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Research Article

STABILITY OF CAROTENOIDS IN DRY MATTER, PULP AND BABYCARROT FLOUR (*DAUCUS CAROTA – L*) UNDER DIFFERENT PROCESSING AND STORAGE CONDITIONS

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ABSTRACT
This study investigated the concentration of carotenoids in dry matter, pulp and carrot flour subjected to different drying temperatures and storage during a three-month period. Carrots *(Daucus carota L)* Strain 0612435 and *Cultivar juliana*, produced by Embrapa Vegetables, Shiraz were minimally processed in the form of baby carrots. Waste of this processing was centrifuged and we named the resultingby-product raw pulp. The pulp was subjected to drying at three different temperatures (50°C, 60°C and 70ºC) for seven hours to obtain flour. Observation noted that as temperature increased, further degradation of β-carotene occurred reaching losses of 56%, 63% and 72% in dry weight ofinitial value, after drying seven hours at temperatures of 50°C, 60°C and 70°C, respectively. This reflected on the color of the flour obtained at different temperatures. This study concluded that with carrot flour; both temperature and packaging caused a decrease in carotenoids concentration over storage time.

Keywords: *Agro-industrial Residues, Flour, Carrot, Drying, Concentration of Carotenoids*

INTRODUCTION
Carrots provide the main sources of α and β-carotene of vegetable origin, which are provitamina carotenoids. Carotenoids comprise one group of natural pigments most widely found in nature, responsible for colors ranging from yellow to red of flowers, leaves, fruits and some roots among which carrot stands out (Britton, 1992).
Foods of vegetable origin such as carrots play an important role in human consumption given their nutritional and sensory attributes. However, physiological, chemical and enzymatic alterations during minimal processing, added to exposure to higher temperatures may result in reduced nutritional quality of these products (Floros, 1993; Cheftel, 1992).
Minimum processing involves subjecting fruit and vegetables to one or more physical changes, such as washing, peeling, slicing and cutting, and in some cases, chemical treatment making them ready for preparation or consumption. After processing, the attributes of quality, as well as maximum nutritional and sensory characteristics such as freshness, aroma, color and flavor must be maintained.
Some minimal processing agro-industries have used carrot peels in the production of organic compounds that are used as fertilizer to improve physical structure and chemistry of soils. However, these carrot peels could be used in human food too, making minimal processing activity even more viable in the country, thus contributing to improved nutrition of the population (Moretti *et al*., 2006).
Shelf life of minimally processed vegetables is directly related to the packaging process and the physical properties of plastic films used, that is, plastic packaging for these products must present permeability rates to gases (CO2 and O2), and to water vapor, specific to each product or product group, so as to allow better quality and longer shelf life to the final product.
The use of packaging and of suitable temperatures can keep the product free from pathogenic microorganisms, better maintaining quality and longer shelf life. Packages act as protective barriers, minimizing water loss by reducing the respiratory rate during storage, as well as facilitating transportation, handling and selling.
The choice of packaging for minimally processed vegetables depends on factors such as the gas permeability of the packaging, the product type, their respiratory rate and temperature storage, among others, in view of increasing the length of shelf life.

The drying of vegetables is very important in relation to food dehydration. There are no records of its origin, but many methods have been used to this day and in many cases based on current processing technologies (Travaglini, 1981).

The objective of this study was to analyze the concentration of carotenoids in dry matter (%DM), pulp and flour carrot subjected to different temperatures of drying and storage conditions during a three-month period.

MATERIALS AND METHODS

Raw Material and Preparation of Materials

This study used carrots *(Daucuscarota* L.), strain 0612435 and *Cultivar Juliana*, from Embrapa Vegetables, Shiraz, Iran. After harvesting, the carrots were peeled by an abrasion processing machine (model PCED, Siemsem *Ltda*.) and processed in the form of baby carrots, according to Moretti and Mattos (2007).

Carrot peels were centrifuged, spread evenly on trays, placed in a kiln with forced air circulation and dried at 50°C, 60°C and 70°C for 7 hours.Samples were taken at zero hour and every subsequent hour of drying time. To assess the storage time, the material was dried at 50°C for seven hours and ground onan ARBEL model mill, with rotation of 3500 rpm. The flour was packed in four different types of packaging (HDPE - high density polyethylene and LDPE - low density polyethylene, having a transparent or milky aspect).75g were added to each package.In this study withdrew aliquots at zero hour and every ten days during three months to perform the analysis.

Chemical Analysis

Profile of Carotenoids

Performed by extraction in acetone and analyzed in triplicate by high performance liquid chromatography on C18 column, according to the method described by Rodriguez (1999).

