

Caffeine

Fact sheet

Caffeine is a substance that occurs naturally in coffee and, in smaller amounts, in tea. It is also found in coke, iced tea, guarana-based drinks, chocolate, and cocoa-containing products such as chocolate milk and chocolate desserts. Energy drinks and energy shots contain caffeine. Usually the same amount that is found in coffee. Caffeine is sometimes used as an ingredient in pain killers or as a flavouring.

The Netherlands Nutrition Centre has drawn up recommendations on caffeine for various groups in the population. The consumption of up to about 400 milligrams of caffeine per day poses no health risks to healthy adults. This equates to approximately four caffeine-rich products, such as a cup of coffee or a standard can of energy drink. This recommendation does not apply to individuals who are sensitive to caffeine.

Pregnant women and lactating women are advised not to consume any caffeine-rich products or to greatly limit their use of such products (less than 200 milligrams of caffeine per day). Accordingly, pregnant women are advised not to drink more than one cup of coffee or one can of energy drink per day. This allows for an average consumption of other sources of caffeine such as tea and soft drinks.

Concerning children, the Netherlands Nutrition Centre follows the recommendations of other countries (no more than 2.5 milligrams of caffeine/kilogram of body weight/day). On this basis, the use of caffeine-rich products by children is not recommended. Adolescents are advised to consume no more than one caffeine-rich product per day.

This fact sheet underpins these Netherlands Nutrition Centre recommendations.



For whom is it relevant?

The recommendations provide safe consumption levels for various groups: healthy adults, pregnant women, lactating women and children. The effects of caffeine in healthy adults are very diverse. This is because what might be considered “too much” varies greatly from one individual to another. Not everyone is equally sensitive to the effects of caffeine.

Due to the potential health risks involved, there is a general warning for children, pregnant women and lactating women.

What issues are involved?

Caffeine can have both beneficial and adverse effects. In small quantities (comparable to the amount in one or two cups of coffee), for example, caffeine can have a stimulating effect. It dispels feelings of fatigue and improves concentration and attention. However, too much caffeine can have adverse effects. For example, people who are sensitive to caffeine may experience restlessness, anxiety, irritability, headaches, tremors, dizziness, insomnia, ringing in the ears and palpitations. When they stop drinking caffeine-rich beverages or switch to decaffeinated coffee, people may experience withdrawal symptoms.

In what and how much?

The table shows the average caffeine content of some commonly used products.

Product	Unit	Caffeine (mg)
Coffee	Cup (125ml)	85 (peaking at up to 180)
Energy drinks	Can (250 ml)	80
Green or black tea	Cup (125 ml)	30
Plain chocolate	Bar (75g)	30
Coke	Glass (180 ml)	18
Milk chocolate	Bar (75g)	15
Chocolate milk	Glass (180 ml)	4



The rise of energy drinks

Due to the rise of energy drinks, there is currently a greater focus than usual on caffeine. These drinks were introduced in the European Union in the 1980s. So energy drinks are relative newcomers to the soft drink segment. The introduction of these drinks changed the consumption of caffeinated foods in younger age groups. More recently, a range of food products with extra added caffeine have become commercially available, such as chewing gum, sweets, water, and coke. Energy shots are a special kind of energy drink. These products are not classified as foods, but are marketed as food supplements. They are packaged in small vials (25-75 ml) with a relatively high caffeine (50-200 mg), and taurine (200-1000 mg) content.

Consumption data from the Dutch National Food Consumption Survey (FCS)¹ show that drinking caffeinated beverages is clearly age-related. Young people drink less coffee than adults. Instead, they tend to drink coke. These differences are less marked when it comes to tea, chocolate and cocoa. Surveys by the Trimbos Institute², the Netherlands Nutrition Centre³ and the European Food Safety Authority (EFSA)⁴ show that energy drinks are popular with the younger age groups.

