

Chocolate: Food of the Gods



Roseanne Schnoll, PhD, RD, CDN
Dept Health and Nutrition Sciences

“Life is like a box of chocolates.
You never know what you’re going to
get.” (*Forrest Gump*)

Objectives



- **Origins and history of chocolate**
- Production of chocolate
- Types of chocolate
- Chemicals in chocolate
- Health benefits of chocolate
- How chocolate can fit into a healthy diet.

History

- The Maya of Central America in the rainforests (250-900 A.D.) collected the cacao beans from cacao trees
- They ground the beans into a paste and made a frothy, bitter chocolate drink called “xocoatl” (“bitter water”)



History

- Chocolate played an important role in their social and religious life
- Used for medicinal purposes
- Favored drink of the wealthy (royalty, priests, etc.)
- Cocoa beans were also used as money and trading



Ancient Medicinal Uses of Cocoa

Consumed to increase longevity

- >150 medicinal uses:
 - Stomach Disorders
 - Stimulant/Reduce Fatigue
 - Weight Gain
 - Antiseptic
 - Emollient
 - Laxative
- CVD-Related Uses:
 - “faint of heart”
 - Angina (reduces)
 - Blood (generates/produces)
 - Heart palpitations (relieves)
 - Heart (strengthens)



Dillingner et al. J Nutr 2000;130(Suppl 8):2057S-2072S

The Aztecs conquered the Maya (1400-1521)

- Conquered the Maya and were then introduced to chocolate
- Only rulers, wealthy merchants and priests could enjoy the drink

Spanish explorer, Cortez, brings the cacao bean to the Spanish court (1528)

- The Aztec emperor Montezuma offered the cacao drink to Hernando Cortez who then brought it back to Spain in 1528.



Spanish explorer, Cortez, brings the cacao bean to the Spanish court (1528)

- Europeans did not like the bitter taste, so they added spices and sugar to the mix. They also heated the drink.



Chocolate in Europe - Some Dates

1528: Hernán Cortéz returned to Spain with cocoa beans and the formula for the chocolate drink

1615: The Spanish princess Anne of Austria married Luis XIII of France, so chocolate came to France

1657: A Frenchman opened the first "Chocolate House" in London
→ became as popular as Coffee Houses

Chocolate in Europe - Some Dates

1674: The first solid chocolate in a stick form had been sold

End of 17th century: chocolate came to Germany
→ first pralines were made by a German cook

1792: A chocolate factory was opened in Berlin

Mid-1700s-Chocolate became more affordable and more than just the wealthy were able to enjoy it.



1875: The first milk chocolate was put on the market

1893- Milton S. Hershey built a chocolate factory in Southern Pennsylvania



- Chocolate production video

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Theobroma cacao plant used to make chocolate

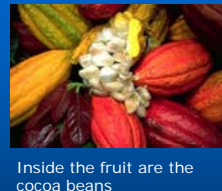


Theobroma cacao, which translates to "cacao, food of the gods."

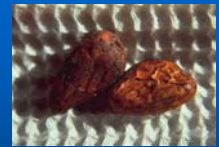
Where Does Chocolate Come From?



Cacao Tree with ripe fruit



Inside the fruit are the cocoa beans



Dried cocoa beans



Cocoa liquor

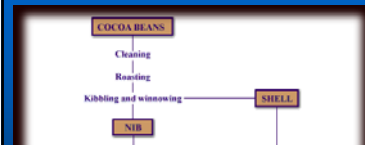


Cocoa powder

The process

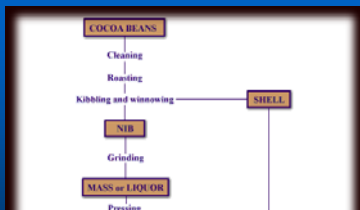
- After harvesting the beans are sorted, fermented then dried (in the sun) for several days and then roasted.
- Next they are opened, the shells are discarded and the nibs are ground and separated into cocoa butter and cocoa powder.

Flow Diagram of Chocolate Production



Step 1: cocoa beans

Flow Diagram of Chocolate Production



Step 1: cocoa beans

Step 2: shell and nibs

Nibs, Shell and Liquor



Flow Diagram of Chocolate Production



Step 1: cocoa beans

Step 2: shell and nibs

Step 3: cocoa powder

Cocoa Powder



Flow Diagram of Chocolate Production



Step 1: cocoa beans

Step 2: shell and nibs

Step 3: cocoa powder

Step 4: plain chocolate

Chocolate production video

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Dark Chocolate vs. Milk Chocolate What's the Difference?

- Dark Chocolate—tastes semisweet
 - Cocoa liqueur, cocoa butter, sugar, sometimes vanilla, no milk
- Milk Chocolate—tastes sweet
 - Milk, sugar, less cocoa liqueur, cocoa butter, vanilla



What About Other Types of Chocolate?

- White Chocolate- made from some of the same ingredients
 - Sugar, cocoa butter, milk, sometimes lecithin, sometimes vanilla, no chocolate liquor or cocoa powder
 - With no cocoa liquor is it not technically considered chocolate
- For Cooking
 - Semisweet Chocolate
 - Bittersweet Chocolate



cheap mass-produced chocolate



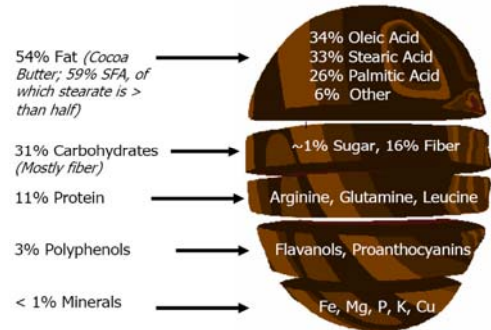
plain, dark chocolate

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Nutrient Profile of the Cocoa Bean



Isn't Chocolate High in Fat?



- 1/3 of the fat is oleic acid, same monounsaturated fat found in olive oil
- 1/3 of the fat is stearic acid, it is a saturated fat, but does not raise cholesterol levels, the body can metabolize it into oleic acid.
- 1/3 of the fat is in the form of palmitic acid, another saturated fat, however careful studies found that eating chocolate does not increase cholesterol levels.

Stearic Acid^{*} has a NEUTRAL effect on serum cholesterol

- Unlike the other long-chain SFA, stearic acid had no effect on total cholesterol and LDL cholesterol in men and women.

Yu et al., Am J Clin Nutr. 1995;61:1129-1139.

- Stearic acid is a unique SFA in that it elicits neutral cholesterolemic effects.

Kris-Etherton and Yu. Am J Clin Nutr. 1997;65(5 Suppl):1628S-1644S.

- Stearic acid lowers total and LDL cholesterol somewhat when it replaces dietary carbohydrate.

Menink and Katan. Am J Clin Nutr. 2003;77:1146-1155.

^{*}Stearic acid is the predominant SFA in chocolate.

