

IFT Experiments in Food Science Series

Experiments in Food Science

Activity #4

Effect of Roasting on Color, Flavor, and Texture of Peanut Butter

A Science Unit for Secondary School Curriculum



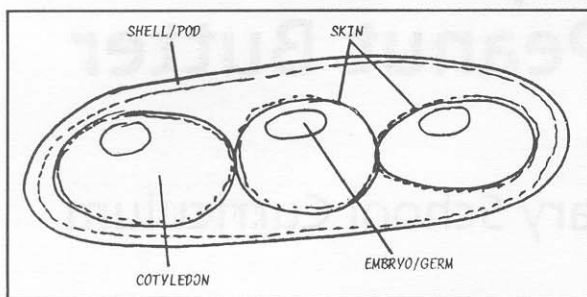
Institute of Food Technologists
The Society for Food Science and Technology

TEACHER ACTIVITY GUIDE

Effect of Roasting on Color, Flavor, and Texture of Peanut Butter

About 10 million tons of peanuts (groundnuts) are grown in the world each year. About 1 million tons are grown in the United States, mostly along the coastal region from Virginia to Texas.

Peanut plants grow to a height of about 3 feet. The fruit of the peanut plant matures beneath the surface of the soil. Each pod or shell of the fruit contains 1–3 seeds (peanuts) at maturity. The peanuts are harvested by plowing the plants out of the ground and stacking them on poles above the ground to dry (cure) for several weeks. The major structural components of the peanut are shown in the following diagram.



Peanuts are marketed and sold either in their shells or after shelling. About 75% of the peanuts in the U.S. are sold without shells ("shelled"). From 35 to 50% of the shelled peanuts are used for production of peanut butter, and about 25% are used as ingredients for making candies, peanut brittle, and baked goods.

The composition of peanuts is on the order of 45–50% fat (oil), 25–30% protein, 5–12% carbohydrate (mainly sugars), about 3% fiber,

and about 2.5% ash (minerals).

PRODUCTION OF PEANUT BUTTER

Production of commercial peanut butter involves the following major processing steps:

1. Whole peanuts are cleaned and shelled.
2. Shelled peanuts are treated by a combination of heat and mechanical processing to remove the skins, split the peanuts, and remove the embryo (germ). This is done to improve the color of the peanut butter, since the skins would give a distinctive red color to the product. The embryos are removed because they contain certain lipids that would undergo chemical deterioration and form bitter components that would detract from the peanut butter flavor. This process is called *blanching*.
3. Blanched peanuts are oven roasted, either dry or in oil. This process destroys certain undesirable enzymes in the peanut that would cause breakdown of the oils in the peanut butter to produce off-flavors. The roasting also produces desirable changes in the color, flavor, and texture of the peanut. The desirable brown color is produced mainly by reaction of sugars with the amino acids of the proteins. This browning reaction also produces a number of chemical compounds responsible for the desirable peanut flavor and tenderizes the peanut by altering the carbohydrate and protein components.
4. The remaining ingredients, including the oil, carbohydrate, emulsifier, and salt, are

measured and mixed into the peanuts. Normally, the peanuts are finely ground prior to adding these ingredients. The oil may be peanut oil, some other high-quality vegetable oil, or partially hydrogenated vegetable oil. Each company selects the combination of ingredients and processing conditions to provide the product that meets its specifications. Some commercial peanut products do not contain added emulsifiers or carbohydrates.

The emulsifiers are added to the product to improve the dispersion of the oil and prevent its separation during prolonged storage. Lecithin is the emulsifier recommended for the laboratory experiments, but other emulsifiers are commonly used, including mono- and diglycerides and others that meet government regulations with respect to functionality and safety. These emulsifiers are normally added at very low concentrations, such as less than 0.5% by weight.

Sugar and salt are added mainly for their contributions to the desirable flavor of the peanut butter.

The composition of commercial peanut butter is closely regulated by the Food and Drug Administration through its standards of identity. The final product must contain at least 90% peanuts and not more than 55% fat. The fat comes from the peanut (about 50%) and the added oil. The product contains no added preservatives, colorants, flavors, or vitamins.

5. The final product formulation is mechanically blended to produce a smooth mass and to finely disperse the oils in the form of an emulsion which will not separate upon standing.

6. The blended peanut butter is filled into glass jars, sealed, and labeled.

MATERIALS REQUIRED

Peanuts
Peanut oil
Lecithin (emulsifier)
Unsalted soda crackers
Oven with 350°F thermostat
Mortar and pestle
200-g-capacity balance
Timer or wall clock
Heavy-duty aluminum foil
100- to 250-mL beakers or small plastic cups
Spatulas
1/4-, 1/2-, and 1-teaspoon (tsp) measures

TEACHING TIPS

1. Raw, unshelled peanuts, generally available from your local supermarket, are recommended for this experiment because their use will demonstrate the various processing steps more dramatically than if shelled peanuts are used. However, if they are not available, you may substitute raw, or roasted, shelled peanuts. If you use roasted peanuts, it is advisable to simply remove their skins and complete the process without additional roasting. You may also include an additional roasting treatment—for a short time only—for a portion of these peanuts to demonstrate the effect that it has on color, flavor, and texture of the peanut butter.
2. Peanut oil should also be available at your local supermarket, but if not, you may substitute any other high-quality vegetable oil, provided that it does not contribute an undesirable flavor to the peanut butter.
3. The emulsifier lecithin will probably be available from your local health food store.

