Custards and Puddings

CUSTARDS AND PUDDINGS satisfy a range of appetites—from a simple, chocolate pudding to a sophisticated crème brûlée. Custards are used to prepare several desserts and sauces. Some of these are savory, such as a quiche or frittata. Although the term "pudding" has multiple definitions in England, American puddings are recognizable as a boiled, cornstarch or gelatin dessert. From pastry cream to flan, puddings and custards can be found in your favorite restaurants and donut shops.

Objective:

Examine custards and puddings, including their associated types, preparations, ingredients, equipment, tools, and cooking science (physical changes and chemical reactions).

Key Baking Terms:

amylose
amylopectin
bain-marie
bain-marie technique
baked custard
bavarian cream (bavarois)
blancmange
bloom test
blooming gelatin
charlotte russe
cheesecake
chiffon
coagulate
coagulation
cornstarch pudding
crème anglaise
crème brûlée
curdling
custard
double boiler
flan
floating island
gel
gelatin
liaison
mise en place
mousse
panna cotta
pastry cream
pudding
quiche lorraine
saccharide
slurry
soufflé custard (soufflé)
starch
Spanish cream
stirred custard
temper
weep

Key Science Terms:

absorption
caramelization
chemical reaction
colloidal suspension
colloid
condensation
conduction
convection
disaccharide
emulsion
endothermic reaction
evaporation
exothermic reaction
foam
gelatinization
heat transfer
homogenous mixtures
hydrolysis
hygroscopic
immiscible
invert sugar
lecithin
monosaccharide
pan flow
pH
pH scale
physical change
polymer
polysaccharide
radiation
retrogradation
surface tension
syneresis
viscosity

Custards and Puddings: Ingredients, Preparation, and Food Science

Custard is a creamy, light dessert or sauce made from boiling or baking an egg-and-milk mixture. Custards are of two types—stirred or baked. They are used as desserts, sauces, bases for other desserts, and some savory dishes, such as a quiche or a frittata.

Pudding is a creamy dessert or filling made from eggs, milk, sugar, flavorings, and a thickener (such as cornstarch or gelatin). American puddings are boiled and made with cornstarch or gelatin (cornstarch is used more often). All custards and puddings are stored under refrigeration. [NOTE: Originally, pudding referred to a savory product, often a meat- or cheese-based dish (Haggis, Roman sausage, or croustades). The English claim the invention of puddings. They still enjoy savory Yorkshire pudding (a thick popover-like batter baked in a shallow pan containing a layer of beef drippings) and black pudding (blood pudding). All references to pudding in this lesson will be about boiled pudding, which is what Americans associate with pudding.] Basic custard and pudding ingredients, terms, and equipment will be covered throughout this section of the lesson.

FIGURE 1. Originally, pudding referred to a savory product, often a meat- or cheese-based dish (Haggis, Roman sausage, crustades, etc.). The English claim the invention of puddings and still enjoy Yorkshire (a thick popover baked in a shallow pan containing a layer of beef drippings), black (blood), and "steak and kidney" puddings.

BASIC CUSTARD AND PUDDING INGREDIENTS AND EQUIPMENT

Some basic custard and pudding ingredients, terms, and equipment should be understood before attempting these dishes.

Starch Basics

STARCH: **Starch** is a complex carbohydrate, a polysaccharide of bonded carbohydrate molecules found in plants. The plants' molecules are tightly packed into small granules. Complex carbohydrates are composed of three or more sugar units. Starches are found in seeds, fruits, tubers, roots, and the stems of plants. The starch molecule contains long chains of glucose that form two types of structures, a long, straight-chain starch called amylose and a short, branched-chain starch called amylopectin. Starch molecules contain both amylase and amylopectin.

Amylose

Amylose is a part of starch that has very long, unbranched chains, is insoluble in water (unless heated), tightly wound, highly glucose-based, and makes up about 20 percent of starch structure. Amylose entraps large amounts of liquid, but cannot dissolve or form a gel in hot water. A **gel** is a semisolid substance that is similar in appearance to jelly. Root starches (e.g., tapioca starch) have longer chains and more thickening power than seed starches (e.g., cornstarch).

Amylopectin

Amylopectin is a short chain starch that is highly branched. Amylopectin can create a starch gel in hot water, and is very soluble in water. Amylopectin makes up about 80 percent of natural starch molecules. Cornstarch and wheat flour contain more amylopectin (about 80 percent) compared to tapioca starch (about 75 percent).

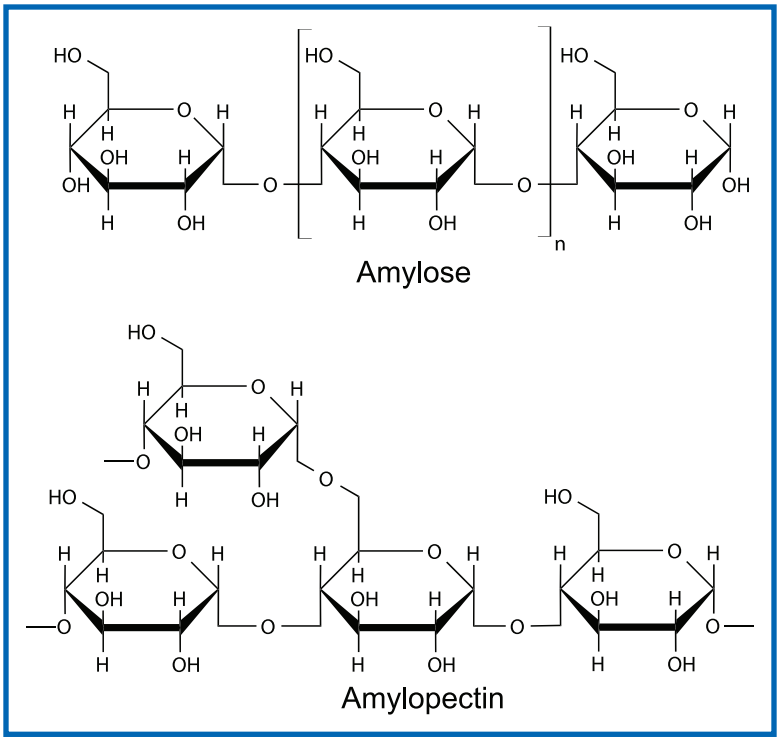

FIGURE 2. The starch molecule contains long chains of glucose that form two types of structures: a long straight-chained starch called amylose and a short branched-chained starch called amylopectin. Starch molecules contain both amylose and amylopectin. Note the difference in the amylose and amylopectin molecules.

Types of Starch

There are three types of starch used in cooking. All of them have different characteristics that make them compatible with different dishes.

Grain Starches

Grain starches (wheat flour, corn, and oat) are clear when heated, but they are cloudy when cold. Grain starches thicken when heated at higher temperatures. Thickening begins at 190°F. Puddings and custards made with grain starches do not freeze well. After a grain starch is thawed, it may **weep** (seep liquid). In order to thicken and not taste "starchy," grain starches must be cooked after they are added to a mixture. These are good for baked and high-heat dishes.

Root Starches

Root starches (tapioca, arrowroot) are clear when hot or cold. Root starches thicken at lower temperatures than grain starches, from 140°F to 160°F. Puddings and custards made with root starches freeze well. Root starch breaks down at high temperatures and becomes thin and stringy. These are good for custards made over a double boiler.

Waxy Starches

Waxy starches (waxy maize, rice) are clear when hot or cold and at their thickest when hot. Waxy starches are used in commercial preparations and provide frozen products that do not weep. They are higher in amylopectin. Thickening begins at 140°F to 160°F.

How Starches Work

All starches work by absorbing liquid into individual starch grains. The amount of liquid a starch grain will absorb (and how concentrated the grains are in the liquid) affects how thick the mixture becomes. Some starches will completely "set" a liquid (as in a molded gelatin salad). When a starch solution is heated, the liquid molecules begin to move around quickly and bump into the grains of starch. Then, the starch granules soak up the liquid, swell, and pop. For example, cornstarch must be at a temperature of 203°F (95°C) before thickening begins. At that point the mixture quickly turns from cloudy to transparent. When the granules pop, starch moves quickly into the liquid to thicken it.

