



# The Cherry Nutrition Report

A Close-Up Look at Today's New Antioxidant Super Fruit



The Cherry Nutrition Report is a summary of the scientific literature on the health benefits of tart cherries and their compounds. The report was commissioned by the Cherry Marketing Institute (CMI), an organization funded by North American tart cherry processors and growers. The intent of the report is to provide an overview of the scientific evidence, not to provide individual recommendations. The information is not intended to substitute for the advice of a physician or another healthcare professional.

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RESEARCHERS CONTINUE TO EXPLORE THE BENEFITS OF "SUPERFRUITS," A UNIQUE GROUP OF NUTRIENT-RICH FRUITS THAT CONTAIN NATURAL COMPOUNDS SHOWN TO HAVE POTENTIAL DISEASE-FIGHTING PROPERTIES.



FEW FRUITS FALL INTO THIS CATEGORY AND EMERGING SCIENCE SHOWS TART CHERRIES (TECHNICALLY KNOWN AS *Prunus cerasus*) ARE AMONG THEM. TART CHERRIES, COMMONLY FOUND IN DRIED, FROZEN AND JUICE FORMS, ARE RICH IN ANTIOXIDANTS AND CONTAIN POTENT PHYTONUTRIENTS INCLUDING ANTHOCYANINS – PLANT PIGMENTS THAT HAVE BEEN LINKED TO A VARIETY OF HEALTH BENEFITS – AND MELATONIN, WHICH MAY HELP AID WITH SLEEP.

THE CHERRY NUTRITION REPORT PROVIDES A SCIENTIFIC OVERVIEW OF THE GROWING BODY OF EVIDENCE ON THE HEALTH BENEFITS OF TART CHERRIES AND THEIR COMPOUNDS. RESEARCH SUGGESTS TART CHERRIES MAY REDUCE INFLAMMATION AND EASE THE PAIN OF ARTHRITIS AND GOUT. EMERGING STUDIES SUGGEST CHERRIES MAY OFFER PROTECTION AGAINST HEART DISEASE AND CERTAIN CANCERS, REDUCE THE RISK OF DIABETES AND INSULIN RESISTANCE SYNDROME AND AID IN THE TREATMENT AND POSSIBLE PREVENTION OF MEMORY LOSS.



## TART CHERRIES AT A GLANCE

- ▶ Antioxidants (ORAC score per 100 grams)
  - cherry juice concentrate: 12,800 ORAC units
  - dried cherries: 6,800 ORAC units
  - frozen cherries: 2,033 ORAC units
  - canned cherries: 1,700 ORAC units
- ▶ Pigments: anthocyanins
- ▶ Nutrients: Tart cherries are excellent sources of beta carotene (vitamin A). In fact, they contain 19 times the beta carotene of blueberries and strawberries. Cherries also are rich in vitamins C and E, and provide potassium, magnesium, iron, folate and fiber.
- ▶ Tart cherries are one of the few known food sources of melatonin – a potent antioxidant that helps regulate our circadian rhythms and natural sleep patterns.
- ▶ Other phytonutrients: quercetin, kaempferol, chlorogenic acid, p-coumaric acid, gallic acid, perillyl alcohol, D-glucaric acid
- ▶ Emerging research suggests that cherries or the natural compounds found in cherries may help...
  - Reduce inflammation and ease the pain of arthritis and gout
  - Offer protection against cardiovascular disease and certain cancers
  - Reduce the risk of diabetes and insulin resistance syndrome
  - Aid in the treatment and possible prevention of memory loss



## THE POWER OF RED

Tart cherries contain powerful antioxidants called anthocyanins – which provide the distinctive red color and may hold the key to the benefits locked inside (Chandra 1992, Wang 1997, 1999). Studies suggest that these disease-fighting pigments possess antioxidant, anti-inflammatory, anti-aging and anti-carcinogenic properties (Blando 2004). Tart cherries are one of the richest sources of anthocyanins.

