



Can you provide an overview of current and/or emerging research regarding the effects of coffee consumption on health?



With the popularity of coffee as a beverage in many countries around the world, there has been significant interest over the past several years regarding the impact that coffee consumption might have on health. In addition to providing caffeine, coffee is now being studied as a source of nutritionally beneficial dietary components such as antioxidants. Recent epidemiological studies suggest that there may be a relationship between coffee drinking and potentially significant health benefits including mental alertness and reduction of risk for certain diseases such as type 2 diabetes, colon cancer and liver cancer. (1, 2)

Antioxidants in Coffee

When oxygen interacts with certain molecules in the body, free radicals are formed, which then react with, and may cause damage to, cellular components such as protein, lipids and DNA. An imbalance in the production of free radicals and the production of the body's own antioxidants can lead to oxidative damage and, when ongoing, to a condition known as oxidative stress. Long-term exposure to oxidative stress is a suspected factor in the etiology of cardiovascular and metabolic diseases, some cancers and many of the deleterious effects of aging. (3, 4)

The body naturally produces antioxidants to aid in the reduction of oxidative stress. In addition, antioxidants are available in certain plant-based foods and beverages. These dietary antioxidants interact with unstable free radicals in the body to reduce cellular damage and oxidative stress, much like the body's natural antioxidant system. Dietary antioxidants include vitamin C, vitamin E, carotenoids and polyphenols. Polyphenols are found in fruits, vegetables, teas, cocoa, wine and coffee. Intake of polyphenols is thought to be partially responsible for the inverse relationship between fruit and vegetable consumption and risk for certain diseases. (3, 5, 6)

The main antioxidant in coffee is chlorogenic acid, which is a type of polyphenol. The antioxidant activity of coffee polyphenols has been shown in *in vitro* and *in vivo* studies (7-10) and also in a recent human intervention trial. (11)

Additionally, compounds called melanoidins, which may contribute to coffee's antioxidant effects, are formed during the roasting of coffee beans. (12) The roasting process, however, must be controlled, to limit formation of deleterious compounds.

Caffeine and Hydration

It has traditionally been thought that consumption of caffeinated beverages should be limited due to potential dehydration effects that might be associated with the mild diuretic effect of caffeine intake. However, recent research has shown that caffeine-containing beverages do not significantly increase 24-hour urine volume, supporting the idea that they contribute to, rather than deter, hydration status. (13) Further, the water component of caffeine-containing beverages outweighs the diuretic effects of caffeine. Therefore, caffeinated beverages contribute to daily water requirements in a similar manner to plain water. (13) The evidence was judged strong enough that the 2004 report on Dietary Reference Intakes issued by the Institute of Medicine's Food and Nutrition Board stated that caffeinated beverages contribute to hydration status similarly to non-caffeinated beverages. [Note of interest to readers: Similar to questions about caffeine's diuretic effect on hydration, there have been questions about caffeine's effect on calcium absorption. According to studies, this negative effect is small enough to be offset by as little as 1-2 tablespoons of milk. Overall, evidence does not suggest any harmful effect of caffeine on bone status or on calcium stores in those who get the recommended levels of calcium. (14)]

Caffeine's Effects on Cognition

Many people drink coffee for its purported ability to act as a stimulant and enhance mental alertness and acuity. A large number of studies support caffeine's ability to increase alertness. Acute caffeine ingestion improves the performance of simple tasks that are aided by high levels of alertness and vigilance. (15, 16) Caffeine's effects on more complex cognitive tasks and memory are not as clear due to variations in the design of experiments; however, one large cross-sectional study using data from a representative sample of British adults has shown a significant positive relationship between coffee intake and cognitive performance, indicating a dose-response trend at higher levels of usual coffee intake. (17) Short-term benefits linked to acute caffeine consumption include significant safety effects in such tasks as night-time driving and shift work. (18, 19) In a 2005 scientific review on attention, psychomotor functions and aging, Kallus and colleagues point out that 11 of

13 studies show a positive effect of caffeine on various measures of cognitive performance. In instances when this effect was not observed, this may have been attributed to an insufficient caffeine dose or a potential decrease in the robustness of the results with aging. Nonetheless, it appears that the majority of available data points toward a positive effect of caffeine on cognitive performance across the lifespan. (20)

