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Effect of storage conditions on phenolic content and antioxidant capacity of spray dried sour cherry powder

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ABSTRACT

The stability of phenolic compounds, antioxidant capacity and colour changes in spray dried Marasca sour cherry juice powders (MP), packaged in two laminates (Pet 12 μm/PP 18 μm met/PE 100 μm *vs.* Pet 12μm/Al 9 μm/PE85μm), stored under different temperatures (4,20,37 °C) over a storage period (0,3,6,9,12 months) were evaluated. Individual anthocyanins, flavonol glycosides and phenolic acids were identified by HPLC-DAD and antioxidant capacity was monitored by DPPH assay. The anthocyanins, as predominant compounds, were more susceptible to degradation during storage compared to other phenolic compounds. Packaging laminates did not significantly influence phenolics stability, whilst the most pronounced were the impacts of temperature and storage length. Obtained results confirmed that MP has potential as functional food ingredient with attractive natural pigment of red colour whereas optimal storage conditions could preserve the nutritive quality and biological value of the powder.

1. Introduction

Sour cherry Marasca (*Prunus cerasus* var. Marasca) is cherry cultivar with unique sensory properties and rich content of phenolic compounds, especially anthocyanins, responsible for high antioxidant properties. In comparison with other sour cherry cultivars Marasca cherry has higher phenols content (Repajić et al., 2015). Anthocyanins the pigment compounds responsible for deep red sour cherry colour, contribute about 65% of the total phenolics (TP) present in the fruit. The major anthocyanins are derivatives of cyanidin, with dominant cyanidin-3-glucosylrutinoside (Zorić, Pedisić, BursaćKovačević, Ježek, & Dragović-Uzelac, 2016). Other colourless phenolic compounds, also presented in Marasca in high content are hydroxycinnamic acids (HCA) and derivatives of flavonols (Pedisić, Dragović-Uzelac, Levaj, & Škevin, 2010; Zorić, Dragović-Uzelac, Pedisić, Kurtanjek, & Elez Garofulic, 2014, 2016).

As a seasonal fruit Marasca sour cherry is mainly processed into products such as juice, concentrate, alcoholic beverages, dried and frozen fruit, juice powder etc. Fruit juice powders have many benefits and economic potentials over their liquid counterpart, such as reduced volume, weight and packaging, easier handling, transportation, consumption and longer shelf life (Phisut, 2012). Dehydration by spray drying is a highly appropriate process for commercial production of fruit juice powders and heat sensitive components such as phenolic compounds (Hofsky Vieira, de Figueirêdo, & de Melo Queiroz, 2007). Addition of carriers is necessary to increase glass transition temperature and prevent stickiness caused by the presence of low molecular weight sugars and organic acids in fruit juices. Also, the carriers protect the fruit's biologically active compounds against oxidation (Ferrari, Germer, Alvim, & de Aguirre, 2013). This process has been successfully used for fruit juices rich in phenolic compounds, including concentrated juices of blackcurrant, apricot, raspberry (Bhandari, Senoussi, Dumoulin, & Lebert, 1993), pineapple (Jittanit, Niti-Att, & Techanuntachaikul, 2010), and pomegranate juice (Yousefi, Emam-Djomeh, & Mousavi, 2011). According to Rao, Nagender, Satyanarayana, and Rao (2011), fruit juice powders have almost the same nutritive value as fresh juices, but during storage and distribution the powder products are exposed to a wide range of undesirable conditions such as humidity, oxygen, toxic vapours, physical contamination, light and the time–temperature history of the package which can cause degradation and the loss of antioxidants (Jaya & Das, 2005). Therefore, it is of great importance to

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preserve the powder products by providing adequate storage conditions and packaging materials with proper barrier characteristics (Khanna & Peppas, 1982) against ingress of moisture, light and oxygen which cause food quality changes such as the loss of antioxidants, volatile flavourings and colour characteristics (Pua et al., 2008).

Powders are usually packed in heat-sealable laminates containing a mono- or multilayers of aluminium, such as aluminium foil-laminated polyethylene (Jaya & Das, 2005). Evelin, Jacob, and Vijayanand (2007) reported that the spray dried banana powder is shelf-stable in aluminium foil laminated pouches for one year under ambient conditions. According to Rao et al. (2011) quamachil aril powders retained characteristic flavour and taste when packaged in polyethylene and metalized polyester polyethylene (MPE) laminated pouches during the 6 months' storage at room temperature (26 ± 2 °C). Hymavathi and Khader (2005) reported that the physicochemical and nutrient changes were less pronounced in the mango powders packaged in metallized polyester/polyethylene than the powders in the polyester poly packaging. Nevertheless, storage temperature plays a critical role in the phenolics stability and especially anthocyanins' stability in fruit juice powders (Ferrari et al., 2013).

Literature data reveal that higher temperatures have a direct influence on colour degradation which is associated to the Maillard reactions and formation of brown pigments (nonenzymatic browning) (Ferrari et al., 2013; Tonon, Brabet, & Hubinger, 2010).