The unique health benefits of cherries first came to light in the 1990s, when numerous studies were published describing the antioxidant content of this fruit. Spurred by what was then anecdotal evidence that cherries alleviated the pain of arthritis and gout, researchers discovered that cherries had high antioxidant activity.

Additional studies identified the active antioxidants as eight polyphenolic compounds, including anthocyanins, chlorogenic acid, gallic acid, p-coumaric acid, and quercetin (Wang 1999).

Research conducted at Brunswick Laboratories in Wareham, Massachusetts, found that tart cherries contain a class of compounds that act like superoxide dismutase (SOD), a powerful enzyme and cellular antioxidant.

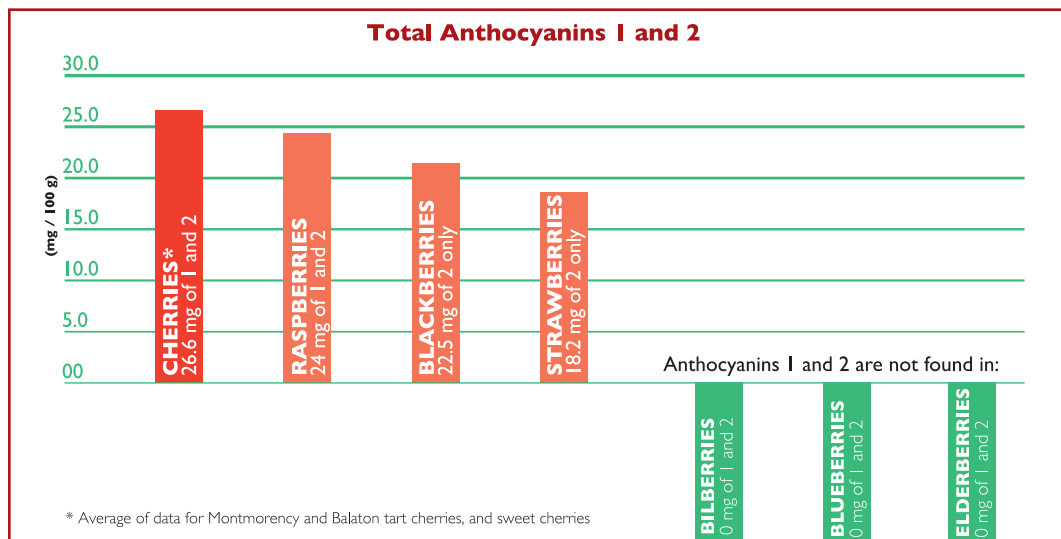
### ANTHOCYANINS

Anthocyanins that give tart cherries their deep, rich color belong to a large group of phenolic compounds called flavonoids. Of the 150 different flavonoids found in plants, anthocyanins appear to have the greatest antioxidant capacity (Elliott 1992).

Research conducted at Michigan State University found that tart cherries contained the highest concentrations of anthocyanins 1 and 2 – which help block enzymes in the body called cyclooxygenase 1 and 2 (popularly known as COX-1 and COX-2) (Seeram and Momin et al. 2001). Some pain medication works by inhibiting COX-1 and COX-2, which may explain why some people find that tart cherries help ease the pain of arthritis and gout.

The researchers found that cherries were the richest source of these beneficial compounds compared to various berries, including raspberries, blackberries and strawberries. Anthocyanins 1 and 2 were not found in blueberries. Tart cherries contain 30 to 40 milligrams of anthocyanins 1 and 2 in every 100 grams of fruit.

Tart cherries contain significantly more anthocyanins and phenols than do sweet cherries. For example, one study found that the total phenolic content of sweet cherries ranged from 92 to 147 milligrams/100 grams, while the same amount of tart cherries contained up to 312 milligrams, or more than twice the phenols (Kim 2005, Chandra 1992).



Source: Seeram and Momin et al. 2001.

Anthocyanins are more effective than vitamin C, four times more potent as an antioxidant than the well-known vitamin E (Rice-Evans 1995), and have been compared to ibuprofen, aspirin, and naproxen for their anti-inflammatory action (Seeram 2001). Numerous studies, including one from the Johns Hopkins Hospital in Baltimore concluded that anthocyanins in tart cherries significantly lowered inflammation and pain in animals. The proposed mechanisms are due to anthocyanins' anti-inflammatory and antioxidant properties, which lower oxidative stress following inflammatory insult (Tall 2004).