In addition to the short-term benefits, recent epidemiological data suggest that regular coffee drinking may provide long-term benefits to cognitive function and may slow or even prevent age-related cognitive decline. A study of more than 1500 men and women from the Rancho Bernardo Study in California (mean age 73.3 and 72.6 years, respectively) assessed cognitive function, along with lifetime and current coffee consumption. (21) Higher lifetime coffee consumption in women was associated with significantly better performance on 6 out of 12 cognitive tests. Further, current coffee consumption was associated with improved performance on 2 of the tests. (21) Another study investigated coffee consumption and 10-year cognitive decline in 676 healthy European men born between 1900 and 1920. (22) Men who drank coffee had significantly less 10-year cognitive decline than non-coffee drinkers. The men drinking 3 cups of coffee per day had the least cognitive decline. Further research is needed to determine what components of coffee work to reduce cognitive decline and whether there may be relationships with the development of Alzheimer's disease. (21)

Coffee and Type 2 Diabetes

During the past 5 years, epidemiological studies have shown a strong relationship between coffee consumption and decreased risk for development of type 2 diabetes. In a cohort study of more than 17,000 Dutch men and women between the ages of 30 and 60 years, individuals who drank 7 or more cups of coffee a day were significantly less likely to develop type 2 diabetes. (23) Since 2002, when this study was published, an additional 16 of 18 cohort studies and 11 of 12 cross-sectional studies have associated varying levels of coffee consumption with a decreased risk for type 2 diabetes. (24) Further research is necessary to determine the effective amounts of coffee, since the method of preparation, quantity of coffee used (strength) and amount of coffee in a "cup" (e.g., demitasse, traditional cup, mug, large insulated container) vary from person to person and among cultures.

Coffee and Liver Health

A growing body of evidence points to the protective effects of coffee drinking on liver health. (2) For example, a large-scale cohort study in Japan found that consuming at least 5 cups of coffee per day resulted in a 76% lower risk of hepatocellular carcinoma. (25) A recent meta-analysis (26) supports the Japanese findings and those of several studies in European populations. Additional research suggests that coffee drinking may protect against liver damage and cirrhosis (2).

Coffee and Digestive Health

Some evidence suggests that coffee may have some preventive effects on development of colon cancer. Results of research have been mixed, however, and depend on the design of the experiments. In general, case control studies have demonstrated a reduced risk for colon cancer with increased coffee consumption; prospective cohort studies have not shown such an effect. (2) Some of the physiological mechanisms that have been proposed as explaining the potential preventive effects of coffee consumption on colon cancer risk include an increase in colonic motility, elimination of carcinogens, improved antioxidant status of the colon due to coffee's intrinsic antioxidants, and decreased synthesis and secretion of bile acids. (2) None of these proposed mechanisms has strong scientific support as of yet. Further research is necessary to understand whether a definitive relationship exists between coffee intake and colon cancer.

Summary

Coffee is a widely appealing and complex beverage containing a mixture of known and unknown substances, the quantity of which may be dependent on the processing (e.g., light vs. dark roast and/or caffeinated vs. decaffeinated), method of preparation (e.g., filtered vs. unfiltered), amount of coffee used in preparation (strength) and/or variation in cup size. While the health benefits of coffee are better understood, much more research is needed to determine coffee's exact components and understand the mechanisms by which they affect health. While some individuals (e.g., those with hypertension) should continue to limit caffeinated beverages, it appears that there may be some significant health benefits for adults consuming moderate amounts of coffee (3-4 cups per day). (1, 2)

References:

