

PureWay-C:

A new way to
think about
health and
vitamin C





Table of Contents

- PureWay-C: A new way to think about health and vitamin C**..... 3
 - What is PureWay-C? 4
 - Research on PureWay-C 5
 - Superior absorption and retention 5
 - Protects against toxins 6
 - Nerve regeneration and wound healing 7
- Market opportunities** 7
 - The right ingredient at the right time 8
 - Immunity and more 9
 - Sports 10
 - Beauty-from-within 11
- Today’s consumers take control of their health** 11
- Sidebar: Benefits of vitamin C** 12
 - Common cold 12
 - Immunity 12
 - Inflammation 12
 - Cardiovascular health 12
 - Blood sugar 12
 - Brain health 13
 - Eye health 13
 - Skin health 13
 - Joint health and uric acid 13
 - Support for iron 13
- Sidebar: Brief history of vitamin C** 14



PureWay-C: A new way to think about health and vitamin C

Vitamin C is one of the most important organic compounds for a healthy human life, it is necessary for a range of physiological functions and maintaining optimal health. It synthesizes collagen, a protein that is the body's cellular glue for skin, tendon, bone, cartilage and all other connective tissue. It also helps drive cellular energy through the production of carnitine, a compound that transports long-chain fatty acids into mitochondria to be oxidized for energy production, stoking the power plant of the cell. Vitamin C even factors into the regulation of gene expression and the maintenance of genome integrity.¹

It is also a powerful antioxidant that protects proteins, lipids, carbohydrates and nucleic acids (DNA and RNA) from damage by free radicals and reactive oxygen species (ROS) that are generated during normal metabolism, by immune cells gone wild, and through exposure to toxins and pollutants.² Simply put, vitamin C is an essential contributor to immune defense.³

Humans are one of the few animals that can't synthesize this essential micronutrient, meaning it must come from diet. In addition, as a water-soluble vitamin, the body doesn't retain it for long when taken orally at higher doses.

Levels of vitamin C in the blood are controlled by the kidneys through a process known as renal reabsorption, which expels excess ascorbic acid in a matter of hours.⁴ Basically, the intestines have a limited ability to actively absorb vitamin C, with studies suggesting that bioavailability drops to less than 50% for amounts greater than 1,000 mg.⁵

While the recommended daily intake of vitamin C—90 mg for men, 75 mg for women—is generally sufficient for healthy individuals, research suggests boosting levels of ascorbic acid in the body can impart an array of health benefits. [See sidebar on benefits of vitamin C.]

Some large, long-range studies, for instance, have shown vitamin C could be one of the secret ingredients for longer life. A study published in the prestigious *Lancet* medical journal followed the health track of 20,000 Europeans and found that a 20 $\mu\text{mol/L}$ rise in plasma ascorbic acid concentration after four years was associated with a 20% decrease in risk of death across the board.⁶ A U.S.-based study came up with similar results for about 14,000 adults over a 14-year period, where researchers observed a dose-response decrease in mortality risks with higher vitamin C levels.⁷

There is particularly strong research that suggests supplementation with vitamin C results in a healthier immune system by optimizing cell and tissue levels of ascorbic acid.⁸ In particular, a number of studies have shown vitamin C can stimulate both the production and function of leukocytes, or white blood cells. In one early study in the 1970s, a group of college-age males were given 1,000 mg of vitamin C for 75 days, causing a “statistically significant increase” in the serum levels of several immune-related biomarkers.⁹

In addition, groups of people who struggle with maintaining healthy levels of vitamin C could benefit from supplementation. Studies have shown smokers have lower plasma and white blood cell vitamin C levels than nonsmokers, due in part to increased oxidative stress.¹⁰ That led the Food and Nutrition Board of the National Academy of Sciences to recommend a higher dietary allowance of vitamin C for smokers.¹¹ People with severe intestinal malabsorption or general ill health, as well as some cancer patients, also may not get enough vitamin C in their diet.¹²

To maximize these and other potential benefits of vitamin C, consumers need a product specially formulated to maximize and retain absorption of this invaluable micronutrient. There is only one patented vitamin C ingredient on the market providing this level of superior bioavailability, with peer-reviewed research to back 55 substantiated structure/function claims under the Dietary Supplement Health and Education Act (DSHEA) of 1994.

What is PureWay-C?

The product is called PureWay-C from One Innovation Labs, a developer, manufacturer and wholesale supplier of nutraceutical ingredients for the natural products industry. PureWay-C is a proprietary bioavailable lipid soluble vitamin C, produced from a mixture of ascorbic acid, lipid metabolites and bioflavonoids.

This powerful combination was specifically developed about 20 years ago by Pedro Perez, a chemical engineer who was looking for a way to significantly boost vitamin C absorption, as well as prolong blood and tissue retention of this vital micronutrient.

“Vitamin C plays a critical role in immunity and overall health and well-being, but its use as a dietary supplement and in foods and beverages has previously been plagued by reduced bioavailability, rapid excretion from the body and major stomach upset and diarrhea,” said Perez, who still serves as the chief chemical engineer and head of product development at One Innovation Labs.

