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THE IMPACT OF COFFEE CONSUMPTION ON HUMAN HEALTH: A REVIEW OF SCIENTIFIC EVIDENCE

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ABSTRACT

The purpose of this review is to present the current state of knowledge on the impact of coffee consumption on human health, with particular emphasis on its bioactive components and physiological effects. The method for the scientific literature review involved were the various systematic analyses, meta-analyses, and also the reports of global public health institutions like the European Food Safety Authority (EFSA) [7], the World Health Organization (WHO) [19], and the American College of Obstetricians and Gynecologists (ACOG) [1].

The theoretical section discusses the chemical composition of coffee, including caffeine, polyphenols, chlorogenic acids, and diterpenes, as well as their mechanisms of action on the nervous, metabolic, and cardiovascular systems. The review indicates that moderate coffee consumption (approximately two to four cups per day) is associated with a lower risk of type 2 diabetes, Parkinson's disease, certain cancers, and reduced all-cause mortality [15][5]. Yet, overconsumption can cause sleep disorders, anxiety, acid reflux, and high blood pressure in people who are easily affected. Besides that, the review also points to factors that influence the impact of coffee on the body, such as the genetics of caffeine metabolism and the ways of preparation. Finally, it is stated that moderate consumption of coffee, particularly filtered, can be a safe practice and even have a positive effect on health. The main factors deciding this are the amount of coffee, the individual's tolerance, and the general dietary and lifestyle context.

KEYWORDS

Coffee, Caffeine, Public Health, Antioxidants, Metabolic Diseases, Literature Review

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Introduction

Coffee is a beverage made from the roasted seeds of the plants of the *Coffea* genus (mostly *C. arabica* and *C. canephora*) and is among the top four globally consumed drinks. It is a product with a long historical tradition, whereby after its initial discovery in Ethiopia, it was spread through the Middle East, then to Europe and the Americas. Today, coffee is among the most popular stimulant beverages worldwide, with hundreds of millions of cups consumed daily [2]. According to FAO and market data, Poland ranks among the leading European countries in terms of per capita coffee consumption.

Coffee, being one of the most popular beverages, has been a source of controversy among scientists for many years, especially concerning its effects on health - is it bad or good for us. Various studies have pointed out benefits in some cases, for instance, lower risk of chronic diseases, while also indicating adverse effects, like sleep disturbances and serum LDL cholesterol increment, which may vary according to the brewing methods [3][16]. The authors argue that the inconsistencies between the results are attributable to differences in the nature of studies (observational vs. interventional), the variety of the studied populations, the dose and confactors such as smoking and dietary habits that may influence the results [11].

This article aims to become a comprehensive resource summarizing the evidence base of health-related studies on coffee consumption. Data from various sources such as epidemiological, experimental, and mechanistic studies are being summarized. Additionally, the publication reveals the determinants of the personal reaction to coffee and, finally, suggests tentative, practical public health advice accountable to the scientific consensus.

Methods

The present review is based on a comprehensive survey of peer-reviewed scientific research published in reputable journals and indexed in databases like PubMed, Scopus, and Web of Science. The works reviewed were systematic reviews, meta-analyses, randomized controlled trials (RCTs), and healthcare-related institutional declarations, e.g., from EFSA [7], WHO [19], ACOG [1], and the International Agency for Research on Cancer (IARC) [10]. The selection of sources was achieved through the application of a set of keywords such as coffee, caffeine, health effects, cardiovascular disease, diabetes, and antioxidants. Only English language articles published between 2000 and 2024 were considered. Studies that explicitly compared different brewing methods or caffeine dosages were prioritized. The findings were pooled qualitatively to identify the most consistent results and the principal mechanisms of action.

Results and Discussion**1. Chemical Composition of Coffee**

Coffee is a complex mixture containing thousands of bioactive compounds, including caffeine, chlorogenic acids, polyphenols, diterpenes (cafestol and kahweol), and trigonelline [2].

Caffeine

Caffeine (1,3,7-trimethylxanthine) is the main psychoactive component of coffee. A typical brewed cup (≈240 mL) contains 70-140 mg of caffeine, depending on bean species, roast level, and brewing method [7]. It acts primarily as a non-selective adenosine receptor antagonist (A1, A2A), increasing alertness, reducing fatigue perception, and enhancing mood and reaction time. However, high doses may induce tachycardia, anxiety, and insomnia [8].

Polyphenols and Antioxidants

Coffee is a major dietary source of antioxidants, particularly polyphenols such as chlorogenic acids. These compounds demonstrate antioxidant and anti-inflammatory activity *in vitro* and *in vivo* [9]. Epidemiological studies suggest that polyphenol intake is inversely associated with risks of metabolic and neoplastic diseases, although translating biochemical effects into clinical outcomes remains challenging.

Diterpenes

Diterpenes, mainly cafestol and kahweol, are abundant in unfiltered coffee (e.g., boiled, French press). These compounds can raise serum LDL cholesterol levels [16]. Filtered coffee removes most diterpenes, reducing this risk.

2. Health Benefits of Coffee Consumption

Neurological and Cognitive Effects

Moderate coffee intake improves cognitive performance, attention, and mood, largely due to caffeine's antagonism of adenosine receptors and the subsequent increase in dopaminergic and noradrenergic activity [7]. Observational data indicate that habitual coffee drinkers may have a reduced risk of depression and cognitive decline [14].

Neurodegenerative Diseases

Numerous meta-analyses report an inverse association between coffee consumption and Parkinson's disease incidence, with the strongest evidence for caffeine's neuroprotective effect through A2A receptor blockade [4]. Data for Alzheimer's disease are less consistent, but moderate intake appears neutral or slightly beneficial [4][14].

