Vitamin C: Our Shield from Misfortune

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Introduction

Vitamin C is a fundamentally essential vitamin for humans, apes and primates. Bats, guinea pigs and a certain group of birds are also dependent on Vitamin C in their diet. All other animals have retained vitamin C synthesizing capability, i.e. they biosynthesize it and, under those circumstances, it no longer fulfils the conditions for being classed as a vitamin. We must therefore regard synthesizing one's own Vitamin C as being normal for the animal world and those members who cannot synthesize it as being unusual. Primates and guinea pigs tend to lead lifestyles that give them Vitamin C in their diets. It seems likely that during their relatively recent evolution, an alteration in the genes that suppressed Vitamin C biosynthesis, albeit a negative change, was linked to some other change that had positive survival value. This would have been an evolutionary "trade-off". Given that these species had a good Vitamin C intake in their usual diet, the downside of the trade-off would not have mattered very much. So today humans are secure from deficiency of Vitamin C so long as their diet contains plenty of fruits and vegetables. The lack of Vitamin C leads, of course, to the deficiency condition of scurvy. As a result of the evolutionary trade-off, we are not free to alter our diet in any way that deprives us of this simple substance, as mariners tried to do in the days of sail.

The History of Vitamin C

The history of Vitamin C is the history of scurvy and of detecting its cause. More than anything else it is associated with sea-faring history because sailors before the age of steam were subject to very long voyages with no chance to re-provision the ship in port. They were therefore subject to a diet of preserved foods. However, this part of the history also impinges upon polar expeditions, armies engaged in long wars and even land-based settled populations deprived of fresh plant foods during long winters. Sadly, the truth about the protective effect of fresh fruits and vegetables only dawned upon people slowly and erratically between 1535 and the beginning of the 20th Century. During that great span of time, although numerous indications began to appear that scurvy was associated with diet, this knowledge had to be discovered, lost and then rediscovered several times over. The entirely avoidable loss of life in that period must have been very great.

The Symptoms and Progression of Scurvy
The symptoms of scurvy were very characteristic. The onset was generally accompanied by weakness and lassitude. This was followed by swelling of the legs and arms, softening of the gums, and haemorrhages. Nose bleeds and bleeding from the gums were usually prominent features. There were haemorrhagic spots appearing under the skin, presumably caused by weakness of the walls of the capillary blood vessels. As the disease progressed, the teeth became loose and often fell out. Another symptom was foul breath. Eventually general
strength failed so much that the patient was unable to stand. There was also oedema and ulcerations. If the disease was not relieved death would result from exhaustion or from acute infections such as pneumonia. Such infections usually produced a rapid fatal ending due to the patient’s debilitated state. A typical feature was the frequent sudden death from acute heart failure which was seen even in young men.

Evans described the medical history of infantile scurvy or Barlow's disease (1983). In his Bradshaw Lecture in 1894, Sir Thomas Barlow mentioned the following symptoms: pallor, inadequate subcutaneous fat, screaming when the legs were handled, pseudoparalysis (apparent loss of muscular power without true paralysis), swelling of limbs, crepitus due to fracture in or near the epiphyses (this is a grating sensation caused by the rubbing together of the dry surfaces of the joints), occasional proptosis (bulging of the eye), spongy gums with fetid odour and bleeding, deformities of the ribs, osseous sheaths surrounding bones, and albumin and blood in the urine.

At the start of the Second World War, when vitamin C was well known, a young Boston surgeon conducted a careful experiment in which he induced scurvy in himself (Crandon et al., 1940). Later, British volunteers lived on a diet very low in ascorbic acid to establish the requirements (Krebs, 1953). The first symptom of the onset of the disease is a hyperkeratosis (thickening) of the hair follicles, though this is not diagnostic. Then follow haemorrhages around the hair follicle and haemorrhages in the gums between the teeth. At this stage, wounds will not heal. Occasionally heart symptoms are seen with abnormal electrocardiograms. People subject to acne show exacerbation of the condition. Later the gums become swollen and painful, the teeth become loose in their sockets, and pains in the joints on movement are unbearable. That wounds fail to heal has an important bearing on surgery (Crandon et al., 1940; Hunt, 1941).

