2007-07-01

Quality of hermetically packaged dehydrated carrots during long-term storage

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Original Publication Citation
Bartholomew SR, Jefferies LK, Pike OA. July 27. Quality of hermetically packaged dehydrated carrots during long-term storage. Poster presentation. Institute of Food Technologists Annual Meeting.

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Quality of hermetically packaged dehydrated carrots during long-term storage

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ABSTRACT

There is interest in the long-term storage of food for applications such as space flight, disaster relief, and personal preparedness. Dehydrated carrots intended for long-term storage via packaging in hermetically sealed cans, having a low oxygen atmosphere, are available in the retail market. Research has been done on the quality of dehydrated carrots stored up to two years but the effect of longer-term storage on the quality of the product has not been reported.

Eight samples of dehydrated carrots, representing 6 brands, packaged in nr 10 cans were obtained from donors or purchased from a commercial vendor as a control. Samples ranged in age from <1 to 34 years. Can headspace oxygen, can seam integrity, and dehydrated product water activity and color was evaluated. Rehydration ratio was determined. A 56-member consumer panel evaluated the rehydrated carrots for appearance, aroma, texture, flavor, and overall acceptability using a 9-point hedonic scale. Acceptance for use in everyday and emergency situations was determined. The concentration of alpha and beta-carotene was measured as an indication of nutritional quality.

Can headspace oxygen ranged from < 0.01% to 14.7%. All can seams were determined to be satisfactory. Water activity of the dehydrated carrots ranged from 0.31 to 0.38. L* values ranged from 37.8 to 44.0, a* values from 17.1 to 30.2 and b* values from 23.0 to 37.3. Rehydration ratio ranged from 4.58 to 6.16. Hedonic scores for overall acceptability, of dehydrated carrots declined from 7.1 to 3.4. All samples had an acceptance for use in an emergency situation of over 70%. Beta-carotene and alpha-carotene content of samples ranged from 18.5 to 96.4 mg/100g and 15.2 to 78.6 mg/100g, respectively.

Results indicate that dehydrated carrot quality declined during long-term storage, but retained sufficient sensory acceptance and nutritional quality to be considered for use in long-term storage regimens.

INTRODUCTION

Due to their nutrient content and light weight, various dehydrated food products have been considered for applications necessitating long periods of storage such as military combat rations, extended space travel, humanitarian food aid, and personal preparedness. Carrots can be processed in the form of slices or dices, and dehydrated and stored for future use.

It is possible that with optimum processing and storage conditions, dehydrated carrot shelf life can be enhanced. The shelf life of dehydrated carrots can be improved by treating with sulfite (Baloch 1987) coating with starch (Zhao and Chang 1995) , blanching (Singh and Kumar 2001), storing in tin cans (Mohammad and others 1976) storing in nitrogen flushed atmospheres (Gee 1979), and storing at cool temperatures (Singh and Kumar 2000).

Studies on dehydrated carrots to determine storage life have investigated quality during storage up to two years (Stephens and McLemore 1969, Arya and others 1982, Sherma, 2000). Food manufactured for the purpose of emergency preparedness is often stored for much longer periods of time. The effect of longer-term storage on the quality of dehydrated carrots is unknown.

The purpose of this study was to determine the sensory and nutritional quality of dehydrated carrots stored in reduced oxygen atmospheres up to 34 years at ambient temperatures.

METHODOLOGY

Samples

Eight samples of dehydrated carrot dices in nr 10 cans were analyzed. Samples ranged in age from <1 to 34 years. A control sample (<1 year of age) was obtained from a commercial vendor. All other samples were obtained from donors, and had been stored in residential locations at ambient temperatures (approximately 13-27°C.) Duplicates from the same lot were obtained for sample ages <1, 24, and 29 years.

