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Caffeine Content Investigation in the Turkish Black Teas

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***Abstract*—**Tea is a widely consumed beverage that contains many components. Caffeine belongs to this group of components called alkaloids contain nitrogen. In this study caffeine contents of three types of Turkish teas are determined by using extraction method. After condensation process, residue of caffeine and oil are obtained with evaporation. The oil which is in the residue is removed by hot water. Extraction process performed by using chloroform and the crude caffeine is obtained. From the results of experiments, caffeine contents are found in black tea, green tea and earl grey tea as 3.57±0.43%, 3.11±0.02%, 4.29±0.27%, respectively. Caffeine contents which are found in 1, 5 and 10 cups of tea are calculated. Furthermore, the daily intake of caffeine from black teas that affects human health is investigated.

***Keywords*—**Caffeine, extraction, tea, health.

I. Introduction

TEA is one of the most widely popular nonalcoholic beverage that comes after water, which are produced about 2.5 million tons of tea in the world every year. Tea is made from the processed leaves of a plant, *Camellia sinensis* (Fig. 1 (a)). Tea is the agricultural product of the leaves, leaf buds, and internodes of the *Camellia sinensis* plant, prepared and cured by various methods [1].

Green tea (Fig. 1 (b)) and black tea (Fig. 1 (c)) are the two most popular types of Turkish Teas. The leaves of green tea are dried and roasted but not fermented, whereas black tea leaves are additionally fermented. In the fermentation, the enzymatic oxidation of tea polyphenols takes place leading to the formation of chemical compounds, which are responsible for the characteristic aroma, and color of teas [2].

To produce green tea, the leaves are chopped, rolled and quickly steamed or heated which inactivates polyphenol oxidase. For black tea the leaves are kept warm for 6 hours and the leaf polyphenols, especially the catechins, are oxidized and condensed. Tea drink is prepared by adding the dried leaf in hot or boiling water. It has a cooling slightly bitter astringent flavor which many people enjoy [3].

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(a) (b) (c)

Fig. 1 (a) *Camellia sinensis* (b) black tea (c) green tea [4]

Earl Grey tea is kind of specific tea. Earl Grey tea refers more to the bergamot oil that is used to flavor the tea then the tea base itself. Bergamot is used in Earl Grey tea, and is also often used in aroma therapy, and is considered an essential oil. Bergamot is a citrus fruit, the size of an orange but with an appearance more like a lemon; it is often called the bergamot orange. Bergamot essential oil stimulates the work of the brain, improves concentration and increases immunity [5].

Caffeine (Fig. 2) is a naturally occurring alkaloid which is found in the leaves, seeds or fruits of over 63 plants species worldwide [6]. It is often found in natural products such as tea, coffee and cocoa beans, cola nuts and many others [7]. Caffeine belongs to a large group of natural products that contain nitrogen and have basic properties. This group of natural products is called alkaloids [8].

The amount of caffeine in products varies depending upon the serving size, the type of product, and the preparation method [9].

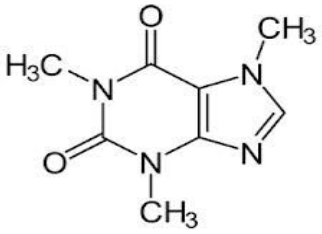

Fig. 2 Structure of caffeine molecule [10]

Caffeine acts as a stimulant, where as it stimulates the heart, respiration and the central nervous system. It is also a diuretic molecule. Ingesting caffeine generally produces a sensation of heightened alertness. Caffeine is added to soft drinks as a flavoring agent; it imparts a bitterness that modifies the flavors of other components, both sour and sweet [11]. The caffeine content of teas varies from 1-5%.

The purpose of this study is to determine the contents of caffeine in the black, earl grey and green teas.

II. Experimental Procedure

A. Preparation of the Tea Samples

Black tea, earl grey tea and green teas are purchased from the local market in Istanbul, Turkey. Teas are used in the analysis without pre-treatment

B. Caffeine Analysis

Extraction method is used for the analysis of caffeine. In this method, ammonia solution is poured to tea in the flask. After a few minutes, chloroform solution is added to the flask.

Then a condenser is placed on the flask and allowed to stand on the water bath for 30 minutes which is shown in Fig. 3.

Fig. 3 Condensation process

After the condensation process, the mixture is filtered into another flask. First flask is rinsed two times with chloroform solution in order to take all of the teas. The filtrate is evaporated on a water bath. After the evaporation, residue of caffeine and oil is obtained which is shown in Fig. 4.

Fig. 4 Residue of caffeine and oil

To separate oil from the mixture hot pure water is added to the residue. The mixture is heated in a water bath while stirring it gently from time to time with a glass rod and cooled to a room temperature. Potassium permanganate solution is added into the flask and left at room temperature for a few minutes. Then hydrogen peroxide solution is added to remove the color of the solution. If the mixture was still colored the addition of hydrogen peroxide solution is continued. The mixture is heated in a water bath for 15 minutes and allowed to cool to a room temperature. After cooling, mixture is filtered using a filter paper. The flask is washed three times with distilled water, filtered and the filtrate is collected. Fig. 5 shows the filtration process.