**Discovery and Identification of an "Antiscorbutic Factor"
**
Gradually recognition developed that "something" was present in lemon juice and other plant foods and extracts that could cure or prevent scurvy. It did not become clear-cut and incontrovertible until around 1920. At first the attempts to find out what the "antiscorbutic factor" was were hampered by its liability to oxidative destruction, as well as by the lack of any really concentrated sources. Prominent in the field were separate contributions from Zilva, King and Szent-Gyorgyi.

**The Chemical Structure of Ascorbic Acid and its Synthesis
**
It has since been discovered that Vitamin C is a water-soluble molecule, having –OH groups predominating in its structure. It quite closely resembles a sugar, from which it is ultimately derived. Earlier biochemists naturally wanted to know what the chemical structure of ascorbic acid was. This was eventually worked out by Haworth in England, a very celebrated carbohydrate chemist, together with contributions from a number of centres in Europe. The ability to produce Vitamin C soon followed. This was achieved by Reichstein et al and Haworth et al in 1933 and 1934.
Overview and the Actions of Vitamin C

Redox Activity and Dehydroascorbic Acid
The ascorbic acid has chemical activity connected with oxidation and reduction, termed "redox". By the removal of hydrogen, it converts to the oxidized form "dehydroascorbic acid" or the salt or ion called "dehydroascorbate". The change is fully reversible as the dehydroascorbic form re-converts back to ascorbic acid. Hence, ascorbic acid or ascorbate is able to scavenge oxygen and hence act as an anti-oxidant. The relative amounts of ascorbic acid and dehydroascorbic acid present in a tissue at any given time tends to be a reflection of what is termed the "redox state" of that tissue. The redox state is the overall condition of the tissue with regard to oxidation or reduction. If there is a lot of oxygen in the tissue then the tissue components will tend to be in an overall predominantly oxidized state. If oxygen and oxidizing substances are in low concentration, then the redox state will shift towards a predominantly reduced condition. Whatever the overall redox situation, there will always be some kind of equilibrium between ascorbic acid and dehydroascorbic acid, with these two actively interconverting. Because ascorbic acid is being constantly regenerated there is always fresh ascorbic acid available to continue the work of oxygen scavenging.

Known Enzyme Dependence
Vitamin C has long been known to be involved in redox reactions and during the middle part of the 20th Century it was beginning to look as though that were its sole or principal role. However, the progress of enzymology has been inexorable and we now know of several enzymic processes that depend upon the vitamin. What is important to the nutritionist is not, of course, the biochemistry of the enzymes. It is the way in which the nature of those enzymes reflects the vitamin's physiological role and the consequences of deficiency.

Physiological Results of Deficiency

Symptoms Related to Connective Tissue
Prominent among the symptoms of severe Vitamin C deficiency, including scurvy itself, are symptoms that relate to lack of strength in connective tissues, and reduced ability for the cells to hold together.

These symptoms are:
1. Softening and bleeding of the gums
2. Ulcerations and poor ability to heal wounds and ulcers
3. Swelling of the legs and arms through oedema
4. Nose bleeding
5. Haemorrhagic spots under the skin
6. Teeth becoming loose and falling out

These conditions all reflect loss of strength by connective tissues and a failure of the intercellular matrix to hold together. Gums depend for their integrity upon connective
tissues. Wounds heal by producing new connective tissue called granulation tissue and this is also needed for healing ulcers. Clearly the blood vessels are losing their integrity so that fluid seeps from them. In the lesser case, oedema is produced as an excessive amount of intercellular fluid permeates through them, but in worse conditions whole blood escapes, causing haemorrhages. The stability of teeth in the jaw depends upon integrity of both the gums and the underlying bone. This connective tissue problem is very closely related to the known functions in the body of the enzymes prolylhydroxylase and lysyl hydroxylase.