Bioactive Compounds in Cocoa

- **Polyphenols**
- Methylxanthine
 - Theobromine
 - Caffeine
- Tryptophan, Arginine
- Phenylethylamine
- Anandamide

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Methylxanthine

- Diuretic agent
- CNS stimulant
- Clinically, used as a bronchodilator.
- Chocolate contains two members of this class of chemicals:
 - Theobromine
 - Caffeine

Theobromine

- Theobromine is the predominant methylxanthine found in cocoa beans.
- Theophylline is the predominant methylxanthine in tea.
- Caffeine is the predominant methylxanthine in coffee.
- Theobromine has a mild diuretic action (increases urine production) similar to caffeine, but does not stimulate the central nervous system like caffeine

Caffeine Content

Double espresso (2oz)	45-100 mg
Brewed coffee (8 oz)	60-120 mg
Instant coffee (8 oz)	70 mg
Decaf coffee (8 oz)	1-5 mg
Tea - black (8 oz)	45 mg
Tea - green (8 oz)	20 mg
Tea - white (8 oz)	15 mg
Coca Cola (12 oz can)	34 mg
Pepsi (12 oz can)	38 mg
7-up (12 oz)	0 mg
Chocolate milk (8 oz)	4 mg
Dark chocolate (1 oz)	20 mg
Milk chocolate (1 oz)	6 mg

Bioactive Compounds in Cocoa

- Polyphenols
- Methylxanthine
 - Theobromine
 - Caffeine
- **Tryptophan**, Arginine
- Phenylethylamine
- Anandamide

Tryptophan

- Tryptophan is an essential amino acid. It is the precursor for the mood-modulating neurotransmitter serotonin.
- Enhanced serotonin function typically diminishes anxiety.



Bioactive Compounds in Cocoa

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- Tryptophan, Arginine
- **Phenylethylamine**
- Anandamide

Phenylethylamine (PEA)

- This compound may be responsible for some of the pleasurable feelings you get after eating chocolate because it releases natural feel-good chemicals called endorphins in your brain.
- This effect led to labeling cocoa as an aphrodisiac.
- PEA is released by the brain when people are falling in love. Perhaps this explains why chocolate and Valentine's Day are so closely linked.

Love Drug?

- Chemicals like tryptophan and phenylethylamine, which are also found in many other foodstuffs, are present in chocolate only in very small quantities.

Bioactive Compounds in Cocoa

- Polyphenols
- Methylxanthine
 - Theobromine
 - Caffeine
- Tryptophan, Arginine
- Phenylethylamine
- **Anandamide**

Chocolate Pot?

- The same is true of anandamide, the current favorite candidate for a psychoactive chocolate ingredient.

Chocolate Pot?

- Anandamide is a neurotransmitter that targets the same brain structures as THC, (Tetrahydrocannabinol) the active ingredient in cannabis.
- But to make a substantial impact on the brain's own natural anandamide levels, Scientists doubt if anandamide and other chemicals in chocolate have much effect because they are present only in small amounts.

Chocolate Pot?

- It is estimated that a 130-pound person would have to eat 25 pounds of chocolate at one time to get any marijuana-like effect.
- As well as anandamide itself, chocolate contains two chemicals known to slow the breakdown of anandamide.
- Chocolate might therefore work by prolonging the action of this natural stimulant in the brain.

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Polyphenols

- A large family of natural compounds widely distributed in plant foods.
- Polyphenols have specific health-promoting actions, and it is generally recognized that they can reduce the risk factors for many types of chronic diseases.

Polyphenols

- The largest and best studied polyphenols are the flavonoids, which include several thousand compounds, among them the flavonols, flavones, catechins, flavanones, anthocyanidins, and isoflavonoids.
- Important dietary sources of polyphenols in Western societies are onions (flavonols); cocoa, tea, apples, and red wine (flavonols and catechins); citrus fruit (flavanones); berries and cherries (anthocyanidins); and soy (isoflavones).



What Are Flavonoids and Flavonols?

- Flavonoids are a type of polyphenols
- More than 4,000 different flavonoids exist
- Naturally found in many different plant foods
- They provide certain health benefits—many act as antioxidants
- Flavonols are one type of flavonoid.

1990 J. Agric. Food Chem. 38(6):1061-1066

COCAO HAS MORE PHENOLIC PHYTOCHEMICALS AND A HIGHER ANTIOXIDANT CAPACITY THAN TEAS AND RED WINE

Ki-Wan Lee,^{1,2} Yoon-Jin Kim,¹ Hyeon-Jin Lee,¹ and Choon-Yeou Lee^{1,2}

¹Department of Food Science and Technology, School of Agricultural Biotechnology, Seoul National University, Seoul 151-747, Korea; ²Department of Food Science and Technology, Seoul National University, Seoul 151-747, Korea; and ³Department of Molecular Biology and Biotechnology, Seoul National University, Seoul 151-747, Korea

Black tea, green tea, red wine, and cocoa are high in phenolic phytochemicals, among which flavonols, epigallocatechin gallate, catechins, and procyanidins, respectively, have been extensively investigated due to their possible role in chemopreventive agents based on their antioxidant capacities. The present study compared the phenolic and flavonoid contents and total antioxidant capacities of cocoa, black tea, green tea, and red wine. Cocoa contained much higher levels of total phenolics (307 mg of gallic acid equivalents, GAE) and flavonoids (284 mg of catechin equivalents, CE) per serving than black tea (226 mg of GAE and 36 mg of CE), respectively. Green tea (150 mg of GAE and 10 mg of CE) and red wine (240 mg of GAE and 40 mg of CE). Total antioxidant activities were measured using the 2,2'-azobis(2-amidinopropane) dihydrochloride (ABAP) and 2,2'-azobis(2-amidinopropane) dihydrochloride (ABAP) radical scavenging assays and are expressed as values of antioxidant capacity (DPPH). Cocoa exhibited the highest antioxidant activity among the samples in ABAP and ABAP assays with IC₅₀ values of 11.0 and 10.0 mg/ml, respectively. The relative total antioxidant capacities of the samples in both assays were as follows in decreasing order: cocoa > red wine > green tea > black tea. The total antioxidant capacities from ABAP and ABAP assays were highly correlated with phenolic content ($r^2 = 0.98$ and 0.97 , respectively) and flavonoid content ($r^2 = 0.98$ and 0.97). These results suggest that cocoa is more beneficial to health than tea and red wine in terms of its higher antioxidant capacity.

Results demonstrate that cocoa has a high flavonoid content and substantial antioxidant capacity:
 4-5 X stronger than black tea;
 2-3X stronger than green tea;
 Almost 2X stronger than red wine.

HERSHEY'S EXTRA DARK

NATURAL SOURCE OF FLAVANOL ANTIOXIDANTS

Comparison of antioxidant capacity - HERSHEY'S EXTRA DARK dark chocolate vs. other products: Data from the recent study sponsored by The Hershey Company and previous data from USDA and others indicate that dark chocolate is one of the most concentrated sources of flavanol antioxidants among plant foods. The antioxidant capacity of 1 serving of HERSHEY'S EXTRA DARK dark chocolate (37g) is equal to 3 cups of tea, 2 glasses of red wine or 1 1/3 cups of blueberries.

