THE PUBLIC HEALTH IMPACT OF CAFFEINE IN COFFEE

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ABSTRACT

Caffeine is the most popular psychoactive substance in the world and one of the most sold coffee, tea and soft drinks products. One of the most important sources of caffeine is coffee. Due to its widespread consumption in human population, scientists have expressed their interest in determining the adverse effects of excessive caffeine in coffee consumption that may affect human health. Careful consumption of products containing caffeine in cardiovascular disease, HTA and renal dysfunction is recommended. This study presents the main classes of coffee pollutants, focusing on organochlorine and organophosphorus pesticides, aromatic polycyclic hydrocarbons. The polycyclic aromatic hydrocarbon residues off different types of coffee (green coffee and roasted coffee) were determined and the pesticides obtained after roasting were analyzed and their determinations were performed with a high-performance liquid chromatograph Varian Pro Star with a detector of fluorescence. Beneficial effects and adverse effects of caffeine on the human body are presented. Among the adverse effects are the differences between green coffee and roasted coffee. Pollutants represented by PAHs are highlighted by the values obtained in the study. This analysis is motivated by the high consumption of coffee in the world and the high levels of harmfulness of these pollutants when the maximum residue levels set by current legislation are exceeded, knowing that the effect of these pollutants is cumulative over time, as they are deposited especially in the kidneys and liver, and their lipophilic character rapidly penetrates the cell membrane, thus their carcinogenic and genotoxic character. Ingestion of PAHs in food is of little concern for human health, but cumulation with other contaminants can lead to health damage.

Keywords: caffeine, green coffee, roasted coffee, PAHs, aromatic polycyclic hydrocarbons

INTRODUCTION

The appearance of caffeine in a variety of plants has played an important role in the long-term popularity of its products. Due to its widespread consumption in human population, scientists have expressed their interest in determining the adverse effects of excessive caffeine in coffee consumption that may affect human health. In the European Community, there is a clear strategy developed by 2020 for the protection of human health [1]. Research is being carried out to standardize European legislation on health risk assessments [2].

The role of the patient is highlighted to know the risks posed by the toxicity of the foods or medications they use [3]. The most important sources of caffeine are Coffea spp., Camellia sinensis, Paullinia cupana, Maté (Ilex paraguariensis), Cola vera and Cocoa (Theobroma cacao). The amount of caffeine found in these products varies - the largest amounts are found in guarana (4-7%), followed by tea leaves (3.5%), maté tea leaves (0.89-1.73%), coffee beans (1.1-2.2%), cola (1.5%) and cocoa beans (0.03%) [4].

Coffee is one of the largest industrial products, currently in about 80 countries on four continents and is considered one of the world's most popular beverages [5]. Coffee bush grows at tropical altitudes (600-1200m), with an average temperature of 15-25 ° C and moderate and muddy humidity on both sides of the equator in the region between the Cancer Tropic and the Tropic of Capricorn. According to the IUPAC nomenclature, the name of caffeine is 1,3,7-Trimethyl-2,6-purindione or, in brief, 1,3,7-Trimethylxanthine. Caffeine is a bitter substance, an alkaloid that is part of the family of heterocyclic compounds, also known as purines, like theophylline and theobromine and a member of a naturally occurring group of substances called methylxanthines. The caffeine structure consists of a double ring, which has a number of substitutes on the outside, the center being the purine nucleus. The chemical formula of caffeine is C8H10N4O2. It has a molecular mass of 194.19 grams, is water soluble and many other organic solvents and has a melting point of 238 ° Celsius. In pure form, caffeine appears as white crystals and can be prepared by extraction from natural sources or by synthesis from uric acid. Xanthine derivatives, classified as plant alkaloids (including caffeine), are considered weak bases because nitrogen atoms can accept protons. However, xanthine derivatives as a solution are not alkaline [6]. For the population, caffeine has many important physiological aspects such as central nervous system stimulation, diuresis and gastric acid secretion [7], but can cause tremor, nausea, nervousness and seizures [8] and mutation effects such as DNA inhibition [9]. Careful consumption of products containing caffeine in cardiovascular disease, HTA and renal dysfunction is recommended [10]. Caffeine acts as a natural pesticide for plants and kills insects trying to feed on the plants. German chemist Friedrich Ferdinand Runge was the one who isolated the first molecule in 1819. Today, artificial caffeine is often used in the production of food, beverages or medicines [11]. Analyzing pollutants and studying risk limits has been an important subject for researchers [12], [13]. The analysis of the effect of contamination on the environment and on the human body with harmful effects on health has also been a subject of great interest [14], [15]. The purpose of this study is to present and characterize the main classes of coffee pollutants with an emphasis on organochlorine and organophosphorus pesticides and polycyclic aromatic hydrocarbons from two analyzed coffee samples: Arabic coffee (green coffee and roasted coffee) and Robusta coffee (green coffee and roasted coffee).

