Handbook of Molecular Gastronomy
Scientific Foundations, Educational Practices, and Culinary Applications
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Waiter! There Is Garlic in My Meringue!

Publication details
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Published online on: 09 Jun 2021

How to cite :: César Vega. 09 Jun 2021, Waiter! There Is Garlic in My Meringue! from: Handbook of Molecular Gastronomy, Scientific Foundations, Educational Practices, and Culinary Applications CRC Press
Accessed on: 10 Oct 2023

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Meringues are the backbone of a range of both sweet and savory dishes, such as soufflés, macarons, angel food cake and dried shrimp patties, also known in Mexico as “tortas de camarón”, and are responsible for much of the structure stability of these foods (Vega & Sanghvi, 2012). Usually, meringues are made of egg white (fresh and/or re-hydrated), sugar and in some cases, an acid source such as lemon juice, vinegar or cream of tartar (McGee, 2004). These ingredients are then beaten to incorporate air while concomitantly unfolding the protein structures in the egg white to provide the required foam stabilization. For a thorough review of the culinary, physical and chemical principles involved in meringue making and stabilization, see Vega & Sanghvi (2012).

Care must be taken during whipping, as it is very easy to overdo it, which is manifested by the formation of evident tiny “lumps” that forecast the imminent collapse of the foam (see Figure 124.1); if this point is reached, there is no choice but to start over with new egg whites. It is well known, however, that the incorporation of an acid (best practice is about 1.5% w/w) significantly increases the stability of meringues against over-whipping, because, according to McGee (2004), the decrease in pH delays/inhibits the formation of disulfide bonds among ovalbumin molecules (Figure 124.2).

The addition of these acids decreases the pH of the whipping mass from 9 to about 7 (Kamozawa & Talbot, 2010), which has a few consequences: (a) it brings the pH closer to the isoelectric point of the egg white proteins and reduces the electrostatic repulsion between them; (b) proteins pack more closely at the air–water interface, promoting stronger films, which creates a more stable foam (Rodriguez-Patino, Naranjo-Delgado & Linares-Fernandez, 1995; Oldham, McComber & Cox, 2000); and (c) the lower pH inhibits the oxidation of two sulfhydryl (S-H) groups and hence the formation of disulfide bonds (S-S) between adjacent ovalbumin molecules.

However, as already explored by Vega & Sanghvi (2012), the physical chemistry of egg white foams is rather complex, and it is dangerous to settle for this explanation without systematically testing its validity. If, in fact, the key factor is the inhibition of S-S formation, then this should be tested at the natural pH of egg whites (pH = 9) to remove any parallel effect related to the pH drop and the change in packing efficiency of the proteins. Vega & Sanghvi (2012) proposed starting by whipping egg whites in the presence of a thiol-blocking group such as N-ethylmaleimide (NEM). Eight years later, it was up to me to bring closure to this question in a novel culinary manner.

Let’s first state the hypothesis:

Whipping egg whites at their natural pH of 9 in the presence of a thiol-blocking compound should render foams as stable as those in the presence of acid at pH 7.
Lo and behold, whipping a 2:1 water:egg white mixture at pH 9 in the presence of 0.03% w/w NEM resulted in a foam of similar overrun (air inclusion) but significantly higher stability (measured as the amount of water drained from the foam) compared with either water and egg white alone or the same with 0.5% added cream of tartar (Table 124.1). Not only that, but the appearance of the NEM foam resembled that of shaving cream: dense, silky and solid-like. I couldn’t actually touch it or eat it, as NEM is toxic – a little detail I forgot to mention! Due to a variety of constraints, the experiment could only be run once, but the results are considered unequivocal: S-S inhibition is the key to egg white foam stability!

Now, I needed to repeat the experiment, but this time, I had to add something that was food grade. It took a while for the culinary muses to pay me a visit.