Product	HERSHEY'S Extra Dark	Red Wine	Blueberries	Black Tea
Standard Serving	37 grams	4 ounce glass	1 1/3 cup	1 cup (2g tea bag)

<<PREVIOUS NEXT>>



Chocolate Polyphenols reduces CVD risk factors



- ## Other benefits



- Improvement in insulin sensitivity
- ↓ cognitive decline in aging
- Protects damage to skin from UV radiation
- ↓ stress hormones in people who had high anxiety levels

Carl L. Koon, PhD

Key words: chocolate, flavonoids, endothelium, glycerolates, polyphenols, cardiovascular disease

Cones and choroid plexus have been deficient for months of years. Only recently have they been recognized as significant sources of phytochemicals with antitumor effects. These foods are among the most concentrated sources of the procarcinogens furocoumarins, isochlorogenic acid, and coumarolins. Recent studies have shown that these phytochemicals are absorbed from the intestine of patients and humans with significant elevated levels after their ingestion. These furocoumarins have potent anticancer and antiplasmodial activities following consumption of cones or choroid.

Key tracking points:

- **Cocaine and crack/crackers products** have the highest concentrations of **terpenoids** among commonly consumed fuels
- The predominant **terpenoids** are **caryophyllene** and **germacolene**, which are found in **peppermint**
- These **terpenoids** have **potent anxiolytic effects** in rats and in **monkeys**, and **open anion-channel channels**
- **Cocaine-derived pyrogallols** also **alter gastric motility**
- Multiple mechanisms are involved in which **therapeutics** from **cocaine** may **exert beneficial effects**

[illegible]

There is no convincing evidence that the use of oral contraceptives (OCs) increases the risk of breast cancer, but not necessarily a recent report (1) that OCs increase the risk of breast cancer. In fact, breast cancer is not statistically a more frequent cause of death in OC users than in nonusers (2). In fact, breast cancer is not statistically a more frequent cause of death in OC users than in nonusers (2). In fact, breast cancer is not statistically a more frequent cause of death in OC users than in nonusers (2).

Presented in part at Basic Research Conference on Medical Issues, "Stress in Medical and Therapeutic Settings," November 8 & 9, 2000, Key Largo, Florida.
Address reprint requests to: Col. E. Ross, PhD, Department of Maritime, University of California at Davis, 714 Shattuck Hall, Davis, CA 95616. E-mail: eross@ucdavis.edu

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Review Article

Cocoa and health: a decade of research

Karen A. Cooper¹, Jennifer L. Donovan², Andrew L. Waterhouse² and Gary Williamson^{3*}

³Department of Psychiatry and Behavioral Sciences, Medical University of South Carolina, Charleston, SC 29425, USA

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It has been over 50 years since the first question in a medical journal asked about the relation to parental sources of information for health. During this time, there has been debate to improve educational status, reduce misinformation and correlate with reduced health disease risk, with these results, and in popularity, it has received wide coverage in the press. However, after 50 years of research, what is known about the potential health benefits of cancer and what are the important next steps in understanding the decision source of information?

Early reflections: why come and why the focus on C/WP?

report reflects this and is not intended to imply that all

"It has been over 10 years since the first mention in a medical journal about cocoa and chocolate as potential sources of antioxidants for health. During this time, cocoa has been found to improve antioxidant status, reduce inflammation and correlate with reduced heart disease risk."

British Journal of Nutrition, 2008

effect is clear. The use of the term *antisocial* in the present study, and the individual's current and antisocial activity

Intervention	Polyphenol content	Control	Subjects	Main outcomes	Industry-funded	Reference
1 Semi-sweet chocolate taking 60 g (one dose of 5, 27 g, 5, 52 g, 5, 80 g)	Total polyphenols (epicatechin) 160 mg (80 mg) (30 mg) (50 mg) (100 mg) (160 mg)	No chocolate	20 healthy adults (20–50 years)	Dose-dependent increase in plasma epicatechins, from significant trend for an increase in plasma antioxidant activity and a decrease in TBARS	Partially	Wang et al. ²⁴
2 18 g polyphenol-rich cocoa powder in 150 ml water (one dose)	80 mg epicatechin and 80 mg polyphenols	Coffee and lactated but dark or white	30 healthy adults (24–50 years), 15 per group	Suppression of platelet activation, Aggregable effect on primary hemostasis 5 h after consumption	Authors from industry not stated	Ross et al. ²⁵
3 100 g of which 50 g chocolate (semi-sweet taking 10 g one dose)	500 mg total polyphenols (of which 100 mg epicatechin)	Vanilla cake	10 healthy adults (20–49 years) + 3 healthy adults (20–30 years) consuming control	12-fold increase in plasma epicatechin 2 h later, increase in plasma total antioxidant activity and decrease in TBARS	Partially	Ross et al. ²⁵
4 12 g cocoa powder × 30 for 2 weeks	20–50 mg total polyphenols (of which 10 mg epicatechin)	Sugar	15 healthy men, 9 in active group (32 ± 4 years)	Increase in LDL oxidation by time, no change in plasma levels of antioxidants, higher excretion of epicatechins/metabolites in urine	Authors from industry not stated	Oishi et al. ²⁶
5 22 g cocoa powder and 10 g dark chocolate for 4 weeks	400 mg polyphenols (of which 111 mg epicatechin)	Average American diet	20 healthy adults (21–62 years)	Increase in LDL oxidation by time, increase in plasma antioxidant capacity, increase in HDL cholesterol	No but industry-funded authors	Wan et al. ²⁷
6 14 g 70% cocoa powder in 300 ml water with sugar, with and without aspartame (one dose)	80 mg epicatechin and 80 mg polyphenols	40 mg aspartame	16 healthy adults (20–40 years)	After 4 h, cocoa inhibited epinephrine-induced platelet activation and function	Industry-funded	Bonaventura et al. ²⁸
7 20 g 70% dark chocolate and 20 mg cocoa powder in a drink for 6 weeks	80 mg total polyphenols (of which 160 mg epicatechin + 60 mg polyphenols)	None	16 healthy adults (20–40 years)	LDL oxidizability was lower, but no effect on inflammation markers, or plasma antioxidant capacity	Partially	Mahar et al. ²⁹
8 25 g semi-sweet chocolate chips (one dose)	200 mg epicatechin and 200 mg polyphenols	None	10 healthy adults	Increase in plasma epicatechin after 2 h with concurrent increase in proinflammatory cytokines and reduction in proinflammatory cytokines	Partially	Ross et al. ²⁵
9 100 g dark chocolate for 14 d	500 mg total polyphenols	90 g white chocolate	13 elderly adults (51–64 years) with mild hypertension	Lower systolic and diastolic blood pressure	No	Takami et al. ³⁰
10 Cocoa flavanols/polyphenols (one dose)	250 mg flavanols and 250 mg polyphenols (in 75 mg lactitol)	Placebo tablets	13 healthy adults (40 ± 10 years) with mild hypertension	Lower platelet aggregation and P-ADP response, higher plasma antioxidant capacity, no change in inflammation markers, increase in plasma epicatechin and catechins	Partially	Murphy et al. ³¹
11 High polyphenol cocoa drink 4 × 200 ml for 4 d	80 mg total flavanols (epicatechin, catechin and procyanidins) 170 mg total polyphenols (80 mg epicatechin)	Low flavanol cocoa drink	27 healthy adults (18–72 years)	Increased procyanidin acetylation after 4 d, larger acute response to P-ADP, NO bioavailability and arterial FMD increased	Partially	Fisher et al. ³²
12 100 mg high cocoa polyphenol drink (one dose)	100 mg polyphenols	Low flavanol cocoa drink	20 adults with 1 CHD risk factor (21 years ± 14 (17% women))	Increased procyanidin acetylation after 4 d, larger acute response to P-ADP, NO bioavailability and arterial FMD increased	Partially	Holte et al. ³³

