LWT - Food Science and Technology 65 (2016) 537–542

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

Changes in bioactive components and antioxidant capacity of maqui, *Aristotelia chilensis* [Mol] Stuntz, berries during drying

Katia Rodríguez [a], Kong S. Ah-Hen [b, *], Antonio Vega-Gálvez [a], Valeria Vásquez [a], Issis Quispe-Fuentes [a], Pilar Rojas [a], Roberto Lemus-Mondaca [a]

[a] Food Engineering Department, Universidad de La Serena, Raúl Bitrán Avenue 1305, La Serena, Chile
[b] Institute of Food Science and Technology, Faculty of Agricultural Sciences, Universidad Austral de Chile, Julio Sarrazín Avenue, Campus Isla Teja, Valdivia, Chile

ARTICLE INFO

Article history:
Received 19 June 2015
Received in revised form
10 August 2015
Accepted 17 August 2015
Available online 22 August 2015

Keywords:
Maqui berries
Bioactive compounds
Air-drying
Antioxidant activity
Phenolics

ABSTRACT

Thermal processing is known to affect the content of the bioactive compounds and antioxidant activity. In this study drying assays were conducted on maqui berries (*Aristotelia chilensis*) between 40 and 80 °C and a constant airflow of 2 m/s. Total phenolics, flavonoids, anthocyanin, free and bound phenolic acids, β-carotene, tocopherols, vitamin B as well as antioxidant activity as ORAC and DPPH values were determined. Evaluation of drying behaviour showed that at 80 °C equilibrium moisture content is reached after 300 min, while at 40 °C a drying time of 1080 min is needed, whereby degradation of bioactivity is more affected by the higher thermal load, which is observed on the berries at lower temperature. The content of total phenolics was found highest at 60 °C, while that of total flavonoids was highest at 70 °C, with a better correlation to DPPH values compared to ORAC values. The degradation behaviour of α- and γ-tocopherol, was also investigated and resistance to degradation was found highest at 70 °C. Results of the present study provide a valuable tool to harness drying process of maqui berries.

1. Introduction

A growing interest during the recent years to develop formulations with integrated berries extracts as a source of bioactive compounds with high antioxidant capacity can be observed in the food and pharmaceutical industries (Gironés-Vilaplana et al., 2014; Nile & Park, 2014; Vasconcelos Costa, Garcia-Diaz, Jimenez, & Ibrahim Silva, 2013). Moreover, the increasing interest of consumers to improve quality of life have spurred numerous research studies focussed on incorporation of easily accessible beneficial compounds in human diet, which subsequently enabled the food industry to develop new products with health-promoting characteristics. A combination of bioactive compounds with nutritional components like dietary fibre, proteins, carbohydrates and others in human diet is known to be favourable in decreasing the risk of different pathologies, particularly cardiovascular diseases and cancer (Anderson, Baird, Davis, Ferreri, Knudtson, Koraym et al., 2009; Vasconcelos Costa et al., 2013), considered by the World Health Organization (2014) to be the main causes of death through non-communicable diseases in modern society.

The berries of maqui (*Aristotelia chilensis* [Mol.] Stuntz) are red purplish in the ripe state and about 6 mm in diameter. They are native to central and southern Chile (Gironés-Vilaplana, Mena, García-Viguera, & Moreno, 2012). Many studies have shown maqui berries to have an outstanding content of bioactive components with anti-inflammatory (Schreckinger, Lotton, Lila, & González de Mejia, 2010), anti-adipogenic (Schreckinger et al., 2010), anti-atherogenic (Miranda-Rottmann et al., 2002) and cardioprotective activities (Céspedes, El-Hafidi, Pavon, & Alarcon, 2008), associated with the high content of anthocyanin (Escribano-Bailón, Alcalde-Eon, Muñoz, Rivas-Gonzalo, & Santos-Buelga, 2006), flavonols (rutin, quercetin and myricetin), flavanols (catechin) and phenolic acids (Céspedes et al., 2010). Dried maqui berries are therefore a potential source of bioactive compounds that may be explored for different purposes in the pharmaceutical, cosmetic and food industries.

The commonly used methods of food preservation involve thermal treatment to reduce moisture content to a safe level depriving moulds of favourable proliferative conditions (Doymaz, 2008). The influence of drying temperature on relevant quality

* Corresponding author.
E-mail address: kshun@uach.cl (K.S. Ah-Hen).

http://dx.doi.org/10.1016/j.lwt.2015.08.050
0023-6438/

attributes of various fruits, especially on total phenolics (Di Scala, Vega-Gálvez, Uribe, Oyanadel, Miranda, Vergara et al., 2011; López et al., 2013; Mrad, Boudhrioua, Kechaou, Courtois, & Bonazzi, 2012; Wojdylo, Figel, Lech, Nowicka, & Oszmianski, 2014;), total flavonoids, carotenoids as well as on antioxidant capacity (Di Scala & Crapiste, 2008; Rodríguez, Ah-Hen, Vega-Gálvez, López, Quispe-Fuentes, Lemus-Mondaca et al., 2014) has been reported by several researchers. Quality characteristics of dehydrated fruits are generally affected by drying conditions, which means that industrial food drying process must be optimised for precise selection of process variables. Good experimental designs, along with sound statistical analysis are also important for successful achievement of high yield from an operational and economical point of view (Vega-Gálvez, Lemus-Mondaca, Tello-Ireland, Miranda, & Yagnam, 2009).

