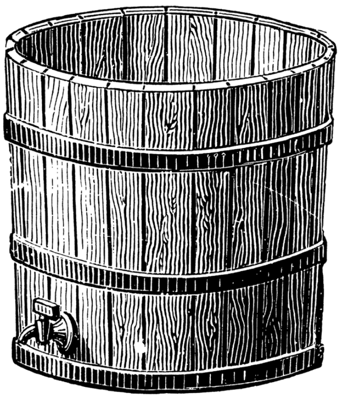
Water Chemistry and How It Affects Your Baking

Water is wonderfully weird. There's lots of trivia about water, some of it obvious (it expands in volume somewhere between 1,600 and 1,700 times when converted to gas, hence the lift it gives in some baking) and some of it brain-smashingly amazing (you can tell the rough latitude a tomato was grown at by examining its water composition).

Tap water isn't just H_2O. Among other stuff, trace amounts of minerals, additives such as chlorine, and dissolved gases can all come pouring out of the faucet and into your doughs and batters. When it comes to yeast and gluten formation (which we'll cover in the next section), those trace minerals and anything that changes the pH of water will make a difference. You might find that a recipe that works perfectly fine in one location will need tweaking when made elsewhere, due to differences in the water alone!

First, let's talk about trace minerals. Trace minerals in water—primarily calcium (Ca^{2+}) and magnesium (Mg^{2+})—occur naturally in water, being absorbed as the water passes through calcium- and magnesium-containing rock such as limestone and dolomite. Our bodies need these minerals; they've been present in water since time immemorial. The water supplies in different regions vary, with different ratios and different amounts of dissolved trace minerals, and those changes impact food. (There's some thought that the different types of teas in the UK evolved from how differences in water supplies changed their flavor. For example, Scotland gets most of its water from surface sources such as rainwater while Southeast England gets most of its water from aquifers, leading to different levels of trace minerals that will interact with compounds in the tea.)



The term *water hardness* refers to the concentrations of dissolved trace minerals in water, *soft water* being a low concentration and *hard water* being high. There's no exact scale for water hardness because temperature, combinations of minerals, and pH all change how these minerals interact with other things (especially gluten). Researchers generally use parts per million (ppm) of calcium as a measure, so we'll go with that. As the quantity of calcium increases, water is said to be harder, presumably because the minerals literally "harden" things.

If you've ever encountered scale buildup on faucets—the bane of household cleaning—it may be calcium carbonate or calcium stearate. Calcium from hard water can combine with carbon dioxide in the air or with stearic acid from soap; vinegar, being ~5% acetic acid, will dissolve it.

Because hard water has more calcium (and generally more magnesium), it makes gluten tougher, less elastic (elasticity is the ability to spring back into shape), and less able to stretch, all three of which will lead to denser baked goods. Depending upon how hard your water is, you may need to adjust recipes to compensate accordingly.

Water treated with sodium carbonate? Your water will have more dissolved sodium in it and you may need to use less salt to compensate for flavor and texture problems.

Water treated with chlorine? Leave a pitcher of it out overnight for the chlorine to dissipate, lest it interfere with yeast.

If your water is too hard—you'll know because yeast-based goods won't ferment as well, breads will come out denser, and vegetables and beans will cook "tough"—try using filtered water as a first attempt. No water filter? Try boiling your water, which will remove any dissolved carbon dioxide and in turn cause calcium carbonate to precipitate out. If neither option works, and your recipe allows for it, see if cutting down on the salt or adding an acid—a squirt of lemon juice (citric acid), a tiny pinch of vitamin C powder (ascorbic acid), or some vinegar (acetic acid)—fixes it.

Range (calcium parts per million)	Problems	Fixes
<60 ppm: Soft water	Soft, sticky doughs; mushy vegetables	Increase salt
60–120 ppm: Moderately hard water	Potentially tough	Filter water
>120 ppm: Hard water	Doughs not rising; toughness	Increase yeast; add acid; decrease salt; filter water

