Pies: Fruit and Custard Fillings and Flaky Crusts

Unit: Preparing Foods

Problem Area: Baking and Pastry

Lesson: Pies: Fruit and Custard Fillings and Flaky Crusts

Student Learning Objectives.

Instruction in this lesson should result in students achieving the following objectives:

1. **Summarize basic pie and piecrust ingredients, equipment, and tools.**
2. **Prepare crusts.**
3. **Prepare fruit and custard fillings.**
4. **Assemble, flute, and bake pies.**
5. **Analyze physical changes and chemical reactions that occur in pastry and pie preparation.**

Resources.

The following resources may be useful in teaching this lesson:

E-unit(s) corresponding to this lesson plan. CAERT, Inc. http://www.mycaert.com.

"Custard Pies," *Food Network*. Accessed Feb. 15, 2018. http://www.foodnetwork.com/search/custard-pies-.

"Decorative Pie Crust Edges," *Recipe Tips.* Accessed Feb. 15, 2018. http://www.recipetips.com/kitchen-tips/t--813/decorative-pie-crust-edges.asp.

Draz, John, and Christopher Koetke. *The Culinary Professional Second Addition.* Goodheart-Willcox 2014.

"Flaky Pie Crust or Pâte Brisée Tutorial," *CraftyBaking.* Accessed Feb. 15, 2018. http://www.craftybaking.com/recipe/flaky-pie-crust-pate-brisee-tutorial.

"Flaky Cookie-Like Tart Dough or Pâte Sucrée," *CraftyBaking.* Accessed Feb. 15, 2018. http://www.craftybaking.com/recipe/flaky-cookie-tart-dough-pate-sucree.

"Fruit Pies," *AllRecipes*. Accessed Feb. 15, 2018. http://www.allrecipes.com.

Gisslen, Wayne. *Professional Baking,* 7th ed. John Wiley 2017.

Johnson and Wales University. *Culinary Essentials.* Glencoe-McGraw-Hill 2010.

Labensky, Sara, Eddy Van Damme, and Priscilla A. Martel. *On Baking Third Edition: A Textbook of Baking and Pastry Fundamentals*, Pearson Prentice Hall 2015.

Maynard, Joy. *Becoming a Restaurant and Foodservice Professional: Year Two,* 2nd ed. National Restaurant Association Educational Foundation.

"Pastry for Pie," *Epicurious*. Accessed Feb. 15, 2018. https://www.epicurious.com/search/pastry%20for%20pie?content=recipe.

"Temperature Tips to Perfect Pies," *ThermoWorks Blog.* Accessed Feb. 15, 2018. http://blog2.thermoworks.com/2015/11/temperature-tips-to-picture-perfect-pies/.

Wiley, Suzanne S. "Types of Pie Crust," *Leaf.* Accessed Feb. 15, 2018. https://www.leaf.tv/articles/types-of-pie-crusts/.

Equipment, Tools, Supplies, and Facilities

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

Key Baking Terms.

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

- all-purpose flour
- baker's percentage
- blind baking
- blind-baked crust
- cooked fruit filling
- crostata
- custard filling
- cut in
- decorating tips
- dock
- double-crust pie
- dough docker
- flaky dough
- formula
- flute
- galette
- lattice crust
- nut flour
- pastry
- pastry bag
- pastry blender
- pastry flour
- pastry wheel
- pâte brisée
- pâte sucrée
- pie
- piecrust
- pie weights
- raw fruit filling
- recipe
- salt
- scaling
- shortbread crust
- short pastry
- shortens
- single-crust pie
- streusel
- vent

Key Science Terms.

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

- absorption
- amino acids
- amylopectin
- amylose
- caramelization
- chemical reaction
- coagulate
- coagulation
- colloidal dispersion
- condensation
- conduction
- convection
- denature
- denaturation
- disaccharide
- emulsion
- endothermic reaction
- evaporation
- exothermic reaction
- foam
- gelatinization
- gluten
- heat transfer
- homogenous mixtures
- hydrogenated fats
- hydrogenation
- hydrolosis
- hygroscopic
- immiscible
- invert sugar
- lecithin
- lipids
- Maillard reaction
- monosaccharide
- osmosis
- pan flow
- pectin
- physical change
- polymer
- polysaccharide
- radiation
- retrogradation
- saccharide
- starch
- surface area
- surface tension
- syneresis
- trans fatty acids
- Tyndall effect
- 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.

> *Introduce the fruit and custard pie and piecrust lesson using some Pie Trivia questions. Use VM–A and VM–B. For more information see the Leoba of Lecelade website article, "Coffyns and Faire Pastes—Early Pastry Recipes" at https://leobalecelad.wordpress.com/2017/03/06/coffyns-and-faire-pastes-early-pastry-recipes/ and the What's Cooking America website article, "A History of Pies" at https://whatscookingamerica.net/History/PieHistory.htm.*

CONTENT SUMMARY AND TEACHING STRATEGIES

Objective 1: Summarize basic pie and piecrust ingredients, equipment, and tools.

Anticipated Problem: What is pie? What is piecrust? What is pastry? What are the basic ingredients and equipment for flaky piecrusts and fruit and custard fillings?

I. Basic ingredients, equipment, and tools

A. A ***pie*** is a pastry that contains a sweet (cream, custard, fruit) or savory (meat, vegetable) filling. Sweet pies are usually served as desserts and savory pies are usually served as an appetizer or as a main course. Some pies have a bottom crust only, others have a top crust only (e.g., chicken pot pie), and others have a double crust (top and bottom).

1. ***Piecrust*** is the pastry container for the sweet or savory pie filling. The most basic crusts are made from flour and water. Standard (traditional) piecrust is crispy and flaky and made of flour, fat (butter, lard, vegetable shortening, and others), salt, and ice water. Other crusts include eggs and sugar as main ingredients.
2. ***Pastry*** is the dough (paste) used to create the bottom and cover casings (crusts) that contain pie and dessert filling. Pastry types include:
   a. Flaky
   b. Short
   c. Crumb and ground nutmeats
   d. Oil (or stirred)
   e. Meringue
   f. Mashed potatoes
3. Baking is science. Bakers use formulas to ensure consistent products. A baking ***formula*** measures ingredients by weight in pounds and ounces or kilograms or milligrams: a general science and math construct that shows the relationship between given quantities. Weight measurement is essential when flours and sugars (anything sifted) are added to a baking formula. In contrast, a baking ***recipe*** measures ingredients by volume: teaspoons, tablespoons, cups, dashes, and pinches, which are perfectly fine for small batches. For example:
   a. ***Scaling*** is the baker's term for weighing out ingredients. Accurately measuring 4.54 cups of cake flour by volume is, at best, a guess, whereas accurately weighing 1 pound of cake flour is very precise. In baking and pastry formulas all ingredients are based on percentages (ratios), and the percentages are what allow one to scale the batter or dough up or down (doubling, tripling, etc.).

b. ***Baker's percentage*** (or formula percentage) is a conventional way to list ingredients in dough in which the quantity of each ingredient is expressed as a percentage of the total amount of flour. For example: 1000g flour, 660g water, 20g salt, 10g yeast is expressed in baker's percentage as 100% flour, 66% water, 2% salt, 1% yeast. In a baker's formula all amounts are expressed in percent of the total flour weight, although the correct term is "ratio" as the percentages always add up to more than 100%. If a formula calls for 4 pounds of flour, then 4 pounds = 100%. In the same formula, two ounces of baking powder = 3.1% of the total flour weight. The reasons to use baker's percentage include:
   (1) Enables the baker to work with precision using only one unit of measure;
   (2) Easy to scale a formula up or down (doubling, tripling, etc.);
   (3) Easy to compare which formula is drier, sweeter, or saltier;
   (4) More accurately measures uniformly an ingredient—such as eggs—in which the quantity per unit may vary; and,
   (5) Serves as a common language among all bakers and baking operations. [NOTE: For a standard "Ingredient Weight Chart," see the King Arthur Flour website at http://www.kingarthurflour.com/learn/ingredient-weight-chart.html.]

4. A drawback to baker's percentages is that the formula does not reflect any impact of the amount of gluten-forming proteins in the flour on the final product and therefore may need to be adjusted.

B. Flour (farine)

1. DESCRIPTION: All-purpose hard-wheat flour is the most commonly used flour for baked goods in the U.S. and contains 11.7 percent protein. French flour is made from soft wheat. Both types contain little germ or husk and keep longer than whole meal-type flours. Flours are used in piecrusts and as thickeners for fruit pie fillings. [NOTE: The protein content of each flour brand may vary. Varying protein content affects the way flours 'handle.' Therefore, some dessert and pastry recipes/formulas call for 2½ to 2¾ cups.] [HINT: When measuring flour, add the smaller amount first. Then, following the recipe/formula directions, the baker adds flour to create the desired condition (e.g., cleans the sides of the bowl, not sticky to the touch, etc.).]
2. FUNCTIONS: Flour adds, provides, and/or creates:
   a. Body (bulk or mass)
   b. Structure and texture (tender and crumbly; firm and chewy)
   c. Flavor (dependent upon the type)
   d. Thickening agent (custard and fruit pie fillings)
   e. Gluten (***Gluten*** is an elastic protein within the endosperm or the starchy portion of a grain that forms when water is added to the two proteins in wheat flour (glutenin and gliadin). Gluten continues to develop as piecrusts are mixed. Avoid over working/mixing piecrust; overworking develops more structure, resulting in tougher piecrust. When flour is exposed to liquids and

stirred or mixed, gluten in the flour develops a "network" (strands) that holds the product together and creates the structure (shape and texture). Overmixing can cause tough piecrusts due to too much gluten production.)

3. CHEMISTRY: Following are the typical flour types associated with piecrusts and fillings:
   a. ***All-purpose flour*** is a blend of hard and soft wheat that can be bleached or unbleached. It is the most common flour used in the U.S. and contains 8 to 11 percent protein (gluten). It is used for quick breads, pastries, and some cakes. Flour that bleaches naturally (usually via oxygen) is called "unbleached" and flour that is chemically treated (chlorine bleach, peroxide, etc.) is termed "bleached flour." Bleached flour has less protein than unbleached flour.
      (1) Bleached flours are best for piecrusts, cookies, quick breads, pancakes, and waffles.
      (2) Unbleached flours are best for yeast breads, Danish pastry, puff pastry, strudel, éclairs, cream puffs, and popovers.
   b. ***Pastry flour*** is a high-starch and low-protein baking ingredient that is softer and more finely textured than all-purpose flour. Pastry flour is used to make biscuits, piecrust, and other dessert pastries and contains about 8.0 percent protein. Lower protein (gluten) flours create tender dough and crust. A substitute for pastry flour is a combination of cake flour and all-purpose flour in proportion.
   c. ***Nut flour*** is finely ground nutmeats from which the oil has been pressed. It is used to produce breads, cookies, cakes, and especially pastry crusts. Types include almond, cashew, chestnut, and hazelnut. Nut flours stale quickly and are held under refrigeration and used in a timely fashion. [NOTE: Nut meals are toasted nuts (with oil) that are ground to a cornmeal-like texture and are stored under refrigeration.]

C. Fat (graisse)

1. DESCRIPTION: Fats are greasy ingredients that melt at low temperatures. Fats are compounds of carbon, hydrogen, and oxygen. ***Lipids*** are dietary fats that include fatty acids, triglycerides, and cholesterol: lipid is the scientific term for fat. Fats are very concentrated body fuel and help to supply energy and build body tissue. One gram of fat contains 9 calories, while 1 gram of carbohydrates or protein contains 4 calories. Fat is found in animal (butter, lard) and vegetable (peanut, palm, corn, canola, olive, shortening) tissue. Solid fats (butter, margarine, hydrogenated products) remain solid at about room temperature. Oils remain liquid at about room temperature and may solidify when refrigerated. The process to create hydrogenated shortenings also produces trans fatty acids that may cause a health risk. Pastry dough is differentiated from bread dough by having a higher fat content.
2. FUNCTIONS: Fats adds and/or works to:
   a. Flavor and richness [NOTE: Hydrogenated shortenings are often tasteless.]
   b. Moisture

c. Tenderness (literally shortens the length of gluten strands)
d. Leavening (e.g., melts to form steam; assists in the flakiness of piecrusts)
e. Browning
f. Carry an added flavor (e.g., vanilla, almond, etc.) evenly throughout the filling or crust

D. Salt (sel)

1. DESCRIPTION: ***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 is the first salt discovered by humans and is typically called table salt. Iodized salt (table salt with added iodine) is the type most often utilized in baked goods. [NOTE: For additional information about salt, see "History of U.S. Iodine Fortification and Supplementation" on the U.S. National Library of Medicine, National Institutes of Health at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3509517/.]
2. FUNCTIONS: Salt provides the following functions to piecrusts and fillings:
   a. Flavor (e.g., enhances the sweetness and flavor of baked goods; adds complexity (without it, one would primarily taste sugar))
   b. Heightens the flavor of other ingredients
   c. Toughens the texture of soft fat-and-sugar mixtures
   d. Strengthens gluten protein which impacts texture in a positive fashion