Too much sugar or acid (such as citrus) in the solution may prevent starches from thickening properly. Starch must be added carefully to a liquid to avoid lumps. For example, starch and sugar can be mixed before the liquid is added to a pudding or custard mix. Also a **slurry** mixture (a blend of equal parts of cool liquid and powdered starch) may be used to thicken other liquids. The slurry mixture is softened and stirred to remove any lumps before adding other ingredients. Starch and flour both function in custards and puddings to provide flavor, structure, thickening, and gluten development.

Gelatin

Gelatin is a colorless, flavorless, collagen-based, water-soluble, edible substance. The collagen comes from proteins found in various animal body tissue. Gelatin prevents coarse crystals from forming in the pudding mixture and creates a smooth texture for chilled mousse and soufflé desserts.

Bloom

Gelatin displaces moisture due to its strength or "bloom." Gelatin can come in a granular, powdered, or sheet form. **Blooming gelatin** is the act of gelatin absorbing a liquid, enlarging, and stabilizing. Due to its collagen base, as the liquid is absorbed, gelatin molecules stretch and enlarge, creating a more solid appearance—a gel. To bloom gelatin, a cook would need to do the following:

- Stir gelatin into a small amount of cold liquid.
- Let it soak for five minutes without stirring until the gelatin has absorbed the liquid. It will look translucent and have a gelatinous consistency.
- You can strain the gelatin mixture to remove excess water or simply move to the next step.
- Add the gelatin mixture into warm liquid. It will dissolve again, and your pudding, sauce, or other dish will become firmer.
- For more information about blooming gelatins, see the short video, "How to Bloom Gelatin," on the Marx Foods website at http://www.askmarxfoods.com/what-is-blooming-gelatin/.

Bloom Test

The **bloom test** is a measurement of the gel strength of a gelatin. Generally, about $2^1/_4$ tsp. of unflavored gelatin sets about 2 cups of liquid. Gelatin sheets (and other forms of gelatin) are labeled by a number that categorizes its bloom strength.

- Low bloom: 50-125
- Medium bloom: 175-225
- High bloom: 225-325

pH Levels

Gelatin completely dissolves in a hot liquid, and it gels as it cools. Gelatins work best in a pH range of 4 to 10. They do not work well in low pH or acidic solutions. (See more information about pH in Objective 3.) Fresh or frozen pineapple, kiwi, figs, papaya, peaches, ginger, mango, and honeydew melon contain an enzyme that breaks down gelatin and inhibits gelling. These foods should be avoided in the hot liquid that is being thickened. Precooking or incorporation into an already chilled gelatin sauce is recommended.

Eggs

Chicken eggs that are grade AA large (about 2 oz. each or 8 per lb.) are the most common eggs used in baked goods. Eggs are a valuable source of vitamins A and B and some D. fresh egg should have a nicely rounded yolk that is well centered in the white. The egg, still in its shell, should sink to the bottom of a water-filled container (good way to check freshness). Cracked eggs have a danger of salmonella and should be discarded.

FIGURE 3. Cracked eggs have a danger of salmonella contamination.

Eggs are easiest to separate when they are cold. To beat whole eggs or egg whites to their greatest volume, they should be brought to an internal temperature of 65°F to 75°F. If more cooking time is used to thicken the pudding or custard, less eggs are needed in the recipe. Weighing eggs is more accurate than measuring.

- *A Large Egg White:* About $1\frac{1}{3}$ oz. or $2\frac{2}{3}$ tbsp.
- *A Large Egg Yolk:* About $\frac{2}{3}$ oz. or $1\frac{1}{3}$ tbsp.
- *Functions:* Eggs function in custards and puddings to provide leavening (via air incorporation from beating or whipping), emulsification (eggs act as a binding agent, a structure that holds other ingredients together), moisture, color (egg yolks add color), flavor (eggs add a distinctive taste to custards and puddings), texture, and thickening via coagulation. **Coagulation** is the changing of a liquid to a semisolid or solid mass via protein denaturation. When proteins denature, they **coagulate** (bond together to form solid clumps).

FIGURE 4. Eggs are easiest to separate when they are cold. To beat whole eggs or egg whites to their greatest volume, they should be brought to an internal temperature of 65°F to 75°F. If more cooking time is used to thicken the pudding or custard, less eggs are needed in the recipe. Weighing eggs is more accurate than measuring.

Liquids

Custards and puddings incorporate various types of liquids. Most include milk or cream, but there are exceptions, such as a lemon pudding that utilizes fresh lemon juice. Weighing liquids is more accurate than measuring. The metric system is preferred for measuring liquid, as it does not differentiate between fluids and solids—a gram is a gram and a kilogram is a kilogram. (Two cups of water and two cups of molasses are the same volume but different weights.)

Liquids function in custards and puddings to provide moisture and hydration (for proteins and starches, including gelatins), flavor (milks, creams, juices, yogurt, sour cream), color (browning from milk and fruit sugars), and steam leavening (from the conversion of liquid to steam).

FIGURE 5. Liquids function in custards and puddings to provide more moisture and flavor. This shrimp and egg custard uses cream and shrimp stock.

Sugar

Sugar is a carbohydrate that is soluble in water, usually crystalline in form, and sweet in taste. **Saccharide** is the scientific name for sugar (or an organic compound containing sugar). Sugars are produced from various types of plants, such as canes (sucrose), beets, sugar maples, and palms. Solid sugars include cane and beet sugars. Liquids can include honey, molasses, corn syrup, or various manmade liquid sweeteners produced for dietary purposes. The various grinds of solid sugar (such as granulated, powdered, superfine, or brown) impact finished products. When baking, liquid sugars do not react in the same fashion as solid sugars.

Weighing

Sugar by weight is more accurate than sugar by volume.

- A cup of granulated sugar is about 7 oz.
- A cup of confectioners' (powdered) sugar is about 4 oz.
- A cup of packed brown sugar is about 7½ oz.
- A cup of molasses, honey, or corn syrup is about 12 oz.

Functions

Sugar has many functions within custard and pudding. It can provide flavor, tenderization (too much sugar keeps starches from thickening), color (caramelization), and moisture retention (sweetened products stay moister than savory ones).

Salt

Salt is a crystalline compound (NaCl, sodium chloride) primarily used as a condiment that comes in two types—sea salt distilled from seawater and rock salt found in the earth. Sodium chloride (table salt) was the first salt discovered by humans. Iodized salt (table salt with added iodine) has been the salt most often utilized in American cooking; however, sea salt has become more popular over the last few years. Salt functions in custards and puddings to provide flavor (adds complexity and highlights other flavors), texture (toughens soft fat-and-sugar combinations), and strength.

Fat Basics

Fats are plant- or animal-based, oily ingredients that melt at low temperatures. Fats are compounds of carbon, hydrogen, and oxygen. Lipids are molecules that include fatty acids, triglycerides, cholesterol, and various nutrients. Fats are lipids found in animal and vegetable tissue. (From animals, butter and lard are produced. From vegetables, nuts, legumes, oils and shortenings are made.) Solid fats (butter, margarine, and hydrogenated products) remain solid near room temperature. Oils can solidify when refrigerated or cooled.

A byproduct of creating hydrogenated shortenings is the production of trans-fatty acids (trans fat) that may cause a health risk. Shortenings are 100 percent fat. A half-and-half split with butter is a good shortening mixture. Four common fats can be used to make baked goods. Butter, margarine, and cream are the most common fats used in custard and pudding. Fats provide many functions in a cake, including flavor and richness (especially butter or lard), moisture, leavening (when creamed), browning, emulsification, even distribution of added flavors (vanilla, almond, etc.), and flavoring.

