candy-making science

splash 2021: caramel edition

mise en place

Ingredients

Fats:

- Dairy: ½ cup heavy cream and 2 tbsp butter
- Nondairy: ⅔ cup full fat coconut milk

Sugar things:

- ¾ cup sugar
- 2 tbsp corn syrup
- 2 tbsp water

Other:

- If using unsalted butter or coconut milk, a little bit of salt
- Flavoring, like vanilla (optional)

Materials

- 2 Saucepans, one of them at least medium sized
- Measuring cups/spoons
  - (½ cups, ⅓ cups, ¼ cups, tablespoon)
- Greased up heatsafe flat surface (cookie tray, baking sheet, largish tray, etc)
- Cooking Spoon
- [Cup with cold water and a spoon] or [a Candy thermometer]
- Whisk (Optional)

Reminder:
Dairy: ½ cup heavy cream and 2 tbsp butter
Nondairy: ⅔ cup full fat coconut milk

let's get started: warm the fats

- Put your fat(s) into the smaller of the two saucepans
  - A pinch of salt if using unsalted butter or coconut milk
- Place over medium-low heat for about 5 minutes
  - Around 4-ish on a 1-10 numbered stove
- Goals
  - Dairy: a relatively homogeneous liquid with the cream and butter mix, to a yellow-ish color
  - Nondairy: heat it up until it is all liquid

Reminder:
¾ cup sugar, 2 tbsp corn syrup,
2 tbsp water

in the meantime... sugar paste

- **NOT OVER HEAT**

- Put your sugar things into the larger of the two saucepans
- Mix it all into a thick grainy paste
- Attach your candy thermometer now, if using one

back to the fats: homogeneous mixture!

~5 minutes in

Notice that it it is a yellow-ish color. Some yellow spots from the butter are ok, just make sure it is mostly well mixed in

For those of you using coconut milk, it should just be coconut milk that's all liquid (the fat dissolved □).

Now, remove this from heat and put it somewhere off to the side where it won't get cold too fast

SUGAR TIME

Let’s put the sugar paste on medium heat

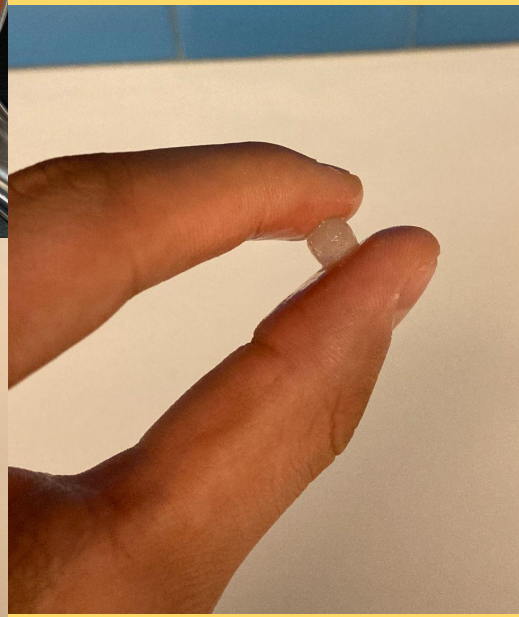
Around 5-ish on a 1-10 numbered stove

Don’t mix it!
Let it come to a boil

the cold water test (wow)

- Using your cooking spoon, take a bit of the mix, and drop it into the cup of water
- At this point, the resulting ball should fill fairly squishy (fish it out with a spoon)

~3 minutes in



Soft Ball

230°F- 240°F

squishy ball, kinda feels like play-doh tbh

Firm Ball

240°F- 250°F

noticeably tougher, feels like modeling clay

Hard Ball

250°F- 265°F

feels like a raw almond (very tough)

