

Review Article

Health Benefits of Dark Chocolate

K. Haritha, L. Kalyani and A. Lakshmana Rao *

V. V. Institute of Pharmaceutical Sciences, Gudlavalleru, 521 356, A.P., India.

Available online: August, 2014 dralrao@gmail.com

ABSTRACT

Chocolate is a raw or processed food produced from the seed of the tropical tree *Theobroma cacao*. Chocolates are increasingly being seen as capable of promoting good health. As these are ideally suited for inclusion in the food matrix of a chocolate bar, complementing the endogenous flavanols, chocolate could be developed as the ideal nutraceutical-polypill delivery system, enhancing health in the form of a tasty treat. Dark chocolate is majorly beneficial in cardiovascular disease. The other health benefits of Dark chocolate includes as antioxidant, improvement in endothelial function, vascular function, insulin sensitivity etc.

Key Words: Dark chocolate, Cocoa, Health, Diet.

INTRODUCTION

Chocolate is a typically sweet, usually brown, food preparation of *Theobroma cacao* seeds, roasted and ground, often flavored, as with vanilla¹. It is made in the form of a liquid, paste or in a block or used as a flavoring ingredient in other sweet foods. Chocolate is a range of products derived from cocoa (cacao), mixed with fat (i.e., cocoa butter) and finely powdered sugar to produce a solid confectionery². Chocolate most commonly comes in dark,

milk and white varieties, with cocoa solids contributing to the brown coloration. There are several types of chocolate according to the proportion of cocoa used in a particular formulation³. Dark chocolate, also called black chocolate, is produced by adding fat and sugar to cocoa. It is chocolate with no milk or much less than milk chocolate. Dark chocolate can be eaten as is, or used in cooking, for which thicker, baking bars, usually with high cocoa percentages ranging from 70% to 99% are sold⁴. Dark is

synonymous with semisweet and extra dark with bittersweet, although the ratio of cocoa butter to solids may vary.

Cocoa products can be very nutritious and the chocolate is the richest source of energy, protein, magnesium, calcium, iron and riboflavin of varying amounts, essential for mental health and heart function⁵. The cocoa seeds are rich in copper, sulphur and vitamin C. Dark chocolate is naturally rich in flavonoids⁶. These compounds are thought to lower blood pressure and protect against heart disease-among other things⁷. Recent studies conducted both in the U.S. and Europe seem to support chocolate's beneficial effects on the cardiovascular system, encouraging chocolate manufacturers to develop proprietary methods of processing cocoa beans aimed specifically at preserving flavonoid content⁸. Traditional roasting and fermentation methods are thought to destroy up to three-quarters of these compounds⁹.

Different types of chocolate contain different amounts of theobromine. In general, theobromine levels are higher in dark chocolates (approximately 10 g/kg) than in milk chocolates (1-5 g/kg)¹⁰. Higher quality chocolate tends to contain more

theobromine than lower quality chocolate. Cocoa beans naturally contain approximately 300-1200 mg/ounce theobromine.

PHYSICAL PROPERTIES

The most common form of cocoa butter has a melting point of around 34–38°C (93–101°F), rendering solid chocolate at room temperature that readily melts once inside the mouth. Cocoa butter displays polymorphism, having α , γ , β' and β crystals, with melting points of 17, 23, 26, and 35–37°C respectively. The production of chocolate typically uses only the β crystal for its high melting point. A uniform crystal structure will result in smooth texture, sheen and snap. Overheating cocoa butter converts the structure to a less stable form that melts below room temperature. Given time, it will naturally return to the most stable β crystal form. Advantage is taken of this phenomenon in the polymorphic transformation theory of chocolate bloom. It is based on the fact that bloomed chocolates are always found to contain the most stable polymorph of cocoa butter. The Refractive index of cocoa butter is 1.44556-1.44573. Its Iodine value is 32.11-35.12, 35.575. Acid value is 1.68. Saponification value is

191.214, 192.88-196.29. It has a Food energy value of 3, 770 kilojoules per 100g (3.5oz).

