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[MUSIC PLAYING]
Wolfing Down Food Science.
Well, welcome back to Wolfing Down Food Science. Today, we're going to talk about some really amazing textural transformations. And specifically, we're going to talk about the transformations that occur to take this liquid product that we love so much, milk, and convert it into three other products which we also love--yogurt, cheese, and ice cream. So let's go ahead and get started.
I can't believe such a crucial liquid that we get from animals can make so many different products. It's really fascinating to me that we've developed technologies, if we want to call it that, to give us such a wide variety of products.
Very true. And the texture is very different among the different products or even within a product. You can have all kinds of different textures of cheese, whether it's runny brie or very hard Parmesan or really crumbly feta. But they all come from this liquid, milk, that we are doing something to in order to make it a solid, which is what we call gelation, when you're taking some kind of liquid--
And typically it has some large molecules in it, which can be proteins or carbohydrates. Either one of those can make a gel. And you do something to it and change it, and all of a sudden it becomes a solid just by that one little action. So really cool textural transformations.
Well, in the case of yogurt, the something that you do to it is going to be fermentation. So I think, to me, that was amazing to see that you could take this liquid, pourable milk product that I was so familiar with and turn it into something which is now either semi-liquid or, in the case of Greek yogurt, something just spoonable. It's very thick material.
So to me, that was a fascinating transformation because I thought, well, you have to lose something or evaporate something or something has to-- something has to be lost here. And no, you're keeping the whole system. But that amazing process of fermentation that we talked about way back in season one is happening here, and it's taking that milk and converting it to yogurt.
Rather, you're adding microbes, and that's what's driving this process.
Yeah. Yeah, they do a great job. So milk has-- milk's the perfect food nutrient-wise. It has everything that we need, lots of vitamins and minerals, but lots of protein and carbohydrates and fats. And so you put those microbes in there-- and typically with these products, yogurt and cheese, it's some type of bacteria. And you put those in there, and they eat all the carbohydrates that are there, or the majority of them. And then you have a lot of waste produced by these bacteria. But that waste is beneficial to us because it's acid. And so that acid changes the structure of the proteins that are there in the milk, and the proteins get together and make this huge net that holds a lot of the water. So that's how you get a conversion from a liquid to a solid.
But you don't have to evaporate that water off. It's still there, but it's just trapped in this giant net of large protein molecules. So pretty cool that bacteria can do that and be beneficial. There are good bacteria. And there are some nasty guys--
I'm convinced.
--out there too.
[LAUGHTER]

Now, speaking of those good bacteria-- so these are lactic acid bacteria is what we call them. They really like lactose. And what they do with that lactose is they turn that into an acid. And so making yogurt, again, to me was interesting just to see it produced, where you're taking milk and you're adding a certain amount of starter culture, which in the case of doing this at home you can just easily make this by adding plain yogurt to milk and then holding it at the right temperature for a certain period of time.

Now, the issue from a food safety standpoint is that all kinds of alarm bells are going off in my head because that right temperature is the wrong temperature if you're trying to avoid getting sick from eating food. So you're literally holding this milk, which is full of all kinds of great nutrients not only for us but for the microbes that could make us sick, you're holding it at body temperature, essentially, something really close to body temperature, which is kind of a no-no for food safety. But in the case of fermentation, can we say it's a yes-yes? It's something we want to do because that's the only way that we're going to get this process to work because that's where these cool lactic acid bacteria do their thing.

Yep. So the lactic acid bacteria really like to grow when it's acidic. So there's another microbe that is added to yogurt that does the initial acidification. And then, once the milk is acid enough, then those lactic acid bacteria take over and make it even more acidic, and to the point where these proteins are really excited to interact with each other. [LAUGHS] If I could give them some personality, just take that liberty.

[LAUGHTER]

So when you're making Greek yogurt, does that just take it to the extra mile? From my understanding, Greek yogurt has a higher protein concentration then what we can call regular yogurt. So do they just elongate this process and let the microbes keep at it?

I think they're actually draining some of the water off. So you're concentrating the solids, essentially.

Yes.

