Advanced Food Science II
E-Learning

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Welcome to E-Learning for Advanced Food Science!

Hope all is well with you and your family. I miss seeing all of you. I hope we will be in class together soon. So please stay healthy and well! ;-)

I am providing more instructional material to get you through the long days ahead. Please read the following material to help keep your learning skills sharp during the school closure. This material will be covered upon your return back to school. If you have any questions, please send an email to earnold@harrisburg3.org.

Thank you!
Mrs. Arnold

Assignment:

During the following school closure, please keep researching and trying new recipes. You can keep a recipe book for yourself of the recipes that you like. Be prepared to share your outcome in class!

I am providing a My Caert Lesson on The Science of Thickening Agents. This will also be posted on Google Classroom.

For students looking for some online instruction, there is a website that provides a few online cooking lessons. Check out www.instructables.com . After you access the website, you will need to search for: Cooking Class . Click on the first square labeled Cooking Class. Scroll down to Lessons. Choose a lesson and click on “Take Lesson”.

Please check Google Classroom periodically for updates and further assignments.

Be safe, stay healthy, and I hope to see you soon!

The Science of Thickening Agents

USING THICKENERS is a common practice for home cooks and professional chefs. Most thickeners are simple to use. However, choosing the right thickening agent is a bit more of a challenge if you do not know specifically how they work and the results they provide. All cooking and baking is just applied science, and thickening agents are the perfect example.

Objectives:

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

Key Terms:

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

Thickeners and Thickening Agents

Thickeners are ingredients used to absorb liquid. As they absorb liquid, the viscosity of the liquid increases. It congeals, sets, coagulates, or clots. Thickeners are able to stabilize liquids by holding particles in suspension and 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, a person must understand their properties, clarity, stability, capacity to absorb liquids (thickening power), and their preferred uses.

THREE AGENTS

Culinary thickening tasks are usually conducted with one of three agents: proteins, polysaccharides, or food ingredients. Proteins are from animal sources and include gelatin, egg whites, and **collagen** (part of the connective tissue in bones; gelatin is extracted during cooking). Polysaccharides are from plant sources and include starches (e.g., potato, corn, rice, arrowroot, and wheat), cellulose (indigestible to humans), pectin, and vegetable gums. Food ingredients are convenient and effective last-minute (final stage) thickening choices. Flour, roux, buerre manié, slurry, liaison, cereal grains (e.g., oatmeal, farina, and couscous), yogurt, coconut milk, starchy vegetables (e.g., potatoes, turnips, and parsnips), meat juice reductions, and tomato purees and pastes are examples.

FACTORS TO CONSIDER

A chef would think about the thickening choice based on several factors, including the following:

- Simmering to reduce some liquid from the food product works to thicken.
- Acidic foods—Arrowroot would be a better thickening choice than cornstarch because cornstarch loses thickening power in acid mixtures. However, cornstarch would be a better thickening choice than flour for a lemon meringue pie because flour produces a cloudy appearance in the filling.
- 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.
- Frozen foods—Tapioca and arrowroot are good choices over cornstarch because cornstarch becomes spongy when frozen.
- High sheen and glossiness (i.e., glazes, toppings, and pie fillings)—Arrowroot and cornstarch are good choices. Products thickened with eggs or flour may be opaque (e.g., cream fillings).
- Transparency—Gelatin will produce "see through" products, such as aspic.

COMMON THICKENING AGENTS

For cooks in residences to chefs at gourmet restaurants, commonly used thickening agents are roux, buerre manié, slurry, cornstarch, eggs, gelatin, vegetable gums, and more.

Roux

Roux (pronounced ROO) is a food ingredient thickener made from equal parts of fat (usually butter) and flour, 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 (e.g., soups and sauces). It causes them to thicken as the liquid approaches the boiling point. Liquids thickened with a 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 three styles: white, blond, and brown. Roux may be added in a cold or a hot form to a liquid. However, never mix a hot roux with a hot liquid because it will result in lumps. Undercooking the roux can cause the flour to separate from the fat, resulting in a curdled appearance. Undercooking of flour results in a "raw" taste. Flour in a raw state (uncooked) is not an efficient thickening agent, though it can be added directly to raw products before cooking (e.g., raw apples in apple pie filling) to help thicken the juices.

Buerre Manié

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.

Slurry

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 any lumps are present in the slurry, it will cause uncooked lumps of starch in the food product. Some slurry-thickened products may be slightly grainy in texture. Liquids thickened with starch-type slurries will be clear or **translucent** (light will pass through it; almost transparent).

