An emulsion in the making

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Picture of the week

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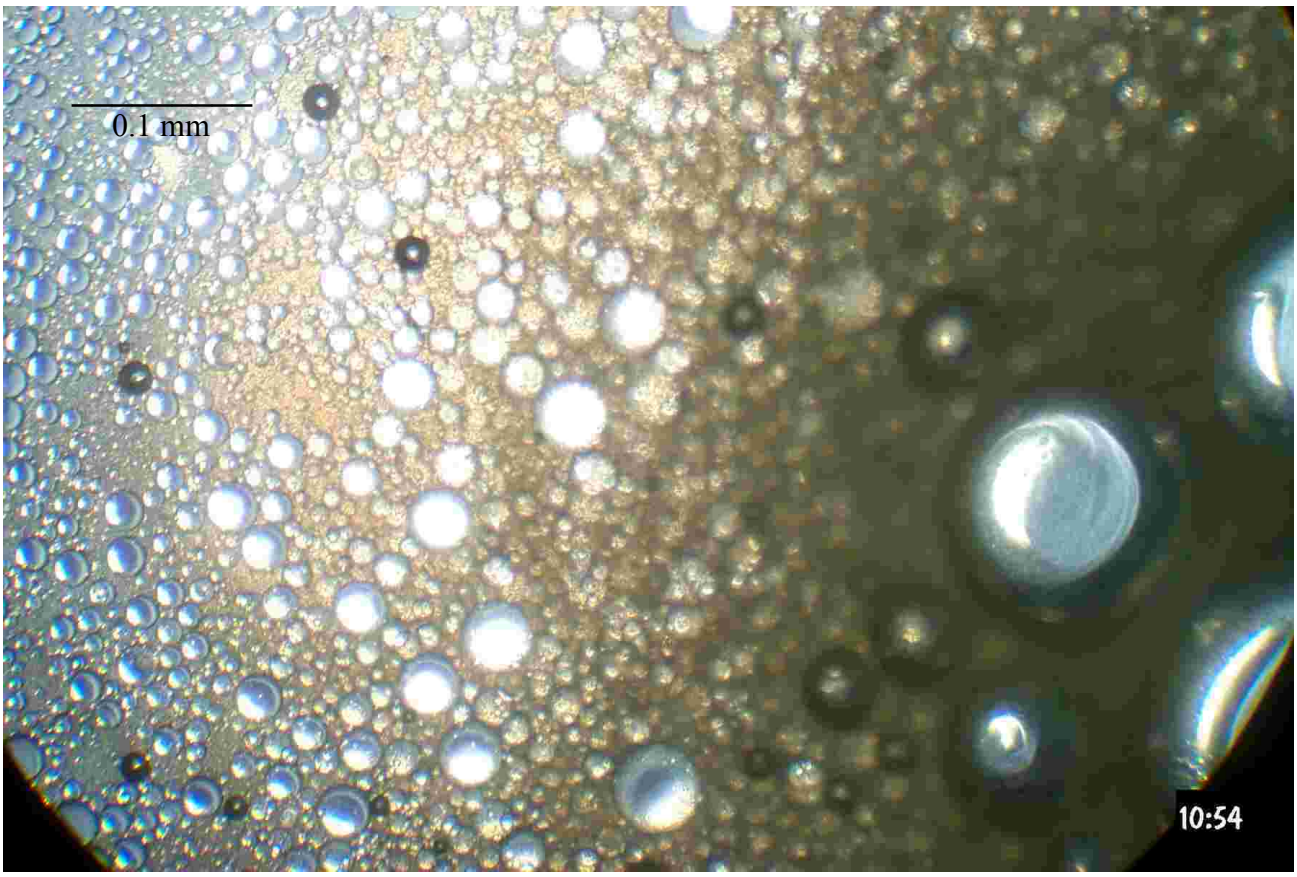