E. Liquid

1. DESCRIPTION: Desserts and pies incorporate various types of liquids including water, milk, heavy cream, and juices. When liquid evaporates under the dry heat of an oven, it produces steam. In turn, air bubbles develop and increase the volume of the baked good. 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 (e.g., 2 cups of water and 2 cups of molasses are the same volume but different weights).
2. FUNCTIONS: Liquids add, provide, and/or create:
   a. Moisture
   b. Flavor (all except water)
   c. Color (browning from milk, cream, and fruit juice sugars)
   d. Steam leavening (from the conversion of liquid to steam)
   e. Gluten (mixes with flour for proper gluten development)
   f. Hydration of proteins, starches (including gelatins)
   g. Binds ingredients together (especially flaky piecrust ingredients)

F. Eggs (oeufs)

1. DESCRIPTION: Eggs are the structural element in baking, along with flour. Chicken eggs are the standard; all other types of eggs (lark, duck, ostrich, etc.) are not used in baking and pastry formulas. Eggs are a valuable source of vitamins A and B and a fair source of vitamin D.
   a. Grade AA large eggs (about 2 ounces each or 8/pound) are the most common size used in baked goods. Eggshell color does not affect the functions eggs provide in baking and pastry products.
   b. Weighing eggs is more accurate than measuring.
      (1) 1 large egg white = about 1 oz. = about 2 tablespoons
      (2) 1 large egg yolk = about ½ oz. = about 1 tablespoon
      (3) 8 whole large eggs = about 1 lb.
   c. A fresh egg sinks to the bottom of a bowl of water and has a nicely rounded yolk that is well centered in the white.
   d. Cracked eggs have a danger of *Salmonella* entrance and should be discarded.
2. FUNCTIONS: Eggs add, provide, and/or create:
   a. Leavening (natural leavening and via air incorporation; egg whites contain lecithin, a protein that lines the outside of the air bubbles created during beating and prevent beaten eggs from collapsing during baking)
   b. Emulsification (eggs act as a binding agent, a structure that holds other ingredients together; eggs are second to flour in providing structure to baked goods)
   c. Moisture
   d. Color (egg yolks provide color to crusts and fillings; an egg wash provides a glaze to piecrusts that browns the surface: a Maillard reaction)
   e. Flavor (eggs add a distinctive taste)
   f. Tenderize (the addition of egg yolk makes baked goods more tender than those that do not contain egg yolk)
   g. Texture
   h. Thickening agent
3. CHEMISTRY: Eggs are easiest to separate when they are cold. To beat whole eggs or egg whites to their greatest volume bring to an internal temperature of 65° to 75°F. Meringue toppings use beaten egg whites. Custard, cream, and chiffon pie fillings use whole eggs, egg yolks, and egg whites. Chiffon pies egg whites separately and then the egg white foam or meringue is folded into the filling mixture.

G. Sugar (sucre)

1. DESCRIPTION: Sugar is a carbohydrate that is soluble in water, usually crystalline with a sweet taste. Sugars are produced from various types of plants: cane (sucrose), beet, sugar maple, and palm. In fact, all fruits and vegetables contain sugar (sucrose, fructose). Solid sugars include cane and beet. Liquid sweeteners include honey, molasses, corn syrup, and various manmade liquid

sugars produced initially for dietary purposes. ***Saccharide*** is the scientific name for the organic compound sugar. Sugars and other sweeteners add taste, tenderness, color, and aroma to baked goods and pastries. [NOTE: Reducing more than one-third the volume of sugar in a recipe negatively affects the tenderness, moistness, browning, and sweetness of the product.]

a. The various grinds of solid sugar impact the baked goods: granulated, powdered, superfine, brown, etc. Most baked goods are produced with solid sugars. Superfine sugar is most often used in foam cakes. Liquid sugars do not react in baked goods in the same fashion as solid sugars. Consult a reference to substitute liquid for solid sugars.

b. Sugar by volume (cups)—regardless of the sugar type—may seem comparable, but sugar by weight is not. Sugar by weight is more accurate than sugar by volume. For example:

(1) 1 cup granulated sugar is about 7 ounces

(2) 1 cup confectioners' (powdered) sugar is about 4 ounces

(3) 1 cup packed brown sugar is about 7½ ounces

(4) 1 cup molasses, honey, or corn syrup is about 12 ounces

2. FUNCTIONS: Sugars add, provide, and/or create:

a. Flavor

b. Tenderizes crusts and fillings (except for artificial sweeteners)

c. Color (caramelizes and aids in browning)

d. Moisture retention (sweetened baked goods stay moist longer than unsweetened types) [NOTE: Artificial sweeteners do not provide the browning, tenderizing, and moisture retention characteristics of natural sugars.]

H. Leavening

1. DESCRIPTION: Leavening is the production of a gas in a dough or batter using an agent: steam, air, eggs, baking soda, baking powder, starter, and yeast. A leavening agent is a substance that causes expansion in a dough batter by releasing gases within the mixture. The steam and air incorporated into foamed and whipped eggs forms the structure/framework of fillings. Chemical leavening agents (baking soda and baking powder) produce CO_2 gas that helps products rise. [NOTE: Leavening agents are discussed in detail in MYcaert CA C8–2 Leavening Agents.]

a. Steam: Moisture from a pastry or filling is converted to steam during cooking and baking. [TIP: Preheating of the oven encourages the greatest production of steam leavening for blind-baked crusts, custard pie filling, etc. Steam—converted from moisture in the filling or crust—can account for 30 to 80 percent of the leavening a filling or crust experiences during baking.]

b. Air: Mechanical incorporation of air occurs during whipping, beating, folding, etc. and results in crust and filling leavening. Air leavening occurs when this vigorous mixing entraps air and creates bubbles that produce foam (air leaven). Air leavening, from beaten egg whites, egg yolks, or

whole eggs, is a common leavening agent for dessert and pie fillings and meringue toppings.

c. Chemical leavening agents (e.g., baking soda and baking powder) produce a gas that helps the product rise. A very few variations of piecrust recipes include a chemical leavening agent added with the flour.

2. FUNCTIONS: Leavening agents in fillings and crusts result in:
   a. Greater volume
   b. Development of flaky crusts (steam, air, eggs)
   c. Added flavor (especially from eggs)

I. Flavoring (parfum)

1. DESCRIPTION: Flavorings and aromatics are used in pie and dessert fillings to "give relish" to foods. Flavorings include extracts (concentrated oils or essences diluted with alcohol) and concentrated oils that are derived from liquid natural flavors (vanilla, almond, cherry), seeds and beans (vanilla, nutmeg, chocolate, coffee), and spices (epices in French) including cinnamon, ginger, cloves, etc.
2. FUNCTION: Flavorings enhance or fundamentally change the taste of crusts and fillings.

J. Basic hand tools and equipment

1. Stand mixer with paddles and whips—Stand mixers sit on a tabletop or on the floor and have several attachments (flat beater, dough hook, wire whip). Fillings may use the flat beater and wire whips are used to beat whole eggs, egg yolks, egg whites (meringues), and heavy cream.
2. Scales—Platform, digital, or balance types are used to accurately measure ingredients. Platform scales are often used to measure moist ingredients, balance scales to measure dry ingredients, and digital scales to measure small amounts (spices, herbs, leavening agents, etc.) and for portion control (e.g., each tart shell receives 2 ounces of chocolate filling).
3. Pastry blender—A ***pastry blender*** is a series of crescent-shaped, bowed metal blades or wires affixed to a handle and used to cut solid fat into flour. A pastry blender cuts fat into flour to create numerous layers that result in flaky piecrust. A food processor or two place knives may be substituted for a pastry blender.
4. Rolling pins—A rolling pin is a long cylindrical tool used to roll out, thin, or shape pastry and other dough (cookies, breads). They are available in wooden, marble, ceramic, porcelain, brass, copper, stainless steel, silicone covered, or glass materials. Rolling pins are in two basic styles: a standard pin with handles and ball bearings and the French-style pin with tapered ends and no handles.
5. Cutting boards—Marble, polyurethane, and wooden boards are used to protect table surfaces and to roll out pastry crusts. (Bakers sometimes use waxed or parchment paper to roll piecrust instead of cutting boards.)

6. Dough scraper—A dough scraper is a hand tool with a handle and a beveled blade that removes excess pastry dough from boards and tables and cuts or sections dough portions. Flexible plastic scrapers are also available.
7. Dough docker—A ***dough docker*** is a handled multi-spike tool a baker rolls over pastry to create small vents that prevent pastry dough from blistering, bubbling, and rising during baking. Aside from pastry dough, dough dockers are used to vent pizza dough, flatbreads, and puff pastry sheets. Rolling dockers are typically 4 to 6 inches wide although some are smaller and some commercial types are 12-inches wide. They cover more area than a fork; a fork is typically used to prick the bottom and sides of piecrust—especially blind-baked pie shells. ***Blind baking*** is a process of prebaking and cooling a crust empty (before it is filled). Crusts are blind baked when a filling takes less time to bake than the crust, when baking the filling in a raw crust would create a soggy crust, or when the filling may curdle in the time it takes to bake the filling in a raw crust. Blind baking also helps control shrinkage that often occurs during baking. Blind-baked shells typically use pie weights to control shrinkage and bubbling.
8. Pastry wheel (or jagger)—A ***pastry wheel*** is a crimped cutter attached to a handle used to cut pastry dough into strips and to create an evenly decorated edge on crusts. A ***lattice piecrust*** is crisscrossed-strips of dough woven to create a vented top covering for a pie or dessert that often highlights beautiful fruits. Pastry wheels are also used to cut fresh pasta, biscuits, crackers, and other pastries.
9. Piecrust edge shields—Edge shields prevent over-baking the fluted edge of a piecrust. The edge shields are available in silicone or metal types. Aluminum foil strips are a substitute for edge shields.
10. Pie and pastry weights—***Pie weights*** are small beads loosely arranged over a raw pastry or piecrust that prevent a blind-baked pastry crust from shrinking and bubbling in the oven. Pie weights types include: linked stainless steel beads, ceramic balls, and/or dried beans or rice. Typically, the crust is docked, lined with aluminum foil or parchment paper, and then the weights are scattered evenly over the surface.
11. Pastry brush—A pastry brush is a 1- to 1½-inch wide brush made with nylon or natural bristles attached to a wooden or plastic handle. These small brushes are used to spread oil, glaze, or egg wash onto pastries before and after baking.
12. Internal temperature probe—An internal temperature probe is a small pointed rod about 3 to 4 mm in diameter that measures the internal temperature of food in which it is inserted. These probes are the most accurate tool for testing the doneness of custards and custard pies.
13. Pie and pastry pans, tins, forms, molds, and dishes—There are numerous types of pastry pans, tins, forms, molds, and dishes including:
    a. Tart pans are shallow, typically round or oblong in shape, with smooth or fluted sides. Most tart pans have removable bottoms to easily remove the

pastry and clean the pan. Tart pans are also available in oval, diamond, and square shapes.

b. Ring and rectangular molds (forms) are constructed of metal sides only and placed atop a parchment or silicone covered baking pan.

c. Pie plates (pie pans) are typically available in 9- and 10-inch sizes for fruit, custard, and pudding pies. Pie plate materials include anodized aluminum, glass, aluminum, ceramic, porcelain, etc.

d. Soufflé molds, ramekins, and custard cups:

(1) Soufflé molds are ovenproof dishes ranging in size from 1 to 2 quarts to individual molds with straight sides and typically made of porcelain. Its round shape and straight sides facilitate rising and soufflés often expand above the sides of the mold.

(2) A ramekin is a small, individual-size ovenproof baking dishes made of porcelain, glass, or ceramic. They are used for individual soufflés, custards, and other sweets.

(3) Custard cups are typically 4- to 6-ounce round ovenproof containers with curved bottoms for baking custards and puddings.

14. Decoration tools:

a. A ***pastry bag*** (decorating bag or piping bag) is a cone-shaped device with two openings, one large opening at the top to deposit icing, and one smaller opening at the bottom, to fit a decorating tip. Pastry bags are made from fabric, plastic, or paper and used to hold icing, whipped cream, and meringue.

b. ***Decorating tips*** (piping tips) are small specially shaped metal cones with open ends to form icing designs and decorations when icing is pressed through them. Each tip has a different number and common numbering formats are from Ateco® and Wilton®. Decorating tips and couplers are affixed to the bag to add details (e.g., borders, leaves, and flowers) to pies and other desserts.

Teaching Strategy: *Many techniques can be used to help students master this objective. Use VM–A and VM–B to introduce some trivia questions about the history of pies and piecrusts. An optional classroom handout about "Edible Coffins; Medieval Pastry" is found on the Leoba of Lecelade website at https://leobalecelad.files.wordpress.com/2016/07/collegium_food_pastry.pdf.*

REVIEW PIE AND PASTRY INGREDIENTS: *Place common pie and pastry ingredients on a tray. Have student pairs describe each ingredient and its main functions in preparing piecrusts, fillings, and desserts. Have each team share their information. Then, use VM–C to review basic piecrust and filling ingredient functions.*

IDENTIFICATION QUIZ: *Set up four or more stations with various tools and equipment listed in this objective ahead of the first pie and pastry laboratory. Cover each station before the students arrive. Divide students into small groups. Assign each group to a station. Uncover the tools and equipment items, and have students identify the names*

and functions of each item for pie and pastry preparation in about 5 minutes using no notes, texts, or references. Each group should submit their work on paper. Discuss each group's item designations and functions. Then, ask the students to select the best responses and finally, reveal the actual designations and functions. Use VM–D, VM–E, and VM–F to review basic equipment and tools used for piecrust and filling preparation.