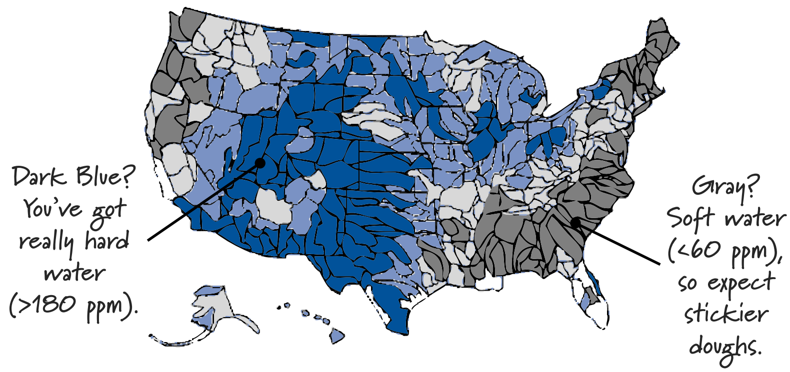
Water that's too soft can produce sticky doughs and present problems for yeast, which, like us, needs minerals to grow and reproduce. If you know you're adding the right amount of water based on ratios, try adding a modest amount of salt. Too much salt, though, and you'll land on the "too tough" side of hardness, plus your bread will end up tasting salty!

What about the pH of your water?

If you have alkaline water (pH above 7—also usually hard, but not necessarily) and are baking with yeast, you'll need to add an acidic ingredient to compensate. Baked goods that rely on yeast need water with a pH below 7, because yeast uses sugar as an energy source and sugar is created from starch by pH-sensitive enzymes (e.g., amylase in flour). Likewise, if your recipe is generating bubbles of carbon dioxide by using baking soda as a base and you have alkaline water, you may need to cut back on the baking soda; otherwise, you might have unreacted baking soda in your final baked goods along with its unpleasant, soapy taste.

You shouldn't have to deal with water that's too acidic: the United States EPA (Environmental Protection Agency) recommends a pH of tap water between 6.5 and 8.5. For most of us, the pH of our water isn't an issue in baking, but it can be for those with especially hard water, which is usually basic.

(PS: Debates about how much salt you should cook beans with often overlook water differences: some ~15% of cooks have too-soft water; then there's the pH of the water. More salt makes beans cook quicker; more acidic water slows down their cooking. Mushy beans are related to too-long cooking time; flatulence occurs with some beans that are not presoaked and are cooked too briefly. Speaking of boiling salty water, it's true that salt raises the boiling point, but by so little that that's not why it can change cooking times. It's the chemical changes, not the physical changes, that can do that.)



Where you live determines how much gluten will form in your bread dough.

MODIFIED VERSION OF MAP BY US GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR/USGS.

How Would Sherlock Holmes Tell Where His Tomatoes Came From?

It's elements, my dear Watson. Isotopomers, to be specific. Most of us—including Watson—think of a glass of water as being H_2O, maybe along with some trace elements, dissolved gases, and the like. H_2O means two hydrogen atoms bonded with an oxygen atom (in water's case, it's a covalent bond, which we'll discuss on page 196). What "H_2O" doesn't say is what *isotopes* of those atoms are present.

Oxygen, as an element, is an atom that has eight protons, thus its atomic number and place on the periodic table of elements. Oxygen normally also has eight neutrons—that's just the fewest neutrons it takes to create a stable nucleus—so chemists don't bother writing out the expanded version, ^{16}O (the 16 comes from the number of protons and neutrons, and ^{16}O is read "oxygen 16").

99.73% of the time, the *O* in H_2O is ^{16}O, as in $H_2{}^{16}O$. But what about the other 0.27%? In addition to ^{16}O, oxygen has two other stable isotopes: ^{17}O and ^{18}O, with 9 and 10 neutrons, respectively.

Hydrogen happens to come in three isotopes as well—no neutrons, one neutron, two neutrons—the first two of which are stable. (Don't ask about the third one—it had too much to drink.) That "simple" glass of H_2O quickly becomes a complex mixture.

Given how complicated water is, it's a wonder supermarkets can manage to label tomatoes with the same SKU number and keep them as consistent as they do. Speaking of tomatoes: the lighter variants of water evaporate more quickly than the heavier ones (more neutrons, more weight). Because evaporation is higher nearer the equator, the ratios of the six isotopomers in soil skew toward the lighter variants. With the right equipment (a mass spectrometer), Sherlock could analyze the water composition of a tomato to tell roughly what climate it was grown in. Add in analysis of trace minerals and, after correlating that with geographical variations in soil composition, he'd probably be able to nail the country of origin down, too. Even Holmes's nemesis, Professor Moriarty, would be impressed.