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Authors: Tahsin ERTAŞ, Bircan DİNÇ, Recep ÜSTÜNSOY

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Calorimetric Analysis of Tea and Coffee

Tahsin ERTAŞ [*1], Bircan DİNÇ[2], Recep ÜSTÜNSOY[3]

Abstract

Tea and coffee are the most popular beverage and there is a variety of forms in both hot and cold temperatures. Black tea is made from green tea leaves that have been oxidized. During the oxidation process, a certain proportion of polyphenol compounds is lost. More than a thousand chemical components can be found in coffee, making it a complex beverage. One of the significant factors that is stressed equally to the scent and flavor of coffee is the caffeine content. Differential Scanning Calorimetry (DSC) was employed in our study to compare the properties of Turkish coffee, green and black tea, and certain instant coffee brands. The evaluated teas and coffees belong to the most consumed brands in Turkey. Caffeine, which has a melting temperature of 234°C was found in abundance in green teas but not in black teas. Glass transition temperatures (Tg) for tea kinds were found to be approximately 40°C. Polyphenol content melting values are known to be approximately 67-75°C, and the study has verified that teas are high in polyphenol content. The findings of the coffee study showed that the peaks at 170 and 201°C were caused by the melting of several elements, including amino acids, lipids, and sugars, including sucrose, glucose, fructose, arabinose, galactose, maltose, and polysaccharides. Caffeine bonds are broken and degraded at temperatures of 253, 266, 278 °C, resulting in exothermic maxima. The endothermic curves at 39, 41, and 71 °C for pure coffee at three different roast levels are shown. The breakdown of the cellulose components causes the transitions to be visible between 389 and 494°C. The findings of this investigation demonstrated that instant coffees have a higher additive content than Arabica coffee.

Keywords: Tea, coffee, polyphenols, differential scanning calorimetry, caffeine

1. INTRODUCTION

Per capita consumption of tea and coffee, which are the most preferred hot beverages, is increasing in many countries. The tea plant (*Camellia sinensis*) is a short camellia species from the "Theaceae" family that thrives in humid regions with plenty of rain and it stays green all year. Chinese tea, which is mostly cultivated in China, Japan, and Taiwan, and Assam tea, which is widely consumed in South and Southeast Asia, are the two types of tea. Turkey is the country that consumes the most tea in the world and

* Corresponding author: ertastahsin@gmail.com (T. ERTAŞ)
[1] Istanbul University, Istanbul Faculty of Medicine, Department of Biophysics, Istanbul, Turkey
E-mail: ertastahsin@gmail.com
ORCID: https://orcid.org/ 0000-0002-1572-1383,
[2] Bahcesehir University, Faculty of Medicine, Department of Biophysics, Istanbul, Turkey
E-mail: dincbircan@gmail.com ORCID: https://orcid.org/ 0000-0002-9717-6410
[3] Atlas University, Faculty of Medicine, Department of Biophysics, Istanbul, Turkey
E-mail: ustunsoyrecep@gmail.com ORCID: https://orcid.org/ 0000-0002-0448-9531

Chinese tea is consumed. Black tea, green tea, oolong tea, and white tea are the other four categories into which tea can be divided [1-4]. Tea is made by steeping *Camellia sinensis* L. leaves in hot water. Around 20% of the world's yearly supply of tea is green tea, 2% is oolong tea, and 78% is black tea [5]. Tea has about 4,000 compounds in it; some of them are polyphenols, caffeine, minerals, amino acids, and carbs are the most common. The tea's content changes based on the fermentation method utilized. Tea has been found to have antioxidants, anti-inflammatory, antimutagenic, anticarcinogenic, anti-obesity, antidiabetic, antibacterial, antiviral, and anti-aging benefits in the literature [6, 7]. The different polyphenols are responsible for their health benefits. To avoid fermentation and oxidation, fresh leaves are dried and steamed to create green tea. The main polyphenolic components in green tea are catechins, which include epigallocatechin-3-gallate (EGCG). Due to EGCG's numerous preventive benefits against cancer and other diseases like diabetes, neurological and cardiovascular diseases, it has received a lot of study attention. Numerous epidemiological and clinical research has shown that taking green tea supplements significantly reduces the risk of developing chronic diseases. To make black tea, the tea leaves must first oxidize by being exposed to air. The flavor of the leaves is enhanced during the oxidation process, which turns them a dark brown color. After that, either the leaves are left alone or roasted, dried, and crushed. The primary thearubigins, theaflavins, flavonols, and catechins found in black tea are. Black tea is the most important source of dietary polyphenols for humans [6, 8].