EXPERIMENTAL PART

Studies have been conducted on the chemical composition of coffee. The raw coffee is also referred to as Green Coffee (% of the dry matter). Green coffee is raw, uncooked and unprocessed coffee, heat-treated, coffee-flavored coffee, but the flavor is much more intense, the coffee in the green coffee being more like much with a tea.

Determined moisture in the coffee. The result is a humidity = 9.5% (with the range of values 5.0-12.1). The composition of green coffee depends on variety, origin, processing and climate. Table 1 lists the main constituents of green coffee.

Table 1. Main constituents of green coffee

Chemical composition	**Content** (µg/kg)	
	Medium value	Variation values
Water-soluble extract	33	29,0-36,2
Protein	10.5	8,7-12,2
Lipids	12,6	8,3-17
Reducing sugars (glucose)	0.45	0-0,5
Reducing sugars after inverting (sucrose)	4.5	2-9
Sucrose	6.33	6-7
Fiber	10.85	10-11,7
Citric acid	0.85	0,5-1,15
Malic acid	0.33	0-0,5
Oxalic acid	1.75	<0,2
Chlorogenic acids (phenolic compounds)	8.25	4,5-11,1
Caffeine	1,45	0,9-2,6
Trigonelline	0,63	0,24-1,2
Minerals	4,0	3,0-5,4

This type of coffee is superior to the classic one (roasted coffee), the curative effects being more obvious because the raw green coffee beans are very rich in chlorogenic acid, a substance that limits the absorption of sugar by the body, thus helping to keep a body in shape. Chlorogenic acid plays an antioxidant role and lowers blood glucose levels as a result of coffee consumption. Diabetics should

consume decaffeinated coffee because caffeine counteracts this effect. Phenolic compounds give the color and taste of the coffee. It has collagen action, not missing from the American diet, for the prevention of liver cancer and cirrhosis. (It turns into other compounds, but maintains these qualities even after roasting the coffee). Much of the amount of formic, acetic, citric, malic acids is destroyed by roasting coffee beans. In Fig. 1-6 shows the chemical structures of the compounds found in the green coffee.

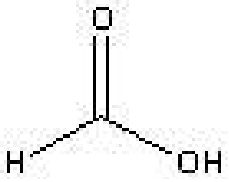

Fig. 1. Formic acid (CH_2O_2)

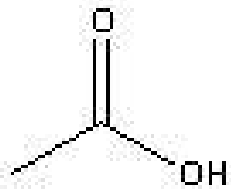

Fig. 2. Acetic acid ($C_2H_4O_2$)

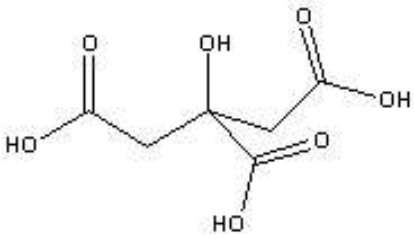

Fig.3. Citric acid ($C_6H_8O_7$) or 2-hydroxypropane 1,2,3-tricarboxylic acid

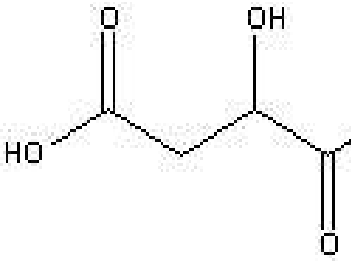

Fig.4 Malic acid (C4H6O5) (hydroxybutanedioic acid)