Intervention	Polyphenol content	Control	Subjects	Main outcomes	Industry-funded	Reference
23 300 ml high polyphenol cocoa drink (one dose)	917 mg flavanols (19% epicatechin)	300 ml low polyphenol cocoa drink	16 healthy males (25–32 years)	Acute elevations in levels of circulating NO species, an enhanced FMD response to carotid arteries, and an augmented nitric oxide release	Partially	Schroeder et al. ³⁴
24 40 g dark chocolate (one dose)	Not stated but same brand as used for flavanols at 25	White chocolate	20 male smokers (age 40 ± 10 years)	Improved FMD after 2 h testing for 6 h. Reduction in platelet function, increased plasma total antioxidant status	No	Hermans et al. ³⁵
25 High polyphenol cocoa drink 4 × 200 ml for 4 d	Per 100 ml, 9.2 mg epicatechin, 107 mg catechin and 69.3 mg flavanols (80 mg polyphenols)	None	15 young (1–30 years) and 15 older (31–50 years)	NO synthesis after cocoa was enhanced in older volunteers, FMD was enhanced in both groups but more in older group. Pulse wave amplitude enhanced in both groups with acute rise with cocoa ingestion, more robustly in older subjects. No change in BP	Partially	Fisher et al. ³²
26 22 g cocoa powder and 10 g dark chocolate (one dose)	111 mg monomers and 406 mg polyphenols	Cocoa butter equivalent in milk	4 (20–40 years) normotensive subjects (pilot trial)	Dark chocolate increased resistance to LDL and VLDL to oxidation while cocoa butter alone decreased resistance. Novel after examination of dietary data that chocolate is third highest contributor of antioxidants to the American diet	No	Vinson et al. ³⁶
27 41 g of high polyphenol dark chocolate either with or without aspartame 60 g for 6 weeks plus dietary advice	Not stated	No intervention except same dietary advice	40 women with cholesterol 4.1–7.8 mmol/l (22–45 years)	Dark chocolate decreased TAG by 21%, 19% when eaten with aspartame and 11% with no intervention. Consistent intercorrelation between individuals with dark chocolate alone	No, industry supplied chocolate only	Kurland et al. ³⁷
28 High flavanol cocoa drink 100 ml × 30 for 1 week	Per 100 ml, 50 mg epicatechin, 15 mg catechin and 252 mg flavanol oligomers (318 mg polyphenols)	Low flavanol cocoa drink	6 male smokers with smoking-related endothelial dysfunction (11 kmol (22–32 years))	Daily consumed FMD increases at baseline (fasted) and a sustained FMD augmentation at 2 h post ingestion. A dose-dependent effect also seen with FMD and other biomarkers for oxidative stress unaffected	Yes	Holte et al. ³³

FE, Fenton equivalent; FMD, flow-mediated dilation; FRAP, ferric-reducing ability of plasma; TBARS, thiobarbituric acid reactive substances.

Intervention	Polyphenol content	Control	Subjects	Main outcomes	Industry-funded	Reference
10 100 g dark chocolate with and without 200 mg milk (one dose)	Polyphenols not stated but FRAP values were 1474 µmol TE/100 g	200 g milk chocolate (FRAP 76 µmol TE/100 g)	42 healthy adults (25–50 years)	Dark chocolate increased plasma and oxidized capacity and epicatechin. Containing milk did not reflect those effects. Milk showed no effect on both both these tests	No	Berghel et al. ³⁸
14 75 g dark chocolate or high phenolic dark chocolate for 3 weeks	Dark = 24 mg/ml flavanols (epicatechin) High = 416 mg/ml (170 mg epicatechin)	75 g white chocolate	40 healthy adults (19–49 years)	Both dark chocolate increased HDL cholesterol and total peroxidation decreased but only with white chocolate control. No change in plasma antioxidant capacity	Partially	Morris et al. ³⁹
15 40 g high phenolic dark chocolate for 14 d	213 mg total polyphenols, of which 40 mg epicatechin	Low phenolic dark chocolate	21 healthy adults (21–60 years)	Improved endothelium-dependent FMD, no change in blood pressure, oxidative markers or blood lipids, higher plasma epicatechin	No	Bright et al. ⁴⁰
16 High polyphenol cocoa drink, 150 ml (one dose)	187 mg total monomers and oligomers polyphenols	Low phenolic cocoa drink	30 healthy males (20–40 years)	R2 scorelines improved 2 and 4 h after exercise	No but industry-funded authors	Wasserg et al. ⁴¹
17 Dark chocolate, 100 g (one dose)	500 mg total polyphenols	80 g white chocolate	15 healthy adults (34 ± 7 years)	Insulin sensitivity higher and insulin resistance lower. Sympathetic activity in the rate of free radical-induced hemolysis	Partially	Graessl et al. ⁴²
18 Phenol-rich dark chocolate 40 g (one dose)	12.8 mg monomers, 7.7 mg oligomers, 20.5 mg polyphenols	Bread and water	8 healthy males (20 ± 3 years)	Decreases in diastolic and mean blood pressure, plasma cholesterol, LDL, malondialdehyde, uric acid and fibrinolytic activity, increase in albumin C-cholesterol ratio. No change in plasma epicatechin but complete week fasting	No	Zhu et al. ⁴³
19 100 g dark chocolate for 14 d	140 mg flavanols (of which 30 mg monomers and 110 mg polyphenols)	Cocoa butter chocolate	28 healthy males (18–20 years) under exercise stress	Decreases in diastolic and mean blood pressure, plasma cholesterol, LDL, malondialdehyde, uric acid and fibrinolytic activity, increase in albumin C-cholesterol ratio. No change in plasma epicatechin but complete week fasting	No	Prigent et al. ⁴⁴
20 100 g dark chocolate (one dose)	242 g of which 54 g monomers and 188 g polyphenols	Bread (chewing and water)	17 healthy adults (24–32 years)	Increase in resting and hyperemic flow-mediated dilation. Increase in FMD at 2 h. Acute augmentation index decreased. No significant change in malondialdehyde and low endothelial reactivity and plasma levels	No	Vlachopoulos et al. ⁴⁵
21 100 g dark chocolate for 15 d	180 mg flavanols (20 mg catechins, 160 mg epicatechin)	80 g white chocolate	20 never-treated adults with essential hypertension (44 ± 8 years)	Insulin sensitivity improved, lower systolic and diastolic blood pressure and LDL, and improved FMD	No	Graessl et al. ⁴²
22 High polyphenol cocoa drink, 150 ml (one dose)	170–180 mg flavanols (140 mg monomers, 30–50 mg oligomers, 130–111 mg polyphenols)	Low phenolic cocoa drink	11 adult smokers (average 31 years)	Increased circulating HDL FMD, both completed to decrease in blood malondialdehyde. Effects were increased with 100 mg epicatechin compared to cocoa like to NO	Yes	Holte et al. ³³

