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INFLUENCE OF THE METHOD OF BREWING VARIOUS TYPES OF COFFEE ON THE CONTENT OF OXALATES IN THEM®

Wpływ sposobu parzenia różnych rodzajów kaw na zawartość w nich szczawianów®

Key words: coffee, Arabica, Robusta, anti-nutritional factors, oxalic acid, oxalates, infusion, brewing methods, brewing time, kidney stones.

The aim of this study presented in the article, the influence of various brewing methods on the oxalate content in different types of coffee was examined. The level of these compounds was determined by permanganometric titration in two coffee species: Coffea arabica and Coffea robusta, using three brewing methods as well as different brewing times. In the experimental part, the content of oxalates in the prepared coffee infusions was determined and the results were analyzed and discussed by comparing the obtained values with the available literature data, and then conclusions were drawn based on them.

Słowa kluczowe: kawa, Arabica, Robusta, substancje antyodżywcze, kwas szczawiowy, szczawiany, napar, metody parzenia, czas parzenia, kamienie nerkowe.

Celem pracy zaprezentowanej w artykule było zbadanie wpływu sposobu parzenia różnych rodzajów kaw na zawartość w nich szczawianów. Poziom tych związków oznaczono metodą manganometryczną w dwóch gatunkach kawy: Coffea arabica oraz Coffea robusta, wykorzystując trzy metody parzenia, a także różny czas zaparzania. W części doświadczalnej oznaczono zawartość szczawianów w przygotowanych naparach kawowych oraz dokonano analizy i dyskusji wyników, porównując uzyskane wartości z dostępnymi danymi literatury, a następnie na ich podstawie wyciągnięto wnioski.

INTRODUCTION

Coffee is a valued food product, mainly due to the distinctive taste and aroma that it signifies, but mainly due to its health-promoting properties. Caffeine is responsible for most of them. This compound has a beneficial effect on many organs, including increases the activity of the central nervous system and improves concentration. Caffeine also raises blood pressure and speeds up the transport of oxygen to the cells. In addition, it affects the digestive system, accelerates intestinal peristalsis, and its consumption may be a prophylaxis for the development of colon cancer. In addition to caffeine, coffee contains valuable polyphenols and diterpenes, which have an antioxidant effect. These compounds contribute to lowering the oxidative stress of the organism by fighting free radicals, the excess of which accelerates the aging processes of the organism, and contributes to the development of neoplastic diseases [12, 13 14]. Despite the number of health-promoting properties that we can attribute to coffee, it is also a source of anti-nutritional substances that may adversely affect the functioning of the body [2, 8, 9, 16]. These substances hinder the absorption of nutrients, i.e. proteins, carbohydrates, vitamins and minerals, thus adversely affecting the body's work. Their presence is conducive to the development of many deficiencies and disorders. These substances are generally of natural origin, but can also be intentionally added to food products or enter with contaminants. The main anti-nutritional compounds contained in coffee include tannins and **oxalates** [1, 10, 11]. Oxalic acid is found in plant-based products such as sorrel, spinach, rhubarb, coffee, tea, cocoa. It shows the ability to bind with minerals, i.e. calcium, magnesium and heavy metals, creating salts that are sparingly soluble in water. The most invasive is calcium oxalate, which only dissolves in highly concentrated acids. Its excess is deposited, among

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others in the kidney tubules, forming deposits and causing painful symptoms. In addition, the presence of oxalates in the body contributes to the deficiency of calcium ions in the bloodstream, and thus upset the calcium-phosphate balance. The ratio of oxalic acid to calcium, which should be less than 1, is important in determining the anti-nutritional effect of the product on the body [1, 5, 7, 19].

The aim of this study is to determine the level of oxalates in infusions made from two types of coffee, using different brewing methods, and to determine the effect of the method and time of brewing on the content of these compounds in the product. The conducted research is also aimed at raising awareness of the anti-nutritional oxalate content in coffee, thus influencing the rational planning of a low-oxalate diet in people with gout or a tendency to build up kidney deposits.

MATERIALS AND METHODS

Research was carried out on coffee infusions made from two types of coffee beans, using different brewing methods and a different brewing time. The following types of coffee beans were analyzed: Coffea arabica and Coffea robusta. Arabica was purchased at a retail point of sale in Opole, while Robusta, due to limited availability, was ordered via an online store.