**Symptoms Involving Weakness**
There are clear reports of reduction of working capacity in even marginal Vitamin C deficiency, while severe deficiency results in debilitating weakness, lassitude and exhaustion. This appears to be due to failure of carnitine biosynthesis in Vitamin C deficiency, which would normally occur in the presence of cytosolic hydroxylase, (Hughes, 1981) coupled with a partial failure of iron absorption. Lack of carnitine inhibits fatty acid oxidation and therefore fundamental energy production. Lack of iron eventually inhibits the iron-dependent enzymes and the supply of oxygen to the end of the respiratory chain. Inhibition of ATP synthesis must result.

**Symptoms Associated with the Adrenal Glands**
Vitamin C has a special affinity with the adrenal glands, both cortex and medulla, and is therefore helpful in cases of adrenal exhaustion. It will suffice here to say that the vitamin is clearly required for the biosynthesis of both the steroid hormones of the adrenal cortex and the catecholamines (adrenaline and noradrenaline) of the medulla in the presence of dopamine beta-mono-oxygenase.

**Appetite Loss**
The loss of the ability to biosynthesise the normal bioactive form of the hormone gastrin may account for the appetite loss in whole or in part. This process is normally facilitated by the enzyme peptidylglycine alpha-amidating mono-oxygenase.

**Raised Blood Cholesterol and Blood Pressure**
The connection between Vitamin C and the ability to hydroxylate cholesterol to remove it from the system makes it likely that cholesterol levels in the blood will be raised in Vitamin C deficiency (normally activated by cytochrome P450-dependent cholesterol-7-alpha-mono-oxygenase enzyme). A recent 10 year study has shown a direct correlation between blood pressure and vitamin C levels in young women. Researchers reported that a 1mg/dl increase in vitamin C levels in the blood was associated with 4.1mmHg lower systolic blood pressure and 4.0mmHg lower diastolic blood pressure.

**Possible Exacerbation of Schizophrenia, Chorea or Dyskinesia**
These neurological diseases are apparently worsened in the presence of simultaneous Vitamin C deficiency because lack of the activity of enzyme dopamine beta-mono-oxygenase leaves high levels of the neurotransmitter dopamine in the brain unrelieved. Of course, in these cases, the provision of Vitamin C may palliate but will not cure the condition.
Other Enzymes Affected by Vitamin C Deficiency
Liver hydroxylating and de-methylating enzymes are a group of detoxification enzymes whose action would only be expected to show up in the long term in the shape of altered incidence of chronic disease. This would be due to less efficient tissue cleansing when the vitamin is deficient.

Immunity Symptoms
We stated above, concerning scurvy that "If the disease was not relieved death would result from exhaustion or from acute infections such as pneumonia. Such infections usually produced a rapid fatal ending due to the patient's debilitated state". That Vitamin C depletion profoundly affects immune competence is very clear. The migration of neutrophils (a class of white blood cells that are central to the immune response) towards sites of infection or damage is inhibited in Vitamin C deficiency and is stimulated by replenishment with the vitamin. Some of the scientific studies on this relationship have been done on patients suffering from rare conditions in which white cell functions are specifically impaired. One of these is called Chronic Granulomatous Disease (CGD), a congenital haematological disorder (Winkelstein et al 2000), sometimes associated with the Kell blood group (Lee et al, 2000). Another condition is Chediak-Higashi syndrome. Daily intakes were around 1g and resulted in "dramatic reductions in infectious attacks". This is about 25 times the daily intake level thought in orthodox circles to be recommendable. The application of this same principle to people not having these specific syndromes has remained a point of recurring controversy between the orthodox and alternative positions. This brings us to considering points that relate not so much to Vitamin C deficiency as to the possible benefits from increasing intakes beyond the basic requirement.

