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Carotenoid Content and Physicochemical and Sensory Characteristics of Carrot Chips Deep-Fried in Different Oils at Several Temperatures

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ABSTRACT: The influence of deep-frying using different oils and temperatures on carotenoid content and physicochemical and sensory characteristics of carrot chips was investigated. Sliced carrots were steam-blanched, cooled, soaked in 0.2% sodium metabisulfite, and deep-fried in canola, palm, or partially hydrogenated soybean oil (PHSO) at 165, 175, or 185 °C. Frying temperature, but not oil, significantly ($P < 0.05$) affected the α-carotene, β-carotene, and total carotenoid contents. Oil type significantly ($P < 0.05$) influenced all color values. Increasing temperature lowered the redness value, which correlated with decreased carotenoid content, color darkening, and decreased hardness value. Trained panelists detected no differences among oil types in crispness, sweetness, odor, and acceptability. The best carrot-chip product was that fried in PHSO at 165 °C.

Key Words: deep-frying, carotenoid, carrot chips, oil, frying temperature

Introduction

CAROTENOIDS ARE IMPORTANT MICROnutrients for human health (Castenmiller and West 1998). The biological function of carotenoids is primarily as vitamin-A precursors (Institute of Medicine 2000). In addition to their provitamin-A activity, carotenoids may have several other important biological functions in animals and man (Van Vliet 1996). Epidemiological studies have shown that high intakes of carotenoid-rich vegetables and fruits and high blood levels of β-carotene are associated with decreased incidence of some cancers (Törrönen and others 1996), age-related macular degeneration, cataracts, coronary heart disease or cardiovascular disease, and perhaps other diseases and pathological processes (Kohlmeier and Hasting 1995; Biesalski and others 1997; Kritchevsky 1999). Low concentrations of dietary carotenoids may also be needed to inhibit oxidative damage and decrease oxidation susceptibility (Jacob and Burri 1996).

Carotenoids are widely distributed among colored fruits and vegetables and are important sources of vitamin A, especially in those parts of the world where the intake of animal foods is relatively low (Van Vliet and others 1996; West 1998). However, the bioavailability of the provitamin-A carotenoids from plants is greatly influenced by many factors such as the structure of the carotenoids, the nature of the embedding matrix, levels of dietary fat, the amount and the type of carotenoids, nutritional status, the presence of antioxidants and fibers, and the extent of processing (Castenmiller and West 1998; Rock and others 1998; Riedl and others 1999).

Carrots, the most important source of dietary carotenoids in western countries including the United States (Block 1994; Törrönen and others 1996), contain the highest amount of β-carotene of the common fruits and vegetables (Desobry and others 1998). β-carotene constitutes 60% to 80% of the carotenoids in carrots, followed by α-carotene (10% to 40%), lutein (1% to 5%), and the other minor carotenoids (0.1% to 1.0%) (Chen and others 1995). Among the provitamin-A carotenoids, β-carotene showed the highest vitamin-A activity on a molar basis (Van Vliet 1996; Biesalski 1997). Other carotenoids are estimated to have only half of β-carotene's potency (Castenmiller and West 1998). Processing may convert some of these carotenoids into cis-isomers (Lessin and others 1997) and epoxy-carotenoids (Ball 1998) that may have lower vitamin-A activities (Johnson and others 1996; Ball 1998).

To maximize the use of carrots as a source of provitamin A as well as an antioxidant, it is important to find an appropriate processing method to manufacture products that are not just highly preferred by consumers but also are good nutritional sources of provitamin A. In recent years, researchers (Slinde and others 1993; Aukrust and others 1994, 1995; Baardseth and others 1995, 1996; Skrede and others 1997) have developed carrot chips from carrot slices, using lactic-acid fermentation to decrease reducing sugars, and deep-frying in palm oil. It has been reported that the carotenoid levels of carrots were well retained during the processing of carrot chips (Skrede and others 1997). In addition, due to deep-frying, the product contains lipids that may further improve the ability of carrot chips to serve as a source of provitamin A for humans. Nevertheless, research on carrot-chip production without lactic-acid fermentation using different oils and temperatures has not yet been reported.

Our objective was to evaluate the effect of deep-frying on carotenoid content and physicochemical and sensory characteristics of carrot chips fried in different frying oils (canola, palm, PHSO) at different temperatures (165, 175, 185 °C) without fermentation prior to deep-frying.

Materials and Methods

Materials

Fresh jumbo carrots (*Daucus carota* cv. Navajo) harvested in Bakersfield, Calif., U.S.A., were purchased from Grimmway Farms (Bakersfield, Calif., U.S.A.) and arrived packaged in linear low-density polyethylene bags (2.54 mil; Mercury Plastics, Inc., Industry, Calif., U.S.A.). The roots were stored in these