1st International Congress on Cancer Prevention
ICCP 2024
Zanjan, Iran
18-19 September 2024
University of Zanjan

The anticancer effects of coffee

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Abstract

Coffee is one of the world's most common and widely consumed drinks. The potential relationship between coffee and cancer is one of the most controversial topics in society because coffee consumption is a factor in preventing the development of cancer. However, there are also many debates surrounding the effects of consuming coffee. This article aims to explore the causes and effects of coffee on cancer and examine its impact on all types of cancers.

Keywords: Antioxidant properties, Cancer, Coffee

1- Introduction

Sometimes, some body cells grow and develop uncontrollably; this disease is called cancer [1]. If cancer is not treated, it will cause death. Smoking, lack of physical activity, dietary factors, obesity, and overweight, alcohol consumption are among the factors that play a significant role in causing cancer [2]. Diet and nutrition are essential for cancer prevention and treatment. An unhealthy diet increases the risk of cancer, and undernourishment reduces the effectiveness of cancer treatments [3].

Coffee is one of the most widely consumed beverages globally. Over the last few years, a substantial amount of research has been dedicated to studying the effects of drinking coffee on health. New studies suggest that drinking coffee could reduce the chances of dying from specific illnesses like heart and brain diseases, diabetes, and certain cancers such as endometrial and liver cancer [4]. Coffee is believed to promote longevity and offer protection against neurological and liver illnesses [5]. Research has

also indicated that drinking coffee may provide a shield against cancer, decreasing the likelihood of contracting the illness [6]. Health professionals are increasingly intrigued by this trend due to the substantial increase in coffee consumption in recent years, driven by economic growth and business demand. Approximately 500 billion cups of coffee were consumed annually, according to a 2011 estimate. Furthermore, higher consumption of coffee has been associated with general anti-inflammatory advantages and protection against certain forms of cancer, acting as a type of chemotherapy, too [7]. The elements in coffee, such as chlorogenic acids, polyphenolics, terpenoids, alkaloids, and other phytochemicals [5], contribute to coffee's effects, including its role in carcinogenesis. Studies have found a connection between drinking coffee and a lower chance of developing different types of cancer, including breast, prostate, oral, melanoma, skin, stomach, colorectal, endometrial, leukaemia, liver, brain, and thyroid cancer [6]. Research has thoroughly investigated the connection between drinking coffee and cancer prevention [5].

2- Methodology

Articles related to the anticancer effects of coffee were studied and reviewed from the year 2013 to 2024 by searching various databases such as Scopus, PubMed, BioRxiv, and Google Scholar.

3- Results

3-1- Antioxidant properties of coffee

Coffee is an important source of antioxidants in diets, ranking sixth out of 1,115 commonly consumed foods in the US regarding antioxidant levels. This implies that antioxidants in coffee could reduce reactive oxygen species (ROS). Previous research has linked coffee consumption to a reduced risk of death from oxidative stress and inflammatory conditions. While coffee contains antioxidants and some research suggests a decrease in oxidative stress markers, there is limited scientific evidence to prove that coffee prevents cancer through its antioxidant properties directly. Coffee likely affects the body's biology by enhancing the immune system with its antioxidant and non-antioxidant components rather than directly [8].

3-2- Important coffee compounds related to cancer risk

3-2-1- Caffeine

The primary sources of caffeine (1, 3, 7-trimethylxanthine), a purine alkaloid, are cocoa beans, tea, and coffee. Caffeine has nutritional advantages, but it can also help in treat several illnesses, including high blood pressure, heart disease, cancer, and AIDS (acquired immune deficiency syndrome)[9]. Caffeine belongs to the Xanthenes group of

chemicals and works on the A1, A2A, and A2B subtypes of adenosine receptors as a competitive antagonist of the neurotransmitter adenosine. In general, this adversarial interaction improves both mental and physical abilities. After intake, caffeine is absorbed mainly by the small intestine and distributed throughout all body tissues, including the brain. The P 450 isoform CYP 1A2 is primarily responsible for its metabolism in the liver. It generates three metabolites: paraxanthines (which enhance lipolysis), theobromine (which dilates the vascular system and induces diuresis), and theophylline (which relaxes bronchial muscles).

Caffeine inhibits the production of leukotrienes, interleukin-6, interleukin-8, prostaglandin E2, and tumor necrosis factor-α, decreasing inflammatory processes. Caffeine and other polyphenols have been shown to have a special potential to activate an antioxidant response element, which lowers oxidative stress [7].

