Development of Healthy Crispy Carrot Snacks Using Sequential Infrared Dry-Blanching and Hot Air Drying Method

Jing Chen[1,3], Chandrasekar Venkitasamy[1], Qun Shen[3], Tara H. McHugh[2], Zhongli Pan[1,2]

[1]Department of Biological and Agricultural Engineering, University of California, Davis, One Shields Avenue, Davis, CA 95616, USA

[2] Healthy Processed Foods Research Unit, USDA-ARS-WRRC, 800 Buchanan St., Albany, CA 94710, USA

[3]College of Food Science and Nutritional Engineering, China Agricultural University, Beijing 100083, China

Abstract

Sequential infrared (IR) dry-blanching/dehydration and hot air drying (SIRDBHAD) is a sustainable technology with high processing and energy efficiencies. To develop healthy crispy carrot snack, the carrot slices were blanched with IR at different intensities followed by hot air drying. The results showed that SIRDBHAD shortened the drying time and produced a redder and crispier product with less residual POD activity compared to the control of using hot air drying only. The product produced from the new processing method also has higher vitamin C and total carotene content. Therefore, SIRDBHA can be an ideal method for producing crispy carrot snack with high sensory and nutritional quality.

Introduction

Carrots are rich in β-carotene and fiber and low in fat which are beneficial to human health. There is a limited availability of ready-to-eat snack food rich in these nutrients. Freeze-drying can be used to produce crispy and crunchy ready-to-eat snacks, however, the method has low processing and energy efficiencies. SIRDBHAD is a new approach to use IR as a heating source to achieve simultaneous blanching and partial dehydration, then followed by using inexpensive hot air drying in the late stage to increase the overall production capacity. IR is a high efficient heating method with high heat transfer rate. IR blanching does not use water and can avoid the nutrient loss caused in traditional water blanching processing. It can shorten the drying time due to pre-dehydration during the blanching stage.

Objectives

1. To study the drying efficiency of SIRDBHAD method for producing crispy sliced carrots
2. To optimize the processing and operation parameters and quantify the product quality

Materials and Methods

A laboratory scale of IR heating system consisted of two 1000 watt IR electric emitters which emit radiation at wavelength of 2 to 10 μm (Fig. 1). The 70% level of output power was chosen for the experiments based on the preliminary experiments. A single layer of carrot slices with thickness of 1.0mm was spread uniformly on the stainless steel wire mesh of IR heater and blanched. Blanched and unblanched carrots were dried to ~5% moisture content using a hot-air drier at the temperature of 60, 70 and 80℃.

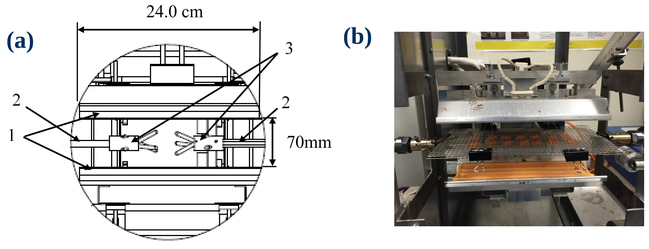


Fig.1 The schematic diagram of the IR heating system.
1. Electric IR emitter; 2. Rotating shaft; 3. Mesh holder

Materials and Methods (Continued)

Blanching and drying conditions

- IR blanching (distance between the emitter and samples): 70mm, 75mm and 80mm
- HA drying conditions (IR blanching: 70mm): 60 ℃, 70 ℃ and 80 ℃

After blanching, the moisture content, surface color and residual peroxidase activity were evaluated. After drying, the sensor quality and nutrients were determined.

Results

a. Effect of IR blanching

Table 1. Blanching time, final surface temperature, moisture content and residual POD activity of blanched carrot slices

Distance between the emitter and samples	70mm	75mm	80mm
Time (s)	110	130	150
Surface temperature (℃)	98.1±6.8	97.4±0.3	83.5±3.7
Moisture content (%, wb)	72.1±1.4	69.2±1.2	68.5±3.3
Residual POD activity (%)	25.6±0.5	25.4±0.7	24.4±3.8