The main active component of energy drinks is caffeine, often in combination with taurine and glucuronolactone, sugars, and other ingredients. In the literature, there is a substantial focus on the safety of energy drinks. One reason for this is the association between problem behaviour and the consumption of energy drinks together with alcohol, or the occurrence of alcohol-related effects.⁵ In the UK, the Committee on Toxicity⁶ concludes that, allowing for existing uncertainties, the available data do not indicate direct interactions between alcohol and energy drinks.

The EFSA takes the view that the amounts of taurine and glucuronolactone used (as ingredients of energy drinks) are safe. However, the EFSA did not comment on the safety of energy drinks themselves.⁷

Legislation

The Commodities Act stipulates that soft drinks may contain no more than 350 milligrams of caffeine/litre^a. If a beverage contains caffeine concentrations in excess of 150 milligrams/litre, this must be declared. The label must also bear the text "high caffeine content". This does not apply to coffee and tea. From 13 December 2014, under the new EC Regulation "Provision of food information to consumers" (Reg. (EC) 1169/2011), the following requirements came into effect:

- The labelling of beverages containing more than 150 milligrams of caffeine/litre must indicate their caffeine content in milligrams/100 millilitres. This must be preceded by the text "High caffeine content. Not recommended for children, pregnant women, or lactating women".
- The labelling of other products to which caffeine has been added must indicate their caffeine content in milligrams/100 millilitres. This must be preceded by the text "Contains caffeine. Not recommended for children and pregnant women".
- This does not apply to lawfully prepared beverages that are marketed in another Member State of the European Union, or in another state that is party to the Agreement concerning the European Economic Area. The dietary supplement category is not part of the soft drinks category, so it is exempted from this section of the law.

Scientific state of the art

How much caffeine do people consume, on average? And what is currently known concerning the effects of caffeine? The answers to these questions form the basis of the Netherlands Nutrition Centre's recommendations for caffeine.

Current caffeine intake

The intake of caffeine can be estimated from the consumption of caffeine-containing foods, as indicated by the 2007-2010 Dutch National Food Consumption Survey.¹ This examined the consumption of coffee, tea, all caffeine-containing soft drinks, such as coke, iced tea, energy drinks, chocolate and cocoa-containing products, such as chocolate milk and chocolate desserts.

The estimated average caffeine intake ranges from 20 milligrams/day, for toddlers aged from one to three, to 500 to 600 milligrams/day, for adults. The difference between the calculated consumption and the recommended safe consumption (according to authorities such as Health Canada²) of 2.5 milligrams/kilogram of body weight for children, shows that there is only a small margin in this group. It is less than the amount of caffeine in a cup of coffee or tea, or in a can of energy drink. For adults, caffeine intake exceeds the general recommendation of 400 milligrams/day (5.7 milligrams/kilogram of body weight at a reference weight of 70 kilograms). In adults, coffee and tea are the largest contributors to caffeine intake. See the table for details of the exact numbers.

Table: Recommended and actual average consumption of caffeine for men and women.

	Age	Reference weight (kilograms) ¹	Recommended safe consumption (milligrams /kilogram of body weight/day)	Recommended safe consumption (milligrams/day)	Average consumption (milligrams/day)
Men	1-3 years of age	14	2.5	35	19
	4-8 years of age	24	2.5	60	29
	9-13 years of age	40	2.5	100	49
	14-18 years of age	65	2.5	163	111
	19-30 years of age	75	5.7 ²	428	316
	31-50 years of age	72	5.7	410	549
	51-69 years of age	74	5.7	422	509
Women	1-3 years of age	14	2.5	35	20
	4-8 years of age	24	2.5	60	27
	9-13 years of age	41	2.5	103	49
	14-18 years of age	59	2.5	148	106
	19-30 years of age	64	5.7 ²	365	281
	31-50 years of age	62	5.7	353	462
	51-69 years of age	64	5.7	365	505

¹ Source Health Council of the Netherlands ² 400 milligrams/day = 5.7 milligrams/kilogram of body weight x 70 kilos (reference weight)

The 2007-2010 Dutch National Food Consumption Survey indicated that, on average, the use of energy drinks was limited. Recent surveys by the Trimbos Institute² and the Netherlands Nutrition Centre³ show that more than a quarter of primary school pupils occasionally consume energy drinks. The figure for Year 8 primary school pupils is around 40%, while for children aged 11 to 18, it is about 60%. A third of all 16-year-olds have combined energy drinks with alcohol. These numbers are in line with figures obtained at EU level.⁴

What happens in the body?