And it's not by evaporation, but it is by actual just physically letting this product set in some type of sieve where the water can escape but the solids stay. And then that makes the yogurt thicker and it changes the nutrient profile.

Right. So with Greek yogurt, we are getting rid of something, and that something is going to be water and then the proteins that are in that water. So as you might recall that Little Miss Muffet sat on her tuffet eating her curds and whey. So essentially, we're making these curds in the yogurt, and that actually forms a gel-like material.

But if we were to strain this-- and this is where that stuff like cheesecloth comes in. If you were to strain this yogurt, then you're going to lose the watery parts, the whey, from this material, and it will become more and more concentrated. So now you have this more and more solid material that's going to go from something that's pourable to something that's very much like a gel to something that's going to be more and more solid.

And you can even get to-- what's the word-- something like cheese by this process. You can even get to something like cheese by following this kind of draining process. And you'll end up with something like a spreadable-- a cream cheese kind of a thing, if you let it drain enough.

That's something you can do at home. If you just have regular yogurt that you made, you can put it in cheesecloth and let it set overnight in the fridge, and it will drain off naturally and form this yogurt-based cheese for you.

Now, that cannot be at body temperature. That has to be in the fridge, I assume. The microbes would have too much fun.

Right. Yeah, well, that's where those food safety rules come back into play. So there are microbes that we don't want in our food that will be happy to grow in yogurt. And they include things like molds and yeasts. They're happy to grow with even the presence of acid, these low pH kind of foods. But once we're done with that fermentation, if we put that yogurt into the refrigerator, then we can-- in a proper container-- then we can not necessarily prevent it, but we can--

Limit it.

We can limit it. And in our fridge refrigerator, yogurt really doesn't last long enough for these molds and yeasts to actually do their thing. But I have heard from a friend that this can happen.

Most definitely. And those molds and yeasts are in the air, so it's very easy for that contamination to occur. And if it sits long enough, then it will definitely-- they will prosper and grow in just about any environment-- food-based environment. But you're not inactivating the microbes that created the yogurt.

So those lactic acid bacteria are not dying because you're putting them in the fridge. They're still there and they're still kicking, which is why you can take a little sample of that yogurt and make a new batch of yogurt. But they just don't grow as well in those lower temperatures. So you're slowing them down and putting them into stasis for a little while in the fridge until you consume them. [LAUGHS]

So as you said, there can be cream cheese made from yogurt if it sits long enough. Is this a continuation of fermentation from milk to yogurt to cheese, or is there a branching point in the fermentation process when you can go right from milk to cheese?

That's a really good question.

So you can make something that is a cream cheese texture from yogurt. The making of cream cheese itself is actually a different process, uses different organisms, different bacteria. So making cheese is still a fermentation, and using the bacteria that you initially put in the milk to make cheese to acidify the milk and make it a solid is part of that. But there's also some enzymatic action that takes place.

So it's a little bit more complex when it comes to cheese in that you can have lots of different types of starter cultures, which is what we call the bacteria that you add to the cheese to cause the fermentation. But you also add in an enzyme that changes some of the protein structure and makes them even more excited to interact with each other and make stronger connections, so that this gel that we're making is even stronger than what you would get in yogurt. So there are some different steps.

And then, of course, to make all of these different types of cheeses with all of these different types of textures, there's all kinds of different processes that we do to that gel once it's made. For example, we can heat up-- once that gel is made, we can heat it up again and make those interactions much stronger. And that's part of a process called cheddaring that we used to make cheddar cheese.

And then, once all those curds are formed and cut, then we gather them up and drain off that whey just like we did with the yogurt. We get rid of a lot of that moisture. And then you stack those curds-- those blocks of curds on top of each other and let them-- just the weight of itself press out more and more of the water that way. And that's how you get a more solid, firm texture, if you compare something like cheddar cheese to the texture of cream cheese. So there's lots of different ways to make cheese, which is really cool.