Previous research confirmed spray drying as appropriate and perspective process for producing Marasca sour cherry juice powder (Elez Garofulić, Zorić, Pedisić, & Dragović-Uzelac, 2016). Though obtained Marasca juice powders (MP) were characterized by high-quality parameters such as sensory attributes, physical and chemical properties, data regarding the effect of storage conditions on the quality parameters of spray dried MP are scarce.

Therefore, the objectives of this study were to evaluate the effect of temperatures (4, 20 and 37 °C) and packaging materials (PET/PPMET/PE and PET/AL/PE) on the stability of phenolic compounds and colour changes of MP during one-year storage time (0,3,6,9,12 months). As antioxidant content is becoming an increasingly important parameter with respect to fruit powder quality, it was also evaluated during observed storage period of MP.

2. Materials and methods

2.1. Material

Sour cherry Marasca concentrated juice (65.5 °Brix) was purchased from "Maraska" factory (Zadar, Croatia) and diluted to 15.3 °Brix with distilled water, measured by digital refractometer (A.Krüss Optronic GmbG, Hamburg, Germany). According to the results of our previous research, juice was mixed with maltodextrin (MD) 13-17DE (Sigma Aldrich) added in ratio juice dry matter:MD = 1:2 (Elez Garofulić et al., 2016). Spray drying experiments were conducted on a laboratory scale spray-dryer SD-06A (Labplant, Hunmanby, UK) with capacity of 1.5 L per h, 1 mm spray nozzle, constant feed rate 485 mL/h, air flow 3.5 m/s, the inlet temperature 150 °C, and outlet temperature 72 °C. 500 mL of juice was spray dried in five batches. The obtained powders were combined and homogenised.

2.2. Packaging and storage conditions of spray dried sour cherries Marasca juice

5 g (±0.0001 g) of MP were packed in bags (10 × 10 cm) of the two different commercially available laminates: (*i*) Pet 12 μm/PP 18 μm met/PE 100 μm (PET/PPMET/PE) and (*ii*) Pet 12 μm/Al 9 μm/PE 85 μm (PET/AL/PE) (Folijaplast, Zadar, Croatia) and stored at: 4 °C, room temperature and 37 °C (experimental design shown in Table 1). Relative humidity and temperatures were controlled (data logger EBI 20TH1, Ebro, Germany) every 6 h for the samples stored at room temperatures. At the end of the storage average temperature and relative humidity was 19.73 °C and 62.4%, respectively. Temperature value was rounded up to 20 °C.

2.3. Chemical and standards

Methanol, formic acid and acetonitrile used for extraction and analysis of phenolic compounds were HPLC grade, purchased from BDH Prolabo, VWR (Lutterworth, England). Water was Milli-Q quality (Millipore Corp., Bedford, USA). Standards of cyanidin-3-*O*-glucoside chloride, quercetin-3-glucoside, phenolic acids and DPPH radical were purchased from Sigma (Steinheim, Germany). Other cyanidins and kaempferol-3-rutinoside were obtained from Extrasynthese (Lyon, France). Trolox was purchased from Fluka (Neu-Ulm, Germany).

2.4. Extraction of phenolic compounds

Phenolic compounds were extracted using a procedure previously described by Elez Garofulić, Dragović-Uzelac, Jambrak, and Jukić (2013). All extracts were prepared in a triplicate and analysed by HPLC-DAD.

2.5. HPLC-DAD analysis of phenolic compounds

HPLC Agilent 1260 quaternary LC Infinity system (Agilent Technologies, Santa Clara, CA, USA) equipped with UV/Vis and DAD, an automatic injector and ChemStation software on a Nucleosil 100-5C18, 5 μm (250 × 4.6 mm i.d.) column (Macherey-Nagel) was used for analysis. The solvent composition and the used gradient conditions were described previously (Zorić et al., 2014). Identification of phenolic compounds was carried out by comparing retention times and characteristic UV/Vis spectra with those of the authentic standards, whereas anthocyanins were identified at 520 nm, flavonol glycosides at 360 nm and phenolic acids at 280 nm (Fig. 1). Quantitative determination was carried out using the calibration curves of the standards. Cyanidin-3-glucosylrutinoside was expressed as equivalent of cyanidin-3-glucoside, kaempferol-3-glucoside as equivalent of kaempferol-3-rutinoside and neochlorogenic acid as equivalent of chlorogenic acid. The results are presented as mg per 100 g dry matter (mean value ± standard deviation, N = 3 replicates).

2.6. Antioxidant capacity (AOC)

The AOC was determined according to DPPH method as previously reported in literature (Zorić et al., 2016). DPPH values were expressed as mmol Trolox equivalents (TE) per 100 g of dry matter, as mean value ± standard deviation (N = 3 replicates).

2.7. Colour analysis

Colour changes for all samples were measured as change in colour before and after storage. The measurements were performed by Konica Minolta colorimeter (Model CM 3500d) at CIEStandard Illuminant D65 by 30 mm thick plate as it was previously described by Kovačević Bursać et al. (2016).

2.8. Data analysis

Previous studies have shown that thermal degradation of