The Science of Thickening Agents

Unit: Culinary Science

Problem Area: Food Science

Lesson: The Science of Thickening Agents

Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. **Explain the various types of thickening agents.**
2. **Explain the science principles of thickening liquids.**

Resources. The following resources may be useful in teaching this lesson:

Imeson, Alan, ed. *Food Stabilizers, Thickeners, and Gelling Agents*. Wiley-Blackwell, 2009.

McGreal, Michael J. *Culinary Arts: Principles and Applications*. American Technical, 2008.

Peterson, James. *Sauces: Classical and Contemporary Sauce Making*, 3rd ed. Wiley, 2008.

"Thickeners," *The Cook's Thesaurus*. Accessed Dec. 4, 2010. <http://sonic.net/~alden/Thicken.html>.

"Thickening Sauces," *Culinary Cult: Portal to the Hospitality World*. Accessed Dec. 4, 2010. <http://www.culinarycult.com/columns/archive/151/Thickening-Sauces.html?dates>.

Equipment, Tools, Supplies, and Facilities

- ✓ Overhead or PowerPoint projector
- ✓ Visuals from accompanying masters
- ✓ Copies of sample test, lab sheet, and/or other items designed for duplication
- ✓ Materials listed on duplicated items
- ✓ Computers with printers and Internet access
- ✓ Classroom resource and reference materials

Key Terms.

The following terms are presented in this lesson (shown in bold italics):

- agar-agar
- break
- break down
- buerre manié
- coagulate
- collagen
- cornstarch
- emulsification
- fiber
- gelatin
- liaison
- non-starch polysaccharides
- opaque
- polysaccharides
- proteins
- reactive agents
- roux
- slurry
- temper
- thickeners
- thickening
- translucent
- vegetable gums
- viscosity

Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

> *Begin by asking students if they know how to thicken liquids. Some may be familiar with roux or slurry. If there are no responses, ask them to guess which products are used as thickeners. Ask if they know how the thickeners work.*

> *Tell students you are going to do a demonstration and you want them to explain what they see you do. Place several spoonfuls of Metamucil (or other powdered cellulose fiber laxative) into a clear glass filled with water. Stir well and let it sit for several minutes. Again, do not tell students what you are using as an additive at this point. While the contents of the glass are resting, have a general discussion about thickeners. Things that would need to be thickened; how those products should look (clear, cloudy, etc.); and how products can be adjusted.*

> *Return to the glass, and demonstrate how thick and gelled the water has become. Ask students to explain what you added. Then ask students to explain what happened to the water in the glass. Finally, tell students what you added, and see if anyone makes a connection. Read the ingredient list on the label and see if that helps. Ingredients of most types include psyllium husk (soluble fiber), gelatin (the source of the thickening), polysorbate 80 (an emulsifier and binding agent—some thickening traits), colorings, and flavorings.*

CONTENT SUMMARY AND TEACHING STRATEGIES

Objective 1: Explain various types of thickening agents.

Anticipated Problem: What are thickening agents? How are thickening agents handled?

I. Thickening agents

A. ***Thickeners*** are ingredients used to absorb liquid. As they absorb liquid, the viscosity of the liquid increases. It congeals, sets, coagulates, or clots. Thickeners increase the viscosity without altering most other properties. Plant thickeners generally do not affect the taste, but some animal thickeners do. They stabilize liquids by holding particles in suspension and by helping form emulsions. ***Thickening*** (in French “liaison,” pronounced lee-ay-zohn) is a process that gives body to a liquid food, such as a sauce, a soup, or a broth. To understand the specific uses for various thickening agents, one must understand their properties, clarity, stability, and capacity to absorb liquids (thickening power) as well as their preferred uses. Culinary thickening tasks are usually conducted with one of the following agents:

