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TEA PROCESSING, BREWING, AND TASTING

This introductory paper describes proper processing and brewing for the primary types of tea processed from *Camellia sinensis*, the “tea plant.” There are a handful of factors in picking, processing, and brewing of the plant that produce hundreds of profoundly differentiated drinks. It is my hope that the reader will develop a curiosity for tea, reverence for the traditions and culture surrounding tea, a deeper appreciation for the processing of tea, and high standards for brewing it. We will investigate processing in detail and touch on some important chemicals in tea (in-depth analysis of effects on the body will not be covered). Some tips on choice of brewing vessel, cups, and how to taste tea are given. A cheat-sheet synthesizing the information in this paper is at the very end. Gather some friends and enjoy.

Processing: the 10 steps

Step 0: tea variety. There are two major varieties of the tea plant: black tea comes mostly from *Camellia sinensis Assamica* in India, and the other types of tea are generally picked from *Camellia sinensis Sinensis*, the Chinese variety. However, it is possible to find any variety of tea from cultivars of either variety.

There are hundreds of cultivars within each variety. Each sub-variety of tea has a few primary cultivars. For example, one commonly harvested cultivar is “Longjing #43”, from which a lot of Longjing green tea is produced. Recommending specific cultivars or growing regions is beyond the scope of this article, but the informed drinker should investigate this on a per-tea basis.

Step 1: picking. Only very low-quality teas are machine-picked. If the leaves are not picked properly, they will not oxidize properly, and oxidation is the step that leaves the most profound effect on the taste of tea. Either fully-grown leaves or flushes (a terminal bud with two young leaves) are picked, with a snap of the wrist. The leaves should not be twisted or pinched.

Choosing a season for picking and what types of buds or leaves to pick is very important. It is the first step in differentiating tea variety and flavor, as well as caffeine content. The bud and first leaf contain 5% caffeine by dry weight, second leaf 3.5%, upper stem 2.5%, lower stem 1.4%.

Step 2: wilting. The leaves and buds start wilting immediately after being picked. The leaves lose a quarter of their water during this process and oxidize slightly (enzymatic oxidation). They can be left in the sun or a cool breezy room, or are sometimes moved outdoors and indoors in cycles to regulate the temperature.

Step 3: bruising. In some varieties of tea, the leaves are bruised by being kneaded with heavy wheels. This serves to speed up oxidation by breaking down cell walls and increasing surface-

to-volume ratio and releases juices from the leaf which aid in oxidation and change the flavor of the tea.

Step 4: oxidation. Teas that require oxidation are left in a climate-controlled room at a specific temperature and relative humidity. Chlorophyll in the leaves break down and tannins are released and transformed. Oxidation is stopped at a certain point that defines the flavor and the type of tea (see cheat sheet below for more details). This process is commonly referred to as “fermentation” in the industry.

Flavonols and catechins are two groups of chemicals found in tea. The principal catechins are EC (epicatechin), EGC (epigallocatechin), ECG (epicatechin gallate) and ECGC (epigallocatechin gallate). Fresh tea leaves are rich in catechins and oxidizing enzymes. The oxidizing enzymes are separated from catechins inside the leaf cells. However, the cell walls break down when leaves are rolled or crushed, and the enzymatic reaction causes catechins to join together to form thearubigins. In short, more oxidation means fewer catechins, including ECGC, and more thearubigins. (for reference, theaflavins are an important component that are a type of thearubigins)

Step 5: fixation. Leaves are heated up to disable oxidative enzymes, thus stopping oxidation at a desired level. Heat applied is only moderate so the flavor is not destroyed. Sometimes fixation and drying are done simultaneously.

Step 6: sweltering. This process is unique to yellow tea. After fixation, tea leaves are heated lightly in a closed container, causing the leaves to yellow.

Step 7: rolling / shaping. The tea leaves, now damp, are optionally shaped. If rolled, leaves are formed into strips using a rolling machine. This causes sap to ooze from the leaves which effects the flavor of the tea. The strips can then be shaped into spirals, kneaded into pellets, or tied into balls, cones, or other shapes. Pu-erh is pressed into dense cakes (usually after step 9).

Step 8: drying. The leaves are now completely dried. This is done by panning, sunning, air drying, or baking the leaves. Care must be taken not to over-cook the leaves.

Step 9: aging & curing. Some teas go through a secondary cooking, oxidation, and/or aging process. Pu-erh goes through a process of non-enzymatic oxidation (post-fermentation) and some oolong teas are baked over charcoal. Yellow tea is also very slightly post-fermented. This secondary oxidation is non-enzymatic, meaning that the oxidation is catalyzed instead by fungus, bacteria, or autooxidation.

