

Chocolate: indulgence or medicine?

In 2003, the UK chocolate confectionery market totalled £3.36bn and some claim our love of chocolate may be a contributory factor in the rising number of people who are obese. Every so often, however, reports of the health benefits of chocolate appear in the media. In this article, Sarah Marshall takes a closer look at whether or not eating chocolate is such a bad thing

Chocolate has been eaten at Easter since the early 1800s, when chocolate Easter eggs first appeared in France and Germany. They were initially solid but eventually became the hollow versions we know today, painstakingly prepared by painting chocolate paste onto moulds until a method was invented to allow liquid chocolate to flow into moulds. Now, over 80 million chocolate Easter eggs are sold in the UK alone each year.

Chocolate is prepared from the seeds (cocoa beans) of the cacao tree. Linnaeus named this tree *Theobroma cacao*, theobroma meaning food of the gods. The cacao tree is indigenous to equatorial regions of the Americas, but is now cultivated in tropical areas throughout the world. The mature tree produces seed pods up to 35cm long and weighing up to 1kg, which grow on both the branches and the trunk and vary in colour from bright yellow to deep purple.

Ripe seed pods are removed from the trees and split open to release the 40–50 beans, which are allowed to ferment for several days so that the flavour develops. The beans are then dried and heated, before the shells are cracked and separated from the heavier nibs. The nibs are then roasted and ground to produce cocoa mass (or chocolate liquor), which comprises cocoa particles suspended in 50–55 per cent cocoa butter.

Cocoa mass is subjected to hydraulic pressing to remove about half of the cocoa butter and produce cocoa cakes, which can then be ground to make cocoa powder. Dark chocolate contains cocoa mass, cocoa butter and sugar, whereas milk chocolate contains additional milk solids, flavourings and, sometimes, other vegetable fats, such as coconut oil. White chocolate is similar to milk chocolate but lacks the cocoa mass. The ingredients are blended, ground to a smooth consistency and stirred (“conched”) to develop the flavour. Lastly, the chocolate is tempered (mixed and cooled) to make it smoother and glossy.

The quality of the chocolate depends on the blend of beans used, the type and amount of milk and other ingredients added, and the kind and degree of roasting, refining, conching or other processing.

Constituents and uses

Fresh cocoa beans contain a complex mixture of constituents, including cocoa butter, tannins and phenols. At least 84 different volatile components produce the characteristic odour. In addition, cocoa kernels and husks contain 0.2–3 per cent theobromine and



traces of caffeine.¹ Constituents of cocoa powder include carbohydrates, fat, protein and minerals as well as theobromine, caffeine and flavanols.

Cocoa butter (theobroma oil) is a yellowish-white, brittle solid fat with a faint odour. Its melting point of between 31 and 35°C — just below body temperature — makes it a useful base for suppositories. It consists of the glycerides of stearic, palmitic, arachidic, oleic and other acids, and may also contain theobromine.²

Theobromine is a purine alkaloid (3,7-dimethylxanthine). It is an isomer of theophylline (1,3-dimethylxanthine) and is structurally related to caffeine (trimethylxanthine; see Figure 1, p400). It has similar properties to these xanthines, but weaker activity — it has a diuretic effect but minimal central nervous system stimulant activity. Nausea and vomiting can occur after ingestion of large doses. Theobromine has been used for its bronchodilator activity and to treat cardiovascular disease.

Theobromine has been shown to suppress capsaicin-induced cough in human volun-

Chocolate history

The Maya, an ancient people living in Central America were cultivating *Theobroma cacao* as early as 600BC, using the beans as currency and the basis of a beverage. Spanish conquistadores arriving in Mexico in 1519 learnt of a drink used by the Aztecs called *xocolatl* or *kukuh*. Prepared from roasted and ground cocoa beans, vanilla, chilli, wild honey and corn, it was widely used in ceremonies and rituals. The recipe was adapted for Spanish tastes by apothecary monks and became popular in the Spanish court. Slowly the beverage spread throughout Europe. It arrived in 1657, as an expensive luxury in London, where it was served as a rather fatty drink mixed with potato starch and sago flour. The development of a method in 1828 for obtaining chocolate powder by pressing much of the cocoa butter from ground and roasted beans made it possible to formulate a more palatable product.