Soft Crack

265°F- 290°F

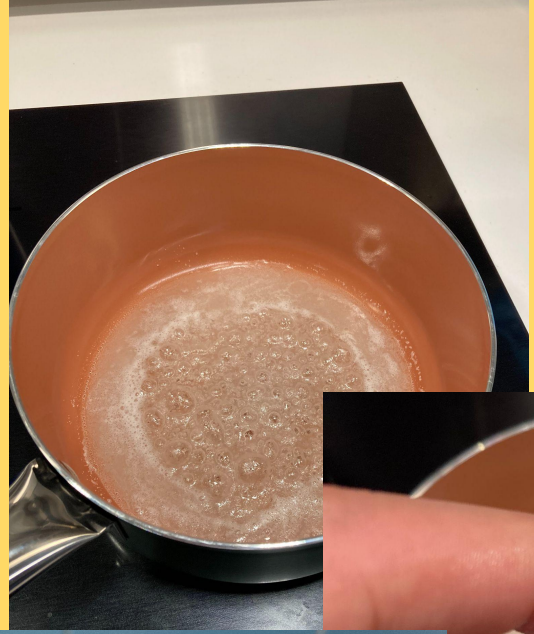
THIS IS WHAT WE WANT

makes a soft cracking noise when dropped, forms pliable threads

and now, a montage of various images

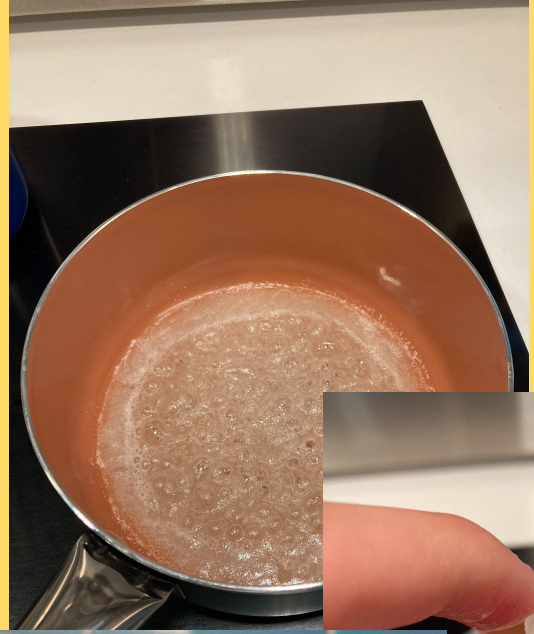
firm ball

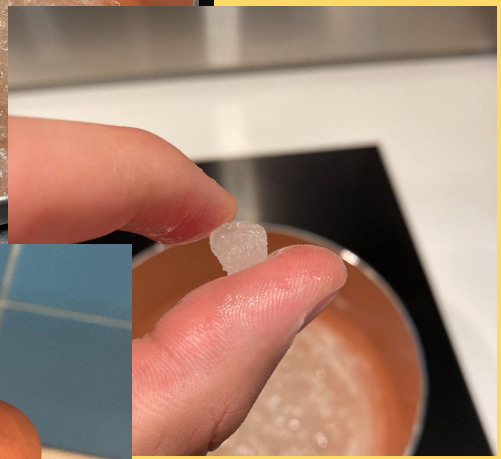
240°F- 250°F
~4 minutes in



hard-ish ball

250°F- 265°F
~6 minutes in





“So basically, on the run that I took these pictures, I messed up and ended the process too soon. Wait no don’t quote me on that”

-Me

beginning soft crack

265°F- 280°F
~7 minutes in

image not available

lol oops

PAUSE

pouring in the fats

- **TAKING IT OFF THE HEAT**
- slowly pour in the fats, whisking them in as you pour
- if you don't have a whisk, use the cooking spoon to mix it in as you pour

sugar-fat mixture

- what we just did is bring the temperature of the sugar mixture down by about 40°F, down to around ~230°F
- let's put it back on medium heat
- separation here is fine, just let it do its thing

