Oxidation & Fermentation

By Robert Heiss

The manufacture of tea is a series of integrated steps that starts with freshly-plucked leaves and ends with what we in the trade refer to as 'finished', or 'made' tea. The seven classes of tea (green, yellow, white, oolong, red, black, and Puerh) have several steps in common (such as plucking, primary sorting, finishing, etc.) as well as other aspects that are unique to only one or several particular finished tea(s). Oxidation is one of the latter, a chemical process that must occur in the manufacture of several of the classes of tea, and prevented in others. In fact, the world of tea has historically been divided into two broad categories based on whether or not a finished tea has been oxidized.

Oxidation in Tea

First, let's define oxidation: Oxidation is a biochemical, enzymatic activity during which oxygen is absorbed by and subsequently causes changes to the host physical matter. In the case of freshly plucked leaf for tea, this is plant matter. Oxidation can be spontaneous or controlled and cause positive or negative change. A familiar example of spontaneous negative oxidation is what happens when one cuts an apple or banana and leaves the cut side open to the air. The exposed cells absorb oxygen, soften and turn brown. This is a very simple form of oxidation that most people have witnessed. Left undisturbed, the fruit may simply air-dry or it may rot, depending on the atmospheric conditions present in the room. Similarly, cutting an apple into slices and drying these in a dehydrator is an example of controlled oxidation, occurring within the process of drying. The browning of the cut surfaces is not considered aesthetically pleasing in the marketplace, so sulfur compounds or citric acid are sometimes used to mitigate the color change, but oxidation occurs in this situation even without a visible change in color.

During the manufacture of tea, both spontaneous and controlled oxidation occurs. Spontaneous oxidation occurs during the withering phase of the manufacture of white, oolong, and red teas. An exacting phase of controlled oxidation is one of the most important components of the manufacture of both oolong and red teas. Green and yellow teas are prevented from oxidizing by meticulous drying and/or frying techniques.

Oxidation is a chemical process that requires an abundance of moist, oxygen-rich air. For red tea production, oxidation rooms (or chambers) must provide ample humidified air to guarantee complete oxidation. The polyphenols in the leaf (tea catechins) bond to oxygen molecules, particularly during the early stages of oxidation. Oxidation in tea manufacture officially begins during the withering stage as spontaneous oxidation, and then accelerates gradually during the subsequent steps necessary to transform fresh leaf into finished red tea. After several preliminary steps, prepped leaf is ready for the controlled oxidation process that is often ***incorrectly*** referred to as 'fermentation'. Several chemical reactions that together comprise oxidation take center stage now under the controlled environment of the 'official' oxidation phase in the manufacture of red tea. In traditional oxidation the sieved leaf is spread out in a thin layer (maximum 2 to 3 inches, or 5 to 8 centimeters) on the floor of the factory, on tables or perforated trays that are similar to the withering troughs used during the (earlier) withering stage. The oxygenation of the polyphenols stimulates them to start the series of chemical reactions that ultimately yield the flavor components and cup characteristics that we expect in red tea. During the first and most important period of the enzymic oxidations, the enzymes polyphenol oxidase and peroxidase act on other polyphenols to produce theaflavins. These red-orange compounds then react with more polyphenols to produce thearubigins, the chemicals responsible for changing the leaf's color from green to golden, coppery, or chocolate brown. The thearubigins, meanwhile, are also busy reacting with some of the amino acids and sugars in the leaf, creating the highly polymerized substances that develop into the various and distinctive flavor components that we expect in red tea.

In general, theaflavins contribute to the brisk and bright taste of red tea, while the thearubigins are what provide strength (depth or body) and color. If the temperature of the leaf is allowed to rise too high, the controlled oxidation will rage out of control; and if it falls too low, oxidation will cease.

At this point the oxidizing leaf takes on a new moniker in Indian/Western tea classification: "*dhool*". Oxidation requires two to twenty-four hours and is controlled by experience, not by science. Although there may be technical markers for determining a prospective end to the process, so many variables come into play that the best method for concluding that the proper oxidation level of the leaf has been reached is to rely on the experienced nose and eye of the expert monitoring the process.

The tea producer must control the thickness and raking of the leaf, which determines the exposure of the surface area of the *dhool* to the air; the ideal ambient temperature (85°F, or 29°C) and relative humidity (98 percent); and the ventilation (ten to twenty complete changes of air per hour). Also, the environment must be completely hygienic; bacteria must be prevented from ruining the *dhool*.