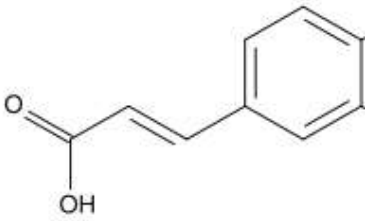

Fig. 5. Caffeic acid (C9H8O4) - or 3- (3,4-Dihydroxyphenyl) -2-propenoic acid

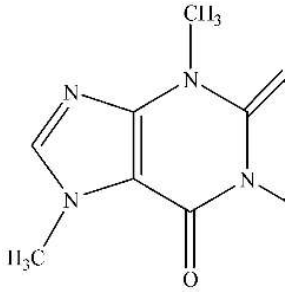

Fig. 6. Caffeine

The beneficial effects of green coffee

- The properties of green coffee cover a wide range of conditions, ranging from metabolic ones, which cause weight gain and ending with heart and liver, caused by the accumulation of excess fat;
- Green coffee contains significant amounts of antioxidants that fight against free radicals and prevent cancer;
- Reduces oxidative stress by 12-16% due to the main antioxidants called polyphenol that inhibits the process of cellular destruction and thus aging is delayed;
- Regulates metabolism, helps eliminate unwanted kilos and acts as a tonic for brain activity;

- Contains also caffeic acid that acts as a general tonic, the green coffee grinded successfully in the detoxification straps;
- Diminishes the risk of diabetes and helps liver fetotoxicity;
- Chlorogenic acid stabilizes blood sugar levels, inhibits hunger, melts fats, and fights free radicals, thus delaying the aging process;
- Green coffee is also a natural disinfectant, useful in fighting bacteria and viruses, having anti-inflammatory, antipyretic and antiseptic effects;
- People with a high cholesterol level could test the benefits of green coffee on their own skin, given that this drink has antihyperlipemic effects, ie it lowers bad cholesterol and increases the good cholesterol;
- Reduces the risk of tachycardia, increased blood pressure or insomnia.

The side effects of caffeine

Coffee also has a number of undesirable effects on the human body. Thus we can list:

- Cardiovascular problems. Caffeine causes increased heart rate, blood pressure in the blood vessels, and may contribute to heart disease. Both regular coffee and decaffeinated coffee cause the increase in cholesterol and homocysteine, a bio-chemical substance that science associates with the risk of heart attack. Caffeine is also responsible for coronary spasms, the cause of about 20% of fatal heart attacks on healthy people.
- Stress. Caffeine stimulates the excretion of stress hormones that cause high levels of anxiety, irritability, muscle tension and pain, indigestion, insomnia and immune degradation. Increased stress levels caused by caffeine affect the reaction to the current stress conditions we are all subjected to in life.
- Emotional disorders. Anxiety and irritability are symptomatic disorders associated with caffeine consumption, but also as depressive and disturbing. Depression can occur as a result of cessation of the caffeine stimulating effect, which is lost over time. It may still occur during the recovery period after a person has dropped caffeine consumption due to the chemical balance of the brain. Instead of increasing mental activity, caffeine actually causes blood flow to the brain to fall by up to 30%, resulting in negative effects on memory and intellectual performance.
- Changes in blood sugar levels. Those who suffer from diabetes and hypoglycaemia should avoid caffeine as this temporarily stimulates the increase in blood sugar, which causes excessive insulin production followed by a dramatic drop in just a few hours of sugar.
- Gastrointestinal problems. Many people feel stomach burns after drinking coffee because it increases the secretion of hydrochloric acid which increases the risk of ulcer. Coffee, including decaffeinated, lowers the pressure of the valve between the stomach and the esophagus so that the strong stomach acid content goes up to the esophagus causing burns and gastro-esophageal reflux disease.
- Roasting increases the risk of polycyclic aromatic hydrocarbons (PAHs). Aromatic polycyclic aromatic hydrocarbons (PAHs) are a chemical group with

more than 100 different organic compounds containing two or more condensed aromatic rings. The most well-known are organochlorine pesticides (which are alkyl, cyclic and aromatic compounds substituted with one or more chlorine atoms) and organophosphorus pesticides (which are esters of phosphoric acid or its derivatives).