bubble time

230°F- 245°F
for about the next 4 minutes

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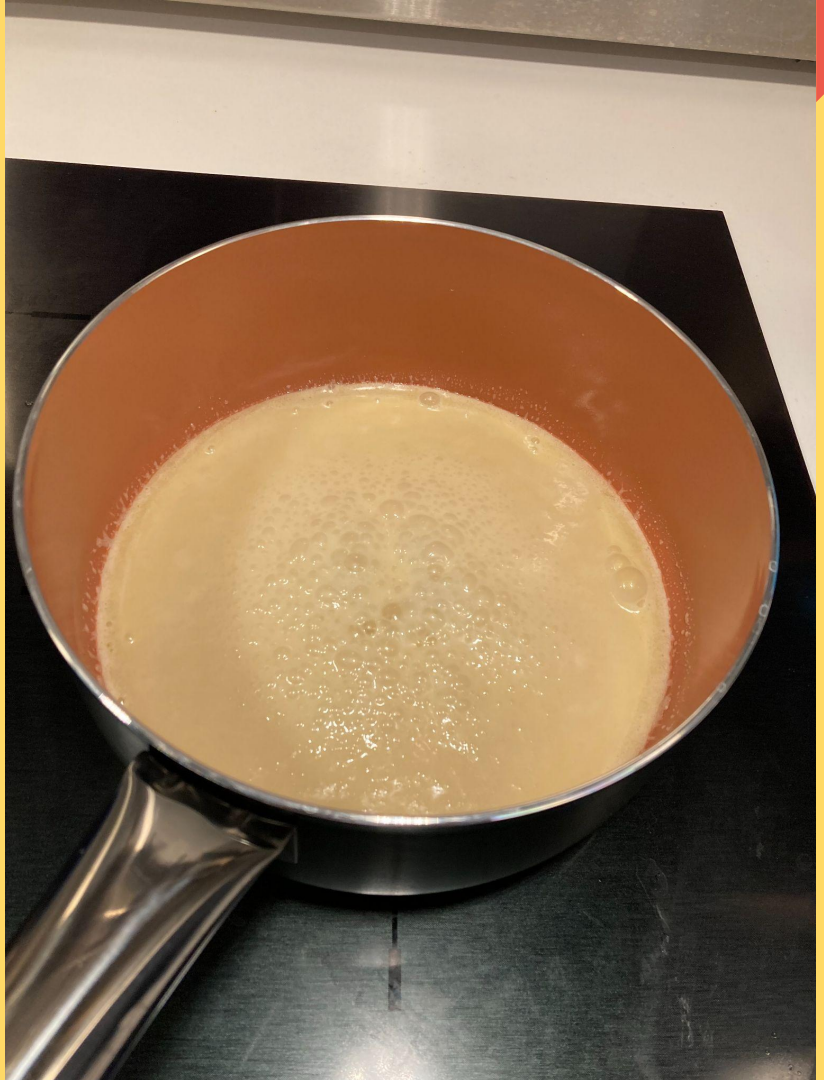
230°F- 245°F
for about the next 4 minutes



bubble time

230°F- 245°F
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230°F- 245°F
for about the next 4 minutes

almost done...

You can remove this from heat anywhere between 245°F-250° F, until you get the color you want

You're looking for a nice orange-ish or brown-ish color at this point.

If you're adding a flavor, remove from heat here, and quickly mix in the flavor

image not available

i'm sorry i didn't get a picture for this one: just go with the color you think looks nice

pouring time

pouring on our prepared greased tray

all done

all done

(just let it cool for at least three hours)

the fats and the sugar stuff

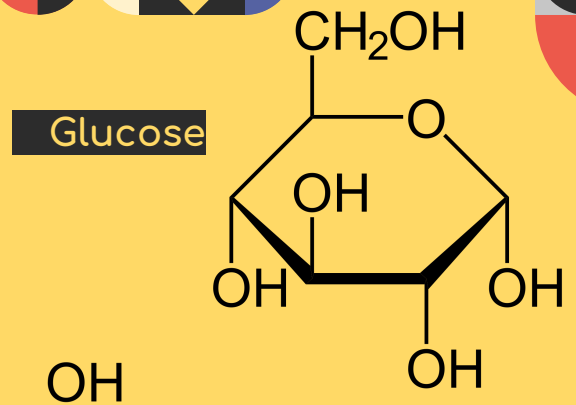
- What is going on with these ingredients?
  - We broke down the ingredients into 2 main sections: the fats section and the sugar stuff section
    - The fats help prevent sugar from crystalizing in the candy
    - The sugars are there to actually make the candy lol
- What's the point of the two separated sections?

