# Fact or Fiction

**Jack W. Dini**
1537 Desoto Way
Livermore, CA 94550
E-mail: jdini@earthlink.net

# Chocolate— LOTS of Chemicals

**Americans consume chocolate at the rate of 3.3 billion pounds a year.[1]**

*A young man was walking along a beach by an ocean, when he found a bottle with a cork holding its contents in place. He picked it up, pulled out the cork, and out popped a genie.*

*"Thank you for setting me free," said the genie, "and for that, you get three wishes." "Well," said the man, "give me a million dollars." POOF! A million dollars lay at his feet.*

*"What is your second wish, master?" "Well, how about an expensive car?" POOF! A new model Mercedes-Benz showed up. "What is your final wish?" asked the genie. The man said, "Make me irresistible to women."*

*POOF! He was turned into a chocolate candy bar.*

This story was probably created by some manufacturer of chocolate. However, it may not be all that far from the truth. It has been documented that women are much more likely than men to prefer chocolate. Waterhouse[2] provides a survey in her book that clearly supports this view.

So, what does all of this have to do with environmental and science issues? The answer is that chocolate is a very complex and fascinating material. One of its key ingredients is cocoa, which contains approximately 800 chemicals, so chocolate isn't chemical-free.[3] Because it has received a lot of press in technical journals in recent times, it's worth some discussion here. First, some words on the materials science of chocolate, followed by health benefits and questions.

## The Materials Science Of Chocolate

For food scientists, the analogy with chemical engineering, metallurgy, and materials science is especially strong with chocolate. Much like a metal alloy, a chocolate treat must undergo careful shepherding through complicated processing to achieve a desirable structure. Cocoa butter, the yellow-white fat made from cacao beans, comes in several different crystal forms. Only one of these structures produces tempting, glossy, melt-in-your-mouth chocolate. Creating that structure requires a procedure called *tempering* (not unlike tempering of steel), which involves a series of steps with controlled heating, cooling, and mixing.[4,5] Another key factor in the processing of chocolate is the requirement that it be shaped to suit its end use: novelty shapes for decoration, filled centers for boxed assortments, etc. Processing complex shapes is not that different from molding alloys or plastics. The same issues concerning flow-around corners, weld lines, stagnation points, differential cooling rates, and coarsening of crystal structures all apply.[6]

## Health Benefits

Food is required to give us energy, and chocolate is able to do this relatively fast.[7] It contains the three essential components of food—protein, carbohydrates and fats—together with some essential minerals, including potassium, choline, phosphorus, calcium, sodium, magnesium, iron, copper, and zinc, as well as vitamins A, B1, B2, B3 and E. A four-oz (~100g) bar of chocolate provides about 520 calories.[8] Typical nutritional values for the different types of chocolate are given in the accompanying table.

Findings reported at recent American Association for the Advancement of Science and American Chemical Society meetings, and elsewhere, suggest a variety of health benefits from chocolate. Ryan,[9] in her review of the technical meetings, says the following: "Reading all the recent scientific reports extolling the benefits of chocolate, you might feel as though you were being transported back in time to Woody Allen's 1973 movie *Sleeper*. The main character, Miles Monroe, is the owner of The Happy Carrot Health Food Store in Greenwich Village before he is frozen for 200 years. He wakes up after his long sleep to find that the new health foods are hot fudge, steak, and cream pies."

Many researchers claim improved protection against cardiovascular disease because of antioxidants present in chocolate.[1-3,7-16] Other claims include help in lactose intolerance[15] and protection against cancer.[11,12] Contrary to what your mother told you, chocolate contributes little to tooth decay, because chocolate bars, although sugary, are not sticky and clear out of the mouth quickly. Also, cocoa contains substances that may inhibit the bacterial growth that promotes plaque formation and, therefore, cavities.[11,14] You've also probably heard that chocolate causes acne. Well, it appears that chocolate neither causes nor aggravates acne.[11,16]

Some researchers say that chocolate is addictive[9, 11,17] while others say it isn't.[17,18] I side with E. di Tomaso and his coworkers, who believe that chocolate contains pharmacologically active substances that have the same effect on the brain as marijuana, and that these chemicals may be responsible for certain drug-induced psychoses associated with chocolate craving.[18]