1. Proteins are from animal sources and include:
   a. Gelatin (processed from the skin and bones of animals)
   b. Egg whites
   c. ***Collagen*** (part of the connective tissue in bones; gelatin is extracted during cooking)
2. Polysaccharides are from plant sources and include:
   a. Carbohydrate starches (glucose polymers, which are insoluble in water) include potato, corn, rice, arrowroot, and wheat types.
   b. Cellulose (a structural component of plants; a polymer made with repeating glucose units; indigestible to humans)
   c. Pectin (Greek for "congealed" or "curdled"), which is commercially produced from citrus extracts and is most commonly used to gel jams and jellies and to stabilize other foods.
   d. Vegetable gums (used for thickening, gelling, clarifying, and inhibiting crystal formation in foods)
3. Food ingredients are convenient and effective last-minute (final stage) thickening choices. However, food ingredient thickeners will add flavor to the food and are not as stable as protein and polysaccharide thickeners. Food ingredient thickeners are:
   a. Flour is not an efficient thickening agent in its raw state, though it is sometimes added directly to raw products—such as sliced apples—and does serve to slightly thicken the juices exuded when baking a pie. Cooked roux, kneaded buerre manié, slurry, and other standard flour-based thickeners are common to cooking tasks.
   b. Liaison thickening is a mixture of cream and beaten egg yolks that improves color, while increasing flavor and texture. To prevent curdling, the liaison must be held below 180°F and is usually added at the last minute.
   c. Cereal grains (e.g., oatmeal, farina, and couscous) are often used to thicken soups.
   d. Yogurt is a common Middle Eastern soup thickener.
   e. Coconut milk is a common Asian sauce and soup thickener.
   f. Starchy vegetables (e.g., potatoes, turnips, and parsnips) are sometimes grated into soups to thicken them.
   g. Meat juice reductions (glacés) serve many last-minute thickening duties.
   h. Tomato purees and pastes are common soup and sauce thickeners.

B. Choosing a thickener
   1. For many food-thickening tasks, simply simmering to reduce some liquid from the food product works to thicken.
   2. For acidic foods, arrowroot is a better thickening choice than cornstarch because cornstarch loses thickening power in acid mixtures. However, corn-

starch is a better thickening choice than flour for acid products (e.g., lemon meringue pie) because flour produces a cloudy appearance in the filling.

3. For high ***viscosity*** (the ability to flow) culinary tasks, vegetable gums are a good choice. They can cause a large increase in viscosity even when used in very small amounts.
4. For frozen foods, tapioca or arrowroot are good choices over cornstarch, which becomes spongy when frozen.
5. For high sheen and glossiness (e.g., glazes, toppings, and pie fillings), arrowroot and cornstarch are good choices. Products thickened with eggs may be opaque (e.g., cream fillings) or shiny (e.g., Hollandaise sauce).
6. For transparent products, thickening liquids with gelatin will produce a "see through" product, such as aspic.

C. Common culinary thickening agents

1. ***Roux*** (pronounced ROO) is a food ingredient thickener made from equal parts of fat (usually butter) and flour, which is cooked for at least several minutes and possibly longer if a brown color is desired. Roux is cooked before it is added to hot liquids, such as soups and sauces. It causes them to thicken as the liquid approaches the boiling point. Liquids thickened with roux are ***opaque*** (cloudy) due to flour's composition of starches and proteins. Roux is one of the most common culinary thickening agents and generally is in one of three styles: white, blonde, or brown.
   a. White roux is used for béchamel and velouté sauces and some specialty soups. It is made by cooking flour and clarified butter for about 5 minutes over heat and by stirring constantly.
   b. Blond roux is made with butter and is cooked quite rapidly. It usually is not prepared ahead of time. The color should remain a pale gold.
   c. Brown roux is used to thicken brown sauces, such as Espangnole and demi-glace and is specified for several Creole dishes. Sometimes it is prepared with butter, and other times it is prepared from the drippings associated with a roast or a sautéed mirepoix. It may be cooked in the oven or on top of the stove and requires frequent stirring. The color should be a medium to deep brown. Cooled brown roux can be kept for a long time under refrigeration. In some recipes, the cook must brown the flour prior to cooking with the fat. Browning does give flour a toasted flavor, and it compromises some of its thickening ability.
   d. Roux may be added in a cold or a hot form to a liquid. However, mixing a hot roux with a hot liquid results in lumps.
   e. Undercooking the roux can cause curdling of a liquid. The flour separates from the fat and causes a curdled appearance. Undercooking of flour also results in a "raw" taste.
2. ***Buerre manié*** (pronounced burr-mahnyay) is a kneaded food ingredient thickener mixture of raw flour and butter (about 4 ounces of soft butter is kneaded with 3 ounces of flour) used as a quick thickening agent for small sauces. Although its ingredients are similar to roux, it is not cooked prior to small pea-

size balls of the buerre manié mixture being added to a sauce near the boiling point. The sauce should boil just long enough to cook the flour.