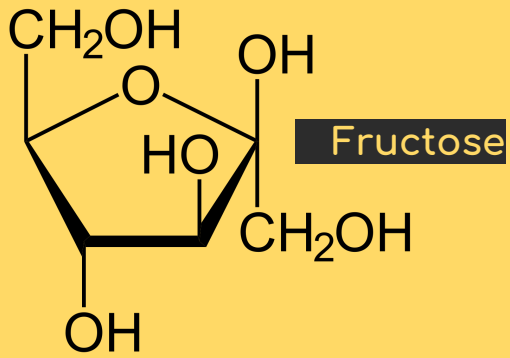
a closer look at sugar

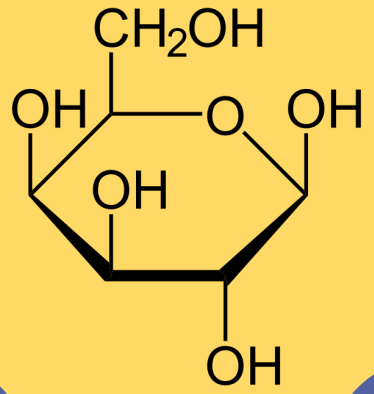
So basically, there are three main basic sugars: glucose, fructose, and galactose. They are all monosaccharides (ie, they are the monomers of carbohydrates.

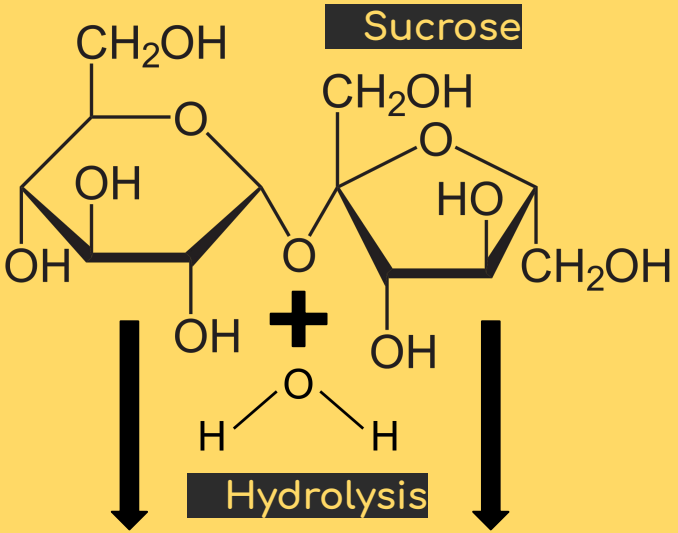
They all have the formula $C_6H_{12}O_6$.

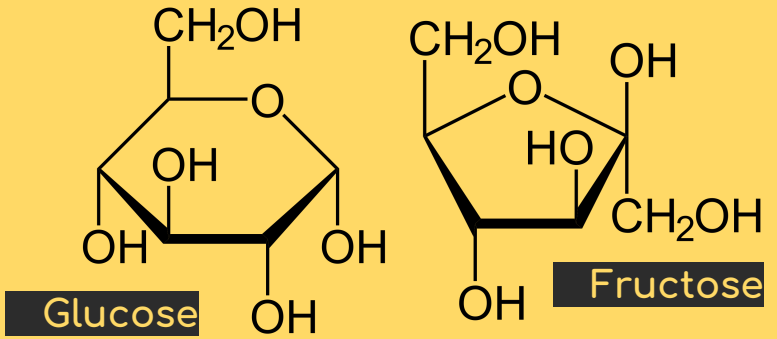
Even though they have the same formula, they're put together in different ways: they are all constitutional isomers of each other.



