



Food-Based Approaches for Ensuring Adequate Vitamin A Nutrition

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More than 250 million children under the age of five have vitamin A (VA) deficiency. Efforts to improve VA status globally have included supplementation and food fortification. Supplementation, however, can result in sharp spikes and declines in VA concentration in the body, while VA fortificants can lead to hypervitaminosis, which requires continuous monitoring to ensure that levels of total-body VA are not excessive. Biofortifying staple crops with β -carotene, a major source of provitamin A, is an emerging option for improving VA status without these shortcomings. This review tests the extent to which biofortification may be an alternative to supplementation and food fortification.

The review first conducted a scan of studies with animals and humans fed provitamin A sources and applied findings to predict the impact of various interventions on VA storage among infants, young children, and adolescents. The review compared the effectiveness of (1) micronutrient sachets containing VA versus a daily serving of orange-fleshed sweet potato consumed by an infant; (2) biofortified maize versus biannual supplements versus VA-fortified sugar consumed by a boy aged one to four years; and (3) two different intakes of fortified sugar versus two different intakes of biofortified maize consumed by an adolescent girl aged 13 to 19.

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Findings revealed that the bioconversion factor was highly correlated to total liver VA reserves, suggesting that VA status was driving conversion of β -carotene to VA. Similarly, a study in Filipino schoolchildren found that conversion of provitamin A carotenoids to VA varies inversely with VA status. Both animal and human studies suggest that provitamin A carotenoids are absorbed and converted to VA as needed, mitigating the risk of hypervitaminosis A.

These and other results from similar studies were applied to three models to evaluate and compare changes in liver VA concentrations of children in response to provitamin A-containing food, food fortification, or supplement interventions.

Animal and human models to study provitamin A activity

A series of studies was performed using Mongolian gerbils to determine bioconversion factors of provitamin A carotenoids to VA for several foods.

Model 1: Comparison of micronutrient sachets versus sweet potato in infants

Infants' consumption of micronutrient sachets containing preformed VA was compared to consumption of cooked orange

sweet potato. This simulation showed that the daily portion of sweet potato was more effective in improving VA status than the daily micronutrient supplement based on adequate intake for infants. In fact, the sweet potato resulted in a steady net increase in VA accumulation, while the supplement yielded a slight decrease.

Model 2: Comparison of VA supplements, food fortification, and biofortified maize in boys

Biofortified maize, biannual VA supplements, and fortified sugar were compared in terms of effectiveness in improving VA status in a one-to-four-year-old boy. The accrual of VA over time revealed that biofortified maize is comparable to fortified food in improving VA concentrations in the liver. While fortification resulted in a continuous increase in VA stores as long as intake was maintained or increased, which could result in subtoxic VA levels, conversion rates of provitamin A into retinol from biofortified maize decreased when liver reserves were adequate, protecting against hypervitaminosis. Biannual supplementation resulted in fluctuations in VA liver concentration, peaking at consumption then dropping steadily until the next dose.

Model 3: Comparison of sugar fortification versus biofortified maize in adolescent girls

The impacts of high and low intakes of fortified sugar were compared to high and low intakes of biofortified maize in an adolescent girl. This simulation found that

at the upper level of VA-fortified sugar intake, the girl will have excessive liver reserves one year after starting. On the other hand, the lower level of intake of fortified sugar did not meet the average girl's VA need and a negative liver reserve occurs. The biofortified maize findings mirrored those from Model 2 in that the body's conversion of provitamin A into VA slows as the VA reserves become adequate. A high maize intake rapidly results in adequate liver reserves. A low maize intake is enough to result in a slow, gradual increase in liver reserves, but may not be able to prevent VA depletion during future pregnancy and lactation.

These simulations demonstrate the efficacy of using biofortified foods to protect against VA deficiency. Furthermore, because they contain provitamin A as opposed to preformed VA, the biofortified foods in these simulations appear to help the body create the amount of VA it needs, minimizing the risk of hypervitaminosis posed by food fortification and the risk associated with supplements of fluctuating VA in the system.

The three scenarios used staple crops as the provitamin A source. However, data now exist showing that provitamin A carotenoids from a variety of fruits and vegetables can improve VA status, making dietary diversification a feasible option for those susceptible to VA deficiency.

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