3. ***Slurry*** (whitewash) is a food ingredient thickener made into a thin paste of flour and water (sometimes from cornstarch or similar pure powdered starches, such as arrowroot and tapioca) added to food products (e.g., sauces, soups, and pie fillings) to thicken them. When added to the food product, the slurry must be absolutely smooth. If there are any lumps in the slurry, it will cause uncooked lumps of starch in the food product. Some slurry-thickened products may be slightly grainy in texture. Key processes for slurry thickening are:
   a. Some of the hot liquid should be added to the slurry to warm it before adding the slurry to the food product.
   b. Some slurry mixtures thicken when the liquid boils, and others thicken just before the boiling point is reached.
   c. Liquids thickened with starch-type slurries will be clear or ***translucent*** (light will pass through it; almost transparent).
4. ***Cornstarch*** is a polysaccharide thickening agent that when mixed with a liquid and heated creates a glossy and semi-clear finished product. Cornstarch (from the endosperm of the kernel) and other starches are commonly used to thicken sweet and dessert sauces as well as Chinese meat and seafood sauces. Uncooked cornstarch sauces may appear cloudy and when heated become clear and glossy. Undercooking a cornstarch product can cause the product to taste "raw."
   a. Cornstarch produces the best product when the dry starch is added to and mixed into a cold liquid rather than into a warm liquid. Then the mixture is added to and cooked with a heated liquid.
   b. Generally, sauces thickened with cornstarch should be brought nearly to a boil, the heat should be reduced, and the sauce or soup should be simmered for a few minutes to ensure maximum thickening.
5. Eggs are a common protein-type thickening agent for dessert custards, soups, and sauces. The process used to incorporate eggs into a hot liquid is a technique called liaison. A ***liaison*** is a mixture of beaten egg yolks to which a small amount of warm liquid (often cream) is added to gently ***temper*** (warm) the eggs to ensure they do not curdle or solidify prematurely when cooked. Then the tempered eggs are slowly stirred and cooked into the hot liquid to thicken. Products thickened with eggs may be opaque (e.g., cream fillings) or shiny (e.g., Hollandaise sauce). Key processes for egg thickening are:
   a. A liaison must be held under 180°F, or the eggs will curdle (coagulate).
   b. Straining through a fine mesh sieve extracts any bits of coagulated protein prior to filling a pie or producing custard.
6. ***Gelatin*** is a flavorless protein byproduct of the meat industry and is extracted from animal skin and bones. It is a translucent, colorless, brittle, and tasteless product that comes in powder, granule, or sheet forms. It becomes gelatinous when dissolved in water, heated, and cooked. For instance, the liquid that con-

geals when a soup is made from a bone-in roast or a chicken is chilled is gelatin. Liquids thickened with gelatin will be transparent.

a. When dissolved in water, gelatin congeals under refrigeration.

b. It becomes a liquid again when heated.

7. ***Vegetable gums*** (and other sugars) are polysaccharide-type thickening agents derived from processed plant powders more commonly used in commercial food processing. Examples are agar-agar, guar gum, pectin, cellulose, xanthan gum, and carrageenan. These vegetable gums are used to thicken commercially produced ice cream, yogurt, bottled salad dressings, sauces, puddings, and other prepared foods. Products thickened with vegetable gums are usually transparent to translucent. For instance, ***agar-agar*** is a type of sugar thickening agent derived from a seaweed source (red algae) used in jellies, in ice cream, and as a soup thickener.

   a. They react similarly to gelatin.

   b. They are a good vegan alternative gelling source.

   c. They gel more firmly than animal gelatin.

   d. They can "set" at room temperature.

   e. They are a form of incomplete protein that provides many minerals.

8. Other thickening agents

   a. Melted butter (not clarified) may be added to a sauce near the end of the cooking process to thicken it slightly. The result is more of a glaze than an intensely thickened product.

   b. Acids, such as lemon juice and vinegar, are able to thicken liquids with or without heat, but only when protein is present in the liquid,making this a less common thickening method. Some acids may cause protein-based sauces or soups to curdle.

