Vinegar

(Albert Mas and María-Jesús Torija)

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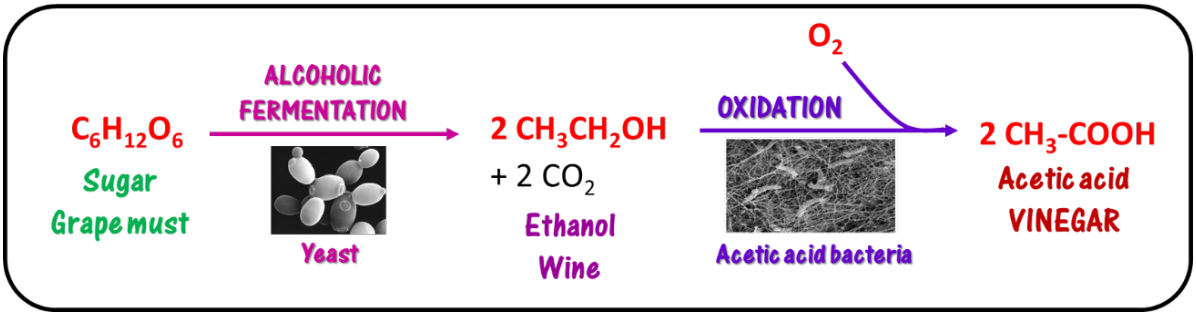
Vinegar. The name vinegar derives from the French "*vin aigre*" or sour wine, thus it is closely related in its origin to wine, which is mostly associated with Mediterranean and European culture. However, other kinds of vinegar are also produced in Asian countries as a very traditional ingredient in their foods and food products.

The most characteristic ingredient of vinegars is acetic acid, which accounts for 3% to 7% of the solution, depending on the product. In fact, before the Romans considered it as a wine, vinegar was highly appreciated as a very strong acid. The presence of acetic acid gives vinegar a distinctive acidic, pungent taste, which is very appreciated as a counterpart of some strong tastes or even very sweet ones. Furthermore, vinegar is extensively used in the pickle industry as preservative, but it is also used as general acidulant in many food industries and to make sauces. In Mediterranean countries, it is used raw, adding it to different foods, especially salads or as an ingredient in a very popular salad sauce called "vinaigrette".

How do we make it?

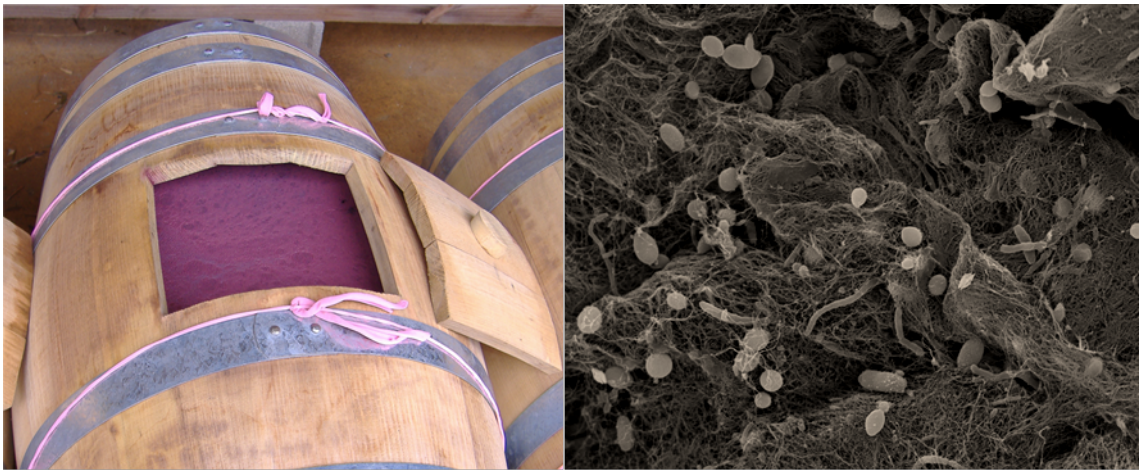
Vinegars are traditionally made from any "sugary" or "starchy" substrate in two sequential biological processes: firstly an alcoholic fermentation to produce alcohol (ethanol) from sugars, and a subsequent oxidation of ethanol (wrongly named as acetous fermentation) to acetic acid. In the case of wine vinegar, the most traditional production, the process starts from grape must to produce wine and, later, vinegar:



Biological processes of vinegar elaboration from grape must

The alcoholic fermentation is performed by yeast, especially led by the "domesticated" yeast *Saccharomyces cerevisiae*. The second stage is carried out by microorganisms given the generic name of "Acetic Acid Bacteria (AAB)". All the members of the ABB group belong to *Acetobacteraceae* family, although not all the members of this family are AAB and, thus, able to produce acetic acid. While there are more than 15 genera and 60 species of AAB, only a few play a role in the production of vinegar: *Acetobacter* (mostly *A. pasteurianus* or *A. aceti*), *Komagataeibacter* (mostly *K. europaeus* or *K. xylinus*) and *Gluconobacter* (*G. oxydans*).

