

*1<sup>st</sup> International Immunonutrition Workshop, Valencia, 3–5 October 2007, Valencia, Spain*

## Immune-enhancing role of vitamin C and zinc and effect on clinical conditions

S. Beveridge<sup>1</sup>, E. S. Wintergerst<sup>2</sup>, S. Maggini<sup>1</sup> and D. Hornig<sup>3</sup>

<sup>1</sup>Bayer Consumer Care, Basel, <sup>2</sup>Bayer Diabetes Care, Basel, Switzerland and <sup>3</sup> Bayer Diabetes Care, Reinach, Switzerland

The present paper is intended to give an overview on the roles of vitamin C and Zn in immune functions. Vitamin C concentrations in the plasma and leucocytes rapidly decline during infections and stress. Supplementation of vitamin C improves components of the human immune system such as antimicrobial and natural killer (NK) cell activities, lymphocyte proliferation, chemotaxis and delayed-type hypersensitivity. Vitamin C contributes to maintaining the redox integrity of cells and thereby protects them against reactive oxygen species generated during the respiratory burst and in the inflammatory response. Similarly, Zn deficiency impairs cellular mediators of innate immunity such as phagocytosis, NK cell activity, and the generation of oxidative burst. Thus, both nutrients play important and complementary roles in immune function and the modulation of host resistance to infectious agents, reducing the risk, severity and duration of infectious diseases. A deficiency in one of these essential nutrients weakens immunity since vitamin C is crucial for cellular immunity and Zn for the production of antibodies. A large number of randomized controlled intervention trials with intakes of  $\leq 1$  g vitamin C and  $\leq 30$  mg Zn are available. These trials show that adequate intakes of vitamin C and Zn ameliorate symptoms and shorten the duration of respiratory tract infections including the common cold. Natural defences can only provide full protection when the body has sufficient Zn, as well as high levels of vitamin C. The physiological effects of vitamin C provide clear evidence and rationale for a number of ways in which it might help to protect against infection. This evidence is termed mechanistic evidence because it stems from knowledge of the chemical reactions and biochemical processes in which vitamin C is known to play an important role (Table). The actions of Zn not only complement the actions of vitamin C to provide 'double protection' (Table), but may even have a synergistic effect. Like vitamin C, in recent years research has proved that Zn is essential for effective immune defence at several different levels.

**Table.** Summary of the role of vitamin C and Zn in body defences<sup>(1,2,3)</sup>

Defence	Vitamin C	Zn
Skin and mucosal barriers	Collagen synthesis Improved strength	Cellular proliferation Maintains thickness
Neutrophils and macrophages	Improved motility and chemotaxis Enhanced killing Overall improvement in phagocytosis	
Lymphocytes		Proliferation of stem cells B- and T-cell differentiation B- and T-cell interaction
B lymphocytes		Antibody production
T lymphocytes	Proliferation	Proliferation and appropriate response Destruction of infected tissue cells and tumours
Interferon	Production enhanced	

Adequate intakes of vitamin C and Zn are essential for health. This is of special importance in populations in which insufficient intake of these nutrients is prevalent. The current belief is that regular prophylactic intakes of vitamin C at doses of  $\geq 200$  mg daily have no effect on the incidence of the common cold, but may be beneficial in the reduction of the severity and duration of the symptoms, suggesting that vitamin C plays some role in the respiratory defence mechanisms. However, the elderly, who have been shown to have a lowered vitamin C status and may therefore be more prone to infections, individuals exposed to continuous oxidative stress, such as chronic smokers, and individuals exposed to heavy physical exercise and/or cold environment may benefit from a moderate continuous vitamin C intake. Other vulnerable population groups include children. As a result of the high prevalence of Zn deficiency, especially in children in developing countries, and the impaired immune status, susceptibility to infectious diarrhoea, malaria and pneumonia is found to be substantially increased. Large intervention trials with daily intakes of 10–30 mg Zn have shown that Zn supplementation could be an important adjuvant therapy for treating these infectious diseases in children in developing countries. Given that both vitamin C and Zn have an important and synergistic effect on immune function and the modulation of host resistance to infectious agents it is hence appropriate and beneficial to combine the trace element Zn with a high dose of vitamin C in one supplement.

1. Wintergerst ES, Maggini S & Hornig DH (2006) *Ann Nutr Met* **50**, 85–94.
2. Wintergerst ES, Maggini S & Hornig DH (2007) *Ann Nutr Met* **51**, 301–323.
3. Maggini S, Wintergerst ES, Beveridge S & Hornig DH (2007) *Br J Nutr* **98**, Suppl. 1, S29–S35.