LWT - Food Science and Technology 62 (2015) 996–1003

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

Quality and sensory attributes of apple and quince leathers made without preservatives and with enhanced antioxidant activity

Carolina A. Torres [a, *], Luis A. Romero [a], Ricardo I. Diaz [b]

[a] Facultad de Ciencias Agrarias, Universidad de Talca, Av. Lircay s/n, Talca, Chile
[b] Centro de Estudios en Alimentos Procesados (CEAP), Conicyt-Regional, Gore Maule (RO912001), Av. San Miguel #3425, Talca, Chile

ARTICLE INFO

Article history:
Received 21 October 2014
Received in revised form
28 January 2015
Accepted 30 January 2015
Available online 10 February 2015

Keywords:
Dehydrated fruit
Snack
Antioxidant
Maqui
Nutraceutical

ABSTRACT

Apple and quince leathers were enriched by maqui (*Aristotelia chilensis* Mol. Stuntz) extract to enhance their antioxidant capacity naturally and to develop a new functional snack for new markets. Fruit puree was dehydrated at 60 °C for 20 h and subjected to accelerated storage. Soluble solids, acidity, pH, water activity (aw), total phenolic (TP), antioxidant activity (AOA) and capacity (ORAC), and color change (browning index, BI) were measured in leathers and raw materials. An untrained panel was used to assess consumer acceptability. Leathers had intermediate aw (0.56–0.69), a moisture content of 17 kg water/100 kg, and 70° Brix. The addition of maqui changed the leather's color and BI. TP and AOA were higher ($p \leq 0.05$) in quince formulations. Apple puree fortified with maqui showed 40% and 45% increased in TP and AOA, respectively. Antioxidants decreased up to 59% in leathers compared to fruit puree. TP slightly decreased and the AOA remained unchanged during storage. The BI increased 0.1 and 0.3 units per day in apple leathers with and without maqui, respectively, while the AOA did at −0.002 and 0.008 mg CAE/100 g per day. Untrained panelists preferred the apple to quince or apple with maqui leathers.

1. Introduction

Fruit leathers are thin layers of dehydrated fruit puree with or without added sugar and preservatives (Maskan, Kaya, & Maskan, 2002; Quintero, Demarchi, & Giner, 2010; Raab & Oehler, 2000). The sheet like-leather appearance is given by pectin gelation during dehydration in a matrix containing acids and sugars (Quintero, Demarchi, Massolo, Rodoni, & Giner, 2012). Fruit leathers are made of many types of fruit (apple, berries, grape, kiwifruit, among others), and are a popular snack in North America (Ayotte, 1976; Garden-Robinson, 2011; Huang & Hsieh, 2005; Raab & Oehler, 2000). Today, they are usually oriented to the gourmet healthy foods market (Vatthanakul, Jangchud, Jangchud, Therdthai, & Wilkinson, 2010).

Many formulations have been used to make fruit leathers. Ingredients such as corn syrup, honey, citric pectin, maltodextrin, lecithin, vegetable oils, and ascorbic acid, among others, have been used in addition to fruit puree from one or more species (Huang & Hsieh, 2005; Irwandi & Che Man, 1996; Maskan et al., 2002; Phimpharian et al., 2011). The addition of sodium bisulfite has effectively reduced the enzymatic browning in papaya (Chan & Cavaletto, 1978) and apple (Quintero et al., 2012) leathers.

Fruit puree dehydration is usually carried out below 80 °C in order to maintain the final leather quality (Bains, Ramaswamy, & Lo, 1989; Vijayanand, Yadav, Balasubramanyam, & Narasimham, 2000). The resulting leather usually has intermediate water activity, low moisture content, and low pH, which leads to microbiological stability during and after elaboration (Azeredo, Brito, Moreira, Farias, & Bruno, 2006; Irwandi & Che Man, 1996; Quintero et al., 2012).