Reference	Subjects	Duration	Dose	Measures	Results
Wan et al., AJCN, 2001	23 males and females	4 weeks	TEST: Cocoa Powder & Dark Chocolate in the diet	Lipid panel, plasma CRAC, LDL lag time, rate of LDL oxidation	• Significant increase in LDL-oxidation lag time (8%); (increased serum antioxidant level correlated with lag time) on CP-DC diet
Kondo et al., Lancet, 1996	12 males	2–4 h	TEST: 35g delipidated cocoa	LDL oxidation	• Cocoa inhibited LDL oxidation at 2 hours
Osakabe et al., Free Rad Res, 2001	9 males	2 weeks	TEST: 36g cocoa	Lag time of conjugated diene formation	• Lag time was significantly prolonged after the cocoa treatment
Osakabe et al., J Health Sci, 2004	8 males	2 weeks	TEST: 18g, 24g, 36g cocoa powder/day	Lag time of conjugated diene formation	• 24, 36g doses resulted in significant differences in lag time prolongation

Reference	Subjects	Duration	Dose	Measures	Results
Baba et al., AJCN, 2007	25 males	12 weeks	TEST: Cocoa drink (26g cocoa, 12g sugar)	Plasma lipids	• Significant increase in HDL-C (24%)
Mursu et al., Free Radic Biol Med, 2004	45 males and females	3 weeks	TEST: 75g dark chocolate; 75g enriched dark chocolate	Lipid panel	Significant increases in HDL-C (11% and 14%) for dark chocolate & enriched dark chocolate
Wan et al., AJCN, 2001	23 males and females	4 weeks	TEST: Cocoa Powder & Dark Chocolate in the diet	Lipid panel	• Significant increase in HDL-C

Reference	Subjects	Time	Dose	Measures	Results
Rein et al., AJCN 2000	30 males and females	2–6 h	Treatments: (3 beverages) • Cocoa • Caffeine • Water	Platelet antigens and microparticle formation; PFA	Cocoa reduced: • Expression of platelet markers after 2 & 6 h
Rein et al., J Nutr 2000	40 males and females	2–6 h	Treatments: (4 beverages) • Cocoa • Wine (ETOH) • Caffeine • Water	Platelet antigens and microparticle formation	Cocoa reduced: • Platelet activity for 6 h
Pearson et al., Thromb Res 2002	16 males and females	2–6 h	Treatments: • 81mg aspirin • 300 ml cocoa • Combination	Platelet antigens and microparticle formation PFA	Flavanol-rich cocoa inhibited epinephrine-stimulated platelet activation and function.



Highlights of the Year in JACC 2005

DeMaria et al., *J. Am. Coll. Cardiol.* 2006;47:184-202;

Chocolate, flavonoids, and endothelial dysfunction.

Some studies have suggested that diets rich in flavonol might increase bioactive NO in plasma. Heiss et al. studied the effects of a flavonol-rich cocoa preparation on the circulating plasma NO and flow-mediated dilation in smokers and showed a dose response between flavonol content and acute increase in circulating NO and flow-mediated dilation after oral ingestion of the cocoa drink. **Thus, there may be some health benefits of flavonol-rich foods such as cocoa.**

Heiss C, Kleinbongard P, Dejen A, et al. Acute consumption of flavonol-rich cocoa and the reversal of endothelial dysfunction in smokers. *J Am Coll Cardiol* 2005;46:1278-83.

Dark chocolate improves endothelial and platelet function

- Cigarette smokers exhibit increased atherogenic potential, as they consistently have endothelial and platelet dysfunction, which are associated with an increased cardiovascular risk.
- Dark but not white chocolate induced a rapid and significant improvement of endothelial and platelet function in healthy smokers

(40 g of dark chocolate or 40 g of white chocolate (4% cocoa, Nestle Galak)

SCIENTIFIC LETTER

Dark chocolate improves endothelial and platelet function

F Hermann, L E Späcker, F Buschirio, I Sodano, M Hermann, C Ringel, T F Lüscher, W Böhm, G Noll, R Corti

Heart 2006;92:119-120. doi: 10.1136/hl.2005.102042

The effects of flavonoids on endothelial function are still a matter of debate. Chocolate may enhance endothelial function and hence of the effect on blood pressure, but this might be possibly a non-specific effect through vasodilatory effects of flavonoids. We studied the effects of dark chocolate on endothelial function and platelet aggregation in healthy young men. The effects of dark chocolate on endothelial function and platelet aggregation were compared with those of white chocolate. The results showed that dark chocolate significantly improved endothelial function and platelet aggregation, while white chocolate had no effect. These findings are most likely mediated by the antioxidant effect of dark chocolate.

Dark chocolate exerts favorable effects on endothelial function and platelet aggregation. These findings are most likely mediated by the antioxidant effect of dark chocolate.

Heart, 2006; 92, 119-120.

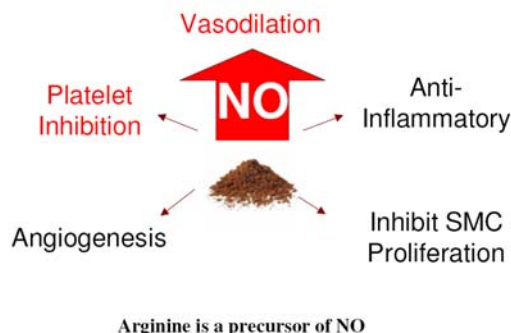
Eating dark chocolate reduces CRP

- Researchers studied 1317 people who did not eat any chocolate and 824 people who ate dark chocolate regularly. They looked at the levels of CRP in their blood to their usual chocolate intake.
- Consuming moderate amounts of dark chocolate can significantly reduce levels of C-reactive protein (CRP)
- Those who ate up to 1 serving (20 g) every 3 days had CRP concentrations significantly lower than those who ate none or those who ate larger amounts.

Eating dark chocolate reduces CRP

- The 17% average reduction observed may appear small, but it is enough to decrease the risk of cardiovascular disease for one-third in women and one-fourth in men
- The lowering of CRP corresponds to a shift from medium risk of cardiovascular disease to low risk.
- If you increase the consumption, the protection is lost, similar to the effects of wine.
- Di Giuseppe R, di Castelnuovo A, Centritto F, et al. Regular consumption of dark chocolate is associated with low serum concentrations of C-reactive protein in a healthy Italian population. *J Nutr* 2008; 138: 1939-1945

A Primary Mechanism by which Cocoa & Chocolate affect Cardiovascular Health



Blood Pressure Benefits of Cocoa: Population Evidence

Hollenberg et al. J Food Comp Anal. 2001.