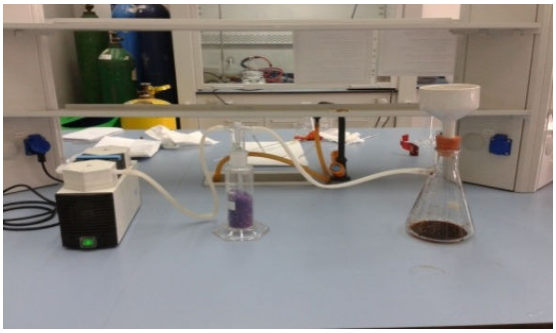

Fig. 5 The filtration process

Filtrate is poured into a separation funnel and rinsed by adding chloroform solution to separate two phases (Fig. 6). The bottom phase is taken into a beaker.

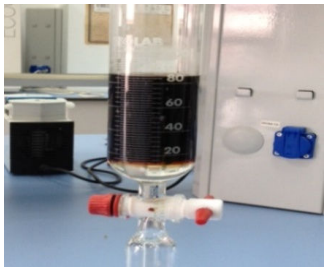

Fig. 6 Two phase in the separator funnel

The collected chloroform solutions are evaporated in water bath and pure caffeine is obtained. In Fig. 7 the crude caffeine is shown.

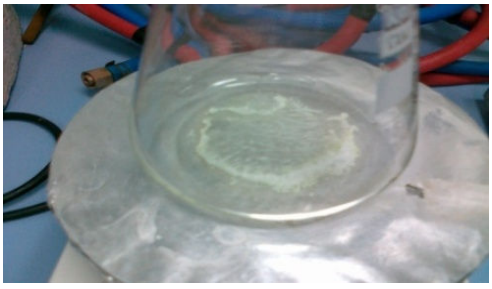

Fig. 7 Crude caffeine

III. Results and Discussion

Analysis results are shown in Table I. From the results obtained the maximum caffeine content is seen in the black tea, and followed by green tea and earl grey tea. The average caffeine content in green tea is analyzed as 3.11%. Also the average caffeine content in earl grey and black tea is analyzed

as 3.57 %, 4.29 %, respectively. As can be seen from the table, caffeine content in the earl grey tea is the highest and it is followed by black tea and green tea.

TABLE I
CAFFEINE CONTENTS OF TURKISH TEAS

Tea Type	Caffeine Content (%)
Black Tea	3,57±0,43
Green Tea	3,11±0,02
Earl Grey Tea	4,29±0,27

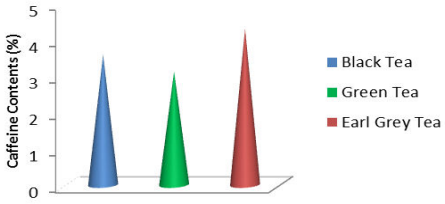

Fig. 8 Caffeine content of teas

IV. CONCLUSIONS

Human daily maximum caffeine intake is given in Table II.

TABLE II
MAXIMUM DAILY CAFFEINE INTAKE [12]

Recommended Maximum Daily Caffeine Intake (mg)	
4-6 Years	45
7-9	60
10-12	85
Women of Childbearing Age	300
Adults	400-450

The green teas and black teas have received a great deal of attention from researchers and the general public due to their possible beneficial health effects. Caffeine is one of the most comprehensively studied ingredients in the food supply. The per capita consumption level of caffeine for all consumers (of all ages) is approximately 120 mg per day, or a mean intake of 1.73 mg/kg body weight/day [11].

Children consume significantly less caffeine than adults. The average daily intake of caffeine by young children ages 1-5 and 6-9 years from all caffeinated beverages was 14 and 22 mg/day, or 0.82 and 0.85 mg/kg body weight/day, respectively [11].

Caffeine is a pharmacologically active substance and, depending on the amount consumed, can be a mild stimulant to the central nervous system. Consumption of caffeine prior to exercise has been shown to improve endurance during physical exercise [13].

From the results obtained in this study it can be said that both three types of teas caffeine content in 1 cup lower than daily maximum caffeine intake for adults. For black tea and green tea, amount of caffeine in 5 cups are lower than daily intake but caffeine content of earl grey tea is equal to maximum value. The value is shown in Tables III and IV.

TABLE III
DAILY CAFFEINE INTAKE

	Daily Caffeine Intake (mg)		
	Black Tea	Green Tea	Earl Grey Tea
1 Cup	71,4	62,2	85,8
5 Cup	357	311	429
10 Cup	714	622	858

TABLE IV
DAILY CAFFEINE INTAKE FOR ADULTS

	Daily Caffeine Intake for Adults (%)		
	Black Tea	Green Tea	Earl Grey Tea
1 Cup	16.26 – 17,85	14,04-15,55	19,06-21,45
5 Cup	81,33 – 89,25	70,2-77,75	95,3-107,25
10 Cup	162.6 – 178,5	140,4-155,5	190,6-214,5

For a tea addict person who drinks ten cups of black tea, green tea or earl grey tea takes more caffeine than daily maximum intake.

As seen that both three types of teas can reach the maximum daily caffeine intake.

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