Caffeine is a xanthine alkaloid found in various plants such as coffee and cocoa beans, tea leaves, guarana berries and the kola nut and is added to soft drinks and a variety of both prescription and over-the-counter drugs. It acts as a natural pesticide, protecting plants against insects that feed upon them. The average caffeine content of ground roasted coffee is around 85 mg per 150 ml (1 cup), of instant coffee it is 60 mg, of decaffeinated coffee is 3 mg, of leaf or bag tea is 30 mg, of instant tea is 20 mg and of cocoa or hot chocolate it is 4 mg. A glass (200 ml) of a soft drink containing caffeine, has between 20 – 60 mg of caffeine.

In Europe, adults consume on average 200 mg daily (ranging from 100-400 mg), mainly from coffee and tea, but also from soft drinks including “energy drinks”. However, the dose depends greatly on cultural habits. Northern European countries are known for their heavy coffee drinking: in Denmark, Finland, Norway or Sweden, the average consumption of caffeine reaches 400 mg/day. Children, young adults and coffee abstainers ingest caffeine mostly in the form of tea and soft drinks.

The presence of caffeine has to be clearly labelled in drinks containing more than 150 mg/L, according to the European Directive 2002/67/E. This rule applies to some soft drinks and energy drinks containing caffeine, but not to tea, coffee, and their related products, as consumers are supposed to know that they are significant sources of caffeine and as the caffeine content will depend on the preparation technique (longer infusion or extraction time). The Member States have national legislation to comply with this Directive.

Caffeine metabolism

Caffeine reaches the bloodstream within 30-45 minutes of ingestion. It is then distributed throughout body water, and later metabolised and excreted through urine. The average half-life of caffeine in the body is 4 hours (estimates vary between 2-10 hours). Pregnancy slows down the rate at which caffeine is metabolised and pregnant women generally maintain caffeine levels longer.

Caffeine’s ability to enhance alertness and sustained attention has been well documented, and its primary mode of action as a central nervous system stimulant is due to its action as an adenosine antagonist. Adenosine is a natural body chemical that acts as a messenger in regulating brain activity and modulating the state of arousal and sleep (it is a “fatigue signal”). Caffeine blocks specific adenosine receptors in the nerve tissue, including the brain, thus maintaining a state of arousal. By this mechanism caffeine can
enhance the capacity for mental and physical effort before fatigue arises. Blocking of adenosine receptors may also be responsible for the constriction of blood vessels, which relieves the pressure of migraines and headaches, and explains why caffeine is an ingredient of many analgesic pills.

Caffeine sensitivity

People differ greatly in their sensitivity to caffeine. Scientists have recently discovered a 'slow metabolizer gene': persons with this gene eliminate caffeine more slowly. A recent epidemiological study showed that, among people with that condition, coffee consumption was associated with a higher risk for non-fatal heart attack, suggesting that caffeine may play a role in this association. This needs to be confirmed in future studies.

Pregnant women, and people who suffer medical conditions or are sensitive to caffeine, should be vigilant and keep intake moderate. Most of the available epidemiological data suggests there is no problem if total intake is below 300 mg per day. The question of possible effects on pregnancy and the offspring at regular intakes above this level remains open. In view of this and because of the slow rate of caffeine metabolism in pregnancy, it is advisable to moderate caffeine intake, from whatever source, during pregnancy. For children, who do not normally consume much tea or coffee, “energy” drinks, cola or other soft drinks might represent an intake equivalent to 5.3 mg per kg of body weight per day (e.g. of 160 mg of caffeine for a 10 year-old child). This could result in transient behavioural changes, such as increased arousal, irritability, nervousness or anxiety.

Acute effects of caffeine

Doses of 100-600 mg of caffeine produce faster and clearer thoughts, and better general body coordination. On the negative side, caffeine may result in restlessness and loss of fine motor control. Amounts greater than 2,000 mg can cause insomnia, tremors and rapid breathing. These symptoms are sometimes seen at lower doses. With regular consumption, however, tolerance develops for many of these effects - the stimulant properties of caffeine affect habitual coffee drinkers less than occasional drinkers.

