TEACHER ACTIVITY GUIDE

OXIDATIVE RANCIDITY IN POTATO CHIPS

Taken from IFT Experiments in Food Science Series

Rancidity is the condition reached by certain foods as the lipid material (fat) undergoes oxidation reactions to produce hydroxy acids, keto acids, aldehydes, short-chain fatty acids, and other compounds which are responsible for the characteristic off-flavors and off-odors in stale foods.

The oxidation of lipids involves many complex steps. Unless mediated by other oxidants or enzyme systems, oxidation proceeds through a free-radical chain-reaction mechanism involving initiation, propagation, and termination. The major initial reaction product is hydroperoxide (ROOH). Using RH to represent the lipid material, the reaction is as follows:

$$RH \rightarrow R\cdot + H\cdot$$
$$R\cdot + O_2 \rightarrow ROO\cdot$$
$$ROO\cdot + RH \rightarrow ROOH + R\cdot$$

Energy considerations imply that the hydrogen adjacent to the double bond is labile (easily removed) and is readily abstracted. Singlet oxygen (O_2 in the singlet spin state) may also be involved in the initiation step, giving a simple reaction:

$$RH + O_2 \rightarrow ROOH$$

Light, especially in the ultraviolet range, accelerates the initiation step in lipid oxidation.

However formed, hydroperoxides are readily decomposed by radiation, thermal energy, metal catalysis, or enzyme activity to form additional radicals. These radicals in turn are capable of further reaction to form the hydroxy acids, keto acids, aldehydes, and short-chain fatty acids that are directly responsible for the off-flavor and odor associated with rancidity.

PROCESSING CONSIDERATIONS

Processors combat the deleterious effects of lipid oxidation in food by speeding up distribution of the product to the retailers, shelf-dating their products, adding antioxidants, and using proper packaging materials to exclude light, water vapor, and/or oxygen.

Most potato chip manufacturers use proper packaging and fast distribution to make sure that the product the consumer purchases is not oxidized. The packaging material is typically a barrier laminate that may be a composite of paper, plastic film, and foil. This material is a good barrier to light and a reasonable barrier to water vapor. The moisture content affects not only the texture of potato chips, as anyone who has eaten soggy potato

chips at a picnic knows, but also the rate of oxidation. There is a moisture content at which the rate of oxidation is minimized; at higher or lower moisture levels, the rate of oxidation is increased.

It is also desirable to package potato chips in an atmosphere that is free of oxygen and in a package that would not allow oxygen to enter from the atmosphere. For most snack foods, such packaging is too expensive. Generally, nitrogen is pumped into snack food packages to exclude the oxygen. The nitrogen gas also provides a pressure "pillow" in the package, which prevents mechanical damage to the snack.

MATERIALS REQUIRED

Fresh potato chips, regular unflavored
Pink or quart canning jars with lids
Aluminum foil.

TEACHING TIPS

1. This experiment is intended to demonstrate the need for controlling lipid oxidation in foods and how packaging can accomplish this. Lipid oxidation not only results in rancid off-flavors and off-odors but in extreme cases can be toxic. Fortunately, the product becomes so unpalatable long before this condition is reached that there is no real hazard from this situation.

2. Potato chips were selected as the food for this experiment because of their high fat content, ease of oxidation, mild flavor, and ready availability. Actually, any high-fat food may be used, as long as the basic food flavor is mild enough that flavors resulting from lipid oxidation are not masked. The potato chips used in this experiment should all be from the same manufacturer and have the same expiration date. Preferably, they should all come from the same bag.

3. The evaluations in this experiment depend on sensory perception that will vary among students and which, even for trained sensory experts, frequently can be expressed only in subjective terms. Also, while it may be difficult for some students to identify the flavor differences after 1-2 days of experiment, just about everyone should be able to detect them after a week's storage.

4. The experiment directs the student to prepare a graph with the independent variable (time) on the x-axis and the dependent variable (flavor score) on the y-axis. Results from both samples should be plotted on the same graph. Graphing data is helpful in visualizing what has occurred, and this part of the experiment may help students develop these skills.

STUDENT EXPERIMENTAL PROCEDURE

1. Wrap a pint or quart canning jar with aluminum foil. Tape the foil in place so that no light can enter the container.
2. Place fresh potato chips in the foil-wrapped jar and in a similar clear jar without foil around it.
3. Taste the potato chips and rate their flavor on a 5-point scale: 1 = extremely dislike the flavor, 2 = slightly dislike the flavor, 3 = neither like nor dislike the flavor, 4 = slightly like the flavor, and 5 = extremely like the flavor. Enter the data on the Day 0 line in the table below.
4. Place the two jars on a window sill where they will be exposed to sunlight. Turn each jar one-quarter turn each day (every 24 hours).
5. Taste potato chips from each jar at intervals of 1-2 days for 1-2 weeks. The length of time for this experiment is dependent on the amount of sunlight that the jars are exposed to. Enter the data in the table below.
6. Make a graph of your data, noting the flavor of the potato chips stored these two ways versus storage time. The y-axis should be the flavor score and the x-axis the time in days.

QUESTIONS & ANSWERS

1. What can you conclude about the effect of packaging material (how a product is packaged) on the flavor of a food?

   Ans. The selection of a proper packaging material is very important to the flavor quality of the product.

2. Why did wrapping the jar in aluminum foil affect the flavor of the stored potato chips?

   Ans. Wrapping the jar in aluminum protects the potato chips from ultraviolet (UV) light and thus allows them to retain their desirable flavor and not oxidize. In the clear jar, the UV light causes lipid oxidation, which caused the off-flavors.

3. Are potato chips that you purchase in the store packaged in containers that permit light to enter or exclude light?

   Ans. They are packaged in containers that exclude light.

4. Is there anything else, besides UV light, in the atmosphere that we would like to keep away from potato chips while they are in the package?

   Ans. Oxygen and water vapor.

DATA TABLE	**Flavor score (1 = dislike extremely, 5 = like extremely)**	
Day	**Clear jar**	**Foil-wrapped jar**
0		
1		
2		
3		
4		
5		
6		
7		
8		
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