Yeah. I should say that cheese is quite romantic, if you didn't realize this. So I actually met my wife in a cheese and fermented foods class.
[MUSIC PLAYING]
And it takes a lot of time. As Paige was saying, the idea that you're adding this starter culture and the microbes are starting to do their thing, they're starting to take advantage of that lactose and convert it into acid. And then you add-- rennet is the name of this collection of enzymes that start to further destabilize that milk protein that the majority of the milk protein is casein.
So they start to make it so that it becomes curds, and then that process continues. Well, that takes like-- that takes five hours. It takes a long time. There's a lot of time for conversation around the making of a cheese.
For romance to bloom. [LAUGHS]
Yes. A lot of measurements must be made. There's a lot of time for conversation over the making of a cheese. So by the time that you're actually pressing this into those blocks and then later putting that away for storage, yeah, there's quite a bit of time there. And so during that time, there are a lot of different transformations that that will occur.
And Paige mentioned that cheddaring process to squeeze out the whey and make this cheese into something which is more solid. And this process-- one of the cool things, I think, about these fermented products is that it's really-- it just keeps going. So there's not really a point where cheese just stops changing. So it started with the milk and the microbes, and we added some enzymes. But as cheese ages, it doesn't stop changing. So the idea of cheddar becoming sharp--
[MUSIC PLAYING]
--and taking nine months to do that is something where there are continued enzymatic actions that happen to continue taking advantage of some of the remaining sugars, converting those to acids. And then we start to get breakdown of some of these proteins and some--
Lipids too.
Yes, as well as some of those fats. And some of this results in really amazing aromas. So I remember when we made Parmesan cheese. So I was in a class where we would make the cheese itself. And that Parmesan cheese, one of the final steps once you got all the curds pressed together, is you would take this whole cheese and you would put it into a large container of salt. You literally put it into a pool of salt, which seems really strange. But you would just let it float around in the salt for a while.
A salt solution.
Yes, a salt solution. Thank you. Yes, it wasn't just solid salt. It was literally just a pool of very high concentration salt. And then you pulled it out and covered this, and then it went into an incubator for two years. So our class never tasted that Parmesan we made. What we did is we pulled the Parmesan cheese out from two years previous, and we tasted that.
And I still remember when we sliced into that. Typically, the term "cut the cheese" is not a good term.
[LAUGHTER]
In this case, it was absolutely amazing because I had never actually been present when you actually opened up this cheese from two years previous. I'd never been present at that time, and I'd never for that reason got the full impact of the flavor of Parmesan. And I can tell you, within a day it was going away. So it was still good the day after, but that first day, it was heavenly. It was absolutely amazing. And part of it

was those wonderful aromas which come from those fatty acids that Paige was mentioning. It was absolutely incredible.
Yeah. You can get some flavors that are pretty acceptable to the majority of people. And then you can get some super funky things that can happen.
[LAUGHS]
Two years in the making. Who knows what--
Yeah. So I don't know if you guys have ever experienced limburger cheese, but things like that are-- there's a lot of lipid breakdown, and it is really some funky, funky stuff that just hangs with you. If you open limburger in the kitchen of your house, you could smell it upstairs probably. It's very intense aromas that are super funky, and that's all of that breakdown.
One of the things that I think is really cool about cheese aging is if you take mold and put it on the outside of cheese-- which is what brie actually is. You start with a solid, firm gel, and they wash the outside of this wheel of brie with mold. And they allow it to age. That mold is creating lots of different enzymatic actions, and they penetrate through to the center of the cheese.
So if you have a new cheese and you slice it open with the mold on the outside, there might not be that much textural difference throughout the depth of the cheese. But if you let it age for six months like Brie when you slice into it, the part that's right against the rind is going to be almost liquidy because of all of that enzymatic breakdown.
So you've made this solid gel with all these proteins and lipids in it, and then these enzymes go in and start chopping it up. They start taking that network of proteins and breaking them down. And so it changes not only the flavor of the cheese, but it also really changes the texture. And you can watch that enzymatic progression through the cheese as it ages. I just think that's really cool.
Yeah. And it gets to what molds do. Molds pre-digest their food. The way that they work on a surface is they-- if you've seen it on a piece of fruit or something like that, they literally pre-digest their food, and then they grow into that material that they've digested. And so that's exactly what's going on with brie. So again, it seems like we're breaking a lot of food safety rules here, but this really, since we're getting close to the Olympics, which I hope will still happen in Tokyo-- we're getting close to that.
Really what we're trying to do here is get competition to happen in a way that we would view as positive. So the idea of competing forces where there are some things that we don't want in foods that could harm us, and then them being out-competed by setting up the circumstances to make those things that we want grow faster-- lactic acid, bacteria, and things of this nature.
And then, in the case of these wonderful flavors like brie, we're literally setting up the conditions. We're just like, here's the food. We're setting up the conditions, and they're taking advantage of that and making, in my opinion, an absolutely wonderful, spreadable texture out of what was formerly a fairly solid cheese. So that to me is pretty cool.
Is it the texture of the cheese that makes the flavor? Or is there a different aspect that plays into that?
I think it has more to do with the bacteria that you're using and the process. So they're related, basically. So different bacteria will break down things in a different way, break down those protein and carbohydrates and lipids in different ways, and that generates those flavors or flavor precursors as its aging.