The determination of oxalates in coffee infusions was based on three reactions:

1. Precipitation of an insoluble calcium oxalate with a 5% solution of calcium chloride $CaCl_2$.
2. Hot dissolving of calcium oxalate in 10% sulfuric acid solution.
3. Hot titration with 0.02 N potassium permanganate.

Robusta and Arabica infusions were prepared using three brewing methods: using a coffee maker, Frenchpress and in the form of traditional poured brewed coffee. To prepare the infusions, 4g of previously ground coffee beans and 100 ml of water at 100 ° C were measured on a technical scale [1].

The coffee brewing time was 5 minutes, then the obtained infusions were transferred to 100 ml beakers. In the case of brewed coffee, it was necessary to filter the infusion to separate the grounds from the infusion to obtain a clear solution.

For a more detailed analysis, the effect of coffee brewing time on its oxalate content was also investigated. Additionally, two infusions of each type of coffee were made using the traditional method. Coffee was brewed for 10 and 15 minutes. After making the coffee infusion, it was transferred in the amount of 2.5 ml to a centrifuge tube with the addition of 1.25 ml of a 5% solution of calcium chloride $CaCl_2$ and 1.25 ml of acetone. The whole was mixed by shaking the test tube and placed in the refrigerator for 30 minutes. Two repetitions were made for each method of brewing two types of coffee and the brewing time. After 30 minutes, the tubes were removed from the refrigerator and to centrifuge the resulting pellet, they were placed in a centrifuge for 10 minutes at 3000 rpm. The fluid from above the sediment was poured out. The resulting calcium oxalate precipitates were transferred to 100 ml conical flasks with 1.25 ml of 10% sulfuric acid H_2SO_4. Then, the obtained solutions were heated in a water bath and subjected to immediate titration with potassium permanganate until a pink color was obtained, which remained for about 1 minute.

ANALYSIS AND DISCUSSION OF RESULTS

The obtained results of titration with potassium permanganate allowed to determine the content of soluble oxalic acid in 100 g of coffee, if 1 ml of 0.02 N $KMnO_4$ corresponds to 0.9 mg $(COOH)_2$. The results are summarized in the tables below:

From the above research results, the choice of the brewing method has an impact on the content of soluble oxalates in the coffee infusion. These differences are visible in both examined types of coffee. This is also shown in the graph below.

Oxalate content determined based on tests using various methods of brewing coffee beans is in the range of 585 – 765 mg /100g of the product. The analysis of the chart shows that

Fig. 1. Methods of making coffee infusions.
Rys. 1. Metody sporządzania naparów kawowych.
Source: Own study
Źródło: Opracowanie własne

Table 1. Oxalate content depending on the brewing method

Tabela 1. Zawartość szczawianów w zależności od sposobu parzenia

SPOSÓB PARZENIA			
zawartość szczawianów [mg/100g]			
	KAWIARKA	**KAWA PARZONA**	**FRENCHPRESS**
ARABICA	585,00	675,00	540,00
ROBUSTA	720,00	765,00	675,00

Source: The own study

Źródło: Badania własne

Table 2. Oxalate content depending on the time of brewing using the traditional method of brewing coffee

Tabela 2. Zawartość szczawianów w zależności od czasu zaparzania stosując tradycyjny sposób parzenia kawy

CZAS TRWANIA			
zawartość szczawianów [mg/100g]			
	5 MINUT	**10 MINUT**	**15 MINUT**
ARABICA	675,00	765,00	967,50
ROBUSTA	765,00	810,00	1035,00

Source: The own study

Źródło: Badania własne

Fig. 2. Graph of the dependence of oxalate content in the infusion on the selected brewing method.

Rys. 2. Wykres zależności zawartości szczawianów w naparze od wybranej metody parzenia.

Source: The own study

Źródło: Badania własne

Robusta has a higher level of anti-nutritional compounds. The oxalate content in infusions made of this type of coffee was determined in the range of 675 – 765 mg /100g, thus from 90 to 135 mg / 100g more than the Arabica species. Comparing the obtained results with the available publications, one can notice discrepancies resulting from various factors. In the studies by Rusinek [15], which were based on the determination of the content of soluble oxalic acid in infusions of various types of tea and coffee, the level of these compounds in ground coffee oscillated around 537 mg/100g. This value is close to the lower threshold of the obtained results. The research methodology used by Rusinek was analogous to that used in this study, i.e. Brzozowska's manganometric method was used [1]. A higher level of tested anti-nutritional substances was also shown in Robusta coffee compared to Arabica coffee.