Coffee is a beverage that has been in our lives for centuries, although its origin as a name and its presence as a plant is not exactly clear. Today, coffee consumption has become an indispensable part of social life with different cultural habits all over the world and it attracts increasing commercial interest [9]. Coffee is a beverage obtained by roasting and grinding the fruit seeds of this tree in the coffee genus of the Rubiaceae family. Coffee beans are the seeds of the tree known as the coffee cherry. Because coffee trees are in a continuous cycle, it is possible to see flowers, green fruit, and ripe fruit on a single tree at the same time. The two main species grown commercially are Coffee canephora (a form known predominantly as 'robusta') and Coffee arabica [10]. It includes many rituals from making Turkish coffee to serving it. Turkish coffee is an important part of social life in Turkey with its taste, aroma, smell, foam, and unique cooking and serving methods.

Coffee is one of the most popular drinks in the world due to its flavor and various health benefits. Coffee is a sophisticated beverage with over a thousand different chemical constituents, including lipids, alkaloids, phenolic compounds, vitamins, minerals, and nitrogenous substances. One of the crucial factors that is stressed as much as the scent and flavor of coffee is the caffeine content [11]. Many studies have shown that drinking coffee stimulates the brain, enabling it to work more efficiently and actively, increasing the body's metabolic rate and being beneficial in some ailments. The positive effects of coffee on health are due to its rich phytochemistry, especially caffeine, chlorogenic acid, caffeic acid, and hydroxyhydroquinone (HHQ). Studies have shown that coffee consumption has a reducing effect on diabetes mellitus, various types of cancer, Parkinson's, and Alzheimer's disease. Caffeine and its metabolites also aid in proper cognitive functioning. The coffee lipid fraction, which contains cafestol and kahweol, acts as a protection against certain malignant cells by modulating detoxifying enzymes. On the other hand, Butt et al., stated that their high levels raise serum cholesterol, for example, myocardial and cerebral infarction, insomnia, and cardiovascular complications pose a significant threat to coronary health [12].

Although coffee trees do not grow in Turkey, "Turkish Coffee" has gained worldwide acceptance with its special cooking method and serving methods. Turkish coffee is made by slowly cooking the coffee beans in water, which is obtained by blending high-quality Arabica coffee beans with medium roasted coffee in a copper pot [13]. As of 2013, “Turkish Coffee Culture and Tradition” has been included in the UNESCO Intangible Cultural Heritage list [14].

Instant coffee has been produced as a commercial idea so that everyone can easily make coffee anywhere. Their construction is much more practical to the purpose of their invention. They can be easily prepared anywhere with just hot water. People can quickly make hot coffee using instant coffee, also known as coffee crystals or ground coffee, by adding hot water to the packet mix and stirring. Nearly 50% of the green coffee produced in the world is used in making instant coffee [15]. Because the Arabica beans contain more soluble solids and thus increase the yield, in many places robusta coffee can be used alone or in blends determined for instant coffee production as a higher percentage compared to Arabica coffee [16].

Although many studies show that coffee consumption has positive effects on metabolic diseases, it is necessary to consider the types of coffee consumed and the additives in these coffees. In the research conducted here, calorimetric analysis of green tea and black tea; different brands of instant coffees, and Turkish coffee was performed. In the measurements made with differential scanning calorimetry, the differences between the glass transition temperatures and characteristic peaks of the samples were evaluated. In addition, evaluations were made regarding their additives.

2. MATERIAL AND METHOD

2.1. Collecting Turkish coffee and instant coffees

Different types of green tea, black tea, instant coffee, and Turkish coffee sold in the markets were purchased.

2.2. DSC analysis

Calorimetric measurements were made using a Shimadzu DSC-60 Plus. Samples of tea and coffee were each given a 3 mg weight. Aluminum pans that had been sealed were heated at a rate of 10 °C min-1 from 10 °C to a final temperature of 600 °C. Measurements were made in a nitrogen-filled environment (50 mL min-1).