Apples and quince have high pectin concentration (>0.15 kg/kg DW), which makes them suitable as raw material for leather production. They have high phenolics content contributing to their antioxidant capacity (Demarchi, Quintero, Concellon, & Giner, 2012; Oszmianski, Wolniak, Wojdylo, & Wawer, 2008), such promoting health benefits for humans.

Abbreviations: AOA, antioxidant activity; TP, total phenolics; ORAC, oxygen radical antioxidant capacity; BI, browning index; CAE, chlorogenic acid equivalent; SS, soluble solids; DPPH, 2,2-diphenyl-1-picrylhydrazyl; AAPH, 2,2′-Azobis(2-amidinopropane) dihydrochloride; DW, dry weight; FW, fresh weight; CFU, colony-forming unit; TE, trolox equivalent.

* Corresponding author. Tel.: +56 71 2200366.
E-mail address: cartorres@utalca.cl (C.A. Torres).

http://dx.doi.org/10.1016/j.lwt.2015.01.056
0023-6438/

The aim of this study was to evaluate physicochemical attributes of fruit leathers made without preservatives and with enhanced antioxidant capacity by the addition of maqui berry (*Aristotelia chilensis* Mol. Stuntz) extract. The latest is a native berry from Chile, with particularly high antioxidant activity and health benefits (Céspedes, El-Hafidi, Pavón, & Alarcón, 2008; Silva, Bittner, Céspedes, & Jakupovic, 1997) that could be used as an ingredient of new and functional snacks.

2. Materials and methods

2.1. Materials

Apples (*Malus domestica* Borkh. L cv. Fuji) and quince (*Cydonia oblonga* L. cv. Champion) were obtained from local producers in the Maule region, Chile. Maqui (*A. chilensis* Mol. Stuntz) freeze-dried extract (Patagonol® FD) was provided by BDS Nutraceuticals (Purranque, Chile). Chemical reagents for biochemical assays were obtained from Sigma–Aldrich (St. Louis, MO, USA).

2.2. Preparation of fruit leather

Whole fruit (1.35 kg) was washed with 5 g/100 mL sodium hypochlorite solution for 5 min and cut into 1 cm^2 cubes discarding the core and seeds. Apples were cooked with 150 mL of water, while quince with 250 mL for 20 min, after which they were pureed using a Sammic SK3 food processor (Azcoitia, Spain) for 5 min. At this point, freeze-dried maqui extract was added (1.8 g/100 g of fruit) to the mixture and layered (8–10 mm thick) onto non-stick pans, and placed in a convector oven (VHC-1A, Ventus Corp., Santiago, Chile) at 60 ± 2 °C, 2.5 m/s dry air for 20 h.

Formulations made of apple with (AppleM) and without (Apple) maqui extract, and quince with (QuinceM) and without (Quince) maqui extract were considered treatments. Each of four different batches was considered a replicate for treatments comparison.

Dehydrated fruit leathers packed with polyethylene (9 mm thick; 11.1 $(10)^6$ kg O_2 m $(m)^{-2}$ $(s)^{-1}$ $(Pa)^{-1}$ and 9.7 $(10)^6$ kg O_2 m $(m)^{-2}$ $(s)^{-1}$ $(Pa)^{-1}$ at 25 °C) were subjected to accelerated storage conditions at 30 ± 2 °C for 35 days in order to increase the speed of biochemical changes associated with shelf-life of the product. During this period, samples were taken every 7 days in order to assess quality parameters such as color (browning index) and antioxidant activity change over time. The rates were calculated by the equation: $V = (dA/dt) = K(A_0)^n$, where V = Reaction velocity, A = Quality attribute, t = time (days), K = Constant velocity reaction, A_0 = Initial attribute concentration, and n = order to reaction (0, 1, 2) (Quintero et al., 2012). Browning index and antioxidant activity were also measured after 6 months in leathers stored at 20 °C.

2.3. Quality attributes

Soluble solids (SS) content was determined using a Hanna HI digital refractometer (Woonsocket, USA) in fruit juice, puree and fruit leathers (AOAC 932.12, 1998).