Flavorings and Added Ingredients

In small quantities, flavorings and aromatics can add something special to a custard or pudding. Flavorings may include extracts (concentrated oils or essences diluted with alcohol), natural liquids (such as vanilla, almond, or cherry, also derived from concentrated oils), seeds and beans (vanilla, nutmeg, chocolate, coffee), and spices (like cinnamon, ginger, cloves, or nutmeg). Flavorings enhance (or fundamentally change) the taste of baked goods. Other added ingredients can include citrus (and other juices), nuts, chips, coconut, cherries, apples (and other fruits), chocolate, and vegetables.

Hand Tools and Equipment

Basic hand tools and equipment are necessary for creating a well-mixed, balanced, and evenly-baked item.

Scales

Platform, digital, or balance scales are used to accurately measure ingredients. Platform scales are often used to measure moist ingredients, and balance scales measure dry ingredients. Digital scales are best to measure small amounts (spices, herbs, leavening agents) or portion control (such as 2 oz. of custard per ramekin).

Custard Cups

A custard cup is a small, heat-resistant, glass or porcelain bowl (similar to a ramekin) in which an individual custard or pudding is baked. Typical custard cups are 6 oz. and 8 oz. in size.

Molds and Special Dishes

Multiple pudding and soufflé recipes are cooked in specialized dishes or molds.

- Soufflé: Soufflé dishes are generally round with straight sides. They range from 1 qt. to 2 qt. in size.
- Charlotte: Charlotte dishes are plain, round, metal molds with heart-shaped handles. They also range from 1 qt. to 2 qt. in size. Ramekins are smaller, individually sized versions of a soufflé dish. These dishes are also used for mousse and frozen desserts.
- Flan: Flan molds are a round, shallow, flat dish. Often made from metal, versions can be found in glass, porcelain, or silicone. Flan molds are from 1 qt. to individual in size and are sometimes called Maryann pans. Some versions include an attached bain-marie.
- Pudding molds: The usual volume of pudding molds is from 7 to 12 cups. These molds have a center tube and fitted lid. Generally metal, they may have decorative sides, bottoms, and tops. Typically, a steamed pudding is cooked on the top stove rack. The bottom rack contains a pan of water, producing steam—hence, steamed pudding. Steamed pudding is found more often in British dishes.

Bain-marie

A **bain-marie** is a hot water bath ("bain" is the French term for bath) used to slow cook foods or keep them warm. In a shallow pan, custard cups, ramekins, or soufflé dishes are placed. Then, hot water is poured around the dishes (about half way up the sides). The water is kept near boiling (either on top of the stove or in the oven) to produce an even heat and to prevent the custard or pudding from overcooking. [NOTE: Bain-marie can refer to a utensil or to a cooking technique.]

Double Boiler

A **double boiler** is a saucepan that is made up of two pans that nestle together—the bottom pan is filled half full (or less) with simmering water, and the top pan holds the ingredients. Typically, the top pan does not touch the simmering water. Custard and pudding mixtures coagulate and/or curdle easily, so the upper pan must not come in contact with the hot water in the lower pan. (The trick is to gently heat the proteins in egg and milk while slowly stirring.)

Instant-Read Thermometer

An instant-read thermometer is a small, thin instrument with a temperature gauge or digital readout. The sensor is located at the tip. To accurately measure the temperature, the sensor must be in the middle of the custard or pudding.

CUSTARD AND PUDDING TYPES AND PREPARATIONS

Custards are of two types: stirred and baked. Both types create a rich, smooth sauce served warm or cold. Baked custards are prepared with whole eggs and are cooked in an oven with water surrounding its dish. Stirred custards contain egg yolks and are cooked on the stovetop, often in a bowl over water. Although the United Kingdom refers to suet- and flour-based items as puddings (that are steamed or baked), Americans' think of pudding as a boiled egg and milk dish. This lesson will cover boiled pudding. All puddings are stored under refrigeration.

Stirred Custard

Stirred custard is a soft, creamy custard made on the stovetop. It is softer in texture than baked custard. Stirred custards can be cooked over a double boiler or by using a **bain-marie technique** (the process of heating ingredients by placing of a bowl over a pan of boiling water). The egg mixture is stirred continuously to stabilize the eggs and prevent curdling. A bain-marie insulates the pan or cups so that the custard does not cook too quickly. Ingredients in stirred custards are egg yolks, granulated sugar, cornstarch (generally), milk, and flavorings (such as vanilla). Examples of stirred custards are pastry cream and crème anglaise. [NOTE: See more information about emulsions and colloids in Objective 3.]

Curdling and Tempering

Curdling is the congealing of overcooked proteins that occurs when heat is applied too rapidly. The result is the formation of lumps (cooked protein pieces). A curdled mixture is referred to as "broken" (separated or congealed). When an egg mixture curdles, it tastes like scrambled eggs.

Tempering is the changing of an item's consistency through heat. The tempering of eggs involves slowly heating the egg mixture while constantly whisking. This stabilizes the mixture and keeps it from curdling. Using a high heat toughens and shrinks the egg albumen, keeping it from successfully combining with the other ingredients.

Creating a Stirred Custard

Follow the following basic steps to create a custard.

- Gradually add hot liquid (cream) to beaten eggs, whisking constantly.
- Continue cooking until the custard reaches 175°F on an instant-read thermometer. The mixture should be thick enough to coat the back of a spoon. **Coats the back of a spoon** is a cooking test for thickness (a liquid mixture is at the right thickness when it coats the back of a spoon). The custard is done when the spoon is removed from the custard and, after running a finger across the back of the spoon, leaves a clear, distinct trail.
- Next, the mixture is removed from the heat and strained to remove any coagulated egg protein (usually the egg white). It is now ready to be part of a dessert.

Pastry Cream

Pastry cream is a stiff, creamy, stirred custard that is used as a filling. It is used in pastries (cream puffs and éclairs), tarts, and cakes (Boston cream pie)—as well as a base for fruit curds. There are various recipes for pastry cream creations.

Crème Patissière

Crème patissiére is a classic, French pastry cream. The difference between this and a regular pastry cream is the use of flour as a thickener (along with the usual cornstarch). A recipe can be found on the website, A Little French Bakery, at http://littlefrenchbakery.com/blog/pastry-creme-creme-patissiere.

FIGURE 6. Pastry cream is a stiff, creamy, stirred custard that is used as a filling. It is used in pastries (cream puffs and éclairs), tarts, and cakes (Boston cream pie)—as well as a base for fruit curds. Here, choux pastry is being filled with pastry cream.

Tarts

Cream and fruit tarts are an easy pastry-cream dish, because once the cream is done, it can be placed right in the crust and served. Pastry creams can also be the base for a fruit curd (a basic stirred custard, with fruit juices and zests added—usually citrus).

Recipes

Multiple recipes can be found online. Below are a few website examples.

- The Joy of Baking website has a "Fruit Tart Recipe and Video" at http://www.joyofbaking.com/FruitTart.html

- Ina Garten's recipe for lemon curd can be seen on the Food Network website at http://www.foodnetwork.com/recipes/ina-garten/lemon-curd-recipe/.
- Martha Stewart: https://www.marthastewart.com/343977/pastry-cream
- Duff Goldman: http://www.chefduff.com/recipes/ (rompope-filled churros)
- Tartelette: http://www.tarteletteblog.com/2008/08/chocolate-eclairoh-pierre.html

Crème anglaise

Crème Anglaise is a thin, lightly sweet, custard sauce. Literally translated "English custard," it is thickened mainly by the egg yolks. Ingredients are egg yolks, granulated sugar, milk, salt, whipping cream, and flavoring. It is the base for most ice creams and mousse desserts, the filling for many pastries, and the foundation of most dessert soufflés. The thickening agent in crème anglaise is a liaison. In cooking, a **liaison** is a thickening agent made of egg yolks and heavy cream. The liaison technique consists of warming the egg yolks with a scalded milk mixture, instead of over water. This mixture is gradually heated, just enough to thicken the liquid but avoiding temperatures hot enough to scramble the eggs (below 185°F).

Creating a Crème Anglaise

Follow these steps to create crème anglaise.