Headspace Oxygen, Can Seams, Water Activity, and Color

Headspace oxygen was measured using a 6500-Series Headspace Oxygen Analyzer (Illinois Instruments, Inc., Johnsburg, IL). Can seams were evaluated using the SeamMate System (Onevision Corporation, Westerville, OH) to measure the following seam properties: thickness, width, body hook, cover hook, and overlap. Seam tightness was rated by an experienced evaluator on a scale of 0-100%. Water activity was measured using the chilled mirror technique (Aqualab CX-2 model Decagon Devices, Inc., Pullman, WA). Color was quantified on the CIE L*, a*, b* scale using a HunterLab ColorFlex spectrophotometer (Hunter Associates Laboratory, Inc., Reston, VA).

Rehydration Ratio

Rehydration ratio was determined by heating for 30 minutes 4 grams of dehydrated carrots in 250 mL distilled water that was brought to a boil. Rehydration ratio was calculated by dividing the drained rehydrated weight by the dry weight of the dehydrated carrots (Zhao and Chang, 1995).

Sensory Analysis

Sensory analysis was conducted at the Brigham Young University Sensory Laboratory using standard procedures. Samples were rehydrated for 20 minutes in filtered water that was brought to a boil. Cooled samples were held on a steam table at 170 C and served in randomized order to a 50-member consumer panel in 4 visits. Six samples (in sets of three) were presented each visit and every sample was evaluated twice by each panelist. Panelists evaluated aroma, flavor, texture, appearance and overall acceptability using a 9-point hedonic scale where 1=dislike extremely and 9=like extremely. Panelists were also asked if they would use the products in everyday and emergency situations.

Nutrient Analysis

Alpha and beta-carotene was determined using a modification of the method of Sulaeman and others (2001). Instead of using a homogenizer the carrot sample was sonicated (Cole-Parmer model 8891, Vernon Hills, Ill.) for 4 minutes while immersed in an ice water bath. Also, the sample was flushed with nitrogen gas instead of argon gas for 3 min, to remove oxygen. After extraction, samples were chromatographed using an Agilent 1100 HPLC (Agilent Technologies, Palo Alto, Calif, U.S.A.) with a diode array detector using the following chromatographic conditions. The solvent was 100% methanol. Injection volume was 20.00 µl. A Luna 5u C18 (2) column was used at 25.0 °C. Wavelength for detection of alpha and beta-carotene was 454 nm. Quantification was done using an external standard. Beta-carotene was purchased from Sigma-Aldrich (St. Louis, MO, U.S.A) while alpha-carotene was purchased from ChromaDex (Irvine, CA, U.S.A). Values were adjusted to reflect a 92.5% recovery for beta-carotene and a 79.6% recovery for alpha-carotene.

Statistical Analysis

Data was analyzed for significance using Statistical Analysis System software (SAS Institute, version 9.1). A mixed model analysis of variance (PROC MIXED) was used for the sensory data. PROC GLM was used for the color, rehydration ratio and vitamin data. Both models used the Tukey-Kramer multiple range test to determine significant differences between means. Significant differences were defined as p<0.05. Correlations were determined using Microsoft Excel software .

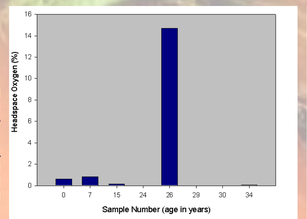

Figure 1 - Percent oxygen in can headspace of dehydrated carrot samlpes stored up to 34 years.

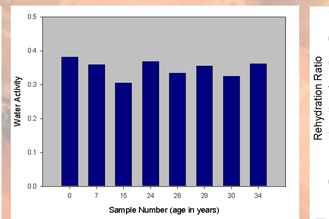

Figure 2 - Water activity of dehydrated carrot samlpes stored up to 34 years.

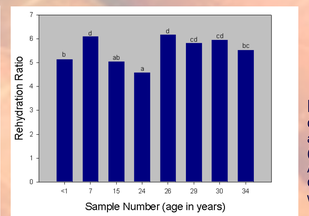

Figure 3 - Rehydration ration in dehydrated carrot sample stored up to 34 years.