Caffeine is a stimulant. After ingestion, it is quickly absorbed in the gastrointestinal tract. Ninety-nine percent is absorbed within 45 minutes. Absorption is less complete in the case of coffee. Your blood caffeine levels peak at between 15 and 120 minutes after ingestion.⁹ From 2.5 to 4.5 hours after ingestion, half of the caffeine has been broken down. Caffeine affects the brain in various ways. The most important effect is caused by caffeine binding to adenosine receptors, instead of the substance that normally binds to these receptors. This binding triggers abnormal responses in your body. For example, the neurotransmitters/hormones norepinephrine, dopamine and serotonin are secreted in the brain.^{8,9} This could explain caffeine's potential effects on alertness, behaviour and sleep, for example.



Caffeine and health

In studies into the health effects of caffeine, it is not always clear whether these effects can be attributed to caffeine itself or to other ingredients in the caffeinated food in question. For instance, drinking normal amounts of coffee appears to reduce the risk of type 2 diabetes, whereas acute exposure to caffeine itself has been found to adversely affect the regulation of blood sugar levels.^{10,11} As a result, it is not possible to make unequivocal statements about the health effects of caffeine-containing products.

Cancer

The International Agency for Research on Cancer¹² does not classify caffeine as carcinogenic to humans (group 3). The evidence appears to show that, at levels of up to five cups of coffee a day, there is no risk of cancer.^{13,14,15}

Cardiovascular disease

There is very little evidence to suggest the existence of a relationship between a regular intake of caffeine and the incidence of cardiovascular disease. Such studies were primarily related to the consumption of coffee. A moderate caffeine intake (4-5 cups of coffee, or less, per day, which equates to 400 milligrams of caffeine) has either a moderately positive effect on cardiovascular health or none at all. Caffeine has an acute hypertensive effect. Various systematic reviews and a meta-analysis have shown that no long-term effects of coffee drinking on blood pressure have been demonstrated.^{17,18}

Weight

The EFSA¹⁹ has concluded that there is insufficient evidence that caffeine affects fat burning and energy consumption. Thus, caffeine causes neither a reduction in the percentage of body fat nor weight loss.

Bone density at high intakes

At an intake of at least 800 milligrams of calcium per day, a daily caffeine intake of up to 400 milligrams has no significant effect on bone density.¹⁰

Behaviour

References in the literature to a possible relationship between caffeine intake and behaviour are limited to the relationship between the consumption of energy drinks and behaviour. Based on results from the few studies conducted to date, this does appear to be related to "problem behaviour" in young people.⁵ The consumption of energy drinks seems to be just one of the many manifestations of that lifestyle.²⁰

Performance

In adults, various beneficial effects on performance, such as a feeling of increased energy, efficiency, alertness, motivation, and concentration, have been observed at low doses of 20 to 200 milligrams of caffeine (1 milligram/kilogram of body weight).⁹ The EFSA has confirmed that moderate caffeine consumption can boost alertness and attention (concentration). A cause-effect relationship has been established between a dose of 75 milligrams of caffeine (roughly the amount present in one standard cup of coffee) and elevated alertness and concentration.²²

The International Society of Sports Nutrition's stand-point is that caffeine use by athletes can have a positive effect on mental focus and alertness, as well as on anaerobic performance and endurance performance.²³ The EFSA has endorsed claims of a positive relationship between caffeine and endurance effort, but not those relating to short, intensive performance.²²

Fluid balance

Caffeine-containing beverages, like all other beverages, supply the body with fluid. Caffeine-containing beverages do not have a diuretic effect. Drinking coffee, for example, does not cause the body to lose more fluid. However, caffeine does accelerate the excretion of fluids from the body.²⁴

The effects of high intake or of giving up completely

There is no evidence that long-term caffeine intake leads to addiction. Either the regular consumption of large amounts of caffeine or giving up caffeinated beverages completely may elicit a range of symptoms, such as restlessness, anxiety, irritability, agitation, muscle twitching, insomnia, headaches, increased urination, sensory disturbances (tinnitus), cardiovascular disorders (tachycardia, arrhythmia) and gastrointestinal symptoms (nausea, vomiting, diarrhoea).^{8,25} In addition, individuals vary widely in their sensitivity to caffeine.