In the analysis by Sperkowska, Bazylak [17] the oxalate content in ground coffee was determined at the level of 799 mg / 100 g of dry matter, which in turn corresponds to the upper limit of the obtained results. Much greater results were obtained in the studies by Ulewicz-Magulska, Pawełkiewicz, Wesołowski [18]. In this case, the values ranged from 1497 to 2756 mg / 100 g of product. A comparison of the results obtained in various scientific studies showed significant discrepancies. An important factor influencing these differences is certainly the research material, which may come from various sources, have different origins and qualitative values. You should also pay attention to the degree of burnout of the grains, often indicated on the product label, but not in every case. Dark roast coffees have a higher oxalate content than medium or light roasted coffees. The grinding of the grains also has a significant influence on the amount of these compounds in the drink obtained from it. Infusions made of finely ground coffee beans contain relatively more oxalates compared to medium-ground coffees, as shown by the research of Sperkowska, Bazylak. However, no data on the influence of the brewing method on the content of soluble oxalates in the coffee infusion were found in the available literature sources. The obtained results indicate that coffee brewed using the traditional method has the highest content of the tested anti-nutritional compounds. The oxalate content in the infusion obtained with this method was, respectively, 675 mg/100 g for Arabica and 765 mg/100 g for Robusta. Often when drinking coffee prepared with this method, the grounds with oxalate compounds are also consumed with it, so their actual consumption may be even higher. A lower oxalate content was obtained in the infusions prepared in French Prague, the so-called frenchpressie and coffee shop. In the case of Arabica, the values were 585 mg/100 g (coffee maker) and 540 mg/100 g (Frenchpress). In turn, for Robusta, the level of these compounds was equal to 720 mg/100 g (coffee maker), 675 mg/100 g (Frenchpress). Table 2 contains the test results determining the content of oxalate compounds with an anti-nutritional effect in two types of coffee:

Fig. 3. The dependence of the oxalate content on the brewing time.
Rys. 3. Zależność zawartości szczawianów od czasu parzenia naparu.
Source: The own study
Źródło: Badania własne

Coffee arabica and Coffee robusta depending on the length of time it is brewed. The results are presented in graphic form.

The obtained test results are in the range of 675 – 1035 mg of oxalates soluble in 100 g of product dry matter. The amount of these compounds in coffee infusions prepared using the traditional method increases in proportion to the length of the brewing time. This is shown in the chart above, where it can also be noticed that this applies to both examined types of coffee. This is mainly due to the longer extraction of soluble oxalates in the coffee. In this case, the degree of grain grinding also plays an important role. Strong grinding of coffee beans facilitates the extraction of oxalate compounds for infusion, and an extended brewing time may increase the amount of these substances in the coffee. Whole coffee beans were used in the research, which were successively ground to a medium degree in an electric grinder. This degree of grinding of the beans slows down the penetration of soluble oxalates into the brew, as well as other substances contained in the coffee. In addition, coffee brewed for longer than the recommended 5 minutes with a higher concentration of oxalic acid is marked by a greater astringency in taste. It should be noted that the samples of coffee infusions were used in the research, for which 4 g of the product per 100 ml of water were used. The cut person drinks coffee made of 180 ml of water and two teaspoons of coffee corresponding to 9 g of ground beans – a proportion established by the National Coffee Association.

Converting the oxalate content to mg/g dry weight and averaging the results, the content of these substances was 6.0 mg/g of coffee in the case of Arabica and 7.2 mg /g in the case of Robusta coffee. The acceptable daily intake of oxalate compounds should not be higher than 250 mg per day in a healthy adult with no tendency to build up kidney stone plaques. In this case, it is allowed to consume up to 3 servings of coffee. However, it should be remembered that coffee is not the only source of this compound in the diet. Therefore, a moderate dose should be maintained in the form of 1–2 servings a day.

