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Scientific Foundations, Educational Practices, and Culinary Applications
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Eggs: Let Us Have an Egg

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Using codes for describing egg transformations can lead to a wealth of new culinary preparations. Sometimes, the physical or chemical mechanisms of the transformations are known, but often, more scientific research (molecular and physical gastronomy) is needed in order to explain the changes observed during simple processes. Since the beginning of molecular and physical gastronomy, scientific knowledge has been used for making technical innovations (This, 2006a). This “culinary technique” has been called “molecular cooking”, when new tools (in particular, equipment from chemistry or physics laboratories) or methods were used. For example, when considering innovative transformations of eggs, the following systematic system has been proposed (This, 2006b; This, 2007).

**A Code for Innovation**

This system is given in Table 32.1, applied to eggs, but one can easily generalize it to any other food ingredient, and indeed, this has also been done for plant and animal tissues. But let us begin with eggs: the full, whole egg, comprising a shell, yolk and egg white, is given the code number 1, and this makes the first row of a table.

Then, the various possibilities of dividing the whole egg are considered as cells of the second row. The full, intact egg is assigned the label 1.1, the shell alone 1.2, the non-mixed yolk and the white out of the shell 1.3, the mixed yolk and white 1.4, the yolk alone 1.5, and the white alone 1.6 (Figure 32.1).

In the third row of the table examples of transformations of these various constituent “parts” by various processes are found; options include the addition of nothing (1), gas (2), “water” (i.e., any aqueous solution) (3), “oil” (any fat liquid phase) (4), solids (5), ethanol (6), acid (7), alkali (8) or heat (9). Generally, the gas used in the kitchen is air, but many possibilities exist; for example, during an educational dinner organized in 2008 by the Institut des hautes etudes du goût, de la gastronomie et des arts de la table (“Institute for the advanced studies for flavour, gastronomy and arts de la table”) at the Cordon Bleu School in Paris, the dessert was made using helium, so that the guests had a strange duck voice for some seconds after consumption (as sound velocity changes depending on the nature of the carrier gas, hence resulting in a modification of frequency when sounds are emitted in helium instead of air). The “water” in option 3 can be any aqueous solution, as long as the concentration is low and solutes do not noticeably change the properties of the solution. Likewise, “oil” can be any liquid fat, such as ordinary kitchen oil (olive oil, corn oil, sunflower oil, etc.), but also melted butter, melted foie gras, melted chocolate, etc.

Of course, ethanol, acids and alkalis should be edible: this means that they have to be food grade, but also they can be dissolved, for example, in vodka, vinegar, baking powder, etc. Heat, finally, can be applied in many different ways, which means that more slots could be added to the table if necessary (see chapter “Uncook the Egg and Eggs at 6X °C”). In particular, it is useful to consider systematically that heat can be supplied by a hot solid, a hot liquid (water or oil) or a hot gas, or by radiation (microwaves, infrared and also all kinds of electromagnetic radiation, as they transmit energy when they are absorbed).

Using these ingredients, new “products” or culinary concepts can be made, and numbers can be used to describe what they are. For example, in the third row, three numbers describe results of combinations of transformation. Now we shall consider only some cases, because, essentially, the table offers infinite numbers of possible combinations.

**Some Examples**

As the colour indicates, the table contains old results as well as new ones. A first interesting result is given by the code 1.1.6: an egg (1) is stored, whole in the shell (1), in alcohol (6). Because the brandy can enter the egg through the pores, a result called a “baumé” is obtained, after more than one month (Figure 32.2), due to precipitation and possibly coagulation of proteins. The name “baumé” was introduced for this new product in honour of the French pharmacist Antoine Baumé (1728–1804), who devised a density scale.

The next code, 1.1.7, describes eggs that are stored in vinegar, for example, and that coagulate after some time (about one month), making “minus one century eggs” (the “contrary” to “one
Table 32.1
A Coded System for Innovation Using Eggs (Blue Colour Indicates Traditional Applications, While Red Indicates Novel Ones)

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1.1. Whole intact egg</td>
<td>1.2. Shell alone</td>
<td>1.3. Yolk and white out of the shell, un mixed</td>
<td>1.4. Mixed yolk and white</td>
<td>1.5. Yolk</td>
<td>1.6. White</td>
</tr>
<tr>
<td>1.1.1. Nothing</td>
<td>1.2.1. Nothing</td>
<td>1.3.1. Nothing</td>
<td>1.4.1. Nothing</td>
<td>1.5.1. Nothing</td>
<td>1.6.1. Nothing</td>
</tr>
<tr>
<td>1.1.2. Gas</td>
<td>1.2.2. Gas</td>
<td>1.3.2. Gas</td>
<td>1.4.2. Gas: Genoise before cooking</td>
<td>1.5.2. Gas</td>
<td>1.6.2. Gas: Whipped egg white</td>
</tr>
<tr>
<td>1.1.3. Water</td>
<td>1.2.3. Water</td>
<td>1.3.3. Water</td>
<td>1.4.3. Water</td>
<td>1.5.3. Water</td>
<td>1.6.3. Water</td>
</tr>
<tr>
<td>1.1.4. Oil</td>
<td>1.2.4. Oil</td>
<td>1.3.4. Oil</td>
<td>1.4.4. Oil: Mayonnaise (one kind)</td>
<td>1.5.4. Oil: Mayonnaise</td>
<td>1.6.4. Oil: Geoffroy (emulsion based on the white)</td>
</tr>
<tr>
<td>1.1.5. Solid</td>
<td>1.2.5. Solid</td>
<td>1.3.5. Solid</td>
<td>1.4.5. Solid</td>
<td>1.5.5. Solid</td>
<td>1.6.5. Solid</td>
</tr>
<tr>
<td>1.1.7. Acid: Minus one century eggs</td>
<td>1.2.7. Acid</td>
<td>1.3.7. Acid</td>
<td>1.4.7. Acid</td>
<td>1.5.7. Acid</td>
<td>1.6.7. Acid</td>
</tr>
<tr>
<td>1.4.3.9. Lavoisier (extreme royales), Avogadro</td>
<td>1.5.3.9. Royale, flans, flans at low temperature</td>
<td>1.6.2.2. Chaptal (raw preparation for wind crystal)</td>
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<tr>
<td>1.5.3.9. Royale, flans, flans at low temperature</td>
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<tr>
<td>1.6.3.9. Avogadro of white</td>
<td>1.6.4.5. Liebig (physically gelled emulsion)</td>
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</tr>
<tr>
<td>1.6.4.9. Gibbons (chemically gelled emulsion)</td>
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<tr>
<td>1.6.2.2.9. Wind crystal</td>
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<tr>
<td>1.6.3.2.9. Vaquelin (wind crystal preparation cooked in the microwave oven)</td>
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</tbody>
</table>

