Caramel

Introduction:
In this discovery lab you will learn about the chemical changes that take place when heating sugar and make soft chewy caramel candies and a nice caramel sauce.

Background:

Caramelization is what happens when any sugar is *heated* to the point that the molecules undergo chemical reactions with oxygen in the air and with each other – the molecules either break apart into smaller molecules, or combine with one another to make larger molecules. The result is a very complex, brown-colored mixture that we call caramel. Any sugar can caramelize, and the temperature necessary for caramelization is dependent on the chemical structure of the starting sugar. Sucrose (i.e. table sugar) is the most common sugar that is used to make caramel. Caramelization of sucrose produces large brown molecules (caramelan, caramelen, and caramelin) and small, volatile aroma molecules such as furan, maltol, ethyl acetate and diacetyl

The large brown molecules (caramelin, caramelen and caramelan) are what give caramel its color, its viscosity and its stickiness. The aroma molecules give caramel its flavor. The caramelization reactions require intense heat (340˚F/170˚C), and too much heat for too long will produce very dark, sticky and bitter tasting caramel, rather than a light brown, sweet and complex tasting syrupy solid.
Caramelized sugar is a hard, brittle solid, so how then will we make a soft, chewy candy?
When making caramel candies or caramel sauce, we add cream and butter to the caramelized sugar when it is still very hot (> 300 degrees). Cream contributes milk solids and milk sugars and proteins along with some water and fat. The water keeps the caramel from setting too firmly, and the milk sugars and proteins contribute to the browning through Maillard reactions.

The *Maillard reactions* are responsible for the browning of many foods including meat, the brown color on a loaf of bread, coffee beans and "caramelized" onions. *Maillard reactions* take place between sugars like glucose and amino acids that are free or part of proteins. The *Maillard reactions* also require intense heat (250˚F/120˚C) – but not quite as hot as the caramel forming reactions above. When we add milk and butter to the hot, hot sugar - the proteins (remember, proteins are made of amino acids) in the milk and butter undergo Maillard reactions with the sugar to generate additional flavors.

SAFETY REMINDER: The temperature at which sugar reacts to form caramel is very high. The resulting caramel syrup is extremely hot. As a precaution have ice water and a first aid kit on hand. If sugar syrup spills on your hand, putting the burned finger in your mouth will burn your mouth as well. Instead immediately place a burn in ice water then follow standard first aid instructions.

Part 1: Soft Caramel Candies
Makes about 25-30 caramels

In this simple caramel recipe, we will use energy to breakdown the sugar into the tasty brown products that are caramel or caramelization. This browning of sugar is actually the breakdown and oxidation of sugars – which can occur in any food containing sugars when high heat is applied. This caramel recipe requires that you use your powers of observation to determine when the caramel is done.

Ingredients

- 1/2 cup heavy cream
- 2 tablespoons unsalted butter
- 1/4 teaspoon salt
- 3/4 cup white granulated sugar
- 2 Tbsp corn syrup
- 2 Tbsp water
- 1/4 teaspoon vanilla extract

Equipment

- Your small cookie sheet
- Parchment paper
- 2-quart saucepan - *your saucepan must be VERY CLEAN. Sour with an SOS pad if your pan contains burned residue.*
- Instant-read thermometer
- rubber spoonula
- Pastry brush
- Whisk
- Wax paper

1. Prepare the caramel mold. Cut parchment paper using scissors so it just longer than the length of your cookie sheet. Cut the paper to leave excess paper hanging over only *two* side edges. Spray the parchment and the sides of the pan with nonstick cooking spray. Wipe away excess with a clean paper towel.

2. Melt the butter in the cream. Over medium heat, warm the cream, butter, and salt in the 2-quart saucepan until the butter melts. Remove from heat, and carefully pour the cream/butter/salt mixture into your glass-measuring cup. Set aside. Wipe out your saucepan with a clean kitchen towel.

3. Combine the sugar, corn syrup, and water. In your 2-quart saucepan, combine the sugar, corn syrup, and water. Corn syrup is very thick and difficult to pour. Use a butter knife to help you pour, then scrape the corn syrup directly into the pot. Stir until the sugar is evenly moistened and you form a thick grainy paste. Wipe down the sides of the pan with a damp pastry brush so there are no sugar crystals above the surface of the sugar mixture. Spray a paper towel with non-stick cooking spray and wipe down the inside of the pot - above the sugar. Clip the instant-read thermometer to the side of the pan so that the heat sensor is immersed in the sugar. **Do not stir the sugar after this point.**

Note: Although the sugar will barely cover the bottom of the pan, the extra space is necessary because the sugar will bubble up and triple in size when you add the cream.