From a technological point of view, the second step in the production of vinegar – the oxidation – can be done by two very different processes: (i) the surface method, the most classical process, where AAB develop on the surface of the ethanol solution (that could be wine, cider, beer, etc... or even plain diluted ethanol) or (ii) the submerged process, where AAB are mixed throughout the liquid, which is constantly aerated by a continuous flow of air. The difference between the two processes is the length of time – the surface process may take years, whereas the submerged one can be done in hours – and the quality of the product. The surface process allows AAB to have an active metabolism creating new flavour compounds and helping to maintain existing flavour compounds in the substrate.



Left: a barrel where vinegar is being produced by the surface method. On the surface of the diluted wine, a biofilm is formed by the acetic acid bacteria. R: electron microscope image of this biofilm. Acetic acid bacteria cells are embedded in the biofilm matrix of cellulose.

In contrast, the submerged process makes the bacteria biological reactors that transform ethanol into acetic acid, without any other biological transformations. Furthermore, the continuous flow of air purges diverse aromas produced by and from the original substrate. The submerged method is used to produce "white" vinegar from ethanol – not an accurate name, because it is transparent,

not white. This kind of vinegar contains only acetic acid. However, unlike the chemical acetic acid, which is obtained though chemical synthesis, white vinegar produced biologically is authorized for consumption by humans.

The bacteria of the genus *Acetobacter* are very common in the surface process of vinegar production, whereas those of the genus *Komagataeibacter* are more characteristic of the submerged methods.

Variations, regional variations:

We have already mentioned the types of vinegars by the system of production (submerged, surface) and the impact on quality. However, in different countries the vinegars are different. Regarding the names, there are several regulations, from the very strict ones (vinegars that only derive from grape wines with a certain amount of residual ethanol and a minimum of acetic acid, around 5%) to more inclusive ones (vinegars that are produced from a dual biological process – fermentation and oxidation – of any starchy or sugary substrate of any biological origin (fruits, cereals, even serum from milk!)). Some other products that contain acetic acid but do not fulfill other requirements (level of residual ethanol, presence of other non-authorized compounds) are normally referred to as "food condiments or seasonings".

The most famous or appreciated vinegars are generally from wine, often protected by Appellations of Origin. Probably the best known worldwide is the "*Aceto Balsamico di Modena*" (ABM), although here it is important to clarify that there are several qualities, with different names. The highest quality one, which requires at least 12 years of maturation in special systems that include barrels from different woods are called "*Aceto Balsamico Tradizionalle*" (ABT). ABT are produced either in Modena or Reggio Emilia, yielding two different products protected by two different Appellations of Origin. This is a gourmet product that has a popular relative which is the known and less expensive ABM, which does not require such a maturation time and has a simpler process. The main characteristic of all these vinegars is that the acidity of the acetic acid is compensated by the sweetness of different sugars present, which ends up with a pleasant sweet and sour taste.

Barrel set for "*Aceto Balsamico Tradizionalle*" composed by barrels from different woods and increasing volumes, and the resulting vinegar packed in the special glass bottles of *Aceto Balsamico Tradizionalle di Modena*.

In Spain, which is the other country where consumption of vinegar is very high, there are 3 Appellations of Origin, named as "*Vinagre de*"... Jerez, Montilla-Moriles or Condado de Huelva, referring the place or the wines used to produce it.

Apple vinegar is another kind of vinegar that is becoming popular. Derived from cider (fermented apple juice), it is normally less acidic (has lower content of acetic acid) and for some people more palatable. Other fruit vinegars, such as raspberry vinegar, are becoming also popular, although many of them refer to wine or apple vinegars that are aromatized (flavoured) with fruit essences.

Although most of the literature dealing with vinegar focuses on wine vinegar and the European culture, it has to be emphasized that vinegar is also highly appreciated in other cultures, some of them with a long tradition in the use of different sour seasonings. In China, for instance, there are references to these sour seasonings for cooking since 4000 BC, most likely derived from fruits (probably plums), although there is not much information about their production. In Korea, the first references were to rice vinegar, which later extended to China and Japan. Nowadays, in Japan, there are several types of rice vinegars (*komesu* and *kurosu*) depending on the raw material, while, in China, beyond the different rice vinegars, the vinegar produced by solid state fermentation of cereals (mostly sorghum) is also very popular.

Beneficial properties:
The beneficial properties of vinegars are normally linked to the presence of acetic acid, which is a natural acidulant, facilitating the digestion of raw or difficult-to-digest foods. Thus, its use in cooking, salad dressings, etc., is highly appreciated and recommended.

However, it should be emphasized that the recent increase in advice of some "food gurus" that some plain vinegars (mostly apple vinegars) are good as anticancer drugs or for slimming diets are not supported by data and may be very dangerous, as acetic acid is a strong acid that can cause anything from sore throat to damage to the epithelial layer of the esophagus, which can even lead to esophageal cancer. Thus, drinking vinegar directly is not recommended at all.

In conclusion, vinegar is a food ingredient present in our normal life that is closely associated with the sour taste. It is widely use as seasoning in the food industry, in home cooking, and helps the preservation of many different foods by acidulation. The production of vinegar itself is also an important industry, which has spread throughout the world.