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Dairy: Ginger Milk Curd

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While researching gel formation in foods where no “external” hydrocolloid or gelling agent is added (Lersch, 2014), I came across ginger milk curd (in Chinese: 薑汁撞奶). With only three ingredients – milk, ginger and sugar – it immediately caught my attention. I found a recipe and my first attempt was successful. I was amazed! With three seemingly simple ingredients, I was able to form a tender, fragile gel within minutes. I loved the strong ginger taste with a touch of sweetness. After my first success, I had several failed attempts, so I looked up some more recipes on the internet. What puzzled me was that, as I dug up more recipes, the different instructions were specific, but also contradictory. I couldn’t let go at this point, so I continued reading – also scientific papers (Mazorra-Manzano 2013 and Su 2009). Now that I have a fairly good understanding of the science behind ginger milk curd, it is clear that the many recipes I had found were full of kitchen myths.

I found recommendations for using fresh ginger alongside warnings that the gel will only set if you use old ginger. One recipe claimed that the gelling was caused by the white sediment in ginger juice and that this “starch” was located right below the skin, hence requiring careful peeling with a spoon. Advice regarding temperature was very confusing. Some recommended boiling followed by cooling – or no cooling at all – while others recommended against boiling the milk. Some indicated optimal temperatures in the range 60 to 95 °C, while others suggested pouring milk back and forth between containers 10 times, which obviously will help cool the milk. The recommendations regarding milk included full cream, pasteurized, non-pasteurized, non-homogenized, micro-filtered, high-protein and even soy milk. Indeed, very confusing! For a volume of 250 mL of milk, the recommended amount of ginger juice ranged from 10 to 30 mL, which actually seemed like a reasonable range from a culinary perspective. Regarding the preparation, some sources emphasized the importance of pouring milk in one go into the ginger juice (hence the Chinese name “ginger hits milk”), and not the other way around. Most recipes agreed not to stir after milk and ginger juice have been mixed. For firmer gels, recommendations included use of less sugar and addition of a few drops of vinegar.

It’s fascinating how a recipe calling for only three ingredients can lead to so many awkward instructions. No wonder, then, that I found reports from people who only succeeded in half of their attempts, succeeded on their ninth attempt, or gave up and added egg whites (claiming the preparation requires “a lot of skills and a pinch of luck”). Kitchen myths arise when people randomly fail and succeed with a recipe. Depending on the outcome, they try to attribute the result to something they did differently from last time. There is a chance that this was a relevant change, but more often than not it has nothing to do with the outcome. With the wrong conclusion drawn, the kitchen myth is a reality.

Based on what I’ve read so far in the scientific literature, the following is my “best bet” for a ginger milk curd that will not fail (Figure 28.1). The most important piece of equipment is a digital kitchen thermometer.

### Fool-Proof Ginger Milk Curd

250 mL skimmed milk  
18 g fresh* ginger juice**  
20 g sugar

* See comment later regarding the stability of the enzymes.  
Ginger juice should not be made in advance due to a short half-life at room temperature.  
** 18 g ginger juice = ca. 31 g peeled ginger = ca. 43 g raw ginger.

Combine milk and sugar in a pan and heat carefully to 65 °C. Peel and microplane ginger, and squeeze out the juice. Place juice in a bowl and pour milk into the ginger juice from a height to allow sufficient mixing. Do NOT stir, as this will interfere with the gel formation. Leave to set at room temperature and, after 5–10 min, a gel has formed. The curd may be served immediately or kept in the fridge.

In this recipe, I used a milk:ginger juice ratio of 14:1. You can certainly use more ginger juice, but the taste of ginger may then become too powerful. You can also reduce the amount of ginger juice, but I have not tested this yet.

### Mechanism of Gelling

Ginger milk curd belongs to a large group of foods where enzymes are used to curdle milk (including cheese, of course). Traditionally, one would use rennet to prepare a curd known as Junket in the US and Cuajada in Spain. Rennet is found in the stomach of young
mammals and is essential as they digest their mothers’ milk. The active enzyme in rennet is chymosin, also known as rennin. This is a proteolytic enzyme, also known as a protease, which is capable of breaking proteins into smaller fragments.