Teaching Strategy: *Use VM–A to review the basic thickening agents. You may also assign small groups and give each group the title of three popular dishes, asking them to determine what is used as thickener in each recipe.*

Objective 2: Explain the science principles of thickening liquids.

Anticipated Problem: How do thickening agents work?

II. Science principles of thickening liquids

A. ***Proteins*** are naturally occurring spiral-shaped molecules that ***coagulate*** (stiffen or firm) in the presence of a reactive agent, such as heat or acid. Proteins for thickening are from animal sources. ***Reactive agents*** may be chemicals or energy (e.g., whipping or beating) that cause a change in other products. The presence of proteins is one of the primary reasons that liquid thickens. Two common protein thickeners are eggs (especially the white) and gelatin.

1. Eggs in a liquid state (out of the shell) coagulate when heat is applied. Coagulation of eggs takes place in several ways: fried in a pan, baked in a cake or custard sauce, or as a binder for baked meatloaf. Protein begins to coagulate at about 180°F. In a sauce, temperatures above 185°F cause the protein molecules to ***break*** (coagulate so much that the mixture becomes completely solid), resulting in a thin sauce with lumps of cooked protein. Though heat is the primary reactive agent of proteins, an addition of acid (e.g., lemon juice or tomatoes) can further stiffen a liquid in which protein exists. Acids, such as heat, cause the protein molecules to curl and tighten.
2. Gelatin (the animal protein type) is processed, dried, and available in sheets or granules. Gelatin is a less fragile protein thickener than eggs and needs only to be reconstituted with a liquid to activate its thickening power. The degree or intensity of the heat is not relevant in this situation, other than that the liquid into which the gelatin is mixed must be hot enough to be completely dissolved before cooling and gelling. Though gelatin is handled differently than eggs, both products thicken due to protein coagulation. (This phenomenon is further witnessed when cooking or roasting any raw meat product.)

B. ***Polysaccharides*** are repeating carbohydrate structures (monosaccharides or disaccharides) and are commonly considered a type of starch or sugar. Polysaccharides are found in plant sources and are long complex chains of starches that have the ability to absorb liquid, usually many times more liquid than their own weight. Starch formation is the way plants store glucose. Cornstarch, arrowroot (a tropical herb), tapioca, guar gum, carrageenan, pectin, and xantham gum are all polysaccharides. While they each work differently and have different thickening properties, they all thicken for the same reason. They absorb liquid, thereby thickening the mass. All of them require vigorous mixing to fully combine the starch and the liquid for full thickening to take place. None of them have any flavor.

1. Starch granules work to thicken a product by soaking up liquid, swelling (like a balloon), and then popping. When they pop, starch streams into the liquid and thickens it. As the balloon structure of the starch is part of the thickening, it is possible to thin the effect by stirring too much. For instance, if someone prepares a lemon meringue pie filling and the filling is allowed to set, stirring after it has set will cause the starch bonds to break, and the filling will become watery.
   a. Natural starches are extracted from roots, tubers, and grains. Each type, no matter the source, contains two basic types of starch: amylase (a long, straight-chained type) and amylopectin (a short, branched-chain type).
   b. The characteristics and the way the starch reacts when cooked are related to the proportion of each starch type—amylase and amylopectin—it contains. Grain starches all behave in the same fashion, and root starches all behave in the same fashion. Potato starch, a tuber, has characteristics of grain and root types.
      (1) Grain starches (e.g., wheat flour, corn flour, and oat flour) contain a high amount of amylase and are clear when hot and cloudier when

cold. The products they produce are able to be sliced with a knife but deteriorate (become spongy and watery) when frozen. Grain starches thicken just below the boiling point, about 190°F, and do thin when stirred after they are cool. Sauces are opaque hot and cold because flours contain elements other than starch.

(2) Root starches (e.g., tapioca and arrowroot) have a higher ratio of amylopectin than grain starches. For example, corn and rice starches can contain up to 99 percent amylopectin. As a result, they are clear in appearance whether hot or cold. They thicken at about 140° to 160°F and freeze and thaw without thinning.