The texture I think, as far as bacteria go, the texture is more related to processing. So if you're aging this cheese for a long time, you create curd and then heat it. If you are adding in rennet, if you are adding in salts like calcium salts, all of those things will change the texture. If you are adding in another microorganism like mold, that's going to change the texture too, and the flavor. So sometimes texture is really more related to processing, and other times it's related to the bacteria or the other microorganisms that are being added.
Caitlin, I guess where my mind went was the idea of flavor release. So there are times where different types of textures just allow flavor to escape at different rates or in different ways. So it is true that if you have something where that flavor is actually inside of the food and it takes some work for you to take it apart, for you to chew it or for it to melt or something, then that flavor release may be different than, for instance--
And I realize taste and flavor are different, but my son ordered a soft pretzel the other day. And I didn't realize how much salt it had on it. He offered me some, and so I just took one little bite of it. And there was this immediate hit of salt. There was just no delay between when I tried it and when I was like, this is way, way more salt than I want to have right now. It was just immediate.
Whereas if that salt was inside the pretzel-- and the same way with these foods. If these flavors are inside the foods, they release differently. So we can get some things that release very slowly and some things that release very quickly, depending on where it is and how that food breaks down.
It can also depend on the types of molecules that are there. So proteins notoriously bind flavors because they're hydrophobic. So for example, if you have a gummy bear that's made with gelatin versus pectin, which is a carbohydrate, the gelatin is going to bind up that flavor. So you can put the same concentration of flavor in that gummy bear, and the pectin one will release immediately. As soon as you bite down on it, it's a very intense flavor.
But the same concentration in the gelatin gel, you're not going to get that intensity and clarity of flavor. It's a very different. And that's because the flavor compounds are binding with the gelatin and not with the pectin. So what's making up that gel is important as well as the structure that it's creating, just like you said.
And this is what happens when you ask food scientists a simple question.
[LAUGHTER]
Mm-hmm.
[INAUDIBLE].
Yep.
So complex. We're really a pain to take out to restaurants. No fun at all. [LAUGHS] So as much as I love cheese, there's one other textural transformation that can happen with milk that I might love more, and that's ice cream. [LAUGHS]
Before we go there, I just want to say food scientists must be magicians, because when I grow mold, it makes me sick. But when food scientists grow molds, it's this beautiful luxury cheese that everyone goes crazy for. And I don't know how you guys do it.
There's a lot of art in cheese. [LAUGHS]
Yeah. Well, I think part of it is just encouraging the right mold-- versus the--
Yeah. The wrong one.