As for the potency of COX inhibition, researchers indicate that one serving of tart cherries (canned) is the equivalent of 1.41 grams of aspirin. A serving of tart cherry juice contains the equivalent of 0.30 grams of aspirin; and frozen cherries equal 0.90 grams. A standard aspirin tablet is 0.325 grams.

### ANTIOXIDANTS

Oxygen is an important component of the air we breathe. We couldn't survive without it. But oxygen can also be a source of free radicals – unstable oxygen molecules associated with cancer, heart disease and the effects of aging.

Luckily, antioxidants can counter, scavenge, and deactivate these damaging free radicals. Thousands of studies spanning decades of research consistently and repeatedly show that maintaining a high antioxidant defense system lowers a person's risk for disease, stimulates the immune system, protects brain neurons from damage, and possibly even slows the aging process.

Oxidative stress associated with disease occurs when oxidative damage exceeds our antioxidant defenses. That antioxidant system depends on the food we eat.

A lab testing procedure called Oxygen Radical Absorbance Capacity or ORAC measures the total antioxidant capacity of foods. ORAC measures how many oxygen radicals a specific food can absorb and deactivate (Ou 2001). The more oxygen radicals a food absorbs, the higher its ORAC score. The higher the ORAC score, the better a food may be in helping our bodies fight diseases like cancer and heart disease.

Nutrition experts estimate a person needs to consume 3,000 to 5,000 ORAC units a day to reach a significant antioxidant capacity in the blood associated with health benefits. Just slightly more than 3 ounces (100 grams) of tart cherry juice concentrate supplies 12,800 ORAC units. Just one ounce supplies 3,622 ORAC units, or more than an entire day's recommendation. A quarter cup of dried cherries rates 3,060 on the ORAC scale and a half cup of frozen tart cherries supplies, on average, 1,362 ORAC (Wu 2004).

#### Antioxidant Capacity of Tart Cherries

FORM	ORAC units per 100 grams
Frozen cherries	2,033
Dried cherries	6,800
Cherry juice concentrate	12,800

A recent study published in the *American Journal of Clinical Nutrition* found that tart cherries ranked 14 in the top 50 foods for highest antioxidant content per serving size – surpassing well-known leaders such as red wine, prunes, dark chocolate and orange juice (Halvorsen 2006).

### OTHER PHENOLIC COMPOUNDS

Tart cherries are rich sources of other phenolic compounds, such as gallic acid, p-coumaric acid, kaempferol, and quercetin, all of which are potent antioxidants. According to researchers at the University of California, ellagic acid is a potent antioxidant, anti-cancer, and anti-atherosclerotic compound (Seeram 2004). One study found that ellagic acid in fruit extracts reduced cancer cell proliferation in a dose-dependent fashion; that is, as ellagic acid increased, cancer cell growth decreased (Ross 2007).

P-coumaric acid is another phenolic compound that exhibits strong antioxidant activity (Kim 2005). An *in vitro* study of human leukemia cells, found that p-coumaric acid, along with gallic acid and other phenols, enhanced cancer cell death (Dedoussis 2005).

## MELATONIN

Tart cherries are one of the few known food sources of melatonin, a potent antioxidant that helps improve the body's circadian rhythms and natural sleep patterns (Burkhardt 2001). A study conducted by Reiter and colleagues at the University of Texas Health Science Center found that tart cherries contain substantial amounts of melatonin, at levels higher than normally found in human blood. Montmorency cherries, which account for the majority of tart cherries produced in the U.S., contain 13.5 nanograms (ng) of melatonin per gram (Burkhardt 2001).

Produced naturally by the body's pineal gland at the apex of the brain, melatonin has been shown to do much more than regulate our sleep-wake cycle. Studies suggest that melatonin may help protect the vascular system, lessen inflammation, and reduce ischemia and reperfusion injury associated with surgery (Tan 2000, 2003, Cuzzocrea 2001, Lissoni 1997, Reiter 2001, 2000).

