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The Beneficial Effects of Coffee in Human Nutrition

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Abstract

Coffee is a complex combination of chemicals such as phenolic chlorogenic acid, di terpenes and caffeine, which is a natural alkaloid that can be found in large amounts more in coffee than in any other dietary products. Coffee is also composed of many other constituents such as potassium, niacin, magnesium, and antioxidant substances, like tocopherols, that may play a role in its biological activity. Coffee is a beverage that can have different caffeine concentrations, depending on the methodology of beverage preparation and type of coffee. The annual amount of coffee consumed per person is about 4 kg in USA and about 3 kg in United Kingdom.

In the last few years several studies have pointed out that the consumption of coffee can bring health benefits by influencing on many biological systems; for instance it has been shown that people who drink coffee regularly have lower risks of developing type 2 diabetes, colon cancer, liver cirrhosis and gallstones. Because the benefits of coffee on health seem to exceed the negative effects, coffee can be regarded as a functional food.

Keywords

Coffee; Nutrition; Disorders

Introduction

Caffeine is considered a psychoactive drug and the most common way through which it is consumed is drinking coffee. There are different species of coffee plants, whose classification is complicated, and the most common ones are coffea arabica and the coffea robusta [1]. Caffeine is the most routinely ingested bioactive substance throughout the world. It is a natural alkaloid found in more than 60 plants including coffee beans, tea leaves, cola nuts, and cocoa pods. Its concentration varies depending on the type of product, agronomic and environmental factors, and processing [2,3]. Caffeine (1,3,7-trimethylxanthine), which is an alkaloid that can be found in coffee beans, tea leaves, cocoa beans and other plants, has a structure similar to nucleosides and other xanthines that can be found in several natural sources [4]. Traditionally recommended as a beverage to reduce or omit because of a risky global profile, coffee has progressively moved to a less negative position due to its better known phytochemistry. Coffee includes a Complex mixture of compounds, where caffeine has been perhaps the most widely known; however, coffee is also rich in other bioactive substances with a wide array of physiological effects (Figure 1) [2,3]. The list comprises up to 1000 described phytochemicals. Among them, are phenols, including chlorogenic and caffeic acid, lactones, diterpenes, including cafestol and kahweol, niacin, and the vitamin B3 precursor trigonelline. Moreover, coffee is rich in vitamin B3, magnesium and potassium [5,6].

Many aliments and drinks contain caffeine but large quantities of it can be certainly taken in by drinking coffee (Table 1) [2,7,8]. You can find different concentrations of caffeine in coffee, depending on the method of preparation of the beverage and the type of coffee [2,9]. A cup of coffee can contain caffeine in a range from 65 mg up to 360 mg, while the caffeine content of a cup of decaffeinated coffee is less than 10 mg. The actual amount of coffee consumed per person is 8-12 kg in the Scandinavian Countries, 4.2 kg in U.S.A. and 2.8 in United Kingdom. An epidemiological study on the beverage consumption of Canadian adults documents the consumption of coffee at different ages [1]. As far as men older than 50 years old were concerned the consumption of coffee was higher than the consumption of water.

Moreover, many studies have demonstrated that coffee is one of the most important sources of polyphenols, in particular CQAs, among foods and beverages [10]. There are about 71 species of CQAs found in coffee beans, fruits, and vegetables [11]. Among the 8 CQAs present in green coffee beans, the concentration of 5-caffeoylquinic acid (5-CQA) is the highest (40–50 mg/g) [12]. One study demonstrated that 5-CQA exhibited only slight pro-oxidant activity at relatively high levels (100 and 200 μg/mL), whereas it exhibited moderate antioxidant activity at lower levels (5 μg/mL). Roasted coffee beans reportedly exhibited higher antioxidant activities than non-roasted green beans [13], even though the CQA content decreased with roasting [12]. These results suggest that, in the roasting process, CQA produces some potent antioxidants.

