ORIGINAL PAPER

THE EFFECT OF DEHYDRATION ON BIOACTIVE COMPOUNDS IN SWEET RED PEPPER (*CAPSICUM ANNUUM L.)*

ELENA CORINA POPESCU[1], DANIELA AVRAM[1]

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Abstract. *Red peppers are rich in bioactive compounds (β-carotene, vitamin C) and other nutrients, thus they can also be consumed as a dehydrated product. The most used method of dehydration is the hot air convection method. The purpose of this study was to evaluate the effects of convective dryness on the retention of bioactive compounds in order to obtain products with high biological value. The effects of air temperature (50, 60, 70 and 80 °C) on the retention of β-carotene and vitamin C in dehydrated red peppers were studied. The dehydration was carried out in a thermoregulable dryer with forced air circulation. The red peppers were dehydrated to a dry matter content of 90-93%. Fresh red pepper samples had an average content of 7.66 mg β-carotene / 100 g dry matter (DM), while β-carotene content in dried samples at 50, 60, 70 and 80 °C was 5.88, 4.06, 3.45, 4.62 mg / 100 g DM. Vitamin C retention in dehydrated products increases with the decrease of drying air temperature. The results obtained show that the convective drying with hot air at a suitable temperature can reduce the loss of β-carotene and vitamin C from dehydrated peppers.*

Keywords: *red peppers, β-carotene, vitamin C, dehydration.*

1. INTRODUCTION

The Sweet Red Kapia Pepper is part of the *Solanaceae* family, *Capsicum annuum* L. species. It is an important source of bioactive compounds, antioxidants, phytonutrients, carbohydrates, sulphur and potassium. Sweet Red Pepper is rich in carotenoids, with about 43 carotenoids identified, especially betacarotene and zeaxanthin. Red pigments represent 55-60% of total carotenoids. There are higher amounts of carotenoids in red peppers than in yellow or green peppers [1]. β-carotene is transformed into two molecules of vitamin A1, the main provitamin A, by oxidative enzymatic hydrolysis. The Red Kapia is considered a concentrate of vitamins easily assimilable by the human body. It is also rich in vitamin C (ascorbic acid), vitamin B1, vitamin B2, and provitamin A. The peppers are also rich in acids, the most important being citric acid, malic acid and succinic acid. Carotenoids and vitamin C have an antioxidant role [2-6] in the human body, protecting cells from free radicals and reactive oxygen. It has been found that these pigments also have a photoprotective role in human metabolism, being used to treat photosensitivity and chemoprotective diseases, and antimutagenic effects [1, 7, 8].

The high moisture content of peppers makes it susceptible to alteration, and that is why it is processed dehydrated, frozen or preserved with acetic acid [9]. Several simple or combined methods were used to dehydrate vegetables (hot air drying combined with blanching, osmotic dehydration, microwave dehydration, or ultrasound dehydration). The most used and economical method of dehydration for fruits and vegetables is convective

[1] Valahia University Targoviste, Faculty of Environmental Engineering and Food Science, 130004 Targoviste, Romania. E-mail: corinapopescu2003@yahoo.com.

dehydration with hot air [10]. It is well known that the technological parameters used during dehydration lead to a decrease in the nutritional value and to a change in the sensory features of dehydrated products. However, dehydrated vegetables have an antioxidant activity higher than fresh ones [11, 12].

The purpose of this paper has been studying the influence of drying parameters (temperature, time) on the retention of bioactive compounds (β-carotene and vitamin C) from Sweet Red Kapia Pepper.

2. MATERIALS AND METHODS

2.1. MATERIALS

Sweet Red Kapia peppers were used for this study. They were purchased in October from the local market. The samples were stored at 8-10 °C before dehydration to slow down breathing and physicochemical changes. The peppers were sensuously sorted after colour and size, keeping the peppers who did not show any evidence of physical deterioration.