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

	Sample number (age in years)							
	<1	7	15	24	26	29	30	34
L*	41.6	40.3	40.8	37.8	42.9	42.7	44.0	40.5
a*	30.2	30.0	25.8	20.8	31.2	17.1	29.5	27.7
b*	31.1	33.4	30.2	26.0	35.6	23.0	37.3	31.9

Table 2 - Mean hedonic scores of reconstituted carrot samples stored up to 34 years. (n=112)

	Sample number (age in years)							
	0	7	15	24	26	29	30	34
Aroma	6.8^{a}	5.7^{b}	4.6^{c}	3.8^{de}	5.0^{bc}	3.7^{de}	4.4^{cd}	4.3^{cde}
Flavor	7.1^{a}	6.4^{ab}	5.3^{c}	4.0^{fg}	5.1^{cd}	3.9^{g}	4.4^{def}	4.8^{cde}
Texture	6.9^{a}	6.4^{ab}	5.3^{cde}	3.4^{h}	5.2^{cdef}	4.1^{g}	5.5^{c}	5.4^{cd}
Appearance	7.2^{a}	6.0^{bc}	5.1^{d}	2.8^{g}	6.7^{ab}	2.7^{g}	4.1^{f}	4.9^{de}
Overall	7.1^{a}	6.3^{b}	5.0^{cd}	3.4^{g}	5.2^{c}	3.5^{g}	4.5^{cdef}	4.7^{cde}

Common superscripts in the same row indicate no significant difference (p>0.05)

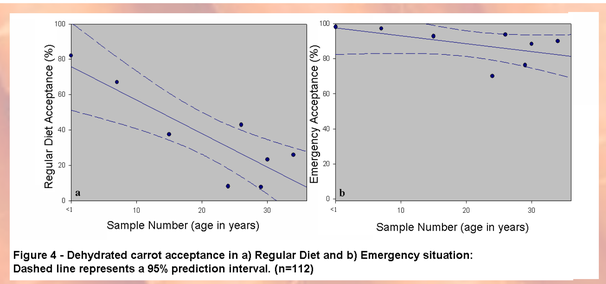

Figure 4 - Dehydrated carrot acceptance in a) Regular Diet and b) Emergency situation: Dashed line represents a 95% prediction interval. (n=112)

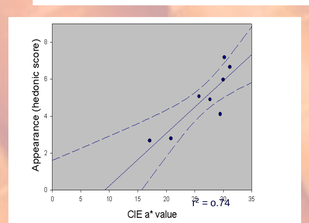

Figure 5 - CIE a* value of dehydrated carrot samples versus sensory appearance of reconstituted carrot samples.

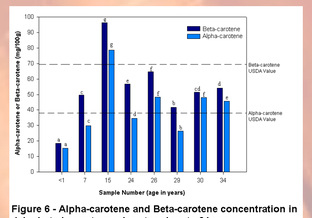

Figure 6 - Alpha-carotene and Beta-carotene concentration in dehydrated carrot samples stored up to 34 years. Dashed lines represent USDA Carotenoid Database values for newly dehydrated carrots.

RESULTS AND DISCUSSION

Headspace Oxygen, Can Seams, Water Activity and Color

Can seams varied in quality, but all were sufficient to maintain a hermetic seal. Headspace oxygen was less than 1.0% except for one sample at 14.9% (Figure 1). Sample water activities (a_w) were relatively consistent, ranging from 0.31 to 0.38 (Figure 2). According to Arya and others (1979), the optima a_w for dehydrated carrots is 0.32 to 0.57. The only sample falling outside this range was sample 15 at 0.31.

As shown in Table 1, CIE L* values ranged from 36.9 to 44.0. CIE a* values ranged from 17.1 to 31.2. CIE b* values ranged from 21.2 to 37.3. CIE L*, a* and b* values did not significantly change with sample age. Though there were differences in color between samples, older samples were not significantly different from newer samples.

Rehydration Ratio

As shown in Figure 3, rehydration ratios ranged from 4.6 to 6.2. Though samples differed from one another in their degree of rehydration, the rehydration ratio did not decline with increasing sample age.