Objective 2: Prepare crusts.

Anticipated Problem: What are types of piecrusts? How are piecrusts prepared? What are single- and double-crust pies? How is a lattice top crust prepared?

II. Crust types

A. Pie and dessert pastry crusts are the wrappings that enclose filling ingredients. Most crusts prepared for pies consist primarily of flour and fat. [NOTE: See Leaf website for examples of piecrust types at https://www.leaf.tv/articles/types-of-pie-crusts/.] Pastry types differ in the:

1. Ratio of flour to fat
2. Way in which ingredients are combined:
   a. Handmade from "scratch" with a pastry blender or spatula
   b. Produced in a food processor or in a stand mixer
   c. Purchased pre-made and rolled (raw or frozen) from groceries and foodservice distributors

B. FLAKY PASTRY: Standard ***flaky pastry*** is crisp, buttery, and puffed crust due to the numerous layers created during mixing. Flaky pastry is created by the technique of cutting shortening into the flour. To ***cut in*** is to work solid fat into dry ingredients by use of a pastry blender or two knives until the mixture is the size of small peas. Cutting chilled shortening (to assist in the creation of more layers) into dry ingredients and the use of high heat (steam leavening) to begin baking creates puffy, layered pastry. The act of cutting the fat and flour together literally ***shortens*** flour proteins and thus interrupts gluten formation (long structural strands of dough). [TIP: Nut crust is an option with flaky dough preparation: about ½ cup of finely ground nutmeats are substituted for ½ cup of flour. Most nut crusts are used with cream pie fillings] Flaky dough is the most commonly used pastry type for pies.

1. Ingredients: The basic ingredients for flaky pastry dough are: flour, salt, fat (cold), and ice-cold liquid (normally water).
   a. Cold fats include: hydrogenated shortening, lard, butter, and often a combination of these fats.
   b. Dry ingredients also include: sugar, baking soda, and spices (cinnamon, nutmeg, or allspice for dessert or basil, curry powder, or chili powder for savory pastry).

2. Measurement: Flaky dough formulas require accurate ingredient measurements. Too much flour toughens the dough and too much shortening makes the dough greasy and crumbly. Too much liquid makes the dough soggy.
3. Mixing method hints:
    a. Always use chilled fat to prepare piecrusts.
    b. Ensure that the sugar and salt are completely dissolved, usually in the cold water, before combining ingredients. Gently add ice-cold water to the mixture to bind the ingredients. Avoid over-mixing flaky dough and avoid adding too much water (sticky dough is the result). Both actions—over-mixing and adding too much water—result in tough piecrust pastry.
    c. Always chill the dough before rolling. Then, roll the dough to at least 1-inch larger than the pie or tart form.
4. Basic flaky pastry preparation steps:
    a. STEP 1: Measure flour and salt. Stir the dry ingredients together in a large bowl.
    b. STEP 2: Measure chilled fat. Cut the chilled fat into the dry ingredients using a pastry blender or by rubbing the fat into the flour with your fingers. [NOTE: A food processor may also be used for this step. The process is to pulse the dry ingredients with half the chilled fat until it resembles cornmeal. Then, add the remaining chilled fat and pulse until the size of small peas.] Return the dough to the large bowl.
    c. STEP 3: Sprinkle 1 tablespoon of ice water at a time onto the flour/fat mixture. Gently toss mixture together with a fork after each addition of chilled water. Then, lightly form the dough into a ball. “Work/mix” the dough as little as possible to avoid tough pastry. [NOTE: Dough for a double crust pie is divided in half and each piece is gently patted into a flattened ball.]
    d. STEP 4: Wrap the flattened dough ball(s) in plastic wrap. [TIP: When making large quantities of flaky pastry, scale the balls in 8 to 9 ounce pieces each, then wrap.]
    e. STEP 5: Chill wrapped dough for 30 minutes to 24 hours before rolling. [NOTE: Once prepared and wrapped, flaky dough can be stored in the refrigerator for several days or frozen for later use. Defrost frozen flaky dough under refrigeration.]
5. Uses for flaky dough
    a. Desserts: fruit pies, tarts, and pastry shells
    b. Appetizers or Entrées: savory pies including quiche (egg custard pie with meat or vegetables), meat potpie (chicken, beef, etc.), and galettes or crostatas (French and Italian flat round free-formed open-faced pastries respectively; savory types contain vegetables).

C. SHORT PASTRY: ***Short pastry*** is piecrust dough that remains crisp and cookie-like (does not become soggy) which makes them a good choice for pies and tarts with cream and custard fillings. Ingredients include: butter, sugar, egg yolk, vanilla, and flour. The sugar allows the dough to be re-rolled when necessary (e.g., The results of re-rolling standard pie crust is not favorable.) [NOTE: See the Martha Stewart

website for a "Short Crust Dough" made on a stand mixer in one step at http://www.marthastewart.com/332912/short-crust-dough.]

1. ***Pâte brisée*** is French for short crust pastry used for pies and tarts.
2. ***Pâte sucrée*** is French for rich, sweet short pastry used for pies, tarts, and filled cookies.
3. ***Shortbread crust*** is cookie-like pastry made with three ingredients—salted butter, flour, and confectioners' sugar—and pressed into pie and tart forms. Unlike standard flaky pastry, shortbread crusts do not rely on the pie or tart form to maintain their shape. This crust may be removed from the form and filled.

D. CRUMB PASTRY: Cookie and sweet cracker crumb crusts are usually prepared as single crusts from graham crackers, gingersnaps, chocolate and vanilla wafers, Oreos®, etc. and transform easily into mealy, tender piecrusts. Melted butter is often the fat that binds the crumb pastry ingredients together. Pies, tarts, cheesecakes, and numerous gelatin and frozen desserts use crumb pastry. The flavor of the crust is enhanced with ground nutmeats and spices. A crumb crust is quickly mixed, pressed into a pie or tart tin, and baked in order to hold the crust together when serving. However, some individual tart crusts can remain unbaked.

E. OIL PASTRY: An oil crust, sometimes called a stirred crust, substitutes a liquid fat for solid shortening that reduces trans fats and saturated fats. Ingredients for oil crusts include: flour, salt, oil, and cold water or milk. Some recipes add sugar or baking powder. The preparation is less complex than flaky crust. [NOTE: See the King Arthur Flour website for a no-roll oil crust recipe with directions at http://www.kingarthurflour.com/recipes/no-roll-pie-crust-recipe. This particular recipe is vegan and contains no cholesterol.] An oil crust is:

1. Mixed with a spatula and does not require the fat to be cut into the flour.
2. Rolled and/or patted into the pie pan (top crusts must be rolled).

F. Other crusts include:

1. Meringue crusts for chilled and frozen pies and desserts
2. Mashed potato crusts for savory pies

G. Single- and double-crust pies

1. A ***single-crust pie*** is a bottom casing and a filling. Single crusts are used for custard pies and tarts (plain, pumpkin, pecan, cream) and for savory custards, such as quiche. Most single crust pies also have a topping: whipped cream, meringue, streusel, chopped nuts, etc. For example, fresh strawberry pie uses a single blind-baked crust topped with sweetened whipped cream. ***Galette*** (French) and ***crostata*** (Italian) are terms for rustic open-faced pies, fruit-filled or savory (with meats and vegetables) that are baked flat (no pie tin or tart form) with the crust edges turned-up and slightly over the filling to create a "bowl." These rustic sweet or savory pies are often topped with a warm apricot or other fruit glaze (sweet) or egg wash (savory).
   a. A ***blind-baked crust*** is an empty bottom casing that is partially or fully baked before the filling is added. For example, custard fillings are very

liquid and, when baked in a raw crust, often result in a soggy crust. Other fillings that are not baked—cream or fresh berry pies—use a fully baked blind crust. Some fillings, such as quiche or pecan and pumpkin custard pies, cook faster than the crust. In these cases, the crust is often partially baked before the filling is added to prevent creating a soggy bottom. [NOTE: See the Kitchn website tutorial, slides, and video, "How to Blind Bake a Pie Crust," at http://www.thekitchn.com/how-to-blind-bake-a-pie-crust-cooking-lessons-from-the-kitchn-197553.] [TIP: Some blind-baked shells have a tendency to shrink as they bake. To prevent shrinkage, the baker can "hook" the fluted edges under the pie plate rim before baking to prevent the edges from sliding down into the pie pan.]

b. To ***dock*** is to prick or pierce the bottom and sides of a blind-baked shell allowing steam to escape from the crust and prevent excessive bubbling of the single crust shell during baking. These holes are usually applied via fork tines or a commercial docking tool. Blind-baked pie shells are often docked and filled with pie weights or dried beans to prevent the pie shell from bubbling and shrinking during baking. Placing parchment paper or aluminum foil on the single crust before adding the ceramic pie weights or the dried beans allows the baker to easily remove the weights or beans from the shell. Some experts recommend removing the pie weights and parchment paper half way through the baking to aid in browning the bottom crust. Egg white is sometimes brushed over partially baked blind crusts and returned to the oven for 1 to 2 minutes to aid in browning.

2. A ***double-crust pie*** is a dessert with two casings: a bottom crust and a top crust with a filling in between. Most cooked fruit pies are double crust types. The bottom crust is prepared as for a single crust and lines the pan. Then, filling is added and finally a top crust is added. Double crust pies are vented. A ***vent*** is an opening in the top crust to release steam from the pie filling as it cooks, such as, slits, decorative cutouts, or woven lattice strips. Then, the top and bottom crusts are trimmed and sealed or crimped together prior to baking. Variations of fruit pie top crusts include:

   a. ***Lattice crust*** is a decorative top casing for a double-crust pie applied by weaving evenly cut strips of rolled pie dough in a crosshatch pattern. For example: A 13-inch round of rolled piecrust dough creates approximately eighteen ½-inch wide lattice strips. Again, fluting of the edge of a lattice crust occurs after the top lattice crust is applied.

   b. ***Streusel*** (the German word for "sprinkle") is a crumbly topping placed over the fruit filling and baked until lightly browned. The crumbly mixture is prepared from various ingredients, such as: sugars, butter, flour, chopped nutmeats, oatmeal, and/or other ingredients.

Teaching Strategy: *Many techniques can be used to help students master this objective. Use VM–G and VM–H to review flaky pastry. Use VM–I to review short pastry types and ingredients. Use VM–J to illustrate shortbread pastry. Use VM–K to illustrate types of crumb crusts. Use VM–M to illustrate types of single-crust pies. Use VM–N to*

illustrate blink-baked piecrusts. Use VM–O to illustrate types of double-crust pies. Use VM–P to show how lattice piecrusts are constructed.

DEMONSTRATE: *Demonstrate to the steps in making flaky piecrust. Then, show how to flute, dock, add pie weights, and protect the fluted edge for baking. Bake the blind crust.*

TASTE TEST: *Consider conducting a blind taste test using the demonstrated blind-baked flaky crust, a premade piecrust available in the dairy department (unroll, place in pan, and flute), and a baked frozen pie shell. Offer samples of each flaky piecrust. Be sure the samples are the same temperature (all cold or all hot). Use three digit numbers to identify each sample to minimize the bias of A, B, C or 1, 2, 3. [For more information on blind taste testing, see lesson MYcaert lesson CA:B3–1 Sensory Perception.]*

QUANTITY CRUSTS: *If your class will be catering pies for a holiday or special event, a large quantity flaky piecrust recipe saves time. The piecrust balls may be frozen for use as needed.*

Ingredients:

- *5 pound bag all-purpose flour (high quality flour)*
- *3 tablespoons salt*
- *3 pounds chilled hydrogenated shortening (high quality shortening)*
- *3 cups chilled ice water*

Instructions:

1. *Use a large commercial bowl or similar sized pan to mix flour and salt. Cut in chilled shortening until pea size. Sprinkle in chilled water, a little at a time, and toss with a fork or with fingers.*
2. *Shape into flattened balls 8 to 9 ounces each. Wrap in plastic wrap or place in a plastic bag. Use a freezer-strength bag to store wrapped flattened piecrust balls in freezer. Freeze up to 6 months.*
3. *Thaw individual flattened balls as needed under refrigeration before rolling crust.*

PIECRUST LAB: *Assign LS–A. Students make and evaluate flaky pie dough and blind baking. This lab allows the instructor to evaluate each step of preparing flaky piecrust.*

Objective 3: Prepare fruit and custard fillings.

Anticipated Problem: What are types of fruit fillings? What are types of custard fillings?