2.2. METHODS

Hot-air drying

Before each drying, the peppers were hand peeled, washed, and cut cube-shaped with 15 mm side. All samples were blanched at 90 °C for 2 min to inactivate the enzyme equipment and to remove the water easily. After blanching the samples were filtered through stainless steel and cooled. The samples were spread in a single-layer on a perforated plate and dried in a SLN STD 53/115/240 dryer. The drying was carried out at 40% relative humidity, 1.5 m/s air speed, in four temperature levels: 50, 60, 70 and 80°C. The peppers were dehydrated to a moisture content of 7-10%. During dehydration the samples were analysed once at 30 min. The sample weight was determined with an analytical balance with 0.0001 g measuring accuracy.

β-carotene extraction

β-carotene is extracted from the sample using petroleum ether. The amount of β-carotene is calculated according to the extract absorbance determined on the spectrophotometer at 451 nm wavelength, taking into account the existing dilution [13].
The amount of β-carotene is expressed in mg / 100 g of DM.

Determination of vitamin C

5 g of the sample are weighed, mixed with HCl 2% (to avoid oxidation), brought to 100 ml with distilled water. The sample is homogenized, filtered and titrated with 2-6 dichlorophenolindophenol. Vitamin C (ascorbic acid) is reduced with 2-6 dichlorophenolindophenol, passing into its leucoderivative. Ascorbic acid content is calculated by the formula:

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Vxt}}{\text{m}} \text{x dx100} \quad (1)$$

where: V - the volume of the 2-6-dichlorophenolindophenol solution used for titration [cm^3]; t - the titre of the 2-6-dichlorophenolindophenol solution [mg / cm^3]; m- weight of the product [g]; d - dilution factor [13].

Determination of dry matter

The dry matter is determined by keeping the sample in the oven at 105 °C until the sample reaches a constant weight.

Real retention of the nutrient

The evaluation of the damage level of a nutrient due to the technological process is done using the method proposed by Murphy, which establishes real retention (Rr) using the formula:

$$Rr = \frac{NpxMp}{NmpxMmp} \text{ x } 100 \text{ [\%]} \quad (2)$$

where N_p is the nutrient content of the dehydrated product (g/100g DM), M_p -weight of the dehydrated product [g], N_{mp} - nutrient content in the raw material [g/100g DM], $M_{mp.}$- weight of the raw material [g] [14].

3. RESULTS AND DISCUSSION

3.1. EFFECT OF DRYING CONDITIONS ON B-CAROTENE CONTENT

The samples were kept at 50, 60, 70 or 80 °C until they reached 90-93% DM content. Each sample was weighed and analysed once at 30 min. The dehydration time was the following: 450 min at 50 °C, 360 min at 60 °C, 300 min at 70 °C, and 210 min at 80 °C. These values are higher than those reported by Vengaiah et al. for the dehydration of the *Capsicum annum* L. [15]. These differences can be due to a lower temperature and a shorter duration of blanching, but also to the usage of a different pepper species.

Variation of β-carotene in the *Capsicum annum* L., together with the parameters of the technological process is illustrated in Fig. 1. The initial average amount of β-carotene found in the fresh pepper is 7.66 mg/100 g DM. This value is higher than the value reported by Bushway et al., 0.131 mg/100 g DM. The difference is due to the use of another variety of pepper (i.e. green pepper), solvent used for extraction, and the values shown are not related to the amount of dry matter in the sample [16, 17]. Higher values of β-carotene were reported by López et al. for the analysis of red pepper, *Physalis peruviana* L. species [18].

The results showed an average content of β-carotene of 5.88 mg/100 g DM for the samples dried at 50 °C, 4.06 mg/100 g DM for the samples dried at 60 °C, 3.45 mg/100 g DM for the samples dried at 70 °C and 4.62 mg/100g DM for the samples dried at 80 °C. The results confirm that β-carotene losses are influenced by the process parameters (i.e. temperature and time). It is known that at high temperatures and in the presence of oxygen from the air β-carotene is oxidized to 5,6-epoxybeta-carotene. All double bonds in β-carotene can be oxidized. Their breaking starts from the end of the molecule to its centre. Moreover, a longer drying time increases the probability of interaction between β-carotene and oxygen, which decreases β-carotene retention in the dehydrated product [19].