2.3. Statistics

All assays were conducted in triplicate. Mean and standard deviations were estimated using analysis of variance.

3. RESULTS AND DISCUSSION

In recent years, DSC has become very common in food research to determine the heat resistance, quality, and additives that the products may contain. It drew attention because it was worked with a small amount of sample and no treatment was applied to the sample beforehand [17]. DSC measurements are also suitable methods for determining the characteristic melting curves of tea and coffee and the differences between different types. DSC was applied to assess the characteristic peaks and thermal stability. The same amount of two known brands of black tea and one common green tea brand was measured (Figure 1)

Green tea is the most popular choice because it is high in a type of polyphenol called epigallocatechin gallate (EGCG). EGCC is a powerful antioxidant (Figure 2 A) and is known to be beneficial for the brain and heart [18]. Theaflavin is the polyphenol that is most prevalent in black tea (Figure 2B). It is a powerful antioxidant like EGCG and

helps regulate fat cells and speed up metabolism [19]. Polyphenol content melting values are known to be approximately 67-75°C [20], and the study has verified that teas are high in polyphenol content. Furthermore, the greater the polyphenol ratio, the higher the peak temperature value [21], therefore the polyphenol ratio in green tea may be claimed to be higher based on the results.

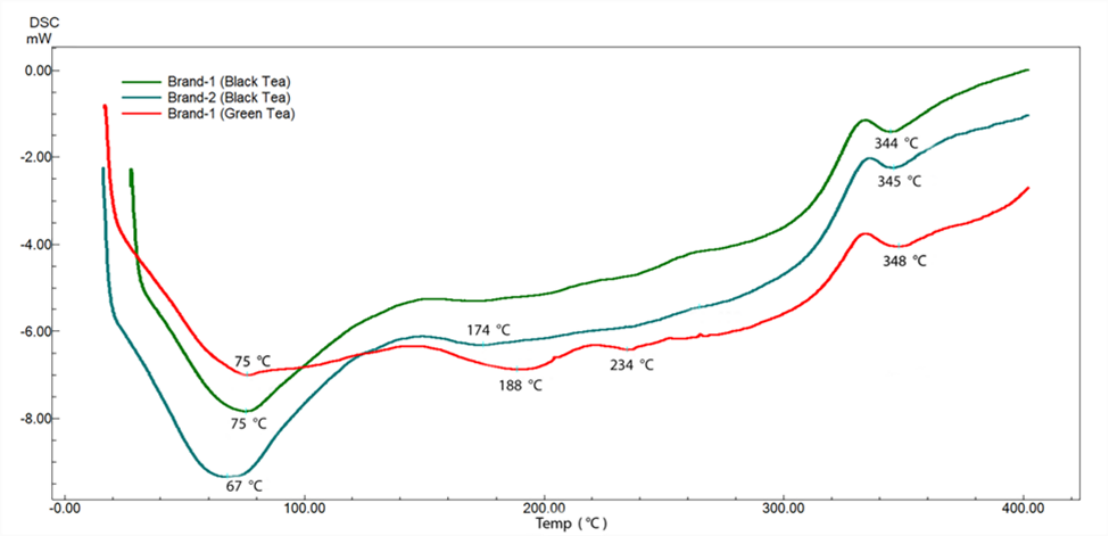

Figure 1 DSC thermograms of 3 different tea samples

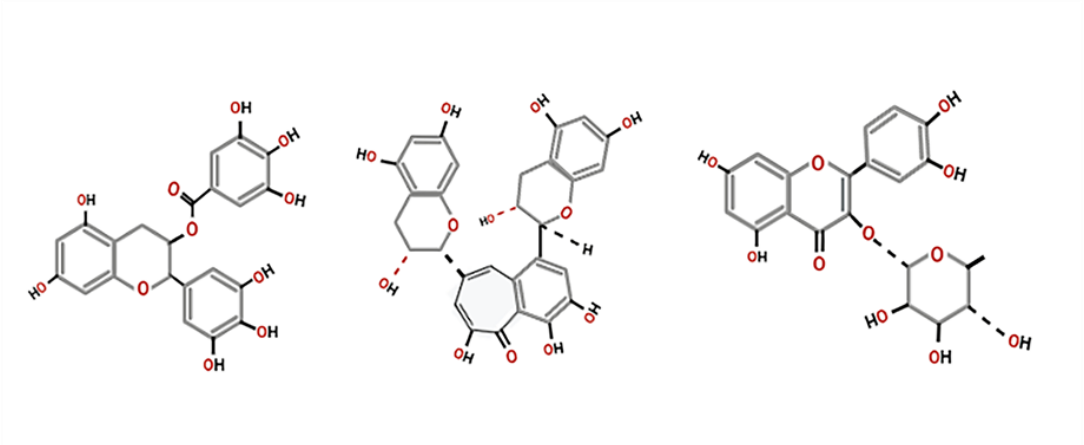

Figure 2 2D Structures of A) EGCG (left), B) theaflavin (right) C) quercetin glucoside

In the literature, results similar to a small plateau at 174 ± 0.5 and 188 ± 0.4°C were obtained in DSC measurements made from green tea extract which belongs to catechin [22]. However, the peak after 340°C was first given in the measurements here since temperatures were not reached up to 400. The peak after 340°C is the characteristic peak of quercetin glucoside [23]. DSC measurements from both green and black tea revealed a peak indicating the presence of quercetin glucoside.

Another known component of tea and coffee, caffeine, which has a melting temperature of 234°C [24, 25], was observed in abundance in green teas but not in black teas (Figure 1). Glass transition temperatures (Tg) for tea kinds were found approximately 40°C.

When the types of caffeine obtained from coffee types are examined, in order to break bonds and degrade caffeine, the temperatures at 253 ± 0.3, 266 ± 0.1, 278 ± 0.2, and 278 ± 0.2°C are exothermic maxima

