

Vitamin C as A Possible Immunity Booster

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Abstract

Deficiency in vitamin C, an essential micronutrient and antioxidant, may result in a compromised immune response because of its central role in immune system regulation. An important question is how effective Vitamin C might be in preventing and treating infections. We reviewed the literature to learn more about vitamin C's role in the health of white blood cells (WBCs) and the expression of genes involved in the immune system and to consider whether or not vitamin C could enhance current therapies. Alternatively, to what extent Vitamin C helps in boosting our immunity?

Keywords—Vitamin C; Ascorbic Acid; immunity;

1. Introduction

Vitamin C (ascorbic acid) is essential for healthy immune system function. The immune system has developed over millions of years to defend the body against invading microorganisms, fungi, parasites, and cancer cells. It consists of a vast web of interconnected organs, cells, genes, proteins, and chemicals. Vitamin C is a crucial micronutrient, but since humans lack a critical enzyme in the biosynthesis route, they must take it in supplement form daily.

Scurvy can develop from a lack of vitamin C or a clinical shortage of the vitamin, which can cause a decreased immune response and altered susceptibility to infection, stunted development, and weaker collagenous structures with delayed wound healing. Which ultimately weakens the body's defences. Vitamin C, a powerful antioxidant found in nature, is involved in many immunological responses and the regulation of genes involved in immunity. This raises the question of whether vitamin C can be utilised to treat illnesses like Covid-19 and to what degree vitamin C influences the immune system.

2. Vitamin C

Vitamin C, also known as L-ascorbic acid, is a necessary vitamin for human health that may be obtained primarily from the consumption of citrus fruits like lemons and oranges and vegetables. Vitamin C has antioxidant properties and is required for the synthesis of proteins like collagen [1]. Glutathione and vitamin E, among others, rely on vitamin C's redox potential to stay reduced and regenerate [2]. In spite of inconsistent clinical findings, vitamin C has been widely utilised for cancer therapy and prevention [1].

L-gulonolactone oxidase (GULO) catalyses the final step in vitamin C production; however, human cells lack the ability to accomplish this reaction, and therefore, we must consume it regularly basis [2]. Among 2668 persons in the northern part of India, 73.9% were deficient in vitamin C, and among 2970 people in the southern part of the country, the prevalence was 45.7%. In the north, just 10.8% satisfied the requirement for sufficient levels, whereas, in the south, 25.9% did [3].

As illustrated in Fig. 1, vitamin C is a lactone (C₆H₈O₆) that has a reduced and an oxidised form, respectively named L-ascorbic acid and dehydro-L-ascorbic acid [2]. Due to its low electron potential and resonance stability, ascorbic acid is capable of donating a hydrogen atom and forming a reasonably stable ascorbyl free radical. All of its known physiological and biochemical reactions indicate that it is a reducing

agent since it is an electron donor. To achieve this, it uses two electrons from the double bond between the second and third carbons in a 6-carbon molecule [1].

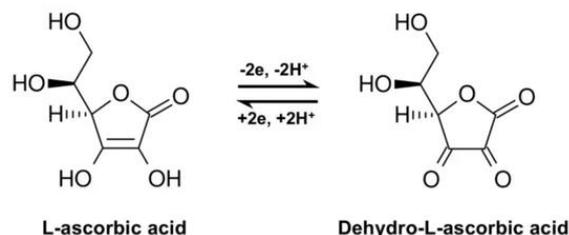


Fig. 1. **Vitamin C in its Reduced and Oxidised states**

3. Vitamin C And Immune Cells

Research on the effects of vitamin C on the immune system in other animals will be reviewed. Fish rely more heavily on their innate immune system as their initial line of defence against infections, since it may suppress lymphocytes and phagocytes without compromising the immunological response. Vitamin C in the diet has a major impact on the Phagocytic Index (PI) and the Respiratory Burst (RB). Compared to yellow catfish on diets supplemented with vitamin C, those lacking vitamin C have lower PI and RB. These findings indicate that including vitamin C in one's diet may promote development and antioxidation performances in the body and, maybe, boost nonspecific immunity [4]. Vitamin C is essential for the proper functioning of white blood cells.

Vitamin C also had a role in controlling the protective immunological response against *P. yoelii* 17XL infection in BALB/c mice in a separate investigation. Vitamin C's ability to boost immunological responses from Th1 cells and Dendritic Cell activity during infections in mice was highlighted in the study. Vitamin C's efficacy in boosting host protective immunity does not appear to be dose-dependent; therefore, its use in the early stages of malaria infection, when it has already been shown to be safe (25mg/kg, 250mg/kg), is warranted [5]. Vitamin C regulates proper cellular immune response.

4. Vitamin C and Immune-related Genes

Vitamin C is involved in a plethora of processes that might together contribute to its immune-modulating effects. Due to its capacity to quickly donate electrons, it acts as a powerful antioxidant that safeguards vital biomolecules (proteins, lipids, carbohydrates, and nucleic acids) from the oxidants produced during normal cellular metabolism and by exposure to toxins and pollutants. This time, researchers looked at how injecting Vitamin C into the eggs of locally bred Chinese yellow broiler chicks affected their ability to fight off free radicals and the expression of genes involved in immunity. Therefore, it was concluded that a dose of VC in the egg (3 mg/egg) might improve the immune system and antioxidant defences of newly hatched chicks [6]. Vitamin C helps in the expression of immune-related genes.