One of my most vivid childhood memories is that of my mother sauteing onions. The aromas coming out of the pan are, still today, tantalizing. Many years later, garlic, whether raw – like in aioli – or roasted (spread onto bread), became one of my most sought-after flavors. It wouldn’t then surprise you that when the book Garlic and Other Alliums: The Lore and the Science crossed my path, I was equally tantalized. I got it and started reading it in earnest. I was enjoying it, and then I read this (Block, 2010):

Cavallito goes on to speculate about the basis for the antibacterial properties of garlic: “The sulfhydryl group is postulated to be a specific stimulator of cell multiplication. Since allicin is considerably more bacteriostatic than bactericide in action, it may operate by destroying –SH groups essential to bacterial proliferation, thus inhibiting growth”…allicin could react readily with almost any –SH group with which it comes in contact.

I jumped off my sofa! The end to my quest was in sight! Garlic contains an edible thiol-blocking agent! I ran to the nearest supermarket and bought 2 kilos of garlic. Back home, I asked my wife, Elizabeth, to help me peel garlic, as we were on a mission: putting garlic to the test!

Garlic, onion and leek are all members of the genus Allium, which is said to come from the Greek ἀλέον, “to avoid”, because of its offensive smell (Boswell, 1883). Garlic (Allium sativum) originated in the very tough climates of what is today the Uzbekistan neighborhood and hence evolved some serious chemical weapons to defend itself. Different alliums accumulate different sulfur compounds, which accounts for their varying flavors. The stockpiles themselves are inert, but when the plant’s tissues are damaged, enzymes therein convert them into reactive, stinging molecules (Block, 2010). When garlic is crushed, alliin, a non-protein amino acid, and alliinase, an enzyme, interact to produce allicin – our main suspect (Figure 124.3).

I proceeded to make some garlic juice with the help of a centrifugal juicer (not the most efficient way, I must tell you) and went on to whip, under similar conditions, the following:

- 200 g of egg white
- 200 g of egg white + 1.5% cream of tartar
- 200 g of egg white + 0.5% garlic juice

The results, shown in Figure 124.4, speak for themselves. Meringues with added garlic juice (at pH 9) showed better stability against drainage than those with added cream of tartar (at pH 7), which, as of yesterday, is no longer best practice. Just as in the case of NEM, the foam made with garlic looks denser, silkier and more solid-like (as perceived by passing a spoon through it).

Confirming that allicin is indeed the chemical entity responsible for the behavior observed deserves further investigation. Knowing that allicin is only formed when garlic is cut, I cooked peeled and intact garlic cloves for 20 min in boiling water to inactivate alliinase. I then tried to make garlic juice out of softened cloves (very, very difficult indeed!) and repeated the experiment. The foam drained rather early and copiously (not shown).

For those of you who, like many of the chefs I have shared this with, wonder if the same takes place with onions, leeks or chives, please take a deep breath and put your knives down. Acting on that impulse is what I call the “cook and look” approach and must be avoided at all costs. Recall that we arrived at using garlic to

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**TABLE 124.1**

<table>
<thead>
<tr>
<th>Parameters for Preparation of Garlic Meringues</th>
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<tbody>
<tr>
<td>Treatment</td>
</tr>
<tr>
<td>2:1 water: egg white mix (i.e., 3.5% egg white protein)</td>
</tr>
<tr>
<td>% active (w/w)</td>
</tr>
<tr>
<td>Whipping conditions</td>
</tr>
<tr>
<td>pH</td>
</tr>
<tr>
<td>% overrun</td>
</tr>
<tr>
<td>Drain in 30 min (g)</td>
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<tr>
<td>As %</td>
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</tbody>
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**FIGURE 124.3** Chemical structure of allicin.
stabilize meringues by virtue of a stated hypothesis and systematic enquiry. That’s a recipe for success.

Macarons, soufflés or even angel food cake can immediately benefit from a garlicky twist. I can’t wait to get cooking! Can you? After all, the proof is in the “pudding”.

REFERENCES

FIGURE 124.4 Drainage (g of liquid expelled from a foam) as a function of time for three different foams: □ egg white; Δ egg white with 1.5% w/w cream of tartar added; ○ egg white with 0.5% raw garlic juice added. Foams were made with 200 g of egg white and whipped for 5 min at speed 8 using a Kitchen Aid mixer.