People at risk with kidney dysfunction and kidney stone formation disorders, the recommended dose is 50 mg, corresponding to 1 cup of coffee. Arabica coffee will be the right choice to reduce the daily intake of oxalates, as it has a lower amount of these compounds compared to Robusta. The research of Gasińska, Gajewska [4, 6] indicated that consumption of coffee and tea infusions influences the formation of kidney stones in 80%. Therefore, to rationally plan a low-oxalate diet, it is important to be aware of the content of these compounds in individual types of coffee, as well as the use of an appropriate brewing method and brewing time, to limit the absorption of anti-nutritional compounds into the body as much as possible. An important factor is also an adequate supply of calcium in the diet, eliminating the depletion of this element in the body, which results from binding with oxalic acid.

Table 3. Comparison of oxalate content per portions of coffee

Tabela 3. Porównanie zawartości szczawianów w przeliczeniu na porcje kawy

ZAWARTOŚĆ SZCZAWIANÓW			
	9 g kawy (1 porcja)	18 g kawy (2 porcje)	27 g kawy (3 porcje)
ARABICA	54 mg	108 mg	162 mg
ROBUSTA	65 mg	130 mg	194 mg

Source: The own study
Źródło: Badania własne

Table 4. Comparison of oxalate content per portions of coffee

Tabela 4. Porównanie zawartości szczawianów w przeliczeniu na porcje kawy

ARABICA	ROBUSTA
2,7 mg wapnia/ g kawy	3,2 mg wapnia/ g kawy
W 1 porcji kawy (9g)	
24,3 mg wapnia	28,8 mg wapnia
Ilość dodanego mleka (100 g – 120 mg wapnia)	
20 g	24g

Source: The own study
Źródło: Badania własne

If 0.9 mg of oxalic acid binds 0.4 mg of calcium in 1 g of coffee, 2.7 mg (Arabica) and 3.2 mg (Robusta) of calcium ions are bound by oxalate compounds, respectively. A preventive measure for the loss of this element in the body will be the addition of an appropriate amount of milk, which is a natural

source of calcium. 20–24 g of milk should then be added to 1 serving of coffee. It is worth noting that the addition of milk to coffee infusion will only reduce the loss of calcium ions in the body and will not reduce the amount of precipitated calcium oxalates. It is therefore important that the daily diet does not consist of excessive amounts of foods rich in these anti-nutritional compounds [2, 3, 15].

CONCLUSIONS

Based on the research, the influence of the method of brewing various types of coffee on the oxalate content in them, the following conclusions were drawn:

1. Regardless of how the coffee is brewed, the Robusta species has a higher content of soluble oxalate. Their content in 100 g of product dry matter fluctuates around 720 mg. In Arabica, the level of these compounds is 600 mg /100 g of coffee.
2. The varied oxalate content in the examined coffee species is influenced by many factors, including conditions of growing the coffee bush, which translate into the quality parameters of the brewed infusion, i.e. acidity, intensity and taste. Arabica has a higher acidity and a milder aroma compared to Robusta. This one is again characterized by a greater intensity of the infusion and a tartness in taste, which is due to, among others, higher oxalic acid content.
3. The conducted research allowed to show the influence of the method of brewing coffee on the content of oxalates in it. The highest amount of soluble oxalates was found in infusions obtained from both types of coffee brewed using the traditional method. It should be emphasized, however, that coffee grounds containing oxalate compounds are often consumed along with the infusion, which is why their actual consumption is higher.
4. The analysis of the results showed slight discrepancies in the oxalate content of the investigated infusions prepared using a coffee pot and Frenchpress. More of these substances were determined in both types of coffee brewed in the coffee maker.
5. The degree of grain grinding has a significant impact on the content of oxalate compounds in the infusion. Finely ground coffee infusions are characterized by a higher amount of these substances, which results from easier extraction of substances contained in the grain. The coffee beans used in this study were ground on average, comparing the obtained results with the available literature data, the oxalate content in the infusions tested was lower than in the case of fine ground coffees.
6. The length of brewing a coffee infusion has a significant effect on its oxalate content. The longer the brewing time, the higher the level of these compounds in the coffee. This relationship applies to both types of coffee. The reason for this phenomenon is a longer extraction of substances contained in coffee beans, including oxalates. As a result of the longer brewing, more of these compounds penetrate the brew and their level increases.
7. By comparing the obtained results with the acceptable daily dose of oxalates for a healthy adult, which is 250 mg per day, respectively, the permitted amount of coffee consumed at the level of 3 portions made from 27 g of coffee, with the limitation of other products that are the source of this anti-nutritional compound.
8. In order to compensate for the loss of calcium ions in the body due to the binding of this element by oxalic acid, supplement the calcium supply, e.g. by adding milk to a coffee brew.
9. For people suffering from gout and those with a genetic tendency to build up kidney stone plaque, it is recommended that coffee be eliminated from the daily diet or consumed in a limited amount.