CHEMISTRY

Cocoa contains more than 300 volatile compounds, the most important components are aliphatic esters, polyphenols, aromatic carbonyls and theobromine, which also prevent rancidity of the fat¹¹. The pharmacologically active ingredients of cocoa seeds include amines, alkaloids theobromine (0.5% to 2.7%), caffeine (approximately 0.25% in cocoa), theophylline, fatty acids, polyphenols (including flavonoids), tyramine, trigonelline, magnesium, phenylethylamine and N-acylethanolamines. A standard chocolate bar (40 to 50 g) contains theobromine (86 to 240 mg) and caffeine (9 to 31 mg). The characteristically bitter taste of cocoa is generated by the reaction of diketopiperazines with theobromine during roasting. Theobromine is produced commercially from cocoa husks. Cocoa butter contains triglyceride fatty acids consisting mainly of oleic, stearic and palmitic acids. It also contains myristic, arachidic, lauric, palmitic, linoleic, α -linolenic acids. Cocoa is rich in polyphenols

that have beneficial effects on cardiovascular disease. In cocoa, the polyphenols of particular interest are flavanols, a subclass of flavonoids, which are in turn a subclass of polyphenols. Cocoa is more than 10% flavanol by weight. Flavanols can be monomeric in cocoa beans these are mainly (-)-epicatechin and (+)-catechin, dimeric (consisting of 2 units of epicatechin with differing linkages) or polymeric (combinations of monomers and chains of up to 10 units or more have been found)¹². These polymers are known as procyanidins¹³.

MECHANISM

Cocoa has been reported to be a source of natural antioxidants, the free radical scavengers that preserve cell membranes, protect DNA, prevent the oxidation of low-density lipoprotein (LDL) cholesterol that leads to atherosclerosis and prevent plaque formation in arterial walls. The antioxidant activity of cocoa has been attributed to the procyanidins and their monomeric precursors, epicatechin and catechin, which inhibit oxidation of LDL¹⁴. Dark chocolate and cocoa inhibit LDL oxidation and increase high-density lipoprotein (HDL)-cholesterol concentrations. Catechin and

Epicatechin has been found in cocoa. Catechins are phytochemical compounds found in high concentrations in a variety of plant-based foods and beverages. The catechin content in dark chocolate is 12 mg/100 gm. The epicatechin content in dark chocolate is 41.5 mg/100 gm. The consumption of catechins has been associated with a variety of beneficial effects including increased plasma antioxidant activity, bronchial artery dilation, fat oxidation and resistance of LDL to oxidation¹⁵. Epicatechin seems to be a major bioactive constituent of cocoa and other flavanol-rich foods and beverages¹⁶. It has been shown to improve endothelial function in animals and humans¹⁷. In salt-sensitive animal models of hypertension, epicatechin lowers blood pressure and the associated end-organ damage. Nitric oxide seems to play a key role in the protection of both hypertension and endothelial dysfunction. The antioxidant capacity of dark chocolate is 13.1/ 100 g.

HEALTH BENEFITS OF DARK CHOCOLATE

Dark chocolate has recently been discovered to have a number of healthy benefits. The various health benefits of dark chocolate

includes, alleviation of cardiovascular disease, protection against heart disease, stroke prevention, alleviation of hypertension (high blood pressure), regulation of blood sugar and insulin dependence, reduced risk of type II diabetes, antioxidant protection, alleviation of cold and cough, reduced cancer risk, reduced risk of colon cancer, slowing aging, increased immune function, slowing the progression of AIDS, DNA repair and protection, alzheimer's protection, alleviation of premenstrual syndrome, prevention of alopecia¹⁸.

For cardiovascular disease

Research suggests that the chocolate, cocoa and flavan-3-ols are used for the prevention of cardiovascular disease¹⁹. Consumption of foods rich in flavanols are also associated with improved cardiovascular outcomes, suggesting that this specific group of flavonoids may have potent cardioprotective qualities²⁰. Dark chocolate may reduce the risk of atherosclerosis by thickening and hardening of the arteries and by restoring flexibility of the arteries and preventing white blood cells from sticking to the blood vessel walls²¹. The possible mechanism of these flavonoids may include

reducing the oxidative stress, increasing the endothelial prostacyclin release, enhancing the endothelial function²², increasing the sensitivity of insulin receptors, inhibiting the lipid oxidation and inhibiting angiotensin-converting enzyme²³.

For cardiometabolic disorder

In general the cardiometabolic disorders exert a burden on people²⁴. However, these are largely preventable. By systematic review and meta-analysis the cocoa products containing flavonol have a potential to prevent cardiometabolic disorders^{25,26}.