“Scientific research has demonstrated that PureWay-C is the most advanced, bioavailable form of vitamin C antioxidant yet developed, with enhanced absorption, distribution and cellular uptake kinetics relative to other forms of vitamin C currently sold,” he added. “It provides these benefits without any adverse side effects, including stomach upset.”

The lipid metabolites, which are fats derived from vegetable sources, are vital components of cell membranes and essential in the regulation and control of cellular function. In PureWay-C, the lipid metabolites



function as ascorbic acid carriers to increase intestinal absorption and vascular distribution of vitamin C, as well as enhance cellular uptake kinetics, which allows ascorbic acid to enter cells more quickly in a safe and effective manner. One Innovation Labs uses that same proprietary liquid metabolite delivery technology in all of its products.

The addition of bioflavonoids, polyphenolic compounds found in plants, assists in the bioavailability and provides an antioxidant punch. The citrus bioflavonoids in PureWay-C shield vitamin C from oxidizers in the body and support the ability to protect against health challenges associated with chronic inflammation, improve immune system function and help heal wounds.

Research on PureWay-C

Several peer-reviewed research papers attest to the superior bioavailability and bioactivity of PureWay-C against other types of vitamin C, including simple ascorbic acid, calcium ascorbate and calcium ascorbate-calcium threonate-dehydroascorbate, known as Ester-C.

Superior absorption and retention

A human study conducted by researchers from the University of Miami School of Medicine measured the absorption levels of those four sources. The researchers found that the average serum vitamin C level was higher in the group taking PureWay-C for a 24-hour period following intake.¹³ The study consisted of healthy volunteers who went on a two-week-long vitamin C-restricted diet and

then received a single 1,000 mg supplement of vitamin C taking either PureWay-C or one of the other three vitamin C forms.

Importantly, there were no adverse effects from PureWay-C. "A lot of vitamin C is associated with giving people upset stomach, diarrhea and epigastric pain," noted Ryan Bishop, senior sales manager at One Innovation Labs, of the clinical trial in which participants were surveyed each day about adverse effects on the stomach.

The University of Miami School of Medicine researchers also determined that the level of inflammatory biomarkers (C-reactive protein) and oxidized low density lipoprotein (LDL) decreased when healthy volunteers took PureWay-C.¹⁴ Researchers found that 24 hours after intake of PureWay-C the serum level of C-reactive protein decreased 15.6% and oxidized LDL dropped 8.4%.¹⁵

The principal investigator from the University of Miami study, Dr. Dario Pancorbo, MD, said the study demonstrates that PureWay-C is more rapidly absorbed by the body and retained for longer periods of time than any other vitamin C formulations.

PureWay-C is more rapidly absorbed by the body and retained for longer periods of time than any other vitamin C formulations



"PureWay-C is the vitamin C formulation of choice for those seeking the health benefits of vitamin C supplementation," he explained. "Consumption of PureWay-C increases plasma vitamin C as well as decreases oxidative stress and biomarkers of inflammation, which indicates that the protective effect of PureWay-C may extend beyond their antioxidant capability."



A separate study out of Adelphi University in New York also compared cellular uptake rates of PureWay-C against other forms of vitamin C, including Ester-C. The absorption was measured in a human lymphoblastic cell line using a spectrophotometric technique. The race wasn't very close. The vitamin C-lipid metabolites in PureWay-C showed a 233% increase of uptake compared to ascorbic acid through the first 45 minutes. Ester-C clocked in at a 189% increase.¹⁶

In addition, the vitamin C-lipid metabolites demonstrated potent antioxidant (12% higher) and significant free radical scavenging (11% higher) capabilities.¹⁷ The authors noted, "Vitamin C-lipid metabolites are excellent antioxidants and free radical scavengers and are more rapidly absorbed and lead to higher cellular vitamin C than do calcium ascorbate-calcium threonate-dehydroascorbate or any other tested vitamin C formulation."¹⁸

Protects against toxins

The researchers in that study noted supplementation with the vitamin C lipid metabolite formulation peaked in about two hours and also increased protection of T cells from pesticide toxicities.¹⁹ Specifically, pesticide-induced T-lymphocyte aggregation decreased by 84% in the cells treated with PureWay-C, while Ester-C reduced aggregation by only 34%.²⁰ An earlier paper by the same researchers was the first to suggest that PureWay-C could provide a health benefit against such toxins, with nearly identical results.²¹

The rapid uptake enabled by the lipid metabolites, they emphasized, is linked to the ability of PureWay-C to protect immune cells from toxin exposure.²² A larger team of researchers at Adelphi University further investigated the link between PureWay-C's immune-modulation capabilities and similar environmental toxins. In that study, the researchers tested the efficacy of the lipid metabolite formulation with Natramune, another immune-boosting proprietary ingredient from One Innovation Labs that consists of an all-natural hemicellulose nutrient mixture.²³

The study found that the combination of those two ingredients protect T-cells from a type of cellular adhesion associated with inflammation, suggesting the possibility that dietary supplementation with Natramune and PureWay-C provides anti-inflammatory protection against exposure to common household pollutants like pesticides.²⁴

"Due to the increasing use of household chemicals, it may be important to reconsider the nutritional requirements and incorporate dietary supplements, such as Natramune and PureWay-C as a routine barrier to xenobiotic-induced disease," the authors wrote.²⁵