This study pointed out an exception to the tendency towards coffee among the people from 19- to 30-year-olds, who were more likely to report having had milk the previous day and, as well, the percentage of men within this age group who reported having had regular soft drinks exceeded the proportion who had coffee. Among those who drank coffee, consumption peaked at ages 31 to 50, averaging 639 grams for men and 586 grams for women. By the age 71 or older, the average amounts were considerably lower at 489 grams and 398 grams.

Coffee accounted for almost all the caffeine that adults consumed: 80.6%. Tea and soft drinks made up 12.3% and 5.9%. Caffeine causes several effects such as stimulating central nervous system; increasing respiratory rate, bronchodilatation, lipolysis, and dieresis, gastrointestinal disturbances, cardiac arrhythmias [14,15]

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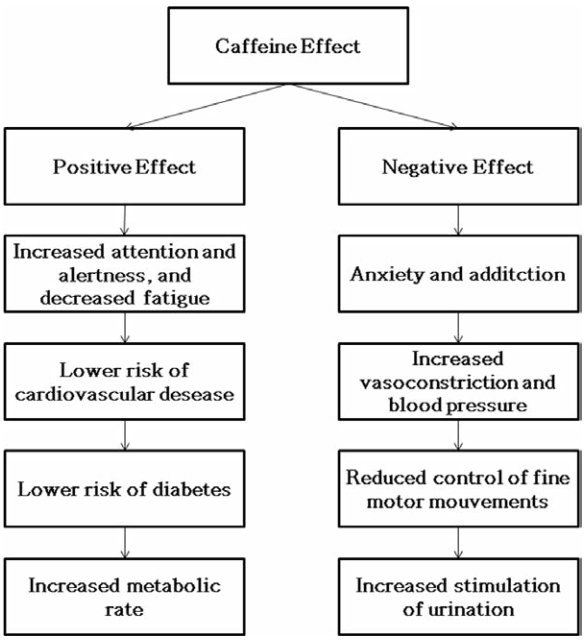

Figure 1: Physiological effects of caffeine.

Product	Serving Size	Caffeine per serving	Caffeine per liter
Red Bull	250 ml	80 mg	320 mg
Hot 6ix	250 ml	62.5 mg	250 mg
Monster Energy	347 ml	164 mg	472 mg
Energy	180 ml	8 mg	44 mg
Bacchus D	100 ml	30 mg	300 mg
Cap Coffee	12 g	65 mg	-
Can Coffee	175 ml	74 mg	422 mg
Coca-Cola Classic	250 ml	23 mg	92 mg
Chocolate	30 g	16 mg	-

Table 1: Caffeine Content in Energy Drinks and foods.

potentially hypertensive palpitations [16]. Caffeine is a natural alkaloid methylxanthin. Some 99% is absorbed after oral ingestion, the blood concentration peaks 1-1.5 h after ingestion, and its half-life in adults is 3–6 h. Caffeine is metabolized by the cytochrome P450 hepatic enzyme system [17].

Effect on the Degenerative Brain Diseases

Alzheimer's disease is the most common form of dementia degenerative that hits our elderly population and, in spite of the improvements achieved in the last years research, the awareness of the environmental risk factors associated with this disorder is still modest.

Caffeine, which is an easily modifiable environmental factor, may have a protective effect on the probability of developing Alzheimer's disease. Some favorable data from experimental studies has nourished the hypothesis that caffeine [18], chlorogenic acid [19], or their combination [20] may protect against the cognitive deterioration or biological features of Alzheimer's disease in the central nervous system [3].

Although epidemiological studies reported that regular consumption of coffee seemed to be protective for Alzheimer's disease in Canadian people [21], further investigations need to be done in order to determine whether caffeine consumption can have a major affect on the development of Alzheimer's disease or age-related cognitive decline [22–24]. The results obtained in case-control studies and of a prospective investigation in men suggest that consumption of coffee could protect against the risk of Parkinson's disease, but the active constituent is not clear. In order to support the hypothesis that caffeine is protective against Parkinson's disease. Ascherio, et al. [25] focused on the relationship between coffee and caffeine consumption and the risk of this disease among patients in two ongoing cohorts, the Health Professionals' Follow-Up Study and the Nurses' Health Study. The research include 47,351 men and 88,565 women who were free of Parkinson's disease, stroke, or cancer at baseline. A comprehensive life style and dietary questionnaire was filled in by participants at the beginning and then it was updated every two to four years.