The Benefits of Luxus Consumption
Further Immune Benefits
Most nutritionists acknowledge high daily intakes of Vitamin C, well above ordinary nutritional requirements, produce immune benefits that protect against infections. Pauling (1970) reported that susceptibility to the common cold was very much improved by very high intakes of Vitamin C. Today there is little ground upon which one can claim that Vitamin C is of much benefit for this purpose (Briggs, 1984). Some nonetheless claim that if the susceptibility to colds is unchanged by Vitamin C, then the severity of symptoms is reduced (Hemila, 1992) and enhanced with the addition of zinc. There is still considerable debate on this topic (Douglas et al, 2007). However, there is some evidence that the vitamin affects response to other infections both in animals and humans, including sepsis (Tyml, 2011). Whilst the serious infections that befall scurvy victims are correctly interpreted to be evidence of immune system failure, evidence that Vitamin C in a quantity greater than that required to keep scurvy at bay, or alternatively, greater than the officially recommended daily intake, is another matter. Like other aspects of luxus consumption, the whole idea is subject to debate at the present time. Weiner (1986) showed that five different criteria of immune function are improved by an "excess" of Vitamin C, whilst just one other criterion showed ambiguous results. However, the real proof has to come from clinically demonstrable protection from actual infectious attack. Weiner (1986) writes quite fully on
the role of Vitamin C at high intakes in combating various virus infections such as influenza, herpes and even AIDS. The evidence he quotes is that of Cathcart (1981, 1984), who clearly undertook a great deal of treatment with very high dose Vitamin C and became entirely convinced of its benefits. It is equally clear that Cathcart was "out on a limb" in relation to most other opinions. This evidence is likely to be regarded as being suspect because it was offered by an enthusiast and may not be thought objective. However, the doses were so high as to place this work in a category of its own. In other research, Schwartz & Weiss (1990) showed that people with higher serum ascorbate levels were protected from bronchitis. Other researchers in the literature have reported benefit in hepatitis, toxoplasmosis and herpes.

**Anti-Cancer Effects**

There are many reports of inverse correlations between Vitamin C intake (or blood levels of Vitamin C) and cancer incidence. They generally indicate a very favourable effect indeed upon cancer incidence. Werbach (1993) quotes some of these. Significantly, three of these references are to review articles that each offer conclusions from extensive literature surveys. Work by Block (1991) states that approximately 90 studies of this topic had been published by that date and "the vast majority have found statistically significant protective effects". This reviewer further concluded that the evidence was strongest in cancers of oesophagus, oral cavity, stomach and pancreas, with less complete evidence also for cervix, rectum, lung and breast cancer. These together represent a high percentage of all cancers. Laryngeal and bladder cancers are also covered by papers referenced by Werbach, together with adenomatous rectal polyps, a precancerous condition.

A second review article by Howe et al (1990) is concerned entirely with breast cancer and concluded, from a review of 12 studies on breast cancer as follows: "Increasing Vitamin C intake to 380mg per day would lower breast cancer rates in the US by 16%". The third reviewer, Kyrtopoulos (1987) states, "epidemiological studies have consistently shown a strong negative association between ascorbic acid intake and the incidence of gastric cancer". The work of Mirvish (1986) also stresses the protective effect of Vitamin C against gastric cancer through neutralizing the effect of the carcinogenic nitrosamines, but considers that similar protective effects extend also to the liver and upper respiratory tract. A few studies have been reported that do not fit in with these results and they have, for the time being at least, prevented most of the orthodox profession from accepting the value of Vitamin C in prevention of cancer. Given the massive amount of evidence in favour and the virtual absence of any disadvantage from using the amount of daily vitamin C suggested by Howe et al, it is hard to see what stands in the way of advocating this level of Vitamin C for prevention. More recent research has found that Vitamin C's role against cancer may be to destabilize tumour growth in hypoxic conditions, rather than relying on its antioxidant effect (Gao et al, 2007), adding to its repertoire of functions in vivo.