Due to the increasing use of household chemicals, it may be important to reconsider the nutritional requirements and incorporate dietary supplements, such as Natramune and PureWay-C as a routine barrier to xenobiotic-induced disease



Nerve regeneration and wound healing

Last, but certainly not least, vitamin C delivered by PureWay-C has shown in a peer-reviewed study using cell cultures to significantly promote nerve regeneration and stimulate wound healing.²⁶ When compared with other ascorbate brands, PureWay-C treatment drove nerve regeneration 12-fold more efficiently and wound healing three-fold more efficiently. Specifically, enhanced neurite outgrowth reached 12% within one hour of treatment of neuronal cells and 45% of the cells extended neurites by hour nine. Ester-C showed zero activity on neuronal cells in the first hour and only 15% extended neurites after nine hours.

Overall, the cells treated with PureWay-C maintained a measurable difference compared to Ester-C, ascorbic acid and calcium ascorbate over a 24-hour period.

“The ability of PureWay-C to quickly affect cultured cell behavior is an indication of its rapid cellular uptake and improved activity,” the authors concluded.

Market opportunities

Sales of cold, flu and immunity supplements are expected to grow by more than 50% over last year, reaching US\$5.2 billion in 2020, according to Claire Morton Reynolds, senior industry analyst for New Hope Network's *Nutrition Business Journal* (NBJ). That number represents nearly 10% of the projected \$54.55 billion in U.S. supplement sales.

In fact, the immune support category is driving the best overall growth year for U.S. supplements since NBJ began keeping track, in what could be described as the COVID-19 bump. The NBJ *2020 Supplement Business Report* predicts total sales will spike by 12.1%, “remarkably higher” than the 7.5% notched in the record-setting years of 2012 and 2013. That new record percentage represents \$6 billion in additional sales.



Drilling deeper into the numbers from NBJ's latest annual report: Vitamin sales are projected to grow by 12.4% in 2020 to reach \$16.3 billion compared to just 3.8% in 2019. That's particularly noteworthy given the size of the category, accounting for nearly a third of the \$6 billion in additional sales predicted from the previous year. The COVID effect cannot be overstated: The NBJ model would have projected vitamin sales to climb by just \$577 million without the virus.

And the ingredient projected to receive the biggest boost in sales isn't a trendy adaptogen or niche supplement with dubious scientific backing. It's L-ascorbic acid, or vitamin C, with sales expected to grow by more than 17% this year.

“Vitamin C is still the star player in the category, contributing \$798 million to immunity supplement sales this year,” Reynolds said. In a survey of 1,000 U.S.-representative consumers conducted May 12, 47% reported taking vitamin C to support immunity right now—the highest percentage of surveyed consumers.

That demand hasn't gone unnoticed by raw material suppliers of immune-boosting nutritional ingredients like vitamin C and others. Consumers are seeking supplements to support healthy immune response and

dietary supplement brands have paid attention, upping their raw material procurement to meet this increased demand.

“We’ve had a lot of clients ordering more PureWay-C because of the demand, and then we’ve had a lot of new clients hop on board because vitamin C and immunity are very on trend with COVID-19,” Bishop said.

He also noted that e-commerce sales of branded products using PureWay-C are particularly strong. That reflects the current zeitgeist around online dietary supplement sales in general, which the current pandemic is only accelerating, according to Reynolds at NBJ.

For context, brick-and-mortar growth in 2019 was 2.8% while e-commerce grew at nearly 10 times the rate—26.5%. In 2020, online supplement sales are expected to grow a stunning 61.4% in 2020.

“The growth this year is notable, but even more notable is the long-term impact of consumer sales shifting to e-commerce,” Reynolds said. “NBJ expects that many consumers who discovered online platforms as a result of quarantine and stay-at-home orders in 2020 will remain loyal to this channel moving forward.”

As a result, online sales are projected to grow from \$5 billion in 2019 to more than \$10 billion in 2022 and are expected to represent 19.6% of all supplement sales by 2023.

The right ingredient at the right time

PureWay-C is particularly well positioned to meet the demands of a renewed interest in personal health for immunity and beyond, especially as preferred market channels shift. A globally recognized ingredient, it is used in hundreds of products in markets throughout Europe, Asia and North America.

“I think COVID brought back to the forefront that people need to prioritize their health and do things proactively to have a healthy immune system, instead of just waiting until you get sick to take vitamin C,” Bishop said.

Manufactured in the United States from non-GMO ingredients, PureWay-C has attained generally recognized as safe (GRAS) status. It comes in a number of forms depending on the formulation needed, from powders with nanoparticle size to tablets and capsules. Bishop noted that PureWay-C could be used as either a stand-alone ingredient or to complement various formulations across a wide spectrum of applications, including dietary supplements, functional foods and beverages and cosmetics.

“We have 55 FDA substantiated claims on everything from immunity to wound healing, cognitive health, cardiovascular health and antioxidants. It’s very marketable outside of just the classic immunity that you see with vitamin C,” he said. “It’s great for that, but it can be used in ingredient lines such as beauty-from-within cosmetics, collagen and joint support, and in anti-inflammatory formulations. I know a company looking into it for prenatal.”



