

Technical Note

Caffeine Content of Brewed Teas

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Caffeine is the world's most popular drug and can be found in many beverages including tea. It is a psychostimulant that is widely used to enhance alertness and improve performance. This study was conducted to determine the concentration of caffeine in 20 assorted commercial tea products. The teas were brewed under a variety of conditions including different serving sizes and steep-times. Caffeine was isolated from the teas with liquid-liquid extraction and quantitated by gas chromatography with nitrogen-phosphorus detection. Caffeine concentrations in white, green, and black teas ranged from 14 to 61 mg per serving (6 or 8 oz) with no observable trend in caffeine concentration due to the variety of tea. The decaffeinated teas contained less than 12 mg of caffeine per serving, and caffeine was not detected in the herbal tea varieties. In most instances, the 6- and 8-oz serving sizes contained similar caffeine concentrations per ounce, but the steep-time affected the caffeine concentration of the tea. These findings indicate that most brewed teas contain less caffeine per serving than brewed coffee.

Introduction

Caffeine is the world's most popular drug and is found in many beverages including tea. Although caffeine is commonly ingested to enhance alertness and improve performance, its use should be avoided by pregnant women, children, and persons with cardiovascular disease and anxiety disorders. For example, studies have demonstrated a link between caffeine ingestion and an increased risk of miscarriage. One study supporting these findings indicates that ingesting > 300 mg per day of caffeine doubles the risk of miscarriage when compared to women whose caffeine intake is < 151 mg per day (1). Another study shows that caffeine consumption of > 300 mg per day is associated with lowered birth weight and smaller head circumference (2).

As for caffeine's effect on children, one study assessed the physiological effects of caffeine on young boys and girls ages 7 to 9 years old. The study demonstrated that, in both boys and girls, caffeine can produce a lower heart rate and higher

blood pressure (3). Caffeine may also affect sleep patterns in teenagers (4).

Because of caffeine's adverse effects, some people may choose to control and/or reduce their caffeine intake. Caffeine is most commonly consumed through coffee, and therefore, many websites suggest switching to tea in order to limit daily caffeine intake. Besides less caffeine, tea can also have health benefits including the prevention and treatment of liver and cardiovascular disease, as well as producing strong bones (5–7).

Black, green, white, and many other teas (but not herbal teas) are prepared from the leaves of the *Camellia sinensis* plant. The leaves are harvested when the plant is about three years old. The different processes for the treatment of the leaves determine which type of tea is produced. Black and green teas are made from young tea leaves and buds. For black tea, the leaves are allowed to oxidize for two to three days, whereas green tea is not allowed to oxidize at all. Instead, the leaves are steamed and then quickly dried and stored. Like green tea, white tea leaves are not allowed to oxidize. The difference between green and white tea is the time at which the leaves are harvested. The leaves and buds used to make white tea are harvested before the tea leaves are fully opened and are still covered with thin white hairs (8).

Method

Twenty different commercial tea products, including black, green, white, decaffeinated, and herbal, were purchased with the following brands being represented: Bigelow, Lipton, Stash, Tazo, Twinings, and Two Leaves and a Bud. Each tea was brewed at 1, 3, and 5 min steep-times. All 20 varieties were brewed in 6 oz of water, and 8 of them were also brewed in 8 oz of water for comparison purposes.

A standardized procedure was utilized for brewing tea from the different commercial products. To brew the teas, a beaker was filled with the appropriate amount of deionized water—either 6 or 8 oz. A stir bar was added to the beaker, and the liquid was stirred and heated until lightly boiling at 90–95°C. The beaker was then removed from the heat, and the tea bag was held in the beaker for the allotted time while lightly stirring. The tea bag was then removed, and the liquid was stirred

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Table I. Caffeine Content of Brewed Teas (6 oz Serving Size) with Different Steep-Times

Brand	Tea Type	Steep-Time		
		1 min mg/6 oz	3 min mg/6 oz	5 min mg/6 oz
Bigelow Cranberry Apple Herb Tea	herbal	ND*	ND	ND
Tazo Passion	herbal	ND	ND	ND
Bigelow Constant Comment	decaf/black	< 1.8 [†]	< 1.8	1.8
Lipton Decaf	decaf/black	< 1.8	2.7	3.1
Stash Premium Green Decaf	decaf/green	5.5	8.7	10
Lipton Regular	black	17	38	47
Stash Darjeeling Black	black	14	22	27
Stash Earl Grey Black	black	24	41	47
Tazo Awake	black	59	59	61
Tazo Earl Grey	black	40	57	59
Twinings Earl Grey	black	19	22	29
Twinings English Breakfast	black	14	22	25
Twinings Irish Breakfast	black	17	24	30
Twinings Lady Grey	black	14	29	30
Twinings Prince of Wales	black	14	26	29
Two Leaves and a Bud Organic Darjeeling	black	19	39	49
Tazo China Green Tips	green	23	46	41
Stash Premium Green	green	16	27	36
Stash Fusion Green and White	green/white	15	26	28
Exotica China White	white	23	41	47

* ND = none detected.
[†] < 1.8 indicates that caffeine was detected, but the concentration was below the limit of quantitation.

for 30 s. The temperature was checked, and the beaker was left to cool for 1 h. The liquid was stirred on high for 2 min. Finally, 12 to 15 mL of the liquid was transferred to a conical tube, labeled, and stored at 4°C.

