Mongolian Gerbils Can Utilize Provitamin-A Carotenoids in Deep-Fried Carrot Chips[1]

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ABSTRACT Deep-fried carrot chips, containing provitamin-A carotenes, were developed as an alternative mode of dietary intervention to combat vitamin A deficiency. The biological use of carotenoids in this product as vitamin A precursors was evaluated in Mongolian gerbils. Male 4-wk-old gerbils were fed a diet containing all essential nutrients for 1 wk. Then six gerbils were killed, and the remaining gerbils were fed the diet without vitamin A for 6 wk to produce marginal vitamin A deficiency. After depletion, six gerbils were killed and the remainder divided into four groups of 12 gerbils each and fed vitamin A-containing diet (+VA), β-carotene-containing diet (BC), carrot chip-containing diet (CC), or diet containing no vitamin A/provitamin-A carotenes (−VA). The first three diets contained ~6 μg RE/g. Six gerbils from each group were killed after 2 wk of consuming these diets, and 6 after 4 wk. Final body weight and weekly food consumption did not differ among groups after 2 or 4 wk of repletion. Total liver vitamin A stores of BC and CC gerbils killed after 4 wk of repletion were not different from those of gerbils killed before depletion, but those of −VA gerbils were significantly lower ($P < 0.05$) and those of +VA gerbils were significantly higher ($P < 0.05$). Plasma retinol levels of gerbils killed after 4 wk of repletion, including the −VA group, did not differ. Total liver α- and β-carotenes and 9-cis β-carotene contents of the CC group were significantly higher ($P < 0.05$) than in the BC group after 4 wk of repletion. This carrot chip product effectively reversed vitamin A deficiency in gerbils. J. Nutr. 132: 211–217, 2002.

KEY WORDS: • *carrot chips* • *carotenoids* • *vitamin A* • *gerbil*

Vitamin A is important for vision, gene expression, reproduction, embryonic development, growth, and immune function (1). Humans need <1 mg of vitamin A daily to maintain health, yet it was estimated that 3 to 10 million children, mostly in developing countries, become xerophthalmic and 250,000 to 500,000 go blind annually (2). An additional 250 million children under 5 y of age were estimated to be subclinically vitamin A-deficient and at risk of severe morbidity and premature death (3).

Due to the enormous cost of vitamin A deficiency to society, vitamin A intervention is of importance. Vitamin A intervention approaches are commonly grouped into two main control strategies: direct increase in vitamin A intake through dietary modification with natural or fortified foods and supplements and indirect public health measures to control disease frequency (4). For improving vitamin A status, food-based approaches could be most effective where there is widespread availability, variability, adequacy, and acceptability of vitamin A-containing foods among targeted populations (3). In addition, food-based approaches deserve attention because they are more likely to be sustainable in the long term and will increase the intake of other nutrients simultaneously (5). Such foods are vegetables and fruits that have high provitamin-A carotenoid concentrations, especially β-carotene.

Deep-fried carrot chips that are high in provitamin-A carotenoids were developed in our laboratory as an alternative product for intervention programs to overcome vitamin A deficiency (6). Carrot chips contain fat, which is important and a key factor in carotene absorption (7,8). Underwood (4) reported that vegetable food-based interventions in vitamin A-deficient areas can successfully improve vitamin A status, particularly when dietary fat levels are also increased sufficiently. Carrot chips have a pleasant taste and an appealing appearance; laboratory sensory evaluation and consumer studies indicated that this product was acceptable to both American and Southeast Asian consumers (unpublished data). The retention of provitamin-A carotenoids during storage was above 80%, which is important for optimal usage of this product (9).

Using the conversion factors given by the National Research Council in 1989 (10), the deep-fried carrot chips developed in our laboratory had vitamin A activities of 7322–8532 μg retinol equivalents (RE)[4]/100 g chips (11). Using the new conversion factors (1), this product had vitamin A activities of 3661–4266 μg retinol activity equivalents (RAE) per 100 g chips, an amount high enough to satisfy the human adult daily need for vitamin A. However, to accurately measure the biological activity of provitamin-A carotenoids in the carrot

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[4] Abbreviations used: BC, β-carotene-containing diet; CC, carrot chip-containing diet; RAE, retinol activity equivalents; RE, retinol equivalents; +VA, vitamin A-containing diet; −VA, diet containing no vitamin A/provitamin-A carotenes.

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