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Bioactive Compounds and Antioxidant Capacity of Ascorbic Acid

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ABSTRACT:
Vitamin C (Ascorbic Acid), the antiscorbutic vitamin, cannot be synthesized by humans and other primates, and has to be obtained from diet. Ascorbic acid is an electron donor and acts as a cofactor for fifteen mammalian enzymes. Two sodium-dependent transporters are specific for ascorbic acid, and its oxidation product dehydroascorbic acid is transported by glucose transporters. Ascorbic acid is differentially accumulated by most tissues and body fluids. Plasma and tissue vitamin C concentrations are dependent on amount consumed, bioavailability, renal excretion, and utilization. To be biologically meaningful or to be clinically relevant, in vitro and in vivo studies of vitamin C actions have to take into account physiologic concentrations of the vitamin. In this paper, we review Ascorbic acid's ability to replenish -tocopherol and maintain its antioxidant capacity through circulation and pro-oxidation inhibition is essential for the synergy between -tocopherol and ascorbic acid. Inhibiting the formation of protein carbonyls and amyloid cross-structure, fructose-induced BSA glycosylation samples have been shown to preserve the integrity of proteins.

KEYWORDS: Vitamin C, Dehydroascorbic Acid, Vitamin C Transport, Scurvy.

I. INTRODUCTION

The best-known use of vitamin C is as an antioxidant and as an essential nutrient for preventing deficiency diseases, particularly scurvy. Ascorbic is a word that implies "no scurvy." The majority of plants and mammals can synthesise vitamin C from glucose on their own. However, consuming food is the only way for people to obtain vitamin C. Lglucono-gamma lactone oxidase, a specific enzyme required for in vivo synthetization, is absent in humans. Citrus fruits, leafy veggies, and broccoli are some foods that contain vitamin C.

The chemical make-up of vitamin C LAscorbic Acid (LAA) and D-Ascorbic Acid are two distinct forms of ascorbic acid that are mirror images of one another. (DAA). Only the second is biologically active. The construction is shown in Figure 1. It has a 5-carbon ring, comparable to glucose's. (1).

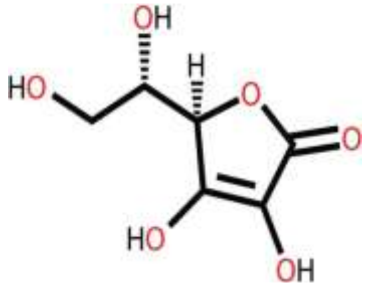

FIGURE 1: ASCORBIC ACID'S STRUCTURE

Water-soluble vitamin C, also referred to as L-ascorbic acid ((5R)-5-((1S)-1,2-dihydroxyethyl)-3,4-dihydroxy-2,5-dihydrofuran-2-one), is found in some meals naturally, is added to others, and can also be purchased as a dietary supplement. Because vitamin C cannot be synthesised by humans, unlike most mammals, it is a vital dietary component. Vitamin C is necessary for the production of certain neurotransmitters, L-carnitine, and collagen.Vitamin C is unfortunately known to be sensitive to light, pH, high temperatures and exposure to oxygen, which cause degradation (2).

The high instability and reactivity of ascorbic acid is the primary obstacle in the development of ascorbic acid products. When ascorbic acid is exposed to light, heat, transition metal ions, and pH (alkaline condition), it reversibly oxidises into dehydroascorbic acid (DHA), which then irreversibly hydrolyzes to produce 2,3-diketogulonic acid. (Figure 2A). Researchers have become very interested in the method of protecting ascorbic acid from delicate environments by encasing it inside a coating of wall material in recent years. Microfluidic (3), melt extrusion (4), spray drying, and chilling (5,6) are just a few of the innovation delivery technologies that have evolved. These techniques typically result in microscale particulates. In certain circumstances, ion gelation of chitosan or complicated coacervation with other materials can be used to achieve nano-encapsulation of ascorbic acid.

II. BIOACTIVITY OF ASCORBIC ACID

2.1. Antioxidant

Reactive oxygen species (ROS), which include superoxide radicals (O2•), singlet oxygen (1O2), hydrogen peroxide (H2O2), and extremely reactive hydroxyl radicals (OH•), are byproducts of normal cell metabolism. The negative impact of ROS is that it can start a chain reaction of radicals that results in the production of hydroxyl free radicals and other harmful species. These further cause lipid peroxidation, protein and DNA damage, and ultimately cell death (7). Ascorbic acid can prevent a variety of illnesses brought on by oxidative stress in the body, including cancer, cardiovascular disease, aging, and cataracts, with the fewest adverse effects (8). According to studies, the plasma concentration of ascorbic acid is inversely linked to the mortality from these diseases (9). Age-related lipid peroxidation in vivo can be decreased by ascorbic acid and its compounds (10). Ascorbic acid can lessen the incidence of mutations brought on by H2O2 in human cells in the absence of transition metals (11). Ascorbic acid ends the free radical chain reaction through a disproportionation reaction, as opposed to other polyphenols or flavonoid antioxidants, and the reaction products, such as DHA and 2,3-diketogulonic acid , are non-damaging and non-radical (12). Ascorbic acid's ability to create comparatively stable ascorbic acid free radicals and donate single electrons is another example of its antioxidant properties (13). According to research, in order to keep the integrity of proteins, antioxidants can also repair tryptophan free radicals created by the one-electron oxidation of free tryptophan in lysozyme (14).