Results obtained for content analysis of aromatic polycyclic hydrocarbons (PAHs).

This study is motivated by the high consumption of coffee in the world and the high toxicity of these pollutants when the maximum residue levels established by the legislation in force are exceeded, knowing that the effect of these pollutants is cumulative over time, chosen in the kidneys and liver, and their lipophilic character rapidly penetrates the cell membrane, hence their carcinogenic and genotoxic character. Determined aromatic polycyclic aromatic hydrocarbon residues from four types of coffee: Arabica (green coffee and roasted coffee), as well as Robust (green coffee and roasted coffee) are the main types of coffee on the market (see Table 2).

The determinations were performed with a high-performance liquid chromatograph Varian Pro Star with a fluorescence detector. The method of determination used is suitable for the determination of PAHs in coffee and is also a quick method of detraction.

Table 2. Coffee samples analyzed for determination of PAH content

Name of the sample			
Arabic Coffee		Robust Coffee	
Green coffee	Roasted coffee	Green coffee	Roasted coffee
10,00g	10,00g	10,00g	10,00g

The detection limits (LOD) obtained were between 0.01 and 0.05 µg / kg and the limit of quantification (LOQ) was 0.2 µg/kg. Table 3 presents the results obtained for the PAH content in the analyzed samples.

Table 3. Results of determination of PAH content

Analyte	Concentration (µg/kg)			
	Arabic coffee		Robust coffee	
	Green coffee	Roasted coffee	Green coffee	Roasted coffee
Naphthalene	0,578	1,005	0,458	0,903
Acenaphthylene	ND**	ND	0,076	0,135
Acenaphthene	0,168	0,178	0,028	ND
Fluorene	0,235	0,255	0,067	0,184
Phenanthrene	0,097	0,389	0,087	0,497
Anthracene	ND	0,024	ND	ND
Fluoranthene	ND	0,078	0,042	0,073
Pyrene	0,015	0,017	0,017	0,014
benzo[〈]anthracene	ND	0,015	ND	ND
Chrysene	ND	ND	ND	ND
benzo[k]fluoranthene	ND	ND	ND	0.008
benzo[〈]pyrene	ND	ND	ND	ND
benzo[ghi]perylene	0,039	0,044	0,026	0,149
dibenzo[〈,h]anthracene	ND	ND	ND	ND
indeno[1,2,3–cd]pyrene	0,051	0,129	0,150	0,323

**ND = not detectable (not detected at detection limit of method)

The results indicated the contamination of samples with PAHs. High concentrations of PAHs were found in all roasted coffee beans compared to green coffee, but did not exceed the maximum permitted by the current regulation (maximum admissible limit = 2 µg / kg). This confirms that the levels of contamination depend both on the place of growth and development (there is the possibility of contamination of plants with polluted air) and the roasting regime when the combustion gases can come in direct contact with the lubricating oil products or traces used in the maintenance of coffee bean processing equipment and the treatment with mineral oils of jute bags used for transport. These levels meet the requirements of European Regulation 333/2007 (detection limit < 0,3 µg/kg, quantification limit <0,9 µg/kg). The recovery obtained at the contamination level of 2 µg / kg with PAH mixture falls within the proposed range of 50-120%.

CONCLUSION

- Coffee has many positive effects, even if the amount of chemical compounds in green coffee decreases by roasting.
- Coffee also has negative effects that can be enhanced by increasing the amount consumed and the patient's condition.
- With regard to the PAH content, comparing the experimental results obtained with the maximum allowable residue levels in European Regulation 1881/2006, a high concentration of naphthalene in the Arabica coffee samples (1.005µg / kg) was noted. Naphtalene is on the list of priority US-EPA (US

Environmental Protection Agency) pollutants because of its carcinogenic properties.

- Moderate coffee consumption is recommended daily depending on the condition of the patient, consistent with other conditions presented by the patient.

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