Summary

Tea, *camellia sinensis*, includes a number of bioactive chemicals including caffeine.

The precise amount of caffeine extracted from tea depends on a combination of factors that include 1) the location or region; 2) the material of the tea leaves; 3) the processing itself; and 4) brewing parameters. The aging of tea is a potential factor, but requires more research.

First, the location or region of the tea matters because of the varietals used when producing tea. In one study, the differences in biochemical indicators, such as caffeine, were examined among green tea because of its wide distribution and processing green tea can vary depending on the region (Fu et al. 2024). They found that the Southwest region (Yunnan, Guizhou, Sichuan, and Chongqing) typically had higher caffeine levels compared to the Jiangnan region (Zhejiang, Hunan, Anhui, Jiangxi, Jiangsu, and Hubei), South region (Guangxi, Fuijan, and Hainan), and Jiangbei region (Shanxi and Shandong). The authors speculate that the Southwest region tend to use large-leaf varieties when producing tea which have a higher caffeine content than small-leaf tea varieties.

Second, the material of tea leaves can impact the level of caffeine. White Tea is known for having a grading system of silver needle (only uses buds), White Peony or BaiMudan (uses two or more larger leaves and one bud), Gong Mei (has a blend of buds and leaves) and Shou Mei (Mostly leaves). One study compared the caffeine content of the different grading levels of White Tea for the same year (Ning et al., 2016). They found that Silver Needle had the highest amount of caffeine concentration followed by Bai Mudan, Gong Mei, and Shou Mei. Thus, the highest grade has the most caffeine and the lowest grade has the lowest levels of caffeine. The grading system for White tea reflects the amount of buds and leaves used when producing tea. Buds and young leaves are likely to have a higher caffeine concentration compared to mature and older leaves.

Third, the processing itself can impact caffeine, specifically roasting and microbial fermentation. Roasting the tea leaves sublimates the caffeine which results in a lower caffeine content (Fu et al., 2024). Several articles have found that oolong teas tend to have lower caffeine levels compared to other types of teas (Hicks et al., 1996; Fu et al., 2024; Zuo et al., 2002). Fermentation, specifically pile-fermentation was found to increase the level of caffeine content in green tea and black and that the effects are more pronounced in green tea (Wang et al., 2005). This seems supported by another where shu pu'er and young raw pu'er were found to have similar caffeine levels (Pedan et al., 2018).

Finally, brewing parameters will ultimately influence how much tea an individual extracts. These parameters include the amount of leaf used during the brewing session, the length of the steeping time, the amount of infusions made, and the temperature of the water (Astill et al., 2001). The more leafs used and longer steeping times, the more caffeine will be extracted. More infusions means an individual will consume more caffeine. Boiling water temperature agitates the tea leaves

more compared to using cooler water temperatures. As a result, using boiling water means extracting more caffeine.

Side Note: The effects of aging tea seem to suggest that as one stores tea for a long period of time, the level of caffeine can increase. When comparing the different ages of Shou Mei from 2013, 2012, 2010, and 1993, caffeine levels did not differ between 2013, 2012, and 2010 (Ning et al., 2016). However, the 1993 Shou Mei had the highest levels of caffeine content compared to the 2013, 2012, and 2010 Shou Mei (Ning et al., 2016). When comparing the different ages of Ya'an Tibetan tea, they found that caffeine levels did not differ much from 1 to 5 years, but that 10 year aging had more caffeine levels compared to 1 year and 5 year aging. For pu'er teas, one study suggests that caffeine levels did not change much from the length of storage for raw pu'er teas (Zhou et al., 2020). These suggests suggest a certain threshold in aging is needed before the caffeine content is increased.

It is unclear whether one should recommend a hard and fast rule for the general amount of caffeine in the type of tea. For example, google searching "which tea has the lowest (or highest) caffeine" will produce results that suggest black/red tea has the highest caffeine content and white tea has the lowest caffeine content. But the material used or the processing production are important factors to consider as well. For example, white tea is claimed to have low caffeine, but this depends on whether young buds or mature leaves are being used (Ning et al., 2016).

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