Caffeine analysis was performed using a previously validated method that utilized liquid–liquid extraction followed by gas chromatography with nitrogen-phosphorus detection. The method has been used previously to quantitate caffeine in a variety of cold and hot beverages (9–11). Quantitation of caffeine was determined with linear calibration curves (4–6 points) that encompassed the wide range of caffeine concentrations present in brewed teas. For example, higher caffeine concentrations were determined with a linear range of 25–500 mg/L, and lower concentrations determined with a linear range of 10–100 mg/L. The limit of quantitation was 10 mg/L (or 1.8 mg/serving), and the limit of detection was 2.5 mg/L. Quality control samples were prepared in water and interspersed throughout the analytical batch, representing a minimum of 10% of the batch. Control sample concentrations were appropriate for the corresponding curve (e.g., 50, 75, and 250 mg/L).

Results and Discussion

The amount of caffeine detected in the brewed teas ranged from none detected to 61 mg/serving. The results are detailed in Tables I and II. Caffeine was not detected in either of the herbal teas tested, and all of the decaffeinated teas yielded < 12 mg/serving of caffeine. The caffeinated tea varieties (black, green, and white) yielded a caffeine content ranging from 14 to 61 mg/serving. There were no observable trends with the different tea varieties.

Table II shows a comparison between the 6- and 8-oz servings and demonstrates that an 8-oz serving typically had a higher caffeine content. The caffeine extraction efficiency was calculated for the different steep-times (1, 3, and 5 min) for both serving sizes (6 and 8 oz). The mean extraction efficiency (%) was determined by the ratio of the caffeine concentration in two different steep-times. In the 6-oz serving, the mean

Table II. Caffeine Content of Brewed Teas Based on Serving Size and Steep-Time

Brand	Tea Type	Steep-Time					
		1 min		3 min		5 min	
		mg/6 oz	mg/8 oz	mg/6 oz	mg/8 oz	mg/6 oz	mg/8 oz
Lipton Decaf	decaf/black	< 1.8*	2.8	2.7	3.9	3.1	4.2
Stash Premium Green Decaf	decaf/green	5.5	8.6	8.7	9.2	10	11
Lipton Regular	black	17	29	38	47	47	49
Stash Darjeeling Black	black	14	26	22	36	27	44
Stash Earl Grey Black	black	24	39	41	48	47	51
Stash Premium Green	green	16	24	27	29	36	39
Stash Fusion Green and White	green/white	15	30	26	35	28	36
Exotica China White	white	23	32	41	37	47	34

* < 1.8 indicates that caffeine was detected, but the concentration was below the limit of quantitation.

extraction efficiency was 60% and 87% for the 1-min steep-time compared to the 3-min steep-time and the 3-min steep-time compared to the 5-min steep-time, respectively. For the 1-min steep-time compared to the 3-min steep-time, one tea (Tazo Awake) was an exception with 100% extraction efficiency. Likewise, there was an exception (Tazo China Green Tips) of 112% extraction efficiency in the 3-min steep-time compared to the 5-min steep-time. In the 8-oz serving, the mean extraction efficiency was 78% and 89% for the 1-min steep-time compared to the 3-min steep-time and the 3-min steep-time compared to the 5-min steep-time, respectively. One tea (Exotica China White) had an extraction efficiency of 108% for the 3-min steep-time compared to the 5-min steep-time. These calculations indicate that the brewing conditions of steep-time and serving size do in fact affect the caffeine content of brewed teas. Overall, longer steep-times increase the caffeine content. Also, when brewed in a larger serving size, one tea bag tends to yield a larger amount of caffeine. However, when concentrations per ounce are calculated, the caffeine content is typically similar.

When compared to previous studies, the caffeine concentration (per oz) in brewed teas tended to be lower than in specialty coffees and energy drinks, but similar or higher than carbonated sodas. Furthermore, decaffeinated brewed teas tended to have higher caffeine concentrations than brewed decaffeinated coffees (per oz), but lower than decaffeinated espresso (9–11).

Although it is desirable to consumers that tea packages contain information on caffeine content, only Two Leaves and a Bud and Lipton refer to caffeine on the product label. Two Leaves and a Bud states that Organic Darjeeling contains less caffeine than coffee. Lipton reports concentrations of 55 mg/serving for its regular tea and 5 mg/serving for its decaffeinated tea, which are, in fact, consistent with the findings of

this study. Declaring the caffeine content on product labels is important for consumers wishing to limit caffeine intake.

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