[26]. Three levels of roast are represented by the endothermic curves at the beginning (39 ± 0.1, 41 ± 0.5, and 71 ± 0.2°C) for pure coffee [27]. Due to the breakdown of cellulose components, changes between 389 ± 0.1 °C and 494 ± 0.1 °C are seen [28]. DSC is an additional method that can provide a quantifiable fingerprint for measuring and detecting coffee adulteration. Our findings indicate that quick coffees have a higher additive content than filtered coffees. Because of this, we believe filtered coffee to be healthier and advise avoiding instant coffee if possible.

Consumers have recently begun to favor the several types of instant coffee available in the marketplace. The effects of this new habit, which is becoming more and more widespread, on health are of great importance. The presence of acrylamide, which is known to have a dangerous and carcinogenic effect during the packaging of instant coffees, makes the subject even more important. Due to this, we used Differential Scanning Calorimetry (DSC) to compare Turkish coffee and a few brands of instant coffee in our study.

In a 2013 study, they found that instant coffee contains 100% more acrylamide than freshly roasted coffee. Also, light-colored coffee beans contain more acrylamide than darker-roasted coffee beans [28]. Acrylamide is a substance formed through a natural chemical reaction between free asparagine and reducing sugars during cooking, such as frying, roasting, and baking at temperatures above 120°C in plant-based foods, including potato and grain-based foods [29]. It is known that acrylamide is formed by roasting coffee beans. When coffee is roasted, acrylamide is formed in the first step. However, the longer the roasting takes, the lower the acrylamide levels. When the acrylamide content of Arabica and Robusta coffees are compared, the acrylamide level of Robusta coffee is high; but in most cases not statistically significant [30, 31]. In contrast to affected foodstuffs such as potatoes and cereals, effective solutions have not yet been found to reduce acrylamide levels in coffee [26].

Turkish coffee and granulated instant coffee differ in a clear way (Figure 3). The melting of some elements, such as amino acids, lipids, and sugars, such as sucrose, glucose, fructose, arabinose, galactose, maltose, and polysaccharides, is what causes the peaks at 170 ± 0.4 °C and 201 ± 0.1 °C. Three levels of roast are represented by the endothermic curves in the beginning (39 ± 0.1, 41 ± 0.4, and 71 ± 0.2°C) for pure coffee [26].