2. Pure starch powders (e.g., cornstarch, arrowroot, and tapioca) are powerful thickening agents when mixed with liquids and then exposed to heat (the reactive agent). These pure polysaccharide molecules absorb liquid and swell up efficiently and effectively, thickening all the liquid. However, the application of too high a heat can cause these starch powder thickening agent starch molecules to ***break down*** (lose their thickening strength) and cause the sauce or soup to return to a more liquid (low viscous) state. They work most effectively when brought to a boil and then immediately have the heat reduced. Additionally, some starches, such as cornstarch, will not work as well if an acid is present. Arrowroot is a better choice for acidic liquids that need thickening.

3. Xantham gum, carrageenan, pectin, and other "gum-type" thickeners are polysaccharides that absorb liquids and swell up. They are different from other thickeners in that they do not require heat to work. These types of thickeners need to be vigorously mixed with liquid for thickening to occur.

   a. Vegetable gum thickeners are ***non-starch polysaccharides*** (essentially ***fiber***—the indigestible parts of plants) that act like fiber in the diet; they are able to easily absorb large amounts of liquid and then become somewhat "gummy" or gel-like.

   b. Vegetable gum thickeners readily absorb liquids and thicken on their own without a reactive agent, making them great for products such as dressings, ice creams, and other processed foods in which heat is not applied in production.

   c. Vegetable gum thickeners are exceptionally stable; they do not readily "break" like those that require heat to thicken. The resulting product, however, can look more gel-like than thickened sauces (e.g., fruit preserves and jams).

C. Food ingredient thickeners

1. Flour is a polysaccharide and a protein thickener combination, as it contains starch and protein. As such, it works a bit differently and must be cooked prior to using it as a thickener (e.g., a roux). Cooking the flour first isolates the protein molecules and makes the starch more available to absorb liquids. Adding raw flour to liquid results in lumps that are tough to get out, and it will have only marginal thickening strength. Still, flour as roux thickens because it absorbs liquids when exposed to heat. Because it contains flour and protein, it

is a very strong thickener. Therefore, it is less likely to break down than other starch thickeners.

2. Whole butter is a protein thickener that is able to thicken hot sauces due to its inherent fat molecules that emulsify the sauce. ***Emulsification*** is the act of bonding two or more products that normally combine well into a fully incorporated product. The result of mixing (energy emulsification) bits of fat (butter)—along with the milk solids (protein thickening) in whole butter—into a liquid sauce over heat causes the entire mass to thicken. The effect is subtle by comparison to starch thickeners.
3. Acids can be used as thickeners when a protein is present. Acids cause the protein molecules to tighten and can have a thickening affect, but care must be taken when using this technique. The chemical reaction can ruin sauces, particularly if dairy products are in the liquid. For example, the protein in milk curdles in the presence of an acid. The liquid will thicken, but it will also appear "chunky" or broken, such as thickened buttermilk. This technique is used successfully in preparations such as "no-bake" Key Lime Pie, in which dairy protein is present in the form of cream cheese or sour cream and the act of adding the lime juice thickens the filling without eggs or baking.

Teaching Strategy: *Use VM–B to illustrate a protein molecule, a polysaccharide, and a vegetable gum. Assign LS–A. Facilitate a discussion of the results and the reasons behind the results.*

Review/Summary. Use the student learning objectives to summarize the lesson, and remind students about the specifics of demonstrations. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle.

Application. Use the included visual masters and lab sheet, along with practical experiment/demonstration to apply the information presented in the lesson.

Evaluation. Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

Answers to Sample Test:

Part One: True/False

1. F
2. T
3. F
4. T
5. T
6. T

7. F
8. F
9. T
10. T

Part Two: Completion

1. roux
2. gelatin
3. liquid
4. coagulates
5. reactive agents
6. fiber
7. animal, plant
8. popping
9. break
10. agar-agar

Part Three: Short Answer

1. Proteins begin to coagulate at 180°F. Temperatures beyond 185°F can break.
2. Polysaccharides are commonly thought of as a type of starch or sugar. They are found in plant sources and are long complex chains of starches that have the ability to absorb liquid, usually many times more liquid than their own weight. Examples of polysaccharide thickeners include cornstarch, arrowroot, tapioca, guar gum, carrageenan, pectin and xantham gum.
3. Liquids thickened with roux (or other flour-based thickeners) or eggs produce opaque products.