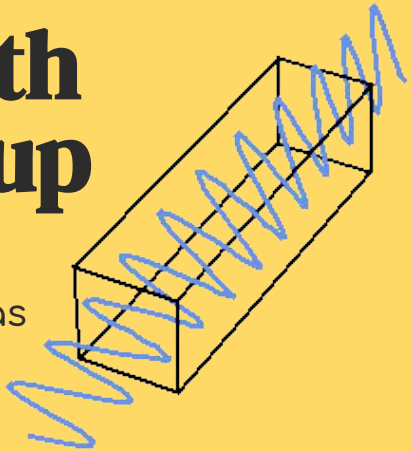




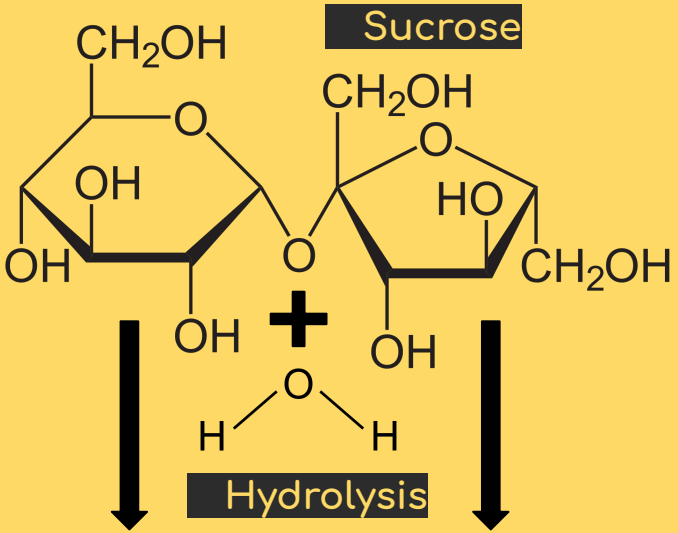


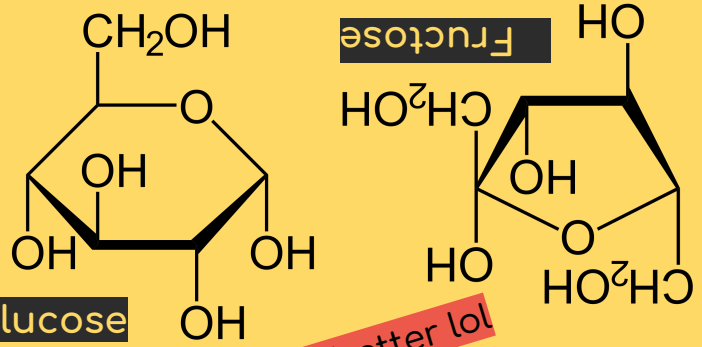


what's up with the corn syrup



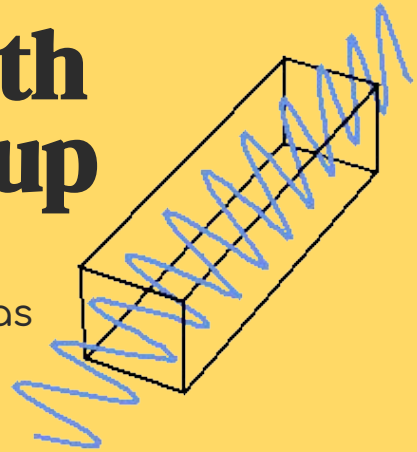
- Corn syrup is an invert sugar, meaning that it has the opposite optical rotation to that of its original sugar.
- These optical properties arise because sugars are chiral molecules.
- We make it by hydrolyzing sucrose (table sugar) into its monosaccharides, glucose and fructose.
- Why do we need it in the first place?