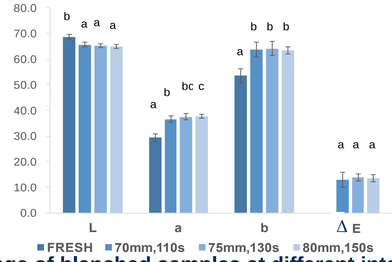


Fig 2. Color change of blanched samples at different intensities ($p < 0.05$)

b. Effect of SIRDBHAD on drying

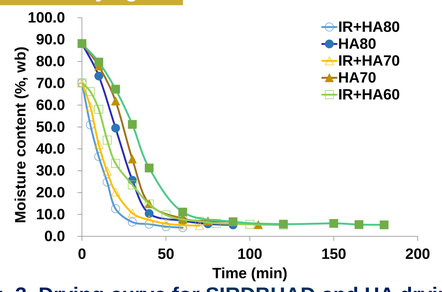


Fig. 3. Drying curve for SIRDBHAD and HA drying

c. Effect of IR+HA and HA drying on product color

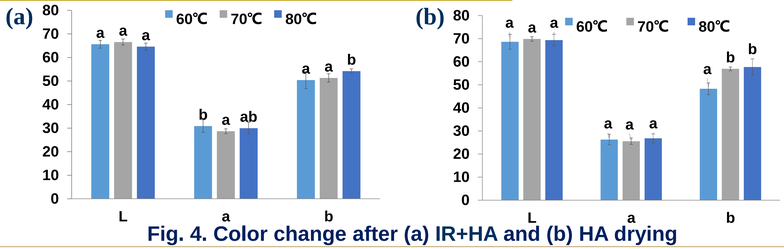
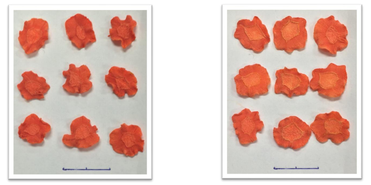


Fig. 4. Color change after (a) IR+HA and (b) HA drying

Results (Continued)



IR+HA drying (70℃) HA drying(70℃)

d. Effect of IR+HA and HA drying on crispness and POD activity

Table 2. Comparison of crispness and POD activity after SIRDBHA and HA drying

	Crispness (kg/sec)		Residual POD activity (%)	
Temperature	IR+HA drying	HA drying	IR+HA drying	HA drying
60℃	1.86±0.54 a*	1.28±0.32 a*	30.73±0.43 b*	52.56±1.74 c*
70℃	1.94±0.50 a*	1.54±0.25 a*	15.31±0.07 a*	26.86±0.52 b*
80℃	2.11±0.56 a*	1.60±0.32 a*	14.00±0.02 a	13.53±0.28 a

e. Effect of IR+HA and HA drying on nutrition

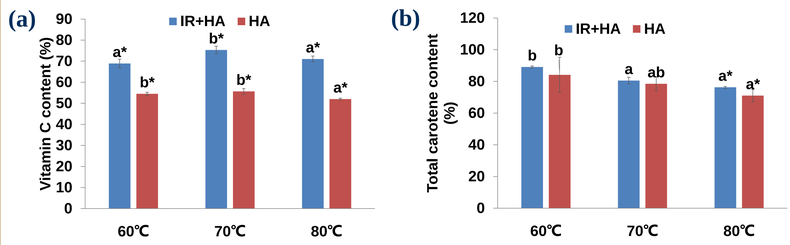


Fig. 5. Effects of IR+HA and HA processing on (a) Vitamin C and (b) total carotene contents

After IR blanching, the moisture content and residual POD activity of the samples with different intensities were not significantly different (Table 1). For color change, the L value (brightness) decreased and a and b value (redness and yellowness) increased. The overall color changes were similar (Fig.2). IR blanching shortened the drying time for the temperature of 60, 70 and 80℃ by 33%, 43% and 50%, respectively (Fig.3). The L, a and b values of IR+HA and HA dried samples were significantly different ($p < 0.05$) (Fig.4). The IR+HA processed samples were crispier and had less residual POD activity at 80℃ (Table 2). Compared to HA drying, IR+HA drying samples had more vitamin C retention. IR+HA and HA dried samples had more total carotene retention at a lower temperature of 60℃ (Fig.5).

Conclusions

1. IR blanching shortened the drying time at the temperature of 60, 70 and 80℃.
2. IR blanching contributed to redder products. SIRDBHA dried carrot slices were crispier and had less residual POD activity.
3. IR blanching helped maintain vitamin C and low temperature caused less total-carotene loss during processing than high temperature.

Acknowledgements

California Energy Commission (PIR-13-077) for funding the research.

Contact: Dr. Zhongli Pan
Healthy Processed Foods Research Unit, Western Regional Research Center, USDA-ARS, Albany, CA, USA, zhongli.pan@ars.usda.edu