It comes in a number of forms depending on the formulation needed, from powders with nanoparticle size to tablets and capsules



Sales of vitamin C, thanks to its leading role in immunity, are predicted to shoot up by 17.3% in 2020, more than tripling its growth from just 5.3% in 2019

Indeed, a meta-analysis of nearly 30 studies showed that vitamin C supplementation led to a 36% lower risk of placental abruption, a condition where the placenta separates from the inner wall of the uterus before birth, potentially depriving the baby of oxygen and nutrients, as well as causing heavy bleeding in the mother.²⁷

Even cannabis companies are getting cozy with vitamin C and PureWay-C. For example, Zativa Life has combined 200 mg of a CBD extract with 250 mg of PureWay-C in a single capsule that the company claims both boosts immunity and imparts an overall feeling of well-being. Until the 2020 pandemic, hemp CBD had been the hottest functional ingredient ever, with NBJ projecting hemp CBD sales to hit \$4 billion by 2023.

Let's take a closer look at some of the major categories where PureWay-C is making a difference.

Immunity and more

This is the wellness category driving growth in the dietary supplement industry in 2020. Sales of vitamin C, thanks to its leading role in immunity, are predicted to shoot up by 17.3% in 2020, more than tripling its growth from just 5.3% in 2019.

Companies interested in developing finished goods around immunity specifically have 10 DSHEA-compliant claims to choose from, including:

- Supports healthy immune functioning
- Boosts immune health
- Promotes immune functioning
- Strengthens immune health/immune functioning
- Immune support formula
- Promotes a healthy inflammatory response
- Inflammation support formula
- Effective antioxidant defense
- Supports antioxidant defense
- All day immune protection

A product begins with immunity, but it doesn't have to stop there. Take the example of Jigsaw PureWay-C Plus, an immunity product that starts with 1,000 mg of the vitamin C formulation of ascorbic acid, lipid metabolites and bioflavonoids. It then adds 100 mg of an essential amino acid called Lysine, or L-Lysine, which like vitamin C plays an essential role in the production of carnitine, a nutrient responsible for converting fatty acids into energy. It also shows up in the formation of collagen, where vitamin C is the glue that holds cells together and lysine strengthens those bonds. Rounding out the formulation from Jigsaw Health is a complementary bioflavonoid to vitamin C called quercetin that enhances absorption and promotes heart health.

In this case, an immunity supplement with PureWay-C at the foundation is also a powerful heart healthy supplement that can make additional claims:

- Build and strengthen collagen to provide essential support for the blood vessels, arteries, ligaments, bones, gums and teeth
- Maintain healthy heart function and overall cardiovascular health
- Support artery and blood vessel flexibility

Going down the alphabet, vitamin D is gaining in popularity for its immune-modulating benefits. NBJ projects it will see the next fastest growth for a single letter vitamin, with 9.5%, making vitamin C combined with vitamin D a potentially dynamic duo. Manufacturer Purity Products has already taken note, offering a C & D Booster Formula using PureWay-C.

Multivitamins is also a dietary supplement category experiencing extraordinary growth in these extraordinary times. The biggest single-product category in the supplement industry, multivitamins are on track to rack up \$7.6 billion in sales in 2020 on projected growth of 17.1%, according to NBJ. The authoritative market intelligence publication for dietary supplements noted, "This suggests consumers are buying into the intuitive argument that good nutrition is part of good health and good health is essential for strong immunity. Smart brands were already offering immunity-targeted multivitamin formulas even before the pandemic hit." Again, PureWay-C would provide a powerful foundation for any multivitamin formulation.

Sports

Vitamin C delivered by PureWay-C also plays well in the world of sports, a nutrition category projected to see growth rise from 6.5% in 2019 to 8.7% in 2020, according to NBJ. That would end a years-long slide in growth since the heyday of 2013, bringing the total market to about \$7 billion. Much of that growth will come from sport powders—a format particularly suited for PureWay-C—and a category that accounts for more than 80% of the entire sports nutrition market. Functional sports beverages, another delivery format consumers are increasingly choosing over pills and tablets for their dietary supplement consumption of ingredients like vitamin C, are also predicted to pace the larger growth in the category.

With PureWay-C, products can make claims around anti-inflammatory and rejuvenation properties that are critical for healing muscle tissue and reducing recovery time between workouts. Athletes will see the clear benefit of choosing supplements that will boost their immune system, minimize inflammation and maximize training time.

A brand from Olimp Sport Nutrition, for example, is marketed as GOLD-VIT C 1000 SPORT EDITION. It contains 1,000 mg of PureWay-C, making powerful claims such as, "Supports the proper functioning of the immune system, reduces the feeling of tiredness and fatigue and contributes to maintaining proper energy metabolism."



Beauty-from-within

PureWay-C is catching the eye of more and more manufacturers of beauty-from-within products, a \$1.2 billion market projected to grow by more than 11% to \$1.4 billion in 2020, according to NBJ's *2019 Condition Specific Report*.