In 1847, the English firm Fry & Sons produced chocolate for eating by combining chocolate liquor with extra expressed cocoa butter and sugar. In 1876, Daniel Peter of Switzerland added dried milk to produce milk chocolate. This led to the widespread proliferation of chocolate and associated products.

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teers and is thought to act via direct inhibition of sensory nerve activation. As such, it has a unique antitussive mode of action.³ However the clinical relevance of chemically induced cough models in evaluating agents for cough is open to question.

In the late 17th and 18th centuries cocoa was promoted in medical literature as a remedy for almost every ailment imaginable. Some of the earliest cocoa makers, such as the founders of Fry's of Bristol and Terry's of York, were apothecaries who became interested in cocoa for its reputed medicinal properties, and had the expertise and equipment needed to heat, measure and blend the ingredients. Interest in cocoa products as medicines has persisted, particularly in their potential cardioprotective effects.

Antioxidant and cardioprotective properties Several plant-derived foods and drinks, such as red wine, tea and various vegetables, fruits and, more recently, cocoa and its products, are thought to improve cardiovascular health and this has been linked to their flavanol content. Cocoa is a particularly rich source of flavanols, such as the monomers (-)-epicatechin and (+)-catechin (see Figure 2), and procyanidins (polymers of up to 10 units of epicatechin and/or catechin). Flavanols belong to the flavonoid class of polyphenolic phytochemicals with a C6-C3-C6 backbone, two aromatic rings and varying numbers of hydroxyl substituents. The chemical structure of cocoa flavanols gives them free radical scavenging ability, and thus antioxidant properties.

Many studies have been published on both experimental and clinical aspects of cocoa and its flavanols with regard to cardiovascular health. The physiological mechanisms behind the development of cardiovascular disease are complex but include inflammation, endothelial dysfunction and platelet aggregation. Cocoa-derived flavanols have been shown to have a variety of beneficial effects on these processes.

Atherosclerosis can activate several proinflammatory enzyme systems, such as xanthine oxidase, NADH/NADPH oxidase and myeloperoxidase. These enzymes produce reactive oxygen species (ie, free radicals) which lower nitric oxide availability and oxidise low density lipoprotein and contribute to endothelial dysfunction.⁴ Cocoa flavanols have been shown to reduce the activities of xanthine oxidase and myeloperoxidase in animal models.⁵

In humans, chocolate reduces leukotriene levels and increases prostacyclin levels. Leukotrienes are potent vasoconstrictors and proinflammatory mediators, and stimulate platelet aggregation. On the other hand, prostacyclins are vasodilators and platelet aggregation inhibitors, and reduce the entry of low density lipoproteins into the arterial wall.^{6,7}

Nitric oxide (NO) is a mediator produced by healthy vascular endothelium, resulting in vasodilation. Free radicals inactivate nitric