As cardiorespiratory stimulant

Theobromine, the primary alkaloid in cocoa, is a weak CNS stimulant, with only one-tenth the cardiac effects of other methylxanthines (e.g., caffeine, theophylline). Theobromine has activity similar to that seen with caffeine (i.e., increases in energy, motivation to work and alertness). Theobromine, when ingested in the form of a large chocolate bar, did not cause any acute hemodynamic or electrophysiologic cardiac changes in young, healthy adults²⁷. Theobromine pharmacokinetics were similar in healthy men when measured after 14 days of abstention from all methylxanthines and

then after 1 week ingestion of dark chocolate (theobromine 6 mg/kg/day). Hence, the results of these studies cannot be extrapolated to patients with any conditions or diseases or to the effects of chronic chocolate consumption.

For endothelial and vascular function

Dark chocolate induced a rapid and significant improvement of endothelial and platelet function in healthy smokers 2-8 hours after ingestion²⁸⁻³⁰. Cigarette smokers exhibit increased atherogenic potential, as they consistently have endothelial and platelet dysfunction, which are associated with an increased cardiovascular risk³¹. These findings are mediated by the antioxidant effect of polyphenol-rich dark chocolate. Hypertension and excess body weight are important risk factors for endothelial dysfunction. Recent evidence suggests that high-polyphenol dark chocolate improves endothelial function and lowers blood pressure in stage 1 hypertension³². Hence consumption of chocolate bars resulted in reductions in systolic and diastolic blood pressure.

For blood sugar

Dark chocolate helps blood vessels healthy and circulation unimpaired to protect against

type II diabetes. The flavonoids in dark chocolate also help to reduce insulin resistance by helping cells to function normally and regain the ability to use body's insulin efficiently³³. Dark chocolate also has a low glycemic index and it won't cause huge spikes in blood sugar levels.

For brain

Dark chocolate increases blood flow to the brain as well as to the heart, so it can help to improve cognitive function³⁴. Dark chocolate contains several chemical compounds that have a stimulant action and positive effect on the mood and cognitive health³⁵. Chocolate contains phenylethylamine (PEA), PEA encourages brain to release endorphins and feel alert. Dark chocolate also contains caffeine, a mild stimulant. However, dark chocolate contains much less caffeine than coffee and hence ingredients of chocolate were used in mood disorders³⁶.

For oral hygiene

Dark chocolate contains theobromine, which has been shown to harden tooth enamel. That means that dark chocolate lowers the risk of getting cavities in proper dental hygiene. Theobromine is also a mild stimulant, though not as strong as caffeine. It

can, however, help to suppress coughs. Theobromine works by suppressing the activity of the vagus nerve, which causes coughing and cures the cough.

As antioxidant

Dark chocolate is loaded with antioxidants. Antioxidants help against free radicals, which cause oxidative damage to cells³⁷. Free radicals are implicated in the aging process and may be a cause of cancer, so eating antioxidant rich foods like dark chocolate can protect the body from many types of cancer and slow the signs of aging³⁸.

As vitamins and minerals

Dark chocolate contains a number of natural vitamins, minerals and nutrients that can support the health. Dark chocolate contains proteins, saturated fat, calories, vitamins like vitamin B1, vitamin B2, vitamin B3, vitamin B9, vitamin K, calcium, dietary fiber, magnesium, phosphorous, manganese, selenium, iron, potassium, copper and zinc. The copper and potassium in dark chocolate help prevent against stroke and cardiovascular ailments. The iron in chocolate protects against iron deficiency anemia and the magnesium in chocolate

helps prevent type II diabetes, high blood pressure and heart disease.

In magnesium deficiency

In rats, the magnesium contained in cocoa has been shown to prevent and correct chronic magnesium deficiency. Low intakes of magnesium may be responsible for some cardiovascular alterations as well as renal, GI, neurological and muscular disorders. The use of cocoa to treat or prevent magnesium deficiency in humans has not been explored³⁹.

For cognitive performance

Free radical damage has been implicated as a cause of cognitive decline and memory loss in aging. A study using functional magnetic imaging in healthy young people found that ingestion of flavonol-rich cocoa was associated with increased cerebral blood flow, suggesting that cocoa may play a role in the treatment of cerebral impairment, including dementia and stroke.

In cancer

Data suggest that flavonoid-rich food contributes to cancer prevention. An *in vitro* study showed that breast cancer cells are selectively susceptible to the cytotoxic effects of cocoa-derived pentameric procyanidin and suggest that inhibition of

cellular proliferation by this compound is associated with the site-specific dephosphorylation or down-regulation of several cell cycle regulatory proteins⁴⁰.