Sensory Analysis

As shown in Table 2, ranges for hedonic score means were: 3.7-6.8 for aroma, 3.9-7.1 for flavor, 3.4-6.9 for texture, 2.7-7.2 for appearance, and 3.4-7.1 for overall acceptability. Scores in each category declined significantly with increasing sample age. Acceptance for everyday use ranged from 7.6 to 82.1%, and acceptance for emergency use ranged from 70.1 to 98.2% (Figure 4). Percent acceptance declined significantly with increasing sample age. Interestingly, the sample with the highest headspace oxygen (sample 26 at 14.9% oxygen) did not have lower sensory scores.

Sensory appearance scores were correlated (r^2=0.74) with CIE a* values, indicating that panelists preferred dehydrated carrots that were more red (presumably orange) in color (Figure 5).

Nutrient Analysis

Beta-carotene and alpha-carotene content of samples ranged from 18.5 to 96.4 mg/100g and 15.2 to 78.6 mg/100g, respectively (Figure 6). There was no significant change in beta-carotene or alpha-carotene over time. The wide variation observed in carotene content could be related to differences in product cultivars. It is noteworthy that after 34 years of storage, a single 22 g (1/2 cup rehydrated) serving of dehydrated carrots still contained over 150% of the Dietary Reference Intake (DRI) for vitamin A.

CONCLUSIONS

Hedonic scores for dehydrated carrot dices stored at ambient temperatures declined significantly over time. However, the percent acceptance for use in an emergency situation remained above 70% for all samples. As would be expected redder (presumably more orange) samples were preferred by consumer panelists. Beta and alpha-carotene levels ranged widely but showed no significant change over time. Results indicate that dehydrated carrot quality declines during long-term storage, but retains sufficient sensory acceptance and nutritional quality to be considered for use in long-term storage regimens.

REFERENCES

Arya SS, Natesan V, Parihar DB, Vijayaraghavan PK, 1979. Stability of carotenoids in dehydrated carrots. J Food Technol 14(6):579-586.

Arya SS, Natesan V, Premavalli KS, Vijayaraghavan PK, 1982. Energy use, cost, and product quality in preserving vegetables at home by canning, freezing and dehydration. J Food Sci 45(6):1561-1565.

Baloch AK, 1987. Effect of sulfur-dioxide and blanching on the stability of carotenoids of dehydrated carrot. J Sci Food Agric 40(2):179-187.

Gee M, 1979. Stability of ascorbic acid, thiamine and beta-carotene in some low temperature dried vegetables. Lebensmittel-Wissenschaft und-Technologie 12(3):147-149.

Mohammad N, Shah MA, Mohmood-Ul-Hassan, Ehteshamuddin AF Mohammad, 1976. Effect of some additives and packing materials on the shelf-life of drum-dried carrot powder. Pakistan J Sci Ind Res 19(3/4):179-181.

Sherma GK, 2000. Effect of processing treatments on the carotenoids composition of dehydrated carrots. J Food Sci Technol India 37(2):196-200.

Singh NP, Kumar RS, 2000. Effect of low-cost storage and packaging on quality and nutritive value of fresh and dehydrated carrots. J Sci Food Agric 80(15):2169-2175.

Singh NP, Kumar RS, 2001. The effect of blanching on quality attributes of dehydrated carrots during long-term storage. Eur Food Res Technol 221(4):445-448.

Stephens TS, McLemore TA, 1969. Preparation and storage of dehydrated carrot flakes. Food Tech 23(12):1600-02.

Sulaeman A, Keeler L, Giraud DW, Taylor SL, Wehling RL, Driskell JA, 2001. Carotenoid content and physicochemical and sensory characteristics of carrot chips deep-fried in different oils at several temperatures. J Food Sci 66(9):1257-1264.

Zhao YP, Chang KC, 1995. Sulfite and starch affect color and carotenoids of dehydrated carrots (*Daucus carota*) during storage. J Food Sci 60(2):324-326, 347.

ACKNOWLEDGEMENTS

The authors appreciate the funding for this research provided by Ira Fulton and the contributions of the following individuals: Raymond Lambert, Jordan Chapman, Heather Pahulu, Daniela Garcia-Jacques, Dr. Jiping Zou, and Airy Zamora-Morris.

Presented at the Annual Meeting of the Institute of Food Technologists in Chicago, Illinois, July 2007