Different types of proteins associated with the ability of the body's immune response can also be used to study the effects of Vitamin C to boost or regulate immunity. IgM is the first antibody to develop in the immune response and the first antibody to combat infections. It is also the first immunoglobulin to appear in phylogeny and ontogeny. Evidence suggests that VC may elevate immunoglobulin-like molecules in shrimp. The optimal dosing for *S. sihama* was determined to be 139.03 mg/kg. According to a study conducted on juvenile *S. sihama*, adding the right amount of dietary VC supplement increased growth, hepatic immunity, and antioxidant capacity in the liver and intestines [7].

Antioxidant defence proteins were also studied in cows; Serum levels of SOD, CAT, and GR were considerably higher in cows given a combination of vitamins AD3E and C, while GPx levels were greatest in the VC group. Vitamins AD3E and C injected into dairy cows early in pregnancy were found to improve immunity, regulate cytokine production, and boost antioxidant enzymes using the Ovsynch programme [8]. Vitamin C helps in the production of immune-related proteins.

5. Vitamin C and Regular Immune Response

In the human immune system, also Vitamin C plays a vital role. As mentioned, a deficiency of VC can lead to impaired immune response and extreme cases of Scurvy. Studies on long-term vitamin C supplementation in the elderly have shown that the participants' immune functions may be brought up to levels similar to those seen in young individuals. After six months, these benefits persisted in various functions without any additional supplementation. The results for the elderly who took both vitamin C and E supplements were the same. Therefore, the employed dosages of vitamin C over the course of a short period of time increase immune function in the elderly, which may contribute to a healthy lifespan [9]. These results showed that regular supplementation of Vitamin C could improve regular immune response.

6. Vitamin C and Infections

We also need to consider the effect of Vitamin C supplementation in case of an infection. One hundred seventeen tetanus patients were included in a single, non-randomized, poorly reported trial of vitamin C as a therapy for tetanus in Bangladesh. The results revealed a significant decrease in death. Along with standard care, patients received 1 g of intravenous vitamin C daily [10]. According to the aforementioned study, Vitamin C therapies for Tetanus were associated with a lower fatality rate. A total of 2985 individuals were analysed in another meta-analysis of 16 randomised controlled trials (RCTs) on sepsis/septic shock. There was no statistically significant difference in death rates between the study group, who were given vitamin C-containing therapy, and the control group after 28 days. This study and meta-analysis found that treatment supplemented with vitamin C did not enhance clinical outcomes [11].

In yet another meta-analysis, 37 randomised controlled trials (RCTs) and 2747 patients were included. There was no correlation between vitamin C intake and the length of follow-up procedures that did not involve the heart [12]. These hints point to inconclusive and mostly unstudied consequences on morbidity and death. Despite this, the aforementioned review did find a marginal improvement in postoperative discomfort. These RCTs suggest Vitamin C might not be helpful in the treatment of infections, but they help in immune regulation to promote treatment.

7. Vitamin C and possible Treatments

Through technological simulations, also we need to study the effects of vitamin c. Vitamin C's mechanism and pharmacology in the treatment of newborn Hypoxic Ischemic Encephalopathy (HIE) were uncovered systematically and intuitively by employing the cutting-edge techniques of network pharmacology, molecular docking, and molecular dynamics modelling. In our investigation, we found that vitamin C and HIE have 16 common targets, and we were able to narrow them down to 7 primary targets. It is possible that vitamin C can cure newborn HIE by influencing inflammation, the immunological response, and cellular transcriptional regulation. Since this is the case, vitamin C is likely one of the primary medications used to treat HIE [13]. This study suggests a possible treatment by Vitamin C through certain pathways.

8. Vitamin C and Cancer

Vitamin C also plays a role in the treatment of cancer by affecting cancer cells themselves and anticancer immune responses with the help of ten-eleven translocation (TET) methylcytosine dioxygenases proteins. Researchers showed that a lack of vitamin C in the plasma was linked to an increased risk of death from both cardiovascular disease and haematological malignancies. Studies in mice models have also indicated that large doses of vitamin C are an effective drug for boosting the anticancer effects of immune checkpoint treatment. High-dose vitamin C synergized with immune checkpoint therapy (anti-PD1 with or without anti-CTLA4) in several cancer types and increased infiltration of CD4+ and CD8+ T cells and macrophages into the tumour microenvironment. As a result, CD8+ T cells and natural killer cells produced more granzyme B, while macrophages produced more interleukin-12, and it reduced tumour growth in a T cell-dependent manner [14].

9. Vitamin C and Covid-19

In a meta-analysis of current coronavirus research, researchers looked at data from five papers and a total of eight articles. There was no statistically significant difference in hospital stay duration between the High-Dose Intravenous Vitamin C (HDIVC) and control groups. Furthermore, the meta-analysis showed

that HDIVC had a trend toward reducing the in-hospital mortality rate in patients with severe COVID-19. However, there was no statistically significant difference between the in-hospital mortality rates of patients treated with HDIVC and those who did not receive HDIVC [15]. Which suggests the low effectiveness of Vitamin C in the treatment of Coronavirus.

10. Conclusion

Finally, vitamin C aids in the expression of immune-related genes and promotes proteins involved in immune response, boosting the activity of white blood cells and cellular immune response. Vitamin C aids in normal immune system function and promotes the treatment of various infections. Further verification via RCTs for various infections is required, as there are inconsistent findings, to establish whether or not vitamin C facilitates treatment by regulating specific pathways. Covid-19 treatments that are not very effective can still benefit from vitamin C. While these findings are encouraging, they also raise the possibility that vitamin C is ineffective as a stand-alone treatment for infection and should be investigated further. According to these findings, vitamin C may serve as an excellent immunity booster.

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