- Step 1: Scald the milk, and slowly add it to a mixture of beaten egg yolks, sugar, and salt. The egg mixture is tempered by slowly adding the milk while whisking. This keeps the temperature from rising too fast.
- Step 2: The mixture is placed on the stovetop over low heat until the custard coats the back of a spoon.
- Step 3: After cooking is complete, the crème anglaise is removed from the heat and placed in a cold-water bath to stop cooking. Stirring continues until cool.
- Step 4: Strain the sauce to remove the egg white that invariably clings to the yolks. Then, vanilla and cream are added. (Folding in whipped cream creates a mousse.) The sauce can be chilled for use with a cold dessert, or it can be poured directly over a warm dessert. [NOTE: Many recipes have the vanilla (or other flavorings) and half of the sugar added to the milk at the beginning of this process.] A crème anglaise recipe is on the Epicurious website at http://www.epicurious.com/recipes/food/views/creme-anglaise-4984.

FIGURE 7. This traditional English apple pie is topped with stirred crème Anglaise.

Ice Cream

Ice cream is a frozen dessert made from cream, butterfat, sugar, and eggs. When created with a crème anglaise base, ice creams are rich and velvety. A french-vanilla recipe can be found on the Baking Bites.com website at http://bakingbites.com/2011/01/homemade-french-vanilla-ice-cream/.

Mousse

Mousse is the folded mix of a custard base and whipped cream. It can be lightened by whipped cream, whipped egg whites, or a combination of both. In French, mousse literally means froth or foam. A "Chocolate Mousse for Pastries" recipe and video is on the Callebaut website at http://www.callebaut.com/en-US/chocolate-video/technique/mousse-sauce#group-items-wrapper.

Chiffon

Chiffon is a flavored custard in which whipped egg whites are folded into a cooled custard sauce. It is used as a base for chiffon cakes or pies. Most chiffon preparations are baked, due to the raw egg whites, but some are not. Chiffon cakes have a creamy, fluffy texture. Chiffon pies are light and airy, and they usually include gelatin as a thickening agent. The "Lemon Chiffon Pie with Gingersnap Crust" recipe is on the Epicurious website at http://www.epicurious.com/recipes/food/views/lemon-chiffon-pie-with-gingersnap-crust-235364.

Floating Island

A **floating island** is a dish of poached meringue afloat a crème anglaise. This dessert is a classic French dish. Cafe Johnsonia has a version of a Julia Child recipe at http://cafejohnsonia.com/2012/07/julia-childs-floating-islands-recipe.html.

Baked Custard

The most common custards are baked. **Baked custard** is a light, slightly eggy custard that has been cooked in the oven. Ingredients include eggs, granulated sugar, salt, steaming milk, and flavoring. These custards typically retain the shape of their container and are relatively solid. Preparing baked custard is a simple process, in which the ingredients are whipped together, strained through a fine sieve, poured into custard cups or pie/tart shells, and baked in a water bath. Keeping the custard dishes surrounded by water allows for even heating. This tends to keep the individual custards consistently baked, instead of being over- and under-cooked in different areas. Examples of baked custard desserts and main dishes include custard cups, custard pie, flan, crème brûlée, crème caramel, cheesecake, and quiche lorraine.

Doneness

Unlike golden-brown cakes and pastries, perfectly baked custard should be creamy yellow in color. The doneness is tested by inserting a thin knife that comes out clean. Baked custards set more firmly than stirred custards and many have a skin that forms on top. Knowing when a

baked custard is done can be tricky. Some bakers look for a skin formation or insert a thin knife in the center.

A classic test is the gentle shaking of the dish. The entire center of the custard should jiggle "at once." If any element of the custard jiggles independently, it is not done. Also, baked custards continue to cook after being removed from the oven, so experience with a specific recipe is helpful in determining when the dessert is "done." An "Easy Old-Fashioned Baked Custard" recipe, using whole eggs, is on The Spruce Eats website at https://www.thespruce.com/easy-old-fashioned-baked-custard-3059894.

Custard Pies

A custard pie is the addition of uncooked custard added to an uncooked or partially cooked pie crust that is baked until the custard is set. **Cheesecake** is a baked custard that is made with the addition of cream cheese. It typically has a crumb crust made of cookies or graham crackers. It is generally baked in a springform pan. For a "Classic Custard Pie with Nutmeg" recipe that uses a prebaked crust, go to The Spruce Eats website at https://www.thespruce.com/classic-custard-pie-with-nutmeg-3052755.

Flan

Flan is a Hispanic classic—baked custard served upside down (unmolded), usually in a sauce. Flan comes from a line of desserts called crème caramels. A **crème caramel** is a sweetened baked custard that is served upside down (unmolded) with a caramelized-sugar sauce. On The Spruce Eats website, look at the "Dulce de Leche Flan" recipe that

FIGURE 8. If any element of the custard jiggles independently, it is not done.

FIGURE 9. Keeping the custard dishes surrounded by water allows for even heating. This tends to keep the individual custards consistently baked, instead of being over- and undercooked in different areas.

FIGURE 10. Crème caramel is sweetened baked custard unmolded upside down and served with caramelized sugar sauce.

uses sweetened condensed milk at https://www.thespruce.com/dulce-de-leche-flan-3029065. See the "Crème Caramel Recipe" on the Easy French Food website at http://www.easy-french-food.com/creme-caramel-recipe.html.

Brûlée

Crème brûlée is baked custard served under a crispy sugar-topped crust. It is typically served in a ramekin or shallow baking dish. Find the simplified "Crème Brûlée" recipe on the Betty Crocker website at http://www.bettycrocker.com/recipes/creme-brulee/67864cdb-de54-48b0-adca-02b9839ba033. On this site, look at the "Expert Tips" section about using the broiler instead of a torch to caramelize the sugar.

Quiche

Quiche lorraine is a savory custard pie from the Lorraine region of France. Originally, this dish was prepared with only eggs, heavy cream, and bacon or chopped ham (and no cheese). The term "quiche" actually comes from the German "kuchen," meaning cake. In general, a quiche is any savory, baked custard pie. Today, numerous vegetables, meats, seafood, and cheeses are used in quiche recipes. The Martha Stewart website has a quiche lorraine recipe at http://www.marthastewart.com/338286/quiche-lorraine. This recipe uses a tart crust that is available through a link on this site.

Soufflé

A **soufflé custard (soufflé)** is a baked custard prepared with whipped egg whites for an extremely light, highly risen finish. It can be either a sweet dessert or a savory pie baked in the oven. Fluffiness and height are achieved when whipped egg whites are folded into a pastry cream. The soufflé custard is baked immediately after folding the batter into an individual, 1 qt., or 2 qt. ramekin that has been buttered and sugared. For savory soufflés, salt and spices take the place of sugar and flavorings.

Mise en place (a French cooking term that means "to set up" or "to arrange") is especially important when constructing baked soufflé custard. The oven must be preheated, the egg whites at room temperature, and the soufflé ramekin and optional collar (oven-safe paper wrapped to keep soufflé from expanding over edges) readied prior to mixing. Savory soufflé custards are

FIGURE 11. A soufflé is a baked custard prepared with whipped egg whites for an extremely light, highly risen finish. It can be either a sweet dessert or a savory pie baked in the oven.

FURTHER EXPLORATION...

Online Connection: Cream Puffs and Crème Brûlée

Who first decided to fill a pastry with cream? What made someone want to burn sugar on a custard? Visit the LoveToKnow website at https://gourmet.lovetoknow.com/History_of_Cream_Puffs. Read Jeanne Grunert's article about the history of cream puffs. Afterward, scroll down to her history of crème brûlée.

Cream puffs (made from a choux pastry) and crème brûlée have been around a long time. Who originated these classic, tasty desserts?

most popularly cheese-based, but can include anything. Other popular items are seafood, asparagus, and mushrooms.

Cornstarch Pudding

When Americans refer to pudding, they are referring to boiled pudding. Boiled puddings have a thicker consistency than custard, and they are made with cornstarch or gelatin. **Cornstarch pudding** is a boiled pudding thickened with cornstarch. Generally, they are a mixture of milk, sugar, cornstarch, and eggs that are cooked until thickened into a smooth, shiny, creamy consistency. An example of a cornstarch pudding without eggs, "Grandma's Corn Starch Pudding," is on the Cooks.com website at http://www.cooks.com/recipe/259q973t/grandmas-corn-starch-pudding.html.