A key driver in the market is collagen, which vitamin C helps synthesize, so PureWay-C is an obvious choice for beauty-from-within products that emphasize those benefits. In 2018, the collagen market was worth \$147 million, up \$55 million from 2014. It now represents about 12% of the whole category. The next biggest category after collagen is actually vitamin C for beauty, which has been growing rapidly and now accounts for nearly 7% of the beauty-from-within market. NBJ projects vitamin C to surpass \$100 million in sales for this specific category by 2021.

Brands integrating PureWay-C into their products are looking to its power to repair sun damage, reduce wrinkles and minimize fine lines. As an antioxidant, PureWay-C can enhance any cosmetic or massage oil with an assortment of revitalizing benefits that may prevent and even reverse visible imperfections on skin. Best of all, the formulation will not change the established smell or color of any product.

One example of how companies are leveraging the power of PureWay-C can be found in a vitamin C cream that Botanic Choice produces under its Botanic Spa line. The product features PureWay-C, along with a cornucopia of oils including arnica Montana, sunflower and soybean, along with soluble collagen and more. Vitamin C Cream with PureWay-C has garnered rave five-star reviews from consumers:²⁸

- "This topical cream for your skin does a wonderful job of rejuvenating the face."
- "This cream feels really nice on my face and neck, it absorbs easy [sic] and has a pleasant smell."

Today's consumers taking control of their health

Consumers are increasingly taking control of their health and wellness, whether it's to boost their immunity to help fight infections and toxins or to improve their energy and skin health. Vitamin C has a large body of scientific evidence that suggests it is not only vital for maintaining immune health but that it can be part of a strategy to support a healthy lifestyle across multiple categories.

Because of its increased bioavailability, PureWay-C provides superior beneficial effects from vitamin C, not only as an antioxidant but also in other areas of metabolic activity that are important for maintaining optimal health of the body. Laboratory analytical testing and a human clinical trial demonstrate that, compared to other forms of vitamin C, PureWay-C promotes more rapid absorption and greater retention by cells, increased antioxidant and free radical scavenging activity, increased stimulation of healthy neuron growth, better immune system support, more sustained anti-inflammatory protection, as well as enhanced cardiovascular support.

"At One Innovation Labs, we pride ourselves in being at the forefront of improving health, wellness and the overall quality of life," Perez said.

The next biggest category after collagen is actually vitamin C for beauty, which has been growing rapidly and now accounts for nearly 7% of the beauty-from-within market



PureWay-C is a registered trademark of One Innovation Labs

Benefits of vitamin C

There have been more than 65,000 studies on vitamin C, according to the PubMed database of biomedical scientific literature. Below are some of the more profound ways in which ascorbic acid can promote health and wellness.



Common cold

A 2013 meta-analysis of 53 placebo-controlled trials involving vitamin C concluded that there are indeed benefits to regular supplementation.²⁹ The biggest payoff appeared to be in reducing the duration of colds—by 14% in children and by 8% for adults.³⁰ And while regular supplementation with vitamin C of up to two grams per day (the maximum recommended dosage) did not reduce the incidence of colds in the general population, the researchers noted that participants undergoing heavy physical stress (such as marathon runners, skiers or even subarctic soldiers) experienced considerable protection by halving the incidence of colds.³¹



Immunity

Beyond the common cold, ascorbate has certainly risen to the top of the vitamin chart thanks to its association with boosting the immune system. Possibly its most important role is to stimulate both the production and function of leukocytes, especially white blood cells known as lymphocytes and phagocytes. In particular, a type of lymphocyte called a T cell plays a starring role in immune response. In addition, the antioxidant properties of vitamin C can help protect these infection-fighting cells from self-inflicted damage caused by the release of free radicals and ROS.³²



Inflammation

Several studies have shown that vitamin C can support a healthy inflammatory response thanks to its antioxidant properties. A cross-sectional study of more than 3,000 men aged 60 to 79 years old found that both dietary intake and plasma levels of vitamin C were inversely related to biomarkers of inflammation.³³ Another study that involved more than 14,500 U.S. adults also found vitamin C was associated with a healthier inflammation response.³⁴ Conversely, low plasma and white blood cell concentrations of vitamin C have been observed in patients with

sepsis where whole-body inflammation can lead to organ failure.³⁵ Sepsis is one of the leading reasons why patients end up in intensive care units.³⁶ Last year, in a meta-analysis that looked at a dozen controlled trials, researchers found that vitamin C appeared to reduce the length of time patients spent in the ICU.³⁷ On average, vitamin C administration shortened ICU stays by 7.8%, as well as the need for mechanical ventilation by 18.2%.