- KUNA Amerinds:**
 - Indigenous population off the coast of Panama
 - Traditional high salt diet
 - Showed no rise in blood pressure with age
 - Immigrants did develop hypertension
- Island dwelling Kuna's consume an average of 5 cups of cocoa per day



Slide: Courtesy of Dr. Amy Griel

Cocoa Intake, Blood Pressure, and Cardiovascular Mortality

The Zutphen Elderly Study

Bruneau, 1992; 1993; 1994; 1995; 1996; 1997; 1998; 1999; 2000; 2001; 2002; 2003; 2004; 2005; 2006; 2007; 2008; 2009; 2010; 2011; 2012; 2013; 2014; 2015; 2016; 2017; 2018; 2019; 2020; 2021; 2022; 2023; 2024; 2025

Background: Cocoa flavanols have been shown to lower blood pressure and improve endothelial function. We evaluated whether cocoa intake was associated with cardiovascular mortality.

Methods: Data from 1,000 elderly men participating in the Zutphen Elderly Study and free of disease at baseline. Blood pressure was measured at baseline and 10 years later. Cocoa intake was assessed using a validated food frequency questionnaire. Cardiovascular mortality was assessed using the cause-specific death rate.

Results: Men who consumed more than 10 g of cocoa per day had a lower risk of cardiovascular mortality compared to those who consumed less than 10 g per day. This association remained after adjusting for age, sex, and other risk factors.

"This study suggests that higher cocoa intake is associated with reduced blood pressure and reduced risk of cardiovascular and all-cause mortality in elderly men."

Effects of Low Habitual Cocoa Intake on Blood Pressure and Bioactive Nitric Oxide

A Randomized Controlled Trial

Dark Tashiro, MD, PhD

Ramirez-Ruiz, PhD

Chen, PhD

Norris, PhD

Edgar, PhD

Edgar, PhD

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Recent News

- New study found only 6 grams dark chocolate necessary to show positive results
- About 1 and ½ Hershey's Special Dark Chocolate Kisses (30 calories, 2 grams of fat, 4 grams of sugar) decreased blood pressure in middle-aged men and women with slightly high blood pressure



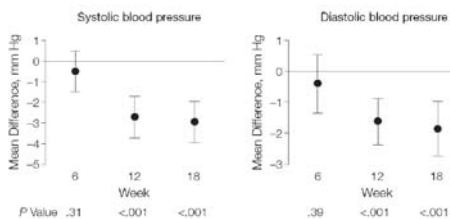
"The inclusion of small amounts of polyphenol-rich dark chocolate as part of a usual diet efficiently reduced BP and improved formation of vasodilative nitric oxide."

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Journal of the American Medical Association, 299:10, 1007-1010 (2008) 1-10

Effects on Blood Pressure

44 Adults (56-73 yo); Stage I Hypertension; 30 mg Polyphenols



6.3 g/day Dark Chocolate = 30 calories

Taubert D et al. JAMA. 2007;298:49-60.

Short-term administration of dark chocolate is followed by a significant increase in insulin sensitivity and a decrease in blood pressure in healthy persons 1-3

David G. Knorr, Edgar, Robert Knorr, Gerdhard Knorr, and Claudio Fari

Abstract: Because insulin resistance is a major risk factor for cardiovascular disease, we investigated whether polyphenol-rich dark chocolate could improve insulin sensitivity and lower blood pressure in healthy subjects. Therefore, we compared the effects of 2 different kinds of chocolate bars, one with a high or a low polyphenol content, on the glucose and insulin response to an oral glucose challenge and on blood pressure in relatively young subjects without metabolic disease and cardiovascular risk factors.

Subjects and Methods: The study was conducted in 15 healthy persons (7 men and 8 women) aged 35 to 45 years with a BMI of 22 to 28 kg/m². They were randomly assigned to receive either 100 g of polyphenol-rich dark chocolate (70% cocoa) or 100 g of polyphenol-poor dark chocolate (50% cocoa) for 7 days. Blood pressure was measured at baseline and after 7 days.

Results: According to the protocol described by Taubert et al., after 7 days of polyphenol-rich dark chocolate intake, the glucose and insulin response to the oral glucose challenge was significantly improved compared with the polyphenol-poor dark chocolate group. Blood pressure was also significantly lower after 7 days of polyphenol-rich dark chocolate intake.

"These findings suggest flavanol-rich, low-energy cocoa food products may have a positive impact on CVD risk factors."

Am J Clin Nutr. 2007;65:1-4. Printed in USA. © 2007 American Society for Clinical Nutrition

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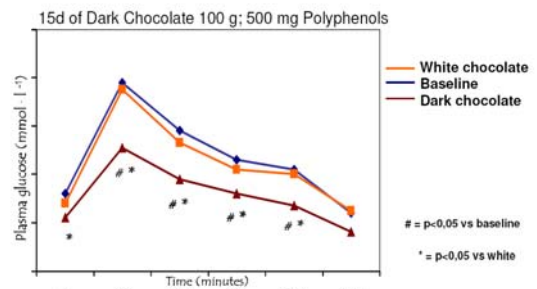
Cholesterol and blood pressure values at baseline and after 15 days of 100g dark-chocolate and white-chocolate consumption

Characteristic	Dark chocolate before (n=10)	Dark chocolate after (n=10)	White chocolate before (n=10)	White chocolate after (n=10)
Total cholesterol (mg/dL)	209	193*	209	209
LDL cholesterol (mmol/L)	131.5	116.0†	131.5	131.5
24-hour systolic blood pressure (ambulatory blood pressure monitoring) (mm Hg)	135.5	123.6‡	135.6	134.7
24-hour diastolic blood-pressure (ambulatory blood-pressure monitoring) (mm Hg)	88.0	79.6‡	87.6	87.5

*p=0.0003 dark-chocolate vs baseline and white-chocolate values
†p<0.05 dark-chocolate vs baseline and white-chocolate values
‡p<0.0001 dark-chocolate vs baseline and white-chocolate value

Grassi D et al. Hypertension 2005; available at <http://hyper.ahajournals.org>

Effects of dark chocolate on plasma glucose (during OGTT) in healthy subjects



Grassi et al. AJCN, 2005;81:611-614

Cocoa increases blood flow to brain

- Cocoa flavonols have been directly linked with improved cerebral blood flow.
- Thirteen men and women (avg age 72) consumed flavanol-rich cocoa and a 21 participants consumed a flavonoid-poor cocoa product.
- Ultrasound methods were used to analyze blood flow to the brain.
- The 13 participants who consumed flavanol-rich cocoa for 2 weeks (900 mg flavanols daily) achieved a 10% increase in cerebral blood flow.