Research has demonstrated that individuals who consume caffeinated or decaffeinated coffee experience the same health benefits, although caffeine may play a role in certain reactions triggered by coffee. Furthermore, several investigations have shown that caffeine induces fatal mitosis in cells and counteracts the G2 phase block caused by DNA-damaging substances. Caffeine prevents G2 arrest by reactivating the activity of Cdc25C and Cdc2. It is intriguing that caffeine is believed to create a π-π bond with the base pairs in DNA, similar to other anticancer drugs because of its flat xanthine configuration. Research conducted by Mora et al. found that coffee can shield DNA from harmful substances, regulate the effectiveness of chemotherapy drugs, and enhance the absorption of DNA. Previous studies have shown that caffeine influences the AMP-activated protein kinase (AMPK), PI3K/Akt, and mammalian target of rapamycin (mTOR) signalling pathways in melanoma cells. In addition, caffeine boosts the generation of a range of proteins in various cancer cell lines, including Rb, ERK 1/2, GSK3β, PDK1, cyclin D1, cyclin E, c-Myc, Akt, and mTOR. Another research discovered that caffeine enhanced the expression of p300 in glioma cells.

Furthermore, caffeine has been seen to decrease NF-κB-induced ERK phosphorylation in osteoclasts. In RAW 264.7 macrophages, the expression of pro-inflammatory genes was reduced after inflammation was induced by lipopolysaccharide (LPS). Moreover, coffee has shown anti-tumor effects inside the body, and various research studies have explored the link between coffee intake and the risk of cancer in humans [10].

3-2-2- Cafestol and Kahweol

Various studies have confirmed that cafestol and kahweol, natural diterpenes present in coffee, exhibit anti-inflammatory and anti-angiogenic properties. Ongoing research is focused on the beneficial effects of coffee compounds, which play a key role in the growth of malignant cells in tumors through inflammatory angiogenesis. Both research with experimental models and studies with human participants indicate that cafestol and kahweol can potentially to hinder tumor growth by obstructing or decreasing neoangiogenesis [7]. Cafestol inhibits cell proliferation, migration, and tube formation in human umbilical vein endothelial cells, showing anti-angiogenic properties. Kahweol

inhibits cancer cell growth in macrophages by activating the NF-κB pathway. Moreover, the combination of cafestol and kahweol has demonstrated chemopreventive properties against cancers caused by heterocyclic amines. These coffee compounds, particularly cafestol and kahweol, are being researched for their potential benefits in preventing and treating cancer due to their antioxidant, cytotoxic, anti-mutagenic, and anti-carcinogenic properties[10].

3-2-3- Chlorogenic Acids

Animals, plants, and meals frequently include phenolic substances such as lignans, polyphenols, phenolic acids, and tocopherols [11]. Chlorogenic acids are essential to plant polyphenols produced from caffeine and quinic acid[7]. Caffeoylquinic acid (CQA), feruloylquinic acid (FQA), caffeic acid (CA), dicaffeoylquinic acid (diCQA), and D-(−)-quinic acid (QA) are the primary polyphenols present in coffee[12]. Up to 98% of the phenolic chemicals in coffee are chlorogenic acids, the most common type [7]. Coffee's chlorogenic acids (CGAs) have biological effects on several human health issues [12]. These acids have anticancer properties mainly due to their ability to neutralize singlet oxygen and free radicals by releasing T cells, NK cells and macrophages, which help stop the development of carcinogens [7]. In coffee, chlorogenic acid has demonstrated potential antitumor effects by reducing cell survival and inhibiting reactive oxygen species (ROS), also aiding in health benefits by promoting the proliferation and activation of T cells, NK cells, and macrophages, potentially slowing or preventing cancer cell growth. It inhibits the generation of cell adhesion molecules in human endothelial cells caused by TNF-α [10].

3-2-4-Ferulic acid

Ferulic acid inhibits angiogenesis by targeting FGFR1 and activating the PI3K/Akt signalling pathways. It restrains cell growth by halting cell division and inducing programmed cell death while also reducing movement, invasion, and the formation of cell clusters [10].

3-3- The effect of coffee on various types of cancer

3-3-1- Breast Cancer

Breast cancer is the cancer that women most often experience [13]. Recent epidemiological studies provide scant evidence linking coffee consumption to the risk of breast cancer [7]. A recent study discovered that there is little to no connection between drinking coffee and the risk of developing breast cancer. Nevertheless, due to the complexity of breast cancer, which can manifest both before and after menopause, these variables could impact the connection with coffee. Some proof suggests that increased coffee consumption could lower the chances of developing breast cancer in postmenopausal women, European women, and individuals with specific bcl-2 gene variations and genetic traits [5]. Simonson et al. have recently found that breast cancer patients undergoing tamoxifen treatment experienced a significantly decreased risk of

primary events when consuming moderate (two to four cups per day) to high (five or more cups per day) coffee. Recent studies suggest that there is a link between decreased chances of developing breast cancer and higher coffee intake, especially in estrogen receptor-negative cases, breast cancer type 1 mutation carriers, postmenopausal women, and those undergoing tamoxifen therapy for breast cancer [14]. Variations in the cytochrome P450 1A2 (CYP1A2) gene, which impacts the breakdown of caffeine, could play a role in these connections. In general, there is no connection between coffee, caffeine, and a higher chance of developing breast cancer [15].

