Dietary control of oxidative stress

a DSM Product

DSM Nutritional Products

Unlimited. DSM

Dietary control of oxidative stress

To stay fit and reduce the health risks associated with aging, it is important to have a regular intake of all the nutrients that the body needs to function properly. Ideally, this should be possible by eating a balanced, micronutrient-rich diet. The increase in environmental and lifestyle stresses that has accompanied civilisation could, however, make it harder for today's populations to obtain the amounts needed from food alone. To be sure that the body gets enough nutrients, so it is able to produce vital enzymes and protective molecules in sufficient quantities, it might therefore be considered prudent to take a dietary supplement.

Many of the conditions that threaten life today, such as heart disease, cancer, diabetes, Alzheimer's disease, rheumatoid arthritis and cataract are, to a considerable extent, the result of "oxidative stress", a condition that occurs when the body's antioxidant defences are impaired. By avoiding oxidative stress, it should be possible to enjoy more years of healthy life.

Why is oxidative stress a problem?

Everyone is exposed to oxidative stress, either voluntary or as a result of normal life. Air pollution, particularly smoking, can be avoided to certain extent, but our body uses oxidative processes for many purposes (table 1):

Oxygen is essential for human life. It is needed to produce the energy from food that allows cells and tissues to breathe, grow, and function properly. The body also uses oxygen to kill intruders (such as bacteria and viruses) and body cells that have got out of control (potential cancers). It does this by producing highly reactive chemicals, known as 'reactive oxygen species' (ROS) that destroy the targeted cells by oxidising vital structures in them.

ROS include oxygen-rich molecules, ions and radicals (also called free radicals). Radicals are atoms or clusters of atoms that contain an unpaired electron in the outermost shell. Because of this extremely unstable configuration, radicals quickly react with other molecules and radicals, causing a chain reaction that continues until a stable situation is reached.

Table 1: Sources of radicals

External	Internal
Air pollution	Energy conversion process (mitochondria)
Gas exhaust	Immune reactions
UV radiation	White blood cells
Smoking	Peroxysomes: oxidation of particular molecules
Irregular physical exercise	Reperfusion after surgery

Reactive oxygen species may interfere with all biological structures modifying thus their original function. Oxidation of DNS may lead to wrong copies of the genetic code, oxidation of polyunsaturated lipids alter the correct mode of action of membranes and even proteins are vulnerable towards oxidative damage.

The immune-defense triggered release of peroxides may injure healthy tissues that can be observed e.g. as red, warm spots on the skin during an infection.

To prevent damage to the body's own healthy cells and tissues from ROS, Nature has provided a complex system of antioxidant protective measures. Some of these are produced by the body itself (enzymes and reducing substances) and some must be obtained from the diet (vitamins, carotenoids, minerals, trace elements, flavonoids, etc).

In modern societies, the body not only has to deal with the desirable, natural sources of ROS, it also has to cope with the detrimental effects of environmental pollution, high levels of solar radiation, tobacco smoke and irregular physical exercise, all of which increase the level of oxidation in normal cells.

Once oxidation has got underway, the reaction continues, producing more ROS (especially the particularly reactive free radicals). As a result of the chain reaction that ensues, damage can be extensive and permanent. This causes premature aging, and could lead to the onset of chronic, potentially life-threatening, disease (Table 2).

Table 2. How oxidative stress affects our health

Triggering factor	Result
High blood pressure, high levels of “bad” cholesterol and, possibly, injury to the artery wall intensify narrowing and hardening of the arteries (atherosclerosis)	Heart disease, stroke
Oxidation of DNA, a vital molecule in the cell nucleus	Cancer
High lipid content of the brain and nerves is highly susceptible to oxidation	Brain and nerve damage (e.g. Alzheimer’s disease, Parkinson’s disease)
Oxidation and inflammation in the joints	Rheumatoid arthritis
Unprotected exposure to sunlight causes oxidation in the lens and/or the back of the eye	Cataract, macular degeneration (blindness)
Unprotected exposure to sunlight makes skin dry and wrinkled	Premature aging of the skin, skin cancer
High blood glucose levels in diabetes increase oxidation of lipids and cell proteins	Heart disease, stroke, damage to the eyes, kidneys and nerves

Can oxidative stress be measured?

Researchers have developed several ways to measure oxidative damage or the potential of an individual to withstand oxidation. Antioxidant levels and enzyme activity can be measured in body fluids and blood cells, for example. However, there are, as yet, no widely accepted “normal” levels nor agreement on which is the most reliable method. Most are considered unpractical or too costly for general use.