Notwithstanding these results, orthodox nutritionists have remained very negative about the benefits of Vitamin C to cancer patients. It is hard to know why they deny so much positive evidence.
Blockage of Nitrosamine Formation
Nitrosamines are formed spontaneously from the reaction of nitrates with amines and amides. Because these compounds coexist widely in nature, nitrosamines are present in foods, cosmetics and tobacco. Some of these, but not all, are carcinogens. Ingestion of nitrate or nitrite in food and water will encourage more to be formed. Whilst they are always present in our body fluids, it is obviously unwise to increase this needlessly. Even though quite natural waters contain some nitrite and nitrate, much of the extra amounts of these in water today come directly from nitrogen fertilizer applied to fields in farming. Most of the nitrate and nitrite in foods comes from their use as food additives to impart flavour to and to preserve cold meats, pates, bacon, sausage, corned beef and other meat products. We can, of course, avoid these, just as we can remove nitrates and nitrites from drinking water by water treatment. However, there is good evidence that the conversion of these into nitrosamines is inhibited by Vitamin C (Dion et al, 1982, Mirvish, 1986). A daily intake of 400mg has been shown effective. This is about ten times normally recommended levels. The involvement of Vitamin C in prevention of nitrosamine formation and possible involvement in nitrosamines breakdown was well reviewed by Walters (1974).

Excretion of Heavy Metals
In dealing with toxic metals we have made it clear that we face a considerable environmental hazard from that cause. It is important that nutrition should contribute all it can to both treating people who have suffered severe exposure and provide on-going protection to those who simply want to reduce the effects from unavoidable life-long low-dose exposure. Vitamin C is one of the nutrients that should be applied. Mirvish (1975) studied forty lead-burdened mothers treated during pregnancy with a combination of calcium phosphate and Vitamin C (1g / day). The 1g daily dose was about 25 times normally recommended intake. The urine content of a metabolite called 5-amino- laevalinic acid was used as an indicator of residual lead toxicity. This parameter decreased during the trial by 65% and the lead content of the placenta was reduced by 90%. Cadmium values were also reduced by this treatment. Where mercury is concerned there is less human evidence available, but guinea pig experiments have shown the same mechanism working. Work by Fox & Fry (1970) and Fox et al (1971) showed that cadmium toxicity in Japanese quail is decreased by ascorbic acid.

Anti-Inflammatory Effects
We have seen above that the effect of Vitamin C on the immune system is generally beneficial and its deficiency leads to immune deficiency. Yet Vitamin C appears to exert an effect whereby it diminishes the less desirable effects of inflammatory reactions. Because inflammation is a necessary part of body defences, nutritionists do not want to prevent it or limit its effectiveness. However, the chemical products generated as part of the inflammatory reaction also have a downside when they are released in excess or for too long a period. There is good evidence that Vitamin C plays an important role in modulating the output of histamine, an amine that is an essential component of the inflammatory reaction. On the one hand the vitamin is required for the production of histamine and yet is also effective in controlling the blood histamine level and keeping it within reasonable bounds (Clemetson, 1980). In view of its role in modulating such an important component of inflammation fluid, Vitamin C is fairly regarded as an anti-inflammatory factor.
**General Naturopathic Effects and Detoxification**

It seems clear that Vitamin C benefits several biochemically recognised detoxification mechanisms. For example, as given above, it acts as a co-factor for liver hydroxylating and demethylating enzymes. These include the P450 cytochrome enzymes that are closely involved with detoxifying foreign substances.

There are strong indications of Vitamin C's involvement, along with bioflavonoids like quercetin, in maintaining the tissue levels of the -SH peptide, glutathione. Vitamin C, as glutathione's "right hand man", can produce indirectly an antioxidant benefit similar to that of giving glutathione itself. Hence, the body's defences against oxidative stress and toxins appear to be "integrated" and various components of the system depend upon others. More and more research studies are serving to emphasize the vital roles played by glutathione and the parlous and relatively defenceless position of the human body that is deprived of its normal tissue concentrations. It is a highly protective metabolite. Its interaction with, and especially, its dependence upon, Vitamin C are important.

These biochemical aspects support the view that has developed out of naturopathic nutritional practice to the effect that Vitamin C is a mild and gentle promoter of detoxification. It seems it will never induce any harsh out-rush of toxins: no hard-to-control eliminations. As a gentle persuader, its influence is obviously welcome in most nutritional treatment.