3-3-2-Hepatocellular Cancer

A recent comprehensive evaluation found that drinking coffee is not linked to various digestive organ cancers, but it does offer a significant protective benefit against liver cancer. Research utilizing information from the UK Biobank found that consuming different types of coffee, such as decaffeinated, was linked to a reduced likelihood of chronic liver disease and liver cancer, with no impact on the risk of other gastrointestinal cancers [5]. According to studies conducted between 2013 and 2023, liver fibrosis can result in cirrhosis, which can then cause liver cancer or liver failure. Additionally, studies have demonstrated that "chlorogenic acid" (CGA) can successfully prevent liver fibrosis, another way CGA protects the liver. Through processes like the rearrangement of antioxidant response elements (ARE) and the activation of detoxification enzymes, "caffeine" not only inhibits the activity of adenosine but also suppresses hepatic fibrosis and the growth of liver cancer cells. Coffee diterpenes, which are also found in fatty acid esters, are well-known for their ability to raise cholesterol as well as for their anti-inflammatory and antioxidant qualities, which help to prevent reactive species-induced damage to liver cells [16].

3-3-3- Gastric cancer

The precise relationship between drinking coffee and lowering the risk of stomach cancer is not well known. However, a rise in the risk of stomach cancer has been noted, particularly among the population in the United States [7]. In the studies reviewed in the last three decades, coffee consumption is considered a factor for preventing and protecting stomach cancer. Anyhow, in statistical analyses based on gender, there is no significant relationship between coffee consumption and the risk of stomach cancer regarding the male or female gender [17].

3-3-4- Kidney Cancer

New studies suggest drinking coffee is unlikely to be associated with a higher chance of developing renal cell cancer[4]. Recent studies found no lower likelihood of kidney cancer with higher coffee consumption. This contrasts with findings from a multi-group meta-analysis and another large study, which showed a 20% decreased risk for

individuals who drink over 2 cups of coffee daily. The advantages could stem from elements found in coffee, such as caffeine and cafestrol, which might inhibit the proliferation and dissemination of kidney cancer cells [5].

3-3-5- Prostate Cancer

The data currently accessible does not definitively prove a link between genetic variations related to coffee and the risk of prostate cancer. Furthermore, studies have produced conflicting results on the link between drinking coffee and the likelihood of developing prostate cancer among different levels of tumor severity [7]. Research suggests that there is an inverse relationship between coffee consumption and the risk of developing prostate cancer. Studies have consistently shown that men who drink coffee regularly may have a lower risk of developing prostate cancer, particularly lethal or aggressive forms of the disease [18]. One study found that a higher intake of coffee may be associated with a lower risk of prostate cancer [19].

3-3-6- Endometrial Cancers

Studies show that coffee drinking is associated with a lower incidence of endometrial cancer. Research demonstrates that a higher coffee intake is linked to a lower incidence of endometrial cancer. The potential of caffeine to raise levels of sex hormone-binding globulin (SHBG) in postmenopausal women may be responsible for this protective effect. Higher SHBG levels lead to decreased levels of these hormones in the bloodstream since SHBG is a primary transporter of estrogen and testosterone. Because they inhibit endometrial growth, low estrogen levels are thought to offer protection against endometrial cancer. By lowering estrogen levels, the positive correlation between coffee consumption and SHBG may help to explain the inverse link between the two conditions and endometrial cancer [20].

On the other hand, a significant study found a link between coffee consumption and a reduced chance of developing endometrial cancer, especially in women with a BMI of 25 kg/m^2 or above [5].

4- Conclusions

According to the studies conducted, coffee's anticancer effect is attributed to the presence of compounds such as caffeine, cafestol, alcohol, chlorogenic acid, and ferulic acid. Coffee possesses antioxidant properties that decrease ROS. Based on the gathered information, it can be inferred that consuming coffee reduces the risk of breast cancer[15], kidney disease, and endometrial cancer [5]. However, there is no significant association between coffee consumption and stomach and prostate cancers [4].

Overall, recent research demonstrates a lower chance of developing oral cancer and possibly breast cancer in individuals who consume coffee. Although we can consume coffee, we can boost our intake of the special energizing and healing substance [4]. The findings indicate that both regular and decaffeinated coffee offer comparable health

advantages, with caffeine possibly impacting coffee characteristics depending on the tumor site [10].

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