When is protection against oxidative stress needed most?

Many chronic diseases can be prevented or postponed by appropriate dietary measures; therefore, nutrition policies have been issued by health authorities of most countries. Thus, the following groups might find it worthwhile to consider antioxidant supplementation:

Who has to pay special attention for an adequate supply of antioxidants?

- **People who live in cities** with high levels of air pollution (e.g. from traffic or industry);
- **People exposed to high levels of sunlight** and/or ozone, especially at high altitudes, in snow or on water (e.g. skiers, mountain climbers, sailors, outdoor workers, sunbathers), especially light-skinned people with blue or green eyes;
- **People who do not regularly eat enough fruit and vegetables** and those with digestive problems that require higher than normal intakes to compensate for poor absorption; this also includes people on weight-reducing diets and elderly, as well as those “on the go” who do not take the time to eat proper meals;
- **People who exert themselves physically,** especially heavy labourers and “weekend” athletes who exercise irregularly (while appropriate regular training increases antioxidant efficacy, serious athletes can also benefit from supplementation);
- **People who are regularly exposed to tobacco smoke;**
- **People with high blood pressure,** high blood levels of cholesterol or problems with their heart or blood circulation;
- **People with diabetes or metabolic syndrome** (a cluster of factors including abdominal obesity, high blood pressure, insulin resistance and lipid abnormalities, which increase the risk of heart disease);
- **People with poor kidney function,** and especially those who need dialysis therapy.

How can oxidative stress be controlled?

The risk of developing oxidative stress can be reduced by avoiding situations with a high level of ROS (crowded, smoky rooms, city centres, industrial areas), by wearing sunglasses and a hat, and using a sunscreen when outdoors, by a healthy life style, and by ensuring an adequate intake of antioxidant nutrients, either from food or from dietary supplements.
In order to protect ourselves, we need a complete set of molecules or enzymes for the conversion of the high energy of radicals to harmless forms like heat.
We can partly produce certain antioxidants ourselves, especially enzymes, but to assure a competent response we have to rely on external antioxidants as well (table 3).

The most important natural antioxidants are vitamin C, vitamin E, coenzyme Q10, carotenoids, phenolic compounds like flavonoids or hydroxatyrosol, while the minerals selenium, copper and zinc (as well as vitamins of the B complex) are essential for the proper functioning of antioxidant enzymes.

Table 3: Antioxidants

Endogenous	Exogenous
Catalase (enzyme)	Vitamin C
Superoxide dismutase (enzyme)	Vitamin E
Glutathione peroxidase (enzyme)	Carotenoids (β-Carotene, Lycopene, Lutein, Zeaxanthin)
Glutathione (peptide)	Flavonoids (EGCG),
CoQ10 (fat soluble antioxidant)	Polyphenols (hydroxytyrosol)
Uric acid (metabolite with antioxidant property)	Selenium

Vitamin C

- Water soluble antioxidant
- Improves iron absorption
- Required by several enzymes as a cofactor in Red-ox reactions
- Enhances immune-defense reactions
- Regenerates radicals such as α-tocopheryl radical
- Essential for humans

Vitamin E

- Fat soluble antioxidant
- Fits perfectly well into membranes to protect unsaturated fatty acids
- Protects cell membranes
- Essential for humans

Coenzyme Q10 (CoQ10)

- Fat soluble antioxidant synthesized by the human body
- Component of the respiratory chain in the mitochondria (energy generation)
- Synthetic capacity diminishes with age

Carotenoids

- Fat soluble plant pigments with antioxidant property
- Over 600 known in nature, but only a few relevant for humans

  · β-carotene
    · Pro – vitamin A
    · Protects the sun-exposed skin from inside

  · Lutein, zeaxanthin
    · Accumulate in the retina of the eye
    · Protect the retina from the high energy of blue light
    · Protects the sun-exposed skin from inside

  · Lycopene
    · Accumulates in the prostate gland
    · Linked to reduced prostate cancer risk
    · Protects the sun-exposed skin from inside

Phenolic compounds

- Flavonoids: large family of polyphenolic compounds
  · Epigallocatechin gallate (EGCG)
    · Most important catechin in green tea
    · Excellent antioxidans
- Hydroxytyrosol
  · Potent antioxidant from olives
  · Antimicrobial and antibacterial activity

