



Carotenoid-Biofortified Maize Maintains Adequate Vitamin A Status in Mongolian Gerbils

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In many areas of the world, especially Africa and Southeast Asia, vitamin A deficiency is a major health problem, particularly in children and women. In addition, staple foods in these areas, such as rice, wheat, and maize, tend to be low in provitamin A. Efforts to breed maize for increased provitamin A have resulted in varieties with enhanced activity, but relatively low concentrations compared to carrots and other orange vegetables. In addition, low predicted bioconversion rates bring into question the bioefficacy of biofortified maize. Before breeding efforts continue, it is important to assess whether maize biofortification with provitamin A carotenoids can contribute to vitamin A status. This research investigated the bioefficacy of β -carotene in biofortified maize in vitamin A-depleted Mongolian gerbils. Study 1 compared the bioefficacy of β -carotene from maize with vitamin A and β -carotene supplements, and study 2 investigated the effect of two types of maize at two dietary levels (*i.e.*, four carotenoid concentrations) on vitamin A status.

Methodology

Four maize lines with differing carotenoid concentrations were used to prepare Mongolian gerbil feeds with variable carotenoid compositions. Forty gerbils were fed a white maize feed for four-weeks to deplete vitamin A reserves before being placed on their respective treatment diets.¹ In study 1, treatments ($n = 10/\text{group}$) included 60% high- β -carotene dark-orange maize with oil supplement and 60% white maize feed with oil, β -carotene, or vitamin A supplements. β -Carotene and vitamin A supplements were matched daily to β -carotene intake by the high- β -

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carotene maize group. In study 2, gerbils were fed 30% or 60% orange or yellow maize feed. Percentages of maize reflect the contribution of staple cereal foods to typical diets in developing countries. After four-weeks of treatment, gerbils were killed and vitamin A concentrations were measured in blood and livers.

Results and Discussion

To evaluate bioavailability, β -carotene from biofortified maize was directly compared with β -carotene and vitamin A supplements in vitamin A-depleted gerbils. Results from the first study showed that dark-orange maize can contribute as much vitamin A to the liver as β -carotene supplements during vitamin A depletion. While the conversion factor for provitamin A carotenoids in maize to vitamin A (2.8 μg β -carotene: 1 μg vitamin A) was much lower than that

¹All animal handling procedures were approved by the University of Wisconsin-Madison's Research Animal Resource Center.

currently proposed by the Institute of Medicine for dietary β -carotene (12:1), the conversion factor was based on β -carotene as the vitamin A source and does not account for other provitamin A carotenoids present in maize.

In both studies, serum vitamin A concentrations did not differ among groups. However, liver vitamin A is considered the best measure of status, because the liver is the primary storage site for vitamin A. In study 1, the only carotenoid detected in the liver was β -carotene, which was found in the dark-orange maize and β -carotene supplement groups. The liver β -carotene content of the maize group was 100% greater than that of the β -carotene supplement group. This could be attributed to preferential conversion of other provitamin A carotenoids and storage of β -carotene in the maize or to differences in consumption between maize (small, incremental) and supplements (concentrated, twice daily doses).

In study 2, no carotenoids were identified in the livers of any treatment group, indicating that provitamin A carotenoids were preferentially converted to vitamin A rather than stored. Storage of β -carotene in the liver might indicate adequate vitamin A status. The theoretical percentage of vitamin A stored in the liver that is attributable to the maize feed decreased as dietary carotenoids increased and as vitamin A status improved (study 2). Only 16% of additional provitamin A carotenoid in the

60% orange maize group was converted to vitamin A and stored in the liver, indicating that the vitamin A requirements of the gerbils in this group had been met.

The 60% dark-orange maize group (study 1) and the 60% orange maize group (study 2) had similar liver vitamin A, even though the dark-orange maize group received twice the provitamin A carotenoids. The presence of β -carotene in the liver of the β -carotene supplement and dark-orange maize groups (study 1) further supports an adequate vitamin A status and suggests that bioconversion may have a greater dependency on vitamin A status than dietary intake.

Conclusion

These studies showed that provitamin A carotenoids in maize are as bioavailable as β -carotene supplements in a vitamin A-depleted gerbil model. The positive effect of biofortified maize on vitamin A status demonstrates the feasibility of this dietary approach. The bioconversion ratio is much lower than that proposed by the Institute of Medicine. Because vitamin A status had a large effect on vitamin A and β -carotene storage, a single conversion factor may not reflect bioconversion under all circumstances. This study thus demonstrates the potential for positively altering or maintaining vitamin A status using maize biofortified with provitamin A carotenoids and indicates that evaluation in humans should be pursued.

SOURCE: Howe, J. A., and S. A. Tanumihardjo. 2006. Carotenoid-biofortified maize maintains adequate vitamin A status in Mongolian gerbils. *Journal of Nutrition* 136: 2562-2567.