III. Fruit and custard fillings

A. Fruit fillings

1. Many fruit-filled pies are prepared with high-pectin fruits: apples, blackberries, and quinces. ***Pectin*** is the natural substance in fruits that cause them to thicken when cooked with sugar. Combining high- and low-pectin fruits increases flavor layers and also reduces the amount of thickener needed. Many fruits only need a small amount of cornstarch or tapioca to thicken a filling. [NOTE: For more information about thickening agents, see the MyCAERT CA:B3–3 lesson and e-unit entitled, The Science of Thickening Agents.] Most fruit pies need some acidity—lemon or orange juice or zest—to brighten the flavor and prevent the darkening of fresh fruits.
2. Popular fruits that contain no or little pectin, and must be thickened, include blueberries, cherries, and strawberries.
3. Fruit fillings are used for fruit pies, tarts, turnovers, or non-pie desserts such as fruit compote, and toppings or fillings for Danish rolls, cheesecakes, and coffee cakes.
4. ***Raw fruit filling*** is a mixture of raw fruit, sugar, starch or flour, and other spices and flavorings. Raw fruit filling is placed into crust(s) and cooks as the pie, tart, or dessert bakes. Dessert applications include: pies, tarts, compotes, Danish, cheesecake topping, etc. The mixing method includes the following steps:
   a. Wash, pare, core/pit, and slice fruit; place in a bowl. (Some fruits, such as cherries or rhubarb, are not peeled.)
   b. Combine starch and/or flour, sugar, and spices or flavorings; add to prepared fruits.
   c. Add acidic juice and/or zest (lemon, orange, lime, etc.) to the fruit mixture.
   d. Gently stir all together.
   e. Fill prepared crust. Dot fruit filling with butter before the top crust is added.
5. ***Cooked fruit filling*** is a mixture of cooked fruit with sugar and other flavorings thickened with cornstarch. Types of fruit cooked on the stovetop include: fresh, frozen, or canned. Dessert applications include: pies, tarts, coffeecakes, cherries jubilee, turnovers, Danish rolls, etc. The mixing method includes the following steps:
   a. Fresh fruit is prepared as indicated for raw fruit filling (peeling, coring/pitting, slicing, etc.).
   b. Sugar and cornstarch are mixed in a saucepan.

c. Fruit and juice are added to a saucepan and the mixture is brought to a simmer, stirring constantly. As the fruit cooks, cornstarch absorbs some of the liquid and thickens the filling.
d. Cool filling and place in a piecrust.

B. Custard fillings

1. ***Custard filling*** is an uncooked mixture, made with a large amount of eggs, in which the filling and piecrust are baked together. Custard pie filling is similar to a sweetened pudding. The ingredients coagulate (thicken or congeal) during cooking or baking due to the large amount of eggs in the filling. The ingredients include: eggs (or egg yolks only), milk or cream (other than in pecan pies), sugar, and optional flavorings and spices. Some custard pies add pecans, coconut, dark corn syrup, pumpkin, or buttermilk. The mixing and baking methods include the following steps:
   a. All ingredients are mixed together and strained to remove any bits of egg that may float and coagulate on the surface of the pie.
   b. The mixture is placed into:
      (1) An unbaked single-crust pie shell
      (2) A partially baked blind crust (to prevent a soggy crust)
      (3) A custard cup or ramekin
   c. The pie shell with filling is baked at the required temperature until a thin knife blade inserted into the center comes out clean. (Note: Some custard pie recipes require a higher temperature for the first 15 minutes before reducing the temperature to a lower setting to complete the baking.)
2. Dessert applications in custard cups or casserole pans (without piecrust) baked in a hot water bath until set include: bread pudding, crème caramel, crème brûlée, flan, and rice pudding.
3. Dessert and savory applications baked in piecrust include the following pies: buttermilk, chess, coconut, egg custard, lemon, pecan, pumpkin, quiche, and sweet potato.

Teaching Strategy: *Many techniques can be used to help students master this objective. Use VM–Q to illustrate fruit and custard pie types. Consider having students sample various types of custard and fruit pies. A local bakery or restaurant may donate pies. For example, many students may not have experienced rhubarb pie, French coconut custard pie, and others. Consider making this activity a blind taste test.*

Objective 4: Assemble, flute, and bake pies.

Anticipated Problem: How are single- and double-crust pies assembled? What decorative edges are used on raw piecrust? What are tips for baking perfect flaky piecrusts? What are tips for baking perfect fruit and custard pie fillings?

IV. Assembling and baking pies

A. Assemble single- and double-crust pies

1. Prepare crust and filling.
2. Chill the crust for 30 minutes to 24 hours to tenderize (relax the gluten) and reduce shrinkage during baking. Crust that is ready to roll feels similar to modeling clay (pliable). If the dough cracks when pressed, it is not ready to roll. In that case, it should rest until it is pliable.
3. Flaky piecrust assembly step-by-step is:
   a. STEP 1 Rolling: Lightly dusting the rolling surface (e.g., table, cutting board, or pastry cloth) with flour prevents sticking. The slightly flattened dough is then placed in the center of the surface and lightly floured. Rolling the dough from the center to just short of the edges in all directions is recommended. Properly rolled flaky dough forms a circle ¼-inch (or less) thick and 2 to 4 inches larger than the pie plate/tin. CAUTION: Rolling over the edges of the crust tends to create a thick "middle" and very thin (less than ¼-inch thick) edges. For a double-crust pie, divide the dough in half and roll out a top and a bottom crust. An alternative method is to roll piecrust between waxed or parchment paper. To prevent the waxed or parchment paper from slipping, wipe the rolling surface with a damp cloth. Then, place the flattened dough on a lightly flour-dusted piece of waxed paper. Next, lightly dust the top of the piecrust dough with flour and top with waxed paper. Again, roll from the center to just short of the edges in all directions as detailed earlier. (HINT: To fit a 9- or 10-inch pie plate/tin, one must roll the dough a little wider than the waxed paper or use four sheets (two overlapped for bottom and two overlapped for top). This alternative method is easier for beginners.) [NOTE: See a Libby's Pumpkin YouTube video, "Rolling Out Pie Crust With Waxed Paper," at https://www.youtube.com/watch?v=t1gZoyGqj-4.]
   b. STEP 2 Mending: Mend any cracks or tears by pushing the dough into place with your fingers or by dabbing cold water on scraps of dough and attaching them to the crust.
   c. STEP 3 Place in Baking Dish: Transfer the dough to the baking dish by resting the rolling pin on the edge of the crust. Then, rolling the pin away, picking up the crust on the pin. An alternative method for transferring dough to pie plate when rolling between waxed/parchment paper: remove the top layer of waxed paper and place the pie plate upside down on rolled dough. Placing a hand under the paper and, in one movement, invert the

piecrust onto the baking dish. Then, carefully move the piecrust into the pie plate without stretching.

d. STEP 4 Fit: Fit the crust into the baking dish.

e. STEP 5 Trim and Flute: Trim any excess crust with a paring knife or scissors to leave about ¾- to 1-inch or more of dough hanging over the edge of the baking dish. Roll up the edge under and flute to produce a decorative effect for a single-crust. For double-crusts, fluting takes place after the filling is added and the top crust or lattices are applied. A "flat top full crust" is vented. Lattice or "cut out" top crusts. Lattice or cut out tops require no additional venting.

f. STEP 6 Fill: For a single-crust pie, add the desired filling. Some single-crust pies are blind-baked before fillings are added. Custard pie filling is mixed and added uncooked. Fruit pie with crumb or streusel topping use a single-crust.

B. Decorative edges

1. To ***flute*** is adding a decorative edge to the rim of the pie, tart, or dessert using one's fingers and/or other hand tools. Decorative edges help finish the pie's look.
2. Types of decorative edges used on piecrust include:
   a. Fluted Pinched Edge: The baker trims the raw crust to one inch, folds that overhang under to make the edge stand up, and then flutes the edge by using the thumb and index finger. The baker gently places a thumb and index finger about ½-inch apart on the outside of the pie plate and presses a "dent" into the edge from the inside of the pie plate using the other index finger.
   b. Scalloped Edge: To make a scalloped edge, the baker follows the fluted pinched edge instructions and loosely pinches the standing edge using a thumb and index finger on the outside and the other thumb on the inside about one inch apart on the outside rim of the pie plate.
   c. Scalloped Forked Edge: To make a scalloped forked edge, the baker begins by making a scalloped edge and adding fork marks to the inside of each scallop.
   d. Pressed Rope Edge: The baker trims the raw crust to one inch, folds that overhang under to make the edge stand up, and then flutes the edge by pressing the side of the thumb, at an angle, into the dough along the edge of the pie plate. Pinching the dough between the thumb and index finger knuckle, at an angle, leaves the thumb imprint. (Some pizzas use this decorative edge.)
   e. Imprinted Scalloped Edge: Trim the crust nearly flush around the pie pan edge. Then, the baker uses an inverted spoon to press (imprint but not cut through the piecrust) one scalloped design around the entire edge at one-inch intervals. Finally, a second imprint is added inside the first around the entire piecrust.

f. Forked Edge: The easiest fluted edge is fork tine imprints. To create a forked edge, trim the raw crust flush around the pie pan and then make fork tine imprints in the crust edge. This flute can be a full (forked all the way around) or partial (leaving a "fork width" space between fork imprints).

g. Checkerboard Edge: The checkerboard edge is made by trimming the raw crust to allow $^1/_8$-inch overhang around the pie pan. Then, the baker makes a series of cuts on the pie tin rim at ½-inch intervals that completely cut through the crust edge. Next, every other "square" is pulled up to form a checkerboard.

h. Leaf and Braided Edges: These fluted edges are shapes formed from raw piecrust dough and placed on top of the trimmed crust rim. The crust is trimmed flush to the rim of the pie plate or with a $^1/_8$-inch overhang. Bakers use their imagination to prepare a variety of cut and braided shapes to attach to the piecrust edge. The piecrust rim and/or the leaf or braid trim is moistened slightly to help adhere the decoration to the raw piecrust. Then, the baker gently presses the decorative edge to the piecrust. (HINT: Making a double-crust recipe allows enough extra raw dough to cut leaf, heart, round, etc. shapes with small canapé or cookie cutters or roll and cut thin strips of dough to braid. Shapes can also be cut by hand.)

C. Tips for baking pies:

1. Double-crust fruit pies:
   a. Place assembled double-crust fruit pie on a baking sheet covered with parchment paper to prevent fruit juices from dripping into the oven.
   b. Vent the fruit pie to release steam and prevent bubbling of the crust.
   c. Bubbling fruit juices are an indication of a perfectly cooked fruit pie. This is especially important in raw fruit fillings.
   d. The fluted edge often cooks faster than the fruit filling. Covering the fluted edge with foil strips or edge protector shields (made from silicone or metal) prevent over-baking of the fluted edge. The foil strips or edge protectors are removed during the last 10 to 15 minutes of baking.
2. Custard pies:
   a. For foil pans, support the weight by placing the pie on a baking tray before adding the custard to make transfer to the oven easier.
   b. The prepared egg mixture is strained (to remove any egg bits) into the raw single-crust or partially blind-baked crust. (TIP: Avoid custard "dribbling" onto the fluted edge of the piecrust, as the dribbled custard mixture burns easily.)
   c. Cover the fluted edge with foil strips or edge protector shields to prevent the fluted edge from becoming too brown. The foil or edge protectors are removed during the last 10 to 15 minutes of baking.
   d. Some custard pies baked in a raw bottom casing require a higher temperature for the first 15 minutes of baking, before reducing the temperature for the remaining time. This process helps to "set" and

prevent a soggy crust. (This practice is not followed for partially blind-baked crusts.)

e. To accurately test the doneness of custard pie, use an internal temperature probe. Egg coagulation begins at 140°F. Coagulation is complete at 175°F for pumpkin and custard pies and at 200°F for pecan pies (due to larger amounts of sugar). Custard pies can also be tested for doneness by inserting a place knife or a thin paring knife into the center of the pie; the knife should come out clean.
   (1) Over-baked custard pies have cracks in the filling.
   (2) Under-baked custard pie fillings are soft and runny when the pie is cut.
   (3) Custard pies are often pulled from the oven a few minutes prior to full coagulation to allow the egg protein to finish cooking from residual heat. (This practice helps avoid "rubbery-textured" custard pies.)

Teaching Strategy: *Many techniques can be used to help students master this objective. Use VM–R to illustrate some decorative edges for pies and pastries. Then, ask students to describe how to: roll raw piecrust; assemble single-crust pies; assemble double-crust pies; bake a double-crust fruit pie; bake a fruit pie with a streusel topping; and, bake a custard pie.*

DEMONSTRATIONS: *Consider demonstrating the steps to making custard and cooked or raw fruit filling for a pie. Then, demonstrate how to cut and assemble a lattice top. If desired, use a piecrust ball from the large quantity recipe. See the step-by-step details for lattices on the Simply Recipes website article, "How to Make a Lattice Top for a Pie Crust," at http://www.simplyrecipes.com/recipes/how_to_make_a_lattice_top_for_a_pie_crust/. You could also show the "How to Weave a Lattice Top for Pies"video on the Saveur website at http://www.saveur.com/article/Video/VIDEO-How-to-Weave-a-Lattice-Top-for-Pies. The video used a fork method instead of a decorative flute. Demonstrate one of the flute methods after the lattice is assembled.*

LAB ACTIVITY: *Assign LS–B. Students prepare and evaluate fruit and custard pies.*

Objective 5:

Analyze physical changes and chemical reactions that occur in pastry and pie preparation.