During the follow-up (10 years in men, 16 years in women), 288 incident cases of Parkinson's disease were documented. Among men, after adjustment for age and smoking, the relative risk of Parkinson's disease was 0.42 for men in the top one-fifth of caffeine intake compared to those in the bottom one-fifth. An inverse association was also observed with consumption of coffee, caffeine from non-coffee sources, and tea but not decaffeinated coffee. Among women, the relationship between caffeine or coffee intake and risk of Parkinson's disease was U-shaped, with the lowest risk observed at moderate intakes (1-3 cups of coffee/day, or the third quintile of caffeine consumption). The results suggest that moderate doses of caffeine can possibly have a protective effect on risk of Parkinson's disease. The association between caffeine intake and risk of Parkinson's disease was observed in a similar way in both fast and slow caffeine metabolizers, supporting experimental evidence in animal models that both caffeine and its major metabolite, paraxanthine, are neuroprotective [26]. Arendash and Cao [27] reported a surprising ability of moderate caffeine intake (the human equivalent of 500 mg caffeine or 5 cups of coffee per day) to protect against or treat AD in a mouse model for the disease and a therapeutic potential for caffeine against AD in humans.

Effect on the Autonomic Nervous System

Different substances and/or experimental manipulations affect the sympathetic nervous system [28–34]. Monda, et al. [35] have examined the role of coffee on autonomic nervous system in young healthy people. This study analyzed the effect of a cup of espresso coffee on the heart rate variability (HRV) power spectral analysis, which is a method providing evaluation of the sympathetic and parasympathetic discharge. In young healthy sedentary subjects, the HRV-power spectrum was evaluated over a period of 150 min after the introduction of espresso coffee (caffeine, 75 mg) or decaffeinated coffee (caffeine, < 10 mg) in supine and seated position. The values of the spectrum were added in low frequencies (LF) and high frequencies (HF) [36–40]. The LF and HF spectra estimate the sympathetic and parasympathetic activity, respectively. In the supine position, coffee increases HF, while decaffeinated coffee causes little modifications of HF. In the seated position, HF is not modified by coffee or decaffeinated coffee. Coffee and decaffeinated coffee do not induce any modification of LF in both positions. The result of the experiment demonstrates how coffee affects the parasympathetic activity in the supine position. Corti, et al. [41] showed that coffee induces comparable increases in sympathetic activity and blood pressure in nonhabitual coffee drinkers, whereas habitual coffee drinkers exhibited lack of blood pressure increase despite sympathetic activation due to coffee [42–44].

Since in this experiment it was showed that also decaffeinated coffee increases blood pressure and sympathetic activity in non habitual drinkers, ingredients other than caffeine could be responsible for

cardiovascular activation. Then the acute intake of coffee or caffeinated drinks can increase blood pressure, as well as activate the sympathetic nervous system in coffee drinkers non-habitual contrary to the habitual drinkers. Restriction of coffee or caffeinated beverages is no longer indicated in the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) guidelines for the handling of hypertension. Indeed, no clear association between coffee and the risk of hypertension or myocardial infarction has been proved. More recent studies evidence how a habitual intake of coffee does not endanger the health, but may be in relations with significant benefits on cardiovascular health.