Caffeine has many other acute effects. It stimulates the release of cortisol and adrenaline, which cause blood pressure to increase and heart to beat faster. It also has diuretic effects, causes bronchial relaxation, increases gastric acid production, and boosts the metabolic rate.

Caffeine and health

Most studies related to caffeine and health are in fact based on coffee. This makes it often very difficult to distinguish effects of caffeine alone from effects of the beverage as a whole.

Moderate daily intake of caffeine up to 300 mg, or the equivalent of 3 cups of coffee, usually does not pose a health concern, provided that other lifestyle habits (diet, alcohol consumption, smoking and exercise) are healthy.
Cardiovascular disease

For several decades, caffeine has been of interest in the research on cardiovascular diseases because it was thought to be associated with alterations in blood lipids, blood pressure, arrhythmia and other impairments of cardiac functions. Although moderate caffeine consumption is usually not associated with increased risk of heart disease in the absence of a medical condition, it is difficult to exclude any relationship for heavy consumption. High caffeine consumption is usually linked with heavy coffee consumption, which is often associated with other factors influencing the chance of developing the disease – these, for example, include smoking, physical inactivity, consumption of saturated fats or alcohol abuse.

Blood pressure

Although caffeine consumption has been believed over several decades to increase blood pressure, the latest clinical and laboratory studies fail to demonstrate that usual levels of consumption have an effect. Despite inconsistent results, increased blood pressure responses have been reported more often in caffeine-naive people, in younger subjects and after acute intakes. In the absence of definitive scientific data, moderation is advised for people already suffering from hypertension.

Blood cholesterol

Studies, mainly from Scandinavian countries, have suggested that coffee may raise levels of total and LDL-cholesterol (bad cholesterol), a known risk factors for heart disease. This effect seems to be limited to boiled, unfiltered coffee (filtered, percolated or instant coffee do not increase blood cholesterol) and not to be linked to caffeine. This effect seems to be caused by some components in coffee called diterpenes, which are present in higher amounts in certain variety of coffee beans, but are removed by filtering.

Coronary heart disease

The evidence for a link between long-term habitual coffee consumption and risk of Coronary Heart Disease (CHD) does not indicate an increased risk from moderate coffee intake. A large prospective cohort study published in 2006, which followed more than 120 000 Americans over 14 to 20 years, failed to provide any evidence that coffee or total caffeine consumption increases the risk of CDH, even among heavy drinkers (higher or equal to 6 cups/day). However, two recent studies indicate that coffee intake may trigger nonfatal myocardial infarction in certain individuals: light/occasional coffee drinkers (less of equal to 1 cup/day), people having three or more risk factors for CHD, and those with slow caffeine metabolism. Several studies show that moderate coffee drinkers have a lower risk of coronary heart disease, which might be due to antioxidants found in coffee.

There is no proven association between caffeine and arrhythmia, a condition where the heart beats irregularly and often too fast.

Cancer
There is no evidence that caffeine intake is a risk factor for the development of human cancer, and this view is supported by the World Cancer Research Fund who stated in a comprehensive review that “Most evidence suggests that regular consumption of coffee and/or tea has no significant relationship with the risk of cancer at any site”. If anything, some recent research suggests that coffee drinking may be protective against the development of certain cancers, like colorectal and liver cancers, but this is still under investigation.

Other potential health benefits

Coffee may have protective effects against type 2 diabetes, Parkinson's disease and liver disease (cirrhosis and hepatocellular carcinoma).

There is growing evidence to suggest that drinking coffee may be protective against the development of Type 2 diabetes. As with many areas of research, the exact mechanism for this apparent protective effect has yet to be clarified. It seems most likely that substances found in coffee other than caffeine would be responsible for the effect as it is seen with both caffeinated and decaffeinated products.

There is also growing recent evidence that coffee consumption may help maintain cognitive functions in aging.

These long-term benefits may be linked to coffee’s caffeine and flavonoids, both anti-oxidants, but this remains to be confirmed.

References


History of caffeine use

2737 B.C. Chinese started to brew tea leaves

575 A.D. Coffee originated in Africa
11th century Arabians consumed coffee

1519 Aztecs introduced Spanish explorers to chocolate

1880s First caffeinated soft drinks

Further information

2. International Food Information Council (2015). Everything You Need to Know About Caffeine