Preparing a Cornstarch Pudding

To Prepare a cornstarch pudding, follow these basic steps.

- Mix the dry ingredients in a saucepan, and gradually stir in a small portion of the cold milk to make a smooth, runny paste.
- Whisk in the remaining milk, and stir constantly over medium heat until the mixture just comes to a simmer.
- Remove from the heat. Stir a small amount of the hot mixture into beaten eggs.
- Stir the warmed eggs back into the milk mixture. Return to low heat, and bring to a simmer.

- Cook and stir constantly for a short time (about one minute) to ensure the starch is evenly distributed and thickening has begun. Remove from the heat and stir in the flavor.
- Chill until the pudding sets into a gel.

Basic Cornstarch Pudding

Puddings placed in cups, or shaped in molds are the most common preparations for cornstarch pudding in homes. Most basic puddings come in vanilla or chocolate. They are served in a cup with whipped cream. A recipe for "Vanilla or Chocolate Pudding" is on the Martha Stewart website at http://www.marthastewart.com/314077/vanilla-or-chocolate-pudding. This recipe whips the egg yolks into the cold milk before cooking which eliminates the step of warming the eggs. There is a basic preparation for most cornstarch puddings, as well as multiple desserts and variations.

Cream Pies

Cream pies are cornstarch puddings that are chilled and placed in a pre-baked pie shell or crumb crust (cookie or graham cracker). A variety of cream pie recipes are available on the Better Homes and Gardens website at http://www.bhg.com/recipes/desserts/pies/cream/cream-pie-recipes/. These recipes include some of the most popular in America—coconut cream, brown-bottom butterscotch, chocolate meringue, and Italian silk pie. Other popular variations are banana cream and lemon meringue.

Parfaits

Called trifles in England, parfaits are chilled, cornstarch-pudding dishes made in a sundae or parfait glass. The pudding is sandwiched between layers of whipped cream, cookies, cakes, candies, or any variation of sweets. The goal is to have a variety of textures and flavors in each spoonful. An example, "Parfait Recipes," is on the Huffington Post website at https://www.huffingtonpost.com/2013/02/22/dessert-parfaits-recipes_n_2734345.html?slideshow=true#gallery/282300/0.

Fillings

Cornstarch puddings are often used as a filling for cakes and cupcakes. Used as a filler between layers or inserted in the middle of the cake, these puddings are typically used to fill butter or sponge cakes. A YouTube video, "Chocolate Cake with Vanilla Pudding Filling," is on https://www.youtube.com/watch?v=wgGNt3t9U08. The assembly of the filled 13" × 9" cake includes an overnight in the refrigerator.

Gelatin Pudding

Chilled, gelatin pudding has ample levels of cream and eggs. Gelatin puddings can have a higher liquid content, since the gelatin can create a stronger gel strength than cornstarch. Common ingredients include milk, cream, gelatin, granulated sugar, heavy cream, flavorings, and added fruits or fruit juices. The resulting desserts may be kept under refrigeration for sev-

eral days (or frozen). Dessert applications of gelatin pudding include panna cotta, Spanish cream, bavarian cream (bavarois), charlotte russe, and blancmange.

Panna Cotta

Panna cotta is an Italian, double-cream pudding made with gelatin and served cold. Panna cotta literally means "cooked cream" in Italian. This rich, light, creamy dessert has a silky mouthfeel. Classically, it is served with a caramel sauce, but it can be found in a variety of flavors—thanks to the onset of international fusions. Watch the "Panna Cotta Recipe and Video" at http://joyofbaking.com/PannaCotta.html.

Molded Creams

Many gelatin puddings have a high milk or cream content. They are often referred to as creams.

Spanish Cream

Spanish cream is a richly flavored, molded gelatin pudding made with milk. Classically, it is flavored with vanilla (and sometimes lemon). See a "Spanish Cream" recipe on Genius Kitchen at http://www.food.com/recipe/spanish-cream-124787.

Bavarian Cream

Bavarian cream (bavarois) is a rich, firm, gelatin pudding made with large amounts of cream. It uses a larger amount of cream than the Spanish version. Bavarois is the French name for bavarian cream. In the United States, this creamy pudding is used as a filling in tortes, cakes, and donuts, but in Europe, it can be found in elaborate molds. See a yummy bavarian cream recipe by Michael Symon on the Food Network website at https://www.foodnetwork.com/recipes/michael-symon/bavarian-cream-recipe-1939359. A classic, French, vanilla bavarois recipe and video are on the CookerySkills.com website at http://www.cookeryskills.com/recipes/dessert-recipes/vanilla-bavarois/.

Charlotte Russe

A **charlotte russe** is a type of bavarian cream that is molded with sponge cake or ladyfingers. "Russe" is French for Russian. Generally, a circular pan or mold ring is lined with ladyfingers and filled with the bavarian cream. After it is chilled, the pan or mold is removed, and the ladyfingers are decorated with a bow, icing, or fruit. See Paula Dean's "Charlotte Russe" recipe on the Food Network website at http://www.foodnetwork.com/recipes/paula-deen/charlotte-russe-recipe/. A modified recipe, "Charlotte Cake Recipe," can be found on the Natasha's Kitchen website at http://natashaskitchen.com/2016/03/18/charlotte-cake-recipe/.

Blancmange

Blancmange is a cold, sweet, classic gelatin pudding molded into various shapes. Some recipes call for the addition of cornstarch in the mixture. This was a favored, fine-dining, pudding recipe from the 1500s to the 1800s, due to its ability to stiffen in elaborate molds and

maintain its creaminess. See a recipe for "Downton Abbey Rose Blancmange" pudding (flavored with rose water) on The Modern Gelatina website at https://themoderngelatina.com/category/blancmange/.

Troubleshooting

When custards or puddings fail, the remedies may be easier than first thought. The following are common issues, their reasons, and possible fixes for custard and pudding recipes.

Troubleshooting: Stirred Custard

Stirred custard failures usually result from separation, flavor, or texture.

- Emulsion Breaks: Ingredients separate if the temperature is too high during cooking.
- Starchy Flavor: If the custard mixture isn't heated long enough for the starch to be absorbed, the flavor gets muddled. Too much cornstarch can cause a similar problem.
- Curdling: If the egg mixture is heated too quickly, the egg starts to cook. This forms lumps of scrambled eggs mixed throughout, causing a lumpy texture, odd mouthfeel, and eggy taste.

Troubleshooting: Baked Custards

Baked custards have similar and unique difficulties.

- Cracked or Pulled: Sometimes overbaking will cause the custard to crack from the top or pull away from the sides of the pan. This can also cause crispy or hard edges.
- Soggy Crust: When baking a tart, pie, or quiche, the liquid and density of the custard can keep the bottom crust from cooking. This is an especially common problem when additional items (fruits in a tart or pie, mushrooms or vegetables in a quiche) touch the crust. Partially pre-baking the crust can correct this problem. [NOTE: A high heat will keep the center from fully cooking before the edges are done. The heat should be lowered and the cook time expanded on the next try.]
- Not Set: If the custard does not set, there could be a few issues. Most commonly, it is underbaked. Other issues could involve the number of eggs used (too few) or the proper blending, whipping, or mixing of the ingredients.

Troubleshooting: Cornstarch Puddings

Cornstarch puddings tend to have similar issues as other items thickened with cornstarch.

- Starchy Flavor: If the pudding isn't heated long enough for the starch to be absorbed, the flavor gets muddled. Too much cornstarch can cause a similar problem.
- Curdling: If the egg mixture is heated too quickly, the egg starts to cook. This forms lumps of scrambled eggs mixed throughout, causing a lumpy texture, odd mouthfeel, and eggy taste. Acidic ingredients, such as citrus, can also cause milk to curdle.