Safety

This is because what might be considered "too much" varies greatly from one individual to another. The few reported cases of mortality due to an excessively high caffeine intake are often associated with the use of medicines. It has been determined that the acute lethal dose for adults is 10 grams per person.⁸

Recommendations for adults

The Netherlands Nutrition Centre's recommendation is based on the large body of evidence that there is no link between the abovementioned risks to health and a moderate caffeine intake, which equates to a dose of less than 400 milligrams/day for adults (5.7 milligrams/

kilogram of body weight/day at a reference weight of 70 kilos).⁸ Taking into account caffeine from other sources, such as tea, soft drinks, and chocolate, it can be concluded that if adults consume around four units of caffeine-rich products per day, they would not be expected to experience any adverse effects. This does not apply to children and pregnant women. Not does it apply to individuals who are extra-sensitive to caffeine. Thus, individuals who suffer from anxiety are advised to exercise caution when using caffeine-rich products.

Recommendations for children

Much is still unclear about the possible effects of caffeine on young people.²⁷ Only a limited number of studies have been conducted in children. In the Netherlands Nutrition Centre study in subjects aged 11 to 18, 66% of the young people involved said that they had had bad experiences with energy drinks. They said that they had been fidgety and hyperactive, had difficulty sleeping and that they had collapsed after an active phase.³ Children (especially pre-adolescents) constitute a high-risk group, as an excess of caffeine can affect the development of the nervous system. Based on experimental animal studies into caffeine, it seems important to allow for the fact that, in this age group, the nervous system is still developing.

The Nordic countries have indicated that, in children, 2.5 milligrams of caffeine/kilogram of body weight/day can give rise to heightened anxiety. The values that correspond to sleep disorders and the development of tolerance are 1.4 milligrams/kilogram of body weight/day and from 1.0 to 1.25 milligrams/kilogram of body weight/day respectively.²⁵ Other studies have also shown that the recommended maximum caffeine intake for children below the age of 13 should not exceed 2.5 milligrams/kilogram of body weight/day.⁸ This is equivalent to a daily intake of 50 milligrams for a child weighing 20 kilograms or 100 milligrams for one weighing 40 kilograms, for example.

At international level, there are no recommended limits for adolescents. This is widely recognized. In this case, Canada has opted to apply the limit of 2.5 milligrams/kilogram of body weight/day to adolescents as well.²⁸

The uncertainty surrounding the effects of caffeine, together with the low limit values involved, are sufficient reason for the Netherlands Nutrition Centre to advise against the use of caffeine-rich products by children under the age of 13, purely as a precaution.

We recommend that adolescents between the ages of 13 and 18 limit their consumption to no more than one drink per day.

Recommendation regarding pregnancy

Caffeine may be harmful to the unborn child. It seems that the more caffeine a mother consumes, the greater her risk of a spontaneous abortion or of having a baby with a low birth weight. Caffeine also passes into breast milk and can make the baby restless.²⁹ Different studies give different upper intake levels. The Generation R study gives an upper limit of 540 milligrams of caffeine per day.³⁰ Other studies indicate that effects on conception and pregnancy can occur at doses in excess of 300 milligrams/day (4.6 mg/kilogram of body weight/day). A moderate caffeine intake (less than 300 milligrams/day) by pregnant or lactating women does not seem to have an adverse effect on their children's postnatal development.⁸ The EFSA and the US Food and Drug Administration, (the American food safety authority) have set their recommendation at up to 300 milligrams/day. The UK's Committee on Toxicity (COT) has associated caffeine intake during pregnancy with an increased risk of retarded foetal growth. The study was unable to indicate a threshold below which this effect did not occur. The Committee believes it plausible that this risk increases at doses starting from 200 milligrams/day or even lower.³¹ This confirms the findings of a Norwegian study.³²