It is an optional ingredient, so if you are unable to obtain it, you may simply omit this part of the experiment.

4. If you do not have an oven with a 350°F thermostat in your laboratory, you may be able to use one in the home economics department or use a home kitchen oven.
5. The mortar should be of sufficient size (at least 5 inches in diameter) to permit students to grind 6–8 peanuts at a time.
6. Cleaning of equipment and glassware: **The students are not to use any equipment or glassware until it has been scrupulously cleaned with a good laboratory detergent, and care must be taken to prevent students from tasting or eating any product contaminated with toxic or poisonous chemicals.** This point needs to be emphasized and reinforced continuously to the class. In fact, it is recommended that this entire project be conducted in your home economics laboratory, if your school has one. This would minimize the risk from toxic and hazardous chemicals that are normally present in science and chemistry laboratories.
7. Assignment of students to groups: Step 7 of the experimental procedure recommends that students be assigned to product groups A, B, C, or D and for each of the roasting conditions. Thus, up to 12 groups are needed if the experiment is conducted as outlined. If modifications are made in the production schedule, you will need to alter this step.
8. The amount of salt is not listed, since the small amounts of peanut butter involved will obviously require only tiny quantities of salt. You may want to predetermine the amount necessary to provide the degree of saltiness desired for one of the formulations, and then have the students add this amount to all peanut butter products to obtain uniformity of flavor.
9. The experiment includes storing the experimental peanut butter products overnight to check on oil separation. If no oil separation is observed at this point, you may extend the storage period to a week or even longer. It is advisable to keep the products at room temperature throughout the extended storage period.
10. The calculations can be solved as follows:

$$\frac{\text{wt. of oil from peanut} + \text{wt. of oil and emulsifier added}}{\text{wt. of peanut butter} + \text{wt. of added oil and emulsifier}} \times 100 = \% \text{ Fat}$$

$$\text{Group A: } \frac{(45 \times 0.50) + 5}{45 + 5} \times 100 = 100 = 55\% \text{ fat (a legal product)}$$

$$\text{Group B: } \frac{(45 \times 0.50) + 10}{45 + 10} \times 100 = 59\% \text{ fat (an illegal product)}$$

$$\text{Group C: } \frac{(45 \times 0.50) + 4 + 1}{45 + 4 + 1} \times 100 = 55\% \text{ fat (a legal product)}$$

$$\text{Group D: } \frac{(45 \times 0.50) + 8 + 2}{45 + 8 + 2} \times 100 = 59\% \text{ fat (an illegal product)}$$

Note: The lecithin is included with the fat for these calculations, since it is similar to fat and would be included for analysis of fat by most analytical procedures used by government agencies. As indicated elsewhere in this experiment, commercial peanut butter would not be expected to contain more than 0.5% by weight, and thus would not contribute significantly to the fat content determination.

11. As an additional project, the students may compare experimental products with commercial products, in terms of ingredients, color, flavor, texture, and oil separation. Students should be able to classify most of the ingredients that they find on the labels of commercial peanut butter into the indicated groups. However, some confusion may occur with respect to the various descriptions of oils. These may be listed as oil, peanut oil, vegetable oil, partially hydrogenated oil, or others. Emulsifiers may include lecithin, mono- and diglycerides, or others. Carbohydrates may include starch derivatives and various kinds of sugar, such as dextrose, sucrose, and others.

12. If you do not include the additional project, it is strongly recommended that you provide the class with at least one commercial peanut butter for comparison. This commercial product can be compared with experimental products in terms of texture (smoothness), color, flavor, and oil

separation.

STUDENT EXPERIMENTAL PROCEDURE

1. Cut 12-inch \times 12-inch sheets of aluminum foil and bend the edges up to form a flat pan.
2. Label the pans 20, 30, or 40 min.
3. Spread about 250 g of unroasted peanuts over the bottom of each pan.
4. Preheat the oven to 350°F.
5. Roast the peanuts in the oven for the prescribed time, stirring them occasionally to provide uniform roasting.
6. Remove the shells and skins from the peanuts and discard them.
7. You will be assigned to one or more groups (A, B, C, or D) by the teacher and will work with one or more of the roasted peanut conditions (20, 30, or 40 min).
8. Each group will grind enough peanuts to obtain 45 g of ground peanuts. Grind the peanuts in the mortar, adding only 6–8 peanuts at a time and grinding them thoroughly, using pressure and a circular motion. Place the mortar on a moist, flat sponge to keep it from slipping. It is very

important to do a thorough job at this stage to produce a smooth final product. You will note that the peanuts take on a dark and moist appearance as the grinding proceeds. This change is due to melting and release of the peanut oil by the

grinding. This oil then coats the solid fiber, protein, and carbohydrate components to provide a smooth, sticky mass.