Step 10: sorting and packaging. This is the last step, but a very important step - sorting. Some teas are sorted into different grades based on quality, the highest of which are often reserved for Chinese elites. During this process damaged leaves and twigs are removed (and likely sold in bulk and put into tea bags). Teas are then packaged and shipped to your favorite local tea houses.

Caffeine, Theanine, EGCG Content

Caffeine will only be discussed here to dispel some common myths: First, oxidation does not increase caffeine content; it decreases caffeine content slightly ^[ref 1]. Second, caffeine content is determined by when and what kind of leaves and buds are picked (see Step 1, Picking) rather than oxidation. Third, high grade white teas and black teas contain equal amounts of caffeine.

However, the caffeine in black tea affects the body more than the caffeine in white tea and other teas. This is because of theanine and EGCG, which dampen the stimulant effects of caffeine while relieving stress, promoting calmness, and increasing awareness (caffeine without the jitters or the crash) ^[ref 2]. White tea, black tea, and high grade green tea have the same amount of caffeine. However, white tea has more theanine and EGCG, and green tea slightly less than white. EGCG and theanine levels are determined primarily by oxidation (see step Step 4, oxidation). There are many factors influencing caffeine content, but we can be sure that if tea came from *Assamica*, was grown in shade, was picked young and oxidized little, the tea contains a large amount of caffeine. If a tea is oxidized more, it contains less EGCG and the caffeine is more potent.

Thearubigins

As mentioned in step 4 (oxidation), oxidation increases concentration of thearubigins. Thus, to understand thearubigins is to better understand black tea and oolong (perhaps pu-erh as well, but post-fermentation may effect pu-erh differently).

Thearubigins are red or yellow-orange in color. This contributes to the amber color of black tea, and the amber color of darker oolongs. Lighter oolongs appear more golden in color and you can regard the spectra of colors with regard to oxidation.

Additionally, since thearubigins are formed by breaking down catechins such as EGCG and theanine, we know that (1) some of the health benefits of unoxidized teas are likely not found in oxidized tea (they are still healthy, just in different ways) and (2) since EGCG concentration is lower, a tea high in thearubigins will also have “more potent” caffeine.

The effects of thearubigins in tea is still being studied. Aside from affecting the taste of tea, they likely have different effects on health compared to theanine. Specifics are still unclear. I am convinced, as many others, that all forms of tea can do wonders for your health. As they all do different things to the body, it is ideal to have a balanced tea diet.

Brewing, Vessels, Tasting, and Buying Tea

Choosing a proper brewing vessel is important. Form follows factor: find a pot good for brewing your favorite tea (or a wide range) before worrying about aesthetics. My recommendation for beginners is to spend \$20 on a generic pot that can be used to brew a wide variety of teas. Do not use tea balls: tea leaves need to expand while they brew. Mesh strainers are acceptable. My preference is for smaller tea-pots with filters on the inside, and handles that look like odd, hollow protrusions (a style common with Korean tea pots). These are nice for brewing tea at hot temperatures and can be used for a variety of teas. However, filters are not a necessity: if you're drinking a lot of loose-leaf tea, you should get used to leaves spilling into your cup. This is not faux pas.

Once you're comfortable with brewing, it's nice to have a good set of small tea-cups. These are useful for serving tea to several people. Small cups are useful for savoring tea or tasting many kinds. Gaiwan-sized cups are nice for meals.

Once you're more comfortable with brewing and serving tea, it's worth investigating gaiwan and yixing pots. Gaiwan are porcelain bowls with lids: use gaiwan with lighter teas (white, green, yellow, and lighter oolong). Gaiwan are thin and the lids are large, so heat is dissipated quickly. Do not try to brew pu-erh or black tea in gaiwan or you will burn yourself. You can drink tea straight from the gaiwan, or decant the tea into other vessels. Do not drink from the gaiwan when serving to guests! Yixing pots are also interesting. They are clay tea pots that come from a special clay in China. The porous clay absorbs some of the tea brewed in the pot, so a coating of tea flavor gradually builds on the inside of the pot. Thus, you should only use a yixing pot for brewing a particular kind of tea: dark oolong, pu-erh, light oolong, and black. It is less common to brew light teas or black tea in yixing pots. It is also worth mentioning the gongfu method of brewing: you use 2-3 times the normal amount of tea leaves when brewing, and brew at a slightly higher temperature but for significantly less time. This produces strong tea and many infusions. My preference is the gongfu method with a small yixing pot and a dark puerh, but gongfu can be used with gaiwan and a lighter tea as well.