Table 4: Suggested intakes of antioxidant factors

Factor	Suggested daily intake (mg)
Vitamin C (ascorbic acid)	75–150
Vitamin E (tocopherols)	15–30
Coenzyme Q10 (CoQ10)	10–20
Beta-carotene	2–4
Lycopene	2–4
Lutein	5
Zeaxanthin	1
Epigallocatechin gallate (EGCG, a catechin in green tea)	30–150
Hydroxytyrosine	5 – 20mg
Selenium	0.03–0.07
Copper	1–1.5
Zinc	7–10

DSM

Bibliography

Carr AC, Zhu BZ, and Frei-B.
Potential antiatherogenic mechanisms of ascorbate (vitamin C) and alpha-tocopherol (vitamin E).
Circulation research, 87, 349-54, 2000

Casetta I, et al.
Oxidative stress, antioxidants and neurodegenerative diseases.
Current pharmaceutical design, 11, 2033-52, 2005

Cherubini, A., et al.
Role of antioxidants in atherosclerosis: epidemiological and clinical update.
Current pharmaceutical design, 11, 2017 32, 2005

Collins A-R.
Assays for oxidative stress and antioxidant status: applications to research into the biological effectiveness of polyphenols.
The American journal of clinical nutrition, 81, Suppl, 261S-267S, 2005

Dryden G. et al.
Clinical implications of oxidative stress and antioxidant therapy.
Current gastroenterology reports, 7, 308-16, 2005

Gann PH., et al.
Lower Prostate Cancer Risk in Men with Elevated Plasma Lycopene Levels.
Cancer Research 59, 1225-1230, 1999

Houston-Mark-C.
Nutraceuticals, vitamins, antioxidants, and minerals in the prevention and treatment of hypertension.
Progress in cardiovascular diseases, 47, 396-449, 2005

Johansen- Schultz J. et al.
Oxidative stress and the use of antioxidants in diabetes: linking basic science to clinical practice.
Cardiovascular diabetology, 4, 5, 2005 (11 pages)

Kelly-Frank-J.
Vitamins and respiratory disease: antioxidant micronutrients in pulmonary health and disease.
The Proceedings of the Nutrition Society, 64, 510-26, 2005

Kris-Etherton P.M., et al.
Bioactive compounds in foods: their role in the prevention of cardiovascular disease and cancer.
The American journal of medicine, 113 Suppl 9B, 71S-88S, 2002

Mandel, S., et al.
Green tea catechins as brain-permeable, natural iron chelators - antioxidants for the treatment of neurodegenerative disorders.
Molecular nutrition & food research, 50, 229 34, 2006

Morganti P., et al. ,
Protective effects of oral antioxidants on skin and eye function.
Skinmed, 3, 310-6, 2004

Prasad K-N.
Rationale for using multiple antioxidants in protecting humans against low doses of ionizing radiation.
The British journal of radiology, 78, 485-92, 2005

Rahman I. et al.
Oxidant and antioxidant balance in the airways and airway diseases.
European journal of pharmacology, 533, 222-39, 2006

Riccioni, G. and N. D'Orazio
The role of selenium, zinc and antioxidant vitamin supplementation in the treatment of bronchial asthma: adjuvant therapy or not?
Expert opinion on investigational drugs, 14, 1145 55, 2005

Sheu S-S., et al.
Targeting antioxidants to mitochondria: a new therapeutic direction.
Biochimica et biophysica acta, 1762, 256-65, 2006

Stahl W. and Sies H.
Bioactivity and protective effects of natural carotenoids.
Biochimica et biophysica acta, 1740, 101-7, 2005

Triggiani, V., et al.
Role of antioxidants, essential fatty acids, carnitine, vitamins, phytochemicals and trace elements in the treatment of diabetes mellitus and its chronic complications.
Endocrine metabolic & immune disorders drug targets, 6, 77 93, 2006

van Leeuwen, R., et al.
Dietary Intake of Antioxidants and Risk of Age-Related Macular Degeneration
JAMA, 294, 3101-3107, 2005

Violi F., and Cangemi R.
Antioxidants and cardiovascular disease.
Current opinion in investigational drugs, 6, 895-900, 2005

Visioli F, and Galli C.
Antiatherogenic components of olive oil.
Current atherosclerosis reports, 3, 64-7, 2001

DSM Nutritional Products Europe Ltd

P.O. Box 3255
CH-4002 Basel
Switzerland

www.dsmnutritionalproducts.com

7/2006 · GAS.Grenzach@t-online.de

xxxxx