

Caffeine and Epigallocatechin Gallate in Coffee Leaf Tea

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Contributor: Dirk W. Lachenmeier

Coffee leaf tea is prepared as an infusion of dried leaves of *Coffea* spp. in hot water. It is a traditional beverage in some coffee-producing countries. From the various ingredients contained in coffee leaves, only two were highlighted as possibly hazardous to human health, namely, caffeine and epigallocatechin gallate (EGCG). Depending on selection and processing (age of the leaves, drying, fermentation, roasting, etc.), coffee leaf tea may exhibit a wide variety of flavors, and its full potential is currently almost unexplored.

coffee leaf tea

novel food

Coffea arabica

caffeine

epigallocatechin gallate

1. Introduction

The *Coffea* genus consists of several species and approximately 6000 varieties ^[1]. The most important coffee species are *C. arabica* and *C. canephora*.

As mentioned by Haller et al. ^[2], *Camellia sinensis* tea is the most widely consumed drink in the world directly after water. It is obvious that making tea from coffee leaves may offer economic potential in the coffee-growing regions ^[3]. **Figure 1** and **Figure 2** show examples of coffee leaves on coffee plants.



Figure 1. Coffee leaves (*C. arabica*) ((A–C): strong, dark brown, new shoots).



Figure 2. Fresh shoots on branches with flowers (A,B) and fruits (C) (*C. arabica*; newly sprouted leaves are darker than older ones).

For illustration, **Figure 3** shows some examples of brewed coffee leaf tea, whereas **Figure 4** shows some examples of dried and chopped coffee leaves for tea infusions.

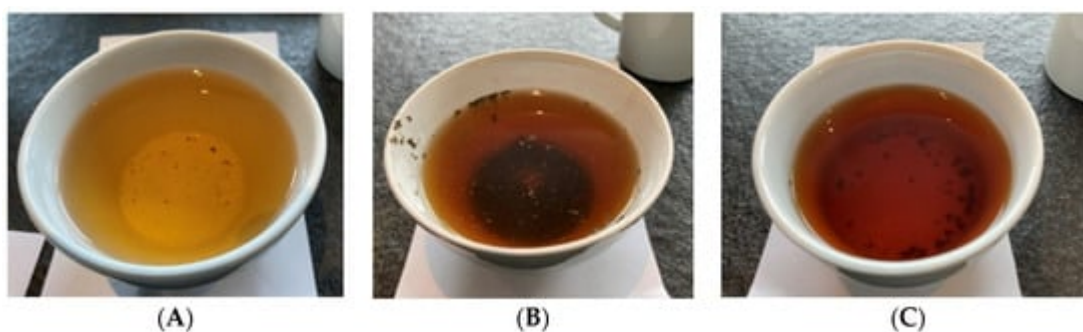


Figure 3. Examples of brewed coffee leaf tea infusions (water extraction)—different processing shows different colors. Preparation: 2 g of dried coffee leaves/100 mL water ((A) = Bourbon, old leaves, air/sun dried, wild fermentation; (B) = Pacamara, old leaves, whole leaves, oven-dried, no fermentation; (C) = Bourbon, old leaves, whole leaves, roasted, no fermentation).

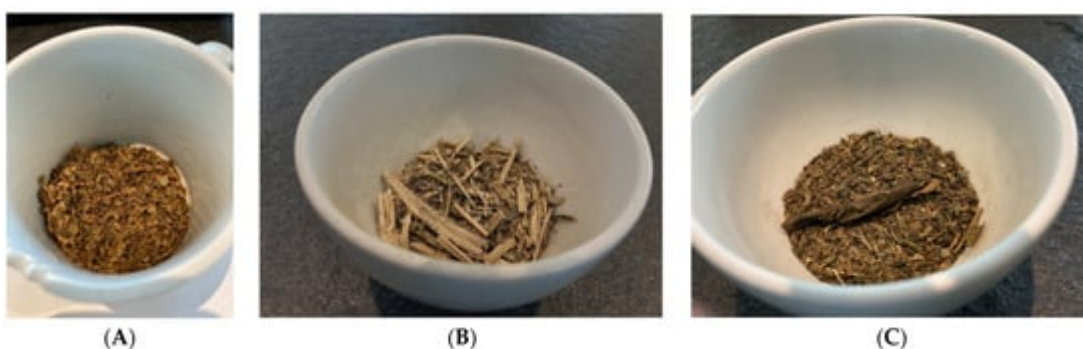


Figure 4. Examples of dried coffee leaf tea ((A) = Pacamara, yellow leaves, mixed, air/sun dried, fermentation by yeast; (B) = Bourbon, whole water shoots, chopped, 1-h steam distilled, air/sun dried; (C) = Bourbon, old leaves, mixed, air/sun dried, wild fermentation).