much better lol

what's up with the corn syrup

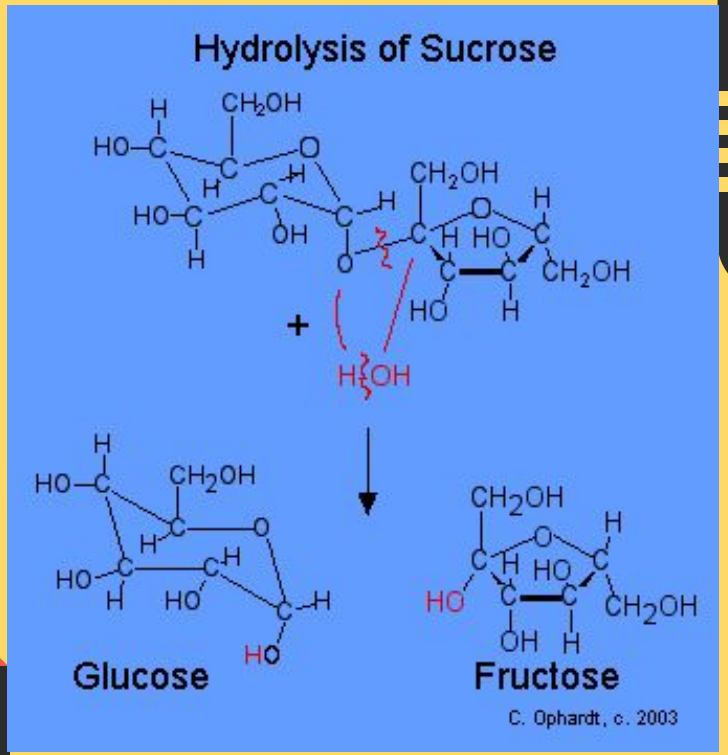


- Corn syrup is an invert sugar, meaning that it has the opposite optical rotation to that of its original sugar.
- These optical properties arise because sugars are chiral molecules.
- We make it by hydrolyzing sucrose (table sugar) into its monosaccharides, glucose and fructose.

Since corn syrup is just the monosaccharides, its mol
are small enough to get in the way of the sucrose
(the rest of the sugar that we put in), which
prevents it from crystallizing.

