Food Chemistry 224 (2017) 212–218

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Influences of convective and vacuum drying on the quality attributes of osmo-dried pequi (*Caryocar brasiliense* Camb.) slices

Kamilla Soares de Mendonça [a,*], Jefferson L.G. Corrêa [a], João Renato de Jesus Junqueira [a], Marcelo Angelo Cirillo [b], Fabiano Vicente Figueira [a], Elisângela Elena Nunes Carvalho [a]

[a] Universidade Federal de Lavras, Department of Food Science, 37200-000 Lavras, MG, Brazil
[b] Universidade Federal de Lavras, Department of Exact Sciences, Brazil

A R T I C L E I N F O

Article history:
Received 16 October 2015
Received in revised form 11 December 2016
Accepted 18 December 2016
Available online 21 December 2016

Chemical compounds studied in this article:
Sucrose (PubChem CID: 5988)
Beta-carotene (PubChem CID: 5280489)
Ascorbic acid (PubChem CID: 54670067)

Keywords:
Leaching
Carotenoids
Ascorbic acid
Shrinkage
Rehydration
Principal component analysis

A B S T R A C T

Pequi is a fruit from Brazilian Cerrado. Despite its ascorbic acid and carotenoid contents, consumption of pequi is restricted to its region of origin. The goal of this work was to study drying of pequi slices (convective or vacuum drying at 40 °C and 60 °C) preceded or not preceded by osmotic pretreatment (sucrose solution concentrations of 40% and 60%). It was found that osmotic dehydration pretreatment substantially decreased the moisture content, duration of the drying process, and the volumetric ratio of the dried product. However, it also promoted leaching of bioactive constituents, such as ascorbic acid and carotenoids. Vacuum and low temperature drying without osmotic pretreatment were preferable because the ascorbic acid and carotenoids were retained, rehydration coefficients were higher and there were minimal volume and color changes.

1. Introduction

Pequi (*Caryocar brasiliense* Camb.) is a typical fruit from Brazilian Cerrado. It has high nutritional value, being very rich in bioactive compounds with antioxidant properties, such as carotenoids and ascorbic acid (Machado, Mello, & Hubinger, 2013). Dietary intake of these molecules has gained attention because they are associated with reduced risk of developing chronic diseases, such as cardiovascular diseases, cancer, cataract and macular degeneration (Neto, 2007). Currently, pequi is consumed in the region fresh or as an ingredient (Geoze et al., 2013). Its consumption abroad, or even in other parts of Brazil, is limited by the lack of appropriate preservation methods (Machado et al., 2013).

Drying is a traditional process for extending the shelf life of foods (Corrêa, Viana, Mendonça, & Justus, 2016). Dried pequi slices could be used as an ingredient in domestic and industrial preparations, and used to enrich foods with bioactive compounds. Thus, the production of dried pequi slices might increase the economic value of the fruit, expand its consumer market and develop its agribusiness potential. However, the drying process should be examined closely taking into account the degradation of bioactive compounds, quality as related to oxidative damage, loss of flavor, browning, and shrinkage (Orikasa et al., 2014).

Ascorbic acid and carotenoids are thermosensitive compounds that are easily oxidized during drying under normal atmospheric conditions (Demiray, Tulek, & Yilmaz, 2013; Gümüşay, Borazan, Ercal, & Demirkol, 2015; Santos & Silva, 2008). Using low temperatures and reducing exposure to oxygen when drying carrots can minimize oxidization, degradation of carotenoids and ascorbic acid, and improve the capacity for rehydration as well as retaining the color (Liu, Wu, & Miao, 2014).

Osmotic dehydration (OD) is used as a pretreatment to partially remove water (Corrêa, Ernesto, & Mendonça, 2016) in combination with drying process (Junqueira, Corrêa, & Mendonça, in press). OD could improve the drying rate in a subsequent process, help inhibit enzymatic browning, retain natural color (Corrêa, Dev, Gariepy, & Raghavan, 2011), limit the structural collapse and shrinkage, hard-

* Corresponding author.
E-mail address: keamendonca@msn.com (K.S. de Mendonça).

http://dx.doi.org/10.1016/j.foodchem.2016.12.051
0308-8146/

ening and poor appearance (Oikonomopoulou & Krokida, 2013) and improve the sensory, functional and even nutritional properties of dried products.

The aims of this work were to (i) investigate the effect of osmotic dehydration on pequi slices at different solution concentrations, (ii) examine the influence of osmotic pretreatment, drying temperature and vacuum use during drying on the quality of dried pequi slices and (iii) to find out suitable treatments for producing high quality dried pequi slices.