Cardiovascular health

A number of studies have shown that vitamin C can help support a healthy cardiovascular system. For example, a 2014 meta-analysis on the effects of vitamin C on vascular function returned some interesting results. Subjects who received short-term supplementation of vitamin C experienced better vascular function.³⁸ A separate meta-analysis of eight randomized controlled trials involving more than 1,000 cardiac surgeries found evidence that vitamin C treatment was associated with better outcomes.³⁹



Blood sugar

Vitamin C supplementation has shown great promise in promoting a healthier response to diabetes. In a major study conducted under the combined auspices of the National Institutes of Health and the American Association of Retired Persons (AARP) that included more than 230,000 participants, the use of vitamin C supplements for at least seven times a week was associated with a 9% percent lower risk of developing type 2 diabetes mellitus compared to non-supplement use.⁴⁰ In another large study that followed a cohort of nearly 22,000 people for 12 years, high levels of vitamin C were strongly associated with a reduced risk of diabetes.⁴¹ In addition, other research has found links between vitamin C concentrations and healthier glucose levels, including in children.^{42,43}



Brain health

An emerging body of research is also linking low levels of vitamin C plasma levels with dementia, particularly

Alzheimer's disease (AD). In one study using mice, researchers found lower levels of ascorbic acid led to increases in oxidative stress and accelerated the build-up of amyloid deposits on the brain that are associated with Alzheimer's.⁴⁴ A cross-sectional and prospective study focused on elderly residents in Cache County, Utah, concluded that the combined use of vitamins C and E was associated with reduced AD prevalence and incidence.⁴⁵



Eye health

Concentration of vitamin C concentration in the fluid that fills the chambers of the eye is about 15 to 20

times higher than in blood plasma, suggesting that ascorbic acid is important in eye health.⁴⁶ That's especially true with age-related diseases such as cataracts, where oxidative damage to the eye causes cloudiness to the lens. In fact, decreased vitamin C concentrations in the lens of the eye have been associated with increased severity of cataracts.⁴⁷



Skin health

Skin also contains high concentrations of vitamin C, which stimulates collagen synthesis and assists in antioxidant

protection against UV-induced damage. A 2017 study that reviewed research on both nutritional and topical applications of vitamin C on skin health found a broad array of benefits.⁴⁸ Some human studies, for example, have suggested a beneficial effect with respect to UV irradiation protection, with most effective formulations containing both vitamins C and E.⁴⁹ A number of studies also support the ameliorative effects of vitamin C on signs of aging in human skin, including objective measures of collagen deposition and wrinkle depth.⁵⁰ Numerous clinical studies in both humans and animals have similarly shown that vitamin C greatly assists in wound healing and minimizes raised scar formation.⁵¹ Another peer-reviewed paper suggested that vitamin C "holds promise as a mainstream drug in future dermatology practice" thanks to its multitude of beneficial effects.⁵²



Joint health and uric acid

Gout is a severe type of arthritis that affects about 4% percent of U.S. adults, with research suggesting that the

incidence of this inflammatory disease has been on the rise for the last two decades.⁵³ Symptoms occur when there is too much uric acid, a waste product, in the blood. A further complication is that people with gout are at higher risk of getting kidney stones.⁵⁴ Research suggests vitamin C may provide health benefits. One study involving more than 1,300 men found an inverse relationship between high levels of vitamin C intake and lower blood levels of uric acid.⁵⁵ A much larger prospective study that followed nearly 47,000 men over 20 years suggested that supplemental vitamin C lowers the risk of gout.⁵⁶



Support for iron

While scurvy may belong to a bygone area, other nutritional deficiencies remain problematic. For example,

more than 1.6 billion people are anemic, and iron deficiency is often the main cause.⁵⁷ In the United States alone, an estimated 10 million people do not get enough iron in their diet.⁵⁸ Vitamin C helps increase the bioavailability of iron from foods by enhancing intestinal absorption,⁵⁹ a finding that dates back to at least the 1970s.⁶⁰ A much later study in the same journal calculated the iron absorption effect from various ingredients and determined that 100 mg of ascorbic acid can boost iron absorption by 67% percent in a standard meat-and-potatoes diet.⁶¹

Brief history of vitamin C

Scurvy was once the scourge of sailors who suffered from a severe lack of vitamin C in their diet, with the first descriptions of the illness appearing in the medieval records of the European Crusades.⁶² By the mid-18th century, the British medical community applied its limited understanding of nutrition to the persistent disease, which caused swollen and bleeding gums, loose teeth, hemorrhaging under the skin, and slow healing of wounds,⁶³ demonstrating that collagen isn't just for lips.

Scottish physician James Lind, drawing upon his experiences as a naval surgeon where he witnessed the apparent preventive and curative powers of citrus fruits, advocated for sailors to be issued rations of lime juice on long voyages.⁶⁴

While scurvy was eventually eliminated from the Royal Navy, no one knew exactly why a daily dose of lime or lemon did the trick. It would take more than a century before an answer finally emerged thanks to Dr. Albert Szent-Györgyi, a Hungarian biochemist credited with first isolating vitamin C, an achievement that helped him win the Nobel Prize in Physiology or Medicine in 1937.

Researchers had suspected the existence of vitamin C as early as 1907, but no definitive candidate emerged until the 1930s.⁶⁵ Szent-Györgyi had been investigating energy production in plants when he discovered that oxidation caused

damage at the cellular level, turning plants brown. In the course of his investigation, he found that he could delay the browning effect with the addition of citrus juice to a plant enzyme active in the oxidation process.⁶⁶

A later series of experiments on guinea pigs helped Szent-Györgyi and his colleague J. L. Svirbely isolate the antioxidant agent, settling on the name ascorbic acid to reflect its anti-scurvy properties.⁶⁷

Prevention of scurvy is only the beginning of the benefits eventually attributed to vitamin C. An American biochemist named Linus Pauling is often credited with popularizing the micronutrient, turning it into the chicken soup of vitamins with the 1970 publication of his book *Vitamin C and the Common Cold*.