Sample Test

Name ______________________________

The Science of Thickening Agents

Part One: True/False

Instructions: **Write *T* for true or *F* for false.**

_____1. An addition of raw flour can successfully thicken hot liquids.

_____2. Starches thicken by absorbing liquids.

_____3. Milk is used as a thickening agent.

_____4. Vegetable gums can thicken liquid without heat.

_____5. Viscosity is the ability of a liquid to flow.

_____6. Thickening gives body to a liquid food, such as a sauce, a soup, or a broth.

_____7. When choosing a thickener for frozen foods, cornstarch is a good choice over arrowroot, which becomes spongy when frozen.

_____8. Polysaccharide thickeners add flavor to foods.

_____9. Gelatin is a less fragile protein thickener than eggs and needs only to be reconstituted with a liquid to activate its thickening power.

____10. Cornstarch is at its best when the dry starch is added to and mixed into a cold liquid rather than into a warm liquid.

Part Two: Completion

Instructions: **Provide the word or words to complete the following statements.**

1. A cooked mixture of equal parts of flour and fat is called __________________________.
2. A protein-based thickener from animal skin and bones is __________________________.

3. Thickeners absorb __________________________. As they do, the viscosity of the liquid increases. It congeals, sets, coagulates, or clots.

4. The reason protein is able to thicken products is that it ____________________________ when heated.

5. Heat and acid are considered __________________________ for protein.

6. Non-starch polysaccharides are better known as __________________________.

7. Protein thickeners come from __________________________ sources and polysaccharides come from __________________________ sources.

8. Starch granules work to thicken a product by soaking up liquid, swelling, and then __________________________.

9. In a sauce, temperatures above 185°F cause the protein molecules to __________________________, resulting in a sauce that is thin but with lumps of cooked protein.

10. A good vegan alternative gelatin source is __________________________, which is extracted from seaweed.

Part Three: Short Answer

Instructions: **Answer the following.**

1. At what temperature does protein begin to solidify? What happens when protein gets too hot?

2. In your own words, what are polysaccharides?

3. List two thickeners that produce opaque products.

BASIC THICKENING AGENTS

- Roux is prepared by cooking together equal parts of fat (usually butter) and flour. Roux is a food ingredient thickener.

- Cornstarch, arrowroot, and tapioca are all white starches used in a slurry or whitewash to thicken food products. These starches are polysaccharide thickeners.

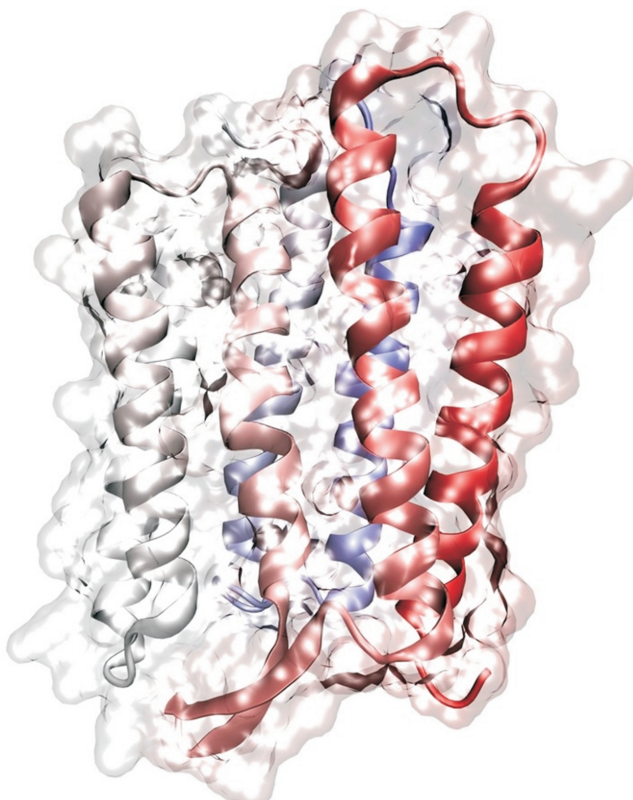
- Gelatin in its pure form is clear, flavorless, and holds liquid in a gelled state. This photo shows gelled chicken juices chopped to form a decoration for a stuffed chicken—aspic. Gelatin is a protein-type thickener.

- This shiny Hollandaise sauce is thickened with egg yolks: a protein-type thickener.