--incorrect one. Yes.
[LAUGHTER]
So anything from mushrooms to one of my very favorite molds, huitlacoche, which is what grows on corn and is a prized thing in Mexico. All these things are different types of molds, but there are others that could certainly do some harm. So the ones we want to encourage are the ones that benefit flavor texture but don't do any harm.
So the one other thing I wanted to mention quickly before we moved to ice cream-- because I was just thinking about this in terms of concentration-- is butyric acid. When we talk about cheese and the process of ripening cheese-- so this is a really good example of concentration effects. So butyric acid is often-- that's that really, really powerful aroma of many cheeses, limburger included. Parmesan.
So at the right concentration, it's really-- if you like that-- it's really wonderful. If you like Doritos, then you consider it to be a wonderful thing. But if you increase that just slightly, then you get into dirty sweat socks territory. That same compound is present in other materials, and it smells like feet. And you can--
Baby vomit.
Yes. And you can keep going and completely clear a room. So if you have-- and this has happened to me once, just once. We opened a bottle of butyric acid, which was a complete mistake. We should not have done it. But we opened a bottle of butyric acid. It will clear a room really fast. It is one of the most terrible, awful smelling things in concentrated form. But if you dilute it to the right amount, then it's Parmesan cheese and Doritos and all these things that, if you like cheese, you probably like that at the right concentration. So it really gets to--
That's me.
Yeah. It really gets to concentration is everything. We say dose makes the poison in terms of toxicology. Dose is important in terms of flavor and acceptability, for sure.
Definitely.
Anyway. That's a bit of a tangent, but I just was like, yeah, butyric acid is what I always think of when we get to fermentation.
No, I totally agree. And it is one of the most potent aromas. You can have very, very tiny amount of molecules, and it will be intense.
[LAUGHS]
Yeah. For some reason, the human body is really good at detecting that. I think it's right up there with hydrogen sulfide, which is rotten eggs.
Yeah.
Oh, good.
Yeah. Well. [LAUGHS] So Paige, you mentioned this other amazing transformation--
[LAUGHTER]
--called ice cream. So what about this is so amazing to you?
I think that it tastes amazing, and it is a really incredible texture. So of course, ice cream is not just milk. It's definitely got a whole lot of other stuff. And if you go to the store, you can see ice cream with a whole lot of other stuff in it. But basic things that go into ice cream are milk, cream, sugar, and some basic flavors. You can add a whole lot of different things to it, just for example, vanilla extract.

And so usually, ice cream has a higher fat content. So you're adding in that cream to it. But then, that's still a liquid system, so we have to do something to change it. And that something that we do is freezing. So we're taking the water that is present there and making it into ice crystals, a solid. In the process of doing that-- we do that with churning.

So in that process, not only are we making a solid by crystallizing the water, but we're also adding in a tremendous amount of air. And the amount of air can make a difference in that texture, does make a difference in that texture. But we are making a foam. So we're taking this product and adding an air and solidifying it by freezing, and that gives us what can be a very light and airy texture that is a solid that melts into this nice, creamy liquid when you put it in your mouth.

So we've got a physical transformation to create this product and then a physical transformation that happens during the consumption of it. So it's just a really cool way to go about this. Not a fermented product, hopefully. I guess you could have fermented ice cream. But the fermentation is not part of the transformation here. We're just really going for a physical transformation.

There food scientists go again being magicians. How do they put air inside the ice cream? That seems like-- I get how I could-- if you freeze it. I guess I would just make it a solid block of ice. So you got to whip in that air. But you can't tell that there's air in there. Just seems like you're in a-- I don't know-- a bath of luxury.

[LAUGHTER]

Well, I think as food scientists, we're often-- before we understand even what food science is, we're just experimenting with our foods. So I remember growing up and putting all these ingredients together, the milk and the cream and the sugar, and then putting this container of liquid into the freezer thinking I'm going to make some amazing ice cream here. And I pulled it back out, and I couldn't get a spoon into it. So it was-- once I scraped a little bit off, OK, well, it had a good flavor, but there was nothing like the texture that I wanted. And so that you can go from that with essentially no stirring-- so you have all the right ingredients, but no air into it. So you can go from that to something where-- growing up, I grew up very close to some older relatives, and they had a hand-cranked ice cream maker.

So this transformation was rather slow and laborious. So it was like all the youngest kids in the family got to turn this crank on this ice cream maker until their arm was about to fall off. And then you get the next kid that's going to do the same thing. And you keep going. And eventually, you would end up with something which had this delicious flavor, but the texture was like sand. It was very, very grainy. So this gets to these crystals.