Acidity and pH were determined using a Schott Titroline easy pH meter previously calibrated with pH 4 and pH 8 buffer solutions (AOAC 981.12, 1998). The acidity was measured by titration and the expression: Acidity = [(NaOH × V1 × EQ acid)/(V2)], where V1 is the NaOH volume, V2 the sample volume, and EQ malic acid equivalents (67 mg/equivalent).

For moisture content, 2 g of sample was taken and left in a Nesco F-50 dehydrator at 70 °C until constant weight was reached (<0.003 g in 2 successive measurements) (Phimparian et al., 2011).

The water activity was measured using a Rotronic Higrolab C1 water activity meter at 20 ± 2 °C (AOAC 978.18, 1998).

Color was assessed periodically (every 7 days) during accelerated storage conditions using a colorimeter Minolta CR-200 (Osaka, Japan). The parameters L*, a*, b* (CIELab) were recorded, and Hue and Chroma calculated. The browning index (BI) was calculated according to Quintero et al. (2012).

2.4. Total phenolics concentration

Fruit cubes, puree and leather samples (3 g) were powdered with liquid N_2 and extracted with 10 mL of 80 mL 100 mL ethanol, homogenized and filtered for use. Total phenolics were determined using the Folin-Ciocalteu method according to Coseteng and Lee (1987) with modifications. Five microliters of the ethanolic extract plus 0.5 mL of Folin reagent (Merck, Darmstadt, Germany) was incubated for 5 min at 20 °C. Then, 0.5 mL of sodium carbonate (10 g/100 mL) was added and incubated again for 15 min at 20 °C. The absorbance was measured at 640 nm and the concentration expressed in chlorogenic acid equivalents (CAE) mg/100 g DW.

2.5. Antioxidant activity determination

From the same ethanolic extract described in chapter 2.4, 0.01 mL were mixed with 2 mL of DPPH solution (2,2-diphenyl-1-picrylhydrazyl; FlukaChemie, Buchs, Switzerland) and incubated for 8 min at 20 °C and the absorbance was read at 515 nm according to Von Gadow, Joubert, and Hansmann (1997) with modifications. Chlorogenic acid was used as a standard and the antioxidant activity expressed in chlorogenic acid equivalent (CAE) mg/100 g DW.

2.6. Antioxidant capacity determination

The antioxidant capacity was determined by the ORAC (Oxygen radical absorbance capacity) method (Szydlowska-Czerniak, Karlovits, Dianoczki, Recseg, & Szlyk, 2008) according to Huang, Ou, Hampsch-Woodill, Flanagan, and Prior (2002) with modifications. The ethanolic samples were diluted with 75 mM phosphate buffer until reaching a phenolic concentration between 0.01 and 0.0006 CAE mg/mL. Subsequently, 25 μL of sample and Trolox® (Aldrich, USA) standards (0, 6.25, 12.5, 25, 50 and 100 uM) were placed in a microplate reader, after which 150 μL of 0.04 μM fluorescein (Sigma–Aldrich, USA) was added and incubated for 30 min at 37 °C. Finally, 25 μL of 300 μM AAPH (Aldrich, USA) was incorporated and fluorescence was read at 485 nm. The antioxidant capacity was determined from the Trolox® standard curve and expressed in trolox equivalent (TE) μmol/100 g DW.

2.7. Microbiological analysis

Samples (50 g) were ground and homogenized with pepton water (0.1 g/100 mL) for 45 s. A series of dilutions were carried out in duplicates, and seeded by pouring method (1 mL) in YGC (yeast glucose chloramphenicol) and PDA (papa dextrose) plates. These were incubated at 24 °C for 3–5 days (Anderson y Calderón, 1999). Colony counts were expressed as colony forming units (mold and yeast) per gram of sample. The Health department in Chile has an acceptable upper limit for fruit in vegetable-based food of 1000 CFU (yeast and mold) per gram of product (Decreto 977/1996).

2.8. Sensory evaluation

Apple, AppleM, and Quince leathers were subjected to sensory evaluation by an untrained panel formed by 120 panelists between 18 and 24 years of age to test for acceptability and preferences of