2. Composition of Coffee Leaf Tea

2.1. Ingredients

Caffeine and EGCG are naturally found in coffee leaves [4][5]. As described by Zheng et al. [6], caffeine is a purine alkaloid found mainly in young leaves and shoots including buds and cotyledons, whereas caffeine is not detected in roots, aged cotyledons or older brown parts of shoots [6]. The results of the aforementioned publication suggest that caffeine accumulation is specific to the above-ground parts (leaves, cotyledons, and shoots) of the seedlings and that biosynthesis is performed in young tissues. The authors describe caffeine synthesis as a defense mechanism of the (soft) parts of plants against predators [6]. Frischknecht et al. [7] found that the formation of purine alkaloids is costly for the plant [7].

Plant-based phenols such as EGCG are products of the plant's secondary metabolism [8]. In contrast to black tea, green tea is neither fermented nor oxidized. Due to that, polyphenols such as epicatechin (EC), epicatechin-3-gallate (ECG), epigallocatechin (EGC), and epigallocatechin gallate (EGCG) can make up about 59% of the catechin content [2]. The proportion of phenolic compounds in fresh, young tea leaves of the tea plant is high [1].

The infusion of coffee leaves is a beverage rich in several bioactive compounds (e.g., chlorogenic acids, xanthones [9], trigonelline, adenine-7-glucosyl, quercetin, and mangiferin [10][11], not only polyphenols (catechins) and caffeine described above.

2.2. Analytical Results

In a recent project conducted with coffee leaves from El Salvador, various coffee leaf teas were analyzed, among other factors, for their caffeine and EGCG content [12]. The samples examined differed in terms of the age of the leaves used, drying, fermentation, and other processing conditions (see examples in **Table 1**). A total of 24 different samples were produced.

Table 1. Some examples of coffee leaf tea samples prepared in El Salvador.

Picture	Coffea arabica Variety	Processing	
		Leaves	Drying, Fermentation
	Pacamara	old leaves, mixed	air/sun dried, fermentation by yeast (<i>Saccharomyces cerevisiae</i> , var. <i>bayanus</i>)

Picture	Processing		
	<i>Coffea arabica</i> Variety	Leaves	Drying, Fermentation
	Pacamara	yellow leaves, mixed	air/sun dried, fermentation by yeast (<i>Saccharomyces cerevisiae</i> , var. <i>bayanus</i>)
	Pacamara	old leaves, whole leaves	Oven-dried, no fermentation
	Pacamara	yellow leaves, mixed	air/sun dried, wild fermentation
	Bourbon	whole water shoots, chopped	1 h steam distilled, air/sun dried
	Bourbon	old leaves, whole leaves	air/sun dried, no fermentation
	Bourbon	old leaves, mixed	air/sun dried, wild fermentation
	Bourbon	old leaves, whole leaves	roasted, no fermentation

10. Chen, X.; Mu, K.; Kitts, D.D. Characterization of phytochemical mixtures with inflammatory modulation potential from coffee leaves processed by green and black tea processing methods. Food Chem. 2019, 271, 248–258.

11. Chen, Y. and Z. Kottmann. Effects of processing method and age of leaves on phytochemical profiles and bioactivity of coffee leaves. *Food Chem.* 2018, 249, 143–153.

3.1. Caffeine Exposure

12. Steger, M.C. Coffee Leaf Tea from El Salvador: On-Site Production Considering Influences of Processing on Chemical Composition. Master's Thesis, University of Hohenheim, Hohenheim, Germany, 2021.