- Not Set: The imbalance of eggs, cornstarch, or liquids can cause the mixture to remain runny. Also, undercooking may be the problem.
- Lumpy: Pudding can have lumps when the egg has curdled, or the cornstarch was not properly added. Straining before chilling will help solve this problem.
- Scorched: A scorched, or burnt, flavor can happen when the temperature is too high during cooking. If a skin or browning is found at the bottom of the pan, this is also a result of a temperature being too high.
- Skin Forms: If the warm pudding is not covered, a skin can form. Plastic wrap helps with this problem. A skin adds a tough texture to an otherwise silky pudding.

Troubleshooting: Gelatin Puddings

Common gelatin issues are related to consistency and lumpiness.

- Not Set: Sometimes, if a gelatin comes in contact with acidic ingredients, the sugar concentration is too high, or it is placed in a boiling liquid, it will not set properly.
- Lumpy: If gelatin is not properly bloomed or the pudding mix chills to too long before being incorporated into a meringue or whipped cream, the resulting dessert can have a grainy or lumpy texture.

Storage

All custards and puddings contain eggs and dairy. This means that they should be covered and placed in a refrigerator to keep bacteria from forming too quickly.

- Refrigerated custards and puddings should be covered with plastic wrap. [TIP: Plastic wrap placed directly on the surface of warm cornstarch puddings prevents a skin from forming.]
- Custards and puddings should be cooled to room temperature before refrigeration. This prevents excess condensation from forming.
- These desserts should be held no more than three days under refrigeration. If frozen, the consistency will change upon thawing. Products tend to lose their freshness and palatability quickly.

Serving Suggestions

Custards and puddings can be served in a variety of ways. Temperature, added ingredients, and presentation should always be considered.

- *Baked Custards:* Baked custards can be served warm or cold. They can be topped with spices (cinnamon or nutmeg), whipped cream, meringue, sweet sauces, or fresh berries. [TIP: Blot condensation from baked custards prior to serving.]
- *Stirred Custards:* Stirred custards can be served warm or cold. Stirred custard can also be used as an element of other dishes (cream puffs, apple crumble, steamed pudding, etc.). Cakes and pastries mix extremely well with custard sauces.

- *Cornstarch Puddings:* Served chilled, cornstarch puddings do well in a single, large dish or various individual dishes. When molding, individual pre-oiled cups are easier to release than a large mold. They can be topped with whipped cream or meringue. This pudding can be a great filling for cakes or pastries.
- *Gelatin Puddings:* Gelatin puddings can be served chilled or frozen and topped with whipped cream or sweet sauces. Gelatin puddings hold well for arrangement on chilled trays for buffet service.

DIGGING DEEPER...

UNCOVERING ADDITIONAL FACTS: How Important Are Mise En Place Rules?

Mise en place is a French cooking term that means "to set up" or "to arrange." The following steps are all part of mis en place.

Why are mise en place rules important when preparing custards and puddings?

- Read the entire recipe.
- Collect all of the ingredients and allow them to come to room temperature (with the exception of heavy cream, which should usually remain refrigerated until use).
- Measure all ingredients accurately, preferably by weighing.
- Follow processes requested by the recipe. This might include chilling a stainless steel bowl in the freezer (to whip heavy cream), ensuring ingredients are at room temperature, or pre-cooking/pre-cutting added ingredients (such as fruit compotes, toasted spices, or nuts).
- Prepare the workstation by cleaning the area, gathering tools (cutting board, knives, etc.), and arranging equipment (such as a stand mixer) as required.
- Preheat the oven.
- Prep baking pans. (For example, the recipe may call for the baker to grease the pan, add parchment paper, or grease a liner).
- Make a cooling station (a clear area with cooling racks, etc.)

What are the benefits of mis en place? Which dishes might having all equipment and ingredients pre-arranged be best for?

THE SCIENCE BEHIND PUDDING AND CUSTARD

Baking is a science. Many scientific actions occur when making and baking custards and puddings. Numerous physical changes and chemical reactions are necessary to prepare perfect custards and puddings. The difference between a chemical reaction and a physical change is compositional. This section will discuss the definitions and various situations related to chemical reactions and physical changes when preparing custards and puddings.

A **chemical reaction** is a process that produces a permanent change in the chemical composition and molecular structure of a substance. For example, fresh eggs that are fried cannot become fresh eggs again. The protein in the egg has been permanently changed, and the structural makeup is very different. Heat creates chemical reactions: exothermic and endothermic reactions. An **exothermic reaction** produces heat. An **endothermic reaction** absorbs heat. Specifically, heat:

- Helps produce tiny gas bubbles that help in thickening and rise (such as in a pudding or a soufflé)
- Causes egg protein to change and "firm up"

A **physical change** is the transformation of a substance that does not alter its chemical properties—a phase change. The change can involve a difference in the way the substance displays appearance (color or shape), texture, temperature, or smell, but it usually results in a change of state, such as liquid to solid. Melting, boiling, and freezing are examples how to create a physical phase change. An ice cube that melts is still water, and its chemical properties remain intact. [NOTE: In the physical change described here, the ice cube and warm temperature are the reactants—the ingredients of physical change. The liquid water is the product, or result, of a physical change.]

Absorption

Absorption is the act of one substance (liquid or solid) taking up (soaking up) particles from another substance (gas or liquid) by physical or chemical means.

Hygroscopic

Hygroscopic is a term relating to the ability of a substance to absorb water from its surroundings. For example, when custard and pudding are prepared, liquid is absorbed into starch or gelatin molecules.

- Pan flow: Mixtures with a high proportion of liquid (whether water, milk, or eggs) creates a batter with more **pan flow** (the ease with which batter fills a pan's shape).
- Viscosity: The higher a batter's **viscosity** (a measure of thickness, or resistance to flow), the more resistant it is to flow. Each type of starch has different physical properties related to viscosity—less or more thickening power that affects the viscous nature of puddings and stirred custards.

Saccharides

Starch is a complex carbohydrate also known as a polysaccharide.

- Monosaccharides: A **monosaccharide** is a basic unit of a carbohydrate and the simplest form of sugar. This includes glucose, fructose, and galactose.
- Disaccharides: A **disaccharide** is two monosaccharides linked together. These include sucrose, lactose, and maltose.
- Polysaccharides: A **polysaccharide** is a link of multiple monosaccharides. This can be ten or ten thousand. Polysaccharides are an example of a polymer. A **polymer** is a substance created from the linkage of multiple, related molecules.

Condensation

Condensation is the conversion (a physical change) of a vapor (gas) into a liquid—the reverse of evaporation. When cold batter and dough are placed into a warm oven, moisture (condensation) is produced on the surfaces. This action cools down the crust, and it allows the baked good to rise before the crust hardens. A porous surface on a baked good can be due to too much condensation.

Evaporation

Evaporation is the conversion (a physical change) of a liquid into a vapor (gas). The rate of evaporation increases with the rise in temperature. Evaporation is used in many culinary processes to concentrate a solution; such as cooking down pan sauces to thicken and intensify the flavor, simmering tomatoes to release moisture, or thickening a roux.

Emulsion

An **emulsion** is a semi-liquid, stable mixture in which one or more liquids are suspended within another. An emulsion can have two or more **immiscible** (unmixable) ingredients. While emulsions are immiscible, **homogeneous mixtures** are a mix of ingredients that have a uniform composition (the same properties throughout).

Emulsions can be "liquid dispersed in fat" or "fat dispersed in liquid." For example, natural emulsions include butter (liquid dispersed in fat) and homogenized milk and cream (fat dispersed in liquid).

Custards and puddings thickened with egg yolks are fats dispersed in liquids. The egg yolks thicken the liquid milk. However, egg yolks cooked to temperatures over 185°F cause the custard to curdle and the emulsion to separate.

Egg yolks contain lecithin. **Lecithin** is a mix of animal or plant lipids that create a substance which attracts both water and fatty substances for binding. This fatty (lipid) substance is often used as a food and drug additive for binding. [NOTE: For more general information about emulsions, see previous CAERT lessons about emulsions.]