Anticipated Problem: What physical changes occur during pastry and pie preparation? What chemical reactions occur during pastry and pie preparation?

V. Physical changes and chemical reactions

A. Baking is a science. Many scientific actions occur when making and baking pie fillings and piecrust pastries: numerous physical changes and chemical reactions are necessary to prepare the perfect piecrust and the perfect fruit or custard pie. The difference between a chemical reaction and a physical change is composition.

1. A ***chemical reaction*** is a permanent change in the chemical composition of a substance in which molecules are broken apart and rearranged into new molecules. For example, fresh eggs that are fried cannot become fresh eggs again: the protein in the egg is permanently changed and the appearance is very different. When pastry and pie fillings are heated in an oven, a chemical reaction occurs and new bonds are formed. Heat creates chemical reactions: exothermic and endothermic reactions. For example, baking a pumpkin custard pie produces an endothermic chemical reaction that changes thin batter to a "pudding-like" consistency. An ***exothermic reaction*** produces heat. An ***endothermic reaction*** absorbs (takes in) heat. Specifically, heat:
   a. Causes egg and dairy proteins to change and "firm up" the custard structure.
   b. Dries the custard batter, but fats help keep the product moist.
2. A ***physical change*** is the transformation of a substance that does not alter its chemical properties: it's just a physical phase change. The change involves a difference in the way the substance displays: appearance (color or shape), texture, temperature, smell, or a change of state of the substance (e.g., frozen or melting or boiling). Melting, boiling, and freezing are examples of a physical phase change: an ice cube (frozen water) that melts is still water (liquid 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.]
3. TEACHER NOTE: Two common baking examples may help students differentiate between a physical change and a chemical reaction: 1) Adding vinegar to baking soda causes the mixture to fizz (a gas is given off). 2) Boiling water produces steam. One of these examples is a chemical reaction and the other is a physical change. To be termed a chemical reaction a new substance must be formed. When water boils, liquid water changes into steam, but it's still water (in a gas form): a physical change. And, it's possible for the steam gas to return to a liquid state. However, when vinegar is added to baking soda, the gas produced is a new substance called carbon dioxide (CO_2) and it is not possible to turn this new solution back into vinegar and baking soda: a chemical reaction.

B. Physical changes

1. ***Absorption*** is the act of attracting (taking up) particles of gas or liquid into a liquid or solid substance. (Absorption can be physical or chemical.) During custard preparation liquid is absorbed into flour or starch molecules. All starches work by absorbing liquid into individual starch grains. Many custard recipes/formulas use cornstarch as the thickening agent. The amount of liquid a starch grain can attract (absorb) and how concentrated the starch grains are in the liquid affect the thickness of the final product. Some starches completely set a liquid (think of Jello®).
   a. How do starch grains absorb liquid? "As liquid heats, its molecules begin to move around very rapidly. These molecules bump into the grains of starch,

disrupting their structure enough to cause the granules to take in water. At a certain point during heating, the solution reaches a balance where the starch grains are still mostly intact but have absorbed as much liquid as they can. If one continued heating, the starch will become too disrupted and the grains will actually lose their ability to hold water and thicken a sauce." For this reason, many custard recipes/formulas indicate a range of time and a recommended heat setting to cook starch and liquid mixtures. (Source: The Kitchn website article, "Food Science: How Starch Thickens," at https://www.thekitchn.com/food-science-how-starch-thicke-83665)

b. Batter with a high proportion of liquid (whether water, milk, or eggs) creates a batter with more ***pan flow*** (the ease with which batter fills the pan's shape). The larger the amount of water absorbed by the flour molecules, the more the batter or dough stretches. For example, when making piecrust, too much water absorbed by flour is undesirable. ***Viscosity*** is the resistance to flow. Each starch type has different physical properties related to viscosity: less or more thickening power that affects the viscous nature of stirred and baked custards.

c. ***Starch*** is a complex nutrient carbohydrate also known as a polysaccharide; from a food sources such as seeds, fruits, tubers, roots, and stems typically potatoes, corn, rice, and wheat. A ***monosaccharide*** is a simple carbohydrate or one sugar (mono = one). For example: glucose, fructose, and galactose. A ***disaccharide*** is two monosaccharide linked together (di = two). For example: sucrose, lactose, and maltose. A ***polysaccharide*** is chemically linked monosaccharides: from ten to several thousand may be linked (poly = many). Polysaccharides are an example of a polymer. A ***polymer*** is a large molecule formed from small molecules of the same kind chained together. The result is that the bottom crust is allowed to stretch too much and the crust will shrink when blind-baked. Fruit fillings contain starch to thicken the filling.

d. ***Gluten*** is an elastic protein within the endosperm or the starchy portion of a grain that forms when water is added to the two proteins in wheat flour (glutenin and gliadin). Gluten continues to develop as the piecrust dough is mixed and as the custard batter is mixed. The more gluten in flour, the less thickening power the flour contains. Cake flour with the least gluten has the most thickening power. Bread flour with the most gluten has the least thickening power. Gluten provides "chew." Again, gluten development is discouraged in piecrust making because it produces tough crust.

e. ***Hygroscopic*** is the ability of a chemical to absorb water from its surroundings. Liquid is absorbed into flour. The more water absorbed into flour or starch, the more the batter or dough stretches. Sugars are hygroscopic; including table sugar, honey, brown sugar, and molasses. Sugar attracts water and keeps baked goods moist and soft. Starch is *not* hygroscopic when cold. Starch is insoluble in water until it is heated and the starch granules swell and burst. Then, the starch moves quickly into the liquid to thicken it. Too much sugar or acid (citrus) in the solution may prevent starches from thickening properly. Fruit and custard fillings both

contain sugar and sugar attracts water that keeps the pie fillings moist and soft.

2. ***Condensation*** is the conversion (a physical change) of a vapor or a gas to a liquid: the reverse of evaporation. Condensation develops on pans of stirred custard and pudding as the steaming liquids gather on the rims of the pan or double boiler and become droplets.
   a. Custard pies also develop condensation on their surfaces as they cool. [NOTE: This condensation is often carefully removed before serving.]
   b. Cold piecrust dough placed into a warm oven produces moisture droplets (condensation) on its surface. This action serves to cool down the crust and allows the flaky layers to rise before the crust hardens. [NOTE: Porous surfaces on piecrust are due to moisture condensation.]
3. ***Evaporation*** is the conversion (a physical change) of a liquid to a vapor at temperatures below the boiling point. The rate of evaporation increases with the rise in temperature. Evaporation is used in many culinary processes to concentrate a solution (e.g., "cooking down" pan sauces to thicken and intensify the flavor, simmering tomatoes to release moisture, and thicken a pasta sauce, etc.) and in custard pie filling, the baker notices a vapor developing as the custard heats; releasing some liquid from the mixture.
4. An ***emulsion*** is a semi-liquid and stable mixture in which one liquid is suspended in another: two or more ***immiscible*** (unmixable or incapable of being mixed unless in an emulsion) ingredients. Emulsions are uniform mixtures: ***homogeneous mixtures*** with a uniform composition and the same properties throughout. Eggs contain protein, fat, and natural emulsifiers. The fats and emulsifiers in eggs work like starch, weakening the gluten network and stabilizing the bubbles in the batter or dough.
   a. Emulsions can be "water dispersed in fat" or "fat dispersed in water." Typical emulsions include a fat or oil and a liquid. For example: natural emulsions include butter (water dispersed in fat) and homogenized milk and cream (fat dispersed in water).
   b. Custards thickened with egg yolks are a fat dispersed in water emulsion. The egg yolk thickens the liquid milk, evaporated milk, or cream. TIP: Avoid cooking egg yolks to temperatures over 185°F as high temperatures cause the custard to curdle.
   c. Egg yolks contain lecithin. ***Lecithin*** is a protein substance found in egg yolks (a phospholipid) that attracts both water and fatty substances and aids in forming emulsions. This fatty (lipid) substance is often used as a food additive to moisturize, emulsify, and preserve food. [NOTE: For more general information about emulsions, see MyCAERT CA B3–8 lesson and e-unit.]
5. ***Heat transfer*** is the physical process of a food coming into contact with a heat source and becoming hot: the exchange of thermal energy between two objects. The action that occurs during heating is food molecules absorbing energy, vibrating quickly, and bouncing off each other. Each collision produces

heat, which is transferred to the food: cooking. There are three methods of heat transfer:

a. ***Radiation*** is heat transmitted as infrared rays. Radiant heat is evident when opening a preheated oven: one can "feel" the warmed air. Warmed air is transferred to food and cooks it.

b. ***Conduction*** is heat transferred between objects by direct contact, by the collision of molecules. For example, stovetop burners conduct heat to pots and pans and pots and pans transfer or conduct heat to the food. Grilling a steak or a hamburger is an example of conduction heat transfer. Cake pans transfer heat, by conduction, to the baked good.

c. ***Convection*** is heat transferred by circulating warm air around food. In a convection oven, a fan blows hot air over and around the food. [NOTE: See the Biscuit People website article, "Heat Transfer for Biscuit Baking," for more information on heat transfer at http://biscuitpeople.com/heat-transfer-for-biscuit-baking/. The process described for biscuits is the same in cooking or baking custards.]

6. ***Osmosis*** is the physical movement of fluid through a semipermeable cell membrane to create an equal concentration of solute on both sides of the membrane. (Source: Kay Mehas, *Food Science: The Biochemistry of Food and Nutrition*, 5th ed., McGraw-Hill Education) A solute is the substance that dissolves another substance in a solution. An example of osmosis is the rehydration of dried fruits, such as raisins, in which water flows from a point of low concentration (a cup or bowl of water) to one of high concentration (the dried fruit). Osmosis occurs in fruit pies. It occurs when the moisture from the fruit moves into the sugar solute to help create an equal concentration. Osmosis also occurs in baked products containing diced or sliced fruit. For example:

   a. Fruits have semipermeable cell membranes. The fruit cells release water when cut. Frozen fruit and cooked fruit wilt and are not as crisp as fresh fruit.

   b. When sugar is added to fresh sliced/diced fruit, the concentration of sucrose is higher around the fruit than inside the fruit cells because sucrose is too large a molecule to move into the cells of the fruit. [NOTE: The Kitchen Pantry Scientist website has simple osmosis and diffusion experiments at http://kitchenpantryscientist.com/diffusion-and-osmosis-experiments/.]

C. Chemical reactions

1. ***Caramelization*** is the oxidation (browning) of sugar, a process used extensively in cooking for the resulting nutty flavor and brown color. (Source: Science of Cooking article, "Why Does Food Brown When Cooked," at http://www.scienceofcooking.com/) Caramelization is the last chemical reaction to occur during baking. It occurs when sugars are heated. The flavors of caramelization occur after 356°F is reached. Fruit pies are typically baked above 350°F and many have a caramelized flavor. Custard pies baked are typically baked at or below 350°F and do not have a caramelized flavor. Fillings for fruit and custard pies contain sugar and some custard pies and desserts

include a "burned sugar" topping. Also, some piecrust recipes contain sugar or are topped with sugar that aids in browning. Each sugar type caramelizes at a different temperature.

a. Fructose caramelizes at 230°F (110°C).
b. Sucrose caramelizes at 320°F (160°C).
c. Baked goods made with honey or fructose develops a darker color because they begin browning at a lower temperature (honey contains fructose).
d. Baked custard develops a small amount of surface caramelization.
e. Crème brûlée is an example of sugar that is caramelized with a torch immediately before serving.

2. ***Hydrolysis*** is the splitting of a compound into smaller parts by the addition of water. For example: Sucrose + Water → Glucose + Fructose. The result of hydrolysis of sucrose is invert sugar. ***Invert sugar*** is equal parts glucose and fructose. Mixing custard pie filling allows time for the beginning of conversion of sucrose (table sugar) with the moisture from the fat and eggs. Fruit pie fillings that are cooked or raw also convert sucrose to fructose by pulling moisture out of the fruit and the fruit juices. [NOTE: Inversion is the process of hydrolysis of sucrose with an acid and heat (used in candy making). See the America's Test Kitchen's "Science of the Perfect Chewy Chocolate Chip Cookie," video for an explanation about sugar hydrolysis (letting sugar/liquid fat batter set 10 minutes before adding flour to ensure the sucrose becomes an invert sugar) at https://www.youtube.com/watch?v=M5fzyhIJYOw.]
3. The ***Maillard reaction*** is a chemical effect that occurs when proteins and sugars break down under heat; a rearranging of amino acids and simple sugars into rings that reflect light and produce a browned appearance and tantalizing aromas in many foods. It is a series of three complex reactions between ***amino acids*** (the building blocks of protein) and reducing sugars (monosaccharide and some disaccharide sugars that can donate electrons to another chemical) that happen at increased temperatures. The reason the Maillard reaction produces different aromas in bread than it does in standing rib roast or baked fish is that the amino acids and simple sugars differ in those foods. The Maillard reaction is evident when double-crust fruit pies, streusel-topped fruit pies, and blind-baked crusts brown in appearance and produce a toasty flavor. As oven, grill, or pan temperatures increase so does the Maillard reaction. [NOTE: See the Food-Info website for more information on complex reactions and about Louis Camille Maillard at http://www.food-info.net/uk/colour/maillard.htm.]
4. ***Hydrogenation*** is a chemical reaction between hydrogen (H_2) molecules and another compound or element under pressure that solidify molecules of liquid vegetable oils by: 1) absorbing the oxygen in the oil's free fatty acids to convert them to fats that are solid at room temperature, 2) improving the keeping quality of the fats, 3) keeping oils solid enough not to melt at room temperature, and 4) making them more resistant to decomposition when exposed to air. Some shortening may have added animal fats, emulsifiers, colorings, and flavorings (butter).

a. ***Hydrogenated fats*** are vegetable fats (or oils) that are hardened or turned into solids through the hydrogenation process: adding hydrogen to unsaturated fat molecules. They provide more volume for baked goods than butter. For example:
   (1) Solid shortenings (e.g., brand name Crisco, etc.) and margarines are hydrogenated.
   (2) Peanut butter can be hydrogenated or partially hydrogenated. Natural peanut butter is partially hydrogenated: oil separates and comes to the top of the jar.

b. During hydrogenation, hydrogen is injected into the oil under pressure, turning the liquid oil into a solid fat. In almost all cases of turning oil into a solid fat, some of the oil remains in a state of "limbo"—neither liquid nor solid—called ***trans fatty acids***. This type of fat is known to have a particularly unhealthy effect on arteries and heart health. It provides no flavor and no cooking or nutritional benefits. The process to create hydrogenated shortenings produces trans fatty acids that may cause a health risk.