Dry Matter

Assessment of dry matter was conducted by thermogravimetric method at 105°C, using a method described by theInstitute of Analytical Standards Shiraz, Iran.

Statistical Analysis

The experiment was conducted in completely randomized design with 24 treatments 3 temperatures 8 times. The evaluation of storage time was performed in a completely randomized design with 40 treatments 4 packs 10 times. The data collected were subjected to analysis of variance and the means compared by least significant difference test.

RESULTS AND DISCUSSION

Drying Curves of Carrot Peels

Figure 1 shows the drying curve results of the carrot peels generated during the minimal processing at three temperatures 50 °C, 60 °C and 70 °C. Observation indicated that, at 70 °C, water loss was higher after 4 hours of drying and at the other two temperatures, unlike 70 °C, this occurred after 5 hours of drying, when stabilization occurred and moisture remained constant until the end of drying time.

The dry matter content at zero hour was 87% for the three treatments and we noticed that towards the end, this figure reached 13%, so we considered seven hours enough time for the drying even at these temperatures, since values obtained are within the legislation for moisture content (13%) of flours in general.

α-carotene

Carotenoids are naturally protected in plant tissues, however, when these are cut or disintegrated, there is an increased exposure of carotenoids to oxygen and contact with enzymes, which catalyze the oxidation process, together with higher temperatures can cause the loss of these pigments (Amaya, 1999).

The HPLC analysis method revealed that the main carotenoids found in the samples were α-carotene and β-carotene. We also noticed that heightened temperature causes an increase in β-carotene degradation (Figure 2) reaching a loss of 56%, 63% and 72% in dry weight from initial values, after seven hours of drying time at temperatures of 50 °C, 60 °C and 70 °C respectively, which reflected the color of the flour obtained at different temperatures.

The concentration of α-carotene at 50 °C remained more stable (Figure 2) than at other temperatures.At 70 °C, the degradation of α-carotene is faster, indicating that at higher temperatures this pigment degrades more easily. Upon completion of drying time at temperatures of 60 °C and 70 °C, no significant difference in decreased alpha-carotene content was observed.

At 50 °C, the degradation process occurred more slowly from the beginning to end of the drying process, finishing with a greater concentration of pigment; therefore, this was the temperature of greater stability for α-carotene. Observation noted a higher oxidation of α-carotene at 70 °C, which is an unwanted substance, because it has no pro-vitamin A activity (Figure 2).

During the follow-up on the different packaging during storage time, we observed that the α-carotene was predominant in samples packed with transparent LDPE (low density polyethylene) up to 70 days of storage, after this period there was a decrease in the concentration of this pigment, ranking below the others (Figure 3).

The results obtained suggest that among the packaging analyzed to preserve α-carotene, the transparent HDPEis the best, when considering that it provided better stability for this pigment among all packaging studied, most likely for the reason that this polymer has low gas permeability.

β-carotene

In the results presented (Figure 4), we observed that α-carotene was predominant in the samples packed in transparent LDPE for up to 70 days of storage, after which period a decrease in the concentration of this pigment occurred, ranking below the others (Figure 4).

There was a decrease in the concentration of β-carotene over the drying period at the three temperatures. The greatest reduction occurred at 70 °C. After 3 hours of drying at 50 °C and 60 °C, we also observed that the loss of β-carotene concentration occurred with almost the same intensity. At the end of seven hours, concentrations of β-carotene pigments analyzed had stabilized at all temperatures, except at 70 °C where this loss was slightly higher (Figure 4). β-carotene was altered during storage time, showing decreased concentration (Figure 5).

The results obtained in this investigation by high performance liquid chromatography (HPLC) concluded that β-carotene was the chief isomeric form found in samples analyzed (Figure 5). However, just as α-carotene, decreased concentration occurred throughout the storage period.

Observation noted that there were small differences in the concentrations of β-carotene pigments analyzed during the storage period among studied packaging, but samples packed with milky HDPE were best preserved (Figure 5).