The taste of Arabica coffee is particularly aromatic, soft, and mild. In contrast, *C. canephora* coffee of most commercial qualities is perceived to be less delicate and develops a higher caffeine content [13]. In addition to many ingredients such as flavorings and aromas, the coffee beans of both varieties contain caffeine. In small amounts, this primarily affects the central nervous system and increases the capacity for mental absorption and memory [13].

13. Medaner, T. Genusspflanzen, 1st ed., Springer, Berlin/Heidelberg, Germany, 2018.

14. National Center for Biotechnology Information. PubChem Compound Summary for CID 2519, Caffeine. Available online: <https://pubchem.ncbi.nlm.nih.gov/compound/Caffeine> (accessed on 30 October 2021).

While at the same time the resulting fatigue is reduced [13]. Therefore, it is not surprising that coffee has an image as a stimulant (central nervous system stimulant) [13][14]. However, consuming it in excessive quantities can cause anxiety, insomnia as well as nausea, vomiting, diarrhea, and gastrointestinal upset [13][14].

15. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans; International Agency for Research on Cancer, World Health Organization. Coffee, Tea, Mate, Methylxanthines and Methylglyoxal, WHO, Lyon, France, 1991.

According to the WHO assessment of the carcinogenicity of caffeine in humans and also in laboratory animals, there is insufficient evidence that caffeine is carcinogenic. Caffeine was therefore classified as group 3, i.e., not classifiable, concerning its carcinogenicity for humans [15]. Intoxication with caffeine is also included in the World Health Organization's International Classification of Diseases (ICD-10) [14]. Caffeine levels of 57 mg/kg intravenously or oral doses of 18–50 g are lethal in human adults [14].

16. Haytowitz, D.B. USDA Database for the Flavonoid Content of Selected Foods, Release 3.1: USDA, Washington, DC, USA, 2014.

17. EFSA. Panel on Food Additives and Nutrient Sources added to Food Scientific opinion on the safety of green tea catechins. *EFSA J.* 2018, 16, 605269.

3.2. Exposure to (–)-Epigallocatechin-3-Gallate (EGCG)

Retrieved from <https://encyclopedia.pub/entry/history/show/44516>

According to Haller et al. [2], polyphenols are the most common antioxidants. Naturally, they are available in fruits, vegetables, grains, legumes, chocolate, and beverages such as tea, coffee or wine [2]. According to the USDA database, EGCG is found in many everyday foods, such as dairy products, apples or bananas [16].

The EGCG content, which is potentially liver damaging (above 800 mg of EGCG/day), does not relate to tea drinks but to extracts [17]. Therefore, from a toxicological perspective, the caffeine content is the focus of attention. However, a value of more than 800 mg of EGCG/day is not reached with normal daily coffee leaf tea consumption.

4. Conclusions

In contrast to black and green tea infusions, which are consumed as traditional foods, coffee leaf tea contains higher levels of caffeine, with the content roughly corresponding to that of coffee beans. The amount of caffeine in coffee leaf tea depends on the processing, the plant (species, variety), the harvest season, the age of the leaves, and the beverage preparation (dosage, temperature, etc.). Due to the caffeine content, up to three cups of coffee leaf tea, drunk throughout the day, are considered safe. Since coffee leaf tea is a niche item in Europe, it is unlikely that this amount will be exceeded.

The positive effects of caffeine and EGCG are less obvious due to the (still) low consumption of coffee leaf tea and should be examined more closely. No EGCG could be detected in our coffee leaf tea samples examined. The results of the analytical data (all species and varieties) for caffeine and EGCG are below the EFSA Safety Thresholds and can be considered safe with moderate consumption in terms of toxicity or side effects.

According to Miedaner ^[13], it takes around nine months before coffee fruits can be harvested. In the press, it has been repeatedly reported that the current coffee prices are well below the production costs. Since it is a plant with evergreen leaves, its leaves can be harvested all year long and therefore represent an additional source of income for coffee farmers, as coffee beans and leaves are from the same plant ^[3].

Finally, it should be noted that EGCG and caffeine in coffee leaf tea occur in a specific matrix rich in polyphenols. This results in differences regarding bioavailability and effects compared with the isolated substances investigated in most studies.