Considered one of the greatest scientists of the 20th century, Pauling was convinced that in large doses vitamin C could be an effective prophylactic or palliative for the common cold—and potentially much more. Research in the succeeding years has confirmed many of his original hypotheses.

*These statements have not been evaluated by the Food and Drug Administration. These products are not intended to diagnose, treat, cure or prevent any disease.

References

- 1 "Vitamin C." Linus Pauling Institute, Oregon State University. [Webpage](#) retrieved on June 29, 2020.
- 2 Ibid.
- 3 Carr AC and Maggini S. "Vitamin C and Immune Function." *Nutrients*. 2017 Nov; 9(11): 1211.
- 4 Michels A. "Questions about Vitamin C." Linus Pauling Institute. May 28, 2015.
- 5 Jacob RA and Sotoudeh G. "Vitamin C Function and Status in Chronic Disease." *Nutr Clin Care*. Mar-Apr 2002;5(2):66-74.
- 6 Khaw KT. "Relation Between Plasma Ascorbic Acid and Mortality in Men and Women in EPIC-Norfolk Prospective Study: A Prospective Population Study. European Prospective Investigation Into Cancer and Nutrition." *Lancet*. 2001 Mar 3;357(9257):657-63.
- 7 Goyal A, Terry MB and Siegel AB. "Serum Antioxidant Nutrients, Vitamin A, and Mortality in U.S. Adults." *Cancer Epidemiol Biomarkers Prev*. 2013 Dec;22(12):2202-11.
- 8 Carr AC and Maggini S. "Vitamin C and Immune Function." *Nutrients*. 2017 Nov; 9(11): 1211.
- 9 Prinz W et al. "The Effect of Ascorbic Acid Supplementation on Some Parameters of the Human Immunological Defence System." *Int J Vitam Nutr Res*. 1977;47(3):248-57.
- 10 Prasad S, Kaiser MA and Cucullo L. "Unhealthy smokers: scopes for prophylactic intervention and clinical treatment." *BMC Neurosci*. 2017; 18: 70.
- 11 Ibid.
- 12 Hoffman FA. "Micronutrient Requirements of Cancer Patients." *Cancer*. 1985 Jan 1;55(1 Suppl):295-300.
- 13 Pancorbo D, Vazquez C and Fletcher MA. "Vitamin C-lipid metabolites: Uptake and retention and effect on plasma C-reactive protein and oxidized LDL levels in healthy volunteers." *Med Sci Monit*, 2008; 14(11): CR547-551.
- 14 Ibid.
- 15 Ibid.
- 16 Weeks BS and Perez P. "Absorption Rates and Free Radical Scavenging Values of Vitamin C-lipid Metabolites in Human Lymphoblastic Cells." *Med Sci Monit*. 2007 Oct;13(10):BR205-10.
- 17 Ibid.
- 18 Ibid.
- 19 Ibid.
- 20 Ibid.
- 21 Weeks BS and Perez PP. "A novel vitamin C preparation enhances neurite formation and fibroblast adhesion and reduces xenobiotic-induced T-cell hyperactivation." *Med Sci Monit*, 2007; 13(3): BR51-58.
- 22 Ibid.
- 23 Weeks BS et al. "Natramune and PureWay-C reduce xenobiotic-induced human T-cell α5β1 integrin-mediated adhesion to fibronectin." *Med Sci Monit*, 2008; 14(12): BR279-285.
- 24 Ibid.
- 25 Ibid.
- 26 Weeks BS and Perez PP. "A novel vitamin C preparation enhances neurite formation and fibroblast adhesion and reduces xenobiotic-induced T-cell hyperactivation." *Med Sci Monit*, 2007; 13(3): BR51-58.
- 27 Rumbold A. "Vitamin C Supplementation in Pregnancy." *Cochrane Database Syst Rev*. 2015 Sep 29;9(9):CD004072.
- 28 Vitamin C Cream product page. [Webpage](#) retrieved on July 4, 2020.
- 29 Hemilä H and Chalker E. "Vitamin C for Preventing and Treating the Common Cold." *Cochrane Database Syst Rev*. 2013 Jan 31;(1):CD000980.
- 30 Ibid.
- 31 Ibid.
- 32 Jariwalla RJ and Harakeh S. "Mechanisms underlying the action of vitamin C in viral and immunodeficiency disease." *Vitamin C in Health and Disease*. New York: Macel Dekker, Inc.; 1997:309-322.
- 33 Wannamethee SG et al. "Associations of Vitamin C Status, Fruit and Vegetable Intakes, and Markers of Inflammation and Hemostasis." *Am J Clin Nutr*. 2006 Mar;83(3):567-74; quiz 726-7.
- 34 Ford ES et al. "C-reactive Protein Concentration and Concentrations of Blood Vitamins, Carotenoids, and Selenium Among United States Adults." *Eur J Clin Nutr*. 2003 Sep;57(9):1157-63.
- 35 Wilson JX. "Mechanism of Action of Vitamin C in Sepsis: Ascorbate Modulates Redox Signaling in Endothelium." *Biofactors*. Jan-Feb 2009;35(1):5-13.
