Sauces

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In the kitchen, sauces are important for many reasons, such as adding a liquid in order to improve swallowing, or adding flavour to a dish (Prinz, 1997). They have been used since antiquity (Apicius, 390), and in the past, various classifications were proposed, such as that of Carême (1833), with “mother sauces” and sauces being derived from them. Of course, the number of possible sauces is infinite, because any ingredient can be chosen for imparting a particular flavour to a sauce, but, in the past, sauces were codified, and variations were considered with caution.

In the decades before the advent of molecular and physical gastronomy, chefs making sauces often referred to the textbook published by Th. Gringoire and L. Saulnier (Gringoire and Saulnier, 1914), created from the Guide culinaire (Escoffier et al., 1903). However, this was based only on processes of sauce making and not intrinsically based on the physical and chemical constitution of the produced systems. The introduction of the disperse system formalism (DSF) (see the corresponding chapter in this book) made it possible to recognize some order in the long list of French classical sauces (and from any other food culture), and also to create entirely new systems.

For French sauces, the research of the DSF formula was published (This, 2004; 2005). The corpus used for the physico-chemical classification was compiled from classical or official culinary books (Académie des gastronomes, 1991; Gringoire and Saulnier, 1914; Escoffier et al., 1903). Each sauce was made strictly following the published recipe and analysed using optical microscopy (size cut-off $d > 10^{-5}$ m). For establishing the DSF formula, assumptions were made, such as:

1. thermally treated plant samples dissociate into separate cells, so that cell aggregates (W/S) can be formed as well as individual cells (W@S);
2. culinary filtration does not separate small cell aggregates;
3. grinding animal or plant tissues disintegrates a certain proportion of cells;
4. depending on the processing time, different results can be obtained when starch granules are heated in water, such as fully gelatinized granules (W/S) or partially gelatinized granules with a solid core (S@(W/S)).

Finally, 23 categories were found. In order of complexity, they are:

- W
- O
- W/S
- O/W
- S/W
- (O+S)/W
- (W/S)/W
- O+(W/S)
- (G+O)/W (Figure 72.1)
- (G+O+S)/W
- (O+(W/ S))/W
- (S+(W/S))/W
- (W+S)/O/S
- (O+S+(W/ S))/W
- ((W/ S)+(W@S))/W
- (O+(W/ S))/W/S
- ((O+(W/S))/W)
- (O/W) + ((G+O)/W)
- (O+(W/S)+(W@S))/W
- ((W/S)+(W@S))/W/S
- (O+S+(W/S)+(W@S))/W
- (O+S+((G+O)/W))/W

Surprisingly, some simple types are missing, such as “foamed veloutés” having the formula (G+(W/S))/W. Such systems are not difficult to produce practically, and their absence from the traditional repertoire leads to the question of why such sauces were not “invented” or recognized officially by cooks in the past. This led to a separate study on the number of different physical kinds of sauces as a function of time (This, 2005). For this study, some traditional French culinary books were used (Menon, 1755; Marin, 1742). The increasing number of types of sauces with time shows that culinary empiricism has probably not yet had enough time to develop all possible kinds of sauces.
How to Use the New Classification?

Let us now consider technological consequences of the previous result. As the sauce called aioli is an emulsion that is obtained by grinding garlic with oil, it was proposed in 1993 that other emulsions of the same kind could be made using the same process, but with other food ingredients, such as animal or plant tissues, because they all contain water, as well as phospholipids from membranes, and proteins (This, 1995). Some examples of such emulsions were known (hummus, aubergine caviar), but most possibilities had not been explored. The general name given for these emulsions was “olis”.

Another idea was proposed in 1995, i.e., a new dish named “Chantilly chocolate” (This, 1996; This, 2008). This one was not based on a generalization of ingredients, but of process: it was a generalization of whipping cream (Montagné, 1996).

