The science behind perfect french fries.

Jared Redington

Introduction

No other food achieves the same balance of crisp exterior and fluffy interior without the need for any sort of external breading or batter as the French fry. It all has to do with the natural balances of starches and moisture in the spuds. Making a perfect French fry is not as simple as dropping potatoes in hot oil for a few minutes. The intricacies involved in taking two ingredients—potatoes and oil—and applying science, heat, and a bit of blind faith are so complex it boggles the mind. This abridged article is an explanation of how to make the perfect French fry.

When you picture a French fry, what comes to mind? For me, the perfect French fry has a substantial, crisp, grease-free crust that cracks open with a fluffy, tender interior.

There are four basic criteria that define a perfect French fry…

Crust: The exterior of the fry must be very crisp, but not tough. To achieve such crispness, the surface of the fry must be riddled with microbubbles. It's these tiny crisp bubbles that increase the surface area of the fry that add crispness. Ideally, this layer should only be as thick as it needs to be to add crispness. Any thicker, and you start running into leathery or tough territory.

Fluffy Interior: The interior of the fry must be intact, fluffy, and have a strong potato flavor. Fries with a pasty, mealy, or gummy interior automatically fail.

Crisp and Tasty: The fry must stay crisp and tasty for as long as it takes you to eat a full serving. Fries that come directly out of the fryer are almost always perfectly crisp. The true test, however, is to see whether it is still the same a few minutes later, after it's been sitting on your plate.

For potato variety, russet is what you want. Its high starch content means that it'll fry up crisper than waxier varieties like Yukon Gold or red skins.

Cooking Technique

Classic French techniques will have you believe that the road to perfect fries involves frying once at a relatively low temperature (between 275° and 325°F), followed by a resting period and then a second fry at a higher temperature (between 350° and 400°F). The most common explanation I've heard for this is that the first low-temperature fry allows the fries to soften through to the center, while the secondary fry crisps up their exterior. I decided to put this theory to the

The first I cooked per the French technique (a two-stage fry, the first at 275°F and the second at 375°F).

For the second, I replaced the low-temperature fry with a trip to a pot of boiling water, then followed up by frying at 375°F as usual.

For the third, I skipped the primary step altogether, simply dropping the potatoes into 375°F oil.

If the only purpose of the first fry were to cook the potatoes through to the center, then potatoes parcooked via another method should work just as well. Conversely, a potato that is not parcooked should not be evenly cooked to the center.

Results

Single-Fry

The single-fry potatoes were quite similar to the boiled-then-fried potates, though slightly less fluffy inside. Still, they were cooked through no problem.

Boiled-then-Fried

The boiled-then-fried potatoes were crisp, but the layer of crispness paled in comparison to the double-fried potatoes.

Double-Fried

The double-fried fries had a substantial, thick crust that stayed crisp for a while, proving that there's something more going on during that initial fry than simply softening...
I was so intrigued by this that I used a set of calipers to determine that the crust on this fry was more than twice as thick as the one on the boiled-then-fried fry.

Blanching is a technique that is often used in the process of frying French fries. Blanching helps to remove excess starch from the potatoes. When potatoes are cut into slices and then fried, the starch on the surface of the potatoes can cause the fries to stick together and become mushy. By blanching the potatoes before frying them, the excess starch is washed off, which helps to prevent the fries from sticking together. To really get to the bottom of this, we need an even closer look at the potato. A view at the microscopic level.

Anatomy of a Potato

Like all plants and animals, potatoes are composed of cells. The cells are held together by pectin, a form of sugar that acts as a glue. Within the cells are starch molecules; large sponge-like molecules composed of many simple sugars bundled together. Starch molecules, in turn, stick together in starch granules.

When starch granules are exposed to water and heat, they begin to swell, eventually bursting and releasing a shower of swollen starch molecules. This water can come from the outside (in the case of a boiled potato) or from inside the potato itself in the case of a double-fried potato), and that bursting of starch granules is essential to forming a thick crust: it's the sticky, gelatinized starches that form the framework for the bubbly crust.

So the path to perfect fries seems easy--just burst a ton of starch granules, and you're home free, right? Not that simple. If your potato contains too many simple sugars, it'll brown long before it crisps.

Starches and simple sugars will naturally convert their forms back and forth, depending on storage conditions. You can see this effect most dramatically with spring vegetables like peas and asparagus, which come off the vine packed with sugar but become noticeably less sweet and more starchy even twenty-four hours after they've been picked.

If potatoes have too much sugar, they won't crisp properly, and they'll become an unattractive dark brown as the sugars over-caramelize in the fryer, developing acrid, bitter flavors.

The other difficulty in bursting starch granules is that if the pectin glue holding the cells together has broken down too much before the starch granules have had a chance to burst and release their sticky innards, they will fall apart and crumble before they get a chance to crisp.

It's the breakdown of pectin that in some cases, nearly too horrible to mention, causes the dreaded condition known as "Hollow fry"

So, how do we wash away excess simple sugars while keeping as much pectin as possible?

Add vinegar.

Acidic enviornments have been proven to reduce or even prevent the breakdown of pectin. To test this theory, I brought two pots of potatoes to a boil side by side, the first in plain water, and the second in water spiked with vinegar. Here’s what I saw...

Water

Vinegar-water

While the plain-water-cooked fries had broken down by the time they were cooked through, the fries cooked in the vinegar-spiked water stayed perfectly intact, even after boiling them for almost double the time.