Sorond FA, Lipsitz LA, Hollenberg NK, Fisher NDL. Cerebral blood flow response to flavanol-rich cocoa in healthy elderly humans. *Neuropsychiatric Disease and Treatment*. 2008; 4: 433-440.

Cocoa increases blood flow to brain

- Harvard researchers report that cocoa flavanols improve brain flow in older adults. It has been speculated that increasing blood flow to the brain could help reduce cognitive decline in aging individuals. The current finding could be helpful in improving cognitive function among individuals suffering from conditions in which brain flow is impaired, such as stroke and dementia.

Sorond FA, Lipsitz LA, Hollenberg NK, Fisher NDL. Cerebral blood flow response to flavanol-rich cocoa in healthy elderly humans. *Neuropsychiatric Disease and Treatment*. 2008;4: 433-440.

Cerebral blood flow response to flavanol-rich cocoa in healthy elderly humans

Farzaneh A. Sorond^{1,2}
Lewisa A. Lipsitz^{2,3}
Norman K. Hollenberg^{2,3}
Naima D. Fisher²

¹Department of Neurology, Stroke Division, Massachusetts General Hospital, Harvard Medical School, Boston, MA
²Department of Medicine, Harvard Medical School, Boston, MA
³Department of Medicine, Harvard Medical School, Boston, MA

Background and Purpose: Cerebral ischemia is a common, cerebral condition accompanied by cognitive decline. Recent reports on the vascular health benefits of flavanol-containing foods suggest a promising approach to the treatment of cerebral ischemia. Our study was designed to investigate the effects of flavanol-rich cocoa (FRC) consumption on cerebral blood flow in older healthy volunteers.

Methods: We used transcranial Doppler (TCD) ultrasonography to measure mean blood flow velocity (MBFV) in the middle cerebral artery (MCA) in thirty-four healthy elderly volunteers (72 ± 9 years) in response to the regular intake of FRC or flavanol-poor cocoa (FPC).

Results: In response to two weeks of FRC intake, MBFV increased by 8% ± 4% at one week (p = 0.01) and 10% ± 4% (p = 0.004) at two weeks. In response to one week of FPC, significantly more subjects in the FRC group had an increase in flow MBFV (p = 0.003).

The researchers tested the effects of beverage containing high amounts of cocoa flavanols on participants between the ages of 59 and 83. The investigators found an 8 percent increase in the participants' brain blood flow following one week of consuming the beverage, and a 10% increase after 2 weeks.

Neuropsychiatric Disease and Treatment, 2008; 4(2), 433-430.

Food and beverage rich in flavanols is associated with a decreased risk of cardiovascular and cerebrovascular mortality (Kiechl et al 1996; Constanter 2000; Gullu 2002; Yonker 2002). In the context of human nutrition, research may be noteworthy because

Cocoa increases blood flow to brain

Table 2 Nutritional content of the study beverages

	Flavanol-rich cocoa (FRC)	Flavanol-poor cocoa (FPC)
Cocoa flavanols, mg	451.1	8.2
Calories	118.1	117.2
Total fat, g	1.4	1.5
Cholesterol, mg	4.4	4.9
Total carbohydrate, g	17.1	16.5
Dietary fiber, g	3.0	3.9
Sugars, g	9.4	9.2
Protein, g	9.4	9.4
Caffeine, mg	18.3	11.7
Theobromine, mg	336.5	327.4
Sodium, mg	105.1	55.0
Potassium, mg	530.1	644.8
Calcium, mg	243.7	341.2
Iron, mg	1.9	2.9
Phosphorus, mg	280.2	365.4
Magnesium, mg	85.9	78.4
Zinc, mg	1.4	1.6
Copper, mg	0.4	0.4
Manganese, mg	0.6	0.6



Eating chocolate can significantly protect the skin from UV light

- Flavonol-Rich Chocolate may offer photoprotection. Eating chocolate rich in flavanols may help protect the skin against ultraviolet (UV) light damage, researchers report.
- In the study, 30 adults were randomly assigned to eat 20 grams of high-flavanol chocolate or regular chocolate daily for 12 weeks. The authors tested the skin's minimal erythema dose (MED), which is the amount of ultraviolet light that causes the skin to turn red.
- The researchers concluded that chocolate rich in flavanols significantly increased the skin's MED. In contrast, the conventional chocolate did not offer protection against UV rays.

Williams S, Tamburic S, Lally C. Eating chocolate can significantly protect the skin from UV light. *J Cosmet Dermatol*. 2009; Sept;8(3): 169-73.



- TORONTO -- Just in time for Valentine's Day, researchers have reported that chocolate may keep sweethearts safe from stroke.

Like wine, chocolate has frequently been spotlighted as an indulgence that may have health benefits, including improved vascular function and decreased blood pressure (See [ACC: Dark Chocolate Improves Vascular Function](#) and [Dark Chocolate a Comfort to Early Blood Pressure](#)).



- For their review, the researchers found 88 studies between 2001 and 2009 that assessed flavonoids and stroke risk, but narrowed it down to three that looked specifically at chocolate and stroke.
- One found that eating chocolate on a weekly basis decreased stroke risk by 22% compared with not eating any (RR 0.78, 95% CI 0.65 to 0.94).
- Another found that flavonoid intake from chocolate -- also on a weekly basis -- cut risk of death from stroke almost in half (HR 0.54, 95% CI 0.30 to 0.96).
- The third found no association between flavonoid intake and risk of stroke or death when 3% of catechin intake came from chocolate (OR 0.92, 95% CI 0.51 to 1.68).
- The researchers said that more prospective studies are needed to He said there are a lot of other healthy behaviors patients can adopt -- quit smoking, monitor blood pressure, eat fruits and vegetables -- that are supported by "convincing data on their effects on cardiovascular disease."

Chocolate May Reduce Stress

- Dark chocolate may help lower stress hormones, according to a new study published in the *Journal of Proteome Research*.
- In the study, 30 healthy adults ate 1.4 ounces of dark chocolate (daily for two weeks. The participants completed psychological questionnaires to determine their anxiety levels. Urine and blood samples were taken at the beginning, middle and end of the study.
- Eating dark chocolate significantly lowered the stress hormones cortisol and catecholamines in people who had high anxiety levels.

Journal of
proteome
research

Metabolic Effects of Dark Chocolate Consumption on Energy, Gut
Microbiota, and Stress-Related Metabolism in Free-Living Subjects

•40 g of dark chocolate were given for 14 days to 30 human subjects who were classified in low and high anxiety traits.

•Dark chocolate reduced the urinary excretion of the stress hormone cortisol and catecholamines and partially normalized stress-related differences in energy metabolism (glycine, citrate, *trans*-aconitate, *proline*, -alanine) and gut microbial activities (hippurate and *p-cresol sulfate*).