Although maqui berries have been investigated for bioactivity and medicinal properties, the effect of processing on these characteristics has not been quantified. Therefore, the aim of this study was to assess the effect of drying between 40 and 80 °C on the bioactivity of maqui berries, including phenolics, flavonoids, anthocyanin, β-carotenoids, vitamins and phenolic acids, as well as on antioxidant capacity.

2. Materials and methods

2.1. Raw materials and drying experiments

Maqui berries were obtained in Valdivia, Chile (latitude ≈39°S). The drying process was performed in a convective dryer with continuous recording of sample's weight (Vega-Gálvez et al., 2009) at constant air flow (2.0 ± 0.2 m/s) and five different temperatures (40, 50, 60, 70 and 80 ± 0.2 °C). The samples were dried until equilibrium state and the dried berries were stored vacuum-sealed in low-density-polyethylene bags, protected from sunlight, until further analysis.

2.2. Proximate analysis

The proximate analysis was performed according to AOAC (1990) methods. Moisture content was determined according to AOAC method N° 934.06 using a vacuum oven (OV-11, JEIO Tech, Seoul, South Korea) at 70 °C for 72 h. Crude protein content was determined using Kjeldahl method (Method N° 960.52). Lipid content was determined gravimetrically following Soxhlet extraction (Method Nº 920.39). Crude fibre was estimated by acid/alkaline hydrolysis of insoluble residues (Method Nº 962.09). Crude ash was estimated by incineration in a muffle furnace (FE-341, Jalisco, Mexico) at 550 °C (Method N° 923.03). The available carbohydrate was estimated by difference. All analyses were performed in triplicate and expressed in g/100 g dry matter (dm).

2.3. Preparation of maqui extracts for chemical analysis

The samples of maqui berries (100–200 mg) were extracted according to method described by Rodríguez et al. (2014), and using fresh maqui berries as control. Extractions were performed in triplicate, and extracts were kept for analysis of total phenolic content (TPC), total flavonoid content (TFC) and antioxidant activity by DPPH (2,2-diphenyl-1-picryl hydrazyl) method.

2.4. Determination of total phenolic, total flavonoid and total anthocyanin

All analyses were performed in triplicate and absorbance was measured using a spectrophotometer (Spectronic® 20 Genesys®, IL, USA).

TPC was determined using Folin-Ciocalteu (FC) reagent (Rodríguez et al., 2014) and absorbance was measured at 725 nm. TPC was obtained using gallic acid standard for calibration. Results were expressed as gallic acid equivalent per 100 g dry matter (mg GAE/100 g dm).

TFC was determined by a colourimetric assay (Rodríguez et al., 2014). Absorbance was measured at 415 nm, and total flavonoids content was expressed as mg quercetin equivalent per 100 g dry matter (mg QE/100 g dm).

Total anthocyanin content (TAC) was determined by pH differential method (Lee, Durst & Wrolstad, 2005), after extraction of the dried maqui berries (500.0 ± 0.1 mg) according to method described by Fredes et al. (2014). The absorbance was measured at 520 nm and 700 nm and results were expressed in mg cyanidin-3-glucoside per 100 g dry matter (mg cya-3-glu/100 g dm).

2.5. Determination of antioxidant capacity by DPPH and ORAC assays

The DPPH radical scavenging activity of maqui extracts was measured using the method of Brand-Williams, Cuvelier, and Berset (1995). The results were expressed as mmoles Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) equivalent per 100 g dry matter (mmoles TE/100 g dm).

For determination of Oxygen Radical Absorbance Capacity (ORAC), an extract of maqui berries was prepared according to the method described by Ou, Huang, Hampsch-Woodill, Flanagan, and Deemer (2002). The ORAC assay was carried out using the synthetic antioxidant Trolox as reference. All measurements were performed in triplicate and result was expressed as mmoles Trolox equivalent per 100 g dry matter (mmoles TE/100 g dm).

2.6. Analysis of free and bound phenolics

The extraction and analysis of free phenolic compounds (FPC) and bound phenolic compounds (BPC) were performed according to Rodríguez et al. (2014). The identification of 25 selected phenolic compounds (gallic acid, pyrogallol, 3-hydroxytyrosol, protocatechuic, chlorogenic acid, catequin, tyrosol, epycatechin, 4-hydroxybenzoic acid, caffeic acid, syringic acid, vanillic acid, rutin hydrate, *p*-coumaric acid, trans-sinapic acid, ellagic acid, salicylic acid, trans-ferulic acid, trans-cinnamic acid, 3-methylcatechol, myricetin, benzoic acid, methoxybenzoic acid, quercetin, kaempherol) in methanol-formic acid (99:1) was performed using HPLC comparing with the respective standards, retention times, spectra and peak areas at maximum absorption wavelength. The content of phenolic compounds was expressed in mg per 100 g dry matter (mg/100 g dm). All reagents were of analytical HPLC grade Merck KGaA, Darmstadt, Germany) and standards were from Sigma Chemical Co. (St Louis, MO, USA).

2.7. Determination of β-carotene

The β-carotene extraction was performed according to method described by Olives Barba, Cámara Hurtado, Sánchez Mata, Fernández Ruiz, and López Sáenz de Tejada (2006), using a solvent mixture of hexane/acetone/ethanol (50/25/25 v/v/v). The chromatographic conditions used were similar to those reported by Rodriguez et al. (2014). The calibration curves were prepared for concentration between 0.5 and 50 μg of β-carotene/mL. Results were expressed as mg β-carotene/100 g dm for determination in triplicate.