Here are some other reported benefits: A Harvard alumni study suggests that men who ate candy lived a whopping one year longer than non-candy eaters,[1] while a Yale study showed that students exposed to the smell of chocolate while studying for an exam can recall the material better if they are also exposed to chocolate smell while writing the exam.[14] This latter finding may not be as far-fetched as it sounds. Scientists at the Smell and Taste Treatment and Research Foundation in Chicago have found that a floral scent helps volunteers perform puzzle-solving tasks 17-percent more quickly, and that aroma engineering in a Las Vegas casino can increase customer optimism and, therefore, willingness to gamble by as much as 53 percent.[19]

## The Rest of the Story

It's a good thing that chocolate wasn't just invented, because with all its chemicals,[3] it is

## Average Content For 100g of Chocolate*

| | Plain | Milk | White |
|---|---|---|---|
| Energy (kcal) | 530 | 518 | 553 |
| Protein (g) | 2 | 6 | 8 |
| Carbohydrate (g) | 63 | 56 | 56.5 |
| Fat (g) | 30 | 30 | 33 |
| Calcium (mg) | 63 | 246 | 306 |
| Magnesium (mg) | 131 | 59 | 31 |
| Iron (mg) | 3 | 2 | 0.2 |

* From Beckett, ref. 7.

doubtful it would ever reach the marketplace as a food these days. Many of these chemicals, such as phenylethylamine (PEA), oxalic acid, caffeine, and theobromine, have no nutritive value, but do affect us.[8,13] Other chemicals that result from processing the cream-colored beans that provide chocolate include esters, lactones, pyrazines, triglycerides, oleic acid, stearic acid and palmitic acid, furfuryl alcohol, anandamide, dimethyl sulfide, and stearic acid, to mention a few.

PEA is one chemical in chocolate that comes close to having a feel-good effect on our brain. Emsley[8] says that PEA has the shape and size of the molecule of the illegal drug "ecstasy," perhaps accounting for chocolate's fan club akin to what was mentioned earlier about addictiveness of chocolate.[18] PEA has the curious property of absorbing carbon dioxide from the air. When people are injected with PEA, the level of glucose in their blood goes up, and so does their blood pressure. These effects combine to produce a feeling of well-being and alertness. PEA may trigger the release of dopamine, which is the brain chemical that makes us feel happy, in which case, PEA would be acting in the same way as amphetamines such as ecstasy. However, for some people, a sudden influx of PEA can cause violent headaches if they eat too much chocolate, because PEA constricts the walls of blood vessels in the brain. Strong[20] reports a number of examples where chocolate has triggered headaches in typical tension-type combined headache sufferers.

Cocoa powder is about two-percent theobromine; therefore, humans may consume hundreds of milligrams of theobromine a day from chocolate.[21] Theobromine, a relative of caffeine, has been shown to be genotoxic in a variety of tests, to promote (as does caffeine) DNA damage by various carcinogens in human cells, and to cause testicular atrophy and spermatogenic cell abnormalities in rats.[21] However, chocolate isn't the only food shown to have antispermatogenic activity. Some others include garlic, celery, coffee, grapefruit, tea and cola. All of this leads to the topic of endocrine disrupters, a term used to describe chemicals that have adverse effects on the endocrine system. The endocrine system is one of the three major regulatory systems in the body (the others are the nervous system and the immune system). The endocrine system plays a critical role in maintaining homeostasis of the organism, as well as a role in reproduction, development, and behavior.[22]

Of particular interest is that a lot of man-made chemicals are claimed to be endocrine disrupters. Theo Colborn's 1996 book, *Our Stolen Future*,[23] has had a strong impact on public and political interest in environmental risks associated with endocrine disrupters. Although Colborn beats the heck out of man-made chemicals, she skips mention of naturally occurring foods, except for sunflower seeds and oil. By contrast, Edwards[24] discloses that more than 300 plants in 16 common families contain estrogens that may bind with the receptors of humans or wildlife. Naturally occurring estrogens abound in many cereals, legumes, fruits and tubers. He concludes: "The authors of *Our Stolen Future* could probably have developed more frightening endocrine disruption scenarios based on healthy human diets containing cereals, fruits and vegetables!"

In effect, endocrine disrupters are all around us, and we eat some of them every day in natural foods. Synthetic chemicals are a good whipping-boy to use when you want to excite the public and media, but it's best not to pick on everyday foods mankind has been eating for long periods of time. And remember that chocolate is one of those naturally occurring foods that could produce endocrine disrupters.