4. Cook the sugar syrup. Place the pot with the sugar mixture over medium to medium-high heat. Let the sugar syrup come to a boil without stirring. At first, you will see small bubbles around the edge of the pan, which will eventually move inward. Around 250°F, the sugar syrup will turn transparent and boil rapidly. You may need to tilt the pan to cover the tip of the thermometer for an accurate reading. Around 320°F, the syrup will darken slightly and smell caramel-like; true caramelization chemistry starts occurring at 320°F. Move on to the next step when the caramel is a few shades lighter than your goal color, as it will continue to cook even after you remove the heat. The darker the caramel, the *more complex* the flavor and the less sweet. Do not let the caramel get above 350 degrees or it will turn bitter. **Use extreme caution!! The pot and sugar will be VERY HOT.**

Sugar mixture is boiling rapidly, temp at 238 degrees)

Note: If your instant-read thermometer isn't quite submerged into the sugar, you may need to tilt the pan to get an accurate reading. Simply tilt the pan by the handle until the thermometer is submerged a few inches in the sugar syrup. If the syrup hasn't reached 250°, wipe down the sides with a pastry brush again. If it has, there's no need.

5. Whisk in the HOT cream and butter. *If your cream and butter are not hot - then zap it in the*

microwave. CAREFULLY remove the pot from the heat and gently place it on the counter. SLOWLY pour the hot cream and butter mixture into the sugar syrup while whisking the sugar syrup gently. The sugar syrup will bubble up and triple in size. Stop whisking once all the milk and butter mixture has been added.

6. **Heat the caramel to 245°F - 250°F**. Return the pan to medium to medium-high heat. Let the caramel come to a boil without stirring. Remove from heat when the caramel reaches 245°F to 250°F.

7. **Whisk in the vanilla**. Quickly whisk the vanilla into the caramel.

8. **Pour the caramels into the mold.** Immediately pour the caramels into the parchment lined cookie sheet. Do not scrape the pan (there are sometimes hard burnt bits on the bottom). Tap the pan against the counter a few times to help air bubbles work their way out. Do NOT touch the molten caramel - it is VERY HOT and will instantly burn your skin.

When the sugar is about 320 degrees, remove from heat and stir in cream, melted butter and salt

9. **Let the caramels set**. Set the caramels somewhere out of the way to set, for at least two hours or (ideally) overnight. Once the caramels have cooled to room temperature, you can cover the pan.

10. **Cut the caramels.** When the caramels have set, lift them out of the pan by the parchment paper flaps and onto a cutting board. Cut the caramels into candies with a very sharp knife. If the caramels stick to your knife, spray your knife with nonstick cooking spray.

11. **Wrap the caramels in wax paper.** Cut squares of wax paper a little longer than your caramels. Wrap each caramel in wax paper and twist the ends closed. Caramels will keep at room temperature for about two weeks.

Part II Caramel Sauce and Caramel Color.

Now that you have made the caramel candies, we will experiment with a ***variation on the recipe*** to make different colored caramel sauces. We will then taste the different sauces an experience the effects of breaking down the sugar.

The color of the caramel depends on how long you allow the caramelization reactions to proceed. Once the temperature of caramelization has been reached (320 degrees Farenheit), the sugar will keep breaking down and the color will continue to darken until the temperature is lowered. The longer the caramelization reactions go on, the less and less intact sugar remains; therefore, the darker the caramel, the *less sweet* and *more complex* its flavor.

As a class, we will make caramel sauces of different colors and then compare their flavors. The extent of caramelization you allow in a sauce is a matter of personal preference (sweetness vs. complexity), but knowing what you like helps you make the caramel sauce to an appropriate color.