**Named Diseases that Benefit**

We give here, a list of named complaints that have been reported as benefiting from Vitamin C. The list is long and diverse, all of which tends to put Vitamin C into a kind of "cure-all" position and that leads to non-acceptance among orthodox doctors. This position needs, however to be better understood than that. The actions of Vitamin C are often non-specific, as we have seen. In many conditions it does not produce "cure" but does produce benefit. Often it produces much more benefit in conjunction with other nutrients than it does by itself. This, then, needs to be viewed very much as a contribution to "normalizing cell biochemistry", which is inherently a non-specific thing, and the benefits that arise from that process to patients with named conditions are incidental to that "normalization". They are nonetheless important for that. The conditions are: Acne, Allergy, Alcoholism, Alzheimers Disease, Anaemia, Arthritis, Atherosclerosis, Hypertension, Bronchial asthma, Bruises, Candidiasis & Thrush, Cataracts, Chilblains, Hypercholesterolaemia, Colds, Sore Throats, Conjunctivitis, Constipation, Depression, Diarrhoea, Diverticulitis, Eczema, Chronic Fatigue syndrome, Fibrositis, Glaucoma, Gout, Gum disease, Haemorrhoids, Heartburn, Hepatitis, Indigestion, Leaky gut syndrome, Osteoporosis, Parkinson’s disease, Premenstrual syndrome, Rheumatism, Shingles, Psoriasis and other Skin Problems, Stress, Sunburn, Skin Ulcers and Varicose veins.
Vitamin C in Foods

Levels in Food Sources
For most people eating a varied diet, meat and fish will make minimal contribution. The Vitamin C content of cow's milk is low, but milk is no Vitamin C concentrate. In fact, the Vitamin C content does not survive the cheese-making process. Eggs contain none. Cereals, nuts and most seeds contain none. Most pulses do not contain any either, except fresh peas and fresh broad beans, resembling fresh vegetables in this respect.

We are definitely left with the conclusion that vegetables and fruits are the chief sources of Vitamin C. However, rather surprisingly, fruit does not quite match up to its popular image as the best source of Vitamin C. Vegetables, on average, are better. Green peppers take the prize, with red pepper, spring greens and parsley all good runners up. No fruit gives such a high value, but blackcurrants are a good source. Figs, among fruits and globe artichoke among vegetables, are dramatically poor sources. This means that a therapeutic diet that contains 1kg of fresh vegetables each day will offer 295mg of Vitamin C. If the same diet contains 300g of fresh fruit daily, then this will add a further 88mg, giving 435mg in total. This assumes that a wide mix of fruits and vegetables of different classes is being used. If one takes a figure of only 40mg / day of Vitamin C as an adult requirement, then this can be supplied by just 33g of fresh green pepper. On the other hand if you want to rely upon apples of average quality for your Vitamin C, you will need to eat 664g of them daily. Obviously, daily intakes well above the above figure of 435mg / day can be obtained with the same quantities of vegetables and fruits by carefully selecting those with higher than average Vitamin C content.

The average UK diet is rather modest in its content of vegetables and this results in a position wherein the potato plays a disproportionate part in providing the nation's Vitamin C. For several decades blood Vitamin C levels in the population have fallen during the winter and have revived in the spring when the new potatoes become available. However, this dependence has altered somewhat in the last 50-60 years due to a fall in potato consumption from 1.88kg / person / week in 1942 to just under 1kg / person / week in 1990. This loss in Vitamin C has been offset by an increase in weekly consumption of citrus fruit from 34g to 133g in a similar period and an increase in citrus juice consumption from 7g to 202g. The outcome of this has been that Vitamin C average intakes have dropped a little, but remain fairly satisfactory in relation to official recommendations at 52mg / day up to 1990 (National Food Survey). However, these figures would not rate as satisfactory by official US standards.