So there is a transformation that we want to happen. There's the foam part. And we definitely were able to get air whipped into this. It was very light material. But it was gritty, and it was because it took so darn long to freeze. So we want to make not just ice crystals, but we want to make tiny ice crystals. And that means speed.

So in commercial ice cream production-- and you could do this at home too with one of the electric mixers-- the faster you freeze it, the smaller those ice crystals become and the smoother the perception is on your tongue. So you get these tiny little crystals. Beyond a certain level, your tongue can't feel them. So the texture that your tongue is getting as you're melting that ice cream is going to be essentially no sensation of these ice crystals. They're not going to be scratchy or sandy.

And then you're taking that butter fat, essentially what you could make butter out of if you did another process, taking that butterfat. It is melting onto your tongue so that it's just a silky material as far as your tongue is concerned. And that's part of the wonder of that texture of ice cream, is it goes from that solid material that you've just spooned into your mouth or bitten off of a cone or however you choose to consume your ice cream, and then it's melting into this silky material on your tongue. Absolutely amazing texture transformation.
For the record, Dr. Harris bites his ice cream.
[LAUGHTER]
Big bites of ice cream. Brain freeze imminent.
I don't know how I feel about that yet.
We did have this discussion. So we went to the-- we went to the NC State Creamery to get some ice cream. And so we were having this discussion. And it goes back to a Ben and Jerry's ice cream recipe book. And basically, what Ben and Jerry's said-- so this is not my original idea. They said that there are two types of ice cream eaters. There are those who lick the ice cream and those who bite the ice cream. And I am definitely in the second category. I just want to bite off a big chunk of that ice cream and go to work on it. So I guess I just don't have--
You must not have sensitive teeth.
[LAUGHTER]
No. No.
That would kill me.
So maybe that's what's driving it. OK. See, I don't have sensitive teeth. [INAUDIBLE].
That pain response is like, don't bite it, don't bite it!
[LAUGHTER]
All right.
Well, ice cream isn't the only thing that having tiny crystals is really important. So having those tiny crystals in the ice cream gives you that creamy perception on the palate. But for things like fudge as well, having tiny little sugar crystals, it's the same deal. So having those crystals there but having them below the perception of your tongue and your palate is really important in lots of creamy textures that we have out there.
And for ice cream, it's all about freezing rate and how much water you have available to freeze into those crystals. So when you look at a label at the grocery store and you see things like stabilizers or different gums like cellulose gum or guar gum, those things typically help bind up the water so there's not as much water to go into these ice crystals and potentially make them large enough that the ice cream feels gritty when you're consuming it or when you take a big giant bite out of it.
[LAUGHTER]

There's another way to get rid of water, and that is simply to up your butter fat content--
That's true.
--in the recipe. So we're just adding more "not water" in the form of fat, and that's what makes for these super rich, ultra premium ice creams. So if you've tried any of these Howling Cow ice creams or other super premium type ice creams, what you see is that, one, they don't whip as much air into this, so it's not

as foamy. So it's more solid. You can literally bend a spoon if you take it right out of the freezer and try to scoop it. You can bend a spoon with that. So I just always--

That's gelato, right? Gelato has less air whipped into it, I believe.

Well, I think, yeah, gelato may have less air. But I think the consistency of it is going to be very scoopable from the start. And I think part of it has to do with that replacing of butter fat, which when it gets cold-- think of a stick of butter in the freezer. That's solid.

[MUSIC PLAYING]

Whereas the fat source for gelato is egg yolks. So it's a different-- it's a different source of fat that's going to give you a different texture. So that wonderfully spoonable, almost soft ice cream-- I'm sure some gelato fans are screaming at us right now, but essentially, almost a soft ice cream texture that gelato has I think is really related to that use of egg yolks versus heavy cream.

Whereas when you have ultra premium ice cream, you stir less air into it so it's less foamy, and you have a lot of butter fat which is acting like solid butter in the freezer. And you get a really thick, very ultra rich and creamy product, which to me is amazing.

Definitely. Definitely tasty.

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