A study conducted by Reiter and researchers from St. Marianna University of School of Medicine in Japan found that feeding chicks a diet containing plants rich in melatonin raised blood levels of melatonin, indicating that melatonin ingested from the diet is absorbed and enters the general circulation, after which it is capable of binding to sites in the brain and other tissues (Hattori 1995).

Reiter and colleagues speculate that eating just a handful of tart cherries will increase melatonin levels in blood, thereby improving the body's natural sleep patterns and potentially providing other health benefits.



## POTENTIAL HEALTH BENEFITS OF TART CHERRIES

Tart cherries and their compounds have been associated with a lowered risk for a number of diseases and disorders.

### ARTHRITIS AND GOUT

For decades, tart cherries have quietly grown a devoted fan base of arthritis sufferers who routinely consumed the fruit (particularly as juice) to help soothe their symptoms. At the time, the only evidence was anecdotal. Today, however, there appears to be science behind the cherry folklore.

The suspicion that cherries might help with arthritis and gout was first proposed in 1950 (Blau 1950). This preliminary study found that daily cherry consumption helped to relieve "gout attacks" and the pain associated with arthritis. After eating the cherries, the patients in the study had lower blood levels of uric acid. Elevated levels of uric acid are associated with the onset and progression of gout.

Since then, several studies have confirmed this link, including a study from USDA's Human Nutrition Research Center at the University of California, Davis where researchers found that healthy women (ages 20 to 40 years) who consumed two servings or 280 grams of cherries after an overnight fast showed a 15 percent reduction in uric acid levels, as well as lowered nitric oxide and C-reactive protein levels (Jacob 2003).

The researchers conclude that "...compounds in cherries may inhibit inflammatory pathways" associated with gout. Additional studies suggest that consumption of cherries may be beneficial for the management and prevention of inflammatory diseases (Kelley 2006, van Acker 1995), including inflammatory pain (Tall 2004).

Nitric oxide also has been implicated in both osteoarthritis and rheumatoid arthritis, while studies show that antioxidants scavenge this oxidant and potentially aid in the treatment or prevention of symptoms (Bezerra 2004, Remans 2005).

### HEART HEALTH

Strong evidence indicates that diets rich in colorful fruits and vegetables may help lower heart-disease risk. Beyond the anti-inflammatory benefits, many of the phenolic compounds in cherries may offer protection against heart disease and stroke.

The Zutphen Elderly Study is a longitudinal study on lifestyle and chronic diseases started in 1985 at the National Institute of Public Health and Environmental Protection in The Netherlands. It has produced a wealth of valuable information about diet and health. One published report from this study of 805 men (ages 65 to 84 years) who were followed for five years found that as flavonoid intake increased, the risk for coronary artery disease decreased. The relative risk for dying from heart disease was 58 percent lower in those men who consumed the most flavonoids compared to those men who consumed the least (Hertog 1993).

Oxidative damage is a major contributor to nitric oxide-mediated functions of the vascular system and in the initiation and progression of cardiovascular disease. In a study on pigs, researchers at Indiana University School of Medicine in Fort Wayne found that anthocyanins, when consumed in large amounts, enhanced vaso-relaxation. Even small amounts protected arteries from oxidative damage (Bell 2006).

Another study published in the *Journal of Nutrition* supports this effect and found that anthocyanins had a vasorelaxant effect on rat arteries that might help reduce cardiovascular mortality (Andriambeloson 1998). Numerous other studies show that other phenolic compounds found in tart cherries, such as quercetin, protect low density lipoproteins (LDL – the “bad” cholesterol) from oxidative damage, thus reducing their atherogenicity (Safari 2003).