1. Nehlig A. *Coffee, Tea, Chocolate, and the Brain*. Boca Raton: Routledge, 2004.
2. Higdon JV, Frei B. Coffee and health: a review of recent human research. *Crit Rev Food Sci Nutr*. 2006; 46:101-23.
3. Barbaste M, Berké B, Dumas M et al. Dietary antioxidants, peroxidation and cardiovascular risks. *J Nutr Health Aging*. 2002; 6(3):209-23.
4. Fang YZ, Zang S, Wu G. Free radicals, antioxidants, and nutrition. *Nutrition*. 2002; 18:872-9.
5. Manach C, Mazur A, Scalbert A. Polyphenols and prevention of cardiovascular diseases. *Curr Opin Lipidol*. 2005; 16:77-84.
6. Fresco P, Borges F, Diniz C, Marques MPM. New insights on the anticancer properties of dietary polyphenols. *Medicine Res Rev*. 2006; 26(6):747-66.
7. Richelle M, Tavazzi I, Offord E. Comparison of the antioxidant activity of commonly consumed polyphenolic beverages (coffee, cocoa and tea) prepared per cup serving. *J Agric Food Chem*. 2001; 49:3438-42.
8. Natella F, Nardini M, Giannetti I et al. Coffee drinking influences plasma antioxidant capacity in humans. *J Agric Food Chem*. 2002; 50:6211-16.
9. Somoza V, Lindenmeier M, Wenzel E et al. Activity-guided identification of a chemopreventive compound in coffee beverage using in vitro and in vivo techniques. *J Agric Food Chem*. 2003; 51: 6861-9.
10. Bichler J, Cavin C, Simic T et al. Coffee consumption protects human lymphocytes against oxidative and 3-amino-1-methyl-5H-pyrido[4,3-b]indole acetate (trp-P-2) induced DNA-damage: results of an experimental study with human volunteers. *Food Chem Toxicol*. 2007; 45:1428-36.
11. Steinkellner H, Hoelzl C, Uhl M et al. Coffee consumption induces GSTP in plasma and protects lymphocytes against (+/-)-anti-benzo[a]pyrene-7,8-dihydrodiol-9,10-epoxide induced DNA-damage: results of controlled human intervention trials. *Mutat Res*. 2005; 591:264-75.
12. Dupas CJ, Marsset-Baglieri AC, Ordonnaud CS et al. Coffee antioxidant properties: effects of milk addition and processing conditions. *J Food Sci*. 2006; 71(3):S253-8.
13. Armstrong LE. Caffeine, body fluid-electrolyte balance, and exercise performance. *Int J Sports Nutr Exerc Metabol*. 2002;12:189-206.
14. Heaney RP. Effects of caffeine on bone and the calcium economy. *Food Chem Toxicol*. 2002; 40:1263-70.
15. Smith A. Effects of caffeine on human behavior. *Food Chem Toxicol*. 2002; 40:1243-55.
16. Lieberman HR. Nutrition, brain function and cognitive performance. *Appetite*. 2003; 40:245-54.
17. Jarvis MJ. Does caffeine intake enhance absolute levels of cognitive performance? *Psychopharmacology (Berl)*. 1993; 110:45-52.
18. Boivin DB, Tremblay GM, James FO. Working on atypical schedules. *Sleep Med*. 2007; 8:578-89.
19. Philip P, Taillard J, Moore N et al. Effects of coffee and napping on nighttime highway driving: a randomized trial. *Ann Intern Med*. 2006; 144:785-91.
20. Kallus KW, Schmitt JAJ, Benton D. Attention, psychomotor functions, and age. *Eur J Nutr*. 2005; 44:465-84.
21. Johnson-Kozlow M, Kritz-Silverstein D, Barrett-Connor E, Morton D. Coffee consumption and cognitive function among older adults. *Am J Epidemiol*. 2002; 156:842-50.
22. Van Gelder BM, Buijsse B, Tijhuis M et al. Coffee consumption is inversely associated with cognitive decline in elderly European men: the FINE study. *Eur J Clin Nutr*. 2007; 61:226-32.
23. Van Dam RM, Feskens EJ. Coffee consumption and risk of type 2 diabetes mellitus. *Lancet*. 2002; 360:1477-8.
24. Van Dam RM. Coffee and type 2 diabetes: from beans to beta cells. *Nutr Metabol Cardio Dis*. 2006; 16:69-77.
25. Inoue M, Yoshimi I, Sobue T et al. Influence of coffee drinking on subsequent risk of hepatocellular carcinoma: a prospective study in Japan. *J Natl Cancer Inst*. 2005; 97:293-300.
26. Montella M, Polesel J, La Vecchia C et al. Coffee and tea consumption and risk of hepatocellular carcinoma in Italy. *Int J Cancer*. 2007; 120:1555-9.