Metabolic Health and Type 2 Diabetes

Systematic reviews have demonstrated a dose-response relationship in which each additional daily cup of coffee reduces type 2 diabetes risk by roughly 6-7% [5]. The effect occurs for both caffeinated and decaffeinated coffee, suggesting that chlorogenic acids and polyphenols contribute through improved insulin sensitivity and anti-inflammatory effects [5].

Cardiovascular Outcomes

Various sizeable populations such as the UK Biobank study have revealed that moderate intake (2-3 cups/day) is linked to reduced total and cardiovascular mortality [17][11]. Nevertheless, unfiltered coffee raises LDL cholesterol as a result of diterpenes, thus the advantages may be neutralized in those individuals who are vulnerable [16]. On the whole, data imply that there is no increased risk of heart disease with a moderate consumption of filtered coffee [12].

Cancer Prevention

IARC concluded that coffee itself is not carcinogenic; rather, consuming very hot beverages (>65 °C) may increase esophageal cancer risk [10]. Epidemiological evidence supports a protective association between coffee and lower risk of liver and endometrial cancers [15][18].

3. Risks of Excessive Coffee Consumption

Although moderate coffee consumption is associated with several health benefits, excessive intake may have adverse effects, particularly in sensitive individuals.

Sleep Disturbances and Anxiety

The stimulant nature of caffeine can interfere with sleep patterns as it delays the time to fall asleep, reduces the total sleep duration, and causes sleep fragmentations during the night [6]. Randomized controlled trials show that caffeine intake even six hours before sleep leads to a marked decrease in sleep quality. Large caffeine doses might cause an anxious feeling and restlessness, particularly in a situation where an individual is already somehow anxious and has an anxiety disorder [6]. Hence, one should avoid consuming caffeine after noon and in the evening [14].

Hypertension and Cardiac Arrhythmias

Caffeine temporarily raises blood pressure in non-habitual consumers, though tolerance develops with regular use [13]. For most healthy adults, this effect is transient and clinically insignificant [7]. However, genetic polymorphisms in CYP1A2 influence caffeine metabolism—"slow metabolizers" may experience greater cardiovascular strain and a higher risk of hypertension or arrhythmias when consuming large amounts of coffee [3].

Gastrointestinal Effects

Coffee stimulates gastric acid secretion and may worsen symptoms of gastroesophageal reflux disease (GERD) in susceptible individuals [20]. Nonetheless, the relationship remains inconsistent across studies; some report aggravation of heartburn, while others find no significant effect. For patients with persistent reflux, individualized monitoring and dietary adjustment are recommended.

4. Individual Differences in Coffee Metabolism

The manners in which people react to coffee are altered by their genetics, physiology, and way of life. Differences in the CYP1A2 gene affect the speed of caffeine metabolism fast metabolizers get rid of caffeine quickly, whereas slow metabolizers are affected by the stimulant for a longer time [3]. Gender, age, and hormonal status are additional factors that influence the effect of caffeine. For instance, during pregnancy, caffeine is metabolized at a slower rate, so the intake has to be lowered [1]. Besides, there are some other substances in coffee like polyphenols and trigonelline that may be good for health even if we consume decaffeinated coffee, as a few studies suggest [5].

5. Public Health Recommendations

Different scientific organizations have set evidence-based guidelines to define safe coffee consumption. The European Food Safety Authority, for instance, limits the total daily caffeine intake of a healthy adult to 400 mg which is roughly equivalent to 3-5 cups of coffee. The agency also recommends that pregnant or nursing women should not consume more than 200 mg of caffeine per day [7][1]. It is recommended that patients having hyperlipidemia or those at a high cardiovascular risk condition should consume filtered coffee so as to lower their intake of diterpenes as paper filters remove the compounds, which cause the increase of cholesterol, such as cafestol and kahweol that are bound to the coffee [16]. Individuals with anxiety, sleep disorders, or gastrointestinal sensitivity are advised to restrict their caffeine intake and, in case decaffeinated products are available, use them. Public health authorities state that the effects of coffee on health depend on the dose, the manner of preparation, and the person, and hence coffee is neither a harmful nor a beneficial product per se [19].

6. Conclusions

This review summarizes extensive evidence on the relationship between coffee consumption and human health. The majority of studies suggest that moderate coffee intake-typically two to four cups per day-is associated with a neutral or beneficial health profile. Benefits include a reduced risk of type 2 diabetes, Parkinson's disease, liver cancer, and cardiovascular mortality [4][5][15][17]. These positive associations are largely attributed to caffeine's physiological effects and to antioxidant and anti-inflammatory compounds such as polyphenols and chlorogenic acids [9]. However, excessive consumption may result in sleep disturbances, anxiety, gastrointestinal discomfort, and transient increases in blood pressure, especially in genetically sensitive individuals or those consuming unfiltered coffee rich in diterpenes [6][16]. The overall impact of coffee depends on dosage, brewing method, genetic factors, and individual health status. As far as public health is concerned, moderate coffee consumption is generally safe for most adults. It is better to consume filtered coffee in order to minimize the increase of LDL cholesterol [16]. A pregnant woman should keep her consumption of caffeine to less or equal to 200 mg per day, which is still considered a wise decision [1]. Upcoming research has to be primarily devoted to long-term randomized controlled intervention trials comparing various coffee types and preparation methods, along with genetic and metabolic studies investigating individual differences in coffee effects.

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