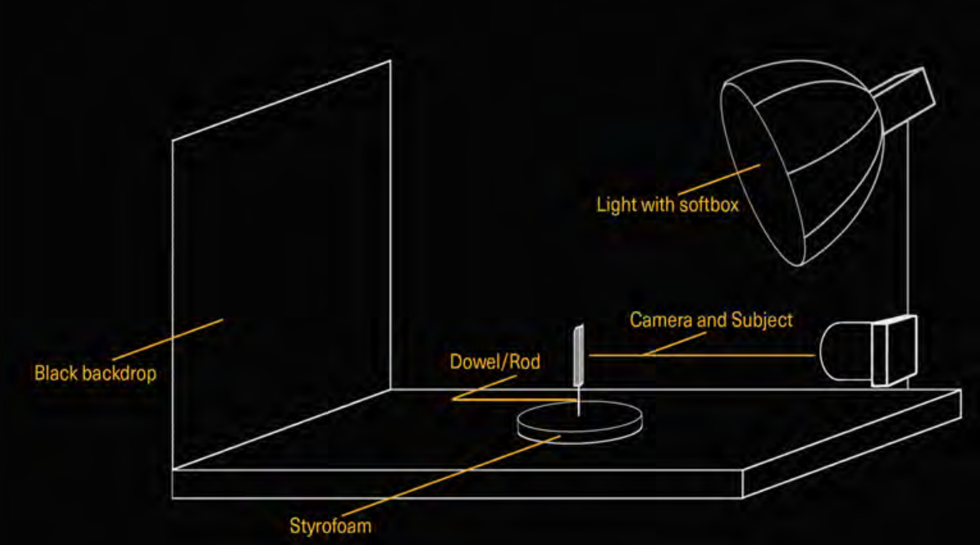
Despite their smooth looking exteriors, I knew that by boiling them for so long, I would burst plenty of starch granules. With the excess sugars washed away and the pectin strengthened, all that remained was to give them an initial fry at 275°F and a second fry at 375°F:

Water

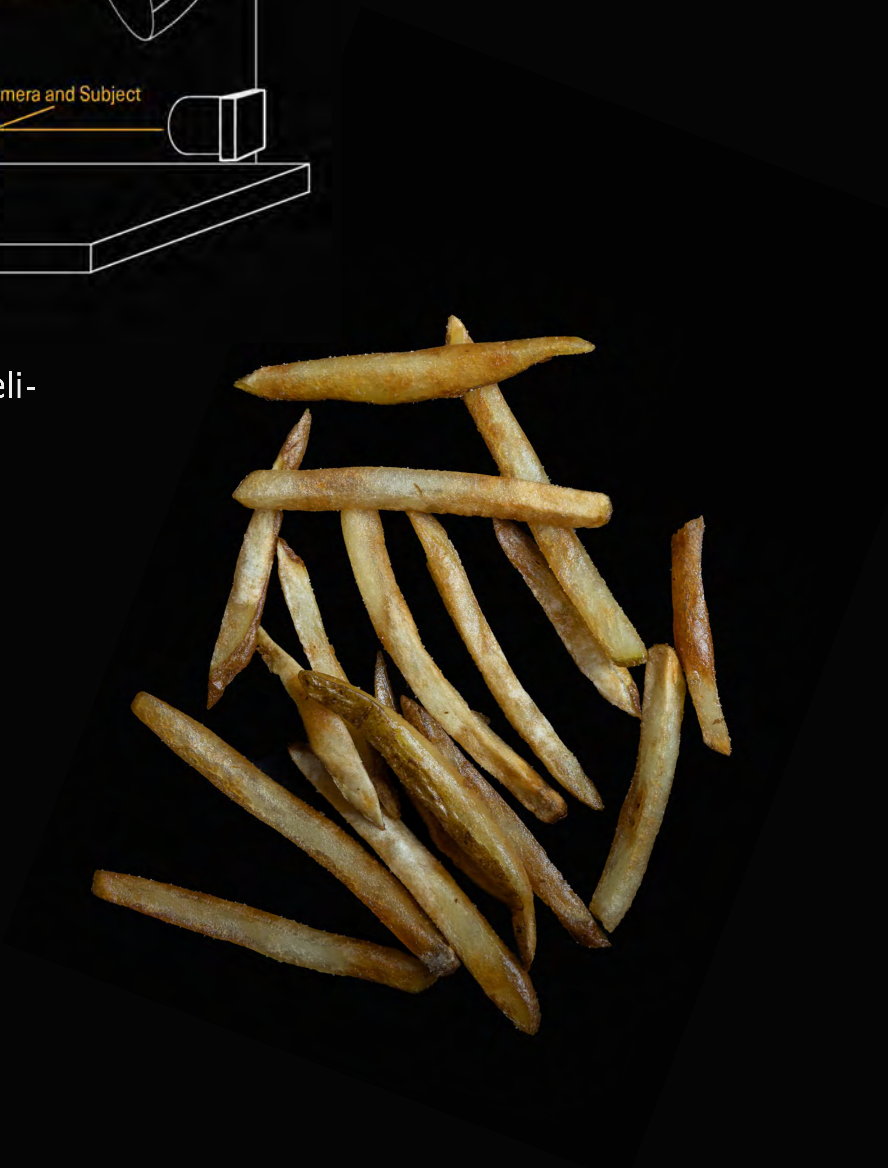
Vinegar-water

Photographic Techniques Used

The images in this article were created using HDR focus stacking. The setup for the photos is as follows:



These photos were then processed in Helicon focus stack, and Adobe Photoshop.



About the author

Hi, I'm Jared Redington! I am a third-year university student at Rochester Institute of Technology studying Photographic Sciences. I like to use my skills in photography to illustrate the various facets of science the world around me!

In my free time, I like to play videogames with my friends, go to the gym, and I also love cooking! I've been a home-cook for the past 6 years where I've made just about everything. Whether it's making something simple like breakfast in the morning, or making a complex dish, I love the whole process. Everything from the chemistry to tasting the food.

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