## Some Final Tidbits

Not everyone knows it, but chocolate can kill a dog. Yin[25] reports, "A couch-sized mastiff can eat a batch of brownies and have no problem. However, mix just one chocolate bar with one Chihuahua and within hours you'll get an explosion of bouncing off every wall in the house—or worse, the little unfortunate will succumb to seizures or a coma." Lin also mentions that even a mastiff's a goner with a good dose of baking chocolate. On Valentine's Day 2001 in British Columbia, a flock of gulls that had feasted on some uneaten chocolate dumped at a landfill fell dead from the skies.[26] The cause of death was "chocolate toxicity." So, for many animals, the active ingredients in chocolate—caffeine and theobromine—can be lethal.

Last, the "world's oldest person in September 1997," Sarah Knauss[118] of Allentown, PA, reportedly feasted on chocolates, pretzels, and potato chips, and shunned vegetables. Her advice for longevity was not to worry about your age.[27] She died December 30, 1999, at the age of 120, and scientists are studying her organs for clues to the factors that gave her a long life.[28]

## Summary

My take on all this: I will not feed chocolate to animals, but will personally eat as much as I can—in spite of the fact it contains all those chemicals. *P&SF*

## References


1. L. Tarkan, "Chocolate a Health Food? Maybe, But Keep the Aspirin," *The New York Times* on the Web (Oct. 31, 2000).
2. D. Waterhouse, *Why Women Need Chocolate*, Hyperion (1995).
3. M. Freemantle, *Chemical & Engineering News*, **78**, 82 (Dec. 4, 2000).
4. J. Gorman, "From Metal Bars to Candy Bars," *Science News*, **159**, 108 (Feb. 17, 2001).
5. P. Fryer & K. Pinschower, "The Materials Science of Chocolate," *MRS Bulletin*, **25**, 25 (Dec. 2000).
6. A.M. Donald, "The Materials Science of Food," *MRS Bulletin*, **25**, 6 (Dec. 2000).
7. S.T. Beckett, *The Science of Chocolate*, Royal Society of Chemistry (2000).
8. J. Emsley, *Molecules at an Exhibition*, Oxford University Press (1998).
9. M.A. Ryan, *Today's Chemist at Work*, **8**, 57 (July 1999).
10. *Wellness Letter*, University of California, Berkeley, **16**, 1 (Nov. 1999).
11. *Wellness Letter*, University of California, Berkeley, **17**, 8 (Feb. 2001).
12. V. Elliott, *San Francisco Chronicle*, EB5 (June 30, 2000).
13. J. Schwarcz, *Radar, Hula Hoops & Playful Pigs*, ECW Press (1999).
14. H. Pearson, *New Scientist*, **167**, 16 (Aug. 16, 2000).
15. M.A. Ryan, *Today's Chemist at Work*, **8**, 11 (Dec. 1999).
16. R. Baxter, *ChemMatters*, **17**, 4 (Dec. 1999).
17. "Chocolate—Melting the Myths," *Chemistry in Britain*, **33**, 32 (April 1997).
18. E. di Tomaso, M. Beltramo & D. Piomelli, *Nature*, **382**, 677 (Aug. 22, 1996).
19. L. Watson, *Jacobson's Organ*, Plume (2001).
20. F.C. Strong, III, *Today's Chemist at Work*, **8**, 9 (Nov. 1999).
21. B.N. Ames, *Science*, **221**, 1256 (1983).
22. J.S. Heath, "Ubiquitous Environmental Contaminants," in *Standard Handbook*

*of Environmental Science, Health & Technology*, J.H. Lehr & J.K. Lehr, Editors, McGraw-Hill (2000).
23. T. Colborn, D. Dumanoski & J.P. Myers, *Our Stolen Future*, Plume (1996).
24. J.G. Edwards, *21st Century*, **52** (Fall 1996).
25. S. Yin, "Keep Dogs Away From Killer Chocolate," *San Francisco Chronicle*, Home Garden (April 19, 2000).
26. "Death by Chocolate," *National Post Online*, www.nationalpost.com (June 22, 2001).
27. C.G. Wagner, "The Centenarians," The Futurist, 16 (May 1999).
28. W.E. Solomon, "Families to reflect multi-generations as lives lengthen," *The Morning Call*, Allentown, PA, p. A11, (March 4, 2001), courtesy Harry Litsch.