Anthocyanins in tart cherries also might lower blood lipids, thus reducing heart disease risk. In a study from the University of Michigan, varying amounts of whole tart cherry powder were fed to rats for 90 days. Results showed that the cherry-enriched diets significantly lowered plasma triglyceride and total cholesterol, fasting glucose and insulin, and a plasma marker of oxidative damage, while slightly raising high-density lipoproteins (HDL - the “good” cholesterol) and significantly elevating blood antioxidant capacity. The cherry-enriched diets also reduced “fatty liver” or the accumulation of triglyceride and cholesterol in the liver. (Seymour 2007).

### **C-Reactive Protein**

Tart cherries also may lower inflammatory processes associated with heart disease. C-reactive protein (CRP) is a substance found in blood that is a marker for inflammation in the body. High levels of this protein are associated with an increased risk of heart disease and low levels with a low risk. The link between elevated CRP levels and heart disease has been demonstrated repeatedly, and there is evidence that CRP may be a more important indicator of heart disease risk than high LDL (“bad”) cholesterol. In an eight-year study involving 27,939 women at Brigham and Women's Hospital in Boston, more than half of the women who eventually developed heart disease had high CRP levels even though their LDL levels were not considered high (Ridker 2000, 2002).

A study from the U.S. Department of Agriculture's Human Nutrition Research Center at the University of California, Davis found that men and women who supplemented their diets with 280 grams of cherries for 28 days had a 25 percent reduction in CRP levels, suggesting reduced inflammation associated with atherosclerosis risk (Kelley 2006).

### **CANCER PREVENTION**

Researchers believe tart cherries may have the potential to reduce the risk of colon cancer because of anthocyanins and cyanidin, another type of flavonoid found in cherries.

Researchers at Michigan State University tested the potential anti-cancer effects of tart cherries in mice and human colon cancer cell lines (Kang 2003). In the study on mice, a diet containing cherries, anthocyanins, or cyanidin produced significantly fewer tumors compared to mice fed control diets. In the second study on human colon cancer cells, anthocyanins and cyanidin reduced cell growth. The researchers concluded that “...tart cherry anthocyanins and cyanidin may reduce the risk of colon cancer.”

A review of the research published in the *Journal of Biomedicine and Biotechnology* concluded that anthocyanins in tart cherries may help inhibit tumor development and growth of human colon cancer cells (Blando 2004).

### *Perillyl Alcohol*

Cherries are rich in a phytonutrient called perillyl alcohol (POH), which is a member of the monoterpene family, along with limonenes. Numerous studies indicate that POH may help prevent the formation and progression of certain cancers. How POH inhibits the growth of cancer is under investigation. Evidence suggests it helps rid the body of carcinogenic chemicals or interferes with signals that cause cells to divide rapidly. POH also might help revert tumor cells back to normal or differentiated cells so they are less likely to become cancerous (Belanger 1998). One study found that POH might help reduce the blood supply to cancer cells, thus starving them of oxygen and nutrition and aiding in their demise (Loutrari 2004).

At the University of Wisconsin-Madison, researchers found that leukemia cells self-destructed (a condition called apoptosis) when exposed to POH *in vitro* (Clark 2006).

POH has been shown to induce the regression of 81 percent of small breast cancers and up to 75 percent of advanced breast cancers in animal studies (Haag 1994). POH was up to five times more potent than the other known cancer-reducing compounds at inducing tumor regression.

Several studies also show that POH might aid in reducing a type of brain cancer called glioblastoma multiforme. This type of cancer forms from glial or support tissue in the brain. It progresses rapidly, is difficult to treat, and prognosis is poor. A study from the University of Wisconsin found that POH helped sensitize glioma cells to radiation and chemotherapy, thus possibly being useful as an adjunct therapy to conventional treatments for this form of brain cancer (da Fonseca 2006, Fernandes 2005, Rajesh 2003).

Additional studies suggest POH might lower the risk for cancers of the prostate (Chung 2006), breast (Yuri 2004, Wagner 2002), lungs (Xu 2004), liver (Crowell 1999), and skin (Barthelman 1998).

### **DIABETES**

Tart cherries and their compounds appear to aid in diabetes control and in reducing the complications associated with this disease.

