VITAMIN C AS ANTIOXIDANT AND PROOXIDANT

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Introduction

Vitamin C (*L*-ascorbic acid) is a vitamin soluble in water and has two bioactive forms that may switch one into another *via* a redox process (Fig. 1.). Recommended daily allowance of vitamin C depends on several parameters, such as age, gender, weight, physical activity, etc. Sources are fruit and vegetables (Fig. 1.), and since it can not be synthetized in the human body (due to lack of *L*-gulonolactone oxidase) it needs to be taken on a daily basis.

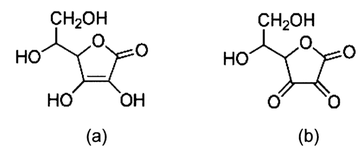

Figure 1. Sources and structure of *L*-ascorbic acid (a) and dehydroascorbic acid (b).

Oxidative stress, antioxidants and prooxidants

Disbalance between concentration of free radicals and the activity of our endogenous antioxidative mechanisms results in oxidative stress. Free radicals may cause damage to biomacromolecules and contribute to the development of various diseases, such as cardiovascular and neurodegenerative diseases, age-related diseases, and even cancer. Natural or synthetic compounds, such as vitamin C (Fig. 2.) may act as exogenous antioxidants and by neutralizing free radicals they interfere with advancement of said diseases. Aside from direct scavenging of free radicals, vitamin C also regenerates other antioxidants, such as vitamin E. Vitamin C also may exhibit prooxidant activity. Such activity may have a positive effect on the body because it induces body adaptation to oxidative stress, additionally activates antioxidant enzymes, and may help with fighting cancer.

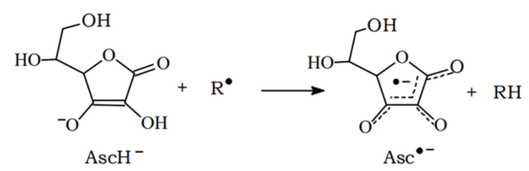

Figure 2. Reaction of ascorbyl with a free radical.

Brief review of studies on vitamin C as antioxidant

AUTHORS	YEAR	STUDY	MAIN RESULTS
Kunert and Tappel	1983	Guinea pigs exposed to CCl_4, fed with high vitamin C conc. (75 mg/100 g)	Guinea pigs fed with vitamin C had reduced amount of exhaled ethane
Kato *et al.*	1984	Guinea pigs exposed to PCB, received vitamin C supplementation	reduced lipid peroxidation in the liver
Wantanowicz *et al.*	1984	older population, during a year received 400 mg vitamin C daily	reduced lipid peroxides in the serum for 13 %
Shankaran *et al.*	2001	chemically induced production of $OH^{\bullet}$ in rats, treatment with vitamin C	reduced formation of $OH^{\bullet}$
Kumar *et al.*	2004	100 mg vitamin C /kg of body mass, daily	antioxidant activity observed
Jelodar *et al*.	2013	200 mg/kg of body mass, daily	increased activity of SOD, GP and catalase
Jelodar *et al.*	2014 a, b, c		

Brief review of studies on vitamin C as prooxidant

AUTHORS	YEAR	MAIN RESULTS	TYPE OF CANCER
Takahashi *et al.*	2012	improved life quality	lungs, breast, stomach, colon, uterus, liver, prostate, ovaries, pancreas, malignant lymphoma
Stephenson *et al.*	2013	improved life quality	anus, breast, choroid, colon, ear, liver, lung, pancreas, rectum, skin, small intestine
Hoffer *et al.*	2015	increased energy, functional increase	lungs, colon, rectum, bladder, ovaries, uterus, biliary tract, breast, tonsils
Schoenfeld *et al.*	2017	prolonged life span	glyoblastoma, lungs
Zhao *et al.*	2018	reduction of symptoms, prolonged life span	acute myeloid leukemia
Impact of vitamin C on the organism in combination with chemotherapeutics or ionising radiation			
Espey *et al.*	2011	pancreas + gemcitabin	tumor growth inhibition
Hatem *et al.*	2018	ovaries + karboplatin i paklitaksel	tumor growth inhibition, reduction of chemotherapy side effects
Du *et al.*	2015	pancreas + ionising radiation	tumor growth inhibition, prolonged life span

Conclusion

Vitamin C is one of the most studied and most popular vitamins. It is a powerful antioxidant, and it's antioxidant activity may play an important role in the prevention and defence against various diseases. In certain conditions, this vitamin may act as prooxidant. Vitamin C prooxidant activity may also aid in defence against some diseases, such as cancer. Hence future studies are in good part aimed to understand the full potential of vitamin C as antioxidant and as prooxidant.