WNIOSKI

Na podstawie przeprowadzonych badań wpływu sposobu parzenia różnych rodzajów kawy na zawartość w nich szczawianów sformułowano następujące wnioski:

1. Niezależnie od sposobu parzenia kawy gatunek Robusta odznacza się wyższą zawartością rozpuszczalnych szczawianów. Ich zawartość w 100 g suchej masy produktu oscyluje w granicy 720 mg. W Arabice poziom tych związków jest równy 600 mg/100 g kawy.
2. Na zróżnicowane zawartości szczawianów w badanych gatunkach kaw wpływa wiele czynników m.in. warunki upraw krzewu kawowca, które przekładają się na parametry jakościowe sporządzonego naparu, tj. kwasowość, intensywność czy smak. Arabika charakteryzuje się wyższą kwasowością i łagodniejszym aromatem w porównaniu z Robustą. Ta znowu odznacza się większą intensywnością naparu i cierpkością w smaku, którą zawdzięcza m.in. większej zawartości kwasu szczawiowego.
3. Przeprowadzone badania pozwoliły na wykazanie wpływu sposobu parzenia kawy na zawartość w niej szczawianów. Największą ilość rozpuszczalnych szczawianów zawierały napary otrzymane z obu gatunków badanych kaw parzonych metodą tradycyjną. Należy jednak podkreślić, że często wraz z naparem spożywane są także fusy, w których zawarte są związki szczawianowe, dlatego też ich realne spożycie jest wyższe.
4. Analiza wyników wykazała nieznaczne rozbieżności w zawartości szczawianów badanych naparów sporządzonych przy użyciu kawiarki oraz praski francuskiej (frenchpress). Więcej tych substancji oznaczono w obu gatunkach kaw parzonych w kawiarce.
5. Stopień zmielenia ziaren ma istotny wpływ na zawartość związków szczawianowych w naparze. Napary z kaw drobno mielonych oznaczają się wyższą ilością tych substancji, co wynika z łatwiejszej ekstrakcji substancji zawartych w ziarnie. Wykorzystane w niniejszej pracy ziarna kawy zostały średnio zmielone, porównując uzyskane wyniki z dostępnymi danymi literaturowymi zawartość szczawianów w badanych naparach była niższa w stosunku do kaw drobno mielonych.
6. Długość parzenia naparu kawowego oddziałuje w znaczącym stopniu na zawartość w nim szczawianów. Im dłuższy czas zaparzania tym poziom tych związków w kawie jest wyższy. Zależność ta obejmuje oba gatunki kawy. Przyczyną tego zjawiska jest dłuższa ekstrakcja substancji mieszczących się w ziarnach kawowych, w tym

także szczawianów. W wyniku dłuższego parzenia więcej tych związków przenika do naparu i ich poziom wzrasta.

7. Zestawiając uzyskane wyniki badań z dopuszczalną dzienną dawką szczawianów dla zdrowej osoby dorosłej, która wynosi odpowiednio 250 mg na dobę, można przyjąć dozwoloną ilość spożytej kawy na poziomie 3 porcji, sporządzonych z 27 g kawy, przy ograniczeniu innych produktów będących źródłem tego antyodżywczego związku.
8. W celu zniwelowania ubytków jonów wapnia w organizmie powstałych na skutek wiązania tego pierwiastka przez kwas szczawiowy, należy uzupełnić podaż wapnia, np. przez dodatek mleka do naparu kawowego.
9. Dla osób chorujących na dnę moczanową oraz tych, którzy są genetycznie obciążeni tendencją do tworzenia się złogów w postaci kamieni nerkowych zaleca się wyeliminowanie kawy z codziennej diety lub spożywane jej w ograniczonej ilości.

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