CONCLUSION

Chocolate is a high calorie, high fat food. Dark chocolate is naturally rich in flavonoids. These compounds are thought to exhibit different therapeutic activities. The major benefit of dark chocolate is in cardiovascular related disorders. The various other benefits of dark chocolate includes, alleviation of hypertension, regulation of blood sugar, antioxidant protection etc.

REFERENCES

1. Vishal P, Shivendra Kumar D, Yusuf Ali J. Chocolates as dosage form- an overview. International Journal of Pharmaceutical and Research Sciences. 2012; 1(6): 397-412.
2. Shahkhalili Y, Duruz E, Acheson K. Digestibility of cocoa butter from chocolate in humans. European Journal of Clinical Nutrition. 2000; 54(2): 120-125.
3. Lee R, Balick M. Rx: chocolate. Explore. 2005; 1(2): 136-139.
4. Pucciarelli DL, Grivetti LE. The medicinal use of chocolate in early North

- America. *Molecular Nutrition and Food Research*. 2008; 52(10): 1215-1227.
5. Cooper KA, Donovan JL, Waterhouse AL, Williamson G. Cocoa and health: a decade of research. *British Journal of Nutrition*. 2008; 99(1): 1-11.
 6. Arts IC, Hollman PC, Kromhout D. Chocolate as a source of tea flavonoids. *Lancet*. 1999; 354(9177): 488.
 7. Buijsse B, Feskens EJ, Kok FJ, Kromhout D. Cocoa intake, blood pressure and cardiovascular mortality. *Archives of Internal Medicine*. 2006; 166(4): 411-417.
 8. Dillinger TL, Barriga P, Escarcega S, Jimenez M, Salazar Lowe D, Grivetti LE. Food of the gods: cure for humanity? A cultural history of the medicinal and ritual use for chocolate. *Journal of Nutrition*. 2000; 130(8): 2057S-2072S.
 9. Lazarus SA, Hammerstone JF, Schmitz HH. Chocolate contains additional flavonoids not found in tea. *Lancet*. 1999; 354(9192): 1825.
 10. Bruinsma K, Taren DL. Chocolate: food or drug?. *Journal of the American Dietetic Association*. 1999; 99(10): 1249-1256.
 11. http://en.wikipedia.org/wiki/Cocoa_butter
 12. Wollgast J, Anklam E. Review of polyphenols in *Theobroma cacao*: changes in composition during the manufacture of chocolate and methodology for identification and quantification. *Food Research International*. 2000; 33(6): 423-447.
 13. Hammerstone JF, Lazarus SA, Schmitz HH. Procyanidin content and variation in some commonly consumed foods. *Journal of Nutrition*. 2000; 130(8): 2086S-2092S.
 14. Schramm DD, Wang JF, Holt RR. Chocolate procyanidins decrease the leukotriene-prostacyclin ratio in humans and human aortic endothelial cells. *American Journal of Clinical Nutrition*. 2001; 73(1): 36-40.
 15. Kondo K, Hirano R, Matsumoto A, Igarashi O, Itakura H. Inhibition of LDL oxidation by cocoa. *Lancet*. 1996; 348(9040): 1514.
 16. Wang JF, Schramm DD, Holt RR. A dose-response effect from chocolate consumption on plasma epicatechin and oxidative damage. *Journal of Nutrition*. 2000; 130(8): 2115S-2119S.
 17. Schroeter H, Heiss C, Balzer J. (-)-Epicatechin mediates beneficial effects of flavanol-rich cocoa on vascular function