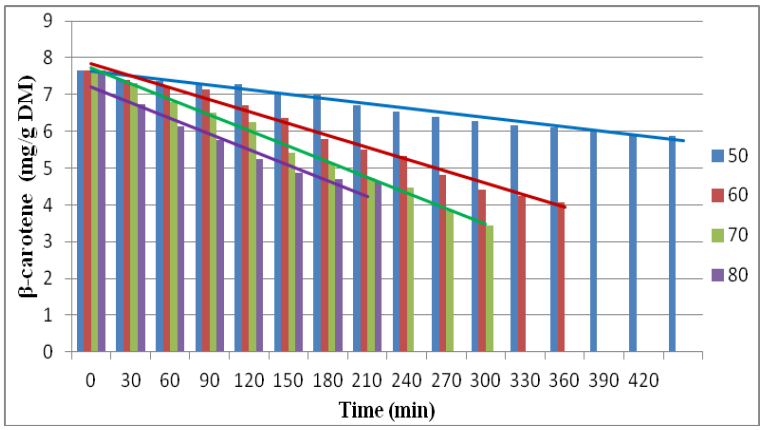

Figure 1. Effect of temperature and time on the degradation of β-carotene.

The effect of drying temperature on real beta-carotene retention is shown in Fig. 2. The highest real beta-carotene retention was found in dehydrated samples at 50 °C and the lowest values in dehydrated samples at 70 °C. It was obtained a higher retention of β-carotene at 80 °C in comparison with the one obtained for the pepper dried at 60 and 70 °C. This higher retention is due to the shorter drying time required to obtain the desired dry matter content for the dehydrated product. The drying time at 80 °C was 53.33% lower than the drying time at 50 °C.

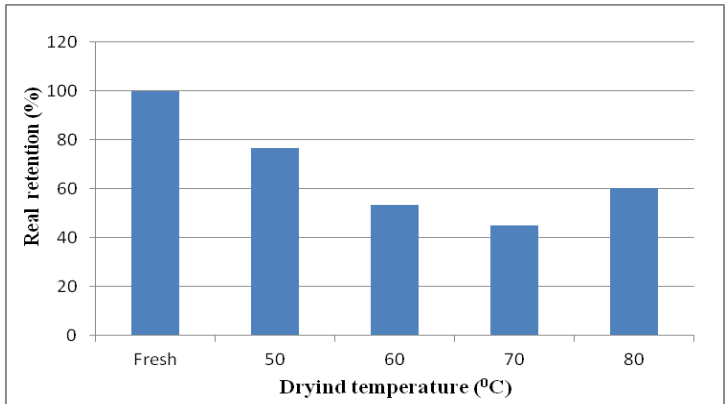

Figure 2. Effect of drying temperature real retention on β-carotene.

Due to keeping longer time at low temperatures, the exposure period of pepper specimens to light and heat increases, and hence oxidation rate and β-carotene degradation increase. Similar results were reported for other types of vegetables by previous researchers [18, 20]. Analysing the results we can say that convective drying with hot air at a suitable temperature can reduce the loss of β-carotene in dehydrated pepper.

3.2. EFFECT OF DRYING CONDITIONS ON VITAMIN C CONTENT

Vitamin C (ascorbic acid) content is used as a reference or indicator for the preservation of nutrients in dehydrated food products because it is a vitamin highly sensitive to heat. If vitamin C is well preserved during the drying process then other nutrients are also well preserved [21].

The effect of dehydration parameters on the variation in vitamin C content is shown in Fig. 3. The average amount of vitamin C in fresh red pepper is 1673.6 mg/100 g DM. This value falls within the range of 1500-2000 mg/100 g DM, value reported in other studies [22, 23].