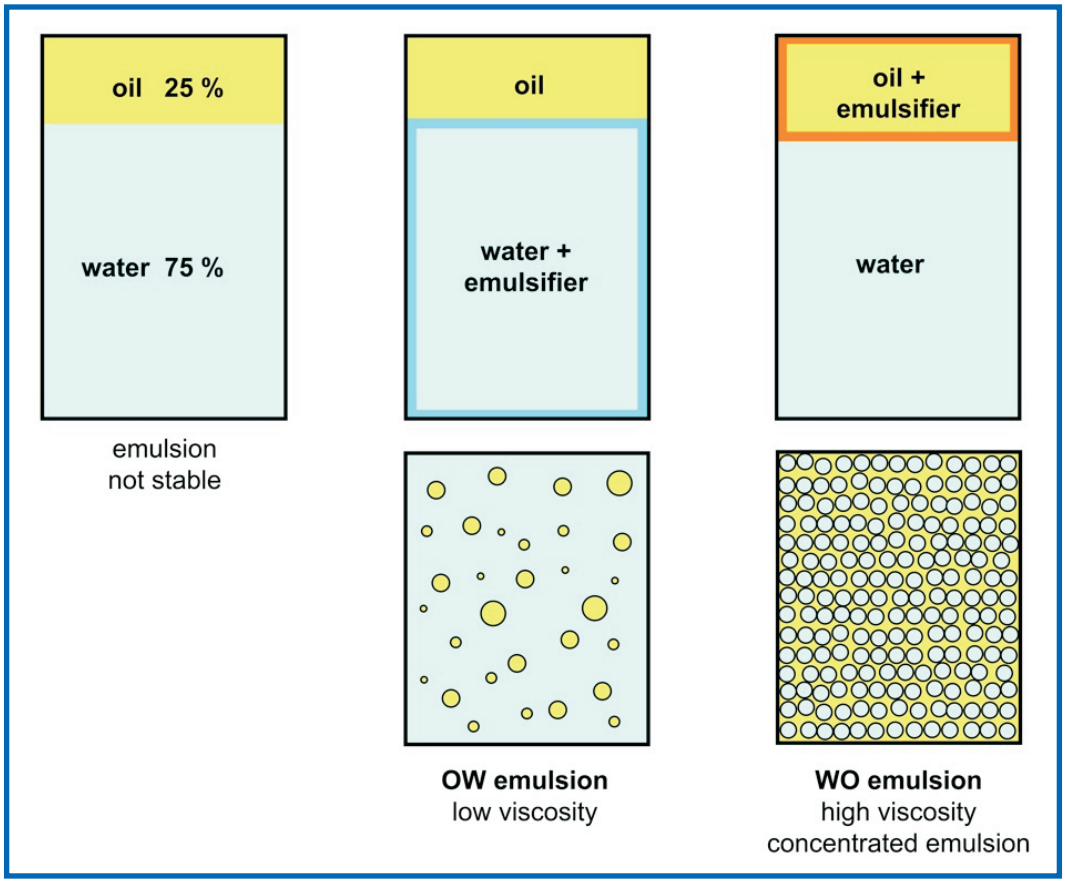

FIGURE 12. Emulsions can be "liquid dispersed in fat" or "fat dispersed in liquid." For example, natural emulsions include butter (liquid dispersed in fat) and homogenized milk and cream (fat dispersed in liquid) Custards and puddings thickened with egg yolks are fats dispersed in liquids. The egg yolks thicken the liquid milk.

Heat Transfer

A **heat transfer** is the exchange of thermal energy between two objects, or the physical process of a food absorbing heat from a source. While heating food, molecules absorb energy, vibrate quickly, and bounce off each other. Each collision produces heat, which is transferred to the food. This is the basis of cooking. There are three methods of heat transfer. [NOTE: For more detailed information, the Biscuit People article, "Heat Transfer for Biscuit Baking," can be read at http://biscuitpeople.com/heat-transfer-for-biscuit-baking/. Their process described for biscuits is the same for baked custards.]

Radiation

Radiation is the transmission of heat through waves of energy. Microwave and infrared waves are two types of radiation in cooking. Radiant heat is evident with the opening of a pre-heated oven, a hand stretched over coals, or the feeling of skin near a boiling pot. Warmed air is transferred to food and cooks it (radiation cooks through indirect contact).

Conduction

Conduction is the passing of heat between solid objects through direct contact. For example, heat is conducted from stovetop burners to pots and pans. Heat is then conducted from the pots and pans to the food. Pans transfer heat, by conduction, to a batter.

Convection

Convection is the transfer of heat by the circulation of warm air or water. In a convection oven, a fan blows hot air over and around the food. (In savory cooking, sous-vide is a method of cooking sealed bags of food in a warmed water bath. In custards, the double boiler and bain-marie are two convection heat sources used.)

Caramelization

Caramelization is the oxidization (browning) of sugar, or the natural sugars in fruits and vegetables, in order to get a sweet, nutty, brown sauce or coating. Caramelization is the last chemical reaction to occur during baking. It only occurs when sugars are heated. The flavors of caramelization occur after 356°F is reached. Custards baked at 350°F have no caramelized flavor. Each sugar type caramelizes at a different temperature. Crème brûlée is an example of sugar that is caramelized with a torch (or under a broiler) immediately before serving. Each sugar type caramelizes at a different temperature.

- Fructose caramelizes at 230°F (110°C).
- Sucrose caramelizes at 320°F (160°C).
- Baked goods made with honey or fructose develop a darker color, because they begin browning at a lower temperature (honey contains fructose).

FIGURE 13. Crème brûlées are caramelized by use of a torch or a broiler.

Hydrolysis

Hydrolysis is the chemical separation of a compound through the addition of water. For example, adding water to sucrose leaves glucose and fructose. The result of this hydrolysis is an invert sugar. An **invert sugar** is equal parts glucose and fructose (derived from water and sucrose). In a baked good, the heating of eggs and sugar (prior to whipping) allows time for the conversion of sucrose (table sugar) to begin (with moisture from the fat—including egg yolks). [NOTE: The inversion processes can involve the hydrolysis of sucrose with an acid and some heat (used in candy making).]

Foam

Foam is a mass of bubbles that is created in or on the surface by whipping or agitation. In a batter, the act of whipping egg whites causes a protein film that holds the foam. A child blowing bubbles with a wand dipped in a soapy solution creates a type of foam.

Colloidal Dispersion

All foams are a type of **colloidal dispersion** (a substance suspended in another substance) in which air is dispersed without dissolving. The smaller substance suspended within another substance is called a **colloid**.

Surface Tension

Not all ingredients foam. To foam, a liquid must have a low surface tension. **Surface tension** is a property of a liquid that allows it to resist external forces. The surface of a liquid, where the liquid is in contact with gas, acts like a thin elastic sheet. (Remember the soap bubble? It's a pressurized bubble of air contained within a thin, elastic surface of liquid. This is surface tension.) Warm temperatures lower the surface tension of liquid eggs, making it easier for bubbles to form. Eggs develop the volume and lightness of custards due to their ability to foam, and the innate surface tension of liquid eggs.