5. ***Gelatinization*** is the thickening of a starch in the presence of moisture and heat. It turns a colloidal system from a temporary suspension to a permanent suspension. Gelatinization is a chemical reaction involving starch, moisture, and heat. There are physical changes that also 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.
   a. ***Amylose*** is a polysaccharide and one of the two components of starch: it comprises 20 to 30% of the starch molecule. The more amylose in a starch molecule, the more the mixture will gel. The thickening properties of starch depend on the ratio of amylose molecules to amylopectin molecules in starch. It mixes easily in liquid and can change paste into a gel.
   b. ***Amylopectin*** is a branched polysaccharide that is the major component of starch (80%). It does not mix easily in liquid due to its branched form and does not gel well. Waxy starches are engineered to contain no more than 10% amylopectin (e.g., they contain more amylose and gel better).
   c. In one or two days, custard or thickened fruit pie filling made from starch breaks down. ***Retrogradation*** is a property of starch in which a chemical reaction occurs that realigns the amylose and amylopectin chains as the thickened filling cools. The "backward movement" (retrograde) returns amylose to a crystalline form that causes the pudding to assume a gritty texture.
   d. ***Syneresis*** is the weeping of a liquid from a gel. Weeping of pie filling or pudding or yogurt occurs a day or two after it is prepared. The released liquid forms puddles as the molecules are pulling back together.

6. ***Foam*** is air (in the form of bubbles) that is incorporated and trapped in a protein film by whipping: the act of whipping egg whites causes bubbles to form and be trapped in a protein film. (Source: Kay Mehas, *Food Science: The Biochemistry of Food and Nutrition*, 5th ed., McGraw-Hill Education). For example,

visualize a child blowing a bubble with a wand or straw dipped in a soapy solution or with bubble gum: this is a type of foam.

a. All foams are a type of ***colloidal dispersion*** (a suspension) in which air is dispersed without dissolving. The ***Tyndall effect*** is a scattering of light that shows the colloids in the colloidal dispersion: a beam of light passing through a true solution, such as air, is not visible, however the particles in colloids are large enough to deflect the light.

b. Some ingredients do not foam. For example: to foam, a liquid must have a low surface tension. ***Surface tension*** is a property of a liquid that allows them 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: surface tension.) Warm temperatures lower the surface tension of liquid eggs, making it easier for bubbles to form. Egg foams develop the volume and lightness of sponge, gênoise, and chiffon cakes due to their ability to foam and the innate (natural) surface tension of liquid eggs.

c. Natural proteins, at the molecular level, are shaped like coils or springs. When exposed to heat, salt, or acid, they ***denature*** (unfold) and the coils unwind. Foams form when the protein liquid of eggs is whipped: the foam forms a film around the air pockets and denatures the protein. When proteins denature, they ***coagulate*** (thicken or congeal during heating) and bond together to form solid clumps). The large percentage of eggs in custard pie allows the mixture to coagulate. ***Coagulation*** is the changing of a liquid to a semisolid or solid mass. It changes a liquid (milk in pumpkin or custard pie and corn syrup in pecan pie) into a soft semisolid or solid mass. Protein coagulation begins at 140°F and completes at 175°F.

d. ***Denaturation*** is a chemical reaction that changes the shape of a protein molecule by loosening the hydrogen bond that originally formed coils and springs and turns it into a long, shapeless chain. Denaturation usually happens during baking due to heating or acidity. Denaturing breaks the hydrogen bond and makes a loose, less compact structure.

D. Other baking chemistry information

1. SURFACE AREA: ***Surface area*** is the total exterior space of a baked product exposed to heat during baking. Deep-dish pies and deep-dish cobblers take longer to bake than do shallow pies and shallow depth cobblers (e.g., Deep-dish pies and cobblers have more exposed surface area.)
2. BATTER DEPTH: Batter depth affects the baking time of all baked goods. As a general rule, custards baked in custard cups are "deeper" than most custard pies and take longer to bake than a pie.
3. OVEN TEMPERATURE: Fruit and custard pie oven settings vary by category type, pan type, humidity, and altitude. For example:
   a. Shiny metal pie pans should use the recipe-recommended temperature. Shiny metal reflects heat.

b. Dark or nonstick pie pans bake faster than shiny pie pans. Dark pans absorb the heat.
c. Glass pans traditionally bake faster than shiny pans and the oven temperature is reduced by 25°F to prevent over-baking and over-browning. Glass pans transfer heat more quickly by conduction heat transfer.

4. ALTITUDE: When baking in an area of high altitudes (3,500–6,500 feet above sea level) increase the oven temperature 10 to 20°F. [NOTE: See the Betty Crocker website for more information on baking at high altitudes at https://www.bettycrocker.com/how-to/tipslibrary/baking-tips/baking-cooking-high-altitudes.]
5. CUT-IN TECHNIQUE: The 'cut in' technique used when preparing flaky piecrust creates pea size pieces of fat when combined with flour. This process has a scientific purpose: wheat flour contains gluten and gluten stretches when moistened and develops structure. The coating of the gluten molecules prevents gluten from developing the stretchy quality, thus preventing a tough crust.
6. TEMPERATURE: Use the correct temperatures when making piecrust.
   a. Fat (shortening, lard, or butter) used in piecrust should be chilled (30° to 45°F) and cold enough to create and hold the pea shaped pieces of fat and flour. If necessary, use ice to chill the water (40°F or below). (No ice is added with the water when making piecrust.) When the piecrust goes into the oven, the little pea size shapes of fat and flour immediately melt and form small pockets of steam. These pockets become the flaky layers in quality piecrust.
   b. After preparing the flaky piecrust dough, the flattened ball of dough is refrigerated (30 minutes to 24 hours) until it resembles the consistency of modeling clay. Chilling the dough prevents stretching and shrinking of the piecrust during baking. [NOTE: If the piecrust is too cold to roll without cracking, bakers pound the dough with rolling pin or let it warm briefly at room temperature before rolling. Some sources recommend chilling the piecrust again after it is rolled, shaped, and fluted in the pan.]

Teaching Strategy: *techniques can be used to help students master this objective. Use VM–S and VM–T to illustrate and reinforce the difference between physical changes and chemical reactions. Use VM–U to show an example of starch grains absorbing heated milk. Use VM–V to illustrate crème brûlée and torch. Use VM–W to illustrate foam protein coagulation and denaturation that occur in fruit and custard pies.*

NGSS and FCS CLASSROOMS: *Learning the biological and chemical basics of food and nutrition benefits all students. Culinary arts courses demonstrate real-life applications of the scientific principles of food preparation and nutrition. Introducing the science behind the skills, gives students a head start in understanding scientific terms and reactions. Science in FCS classrooms encourages students to develop scientific reasoning skills and have fun doing it. Being part of the conceptual shifts in science*

education means getting students prepared for Next Generation Science Standards (NGSS). NGSS states that "K–12 Science Education Should Reflect the Interconnected Nature of Science as it is Practiced and Experienced in the Real World." FCS classes already include problem solving, teamworking, and real-life application of concepts. Adding science concepts in FCS classes is a continuation of what is already taught in our courses. When you are teaching a skill, explain the science behind the skill. This will prepare your students with a scientific and an artistic viewpoint.

RESEARCH LINKS: *The benefit of teaching "science" in Family and Consumer Sciences classrooms seems obvious. The following websites are some quick links to details of teaching science in FCS: "Cooking Class Benefits Kids in Many Ways" at http://health.usnews.com/health-news/diet-fitness/diet/articles/2011/11/10/cooking-class-benefits-kids-in-many-ways; "Six Reasons You Should Study Food Science," http://sciencemeetsfood.org/6-reasons-why-you-should-study-food-science/; "The Top 5 Reasons to Teach Nutrition Education in Your Classroom," at http://www.healthyeating.org/Schools/Tips-Trends/Article-Viewer/Article/521/Top-5-Reasons-to-Teach-Nutrition-Education-in-Your-Classroom.aspx; and, "High School Food and Nutrition Classes Serve Up Skills for Life," at https://www.usnews.com/education/blogs/high-school-notes/2014/06/16/high-school-food-and-nutrition-classes-serve-up-skills-for-life.*

DEMONSTRATION OF TYNDALL EFFECT: *Demonstrate the Tyndall effect by filling on clear glass with water and another clear glass with gelatin softened in water. In a dark space, shine a flashlight through both glasses. The Tyndall effect shows the colloids in the glass with softened gelatin in water. KEY: Gelatin is a colloid large enough to view with the naked eye.*

- **Review/Summary.** Use the student learning objectives to summarize the lesson. 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. If a textbook is being used, questions at the ends of chapters may also be included in the Review/Summary.

- **Application.** Use the included visual master(s) and lab sheet(s) 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: Matching Baking Terms

1. i
2. j

3. c
4. h
5. d
6. f
7. g
8. e
9. b
10. a

Part Two: Matching Science Terms

1. a
2. e
3. b
4. f
5. c
6. j
7. h
8. i
9. d
10. g

Part Three: Completion

1. absorb
2. heat
3. pie
4. starch
5. tenderizes
6. denature (or unfold)
7. shrinking
8. layers
9. shortens
10. fat
11. fluted
12. double-crust pie

Sample Test

Name _____

Pies: Fruit and Custard Fillings and Flaky Crusts

Part One: Matching Baking Terms

Instructions: **Match the term with the correct definition.**

a. blind-baked crust
b. cut in
c. dock
d. flute
e. lattice crust
f. piecrust
g. short pastry
h. single-crust pie
i. streusel
j. vent

_____1. A crumbly topping placed over the fruit filling and baked until lightly browned

_____2. An opening in the top crust to release steam from the pie filling as it cooks, such as, slits, decorative cutouts, or woven lattice strips

_____3. To prick or pierce the bottom and sides of a blind-baked shell allowing steam to escape from the crust and prevent excessive bubbling of the single crust shell during baking

_____4. A bottom casing and a filling

_____5. Adding a decorative edge to the rim of the pie, tart, or dessert using one's fingers and/or other hand tools

_____6. The pastry container for the sweet or savory pie filling

_____7. Piecrust dough that remains crisp and cookie-like which makes them a good choice for pies and tarts with cream and custard fillings

_____8. A decorative top casing for a double-crust pie applied by weaving evenly cut strips of rolled pie dough in a crosshatch pattern

_____9. To work solid fat into dry ingredients by use of a pastry blender or two knives until the mixture is the size of small peas

____10. An empty bottom casing that is partially or fully baked before the pie filling is added

Part Two: Matching Science Terms

Instructions: **Match the term with the correct definition.**

a. coagulate
b. conduction
c. convection
d. gelatinization
e. hydrogenation
f. lecithin
g. lipids
h. osmosis
i. polysaccharide
j. surface area

_____1. To thicken or congeal during heating

_____2. A chemical reaction between hydrogen (H_2) molecules and another compound or element under pressure that solidify molecules of liquid vegetable oils

_____3. Heat transferred between objects by direct contact, by the collision of molecules

_____4. A protein substance found in egg yolks (a phospholipid) that attracts both water and fatty substances and aids in forming emulsions

_____5. Heat transferred by circulating warm air around food

_____6. The total exterior space of a baked product exposed to heat during baking

_____7. The physical movement of fluid through a semipermeable cell membrane to create an equal concentration of solute on both sides of the membrane

_____8. Chemically linked monosaccharides: from ten to several thousand may be linked

_____9. The thickening of a starch in the presence of moisture and heat

____10. Dietary fats that include fatty acids, triglycerides, and cholesterol: lipid is the scientific term for fat

Part Three: Completion

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

1. Dark or nonstick pie pans bake faster than shiny pie pans because dark pans _____ heat.

2. Custard pies are often pulled from the oven a few minutes prior to full coagulation as the egg protein can finish cooking from residual _____.