Additionally, ascorbic acid is employed as an antioxidant to preserve the flavour and nutritious value of food. It acts as an anti-browning agent and can prevent oxidation from turning fruits and vegetables brown. The accumulation of H2O2, which is triggered by the creation of quinones by polyphenol oxidase, results in the browning of polyphenols by peroxidase (15). By performing a "deactivation reaction," ascorbic acid prevents browning by converting the o-quinone that polyphenol oxidase produces back to the initial diphenol (16). Ascorbic acid's competitive inhibition of polyphenol oxidase activity is thought to have contributed to the protective impact in addition to the polyphenols' regeneration mechanism. Ascorbic acid, on the other hand, produces a drop in pH and hinders the expression of polyphenols.

2.2 Pro-Oxidant

According to the Fenton reaction, pro-oxidant activity is the capacity of antioxidants to lower transition metal ions to a reduced oxidation state. In the Fenton reaction, ascorbic acid reduces transition metal ions like Fe3+, and then Fe2+ reacts with oxygen and hydrogen peroxide to produce extremely potent and damaging hydroxyl radicals (17). Ascorbic acid does not always exhibit antioxidant activity; under some circumstances, it can change into a pro-oxidant and exhibit toxic effects. Ascorbic acid has a dual impact on the redox properties of bovine hemoglobin, acting as an antioxidant at the beginning of the process.

2.3Co-Factors

As a free radical scavenger and an electron transfer donor/acceptor, ascorbic acid can also be used as a co-factor for enzymes and other bioactive substances to indirectly perform biological activities while also directly expressing its antioxidant properties. Ascorbic acid does not actively take part in the catalytic cycle during the metabolic process of both plants and mammals. As an essential co-factor for enzymes, ascorbic acid controls the hydroxylation mechanisms in a variety of enzymatic reactions. Ascorbic acid serves the purpose of keeping the transition metal ions of enzymes that contain iron or copper in a diminished form so that they can function at their peak physiological levels (18). Prolyl 4-hydroxylase is one of the non-heme iron - ketoglutarate-dependent dioxygenases that uses ascorbic acid as a co-factor.

Combined Effect

Ascorbic acid is a naturally occurring antioxidant that typically coexists with other elements in nature. When combined with other antioxidants, it might have a multiplicative or even synergistic impact. As chain-scission antioxidants, ascorbic acid and vitamin E significantly suppress the oxidation of lipids in vitro and in vivo, as well as the auto-oxidation of polyunsaturated liposomes found on cell membranes (19). According to research, the combination of 1% -tocopherol and 15% ascorbic acid can greatly reduce sunburn cells and erythema (20). The ability of ascorbic acid to regenerate -tocopherol and sustain the antioxidant capacity of -tocopherol through circulation and inhibition of pro-oxidation is essential for the synergy between -tocopherol and ascorbic acid (21). The synergistic effect in the inhibition of amyloid cross-structure and protein carbonyl formation in fructose-induced BSA glycosylation samples (22) makes the combined use of ascorbic acid and gallic acid a promising approach to prevent the formation of advanced glycation end products. When combined with ascorbic acid and/or -tocopherol, lycopene can inhibit inflammation and further trigger the release of the anti-inflammatory cytokine IL-10 (23). It is possible to choose the antioxidant system of foods and medications more carefully by being aware of the synergy between ascorbic acid and other bioactive substances.(24)

III. CONCLUSION

The bioactivity of ascorbic acid is presented in this review. Another illustration of ascorbic acid's antioxidant capabilities is its capacity to generate relatively stable ascorbic acid free radicals and contribute single electrons .According to study, antioxidants can also repair tryptophan free radicals that are produced by the one-electron oxidation of free tryptophan in lysozyme in order to maintain the integrity of proteins .Research has shown that the mixture of 15% ascorbic acid and 1% tocopherol can significantly lessen sunburn cells and erythema .The synergy between -tocopherol and ascorbic acid depends on ascorbic acid's capability to regenerate -tocopherol and sustain its antioxidant capacity through circulation and inhibition of pro-oxidation. According to study, fructose-induced BSA glycosylation samples have a synergistic effect in inhibiting amyloid cross-structure and protein carbonyl formation, maintaining the integrity of proteins. Studies have demonstrated a substantial reduction in erythema and the development of sunburn cells when 15% ascorbic acid and 1% -tocopherol are combined. It is possible to choose the antioxidant system of foods and medications more carefully by being aware of the synergy between ascorbic acid and other bioactive substances.

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