Brewing temperature runs from 70° to 100°. Lighter, more delicate teas are brewed cooler: white, green, yellow are brewed from 75-80°. Oxidized, post-fermented, and compressed teas are brewed higher: pu-erh and oolong around 90°, black around 100°. The darkest, most heavily compressed pu-erh teas should also be brewed around 100°. A more delicate black tea (like Darjeeling) may be brewed slightly cooler. On the subject of oolong teas, since they have such a wide range: tieguanyin and da hong pao (10% and about 60% oxidation, respectively) should both be brewed at around 88° and 90°. There is little variation there; the issue is that any oxidation will raise the brewing temperature. Temperature and brewing-time ranges for the main kinds of tea are given in the cheat sheet, and while this is adequate, you should always verify brewing time and temperature with the specific tea you buy. Some green teas will become bitter if you brew them for 90 seconds instead of 60 - that thirty seconds can make a huge difference.

Tasting tea: to get all the flavors of the tea, drink it like wine. Slurp it, suck in air over the tea when it's in your mouth, and roll it around your tongue to hit all the flavor centers.

If possible, buy tea at a local tea house. I personally recommend Dobrá Tea (in Madison, WI, and Burlington VI). This is the best place to start making informed purchasing decisions, since it is their job to find the highest-quality tea on the market. Additional factors to look for in buying tea are harvesting seasons, growing region and tea cultivar. These factors are important and very interesting, but also unnecessary until you have developed strong preferences.

Most importantly, make sure you have a good environment to drink your tea in. Get a good book, good friends, or a good view to drink your tea with.

Tea Cheat Sheet

White Tea.

Picking: immature bud growths, sometimes young leaves, hand-picked in early Spring.

Processing: minimal wilting (step 2) results in minimum oxidation. Leaves are then slowly heated (step 5). Occasionally the leaves are shaped (step 7) but often are immediately dried.

Oxidation: close to 0%, which implies high concentration of ECGC, low concentration of thearubigins.

Flavor: light, slightly sweet, delicate flavor exemplified in Bai Hao Yinzhen and Bai Mu Dan, two of the finest white teas. For first tasting, try pairing white tea with green for contrast.

Brewing: white teas are brewed between 75-80° C for 1-2 minutes. Brew at a slightly *lower* temperature and add 30 seconds to successive infusions. Yield 2-3 infusions.

Green Tea.

Picking: varies greatly, but the highest-quality green tea comes from hand-picked flushes (a bud and 1-2 inches of leaves).

Processing: optional wilting (step 2) for 8-24 hours, which evaporates most of the water. Leaves are then fixated (step 5), by steaming or pan-frying them. If oils are used to fry the leaves, the oil may impart a flavor on the tea. The leaves are then shaped (step 7) and dried (step 8).

Oxidation: close to 0%, which implies high concentration of ECGC, low concentration of thearubigins.

Flavor: wide variety, from woody (Houjicha), mellow and grassy (some varieties of Longjing), to oceanic tastes (especially Japanese varieties).

Brewing: green teas are brewed between 75-80° for 1-2 minutes. Brew at a slightly *lower* temperature and add 30 seconds to successive infusions. Yield 2-3 infusions.

Yellow Tea.

Picking: immature bud growths, sometimes young leaves, hand-picked in early Spring.

Processing: see Green Tea. Lightly withered green teas are immediately covered with mats to allow slight oxidation during a slow drying process (step 6).

Oxidation: close to 0% with non-enzymatic oxidation, which implies high concentration of ECGC, low concentration of thearubigins.

Flavor: flowery, fresh, and mild; stronger than white, but milder and without the grassy flavor of green.

Brewing: yellow teas are brewed between 75-80° for 1-2 minutes. Brew at a slightly *lower* temperature and add 30 seconds to successive infusions. Yield 2-3 infusions.

Oolong Tea.

Picking: oolong is picked 3 or 4 times a year (once or twice in the summer). The bud and 3 or 4 mature leaves are picked.

Processing: after being picked, leaves are withered carefully to get the right level of moisture (step 2). Then leaves are bruised. The rule is that light bruising goes with heavy withering; heavy bruising goes with light withering. This process removes moisture and grassiness. The tea-makers either shake the leaves in bamboo baskets and hand-press them, or use wheels to roll over them (step 3). This speeds up the oxidation process (step 4). The leaves are then pan-fried at high temperature (step 5). Leaves enter a process of alternating shaping and heating (step 7). Oolong tea leaves are long and curly, semi-rounded, or fully-rounded. The leaves are then baked in two stages (step 8). The first stage is a short, high-heat baking that fixes the flavor, chemical profile and shape of the tea leaves. Then the leaves are slow-baked, which can last up to 7 hours.

Oxidation: oolong teas have a range of oxidation, from 10-70%. Light oolongs (Tieguanyin) are oxidized little, whereas dark oolongs (Da Hóng Páo) are closer to black tea in oxidation and flavor. Thus, oolongs have an intermediate level of ECGC and thearubigins.