3. A pastry that contains a sweet (cream, custard, fruit) or savory (meat, vegetable) filling is a/an _____.

4. A complex nutrient carbohydrate (also known as a polysaccharide) from food sources such as seeds, fruits, tubers, roots, and stems typically potatoes, corn, rice, and wheat, is _____.

5. Chilling the dough for 30 minutes to 24 hours _____ the dough and reduces shrinkage during baking.

6. Natural proteins, at the molecular level, are shaped like coils or springs. When exposed to heat, salt, or acid, they _____ and the coils unwind.

7. Pie weights are small beads loosely arranged over a raw pastry or piecrust that prevent a blind-baked pastry crust from _____ and bubbling in the oven.

8. Standard flaky pastry is crisp, buttery, and puffed crust due to the numerous _____ created during mixing.

9. The act of cutting the fat and flour together literally _____ flour proteins and thus interrupts gluten formation.

10. Pastry dough is differentiated from bread dough by having a higher _____ content.

11. Fluted edge protector shields or strips of foil are used to prevent over-baking of the _____ edge.

12. A dessert with two casings—a bottom crust and a top crust with a filling in between—is a/an _____.

PIE TRIVIA

This rustic game meat pie is an example of an early savory dish referred to as a "coffyn" (pronounced "coffin"). In medieval times, coffyns referred to baskets or boxes and as few pie "tins" were available, foodstuffs (usually meats and vegetables) were often baked directly in piecrust "coffyns."

- **What was the purpose of the first piecrust "coffyns?"**
- **What ingredients were used in these early piecrusts?**

PIE TRIVIA: ANSWERS

What was the purpose of the first piecrust "coffyns?"

The piecrust "coffyn" was prepared solely to hold the ingredients inside. Early pies were meat pies and not desserts. As the crust's purpose was to hold the ingredients inside, the nobility did not eat the inedible crust. Janet Clarkson, in her book, PIE: A GLOBAL HISTORY, states, "It is surely not likely that such a hard-won resource was simply discarded after the contents were eaten even in the great houses. The crust may not have been intended for lords and ladies, but the well to do were obligated to feed their servants and were also expected to feed the local poor. Would not this largesse of sauce-soaked crust be distributed to the scullery boys and the hungry clamoring at the gate?" [NOTE: Largesse means a generous giving of gifts.]

What ingredients were used in the first piecrusts ("coffyns")?

The piecrust for "coffyns" was a mixture of coarsely ground meal, lots of salt, and water. Flour meal was mixed with water until the gluten protein of the flour developed a firm structure. The salt helped preserve the meat mixtures in the pie.

BASIC PIECRUST AND FILLING INGREDIENT FUNCTIONS

Based on your knowledge of basic piecrust and filling ingredients, which ingredients were used to make this berry pie?

Ingredient	Functions
Flour (farine)	Body (bulk or mass), structure and texture (tender and crumbly; firm and chewy), flavor (dependent upon the type), thickening agent, gluten development
Fat (graisse)	Flavor and richness, moisture, shortens (tenderizes by literally shortening the length of gluten strands), leavens (e.g., melts to form steam; fat assists in the flakiness of piecrusts), browning aid, carries an added flavor evenly throughout the filling or crust
Salt (sel)	Flavor (e.g., enhances the sweetness and flavor of baked goods; adds complexity (without it you would primarily taste sugar)), heightens the flavor of other ingredients, toughens the texture of soft fat-and-sugar mixtures, strengthens gluten protein which impacts texture in a positive fashion
Liquid	Moisture, flavor (all except water), color (browning from milk, cream, and fruit juice sugars), steam leavening, gluten (mixes with flour for proper gluten development), hydration of proteins and starches (including gelatins), binds ingredients together
Eggs (oeufs)	Leavening (natural and via air incorporation), emulsification (a binding agent), moisture, color (egg yolks in fillings and crusts and egg wash glaze that browns the crust surface), flavor, tenderizes (the addition of egg yolk makes baked goods more tender than those that do not contain egg yolk), texture, thickening agent
Sugar (sucre)	Flavor, tenderizes crusts and fillings (except for artificial sweeteners), color (caramelizes and aids in browning), moisture retention (sweetened baked goods stay moist longer than unsweetened types)
Leavening	Causes greater volume in piecrusts and fillings, helps develop flaky crust (via steam, air, eggs), flavor (especially from eggs)
Flavoring (parfum)	Enhance or fundamentally change the taste of piecrusts and fillings

PIECRUST AND FILLING EQUIPMENT AND TOOLS: PART 1

- A pastry blender is a crescent-shaped hand tool constructed of a series of bowed metal blades or wires affixed to a handle and used to cut solid fat into flour. A pastry blender cuts fat into flour to create numerous layers that result in flaky piecrust.

- A rolling pin is a long cylindrical tool used to roll out, thin, or shape pastry and other dough (cookies, breads). They are available in wooden, marble, ceramic, porcelain, brass, copper, stainless steel, silicone covered, or glass materials. Rolling pins are in two basic styles: a standard pin with handles and ball bearings and the French-style pin with tapered ends and no handles.

PIECRUST AND FILLING EQUIPMENT AND TOOLS: PART 2

- A dough docker is a handled multi-spike tool that rolls over pastry to create small vents that prevent pastry dough from blistering, bubbling, and rising during baking. Rolling dockers are typically 4 to 6 inches wide although some are smaller and some commercial types are 12-inches wide. They cover more area than fork tines. An example is shown at https://en.wikipedia.org/wiki/File:Roller_docker.jpg.
- A pastry wheel is a crimped cutter attached to a handle used to cut pastry dough into strips and to create an evenly decorated edge on crusts. The crimped edge on this individual mince pie serves two purposes: it seals the top and bottom crust together and creates a decorative edge.

PIECRUST AND FILLING EQUIPMENT AND TOOLS: PART 3

- Pie weights are small beads loosely arranged over a raw pastry or piecrust that prevent a blind-baked crust from shrinking and bubbling in the oven. Typically, the crust is docked, lined with aluminum foil or parchment paper, and then the weights are scattered evenly over the surface. Why did the baker add parchment paper between the tart crust and these ceramic pie weights?

- Bakers have many choices of pie, tart, and dessert pans, dishes, and molds. Identify each of the types pictured here.

PASTRY TYPES: FLAKY 1

Standard flaky pastry is crisp, buttery, and puffed due to the numerous layers created during mixing. Flaky pastry is created by the technique of cutting shortening into the flour. Describe the piecrust process illustrated in these four images. Why do bakers use ice water instead of warm water for piecrust?

PASTRY TYPES: FLAKY 2

Wrap the flattened dough ball(s) in plastic wrap to rest. Chill wrapped dough for 30 minutes to 24 hours before rolling. TIP: When making large quantities of flaky pastry, scale the balls in 8 to 9 ounce pieces each, then wrap. Notice the flaky piecrust layers in the chicken potpie pictured here.

PASTRY TYPES: SHORT

Short pastry is piecrust dough that remains crisp and cookie-like (do not become soggy) which makes them a good choice for pies and tarts with cream and custard fillings. Ingredients include: butter, sugar, egg yolk, vanilla, and flour. The sugar allows the dough to be re-rolled when necessary. Short pastry crusts include pâte brisée, pâte sucrée, and shortbread crust.

PASTRY TYPES: SHORTBREAD

Shortbread crust is cookie-like pastry made with three ingredients—salted butter, flour, and confectioners' sugar—and pressed into pie and tart forms. Unlike standard flaky pastry, shortbread crusts do not rely on the pie or tart form to maintain their shape. A pre-baked shortbread crust can be removed from the baking pan and filled.

PASTRY TYPES: CRUMB

Cookie and sweet cracker crumb crusts are usually prepared as single crusts from graham crackers, gingersnaps, chocolate and vanilla wafers, Oreos®, etc. and transform easily into mealy, tender piecrusts. Melted butter is often the fat that binds the crumb pastry ingredients together. A crumb crust is quickly mixed, pressed into a pie or tart tin, and baked in order to hold the crust together when serving.

PASTRY TYPES: MASHED POTATOES & MERINGUE

Other pastry crusts include mashed potato crusts for savory pies and meringue crusts for fruit tarts and frozen desserts.

SINGLE-CRUST PIES

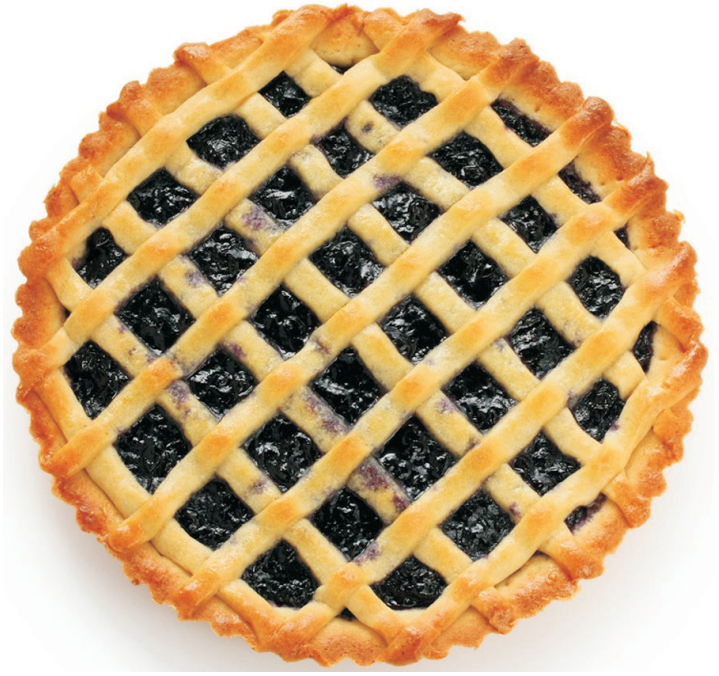
A single-crust pie is a bottom casing and a filling. Single crusts are used for custard pies and tarts (plain, pumpkin, pecan, cream) and for savory custards, such as quiche. Galette (French) and crostata (Italian) are terms for rustic open-faced single-crust pies, fruit-filled or savory, that are baked flat with the crust edges turned-up and slightly over the filling to create a "bowl."

BLIND-BAKED CRUSTS

A blind-baked crust is an empty bottom casing that is partially or fully baked before the pie filling is added. For example, custard fillings are very liquid and, when baked in a raw crust, often result in a soggy crust. Other fillings that are not baked—cream or fresh berry pies—use a fully baked blind crust. Some fillings, such as quiche or pecan and pumpkin custard pies, cook faster than the crust. In these cases, the crust is often partially baked before the filling is added to prevent creating a soggy bottom.

DOUBLE-CRUST PIES

A double-crust pie has two casings: a bottom crust and a top crust with a filling in between. Most cooked fruit pies are double-crust types. The bottom crust is prepared as for a single crust and lines the pan. Then, filling is added and finally a top crust is added. Double crust pies are vented. A vent is an opening in the top crust to release steam from the pie filling as it cooks, such as, slits, decorative cutouts, or woven lattice strips. Then, the top and bottom crusts are trimmed and sealed or crimped together prior to baking.



MAKING LATTICE TOP CRUSTS

Lattice crust is a decorative top casing for a double-crust pie applied by weaving evenly cut strips of rolled pie dough in a crosshatch pattern. For example: A 13-inch round of rolled piecrust dough creates approximately eighteen ½-inch wide lattice strips. Again, fluting of the edge of a lattice crust occurs after the top lattice crust is applied.

FRUIT AND CUSTARD FILLINGS

Raw fruit filling is a mixture of raw fruit, sugar, starch or flour, and other spices and flavorings. Cooked fruit filling is a mixture of cooked fruit with sugar and other flavorings thickened with cornstarch. Custard filling is an uncooked mixture, made with a large amount of eggs, in which the filling and piecrust are baked together. Each of these images represents one of these filling types; which is which?