Requirements
The UK recommendations are those contained in the Dept. of Health Report 41 (1991). The adult Reference Nutrient Intake (RNI) is put at 40mg /day compared to the USA figure of 60mg / day. The UK figure for infants below 1 year is 25mg and 30mg for children below 10 years. These figures are also rather higher in the USA. There is no doubt that the UK Committee is the more cheeseparing of the two, as in the case of many other nutrients. So the questions are "who is right?" and "can either of them be right?" Actually, the situation about what Vitamin C intake is recommendable is a good test of any person's nutritional
philosophy. How should one interpret "requirement"? One needs to define that word. If it were a requirement just for avoiding scurvy, then about 10mg / day would do. However, even the UK Committee on Medical Aspects of Food Policy (1991, 18th impression: 2008) applies a higher standard than that. The figure of 40mg / day is based upon the amount needed to maintain plasma the level at a certain value, but that level was a modest one. Indeed, the avoidance of scurvy really was the sole criterion adopted by the Committee and the recommendation only got raised above 10mg / day because they were looking to provide some basic level of safety against falling to the plasma level at which scurvy symptoms might be expected to begin. This comes across as an extremely narrow view.

The Committee believes that benefits from intakes higher than the "antiscorbutic" ones have yet to be demonstrated. Here we encounter an extraordinary ability to interpret the same scientific data in different ways. There is a huge volume of research literature giving results that indicate that in many respects "the more Vitamin C the better", at least up to a value of about 1g / day. Given all that research, and given the virtual absence of any downside to raised Vitamin C intakes, at least up to 1g per day, the case seems overwhelmingly weighted in favour of using more than just a "normal" dietary intake.

The evidence for any undesirable effects from Vitamin C is very scanty indeed and in many respect unconvincing and usually only applicable anyway to extraordinarily high intakes of, say, 15 to 100g / day. We therefore do not feel any need to have regard to any substantial "downside" from the use of Vitamin C in intakes of up to 5g / day, which is the highest we ever want to employ. The overall conclusion of Shrimpton (1995), acting and writing for the European Federation of Associations of Health Product Manufacturers, was that "daily intakes of up to 2000mg are safe". Shrimpton quotes five significant research references upon which he based his conclusions. The main negative suggestions have been that high ascorbate intake leads to renal stones and may act as an anti-vitamin to Vitamin B12. Overall these allegations have not been substantiated.

Given this position, the question remains as to how much daily Vitamin C is indicated for a person in at least reasonably good health who is seriously interested in optimizing his or her health in the future? The answer that we have come to is a minimum of 250mg / day and a maximum of 1g /day, with a balanced view being about 500mg / day. The so-called "maximum" of 1g per day is not due to consideration of any hazard but simply taking a realist's view of probable cost and benefit. In disease states, however, a higher dosage is recommended. One should note that smoking greatly increases demand for Vitamin C and requirements to reach a given blood level may rise by around 40%.

Maximising Absorption and Metabolism

Absorption and Metabolism of Vitamin C
Vitamin C is rather readily absorbed by an active-transport mechanism in the intestinal wall and under normal circumstances some 70-75% of that ingested is absorbed. Iridologist, Dorothy Hall of Sydney, Australia, has suggested that Australian Aboriginals have a particular difficulty with regard to Vitamin C absorption, but this does not appear to have
been substantiated. Once absorbed, the vitamin can disseminate freely in the blood and tissue fluid, reaching up to 20mg / kg of body weight at generous intakes.

**What Forms Of Vitamin C Are Best?**

We have already seen how the presence of bioflavonoids is required for vitamin C to be effective in returning integrity to blood vessels. We also know that the addition of bioflavonoids to ascorbic acid supplements increases the body's ability to utilise the ascorbic acid, and that they both enhance each other's antioxidant properties. This has therefore become the preferred form of vitamin C supplementation for many. For those who find ascorbic acid too acidic, and therefore irritating to the stomach, the mineral ascorbate form of vitamin C may be a wiser choice, as here the acidity has been neutralised. This is where minerals, such as calcium, magnesium and potassium, are bound to the ascorbic acid, and once in the body, are then freed up again so that both vitamin C and the minerals are all available for use. This means that the mineral content of ascorbates needs to be taken into account when calculating the supplemental intake of those minerals. It was therefore also advisable to use a formula containing a mixture of ascorbates, in order to disturb the body's own electrolyte balance as little as possible.

Whichever you choose, vitamin C has rightly earned its place as a key nutrient for supplementation, not just for scurvy-affected sailors, but for all of us with modern diets and lifestyles.