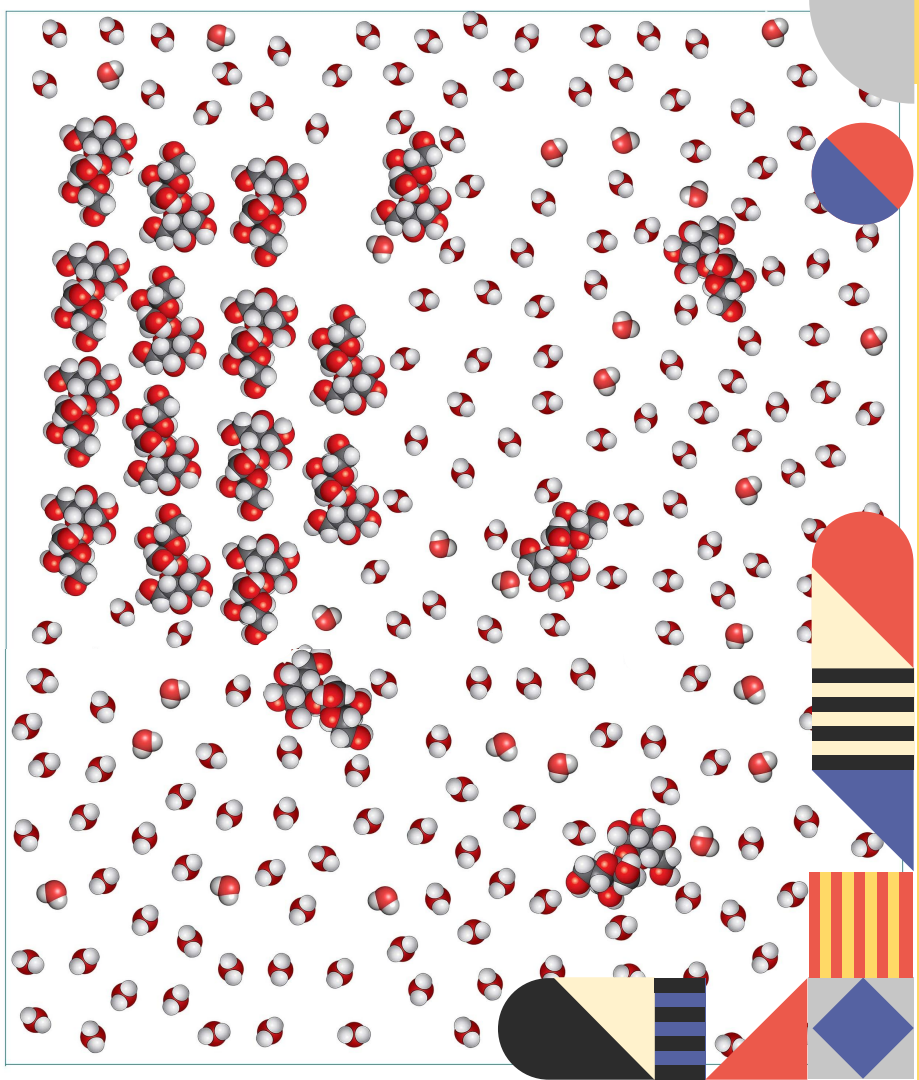
what's up with the corn syrup

- As it turns out, hydrolyzing sucrose is fairly easy to do: all we need is table sugar (the sucrose), water, heat, and some acid to catalyze the reaction.
- You can make your own invert sugar using this reaction: the most common variation is using cream of tartar (an acid) or lemon juice as the catalytic base



why don't we want crystals?

- crystals forming in our candy means that table sugar (the sucrose) isn't fully dissolved
- if crystals form, then we get chunks and lumps of sugar (not great for smooth candies like caramels!)
- as mentioned before, the invert sugar and fats work together to prevent the sugar from crystallizing,



what are we doing anyways

- Great question
- When making crystalline candies, like rock candy, all we need to do is dissolve the sugar in water
- When we let it cool down, the sucrose molecules re-crystallize into bigger crystals
- that's where invert sugars come in (literally)

THE CHEMISTRY OF CANDY

CRYSTALLINE CANDY

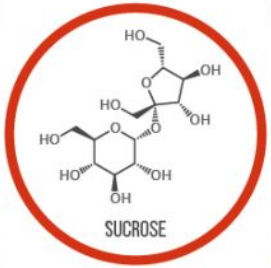
FUDGE

ROCK CANDY

FONDANT

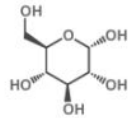
- LOWER SUGAR CONCENTRATION THAN NON-CRYSTALLINE
- °C SUCROSE SOLUTION BOILED AT LOWER TEMPERATURE
- CONTAIN MANY SMALL, FINE CRYSTALS OF SUCROSE

Generally smooth and creamy. Crystalline candies contain crystals of sucrose in their finished form; the sucrose molecules are able to align and form large lattices. They are best formed by slow cooling and little mixing of a solution for crunchy candies, and faster cooling and lots of mixing for smooth candies.

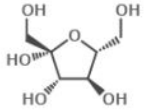


SUCROSE

INTERFERING AGENTS



GLUCOSE



FRUCTOSE

NON-CRYSTALLINE CANDY

LOLLIPOPS

CANDY CANES

CARAMEL

- HIGHER SUGAR CONCENTRATION THAN CRYSTALLINE
- °C SUCROSE SOLUTION BOILED AT HIGHER TEMPERATURE
- FROM VERY SATURATED SOLUTION - NO CRYSTALS

Generally hard & brittle. Non-crystalline, or amorphous candies, form when crystallization is prevented. This can be accomplished by the addition of sugars such as glucose and fructose that interfere with the development of crystals. Often, their mixtures are too viscous for crystals to form.