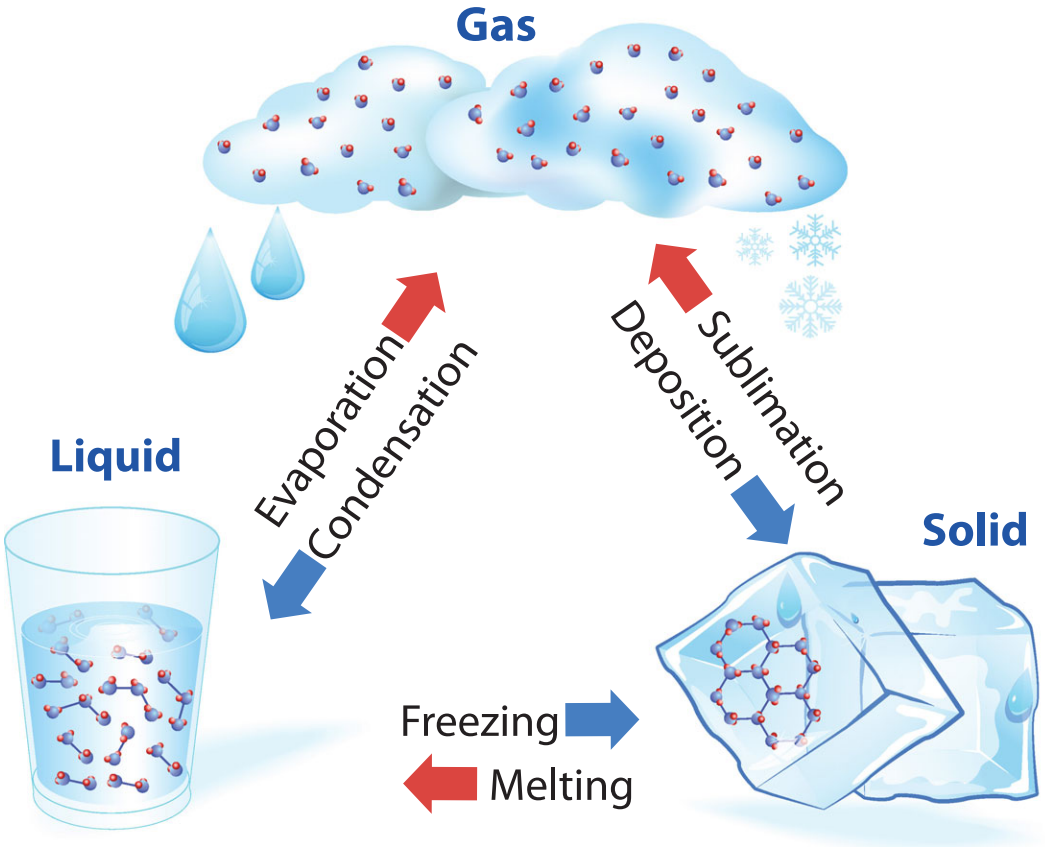
DECORATIVE EDGES

To flute is adding a decorative edge to the rim of the pie, tart, or dessert using one's fingers and/or other hand tools. Decorative edges help finish the pie's look. Identify each of the decorative edges pictured here.

PHYSICAL CHANGES: PHASE CHANGES

A physical change is the transformation of a substance that does not alter its chemical properties: it's just a phase change. Melting, boiling, and freezing are examples of a physical phase change: an ice cube (frozen water) that melts is still water (liquid water) and its chemical properties remain intact. Physical changes occur when matter gains or looses heat: no new substance is produced, just a change in its physical state.

STATE OF MATTER



CHEMICAL REACTIONS: BAKING SODA AND VINEGAR

A chemical reaction is a permanent change in the chemical composition of a substance in which molecules are broken apart and rearranged into new molecules. To be termed a chemical reaction a new substance must be formed. When water boils, liquid water changes into steam, but it's still water (in a gas form): a physical change. And, it's possible for steam (a gas) to return to a liquid state. However, when vinegar is added to baking soda, the gas produced is a new substance called carbon dioxide (CO_2) and it is not possible to turn this new solution back into vinegar and baking soda: it's an example of a chemical reaction.

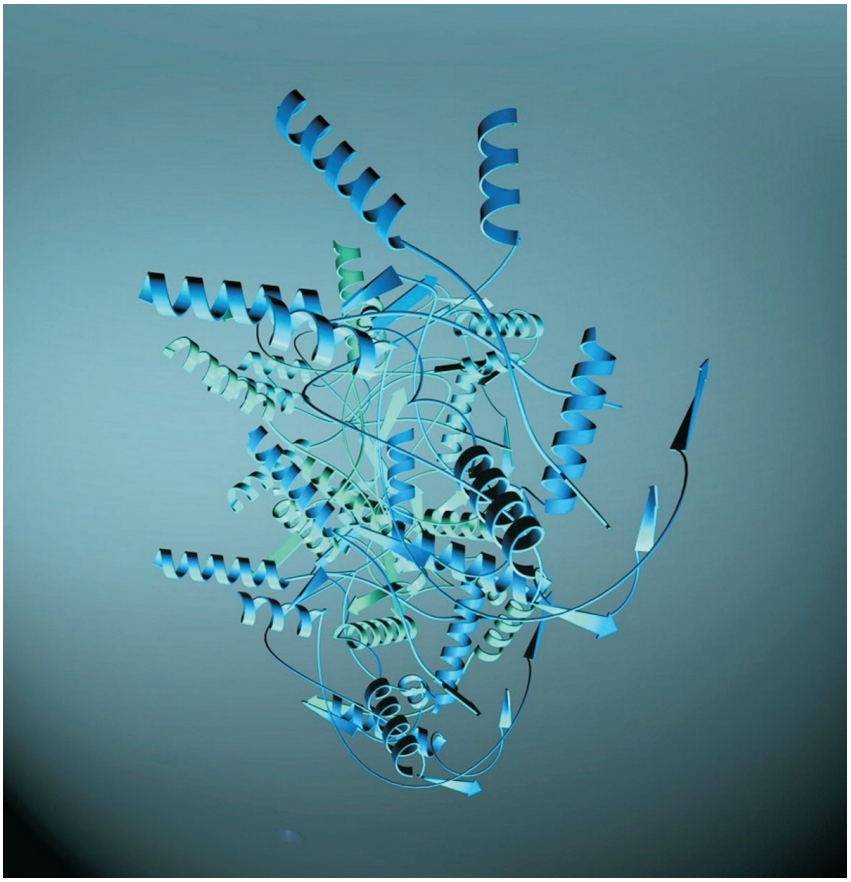
ABSORPTION: THICKENING WITH CORNSTARCH

Absorption is the act of attracting (taking up) particles of gas or liquid into a liquid or solid substance. During custard preparation liquid is absorbed into flour or starch molecules. All starches work by absorbing liquid into individual starch grains. The amount of liquid a starch grain can attract (absorb) and how concentrated the starch grains are in the liquid affect the thickness of the final product. The thickened mixture here is heated milk and cornstarch that is cooked until thickened for a cream pie filling or pudding.

CARAMELIZATION

Crème brûlée is an example of sugar that is caramelized with a torch immediately before serving.

CHEMICAL REACTION: FOAM PROTEIN COAGULATION AND DENATURATION



Natural proteins, at the molecular level, are shaped like coils or springs. When exposed to heat, salt, or acid, they denature (unfold) and the coils unwind. Foams form when the protein liquid of eggs is whipped: the foam forms a film around the air pockets and denatures the protein in the egg. When proteins denature, they coagulate (bond together and form solid clumps). Coagulation is the changing of a liquid to a semisolid or solid mass.

LS–A

Name _____

Blind-Baking a Perfect Flaky Piecrust

Purpose

The purpose of this activity is to prepare a blind-baked standard-formula flaky piecrust.

Objectives

1. Measure all ingredients accurately.
2. Follow the steps to prepare a flaky piecrust.
3. Ask your instructor to evaluate each preparation step as completed.
4. Complete the DATA TABLE to compare and contrast your flaky piecrust with the characteristics of a perfect flaky piecrust

Materials

- lab sheet
- recipe/formula for single piecrust
- ingredients for a standard single flaky piecrust
- equipment to prepare a standard flaky piecrust

Procedure

1. Divide into lab groups. Read the single piecrust recipe.
2. Follow safety and sanitation rules when preparing the blind-baked piecrust.
3. Follow the preparation steps in order. Ask your instructor to initial each step.

Flaky Piecrust Step-by-Step CHECKLIST

Steps	Satisfactory (Instructor Initials)	Needs Work (Instructor Initials)
1. Measure flour and salt.		
2. Mix flour and salt in medium bowl.		
3. Measure cold fat.		
4. Cut in fat to flour until pea size.		
5. Chill water; sprinkle 1 tablespoon over flour/fat and toss with a fork. (Show this technique to your instructor.		
6. Add water, 1 tablespoon at a time and tossing until flour is moistened.		
7. Gather pastry into a ball. Flatten on lightly floured surface.		
8. Wrap flattened ball in plastic wrap and refrigerate 30 minutes to 24 hours.		
9. Preheat oven. Place a damp cloth towel under a cutting board to prevent board movement. (Alternative: Dampen a countertop and place waxed paper over the damp spot.)		
10. Using a floured rolling pin, and floured cutting board (or the alternative method of rolling between floured waxed paper), roll pastry in a circle, lifting up at outside edges until the crust is 2 inches larger than the pie plate.		
11. Move pastry to pie plate. (*Method 1:* Gently fold pastry into fourths, lift, and place in pie plate without stretching. *Method 2:* Hang pastry loosely around rolling pin and place in pie plate. *Method 3:* Remove top sheet of waxed paper, place upside-down pie plate on crust, place hand under bottom of waxed paper and invert pie plate, crust, and waxed paper. Remove bottom waxed paper.		
12. Ease piecrust into pan without stretching.		
13. Trim over-hanging edge of pastry to 1 inch (or more slightly more) from the rim of pie plate.		
14. Form standing rim edge.		
15. Flute edge.		
16. Dock bottom and sides of bottom piecrust.		
17. Add pie weights or “hook” tips of fluted edge under rim of pie plate.		
18. Protect fluted edge from over-baking. (foil strips, etc.)		
19. Blind-bake pie shell, removing protected fluted edge for last 5 to 10 minutes.		
20. Let pie shell cool completely.		

4. Compare your pie to the "Flaky Piecrust Standard Characteristics" using the data table provided. Looking at your finished crust, discuss your evaluation of your finished crust with the instructor.

DATA TABLE: Flaky Piecrust Standard Characteristics

	Yes	No	Explain
Appearance			
1. Rough, blistered surface with no large air bubbles			
2. Golden brown fluted edge			
3. Center of bottom is light in color			
4. Retains pan shape (does not shrink)			
5. Attractively shaped edges			
6. Uniform thickness			

	Yes	No	Explain
Texture			
7. Layers visible when pastry is broken			
8. Crisp and flaky (not mealy)			
Tenderness			
9. Cuts easily with fork while holding shape when lifted			
10. Tender, but not crumbly			
Flavor			
11. Pleasing well blended flavor; slight hint of salt			
12. Free of unpleasant or distracting flavors			

Data table adapted from the Crafty Baking website, Pie and Tart Pastry Crust Dough pages at https://www.craftybaking.com/learn/baked-goods/pastry/types/pie-and-tart.

Blind-Baking a Perfect Flaky Piecrust

1. This lab can be conducted with groups or with individuals. Performing the tasks as an individual helps the student to grasp the steps to making a perfect blind-baked pie shell.
2. Two single piecrust recipes to consider:
   a. This America's Test Kitchen Cook's Country "Single-Crust Pie Dough" recipe uses both butter and shortening at https://mybreadandshutter.files.wordpress.com/2012/01/single-crust-pie-dough-recipe-cook_s-country1.pdf.
   b. This Betty Crocker website recipe, "How to Make One-Crust Pie Pastry," uses only shortening but suggests a fork in place of a pastry blender at https://www.bettycrocker.com/how-to/tipslibrary/baking-tips/how-to-make-one-crust-pie-pastry.
3. It's helpful to give each student or each group a copy of the lab sheet. The student brings you the preparation step to be evaluated and the CHECKLIST for evaluation. Carrying a clipboard makes initialing the steps easy. Instructor initials are used instead of check marks. Consider using an unusual color of ink for your initials that cannot be duplicated. Students are responsible for coming to the instructor and having each step evaluated. Consider a point value for each of the 20 steps. For example, 5 or 10 points per step.

LS–B

Name _____

Prepare Pies

Purpose

The purpose of this activity is to prepare and bake a pie to crust and filling standards.

Objectives

1. Prepare a piecrust according to directions.
2. Prepare a fruit or custard filling pie according to directions.
3. Assemble and bake an attractive and edible pie.

Materials

- lab sheet
- crust ingredients
- filling ingredients
- equipment (e.g., measurement tools, assembly devices, pie plates, etc.)
- crust and filling recipes

Procedure

1. Select a pie and an appropriate crust. Read the recipe for each. Familiarize yourself with the "Pie Production Chart" before you begin the lab. Complete the chart as the lab progresses.
2. Prepare the crust and filling according to the recipes.
3. Assemble the pie.
4. Preheat the oven and bake the pie for the appropriate time and at the proper temperature.

5. Document your pie lab by completing the following "Pie Production Chart." Enter key terms for each step in the "Directions" column (e.g., "measure ingredients accurately," or "cut shortening into flour"). Then, record the start and end times in the appropriate columns.

Pie Production Chart			
Step	**Task Description**	**Start Time**	**End Time**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

6. Evaluate your crust and filling using the "Pie Evaluation Checklist" below.
   a. "Comment" column: Add a short and descriptive term for each element. For example, in the "Shape row" you may write standard shape, perfect shape, or irregular shape.
   b. Use the Rating KEY to assign a number in the "Rating" column.
   c. Then, ask two classmates to evaluate your product. Enter them in the "Names" column.
7. Optional: Take a picture of your pie and piecrust. Use the image to compare with the results of your next pie lab.
8. Turn your evaluation and those of your two classmates to the instructor.

Pie Evaluation Checklist

CATEGORY	Evaluator Names	Rating	Comments
Overall Pie Shape	#1 Me		
	#2		
	#3		
Filling Texture	#1		
	#2		
	#3		
Crust	#1		
	#2		
	#3		
Aroma	#1		
	#2		
	#3		
Flavor	#1		
	#2		
	#3		

Rating KEY: 4 = excellent 3 = good 2 = acceptable 1 = poor