During oxidation the *dhool* goes through a predictable series of flavor profiles: brisk, high color, and overall strength. The tea maker can direct the *dhool* into a particular style by adjusting the length of time allowed in oxidation in combination with regulating the temperature/humidity of the oxidation chamber. Most tea is manufactured to yield a balanced cup showing bright liquor, good intensity in the aroma, and a solid full body. When the tea maker has determined that the *dhool* is oxidized to the desired level ('fully oxidized' is a degree, not an absolute) the critical phase of controlled oxidation is halted by the final process of red tea manufacture: drying.

Fermentation in Tea

Fermentation is an important component in the fabrication of Puerh and other aged teas like *Liu An*, *Liu Bao*, some Oolongs, etc. Therefore, any discussion of fermentation in tea manufacture ideally focuses on—and is well illustrated by—the manufacture of Puerh. So let's examine what fermentation is and why careful, expert fermentation is so integral to the manufacture of traditional, high-quality Puerh. While it is one of the oldest and simplest forms of tea production, the world of Puerh is complex and exacting, to the extent that volumes have been written on the subject by Asian tea experts. However, we will not examine the specific complexities of the different types of Puerh manufacture here, as this article seeks only to offer a more general description of fermentation and oxidation.

Fermentation is microbial activity involving one or more types of bacteria, molds and yeasts. By definition, fermentation occurs most readily in the absence of oxygen, though exposure to some is ideal for aging Raw (*Sheng*) Puerh. The leaf that is being transformed into Puerh must be exposed to bacteria (or have bacteria present inherently) in order for fermentation to occur.

As is the case with the fabrication of traditional 'hard' cider or Roquefort cheese, the bacteria necessary for microbial activity to commence is present naturally, in the atmosphere and/or on the interior surface(s) of the chamber in which the fermentation occurs (the cider-house or cheese-curing cave). In the case of Puerh, the bacteria required to both initiate and maintain fermentation are potentially present during several aspects of its production:

1. On the surfaces of the leaf of the old-growth plants themselves in the primordial forest where the large-leaf tea trees grow—most famously in the mountains of the Xishuangbanna district of southwestern Yunnan Province, China.

2. In the controlled environment of the tea-production rooms in which the 'Raw' (*Sheng*) '*mao cha*' is temporarily stored as it awaits compression; in the piles of *mao cha* during the artificial fermentation of Ripe (*Shou*) Puerh; and finally in the humid steam-enriched environment in which the cakes are compressed.

3. To a lesser degree, in the monitored curing rooms where *Sheng* Puerh cakes are stored during post-fermentation and aging.

During the fermentation phase of Puerh manufacture, several important factors must coalesce. Following the harvest of the appropriate leaf, there should be 'wild' bacteria available on the leaf itself. This will range from 'very little' to 'an abundance' (#1 above). Leaf destined to become Puerh ('*mao cha*': withered, fried in a 'kill-green' (*sa qing*), kneaded (*ro nian*), and then partially-dried leaf) is bagged and stacked to await compression in bacteria-friendly steam; or in the case of Ripe tea (*Shou*), piled in a room whose exposure to the elements is traditionally controllable (#2 above). Unlike the shallow, porous piles of leaf created for oxidation, the mounds of *mao cha* that encourage the artificial fermentation of *Shou* Puerh are stacked thickly, densely and with minimal surface area exposed. The critical bacterial activity being encouraged at this point requires some oxygen replenishment but, as with a mulch pile for a vegetable garden, the *mao cha* pile is stirred infrequently, allowed to rest and generate the heat desired to encourage the multiplication of microbes and the paced decomposition of the leaf. Thermal blankets are often used to cover the surface and further encourage the process. Careful and methodical stirring periodically maintains the proper surface area exposure, temperature and minimal oxygenation of the tea in the pile.

It is somewhat understandable to imagine the early confusion regarding withering, oxidation and fermentation. Seeing piles of leaf on the floor being stirred and piles of leaf in troughs or on slats being turned, early tea traders may have been easily confused as to what processes were occurring during the rudimentary, artisan tea manufacture they were viewing (compounded of course by the reluctance of the Chinese to explain their 'secrets'). However, over the last 75 years much has been written, and definition has been accomplished as to the clear differences between these processes.

Robert Heiss is the owner of Tea Trekker and co-author of "The Story of Tea; A Cultural History and Drinking Guide", written with his lovely wife Mary Lou Heiss.