Keywords: chronic stress • Dark chocolate • Metabolism • Chromatography • Mass spectrometry •

•The study provides strong evidence that a daily consumption of 40 g of dark chocolate during a period of 2 weeks is sufficient to modify the metabolism of free living and healthy human subjects, as per variation of both host and gut microbial metabolism. *Journal of Proteome Research*, 2009, 8, 5568-5579

Red wine, chocolate kill cancer



- Feb 11, 2010: Even though we knew that red wine and dark chocolate have health benefits, a new study finds that the two are actually potent medicine for killing cancer.
- In addition to blueberries, garlic and some teas, red wine and dark chocolate also have cancer-fighting qualities.
- "What we eat is really our chemotherapy three times a day," he said. The foods appear to cut off the blood supply to tumors and quite literally starve them to death. The Foundation went as far as to say that certain foods — like soy, parsley and red grapes — are as effective if not more than FDA approved drugs in battling cancer cells.
- So, this Valentine's Day, indulge in a nice glass of Cabernet and some chocolates without the guilt!



How Much Chocolate?

- Dark chocolate is recommended because it has more of the heart healthy flavonols and flavonoids than milk chocolate.
- To receive the health benefits of chocolate, some studies have found you would need to eat about 1-3 ounces of dark chocolate per day.

Plasma antioxidants from chocolate

Dark chocolate may offer its consumers health benefits the milk variety cannot match.



Plasma antioxidants from chocolate

Dark chocolate may offer its consumers health benefits the milk variety cannot match.

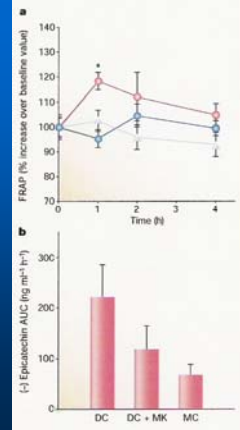
Nature 2003
Aug
28; 424(6952):
1013.
Serafini M, Bugianesi
R, Maiani G, Valtuena
S, De Santis S,
Crozier A.



Figure 1 Stack of benefits? Unlike its milky counterpart, dark chocolate may provide more than just a treat for the taste buds.

Effects of ingesting 100g dark chocolate (DC), 100 g dark chocolate with 200 ml milk (DC+ MK), or 200 g milk chocolate (MC) on total antioxidant capacity and epicatechin content of human plasma.

(red=DC; blue DC+MK; grey=MC. FRAP= ferric-reducing antioxidant potential was used to measure antioxidant capacity. Asterisk = $P < 0.001$)



Ongoing Studies

- How much chocolate should be eaten
- How to keep high levels of flavonoids without affecting the taste
- Chocolate and aging

Aim for 70%

- Make sure cocoa solids, chocolate liquor is listed as the first ingredient.
- One that lists sugars first means that cocoa makes up less than 50% of the bar.

Chocolate for our soldiers

- It's a regular feature in army food rations
- During the Gulf War, critical equipment flown out to US forces included a specially formulated heat-stable chocolate bar.



What Adds Calories?

- In the chocolate making- sugar, milk, added fat
- In chocolate bars
 - Caramel
 - Peanut butter
 - Nuts
 - Marshmallow
 - Added fat and sugar
 - Eggs
 - Milk



A Healthy Diet ~Balance, variety and moderation~

- Chocolate can be part of a healthy diet! The first listed ingredient should be cocoa or chocolate liquor, not sugar.
- Limit yourself to a few ounces a day.
- Moderation is the key!

Watch The Label!



- Look for total calories and sugar (if you're diabetic)
- Look at the serving size
- Example: Dove Dark Chocolate Bar (3.5 oz bar)

Nutrition Facts	
Serving Size 1 ounce (28g)	
Amount Per Serving	
Calories 146	Calories from Fat 82
% Daily Value*	
Total Fat 9g	14%
Saturated Fat 5g	27%
Trans Fat 0g	
Cholesterol 2mg	1%
Sodium 1mg	0%
Total Carbohydrate 17g	6%
Dietary Fiber 2g	9%
Sugars 13g	
Protein 1g	
Vitamin A 1%	Vitamin C 0%
Calcium 1%	Iron 5%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

nutritiondata.com

Reading the Label

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nutritiondata.com

← Serving Size

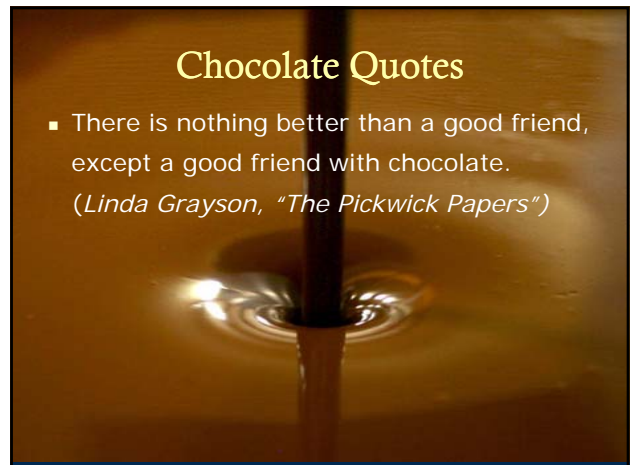
← Calories

← Total Fat

← Carbohydrate (sugar)

Chocolate Quotes

- There is nothing better than a good friend, except a good friend with chocolate.
(Linda Grayson, "The Pickwick Papers")



Chocolate Quotes

- This guy found a bottle on the ocean, and he opened it and out popped a genie, and he gave him three wishes. The guy wished a million dollars and poof! there was a million dollars. Then he wished for a convertible, and poof! there was a convertible. And then, he wished he could be irresistible to all women ... poof! He turned into a box of chocolates. (*unknown*)

Chocolate Quotes

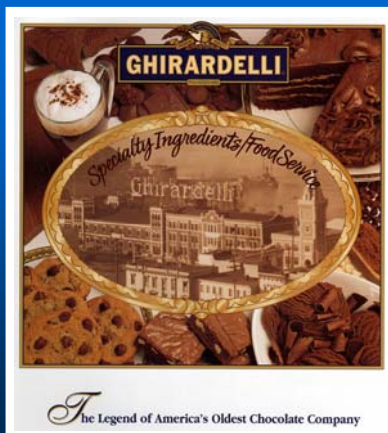
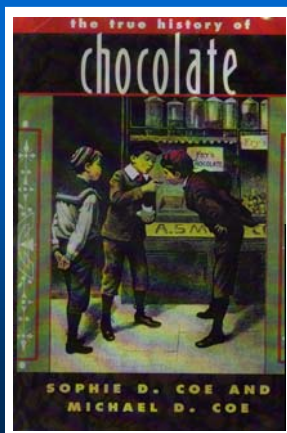
- Chemically speaking, chocolate really is the world's perfect food. (*Michael Levine, nutrition researcher*)
- I have this theory that chocolate slows down the aging process. It may not be true, but do I dare take the chance? (*unknown*)

Chocolate Quotes

- Man cannot live on chocolate alone; but woman sure can. (*unknown*)



It is not that chocolates are a substitute for love. Love is a substitute for chocolate. Chocolate is, let's face it, far more reliable than a man. (*Miranda Ingram*)



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