2. Materials and methods

2.1. Sample preparation

Pequi fruits (*Caryocar brasiliense* Camb.) were obtained from the Cerrado region in the north of Minas Gerais state (Brazil) during the harvest period (January 2013). The fruits were stored at 4 °C (±2 °C) until selection, which was usually within a week. Undamaged ripe fruits were selected by size and uniformity. After selection, they were washed in tap water and sanitized with sodium hypochlorite solution (Corrêa, Ernesto, Alves, & Andrade, 2014; Viana, Corrêa, & Justus, 2014). The external mesocarp was removed manually with a stainless steel knife and discarded. The samples were prepared by cutting the internal mesocarp into slices using a stainless steel knife, the average dimensions of which after thawing were 35.04 ± 1.77 mm in length, 14.61 ± 2.12 mm in width and 3.42 ± 0.73 mm in thickness, obtained with a digital caliper (Western, DC-60 model, Zhejiang, China). Fresh slices were packaged in opaque plastic bags and frozen at −18 °C (±2 °C) until further use when they were defrosted completely.

2.2. Experimental conditions

After preparation, the samples were dried using convective or vacuum drying, with or without osmotic pretreatment. A $3 \times 2 \times 2$ full factorial design was employed. The factors, which were selected on the basis of preliminary experiments, were osmotic solution concentration (40% and 60% sucrose), drying temperature (40 °C and 60 °C) and drying method (natural convection drying at atmospheric pressure or vacuum drying at 10 kPa). For a more complete study of the influences of osmotic pretreatment on dried pequi slices, in addition to the pretreated samples (P40 and P60), some samples were dried without osmotic pretreatment (IN). A total of twelve treatments were performed and coded as shown in Table 1.

The detailed conditions of each process are described as follows.

2.2.1. Osmotic dehydration

The osmotic solution was prepared with commercial sucrose (Guarani sugar industry LTDA) and distilled water. The sucrose solution concentrations were 40% and 60% (w/w). Osmotic treatment was performed for 120 min at 25 °C in a thermally controlled chamber (Eletrolab EL111/4, São Paulo, Brazil). The ratio of solution to sample was maintained at 10:1 (w:w) to avoid dilution of the solution during the treatment (Mendonça, Corrêa, Jesus, Pereira, & Vilela, 2016). The experiments were done in triplicate and the mean results are reported.

The sliced pequi samples were removed from the sucrose solutions and immersed immediately in iced mineral water for 10 s to stop dehydration and remove any remaining sucrose solution before being dried gently with absorbent paper (Corrêa et al., 2014; Mendonça et al., 2016). The samples were weighed and placed in hermetically sealed containers and refrigerated (4 °C) prior to further analysis. The moisture content was determined gravimetrically by drying the samples to a constant weight under vacuum at 70 °C according to the AOAC (2010) standard method 934.06. The samples were analyzed for water loss (WL) and solid gain (SG) in accordance with Eqs. (1) and (2), respectively (Viana et al., 2014).

$$WL = \frac{(w_0 \times x_0) - (w_t \times x_t)}{w_0} \tag{1}$$

$$SG = \frac{(w_t \times S_t) - (w_0 \times S_0)}{w_0} \tag{2}$$

where WL is water loss [kg water/kg wet material], SG is solid gain [kg solid/kg wet material], w is sample weight [kg], S is solid content [kg solid/kg wet material], and x is moisture content in wet basis [kg water/kg wet material]. The sub-indexes “0” and “t” refer to the fresh samples and the samples after the osmotic treatment, respectively.

2.2.2. Drying experiments

The experiments were performed in a lab-scale oven (Solab SL 104/40, Piracicaba, Brazil) where the pequi slices were placed in a single layer in heat-resistant Petri dishes. The temperature (40 °C and 60 °C) (Santos & Silva, 2009) and the absolute pressure (natural convection drying at atmospheric pressure or vacuum drying at 10 kPa) were selected based on experimental conditions. Pressure in the dryer chamber was achieved with a vacuum pump (model DV95, Dosivac, Buenos Aires, Argentina) connected to the lab-scale oven. The pequi slices were dried until their final moisture content was 0.12 kg water/kg wet material. All experiments were performed in triplicate.

Table 1
Experimental conditions.

Code	Pretreatment		Drying	
	Osmotic pretreatment	SSC [kg sucrose/100 kg solution]	Air temperature [°C]	Method
P40T40V	Yes	40	40	V
P40T40C	Yes	40	40	C
P40T60V	Yes	40	60	V
P40T60C	Yes	40	60	C
P60T40V	Yes	60	40	V
P60T40C	Yes	60	40	C
P60T60V	Yes	60	60	V
P60T60C	Yes	60	60	C
INT40V	No	–	40	V
INT40C	No	–	40	C
INT60V	No	–	60	V
INT60C	No	–	60	C

SSC means sucrose solution concentration; V means vacuum drying (P = 10 kPa) and C means natural convective drying.