- This chocolate soft-serve ice cream consists mostly of air. However, it also contains corn syrup, whey, mono- and diglycerides, guar gum, carrageenan, and cellulose gum (all vegetable gum thickeners). Guar gum has almost eight times the water thickening power of cornstarch, and it is inexpensive.

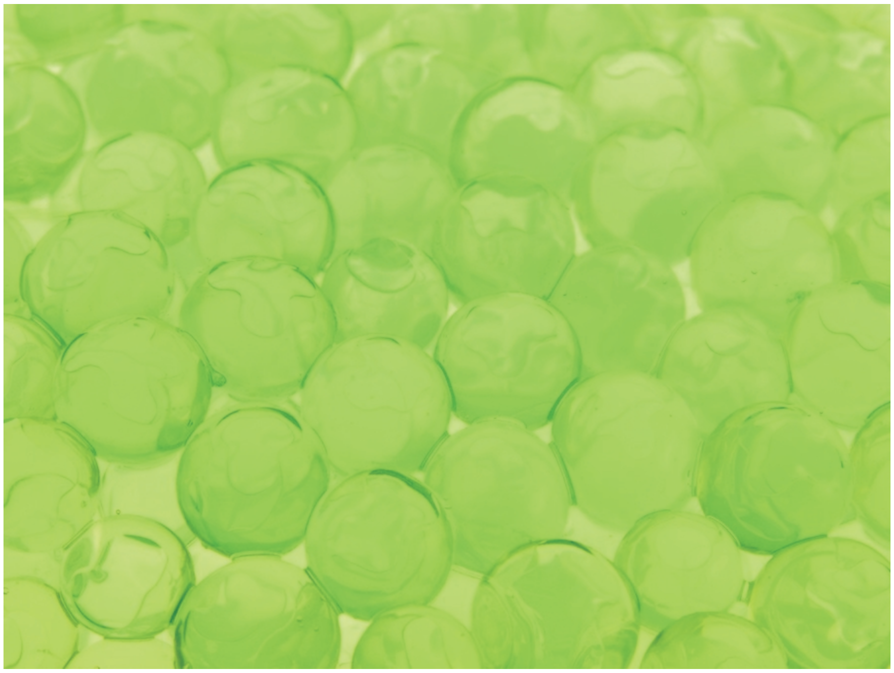
HOW THICKENERS WORK

- This model of a protein molecule shows its spiral nature. As the spirals tighten, the protein coagulates, as in this fried egg.



- Polysaccharides act like sponges, absorbing moisture and swelling in size. In this savory sauce, the illusion is that the sauce rather than the polysaccharides has thickened.

- These tiny spheres are like vegetable gums, swelling with water into a gel-like state.



- Vegetable gums begin as white powders that are used to thicken several products. Toothpaste is an example of a non-food product thickened with vegetable gum, which is a polysaccharide thickener.

Name ________________________________

The Science of Thickeners

Purpose

The purpose of this activity is to apply and observe the science principles of thickening agents.

Objectives

1. Define thickening agents and the way they work.
2. Conduct two hands-on lab experiments with thickening agents.
3. Make observations of each experiment's appearance.
4. Compare and contrast the two experimental products.
5. Explain (orally and in writing) what you observed in each experiment.

Materials

- lab sheet
- research materials (e.g., class notes, textbooks, and reference books)
- hands-on lab materials per group:
- 2 one-quart size saucepans
- 2 wooden mixing spoons
- 2 cups of milk
- 2 eggs
- ½ cup of sugar
- 2 T. cornstarch
- 2 small bowls
- 1 burner or heating element

Procedure

1. Complete the Part 1 research individually.
2. Work in pairs to conduct the Part 2 hands-on experiments with thickeners.

Part 1. Write one or two complete sentences in the space provided to answer the following questions about thickening agents. Use your notes, textbooks, reference books, and/or the Internet as needed to find the answers.

a. What is a polysaccharide? List three examples.

b. How does starch thicken sauces? Explain the reactions that happen.

c. What element in gelatin makes it solidify?

d. Explain the difference in appearance of a sauce thickened with cornstarch slurry and one thickened with a roux.

e. Eggs are a common thickener for custards, but custards "break" if they become too hot. What explains the "break?"

f. You decide to make thick, rich brown gravy for roast beef. Is guar gum a good choice as the thickening agent? What would explain your answer?

g. Why does flour require cooking before it is used as a thickener?