DSC is frequently used to determine the additives in different foods. When we evaluate the results in terms of acrylamide, between 100 and 200°C, it is seen that instant coffees spoil very quickly compared to traditional coffees. DSC is an additional method that can provide a replicability fingerprint for measuring and detecting coffee adulteration. Our findings demonstrated that instant coffees have a higher additive content than traditional or filtered varieties. They pose a health hazard due to the danger of acrylamide in instant coffees and their rapid deterioration. Because of this, we consider that traditional coffees are healthier and advise using them in place of instant coffees. It has been determined that Turkish coffee contains much higher biological active components when compared to other coffee types and preparation methods [32].

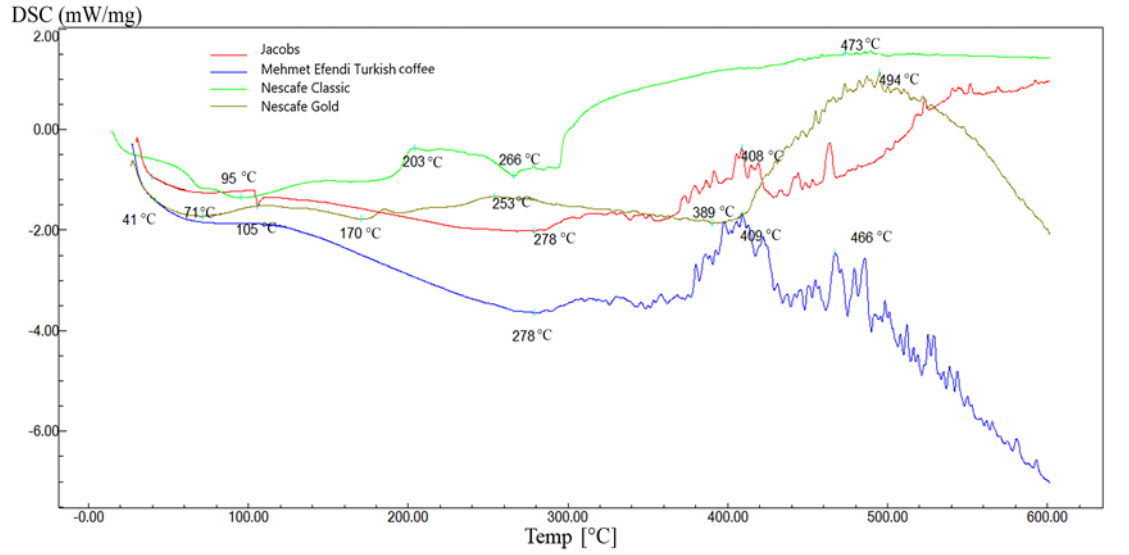

Figure 3 DSC analysis curves of different coffee types

Arabica coffees should be preferred instead of Robusta coffees. Dark roasted coffee beans can be preferred to reduce the amount of acrylamide taken. Also, acrylamide intake can be minimized by avoiding instant coffee varieties as much as possible.

In the oxidation process, a certain amount of polyphenol substances is lost. Therefore, green tea is a stronger antioxidant than other types of tea. Increasing the consumption of green tea will also increase the intake of polyphenols.

4. CONCLUSION

In this study, thermal differences between two known brands of black tea, one known brand of green tea, Turkish coffee (Mehmet Efendi), Arabica coffee for filter coffee (Jacobs), and two known brands of instant coffee were assessed. The data suggest that the degradation of ingredients is faster in Turkish coffee and instant coffees (Nescafe Gold, Nescafe Classics) have more additives than Arabica coffee.

While no differences were observed in terms of thermal degradation time in the three tea samples measured, the endothermic peak observed in green tea at 75°C gave a higher peak than other black teas. This indicates higher polyphenol content in green tea.

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Authors' Contribution
The authors contributed equally to the study.

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No conflict of interest or common interest has been declared by the authors.

The Declaration of Ethics Committee Approval
This study does not require ethics committee permission or any special permission.

The Declaration of Research and Publication Ethics
The authors of the paper declare that they comply with the scientific, ethical and quotation rules of SAUJS in all processes of the paper and that they do not make any falsification on the data collected. In addition, they declare that Sakarya University Journal of Science and its editorial board have no responsibility for any ethical violations that may be encountered, and that this study has not been

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