Drying air temperature has a negative effect on vitamin C content. The results showed a total average content of vitamin C of 987.03 mg/100 g DM for the pepper dehydrated at 50 °C, 798.4 mg/100 g DM for the pepper dehydrated at 60 °C, 654.2 mg/100g DM for the pepper dehydrated at 70 °C, and 418.6 mg/100 g DM for the pepper dehydrated at 80 °C.

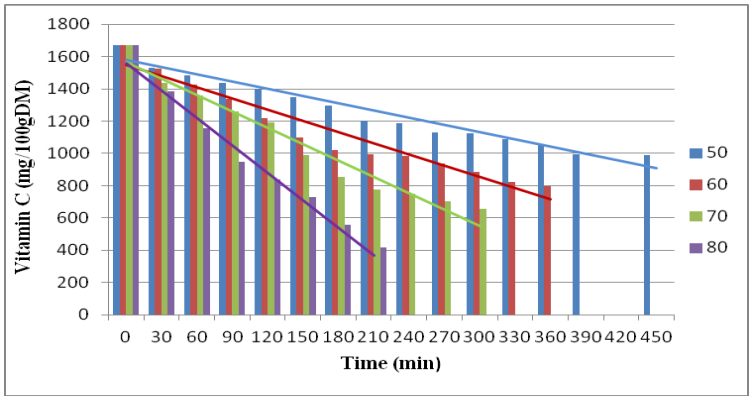

Figure 3. Effect of temperature and time on the degradation of Vitamin C.

The effect of the drying temperature on vitamin C retention is shown in Fig. 4. Vitamin C losses are direct proportional with the temperature. The highest value of real retention was found in dry samples at 50 °C.

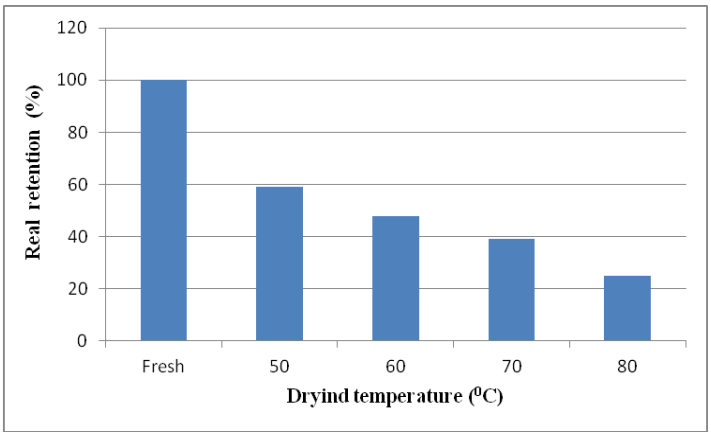

Figure 4. Effect of drying temperature on vitamin C.

The values of actual retention of vitamin C in the dehydrated product are 59.01, 47.73, 39.11 and 25.02% for dehydrated pepper at 50, 60, 70 and 80 °C. These values are higher than those reported in [17] (i.e. 25-45%) where the seabuckthorn (*Physalis peruviana* L.) was dehydrated at air temperature 55-75 °C at 2 m/s. On the other hand, the values obtained in this study were similar to those obtained by Moraes et al. for the dehydration of "dedo-de-moça" red pepper at air temperature 55-75 °C at 0.55 m/s [9]. Managing the temperature during dehydration is the most important factor to ensure higher vitamin C retention in the dehydrated product because the decrease of actual retention is accelerated by high temperatures.

4. CONCLUSIONS

This study shows that convective hot air dehydration influences the amount of bioactive compounds in peppers. Dehydration at a higher temperature (80 °C) shortened the

process time by 53.33% compared to lower temperature dehydration (50 °C). This reduction of dehydration time has influenced real retention of β-carotene.

The results presented may be useful for optimizing the dehydration process in order to obtain products with higher nutritional values (β-carotene, vitamin C).

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