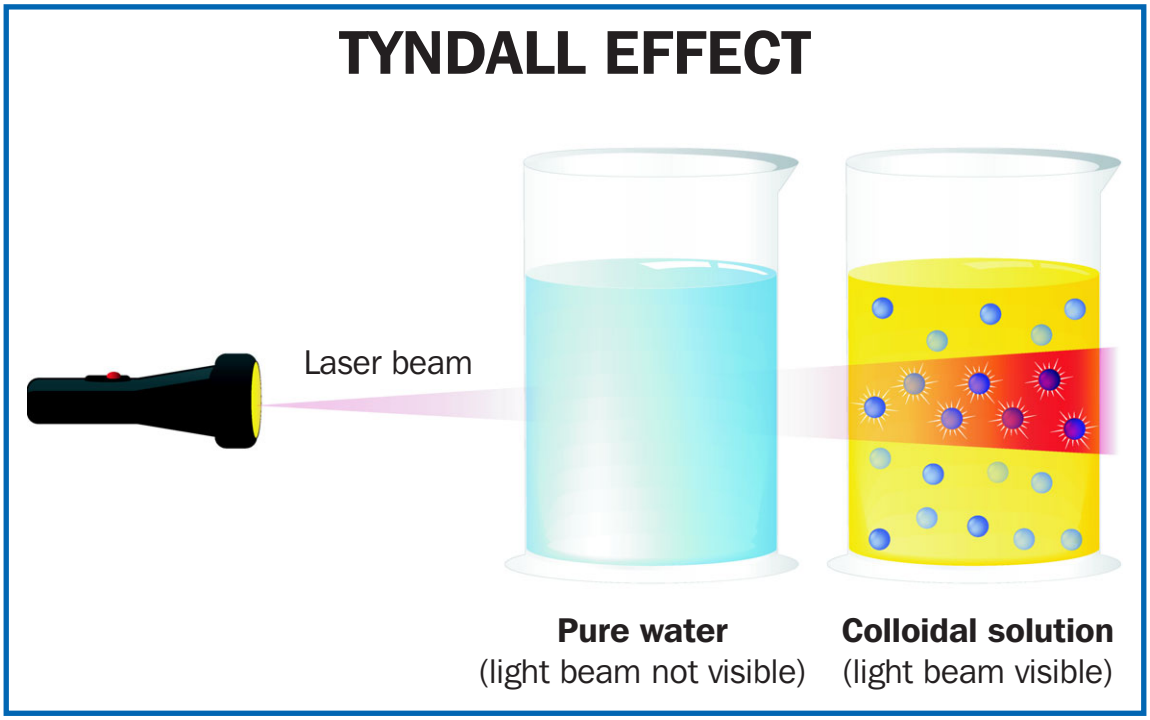

FIGURE 14. All foams are a type of colloidal dispersion (a substance suspended in another substance) in which air is dispersed without dissolving. The smaller substance suspended within another substance is called a colloid.

EXPLORING OUR WORLD...

SCIENCE CONNECTION: What Is a Hydrocolloid?

The prefix "hydro" means water. Colloids are small, suspended particles dispersed in a liquid. Hydrocolloid molecules have long, tangled chains. When added to water, they prevent the water from flowing freely (or they change the solution's viscosity) by getting tangled up into a web that prevents easy flow. Colloids are all around us. For example, paint is a solid-in-liquid, whipped cream is a gas-in-liquid, STYROFOAM™ is a gas-in-solid, and salad dressing is a liquid-in-liquid form of colloidal dispersion. Traditionally, viscosity changes in cooking are made with thickeners, such as flour, fat, pectin, gelatin, and cornstarch. Hydrocolloids are the newest addition to a chef's pantry to change the viscosity of liquids.

Those food scientists who practice molecular gastronomy (a sub-discipline of food science that investigates the physical and chemical aspects of food) are the primary users of hydrocolloids. Types of hydrocolloids include different "gums" (xanthan, guar, and locust bean), agar, and carrageenan. For more information, see the Science of Cooking website article, "Science of Hydrocolloids in Cooking," at http://www.scienceofcooking.com/science_of_hydrocolloids_in_cooking.htm. Then, view the CloveGarden website page, "Starches, Thickeners, and Gels," at http://clovegarden.com/ingred/starch.html.

pH

When working with foods, **pH** is the level of acidity or alkalinity of a given substance. The **pH scale** is a system of numbers used to measure the pH levels of a water-based liquid, with seven being neutral. The scale is a linear measure from 0 to 14. Neutral (neither acid nor alkaline) is a pH of 7 (water). Acid is a pH of less than 7 (lower numbers on the pH scale). Alkaline is a pH greater than 7 (high numbers on the pH scale). Alkaline substances release higher levels of hydrogen when mixed with water. Acids neutralize alkali and vice versa. Acidity is important when dealing with gelatins. Gelatins can break down in acidic atmospheres. [NOTE: For more information about pH and the pH scale, see the MYcaert lesson about pH and cooking.]

Gelatinization

Gelatinization is process of a liquid becoming gelatinous. It turns a colloidal system from a temporary suspension into a permanent suspension. Gelatinization is a chemical reaction involving a starch or gelatin with moisture and heat.

Gelatinization of Starch

There are physical changes that occur during gelatinization of starch—color, viscosity, and texture. Hydrogen bonds form between starch and water molecules, causing the starch granules to swell and absorb water. The more amylose in a starch molecule, the more the mixture

will gel. The thickening properties of starch depend on the ratio of amylose to amylopectin molecules in starch.

- Amylose and Amylopectin: Amylose mixes easily in liquid—it can change paste into a gel. Amylopectin doesn't mix easily in liquid due to its branched form. Waxy starches are engineered to have no more than 10% amylopectin (they contain more amylose and gel better).
- Retrogradation: In one or two days, a pudding gel made from starch breaks down. **Retrogradation** is the movement back to an original position. In starch, it is the realignment of previously separated molecular chains. The amylose and amylopectin chains start to realign as the pudding cools. This "backward movement" returns amylose to a crystalline form that causes the pudding to assume a gritty texture.

Gelatinization of Gelatin

Gelatin has long, stretchy chains of amino acids (and a small amount of hydrogen). These chains are attracted to other chains, and stick on top of each other. When liquid and heat are introduced, they slide apart and absorb the liquid. The hydrogen bonds are weakened from the liquid. Different from starch, the cooling process actually causes the hydrogen bonds to reform and reattach the gelatin chains. This strengthens and reforms the gelatin with the liquid dispersed within, creating a fully gelatinized product. This is why puddings made with gelatin are great for molds and significantly thicker than custards.

Weeping

Syneresis is contraction and separation of liquid from a gel. This is the action responsible for weeping. Sometimes, a pudding used as a pie filling starts to weep a day or two after preparation. This is a result of liquid molecules being pushed out as the solid molecules pull (contract) back together.

FIGURE 15. Syneresis is contraction and separation of liquid from a gel. This is the action responsible for weeping. Sometimes, a pudding used as a pie filling starts to weep a day or two after preparation. This is a result of liquid molecules being pushed out as the solid molecules pull (contract) back together.

Summary:

Custards and puddings can be flavored in a variety of ways and used in numerous desserts and savory dishes. They are cooked on the stovetop or in the oven, generally in some form of a bain-marie technique. Custards can be served warm or cold,

but puddings should be served cold and are stored in the refrigerator. American puddings are actually boiled puddings, and differ from British terms for puddings. Many scientific processes occur when creating custards and puddings. Science terms unique to thickening agents are retrogradation and syneresis.

Checking Your Knowledge:

1. Differentiate between custard and pudding.
2. What are two naturally occurring starch structures? How do they differ?
3. What is a bain-marie technique? What makes it so useful to custard and pudding preparation?
4. Name and describe two stirred custards. Name and describe two baked custards.
5. Name and describe two boiled puddings.
6. How do retrogradation and syneresis affect custard and pudding dishes?

Expanding Your Knowledge:

We often have questions about the foods we are cooking, especially when the results are not what we expect. Sometimes our research does not give us all the answers. Have you ever looked at a dessert menu in a restaurant and wondered, "How do they make that dessert?" Is that dessert healthy? When grocery shopping, have you wondered, "What is the science behind my favorite frozen cream pie?" Now you know about waxy starches. Are waxy starches healthy? When you pack your lunch, do you wonder, "Why isn't a pudding cup refrigerated? When I make pudding it must be refrigerated." Have you ever wanted to ask a chef or a scientist? Several websites offer the chance to ask chefs or scientists questions. Give it a try. Get more information using the following Web Links.

Web Links:

Ask a Chef
https://twitter.com/Ask_A_Chef

Ask a Food Scientist
https://www.facebook.com/M.S.Carmen.Amaya

Ask Dr. Gourmet: Questions About Cooking
http://www.drgourmet.com/askdrgourmet/cooking/#.WNVQCyx1rIU

Talk to Chef
https://talktochef.com/about