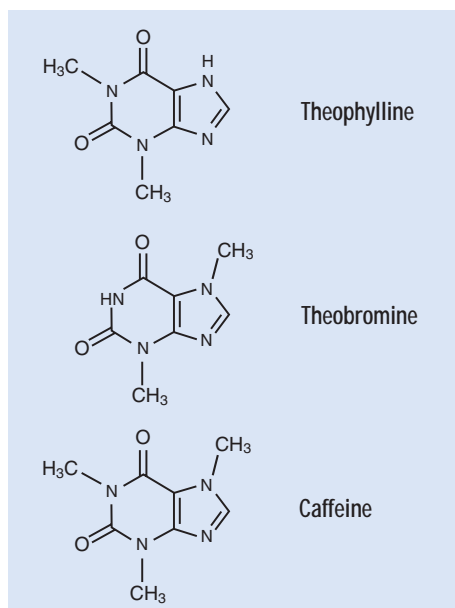


Figure 1: Theobromine, theophylline and caffeine



Cocoa seed pods each contain 40–50 beans

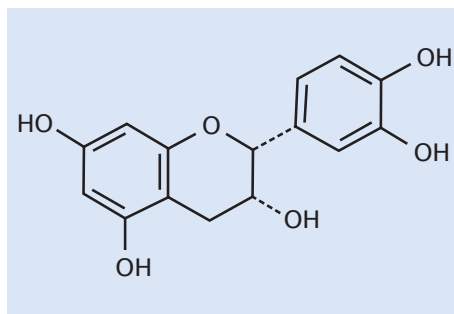


Figure 2: (-)-Epicatechin

oxide production in endothelium and thus contribute to endothelial dysfunction and platelet activation. Antioxidant flavonoids in cocoa sequester these reactive oxygen species inhibiting conversion of NO to peroxynitrite (a powerful oxidant).⁸ Cocoa flavanols may also increase NO synthase.⁸ The net result is an improvement in endothelial function. Cocoa rich in polyphenolic flavonoids has also been shown to reduce platelet activation and function.⁹ Other clinical trials have indicated that chocolate increases high density lipoprotein cholesterol and may decrease blood pressure and low density lipoprotein cholesterol oxidation and improve insulin sensitivity.⁸

Saturated fat consumption is thought to be a contributory factor in the development of atherosclerosis, thus leading to increased cardiovascular risk. However, stearic acid, a saturated fat found in dairy products, meat and cocoa products has been suggested to be non-atherogenic, having no effects on HDL, LDL or total cholesterol.⁶ Whether these findings translate into cardiovascular benefits when cocoa products are consumed outside of clinical trials is as yet unknown.

Mood For most people, eating chocolate (including the anticipation of eating it) is highly pleasurable. Chocolate provides a uniquely enjoyable combination of sweetness, a creamy texture, aroma and a characteristic taste created by at least 550 flavour-giving components. It has been claimed to have stimulant, relaxant, euphoriant, aphrodisiac, tonic and antidepressant properties.

Some people crave chocolate and suggested explanations for this phenomenon include homeostatic correction, pleasure seeking, emotional eating and addiction to psychoactive substances or to the fat and sugar content. Ingredients in chocolate that have been proposed as psychoactive agents include caffeine, theobromine, tyramine and phenylethylamine, although their concentrations maybe so low as to make psychoactive effects unlikely.^{10,11}

Chocolate may interact with neurotransmitter systems, such as dopamine, serotonin and endorphins, which influence appetite, reward mechanisms and mood. Chocolate craving, which can be a symptom of atypical depression and seasonal affective disorder, has been suggested to be a form of self-medication in order to influence serotonin levels and thus bring about antidepressant effects.¹² However this theory is increasingly being disputed.¹¹

Other conditions associated with chocolate craving include pregnancy, menstruation, bulimia and stress, and these may be linked to altered endogenous opioid peptide levels which stimulate craving and thus increase food intake.¹³ Mood states such as stress, boredom, depression, loneliness, self doubt, discord, frustration, anger and anxiety can all trigger emotional eating.¹¹ However any improvement in mood is likely to be only transitory and repeated emotional eating can

lead to dysphoria, probably as a result of negative food-related associations.^{14,15}

Is eating chocolate good for you?

In the UK, obesity in adults has trebled in the past 20 years and childhood obesity is predicted to reach more than 50 per cent by 2020. One of the contributory factors to this increase is the wide availability of confectionery. The British consume 8.4kg of chocolate (equivalent to 44,520kcal) per person annually¹⁶ and it has been proposed that confectionery should not be sold in pharmacies.¹⁷

In terms of cardiovascular benefits, the studies carried out so far have only assessed effects of chocolate on intermediate end-points. Large scale, longer duration, randomised, controlled clinical trials looking at long-term effects on cardiovascular disease are needed. In addition, many studies used dark chocolate, which is high in flavanols, whereas most chocolate confectionery has a low flavanol content.

Flavanol content varies depending on the recipe used — dark chocolate is much higher in flavanols than milk chocolate (which is commercially most popular) and white chocolate is devoid of flavanols. The bioavailability of any flavanols present in a product may be further compromised by other ingredients in the chocolate or in the diet. For example, milk has been shown adversely to affect absorption.¹⁸

Many of the potentially cardioprotective properties of flavanols are dose-dependent and, as yet, the optimal dose and frequency of administration is unknown, as are potential adverse effects. Moreover, the studies use cocoa or chocolate that contains a mixture of flavanols, with little or no characterisation of the active constituents. It should also be borne in mind that the cocoa and chocolate industries have supported much of the research.

The question remains as to whether the potential benefits of eating chocolate are outweighed by concerns over its high fat, sugar and calorie content, especially in those with cardiovascular disease. We cannot yet claim that a bar of (dark) chocolate a day keeps the doctor away.

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