislation: <https://www.nrdc.org/media/2016/160518>.

A summary of the Food Recovery Act that is currently (fall 2016) in congress can be found here: <https://pingree.house.gov/foodwaste/billsummary>.

**Enzymatic and non-enzymatic browning**

 More information on enzymatic browning can be found here:

[ww.food-info.net/uk/colour/enzymaticbrowning.htm](http://www.food-info.net/uk/colour/enzymaticbrowning.htm).

 Harold McGee, author and chemist, explains his recent experiments with caramelizing sugar in this article. His experiments could be adapted for an interesting classroom project or lab. Recent research shows sugar does not have to melt before it caramelizes. (<http://www.curiouscook.com/site/2012/09/caramelization-new-science-new-possibilities.html>)

This site contains considerable information on caramelization with a link to another non-enzymatic browning reaction, the Maillard reaction.

(<https://en.wikipedia.org/wiki/caramelization>)

 The history behind the Maillard reaction, as well as its explanation, can be found at this site: [www.scienceofcooking.com/maillard\_reaction.htm](http://www.scienceofcooking.com/maillard_reaction.htm).

This slide show describes in depth the various reactions that occur when foods are changed by the Maillard reaction: <http://www.slideserve.com/barbra/flavor-compounds-formation-by-maillard-reaction>.

**Rancidification**

This sitecontains information that compares oxidative and hydrolytic rancidity and the storage requirements for fats to prevent these reactions from occurring. (<http://www.gcca.org/wp-content/uploads/2012/09/RancidityAntioxidants.pdf>)

The science of oxidation in fats and the safety of eating the newly oxidized products is presented in this blog post by a food scientist at Nordic Food Lab. The reactions involved in rancidification are thoroughly explained and outlined. The project the scientist is working on concerns whether the rancidification reaction can be used to produce rancid butter with a desirable flavor so that it can be used as a new product.

(<http://nordicfoodlab.org/blog/2016/1/29/aged-butter-part-2-the-science-of-rancidity>)