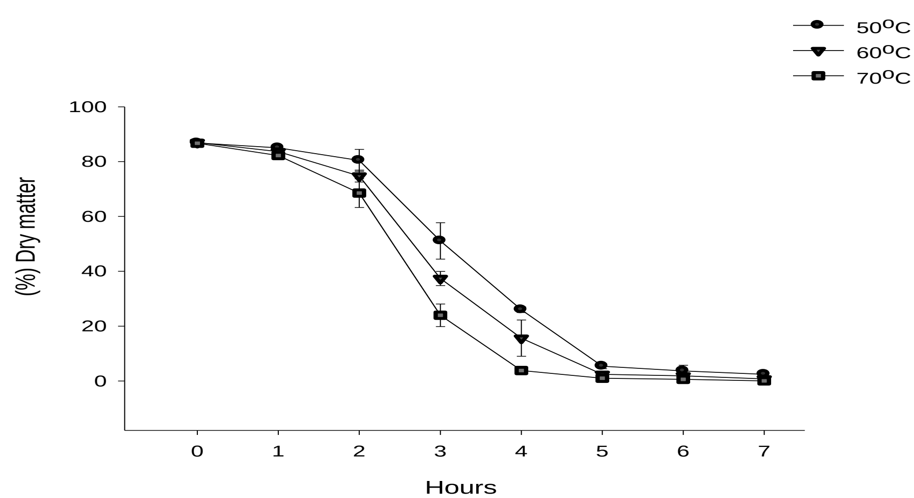

Figure 1: Drying curve of carrot peels (50 °C, 60 °C and 70 °C for 7 hours). Vertical bars represent the standard deviation. Embrapa Vegetables, Shiraz, Iran, 2011

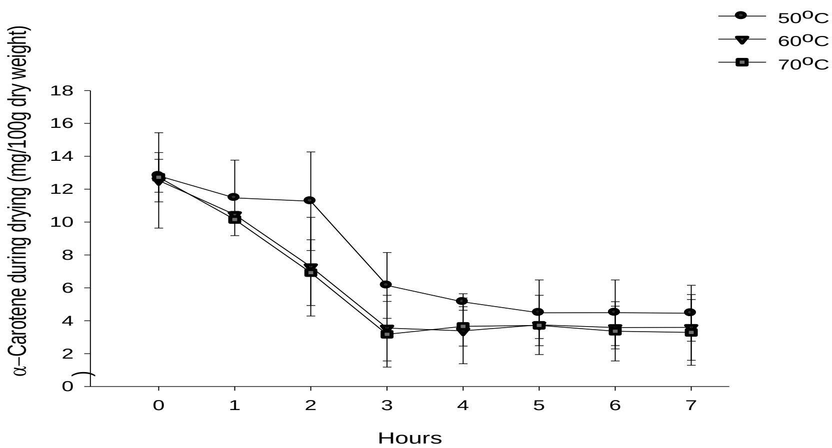

Figure 2: Profile of α-carotene during drying of carrot peels at temperatures 50 °C, 60 °C and 70 °C for seven hours. Vertical bars represent the standard deviation. Embrapa Vegetables, Shiraz, Iran, 2011

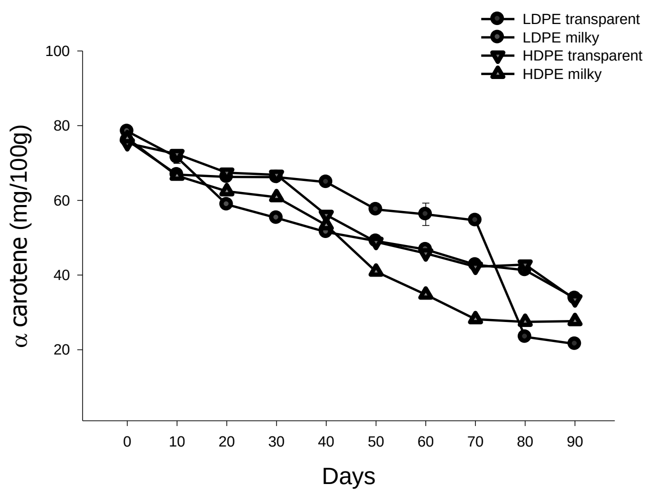

Figure 3: Variation in the concentration of α-carotene in carrot peels, for 90 days of storage in four packaging. Embrapa Vegetables, Shiraz, Iran, 2011

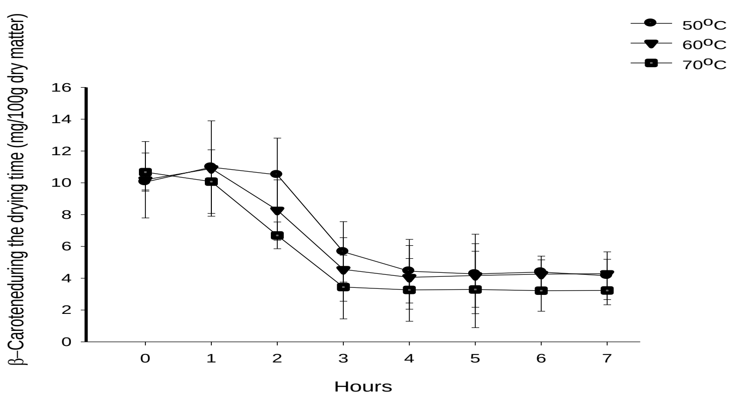

Figure 4: Profile of β-carotene (mg/100 $_{\text{dry weight)}}$ during the drying of carrot peels at temperatures of 50 °C, 60 °C and 70 °C for seven hours. Vertical bars represent the standard deviation. Embrapa Vegetables, Shiraz, Iran, 2011