- in humans. Proceedings of the National Academy of Sciences. 2006; 103(4): 1024-1029.
18. Baron AM, Donnerstein RL, Samson RA, Baron JA, Padnick JN, Goldberg SJ. Hemodynamic and electrophysiologic effects of acute chocolate ingestion in young adults. *American Journal of Cardiology*. 1999; 84(3): 370-373.
 19. Hooper L, Kay C, Abdelhamid A, Kroon PA, Cohn JS, Rimm EB, Cassidy A. Effects of chocolate, cocoa and flavan-3-ols on cardiovascular health: a systematic review and meta-analysis of randomized trials. *American Journal of Clinical Nutrition*. 2012; 1-12.
 20. Fisher ND, Hollenberg NK. Flavonols for cardiovascular health. *Journal of Hypertension*. 2005; 23(8): 1453-1459.
 21. Mink PJ, Scrafford CG, Barraj LM. Flavonoid intake and cardiovascular disease mortality. *American Journal of Clinical Nutrition*. 2007; 85(3): 895-909.
 22. Erdman JW, Carson L, Kwik-Urbe C, Evans EM, Allen RR. Effects of cocoa flavonols on risk factors for cardiovascular disease. *Asia Pacific Journal of Clinical Nutrition*. 2008; 17(1): 284-287.
 23. Engler MB, Engler MM. The emerging role of flavonoid-rich cocoa and chocolate in cardiovascular health and disease. *Nutrition Reviews*. 2006; 64(3): 109-118.
 24. Adil MS, Amer K, Nematullah K, Ihtisham S, Aamer K, Maazuddin, Omer M, Amir S. Role of dark chocolate in minimising the risk of cardio-metabolic syndrome. *Indo American Journal of Pharmaceutical Research*. 2013; 3(8): 6469-6476.
 25. Lopez AB, Sanderson J, Johnson L, Samantha W, Wood A, Angelantio ED, Franco OH. Chocolate consumption and cardiometabolic disorders. *BMJ*. 2011; 343: 1-8.
 26. Taubert D, Roesen R, Schomog E. Effect of cocoa and tea intake on blood pressure: a meta-analysis. *Archives of Internal Medicine*. 2007; 167(7): 626-634.
 27. Mumford GK, Evans SM, Kaminski BJ. Discriminative stimulus and subjective effects of theobromine and caffeine in humans. *Psychopharmacology (Berl)*. 1994; 115(1-2): 1-8.
 28. Hermann F, Spieker LE, Ruschitzka F, Sudano I, Hermann M, Binggeli C, Luscher TF, Riesen W. Dark chocolate

- improves endothelial and platelet function. *Heart*; 2006; 92: 119-120.
29. Rein D, Paglieroni TG, Rein D. Cocoa inhibits platelet activation and function. *American Journal of Clinical Nutrition*. 2000; 72(1): 30-35.
30. Vita JA. Polyphenols and cardiovascular disease: effects on endothelial and platelet function. *American Journal of Clinical Nutrition*. 2005; 81: 292S-297S.
31. Heiss C, Kleinbongard P, Dejam A. Acute consumption of flavonol-rich cocoa and the reversal of endothelial dysfunction in smokers. *Journal of the American College of Cardiology*. 2005; 46(7): 1276-1283.
32. Nogueira LP, Knibel MP, Torres MR, Neto JF, Sanjuliani AP. Consumption of high-polyphenol dark chocolate improves endothelial function in individuals with stage I hypertension and excess body weight. *International Journal of Hypertension*. 2012; 1-9.
33. Grassi D, Lippi C, Necozione S, Desideri G, Ferri C. Short-term administration of dark chocolate is followed by a significant increase in insulin sensitivity and a decrease in blood pressure in healthy persons. *American Journal of Clinical Nutrition*. 2005; 81(3): 611-614.
34. Di Tomaso E, Beltramo M, Piomelli D. Brain cannabinoids in chocolate. *Nature*. 1996; 382(6593): 677-678.
35. Small DM, Zatorre RJ, Dagher A, Evans AC, Jones-Gotman M. Changes in brain activity related to eating chocolate: from pleasure to aversion. *Brain*. 2001; 124(9): 1720-1733.
36. Parker G, Parker I, Brotchie H. Mood state effects of chocolate. *Journal of Affective Disorders*. 2006; 92(2-3): 149-159.
37. Waterhouse AL, Shirley JR, Donovan JL. Antioxidants in chocolate. *Lancet*. 1996; 348(9030): 834.
38. Keen CL, Holt RR, Oteiza PI, Fraga CG, Schmitz HH. Cocoa antioxidants and cardiovascular health. *American Journal of Clinical Nutrition*. 2005; 81(1): 298S-303S.
39. Planells E, Rivero M, Mataix J, Llopis J. Ability of a cocoa product to correct chronic Mg deficiency in rats. *International Journal of Vitamin and Nutrition Research*. 1999; 69(1): 52-60.
40. Ramljak D, Romanczyk LJ, Metheny-Barlow LJ. Pentameric procyanidin from

Theobroma cacao selectively inhibits
growth of human breast cancer cells.

Molecular Cancer Therapeutics. 2005;
4(4): 537-546.