FIGURE 1. Mixing powdery cornstarch or arrowroot into a cold liquid until smooth prepares the slurry to be added to a hot liquid. Slurries are generally polysaccharide thickeners.

Cornstarch

Cornstarch is a polysaccharide thickening agent that when mixed with a liquid and heated creates a glossy and semi-clear finished product. Cornstarch 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. When heated, they become clear and glossy. Undercooking a cornstarch product can cause the product to taste "raw." 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.

Eggs

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. Products thickened with eggs may be opaque (cream fillings) or shiny (Hollandaise sauce). A liaison must be held under 180°F, or the eggs will curdle (coagulate).

FIGURE 2. This shiny Hollandaise sauce is thickened with egg yolks.

Gelatin

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, and sheet forms. It thickens when dissolved in water, heated, and cooked. For example, the liquid that congeals when a soup made from a bone-in roast or a chicken is chilled is gelatin. This is the action of the gelatin found in the bones. Liquids thickened with gelatin will be transparent. When dissolved in water, gelatin congeals under refrigeration. It becomes a liquid again when heated.

FIGURE 3. Gelatin in its pure form is clear and flavorless. It holds liquid in a gelled state. This photo shows gelled chicken juices chopped to form a decoration for a stuffed chicken—an aspic. Gelatin is a protein-type thickener.

Vegetable Gums

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. They usually 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 example, **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. It reacts similarly to gelatin and is a good vegan alternative gelling source.

FIGURE 4. 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.

Less Common Thickening Agents

Less common food ingredient thickening agents include the use of melted whole butter (not clarified) and acids. To slightly thicken sauces at the end of the cooking process, the addition of melted butter will produce more of a glaze than an intensely thickened sauce. However, it does thicken slightly. Acids (e.g., lemon juice and vinegar) can thicken liquids with or without heat, but only when protein is present in the liquid. Some acids may cause protein-based sauces and soups to curdle.

The Way Thickeners Work

PROTEINS

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 protein is one of the primary reasons liquids thicken. Two common protein thickeners are eggs (especially the white) and gelatin.

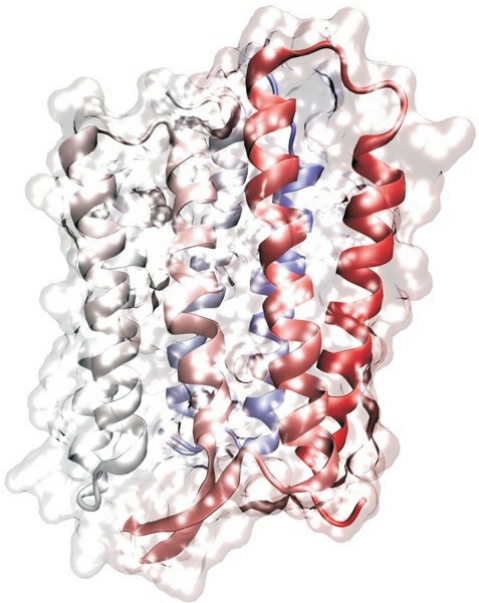

FIGURE 5. The spiral-shaped structure of protein molecules reacts to heat and acid—reactive agents—and tightens up, resulting in firmer textures and thickened liquids.

Eggs

Eggs in a liquid state (out of the shell) coagulate (harden; tighten) when heat is applied. Coagulation of eggs takes place in several ways: fried in a pan, baked in a cake or custard sauce, or used 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 sauce that is thin but 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, like heat, cause the protein molecules to curl and tighten.

Gelatin

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 crucial 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. For instance, note how soft and mushy raw meat is compared to how firm it is after it is cooked.)

POLYSACCHARIDES

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. Cornstarch, arrowroot, tapioca, guar gum, carrageenan, pectin, and xantham gum are all polysaccharides. While they each work a bit 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, and none of them have any flavor.

Starch Granules

Starch granules work to thicken a product by soaking up liquid, swelling, and then popping. When they pop, starch streams into the liquid and thickens it. The balloon structure of the starch is part of the thickening, so it is possible to thin the food product by stirring it too much. For example, if you make a lemon meringue pie filling and allow it to set, stirring after it has set will cause the starch bonds to break, and the filling will become watery. Natural starches are extracted from roots, tubers, and grains.

Pure Starch Powders

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, thereby 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 (e.g., cornstarch) will not work as well if an acid is present. Arrowroot is a better choice for acidic liquids that need thickening.