Effect on the Memory

Coffee has a positive effect on short-term memory by acting on the brain's prefrontal cortex. Functional magnetic resonance imaging (fMRI) has been used by Koppelstaetter, et al. [45] in order to establish how coffee activates different areas of the brain. Before being tested candidates fasted for 4 to 6 hours and abstained from caffeine and nicotine for at least 24 hours; afterwards they were given either a cup of coffee containing 100 milligrams of caffeine, or a caffeine-free placebo drink. After 20 minutes all participants underwent fMRI scans while carrying out a memory and concentration test. Few days later the experiment was repeated under the same conditions but each candidate received the other drink. During the memory tests, participants were shown a fast sequence of capital letters, then were flashed a single letter on a screen and we retold to decide quickly whether this letter was the one which appeared second-to-last in the earlier sequence. They had to answer by pressing "Y" for yes or "N" for no. The whole group showed activation of the working memory part of the brain, but those who received caffeine had significantly greater activation in parts of the prefrontal lobe, known as the anterior cingulate and the anterior cingulate gyrus. These areas are involved in 'executive memory', attention, concentration and planning. These results suggest that caffeine change neuronal activity as evidenced by fMRI signal changes in a network of brain areas associated with executive and attentional functions during running memory processes.

Effect on Anticipatory Processes

Tieges, et al. [46] examined the effects of reasonable doses of caffeine on task switching and task maintenance using mixed-task (AABB) blocks, in which participants alternated predictably between two tasks, and single-task (AAAA, BBBB) blocks. Switch costs refer to longer reaction times on task switch trials (e.g. AB) compared to task-repeat trials (e.g. BB); mixing costs refer to longer response times in task-repeat trials compared to single-task trials. In a double-blind, within-subjects experimentation, two caffeine doses (3 and 5mg/kg body weight) and a placebo were administered to 18 coffee drinkers. Both caffeine doses decreased switch costs confronted to placebo. Event-related brain potentials exposed a negative deflection developing within the preparatory interval, which was superior for switch than for repeat trials. Caffeine amplified this switch-related difference. The results suggest that caffeine valorizes task-switching performance by rising general effects on task switching, related to task-nonspecific (rather than task-specific) anticipatory processes. Caffeine's actions can be mediated by dopaminergic modifications in the striatum or anterior cingulate cortex.

Effect on Glucose Homeostasis

Epidemiological studies make evidence of the fact that coffee consumption is directly in relation with the large risk reductions in the prevalence of type 2 diabetes (T2D). There is other scientific evidence that shows that caffeine causes acute postprandial hyperglycemia and lower whole-body insulin sensitivity. This means that a component of coffee different from caffeine is responsible for the beneficial effects of coffee consumption. This review examines the specific coffee compounds answerable for coffee's effects on T2D, and their possible physiological mechanisms of operation. When green coffee is roasted at elevated temperatures, Maillard reactions generate a number of unique compounds. Roasting generates a portion of the antioxidant, chlorogenic acid, to be changed into quinides compounds known to alter blood glucose levels. Coffee consumption may also mediate levels of gut peptides (glucose-dependent insulinotropic polypeptide and glucagon-like peptide-1), hormones implicated in the regulation of satiety and insulin production. Afterward, coffee may have prebiotic-like properties, changing gut flora and eventually digestion. In conclusion, it is clear that further research on the function of coffee in the development and prevention of DT2 can be used to find out new therapeutic targets and nutraceutical formulations for the disease [47].

Effect on Liver

Several researchers have focused on the correlation between coffee intake and liver disease and the data gained thanks to their homogeneity, confirmed the inverse correlation with the serum enzyme activities gamma-glutamyl transferase and alanineaminotransferase. Coffee consumption is inversely connected with hepatic cirrhosis; however, it was not possible to prove that coffee plays a role on preventing liver injury. Animal models and cell culture studies indicate that kahweol diterpenes and cafestol (some coffee compounds) can operate as blocking agents by modulating multiple enzymes involved in carcinogenic detoxification. These molecules also alter the xenotoxic metabolism by inducing the enzymes glutathione-S-transferase and inhibiting N-acetyltransferase. The benefit produced by coffee consumption on hepatic cancer may be attributed to its inverse relation with cirrhosis, although allowance for clinical history of cirrhosis did not completely account for the inverse association. it seems reasonable to propose experiments with animal models of liver damage and to test the effect of coffee, and/or isolated compounds of this beverage, not only to evaluate the possible causative role of coffee but also its action mechanism. Clinical prospective double blind studies are also necessary [48–52]. Now, considering the results of this research, it is important to recommend experiments with animal models of liver damage and to test the effect of coffee and/or isolated compounds of this beverage, in order to analyze its role and its mechanism of action. Clinical prospective double blind studies also need to be done [48].