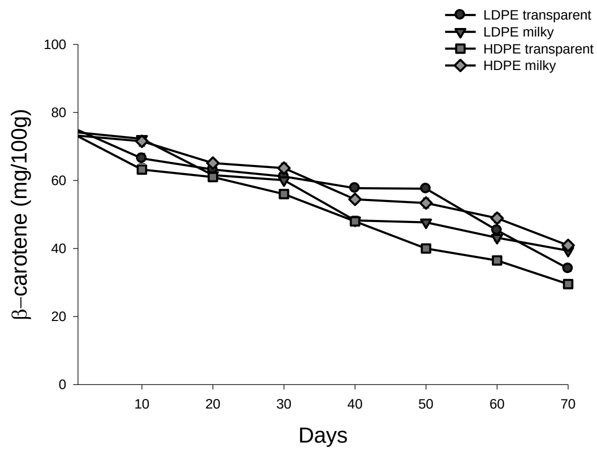

Figure 5: Variation in the concentration of β-carotene of carrot flours during storage in four types of packaging. Embrapa Vegetables, Shiraz, Iran, 2011

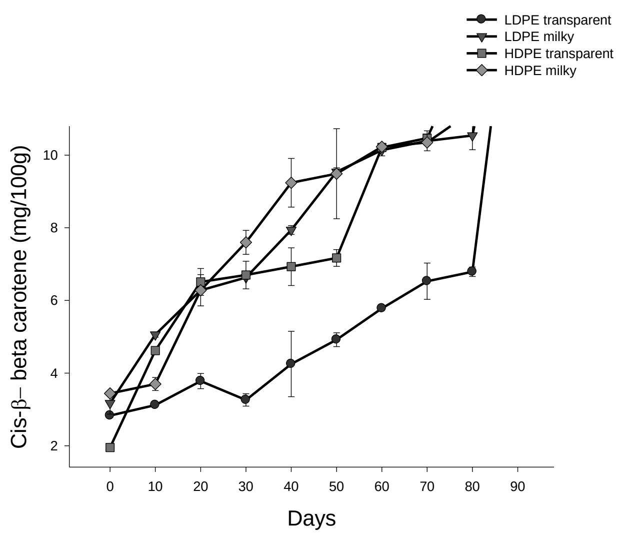

Figure 6: Variation in the concentration of Cis-β-carotene of carrot flours during storage in four types of packages. Embrapa Vegetables, Shiraz, Iran, 2011

Cis-β-carotene

There was a decrease among pigments analyzed over time, yet the opposite occurred with Cis-β-carotene. This component increased over storage time in the four packages studied, and was more intense with transparent LDPE packaging, which has high permeability to gases, but no light shield, and these compounds are formed when the product is exposed to light, high temperature or oxygen (Figure 6).

In this study was observed the appearance of Cis-β-carotene in significant quantities during storage time, clearly indicating that there was conformation in the isomerization of β-carotene, which loses pro-vitamin activity (Figure 6).

Conclusion

In this study was concluded that baby carrots peels can be turned into flour, hence higher product conservation. Among the temperatures studied, 50 °C would be indicated since it increased product life and showed a higher concentration of the carotenoids substances analyzed.

The study of the shelf life of flour is fundamental in determining the final quality, for it is important to know if there is any significant change in the product after staying a few days on supermarket shelves. In this study was noticedthat, in order to preserve the α-carotene carrot flour better, it should be packed in

LDPE (low density polyethylene), and stored for no longer than 70 days. As forβ-carotene the packaging which best held the contents were the milky HDPE (high density polyethylene) for a period of 70 days as well.

Therefore, it is advisable to use milky HDPE for packing carrot flour based on the results obtained in this experiment, to the extent that it was the packaging which best preserved β-carotene, and when considering carrots, the carotenoid pigment carries more provitamin A activity.

Under the conditions in which this experiment was conducted, this study concluded that storage and packaging interfere in carotenoid pigment, contributing to decrease their concentrations, and that this decrease was greater after 70 days of storage, suggesting that this is the maximum storage time under the conditions studied.

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