caramelization products

caramelans

$C_{24}H_{36}O_{18}$
brown color

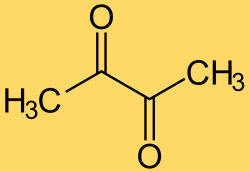
caramelens

$C_{36}H_{50}O_{25}$
brown color

caramelins

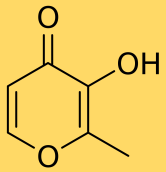
$C_{125}H_{188}O_{25}$
brown color

diacetyl



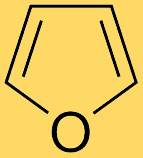
buttery

maltol

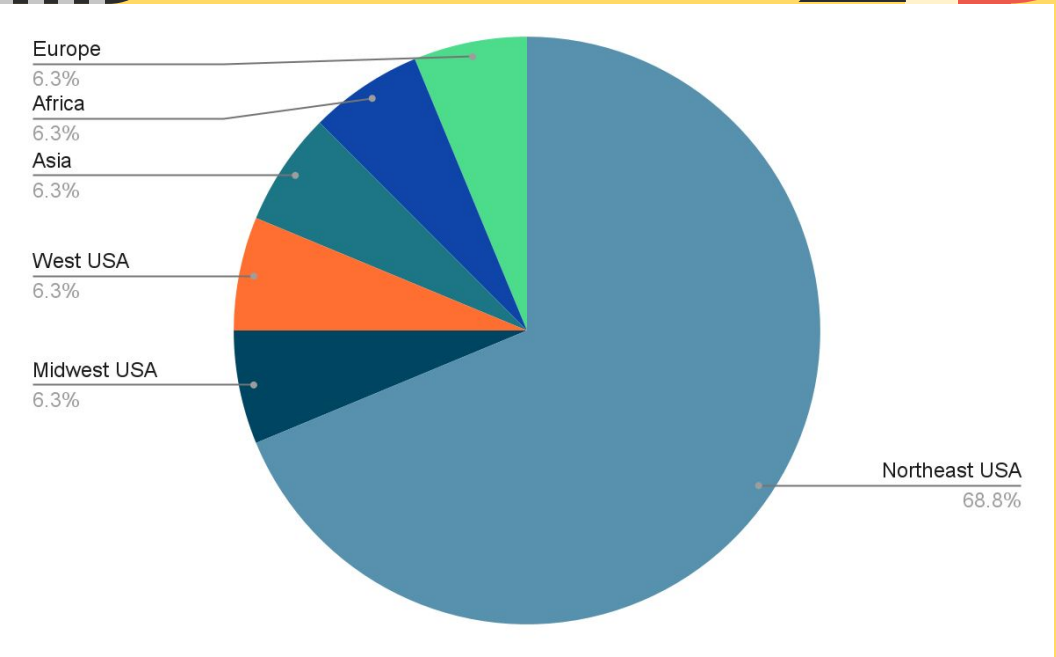


basically the caramel taste

furan

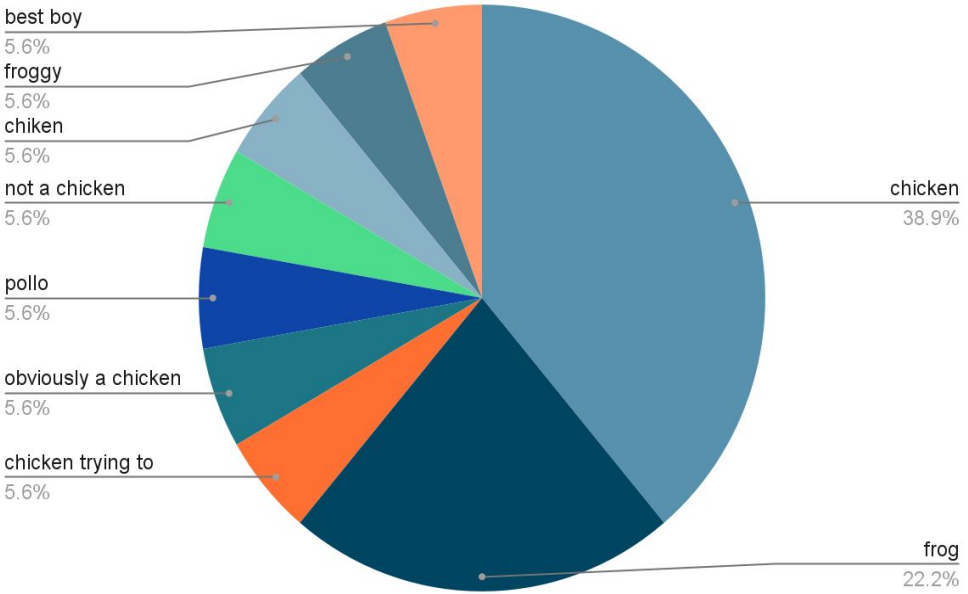


the nutty taste



Here's where y'all are from (according to the survey results)

Here's where y'all thought this was (it is a mountain chicken)



thanks!

Yup that’s pretty much it, have a great time

After three hours, don’t forget, you can cut the caramel up however you want, and shape it (if you want to be fancy).

alright peace out folks