The sauce that we call today "mayonnaise" was derived from "rémoulade" (or "rémolade"), which existed already in the 15th century (Tirel, 1419): both sauces are hot or cold oil in water (O/W) emulsions for which the liquid fat is dispersed in an aqueous solution (stock, vinegar, wine) using mustard as a surfactant' containing ingredient (Menon, 1755). Egg yolks were first added to rémoulade as a seasoning (Blancmesnil, 1850), and

mayonnaise appeared at the end of the 18th century as a very different product (Carême, 1801). It was indeed a surprise that an emulsion could be made without mustard, from egg yolk, vinegar, salt, pepper and oil (howewer, today, it is understood that the emulsifying agents from the egg yolks are primarily proteins and phospholipids, *i.e.* the same than in mustard). The flavour of mayonnaise was recognized to be very different from the one of rémoulade (Carême, 1801; Gilbert,1898).

When mayonnaise appeared, it was first called mahonnaise, or magnonaise (Carême, 1801). At that time, it was made using a mortar and a pestle, or with a wooden spoon with which the walls of the vessel were rubbed for up to 15 minutes, and it was observed that the more the sauce was ground, the lighter its colour was (Carême, 1801; Saint-Ange, 1925).

Also it was observed that mayonnaise can fail, *i.e.*, the water and oil phases sometimes separate. This happens in the start of the process, when too much oil is added in the small quantity of aqueous solution (from the yolk and the vinegar), or at the end, when the viscosity of the sauce is high, the oil proportion becoming more than 95 %. However, in the past, the physical structure of mayonnaise was unknown, and many explanations were given for failed emulsions, such as differences in temperature of the yolks and the oil, changes in the direction of whipping, the presence of women with periods in the kitchen, or even a storm outside (This, 2009).

However all this was imagination, because the only question, during the making of the sauce, it to divide the oil in droplets that are dispersed in the aqueous solution made of vinegar (about 90 % water) and egg yolk (about 50 % water); surfactants from the egg yolk (proteins and phospholipids) lower the surface energy and prevent droplets coalescence (charged proteins at the surface of droplets create both steric hindrance and electrostatic repulsion). Any technique that can emulsify the oil in water can be used. For example, in order to make the sauce whose microscopic appearance is shown here, a fork was used to whisk it. At the beginning of the emulsification process, the sauce remains fluid (the picture shown here corresponds to the addition of about 50 % oil), but after more oil is added, or when the whisking energy is high (corresponding to smaller oil droplets), the viscosity is much increased.

It can be noted that understanding the physical structure of this sauce was not easily obtained, in spite of the availability of microscopes since the 17th century (Leeuwenhoek, 1673): for example, a search in *Google scholar* does not show any scientific article with the keywords mayonnaise+emulsion between 1850 and 1900. Even in the 1980's, the surfactants in mayonnaise were said to be phospholipids, and it was even said in kitchens that the slightest trace of egg white would prevent making the sauce (Gencé, 1900). However, an emulsion can be obtained by whipping oil in egg whites (in which there are no phospholipids, but only proteins) (This, 2021): this shows how effective proteins are for emulsification, having both large steric hindrance (with 386 residues of amino acid, the fully extended ovalbumin would be about 60 nm long) (Stein *et al*., 1991) and electric charges (the isoelectric point is 4.5, *i.e.* higher than in mayonnaise) preventing coalescence (Strixner and Kulozik, 2011).

To take the picture shown here, a few mm^3 of sauce were taken with a spatula and gently spread on a glass slide, without a cover (in order not to disturb the system). In this image, produced with a Meiji microscope (Techno ML Series 2000, model ML2300, equipped with a JVC camera, TKC1380), two types of objects can be seen: numerous discs without dark edges (oil droplets) and discs with dark edges (air bubbles). The diameter of the biggest structures is ~ 0.1 mm.

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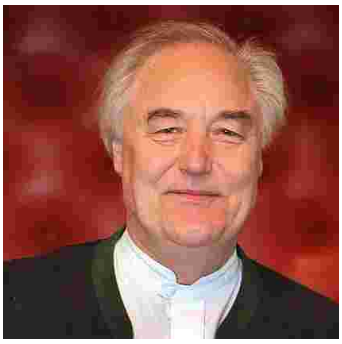

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