"Gum-Type Thickeners"

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 thickeners just need to be vigorously mixed with liquid for thickening to occur. Vegetable gum thickeners are also called **non-starch polysaccharides** (essentially **fiber**—the indigestible parts of plants) because they act just like fiber in the diet. They are able to easily absorb large amounts of liquid and then become somewhat "gummy" or gel-like.

Vegetable gums absorb liquids easily and thicken on their own without a reactive agent, making them great for products such as dressings, ice cream, and other processed foods where heat is not applied in production. They are exceptionally stable, too. They do not readily "break" as those requiring heat to thicken. The resulting products, however, can look more gel-like than thickened sauce. Gel-like natural fruit preserves and jams are thickened with pectin that is in this grouping.

FIGURE 6. Vegetable gums begin as white powders used to thicken several products. Toothpaste is an example of a non-food product thickened with vegetable gum.

FOOD INGREDIENT THICKENER

Flour is a polysaccharide and a protein thickener combination because it contains starch and protein. As such, it works a bit differently and must be cooked prior to using it as a thickener. 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

FURTHER EXPLORATION...

ONLINE CONNECTION: Common Polysaccharide Uses

Polysaccharides thicken all kinds of liquids in cooking, but there are other uses that have nothing to do with cooking. These natural starch and fiber molecules can be manipulated into countless forms and uses. Cosmetics, paints, and medications are made with polysaccharides.

Molded plastics, film wraps, and adhesive products (e.g., glues, pastes, and tapes) incorporate polysaccharides. Even emulsifiers and surfactant cleaners use polysaccharide elements. Polysaccharides are all around you at home, school, and work. In addition, you can find them in your car and in your clothing.

To learn more about these remarkable bio-based materials, visit the following link:

http://www.polysaccharidecenter.com/

have only marginal thickening strength. Still, flour as roux thickens because it absorbs liquids when exposed to heat. In addition, it contains both flour and protein, so it is a strong thickener. It is less likely to break down than other starch thickeners. **Emulsification** is the act of bonding two or more products that normally combine well into a fully incorporated product.

Summary:

Protein thickeners, such as eggs and gelatin, work because protein has a coiled molecular shape that contracts or tightens when heat or acid is applied. Gelatin is easy to use and is quite stable. Meanwhile, eggs require care when used so they do not overheat and coagulate to the point of breaking the sauce.

Polysaccharide thickeners include starches (e.g., flour, cornstarch, arrowroot, and tapioca) and fiber-based thickeners (e.g., guar gum, xanthan gum, pectin, and cellulose). All work to thicken food products because their long strands of fiber or starch easily absorb liquid and "thicken" liquid mass. Starch granules work to thicken a product by soaking up liquid, swelling, and popping. When they pop, starch streams into the liquid and thickens it. Starch thickeners require heat to work but can "break" if overheated. Fiber thickeners just require liquid and mixing to thicken and are far more stable.

Checking Your Knowledge:

1. Why is flour cooked before it can be used as a thickener?
2. What type of thickener is a good choice for use in a salad dressing?
3. At what temperature does protein begin to coagulate?

4. Describe the texture of a liquid thickened with a fiber-type polysaccharide.
5. What is a liaison and how is it made?

Expanding Your Knowledge:

This lesson illustrated a number of common additives to thicken liquids for a variety of uses, but there are other ways to thicken liquids. Do you know any? Oddly enough, other methods of thickening liquids are still based on common methods mentioned above, but they are applied in different ways. For example, starches (e.g., rice, potatoes, and noodles) can be added to thicken a soup. Why does that work? Other soups (e.g., cream of broccoli) require the cooked broccoli be pureed, and the soup comes out thick. Why?

Many chefs make sauces. Instead of adding a thickener, some chefs just let the sauce simmer or even boil for long periods of time. The result is a thickened sauce. What is happening there? The more you learn about ways to thicken liquids, the more options you have as a cook! Are there any other ways to thicken liquids?

Web Links:

The Pantry: Thickeners
http://www.baking911.com/pantry/thickeners.htm

Thickening Sauces
http://www.culinarycult.com/columns/archive/151/Thickening-Sauces.html?dates

Thickeners
http://sonic.net/~alden/Thicken.html

Thickeners: Strategies, Tips, and Tricks for Using These Cooking Agents
http://findarticles.com/p/articles/mi_m0FDE/is_1_26/ai_n27127355/

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.