Carotenoid Content, Physicochemical, and Sensory Qualities of Deep-Fried Carrot Chips As Affected by Dehydration/Rehydration, Antioxidant, and Fermentation

Ahmad Sulaeman,[†] Laurie Keeler,[§] Steve L. Taylor,[‡,§] David W. Giraud,[†] and Judy A. Driskell*,[†]

Department of Nutritional Science and Dietetics, Department of Food Science and Technology, and Food Processing Center, University of Nebraska, Lincoln, Nebraska 68583

Carrot slices were subjected to one of the following experiments prior to deep-frying: (A) dehydration/rehydration, (B) soaking in different antioxidants, and (C) fermentation with/without blanching. There were no significant differences ($P \geq 0.05$) in carotenoid contents among carrot chips treated with/without dehydration. Soaking in sodium metabisulfite resulted in the highest carotenoid content and lightness (L), redness (a), and yellowness (b) values among the antioxidant treatments. Fermentation without blanching significantly decreased ($P < 0.05$) carotenoid content, vitamin A activity, and fat content. Dehydration and fermentation with blanching significantly increased ($P < 0.05$) the lightness (L), redness (a), and yellowness (b) values of the chips. Dehydration/rehydration, but not antioxidant and fermentation, significantly decreased ($P < 0.05$) the water activity of the chips. The textural values of carrot chips prepared using sodium metabisulfite, without dehydration and without fermentation, were the lowest among other treatments which suggests the crispiest. Carrot chips prepared using sodium metabisulfite, without dehydration and without fermentation, had the highest carotenoid content and retention, and the highest overall acceptability score.

Keywords: *Carrots; chips; carotenoids; color; sensory qualities; fermentation*

INTRODUCTION

Vitamin A deficiency is the leading cause of blindness in children in developing countries. Dietary intervention with foods rich in provitamin A carotenoids has been suggested as one solution to this problem (*1*). In addition, due to its antioxidant activity, foods rich in provitamin A carotenoids and other carotenoids may also be beneficial in preventing major health problems in developed countries such as cancer, cardiovascular/coronary heart diseases, and other diseases (*2*, *3*).

Carrots have the highest carotene content among human foods (*4*). In the U.S., carrots are a principle vegetable crop, contributing 14% of the total vitamin A consumption (*5*). Efforts have been made to prepare high carotenoid food product from carrots. Dried carrot slices (*6*), carrot juice (*7*, 8), and carrot chips (*9*−*11*) have been produced. However, the carotenoid bioavailability from plant sources depends, among other factors, on the dietary fat concentration (*12*, *13*) and on the type and extent of processing (*14*). Skrede et al. (*15*) and Sulaeman et al. (*11*) reported that the carotenoid levels of carrots were well retained during the processing of deep-fried carrot chips, and the chips contained high levels of fat which may further improve the ability of carrot chips to serve as a source of provitamin A for humans.

A previous study in our laboratory (*11*) demonstrated that deep-frying of carrot slices in partially hydrogenated soybean oil at 165 °C resulted in the highest carotenoid content and the most preferred carrot chip product. However, to further improve and to find other alternative methods in preparing deep-fried carrot chips, additional research was undertaken. Several promising pretreatments were investigated including dehydrating the carrot slices prior to frying, which has been applied with potato chips (*16*), a fermentation step to reduce the sugar content (9), and the soaking of carrot slices in different types of antioxidants.

The purpose of the present study was to evaluate the influence of the following pretreatments prior to deep-frying of the carrot slices: dehydration/rehydration, the soaking in different antioxidants (sodium metabisulfite, erythorbic acid, L-cysteine, and salt brine), and fermentation (with *Lactobacillus sakei* and *L. plantarum*) with or without blanching, on carotenoid content, physicochemical, and sensory qualities of deep-fried carrot chips.

MATERIALS AND METHODS

Materials. Fresh jumbo carrots (*Daucus carota* cv. Navajo) harvested in Bakersfield, CA, were purchased from Grimmway Farms (Bakersfield, CA). The roots were stored in plastic bags in the dark at 0−2 °C (*17*) and 98% relative humidity (RH) for 1−2 months prior to processing. The oil utilized was partially hydrogenated soybean oil (PHSO) (Bunge Food, Bradley, IL). *L. sakei* (ATCC 15521) (ATCC, Manassas, VA) and *L. plantarum* (ATCC 4008) were used in the fermentation experiment. Cells were grown in Lactobacilli MRS Broth (Difco Laboratories, Detroit, MI) harvested in logarithmic growth phase by centrifugation (10000*g* for 5 min) and resuspended in 0.9% saline to obtain 10^7 cells/mL, as indicated by an absorbance equal to 0.1 at 600 nm in a spectrophotometer (Beckman DU 640, Beckman Instruments Inc., Fullerton, CA) (*18*).

* To whom correspondence should be addressed. Dr. Judy A. Driskell, Department of Nutritional Science and Dietetics, University of Nebraska, Lincoln, NE 68583-0806 U.S.A. Phone: 402-472-8975. Fax: 402-472-1587. E-mail: jdriskell@unl.edu.

[†] Department of Nutritional Science and Dietetics.

[§] Food Processing Center.

[‡] Department of Food Science and Technology.

10.1021/jf010142s CCC: $20.00 © 2001 American Chemical Society
Published on Web 06/21/2001