9. Weigh or measure out the following ingredients and combine them as follows:

Material	Group A	Group B	Group C	Group D
Ground peanuts	45 g	45 g	45 g	45 g
Peanut oil	5 g or 1¼ tsp	10 g or 2½ tsp	4 g or 1 tsp	8 g or 2 tsp
Lecithin	—	—	1 g or ¼ tsp	2 g or ½ tsp
Salt	----- (add salt to taste)-----			

10. For those products containing added lecithin, combine the peanut oil and lecithin in the mortar and mix them before adding the other ingredients.
11. Add all remaining ingredients to the mortar and thoroughly blend them by using pressure and a rotary motion of the pestle.
12. Spread a small amount of each peanut butter on separate crackers and evaluate them for color, flavor, and texture (smoothness).
13. Cover the remaining peanut butter in beakers or small plastic cups and store at room temperature overnight. Examine them the next day for degree of oil separation.
14. Record all data and observations in Table 1 below.

15. Assume that your peanuts contain 50% oil (fat) and calculate the expected total fat content. For this exercise, assume also that the total fat added is equivalent to the weight of peanut oil plus emulsifier. Identify which of your peanut butter products were within the legal standards of the Food and Drug Administration.

ADDITIONAL PROJECT

1. Go to your local grocery or supermarket and make a list of the different kinds and brands of peanut butter available.
2. Make a list of the various ingredients listed on the labels and group these into peanuts, oil, emulsifier, carbohydrate or sugar, and salt.
3. Purchase representative commercial

products and compare them with those that you prepared in the laboratory in terms of color, flavor, and texture, as well as oil separation after standing overnight.

4. Record your observations in Table 2 below and discuss possible reasons for the observed differences between commercial and experimental peanut butter products.

QUESTIONS & ANSWERS

1. What are the legal requirements for composition of peanut butter in the U.S.?

Ans. Peanut butter must contain at least 90% peanuts and not more than 55% fat. It must not contain added colorants, flavors, preservatives or vitamins.

2. Where are peanuts grown in the U.S.?

Ans. Peanuts are grown mainly in the coastal region from Virginia to Texas.

3. What are the reasons for roasting peanuts?

Ans. Peanuts are roasted to destroy enzymes that would contribute to deterioration of the peanut butter, to improve the flavor, and to produce desirable color and texture in the peanut and peanut butter.

4. What are the major processing steps in producing peanut butter?

Ans. The major processing steps in processing peanut butter are cleaning, shelling, blanching, grinding, blending with other ingredients, and packaging.

5. Why is commercial peanut butter smoother than that produced in the laboratory?

Ans. The commercial peanut butter is produced under factory conditions that use highly efficient grinding and blending equipment to provide much better subdivision and mixing (homogenization) of the peanut butter.

6. What are the major chemical components of the peanut?

Ans. The major chemical components of the peanut are fat, protein, carbohydrate, fiber, and minerals.

7. About how much fat (oil) and protein are in the peanut?

Ans. The peanut contains about 45–50% fat and 25–30% protein.

8. What are the major anatomical (structural) parts of the whole peanut?

Ans. The major structural components of the peanut are the shell/pod, skin, cotyledon, and embryo/germ.

DATA TABLE (Typical Results)

Table 1—Comparison of Experimental Peanut Butter Products

Roasting time/ peanut butter product	Color (0 = light, 5 = dark)	Flavor (0 = mild, 5 = strong)	Texture (0 = smooth, 5 = coarse)	Oil separation (0 = none to slight, 5 = large amount)
20-minute roasting				
A	0-2	0-2	1-2	2-4
B	0-2	0-2	0-1	4-5
C	0-2	0-2	1-2	0-1
D	0-2	0-2	0-1	0
30-minute roasting				
A	2-3	2-3	1-2	2-4
B	2-3	2-3	0-1	4-5
C	2-3	2-3	1-2	0-1
D	2-3	2-3	0-1	0
40-minute roasting				
A	4-5	4-5	1-2	2-4
B	4-5	4-5	0-1	4-5
C	4-5	4-5	1-2	0-1
D	4-5	4-5	0-1	0

Table 2—Comparison of Commercial Peanut Butter Products

Peanut butter product	Color (0 = light, 5 = dark)	Flavor (0 = mild, 5 = strong)	Texture (0 = smooth, 5 = coarse)	Oil separation (0 = none to slight, 5 = large amount)
<i>A—Skippy, Smooth</i>	<i>1–3</i>	<i>1–3</i>	<i>0</i>	<i>0</i>
<i>B—Skippy, Chunky</i>	<i>1–3</i>	<i>1–4</i>	<i>5</i>	<i>0</i>
<i>C—Knott's Berry Farm, Crunchy, All Natural (contains no lecithin or other emulsifiers)</i>	<i>1–3</i>	<i>1–4</i>	<i>5</i>	<i>3–5</i>