- 36 Sakr Y et al. "Sepsis in Intensive Care Unit Patients: Worldwide Data From the Intensive Care over Nations Audit. *Open Forum Infect Dis*. 2018 Dec; 5(12): ofy313.
- 37 Hemilä H and Chalker E. "Vitamin C Can Shorten the Length of Stay in the ICU: A Meta-Analysis." *Nutrients* 2019, 11(4), 708.
- 38 Ashor AW et al. "Effect of Vitamin C on Endothelial Function in Health and Disease: A Systematic Review and Meta-Analysis of Randomised Controlled Trials." *Atherosclerosis*. 2014 Jul;235(1):9-20.
- 39 Hu X et al. "Efficacy and Safety of Vitamin C for Atrial Fibrillation After Cardiac Surgery: A Meta-Analysis With Trial Sequential Analysis of Randomized Controlled Trials." *Int J Surg*. 2017 Jan;37:58-64.
- 40 Song Y et al. "Multivitamins, Individual Vitamin and Mineral Supplements, and Risk of Diabetes Among Older U.S. Adults." *Diabetes Care*. 2011 Jan;34(1):108-14.
- 41 Harding AH et al. "Plasma Vitamin C Level, Fruit and Vegetable Consumption, and the Risk of New-Onset Type 2 Diabetes Mellitus: The European Prospective Investigation of cancer--Norfolk Prospective Study." *Arch Intern Med*. 2008 Jul 28;168(14):1493-9.
- 42 Donin AS et al. "Fruit, Vegetable and Vitamin C Intakes and Plasma Vitamin C: Cross-Sectional Associations With Insulin Resistance and Glycaemia in 9-10 Year-Old Children." *Diabet Med*. 2016 Mar;33(3):307-15.
- 43 Kositsawat J and Freeman VL. Vitamin C and A1c Relationship in the National Health and Nutrition Examination Survey (NHANES) 2003-2006. *J Am Coll Nutr*. 2011 Dec;30(6):477-83.
- 44 Dixit S et al. "Vitamin C Deficiency in the Brain Impairs Cognition, Increases Amyloid Accumulation and Deposition, and Oxidative Stress in APP/PSEN1 and Normally Aging Mice." *ACS Chem Neurosci*. 2015 Apr 15;6(4):570-81.
- 45 Zandi PP et al. "Reduced Risk of Alzheimer Disease in Users of Antioxidant Vitamin Supplements: The Cache County Study." *Arch Neurol*. 2004 Jan;61(1):82-8.
- 46 Reiss GR et al. "Ascorbic Acid Levels in the Aqueous Humor of Nocturnal and Diurnal Mammals." *Arch Ophthalmol*. 1986 May;104(5):753-5
- 47 Tessier F et al. "Decrease in Vitamin C Concentration in Human Lenses During Cataract Progression." *Int J Vitam Nutr Res*. 1998;68(5):309-15.
- 48 Pullar JM, Carr AC and Vissers MCM. "The Roles of Vitamin C in Skin Health." *Indian Dermatol Online J*. 2013 Apr-Jun; 4(2): 143-146.
- 49 Ibid.
- 50 Ibid.
- 51 Ibid.
- 52 Telang PS. "Vitamin C in dermatology." *Indian Dermatol Online J*. 2013 Apr-Jun; 4(2): 143-146.
- 53 Zhu Y, Pandya BJ and Choi HK. "Prevalence of Gout and Hyperuricemia in the US General Population: The National Health and Nutrition Examination Survey 2007-2008." *Arthritis Rheum*. 2011 Oct;63(10):3136-41.
- 54 Landgren AJ et al. "Incidence of and risk factors for nephrolithiasis in patients with gout and the general population, a cohort study." *Arthritis Res Ther*. 2017;19:173.
- 55 Gao X et al. "Vitamin C Intake and Serum Uric Acid Concentration in Men." *J Rheumatol*. 2008 Sep;35(9):1853-8.
- 56 Choi HK, Gao X and Curhan G. "Vitamin C Intake and the Risk of Gout in Men: A Prospective Study." *Arch Intern Med*. 2009 Mar 9;169(5):502-7.
- 57 Miller JL. "Iron Deficiency Anemia: A Common and Curable Disease." *Cold Spring Harb Perspect Med*. 2013 Jul; 3(7): a011866.
- 58 Ibid.
- 59 "Vitamin C." Linus Pauling Institute, Oregon State University. [Webpage](#) retrieved on June 29, 2020.
- 60 Cook JD and Monsen ER. "Vitamin C, the Common Cold, and Iron Absorption." *Am J Clin Nutr*. 1977 Feb;30(2):235-41.
- 61 Hallberg L and Hulthén L. "Prediction of Dietary Iron Absorption: An Algorithm for Calculating Absorption and Bioavailability of Dietary Iron." *Am J Clin Nutr*. 2000 May;71(5):1147-60.
- 62 "Albert Szent-Györgyi's Discovery of Vitamin C." American Chemical Society. [Webpage](#) retrieved on June 29, 2020.
- 63 Ibid.
- 64 Ibid.
- 65 Ibid.
- 66 Ibid.
- 67 Ibid.