Flavor: somewhere in between green and black, without the grassy tones of green or the sweet aroma of black. Brewed strong, it is bitter with a sweet aftertaste. Oolongs can be golden and light (Tie Guan-Yin) or very dark (Da Hong Pao).

Brewing: Oolong teas are brewed around 90° for 90 seconds. Successive brews can be at the same temperature for about the same amount of time.

Pu-erh Tea.

Picking: pu-erh starts as large-leafed green tea from Yunnan province (as of 2008), complete with fixation. Thus, pu-erh first goes through all the processes associated with green tea.

Processing: Raw pu-erh is directly compressed and is thus also a subcategory of green tea. Cooked pu-erh goes through additional processing before being compressed. First, it is wet-piled (step 9) where the tea leaves essentially are composted, although in a very controlled environment. Each fermenting pile has a unique culture of bacteria, which are unfortunately not as well-studied as the bacteria used to produce beer and wine. This composting process takes 6-12 months to complete. The leaves are then pressed into dense cakes, often in the shape of bowls, round cakes, or rectangular bricks (step 7).

Oxidation: uncertain; puerh goes through no enzymatic oxidation, but non-enzymatic oxidation necessarily imparts a unique chemical profile to pu-erh teas.

Flavor: pu-erh has an “earthy” flavor (you are, after all, drinking composted tea). Raw pu-erhs have a more astringent, “fermented” taste. Darker pu-erhs can have the color and intensity of black coffee. The quality of the pu-erh flavor improves as the leaves age.

Brewing: Pu-erh teas are brewed around 90° for 2.5 minutes. Successive brews can be at the same temperature for about the same amount of time. Darker, more heavily compressed teas can be brewed at 100° for 2 minutes, whereas raw puerhs should be brewed at 90° for 20 seconds.

Black Tea.

Picking: black tea leaves are either picked from broad-leafed Assam plants in India and Sri Lanka or small-leafed plants in China. Most black tea in the West comes from Assam.

Processing: tea leaves go through the initial drying process (step 2). The leaves lose 30-70% of their moisture. Often, warm air is intentionally blown over the leaves to speed up the drying process. There are several methods for processing the tea after this, but most of these processes are used for lower-quality teas that end up in bags. Thus, we focus on the *orthodox* method. This is essentially a bruising process (step 3) that differs greatly by type of black tea and also informs the final shape of the tea. The tea is then left to oxidize fully in a climate-controlled room (step 4). Leaves are dried (step 5). This process is simple because the tea leaves have mostly dried during the oxidation process.

Oxidation: 100%, which implies low concentration of ECGC, high concentration of thearubigins.

Flavor: variously described as deep, rich, earthy, sweet, and malty.

Brewing: the cups being used and the pot for brewing the tea should be warmed before any tea leaves are in the pot. Rinse them with warm water. With the loose tea leaves in the pot, bring water to a rolling boil and pour it slowly over the leaves. Steep for 3-5 minutes. Delicate Darjeeling tea should be steeped for 2-4 minutes.

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References

Ref 1: Desai MY, Armstrong DW (2004). Analysis of derivatized and underivatized theanine enantiomers by high-performance liquid chromatography/atmospheric pressure ionization-mass spectrometry. *Rapid Commun Mass Spectrom*. 2004; 18(3): 251-6.

Ref 2: Kakuda T, Nozawa A, Unno T, Okamura N, Okai O (2000). Inhibition effects of theanine on caffeine stimulation evaluated by EEG in the rat. *Biosci Biotechnol Biochem*. 2000 Feb; 64(2): 287-93.

Ref 3: Tea and tea products: chemistry and health-promoting properties. Boca Raton, FL: CRC Press, 2009. 257. Print.

Ref 4: An excellent article on yellow tea processing and what makes it unique. "Junshan Yinzhen : Yellow Tea : HOJO TEA." HOJO TEA. Hojo Co., LTD, n.d. Web. 9 Oct 2010. <http://hojotea.com/item_e/y01e.htm>.

Ref 5: How oxidation effects catechins. Higdon, Jane. "Macronutrient Information Center - Tea." Linus Pauling Institute at Oregon State University. Linus Pauling Institute, 01 Jan 2005. Web. 17 Oct 2010. <<http://lpi.oregonstate.edu/infocenter/phytochemicals/tea/>>.

Ref 6: Flavor profiles of tea. "Tasting Tea | Teasophy." Teasophy. Teasophy, AMES International, n.d. Web. 17 Oct 2010. <<http://www.teasophy.com/education/tasting.aspx?detect=yes>>.

Ref 7: "How to select a Long Jing (Dragonwell) product of your taste." Steepster. Life in a Teacup, May 2010. Web. 17 Oct 2010. <<http://steepster.com/discuss/524-how-to-select-a-long-jing-dragonwell-product-of-your-taste>>.