Based on the COT report, the UK's Food Standards Agency (FSA) advises pregnant women to limit their consumption to less than 200 milligrams of caffeine per day.³³ In compliance with the precautionary principle,

the Netherlands Nutrition Centre has adopted this recommendation. Accordingly, pregnant women are advised not to drink more than one cup of coffee or one can of energy drink per day. This allows for an average consumption of other sources of caffeine such as tea and soft drinks.

Looking to the future

A safe intake of caffeine, together with this substance's direct or indirect influence on behaviour, have been spotlighted as a result of the introduction of energy drinks and the associated potential for higher caffeine intakes in young people. This was sufficient reason for the EU to investigate this behaviour.⁴ In line with this, the EFSA is currently preparing an opinion on this subject. The same applies to Australia and New Zealand.

A review covering the period from 1966 to 2011 concluded that it is not possible to formulate definitive recommendations for the safe use of energy drinks. Until this issue is sufficiently well understood, caution is advised. In a recent opinion, the French Agency for Food, Environmental and Occupational Health & Safety (ANSES) warned against the potential risks of multiplying sources of caffeine, especially through the use of energy drinks.^{34,35} This is why, with regard to recommendations concerning the use of caffeine-rich products, the Netherlands Nutrition Centre has opted to proceed in compliance with the precautionary principle.

The following experts were consulted in the course of drafting this document:

Dr R. Bakker, Erasmus MC
Dr J.J.M. Castenmiller, The Netherlands Food and Consumer Product Safety Authority
Prof. E.J.M. Feskens, Wageningen University
Prof. J.M. Geleijnse, Wageningen University
Dr R. Hursel, Maastricht University
Prof. M.M. Lorist, University of Groningen
Dr W. Mennes, National Institute for Public Health and the Environment
Ms H.W. van der Torre, Coffee and Health Information Bureau
Prof. J.C. Verster, Utrecht University

Selection of the literature used (the full list can be found at: www.voedingscentrum.nl/factsheetcafeine)

5. Voedsel en Waren Autoriteit (huidige Nederlandse Voedsel- en Warenautoriteit), Bureau Risicobeoordeling. Advies inzake veiligheid van alcohol in combinatie met energiedrank. Den Haag, VWA/BUR, 2009, 11837.
7. EFSA - European Food Safety Authority. Scientific opinion: The use of taurine and D-glucurono-lactone constituents of so-called "energy" drinks. EFSA Journal (2009) 935; 1-31.
8. Nawrot P, Jordan S, Eastwood J, Rotstein J, Hugenholtz A, Feeley M. Effects of caffeine on human health. Food Addit Contam; 2003; 20(1): 1-30.
9. Frelholm BB, Bättig K, Holmén J, NEhlig A, Zvartau EE. Actions of caffeine in the brain with special reference to factors that contribute to its widespread use. Pharmacological Reviews; 1999; 51(1), 83-133
10. Ohnaka K e.a.. Effects of 16-week consumption of caffeinated and decaffeinated instant coffee on glucose metabolism in a randomized controlled trial. J Nutr Metab.; 2012; 207426
16. Mostofsky E e.a. Habitual coffee consumption and risk of heart failure: A dose-response meta-analysis. Circ. Heart Fail 2012 July 1; 5(4): 401-05
20. Vester JC, e.a. Energy drinks mixed with alcohol: misconceptions, myths and facts. Int. J. General Medicine 2012; 5; 187-98
21. Heinz AJ, de Wit H, Lilje TC, Kassel JD. The combined effects of alcohol, caffeine, and expectancies on subjective experience, impulsivity, and risk-taking. Exp.Clin Psychopharmacol. 2013 Jun;21(3): 222-34

Authors: Mr B.C. Breedveld and Dr J.A.C. Peters

November 2013