**The Benefits of Vitamin C Plus Bioflavonoids**

Many suppliers offer ascorbic acid or ascorbates in the form of mixtures with bioflavonoids. These are usually citrus fruit bioflavonoids, though they may occasionally come from other sources. The rationale is that quite a lot of evidence shows that the bioflavonoids enhance the actions of the vitamin in various ways. These indications existed from the earliest days.

Szent-Gyorgyi, one of the initial discoverers of Vitamin C, observed that pure ascorbic acid, which is today most often taken to be equivalent to Vitamin C, did not by itself relieve quite all the effects of scurvy. The symptoms of scurvy included a marked tendency to multiple small haemorrhages - bleeding from the smallest blood vessels – in various parts of the body, but exemplified by the bleeding gums that were a typical feature of the disease. This feature could be cleared up using, instead of pure Vitamin C, a crude concentrate of the vitamin derived from peppers. This crude concentrate contained bioflavonoids - a class of "phytonutrients" (literally, "plant nutrients") contained in some fruits, but not all. This subsequently led to the concept of the so-called vitamin activity, or vitamin-enhancing activity of bioflavonoids. It became known as "Vitamin P activity". Vitamin P activity consisted of the relief of conditions arising from weakened and damage blood vessels that had become more porous or leaky than they should be. The existence of Vitamin P was supported by Russian workers but generally derided by science in the West. The point here was that the bioflavonoids did not exert that action by themselves - it needed both bioflavonoids and Vitamin C. This opens an important question about the real nature of Vitamin C. Purified ascorbic acid as widely sold has most of the recognised physiological actions ascribed to natural Vitamin C but experiments on the so-called "Vitamin P effect" of bioflavonoids led to the view that the main difference between Vitamin C in foods and pure ascorbic acid was due to the presence of bioflavonoids in the foods. By mixing bioflavonoids

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with Vitamin C it was shown that several benefits could be gained compared with ascorbic acid alone. In particular it was noted that bioflavonoids used in conjunction with the vitamin could increase absorption, tissue uptake and tissue retention of the vitamin. Several different in vitro measures of Vitamin C activity were found to be enhanced with bioflavonoids, as were several in vivo and clinical effects. The conclusion is that since bioflavonoids do enhance many actions of Vitamin C, products that include both Vitamin C and suitable bioflavonoids do have real merit. On the other hand, a therapeutic diet that contains plenty of onions, green tea and some citrus juice may itself contain sufficient bioflavonoids to act as Vitamin C enhancers without further supplementation.

Summary

Many might query the high dosages when it comes to the subject of Vitamin C supplementation. As we can no longer manufacture Vitamin C in the body, unlike most other mammals, the subject of supplementation is one of importance. It should be remembered that this is a very labile substance, subject to deterioration in raw fruits and vegetables over time, so that the amount of Vitamin C in the cooked food that arrives on our plate will be much lower than it really ought to be. The body pool of Vitamin C in the healthy adult is maintained at 900mg if 40mg/d is the intake, but this does not take into account its utilization in the body of an individual with greater need. The Recommended Daily Amounts or RDA is quoted as 'the average amount that should be provided per head in a group of people if the needs of practically all members of the group are to be met'. A shortened translation might be that it is the average amount for the average 'healthy' person. This level does not cater for our individuality or our own particular nutritional needs. Therefore, the term RDA could be construed as the minimum to avoid a deficiency state. Research that has shown its diverse functions in cardiovascular disease, adrenal function, immunity, detoxification, anti-oxidation, anti-inflammatory processes and cancer support are a tribute to its necessary roles in disease states. It would also indicate that at some level, it is essential to maintain peak function in health. Even so, dosages that are higher than the recommended daily intake may cause worry for non-practitioners. Thus, the assurance should be that as it is water soluble, Vitamin C is readily excreted in urine. So, unless there is significant kidney impairment, that which is not used will be eliminated. Vitamin C is one of the most fundamental nutrients in the practitioner's programme and, with modern food practices, it may become an even more important supplement to support today's diet.

References

Vitamin C: Our Shield from Misfortune