In a study from Michigan State University, partially funded by the U. S. Department of Agriculture, the effects of extracts of anthocyanins from tart cherries were tested on mouse pancreatic cells, which produce the hormone insulin in the presence of glucose (sugar). Results showed that anthocyanin-exposed cells increased insulin production by 50 percent compared to cells not exposed to anthocyanins. The researchers conclude that cherries might be useful in the prevention of type 2 diabetes (Jayaprakasam 2005).

In another study on rats, a single dose of anthocyanins decreased fasting blood glucose levels by 19 percent and improved glucose tolerance by 29 percent. After one month of treatment with anthocyanins, fasting blood glucose levels had dropped to half of the pretreatment levels and glucose tolerance had improved by up to 41 percent (Cherian 1992).

Small blood vessels, called capillaries, are damaged in diabetes as a result of elevated blood sugar levels. Collagen proteins become linked to the elevated sugar and form abnormal complexes that damage tissues and blood vessels. One study on rats found that anthocyanins significantly reduced the formation of these abnormal protein complexes (Cohen-Boulakia 2000).

Retinopathy is a serious complication of diabetes, resulting from the overproduction of abnormal proteins produced when the body attempts to repair damaged capillaries. Anthocyanins appear to prevent this damage to blood vessels and also might prevent production of abnormal proteins. In one study, this damage was significantly reduced in 12 diabetic patients who consumed 600 milligrams of anthocyanins a day for two months (Boniface 1996). In another study, 31 patients with diabetic retinopathy showed marked improvement in permeability and a reduced tendency to hemorrhage when treated with anthocyanins (Scharrer 1981).

Studies have shown that tart cherries have a low glycemic index (GI) score of 54 (any score less than 55 is considered low), thus producing only a mild rise in blood sugar levels associated with lowered risks for diabetes and weight gain. Dried cherries have a moderate score of 58. Canned cherries have a higher GI score of 76, possibly because of the effects of processing (Glycemic Index Laboratories, Toronto, Canada).

## **BRAIN HEALTH**

The brain is particularly susceptible to oxidative damage, since it accounts for about 20 percent of the total body's oxygen consumption, but it is only about 2 percent of the body's weight. Numerous studies show that the phytonutrients in tart cherries aid in protecting neurons in the brain from oxidative damage associated with neuronal loss.

Researchers at USDA's Human Nutrition Research Center on Aging at Tufts University in Boston state that there is "...ample research [that] indicates age-related neuronal-behavioral decrements are the result of oxidative stress that may be ameliorated by antioxidants" (Joseph 1999). This oxidative damage has been linked to a higher risk for memory loss, dementia, and even Alzheimer's disease, while antioxidant-rich phytonutrients, such as the phenols, help reverse the course of neuronal and behavioral aging, and possibly improve memory (Gailli 2002, Joseph 1996, Andres-Lacueva 2005, Shukitt-Hale 2006, Lau 2005).

In a study from Korea, cherry phenolics protected brain neurons from oxidative damage in a dose-dependent fashion, primarily due to the amount of anthocyanins in the fruit (Kim 2005).

Another study investigated the effects of anthocyanins on cerebral ischemic injury (stroke) in rats. Results showed that rats fed anthocyanins had significantly less damage to brain tissue from reduced blood supply caused by stroke. The researchers concluded that "...consumption of anthocyanins may have the possibility of a protective effect against neurological disorders, such as brain ischemia" (Shin 2006).

An animal study from Spain found that anthocyanins were able to cross the blood brain barrier and localize in various brain regions important for learning and memory (Andres-Lacueva). Researchers at Tufts University conclude that anthocyanins show the most efficacy in penetrating the cell membrane and in providing antioxidant protection (Galli 2002).

## **OTHER HEALTH BENEFITS**

Tart cherries or their compounds also may have additional benefits, although the research is still emerging.

### *Weight Management*

One study found that feeding anthocyanins to mice that were on high-fat diets suppressed the diet-induced increase in body weight gain. While high-fat diets typically cause hyperglycemia, hyperinsulinemia, and hyperleptinemia, all of these effects were normalized with anthocyanin supplementation (Tsuda 2003).



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