Ingredients

- 1/2 cup Heavy Cream
- 1 Tbsp Butter
- a pinch salt
- 1/2 cup white granulated sugar
- 1/2 Tbsp Corn syrup
- 2 Tbsp Water
- 1/2 Tsp Vanilla Extract

Review the information on making candies. What chemical reactions and interactions between the sugars, fats and proteins take place while making caramel? How do these components impact the final consistency and flavor of your product? Such considerations can add to the variation in your experiment

1. **Melt the butter in the cream.** Over medium heat, warm the cream, butter, and salt in the 2-quart saucepan until the butter melts. Remove from heat, and carefully pour the warm cream and butter into your glass-measuring cup. Set aside.

2. **Combine the sugar, corn syrup, and water.** In your 2-quart saucepan, combine the sugar, corn syrup, and water. Corn syrup is very thick and difficult to pour; use a butter knife to help you pour, then scrape out your tablespoon directly into the pot. Stir until the sugar is evenly moistened and you form a thick grainy paste. Wipe down the sides of the pan with a damp pastry brush so there are no sugar crystals above the surface of the sugar mixture. Spray a paper towel with non-stick cooking spray, and wipe down the inside of the pot - above the sugar. Clip the instant-read thermometer to the side of the pan so that the heat sensor is immersed in the sugar. **Do not stir the sugar after this point.**

Note: Although the sugar will barely cover the bottom of the pan, the extra space is necessary because the sugar will bubble up and triple in size when you add the cream.

3. Cook the sugar syrup. *Before beginning this step decide how dark you want your caramel sauce - the color of the sauce is a function of how long you allow the caramelization chemistry go on.*

Place the pot with the sugar mixture over medium to medium-high heat. Let the sugar syrup come to a boil **without stirring**. At first, you will see small bubbles around the edge of the pan, which will eventually move inward. Around 250°F, the sugar syrup will turn transparent and boil rapidly. *You may need to tilt the pan to cover the tip of the thermometer for an accurate reading.* Around 320°F, the syrup will darken slightly and smell caramel-like; true caramelization chemistry starts occurring at 320°F. Move on to the next step when the caramel is a few shades lighter than your goal color, as it will continue to cook even after you remove the heat. The darker the caramel, the more complex the flavor and the less sweet. Watch the temperature, and do not let the caramel get above 350 degrees or it will turn bitter. Adjust the heat on the burner as necessary. **Use extreme caution!! The pot and sugar will be VERY HOT.**

Note: If your instant-read thermometer isn't quite submerged into the sugar, you may need to tilt the pan to get an accurate reading. Simply tilt the pan by the handle until the thermometer is submerged a few inches in the sugar syrup. If the syrup hasn't reached 250°, wipe down the sides with a pastry brush again. If it has, there's no need.

4. Whisk in the cream and butter. CAREFULLY remove the pot from the heat and gently place it on the counter. Wait a few seconds, then **SLOWLY** pour the warm cream and butter mixture into the sugar syrup while whisking the sugar syrup gently. The sugar syrup will bubble up and triple in size. Once all the milk and butter mixture has been added, whisk until caramel sauce is smooth. Add the vanilla. Let it cool in the pan for a couple minutes, then pour into a glass bowl and let sit to cool to room temperature. (Remember to use pot holders when handling the bowl filled with hot caramel sauce). *Adding the cream and butter lowers the temperature of the sugar and stops the caramelization reactions.*

5. Place your caramel sauce on the table with sauces from other groups. Take a photo of all the caramel sauces contributed by the class after they have been ranked by color. Rank the sauces from light to dark before tasting. The instructor will provide vanilla ice cream to taste with your caramel sauce.

6. Store caramel sauce in the refrigerator for up to two weeks. When the caramel tasting is complete, you can store your sauce refrigerated for up to 2 weeks. Warm before serving.

Analysis

Before analysis you should have cleaned up your work area, washed and put away all materials and equipment. You should perform the assigned reading that accompanied this lab before attempting the analysis. Referencing class handouts will also be helpful when answering the questions.

(A) Caramel

1. Why does the recipe call for two different types of sugar? Table sugar – sucrose, and corn syrup – a mixture of glucose molecules and different length polymer chains of glucose.
2. What is happening to the molecules chemically, when breakdown of sugar produced an aroma?
3. What is the chemical explanation for the brown color that forms during caramelization?
4. Why does caramelization of the sugar stop when you add the cream-butter-salt mixture?
5. Some recipes call for lemon juice – an acid? Why?
6. How long did you have to microwave to achieve your desired caramel color? What is the chemical explanation behind the caramel color?
7. What was the appearance, consistency and taste of your caramel after it cooled?