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Quality of hermetically packaged dehydrated carrots during long-term storage

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ABSTRACT

Storage at the long-term storage of dehydrated carrots in a humidified atmosphere, similar to the storage condition used during industrial dehydration would lead to the rehydration of the dry products. The dehydrated samples were stored for 34 years in hermetically-packaged conditions at 4ºC, 12ºC, and 20ºC. Samples were examined for 1) color using CIE L*, a*, and b* values; 2) sensory attributes: appearance, texture, and flavor; 3) quality evaluating beta-carotene (beta-C) and lycopene (lyco-B) concentrations; 4) chemical composition, and 5) nutritional characteristics. The hermetically-packaged dehydrated carrots stored at 20ºC for 34 years maintained similar color and nutritional characteristics compared to the fresh carrot. The sensory attributes were reduced, though still acceptable. The nutritional parameters, particularly beta-C, remained stable over time. The data from this study suggest that dehydrated carrots can be used as a long-term food source.

INTRODUCTION

Due to their nutrient content and light weight, vegetables have been considered for applications requiring long periods of storage such as military rations, extraterrestrial space food, human food, and personal preparedness. Carrots can be stored in dried form as dried, vacuum-packed, or cryopreserved. In addition, carrots may be dehydrated and incorporated into meals via the freeze-drying process. Hermetically-packaged dehydrated carrots can be used for long-term storage under low oxygen and high nitrogen atmospheres. The purpose of this study was to determine the sensory and nutritional characteristics of dehydrated carrots stored in reduced oxygen atmospheres up to 34 years at ambient temperatures.

METHODOLOGY

Samples

Eight samples of dehydrated carrots (i.e. in or on 10 cm paper bags) were selected. Samples ranged in age from 0 to 34 years. A control sample (i.e. newly dehydrated) was obtained from a commercial vendor. All other samples were obtained from dehydrated carrots purchased by the authors. The dehydrated carrots were stored in hermetically-packed atmospheres at 4ºC, 12ºC, and 20ºC from 1984 to 2018. The analysis of the samples was performed at the Department of Nutrition, Dietetics and Food Science, Brigham Young University, from 2018 to 2020.

Headspace Oxygen, Can Seams, Water Activity, and Color

Headspace oxygen was measured using a 280-Scribner Headspace Oxygen Analyzer (Irvine, Calif.). Can seams were evaluated using the Sheerness System (Direction Corporation, Westminster, Calif.) to measure the following listen properties: thickness, leak tightness, and oxygen barrier. Samples were placed in a pressure vessel and stored at 15ºC for 13 days. Oxygen levels were measured using the Chlorine indicator method (Chemical Research for Model Dehydrated Cans, Inc., Middleton, WI). Color was quantified on the CIE L, a*, and b* system (Abele, 1990) using a Spectralon calibrated Colorimeter (HunterLab, Reston, Va.).

Rehydration Ratio

The rehydration ratio of dehydrated carrots was determined by boiling for 30 minutes at 100ºC (approx. 1 atm) of dehydrated carrot samples in 200 mL distilled water that was brought to a boil. A rehydration ratio was calculated by dividing the dry weight of the dehydrated sample by the weight of the rehydrated sample (Singh and Chee, 1966).

Sensory Analysis

Sensory analysis was conducted at the Brigham Young University Sensory Laboratory using standard procedures. Samples were rehydrated by boiling for 30 minutes. A five-member trained panel (6 experts from the Food Science Department, Department of Consumer Science and the Department of Nutrition, Food Science and Human Nutrition) evaluated the samples from a five-point hedonic scale, on a 1 to 5 scale. The analysis included the following sensory attributes: appearance, texture, and flavor. The scale was extended to include a 1 to 5 scale with quality as the dependent variable. Post-sensory analysis of all samples was performed using an analysis of variance (ANOVA) and Tukey’s post-hoc test for significance difference. Significant difference was defined as p<0.05. Contrasts were determined using Excel Software.

Nutrient Analysis

Nutrient analysis was determined using standard Analytical Chemistry Procedures (AOAC, methods 954.15). A mixed model analysis of variance (PROC MIXED) was used to assess the sensory data. PROC GLM was used for the color, rehydration ratio and oxygen data. Significant differences between the Tukey’s Honest Significant Differences (HSD) Procedure were determined to assess the significance of the differences between the samples. Significant differences were defined as p<0.05. Contrasts were determined using Excel Software.

RESULTS AND DISCUSSION

Headspace Oxygen, Can Seams, Water Activity and Color

Carrots retain their quality for a long time (Singh and Chee, 1966). Headspace oxygen was less than 1% except for one sample at 14% (Figure 1). Water activity (aw) values were relatively constant, ranging from 0.31 to 0.37 (Figure 2). According to Arya and others (1995), the optimum water activity for dehydrated carrots is 0.30. As shown in Table 1, CIE L* values ranged from 38.0 to 40.0, CIE a* values ranged from 17.3 to 21.3, CIE b* values ranged from 21.2 to 27.3, and CIE h* values ranged from 29.2 to 34.2. All samples maintained CIE L* values at ≥40.0, which is consistent with the age of 3.4 years. Significant differences were determined using ANOVA and Tukey’s post-hoc test.

Table 1 - CIE L*, a*, and b* values of reconstituted carrot sample stored up to 34 years.

Sensory Analysis

As shown in Table 2, ranked for hedonic scores were 3.7-4.8 for aroma, 3.7-4.1 for flavor, 3.4-6.6 for texture, 2.7-2.8 for overall acceptability. Scores in each column ranged with significant increasing with storage age. According to Arya (1999), acceptance levels of food products range from 1.0 to 5.0, indicating a range of 1.0 to 5.0 for overall acceptability. The scores in Table 2 indicated that dehydrated carrots stored from 7 to 34 years did not have lower sensory scores.

Nutrient Analysis

Beta-carotene and alpha-carotene content of samples ranged from 19.5 to 76.9 mg/100g and 15.2 to 76.6 mg/100g, respectively (Figure 3). There were no significant change in beta-carotene or alpha-carotene content. The wide variation observed in this study could be related to differences in product sources. It is noteworthy that after 34 years of storage, a single (210 g) cup rehydrated serving of dehydrated carrots still contained over 100% of the recommended Reference Daily Allowance (RDA) for vitamin A.

CONCLUSIONS

Hedonic scores for dehydrated carrot slices stored at ambient conditions were significantly low over time. However, the percent acceptance for use in an emergency situation remained around 70% to 80%. As would be expected (probably more storage years would be needed), the percent acceptance of dehydrated carrots reduced significantly. The data from this study suggest that dehydrated carrots can be used as a long-term food source. However, more research is needed to further understand the characteristics associated with long-term storage, but these results suggest that dehydrated carrots can be used as a long-term food source.

REFERENCES


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