Indeed, milk cream is primarily made of fat globules dispersed in a water phase (with an appropriate reference size, casein micelles not taken into account in its formula) (Montagné, 1996). It is sometimes described as “oil-in-water emulsion resulting from the concentration of milk”, but this description is inaccurate, as part of the fat is solid at room temperature (Michalski et al., 2004); hence, a formula such as \( f(O,S)/W \) should be preferred to \( O/W \), the function \( f(O,S) \) of \( O \) and \( S \) being as yet unknown, as it is not established whether \( f(O,S) \) is equal to \( S@O \) or to \( O/S \).

Anyway, whipping cream can be described by the equation:

\[
f(O,S)/W + G \rightarrow [G + f(O,S)]/W
\]

Looking for formulae is an invitation to changes: O, it was said, can be any liquid fat, W any aqueous solution and G any gas. In particular, “Chantilly chocolate” is obtained when, starting from a chocolate emulsion made of chocolate dispersed in water, whipping is performed while cooling below a temperature of 34 °C (the lecithin in chocolate is the surfactant, but if needed, other compounds can be added, e.g., gelatine). When the proportions are well chosen, the final consistency can be as aerated as whipped cream/Chantilly cream.

Alternatively, Chantilly foie gras, Chantilly butter, Chantilly brown butter or even “Chantilly olive oil” can be made (when cooling is sufficient, for olive oil) from foie gras, cheese, butter, brown butter and olive oil, respectively.

In practice, making these products is easy. For example, with chocolate:

1. first make a chocolate emulsion \( O/W \) by heating chocolate into a water phase (the proportion of chocolate and water has to be chosen so that the final fat/water ratio is about the same as the fat/water ratio in ordinary cream);
2. then whip \( (+G) \) at room temperature while the emulsion is cooled: after some time (some minutes, depending of the efficiency of the cooling), a “chocolate mousse” \( [G + f(O,S)]/W \) is obtained.

This mousse is not a ganache montée, as it contains no cream, and it was initially considered “impossible” by some of the most famous pastry chefs (Thuries, 1995) because water and melted chocolate were mixed, making chefs fear graining (but it has to be observed that water is not added to melted chocolate; rather, chocolate is dispersed in water). It needs no eggs, contrary to traditional chocolate mousse, which can be an advantage for people having food allergies; given the right amount of water, the texture can be the same as that of whipped cream. As whipped cream is called “Chantilly cream” when sugar is present, the name “Chantilly chocolate” was given to the new dish made from chocolate.

Another example can show how formulae can lead to new systems having scientific and culinary interest. For example, the formula \( O/W \) can be made with oil dispersed in water, using surfactants. In particular, when one whips oil in an aqueous solution of gelatine, the emulsion obtained gels slowly; a jellified emulsion called a “liebig”, in honour of the German chemist Justus von Liebig (Figure 72.2) is obtained, according to the

![FIGURE 72.1 Microscope picture of an emulsified foam obtained by whipping oil in an egg white. The DSF formula is (G+O)/W. Such systems can also be obtained by mixing a whipped egg white and a mayonnaise. The proportion of air bubbles (disks with dark edge) and oil droplets can be anywhere between 0 and 1.

![FIGURE 72.2 A “liebig” made by chef Pierre Gagnaire in his Paris restaurant.](image-url)
following equation (where gelation goes with partial coalescence of the dispersed oil droplets):

\[ \frac{D_0(O)}{D_3(W)} \rightarrow \left[ \frac{D_0(O)}{D_3(W)} \right] \times D_3(S) \]

Here, the gel is a physical gel, but a chemical gel can also be obtained by using egg white instead of the aqueous solution of gelatine, as the heated proteins can link through disulfide bridges. The emulsion obtained before coagulation was called a “geoffroy”, in honour of the French dynasty of chemists of this name, and the chemically jellified system was called a “gibbs”, in honour of the American physical chemist Josiah Willard Gibbs.

Finally, a new dish called a “faraday” (in honour of the great British physical chemist) was introduced as a demonstration that physical systems could be made from formulae (here \( \frac{(G+O+S_1)}{W}/S_2 \)). The number of possibilities is innumerable. It can be easily calculated that, using four phases and four operators, the number of formulas is 114,688, and more than \( 10^6 \) with six phases: there is plenty of room for innovation!

REFERENCES


