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Turkey Day Chemistry in the Kitchen

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What makes Thanksgiving such a complicated meal? Family dynamics are tough enough to decode without the added pressure of figuring out a multi-course feast. *PopSci* is here to help you understand some of the science of Thanksgiving dishes in order to make your meal easier—and more fun—to prepare.

Turn the page below for scientific tricks to making your bird tender yet crispy, your mashed potatoes ultra-fluffy and a pie crust to rival granny's.

And when you're through, make sure to pick up all our high-tech tips for a fantastic feast:

- Brush up on "The Science of Yummy," then learn how to chop an onion without crying, sear a steak to perfection and more with "Kitchen Science 101."
- Whether pro chef or home chef, our guide to the "Kitchen-Counter Lab" will keep you properly equipped.
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Happy cooking! The Perfect Bird

The centerpiece of the dinner has a puzzle built right in. You have a 15 or so pound object—the turkey—made of two different types of meat that must remain stuck together, at least until after a dramatic table presentation just before serving. The white meat, or breast, is delicate, low in fat, and is at its juiciest at about 155ºF. The dark meat doesn't begin to get tender until its collagen-rich connective tissue turns to gelatin. And that doesn't get going until around 165º. So how can you get both in the oven at the same time, take them out at the same time, and keep them at the correct temperatures throughout?

Food-science expert Harold McGee, author of the encyclopedic culinary reference On Food and Cooking, has come up with the answer. He builds in a temperature differential before putting the turkey in the oven, giving the leg meat a head start at heating up.

Here's how he does it: A couple hours (no more than three) before cooking, he moves the turkey from the fridge to the counter and places sealable plastic bags filled with crushed ice on the breast. As the legs warm up, the breast stays cool. When the breast meat is around 40º and the leg meat is close to 60º, he puts the bird into the oven. It's done when the breast meat reaches between 155º and 160º and the dark meat around 180º. Both meats are perfectly cooked. For perfect browning, McGee applies some final touches to the skin with a heat gun.

Mashed-Potato Primer

Whether you like your potatoes fluffy or creamy or something in between, you can use science to get them just the way you want. There are three basic variables—potato type, cooking method and mashing technique. Here's a primer:

Potato type:

There are more than 200 species of potatoes, but for cooking purposes they can be split into two general categories. The more delicate "floury" or "mealy" potatoes, such as Idaho or russet, have more starch granules in their cells. When heated, they combine with water molecules, and the cells expand and separate, making for fluffier spuds. "Waxy" varieties, such as new potatoes, have cells that stick together and stay firm and dense when cooked. They make a creamier mash.

Cooking:

Potatoes contain an enzyme in their cell walls, activated at 120º, that helps its cells resist breakdown. So science's best answer for mashed potatoes is to precook chunks of the mealy type at 130º to 140º for 20 minutes to activate the enzyme and keep the cell walls strong. Drain them and then re-cook. When they are tender, drain them again and return them to the pan to dry off any extra moisture.

Mashing:

If you've ever had the not-so-great idea of making mashed potatoes in a food processor, then you know what happens when cells get damaged and too much starch is released. You make glue. Even precooking won't prevent that. The fluffy but fragile granules of the floury type of potato are best separated using a food mill or gentle mashing, and their vast surface area can absorb a good amount of cream, butter or milk. The waxy type can take more of a beating, and less add-ins—they're best for rough-mashed, country-style potatoes.

A Calculated Cranberry Sorbet

On the spectrum of pure ice to soft sorbet, texture can range from crumbly and crunchy to creamy and smooth. In each case, the same process is at work. Sugar is interfering with the formation of ice crystals and, in doing so, is lowering the mixture's freezing point. The smaller the crystals are, the creamier the ice and the more scoopable it will be straight from the freezer. The larger they are, the more the frozen mixture will resemble sharp shards and remain impenetrable unless partially thawed.

The trick to making a perfect ice, whether a flaky granita or a smooth sorbet, is calculating the perfect balance of water to sugar for freezing while keeping the tartness just right for taste, and stirring or pureeing the mixture to break up the crystals as it chills. This can usually be assessed by calculating the total percentage by weight of the sugar in the mixture. From 15 percent to 20 percent, the ice that would freeze solid if left undisturbed will make a granita if stirred frequently during freezing. Above 35 percent, it will remain syrupy. At 30 percent, it will be solid yet smooth. Between the two, something in between.

So then you just need to figure out the fructose and glucose in the fruit; the amount of sucrose—or table sugar—you need to add for your desired texture; and the amount of acid—or lemon juice—necessary for a nice acid balance. It's simple . . . if you have a refractometer or saccharometer to measure the sugar in your fruit, and can do the math.

In his second book, The Curious Cook, McGee kindly does these calculations for us, listing multiple fruits and three consistencies of ice and how much fruit, water, sugar and lemon juice is needed for each. Cranberry sorbet presents a special situation, though, if you want to use the

fresh fruit. Pureed uncooked cranberries separate into unpleasant dry bits and liquid—not good for a sweet frozen dessert. Cooked, though, as the cell walls break down, two significant events occur. The fruit becomes soft enough to be pureed into a smooth mixture, and pectin is released to thicken it. But that pectin throws off the straight sorbet calculation, because will keep a less sweet sorbet creamy at a lower temperature. You also need to add back the water that evaporated off during cooking.
Here's the recipe:

Combine 1 cup of fresh whole cranberries, I cup of water, 6 tablespoons of sugar and 2 long strips of orange zest (taken with a vegetable peeler from a navel orange), thinly sliced, in a small saucepan. Bring to a boil, reduce the heat, and simmer until the cranberries have burst and are soft, about 5 minutes. Cool, add cold water to make 2 cups of liquid (about a 1/2 cup), puree, and transfer the mixture to a metal cake or pie plate and freeze, stirring occasionally with a fork, until solid, for about 6 hours. Puree in a food processor before serving.

The Secret Science of Sweet-Potato Pie

The sweetest sweet potatoes:
Ever tasted an uncooked sweet potato expecting it to be crisp and sugary like a fresh-pulled carrot? Surprise! Sweet potatoes are made of starch as well as a heat-activated enzyme that turns the starch to maltose, which means their sweetness doesn't develop until they're cooked. The enzyme revs up at close to 135º and is deactivated at about 170º. So the longer the sweet potato remains at a temp in the 135º-to-170º range, as in a long slow roast, the sweeter it will be.

To roast the potatoes, prick them with a fork and bake them at no more than 400º (remember, the oven must be this hot to make the internal temperature of the potatoes reach the desired 135º–170º) until they are soft. Then use them in your favorite pumpkin-pie recipe. You can probably even use a bit less sugar.

The flakiest crust:
The flakes in crust are formed from the layering of strong dough particles (made of wheat-flour gluten and water) with fat. So when your recipe says to break the fat—butter, shortening, lard or a combination—into pea-size chunks, make sure to do so. When the dough is rolled out after resting, those little lumps of fat will separate the starchy dough layers, and these, when baked, will become flakes. Shortening and lard melt at a higher temperature than butter, so their flakes remain more pronounced. Butter has great flavor, though, so a combination makes a nice balance.

Dessert's just the beginning! Pick up more high-tech tips for a fantastic feast:

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