Effect on Gallbladder Disease

Gallbladder disease affects more than 20 million adults in the USA and it is a cause of considerable morbidity. The habit of drinking coffee is connected to a reduced risk of increasing gallbladder disease even if risk factors for gallbladder disease are not completely understood. Men who drank regularly at least 2 cups (473 ml) of coffee per day had a risk of being affected by symptomatic gallbladder disease that was 60 percent or less lower than men who did not drink coffee [40, 53–55].

Coffee Consumption and Cancers

Many studies have shown an inverse correlation between coffee consumption and the incidence of cancers such as colorectal cancer. Animal research supports the chemopreventive studies on coffee. A study was made to identify the components of coffee responsible for its beneficial effects. In animal models and cell culture systems, the coffee

diterpenes cafestol and kahweol (C+K) were shown to produce a broad range of biochemical effects resulting in a reduction of the genotoxicity of several carcinogens. Various mechanisms appear to be engaged in these chemoprotective effects such as an induction of conjugating enzymes, an increased expression of proteins involved in cellular antioxidant defense, and an inhibition of the expression and/or activity of cytochromes P450 involved in carcinogen activation. In animal models the C+K-mediated induction of conjugating and antioxidant enzymes has been observed in hepatic, intestinal and kidney tissues.

It was verified that in the small intestine these inductions were caused by Nrf2-dependent transcriptional activation. In vitro investigations obtained in cell cultures of human origin indicate that the effects and mechanisms observed in animal test systems with C+K are likely to be of relevance for humans. In human liver epithelial cell lines transfected to express AFB(1)-activating P450s, C+K cure resulted in a decrease of AFB(1)-DNA binding. This defense was correlated with an induction of GST-mu, an enzyme known to be involved in AFB(1) detoxification. In adding, C+K was found to inhibit P450 2B6, one of the human enzymes responsible for AFB(1) activation. Entirely all the data on the biological effects of C+K point out a plausible hypothesis to clarify some of the anti-carcinogenic effects of coffee observed in human epidemiological studies and in animal experiments [56]. Conclusions reached by recent meta-analysis propose that coffee consumption may play a role on reducing the total cancer incidence and it also has an inverse association with some type of cancers. Overall, an increase in consumption of 1 cup of coffee per day was associated with a 3% reduced risk of cancers. In subgroup analyses, we observed that, coffee drinking was directly correlated to reduced risk of bladder, breast, buccal and pharyngeal, colorectal, endometrial, esophageal, hepatocellular, leukemic, pancreatic, and prostate cancers [57].

Coffee and Health Risks

Coffee lipid fraction containing cafestol and kahweol raises serum cholesterol that may play a role in the onset of coronary heart disease as myocardial and cerebral infarction, insomnia, and cardiovascular complications. Caffeine produce most of its biological effects via antagonizing all types of adenosine receptors and its withdrawal is accompanied with muscle fatigue and allied problems in those addicted to coffee. The evidence about pregnant women or those with postmenopausal suggest not to use coffee as it may interfere with oral contraceptives or postmenopausal hormones.

Conclusion

Caffeine is the most investigated component in coffee. Originally isolated from coffee beans in 1820, it was then subjected to intensive pharmacologic research and initial clinical application. The global view on the impact of coffee on health has been displaced from a mostly harmful balance toward a likely beneficial profile. The data in favor of this optimistic perspective derive from the rather clear benefit deriving from liver protection, Parkinson's risk reduction or recent observations on global mortality. Finally, coffee should not be taken as a substitute, but only as a one more partner in a general strategy to promote health, where exercise and healthy diet continue to play key and irreplaceable roles. In conclusion, a growing body of evidence from epidemiological studies suggests that coffee drinking in most people is beneficial and inversely associated with risk for various diseases. However, because association does not prove causation, randomized controlled studies are needed to elucidate the relationship between caffeine consumption and certain diseases and to analyze patterns of consumption with respect to health outcomes.

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