Ginger (the root of *Zingiber officinale*) enters the scene because it also contains proteolytic enzymes. The ginger proteases (GP, sometimes called zingipain) are very sensitive to temperature. At temperatures above 70 °C, they are rapidly denatured (irreversibly inactivated). This explains why so many people fail when trying to make ginger milk curd. The milk clotting activity (MCA) of GP peaks around 63 °C and falls off rapidly above 65 °C and below 60 °C (Figure 28.2). This means that one is left with a relatively narrow temperature window of 60–65 °C. GP does show proteolytic activity (PA) outside this window, but this PA is more of a non-specific kind. MCA, on the other hand, is related to a specific hydrolysis of κ-casein (more on casein in a second; the greek letter κ is pronounced “kappa”).

By now, you may be wondering if it’s possible to make cheese with ginger – and the answer is yes. Scientists have studied several plant extracts and found that ginger, kiwi and melon all contain proteases with a relatively high MCA/PA ratio (albeit not as high as that of chymosin found in rennet). The temperatures for maximum MCA of kiwi and melon proteases are 40 °C and 70 °C, respectively.

Enzymes are catalysts, the tireless workers responsible for building the gel. However, it is caseins, a group of proteins found in milk, that are the actual building block of the gel. The casein proteins group together to form large “balls” known as micelles, which are held together by calcium ions. The outside of the micelles is covered with κ-casein, which is composed of a water-soluble part (an acidic glycopeptide) and another part that is much less soluble in water (*para*-κ-casein). The water-soluble part is found at the surface and leaves the micelles covered by a “hairy” layer. This layer both keeps the micelles dissolved in water and prevents the micelles from coming too close to one another that they coalesce and aggregate.

It is thanks to this “hairy” layer that milk is stable (i.e., does not spontaneously form a gel), and all is well until we add the above-mentioned proteases to milk. What chymosin, GP and other proteases do is cleave off the water-soluble part of κ-casein, leaving the less water-soluble *para*-κ-casein behind. Suddenly, the micelles can collide, and the calcium present in milk aids in the formation of aggregates (Figure 28.3). These aggregates of “shaved” micelles make up the actual gel. It all happens within a couple of minutes. The resulting gel is very fragile and easily loses water, a process known as syneresis (Figure 28.1).

I mentioned the very narrow temperature window for GP, but one remaining question was whether heating milk to a higher temperature (before cooling to the same temperature window) would be beneficial. It turns out that if milk is heated above 65 °C, the strength of the resulting gel is reduced. The reason is that the heat causes other proteins in the milk (specifically the whey protein β-lactoglobulin) to precipitate onto the κ-casein, which interferes with the gel formation. The same is true for milk fat, so skimmed milk is the choice for a stronger gel. Since calcium plays a role in the aggregation of the “shaved” micelles, a higher calcium concentration will also result in a stronger gel.

The ginger juice also deserves a couple of extra words. In freshly squeezed ginger juice the GP has a half-life of 20 min.
at 30 °C, so in a warm kitchen, half of your enzyme activity is lost 20 min after you have grated and squeezed your ginger. If you leave it another 20 min, you’re only left with 25% of the original activity. This means that the ginger juice can’t be prepared in advance or stored unless you use a little trick. The reason for the instability is that ginger also contains another enzyme, polyphenol oxidase (or PPO for short) – the same enzyme that is responsible for the browning of apples (an example of enzymatic browning, as opposed to the Maillard reaction, which is an example of non-enzymatic browning). Once the ginger has been grated, PPO attacks phenolic groups, yielding ortho-quinones. These, in turn, can react with the GP enzymes to inactivate them. A well-known trick to prevent the browning of apples is to use ascorbic acid (more commonly known as vitamin C). Ascorbic acid blocks the action of PPO, which in turn prevents the inactivation of the GP enzymes (Figure 28.4). The same trick also works for ginger juice. If you need to make ginger juice in advance, just add a pinch of vitamin C (0.2%, to be precise).

\[ \text{FIGURE 28.3} \quad \text{Protease and aggregated micelles.} \]

**Ideas for Further Experimentation**

Even though the recipe given here works fine, there are several claims that remain to be tested. Feel free to join in with the experimentation or share it as an idea for a school science project:

- Is there any difference between old and young ginger? Which works better?
- What is the minimum amount of ginger juice required to make the gel set? Does more ginger juice make the gel harder or softer?
- Does it matter if you pour the milk from a low or a high height?
- Is it true that mixing within the first couple of seconds destroys the gel?
- Can milk and ginger juice be mixed cold and then heated carefully to 65 °C? For instance, this could be heated in a microwave oven.
• Does the amount of sugar influence the firmness of the gel?
• Will a few drops of vinegar promote the gelling?
• Instead of adding milk to the ginger juice, try to add ginger juice to the milk. What happens?

REFERENCES