Part 2. These two hands-on experiments are designed to show the nature of thickeners in action. It has two separate experiments. Your group will make two similar products and see very different results.

Experiment A.

a. Heat 1 cup of milk in a small saucepan, and bring it to a simmer.
b. In a separate bowl, mix an egg with ¼ cup of granulated sugar until it is thoroughly mixed.

c. Slowly pour the hot milk into the egg mixture, stirring constantly.
d. Pour the mixture back into the saucepan, and bring it to a boil. When it boils, immediately remove the mixture from the heat.
e. Observe the appearance—color, texture, and surface features.
f. Using what you know about the science of thickeners, what would explain your results?

Experiment B.

a. Heat 1 cup of milk in a small saucepan, and bring it to a simmer.
b. In a separate bowl, combine an egg, ¼ cup of granulated sugar, and 2 T. cornstarch until thoroughly mixed.
c. Slowly pour the hot milk into the egg mixture, stirring constantly.
d. Pour the mixture back into the pot, and bring it to a boil. Remove it from the heat.
e. Observe the appearance—color, texture, and surface features.
f. Using what you know about the science of thickeners, what would explain your results?

3. Compare and contrast the two products in writing. Show your analysis in the space provided.

4. Participate in an oral description of the two experiments during a whole class discussion. Each partner should address some elements of your analysis in Step 3.

5. Turn in your completed lab sheet, Parts 1 and 2, to your instructor.

The Science of Thickeners

Part 1.

a. Polysaccharides are long chains of starch or fiber with the ability to absorb liquids and take on a "thickened" appearance. Examples are cornstarch, arrowroot, tapioca, guar gum, carrageenan, xanthan gum, pectin, and cellulose.

b. Pure starch powders (e.g., cornstarch, arrowroot, and tapioca) are powerful thickening agents when mixed with liquids and then exposed to heat (the reactive agent). These pure polysaccharide molecules absorb liquid and swell up efficiently to effectively thicken all the liquid. However, the application of too high a heat can cause these starch powder thickening agent starch molecules to break down (lose their thickening strength) and cause the sauce or soup to return to a more liquid (low viscous) state. They work most effectively when brought to a boil and then immediately have the heat reduced. Also, flour contains protein as well as starch, so it must be cooked first on its own before it can be used in hot liquid to thicken.

c. Gelatin contains protein, which is a molecule that tightens and solidifies with heat.

d. Roux-based sauces are opaque and are less susceptible to breaking down than cornstarch-based slurry sauces. Cornstarch-based slurry thickened sauces are more transparent or translucent than roux-based sauces and easily break down in excessive heat.

e. Protein has a spiral or coil shape that tightens when heated. If the custard gets too hot, the protein spirals tighten so much that they can become completely solidified, forcing out any liquid. The result is a liquid with solid chunks of solidified protein rather than the desired thickened liquid.

f. No. Guar gum, or any vegetable gum thickener, creates a gel-like texture that is certainly thick but is also jelly-like. Jelly-like is not the most appetizing texture for roast beef gravy.

g. Flour contains a type of protein that does not readily absorb liquid. By cooking the flour prior to adding it to a liquid, you are allowing the protein in the flour to become isolated from the starch (polysaccharide), making it more readily available to absorb liquids.

Part 2.

NOTE: The results and explanation of each experiment should resemble the following:

Experiment A: Observations should include descriptions similar to "a broken and lumpy product" or "a sloppy mess." Even in those cases in which the custard is smooth when removed from the heat, it usually continues to cook and eventually breaks. This is an example of proteins that are overheated, resulting in coagulation (lumps) in a liquid mixture. Students thinking three-dimensionally will mention that this could have been prevented with the use of a thermometer, and/or by placing the custard in an ice bath to cool it quickly, thus stopping the cooking process.

Experiment B: Observations should include descriptions similar to “very thick custard.” The cornstarch absorbs and thickens the custard, holding the mass together in a way that prevents broken protein molecules from ruining the product. Students making the connection will surmise that adding some starch to egg-thickened products can act as an extra thickener and as a protection against lumps. Should this mixture break, it indicates overheated proteins and overheated starches, suggesting a product cooked well beyond the written instructions.