Throughout the centuries, eggs have been consumed and used in various ways. “Century eggs” prepared by Asian populations by storing eggs in mixtures containing alkali such as lime or potash (Figure 32.3). Label 1.1.9 describes in particular the hard-boiled egg (Figure 32.4), as the full egg in its shell (1.1) is heated (9). But considering the various denaturation temperatures of proteins from the egg, many other possibilities exist, such as “eggs at 6X °C”, i.e., eggs that are heated at 62 °C, 63 °C, 64 °C... up to 100 °C, until the temperature is constant in the egg (This, 1997a), with many different results being found at different temperatures between 61 °C and 100 °C (Figure 32.5).

The code 1.3.9 corresponds to fried egg, or “œuf cocotte”, and it is not new. The mechanism of this transformation was shown in This (1997b): for example, in egg white, the denaturation of proteins can lead to the exposure of thiol groups from cysteine residues, and the formation of disulfide bridges (oxidation) can make a three-dimensional protein network trapping the 90% of water making up the egg white.

The code 1.5.6 is a yolk coagulated by ethanol (and 1.6.6 is an ethanol-coagulated egg white) (Figure 32.6). It was named a “thenard” (of white, or of yolk), from the name of the French chemist Louis-Jacques Thenard (1777–1857), who made many discoveries (hydrogen peroxide, Thenard blue, etc.) and in particular introduced “osmazome”, i.e., the result of extraction of meat in ethanol.

Label 1.6.4 describes what was considered impossible by chefs of the past, who published that “the slightest trace of egg white with the egg yolk prevents making a successful mayonnaise” (Gencé, 1900). Here, considering that proteins are much better surfactants than phospholipids, it was proposed to whip oil in an egg white in order to make an emulsion. The oil used can be ordinary plant oil (e.g., sunflower, soybean) but also melted butter (ordinary, clarified or brown) or even melted foie gras or cheese, as long as its temperature remains lower than 61 °C, i.e., the first coagulation point of a protein of egg white. The obtained emulsion was called a “geoffroy”, from the French chemist family of scientists, including Claude Joseph Geoffroy (1685–1752), a botanist; Claude-François Geoffroy (1729–1753), who discovered bismuth; and Etienne Louis Geoffroy (1725–1810), an...
Entomologist (Figure 32.7). Other products, differently labelled, can also be produced but have not received names up to now.

When the fourth row of the table is considered, products are now labelled with codes written with four figures. Again, some of them are traditional (a few), and many new possibilities arise. The “gibbs” (1.6.4.9), for example, is obtained by heating a Geoffroy: the chemical gelation of the proteins previously used for the emulsion creates a three-dimensional network trapping the oil droplets (stabilities of more than three months were observed) (Figure 32.8). The name is from the American physical chemist Josiah Willard Gibbs (1839–1903).

On the next line of the table, there are more possibilities, such as 1.6.3.2.9, a product to which the name of the French chemist Nicolas Vauquelin (1763–1829) was given. This product consists of egg white, with added air, to which water is added, and the result is heated (in this case, using a microwave oven). Figure 32.9 shows a vauquelin made by the chef Denis Martin (Restaurant Denis Martin, Vevey, Switzerland).

And, of course, there are many other new possibilities, because, as said, the table is infinite in length. If one wants to create a new dish, one can just select a code and turn it into food!
FIGURE 32.3  The various steps of transformation of an egg stored in vinegar. First the shell is dissolved, then the egg expands by osmosis, and finally the proteins coagulate.

FIGURE 32.4  A hard-boiled egg. When the temperature of 100 °C is applied for a long time, sulphur-containing proteins are degraded, and they release hydrogen sulfide, as can be shown, for example, by applying a filter paper previously dipped in a lead acetate solution.

FIGURE 32.5  An egg cooked at 65 °C. The name initially given, “perfect egg”, is still used in many restaurants of the world.

FIGURE 32.6  A “thenard” of egg white.

FIGURE 32.7  A “geoffroy” is an emulsion obtained by whipping a liquid fat in an egg white, as for the making of a mayonnaise.
Conclusion

This digital system for eggs can be applied to any other food ingredient, such as meat, vegetables, fruits, etc. Moreover, the system is indeed a “code”, an example of many that have been produced in the last decades, such as the “table of double cooking” (This, 2002), the formalism for dispersed systems (see chapter “Dispersed System Formalism”) and the “tree of doughs” (This, 2002). All of them arise from the same idea, as used by Antoine Laurent de Lavoisier for chemistry in 1791 (Lavoisier, 1791) and later formalized by Goblot (1918).

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