LWT - Food Science and Technology 59 (2014) 101–107

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

Fresh-cut aromatic herbs: Nutritional quality stability during shelf-life

J. Santos [a], M. Herrero [b], J.A. Mendiola [b], M.T. Oliva-Teles [c], E. Ibáñez [b], C. Delerue-Matos [c], M.B.P.P. Oliveira [a, *]

[a] REQUIMTE, Departamento de Ciências Químicas, Faculdade de Farmácia, Universidade do Porto, Rua de Jorge Viterbo Ferreira, 228, 4050-313 Porto, Portugal
[b] Laboratory of Foodomics, Institute of Food Science Research (CIAL-CSIC), Nicolás Cabrera 9, Campus Cantoblanco UAM, 28049 Madrid, Spain
[c] REQUIMTE, Instituto Superior de Engenharia do Porto, Rua Dr. António Bernardino de Almeida, 431, 4200-072 Porto, Portugal

ARTICLE INFO

Article history:
Received 5 December 2013
Received in revised form
9 May 2014
Accepted 11 May 2014
Available online 20 May 2014

Keywords:
Vitamins
Minerals
Parsley
Coriander
Spearmint
Chives

ABSTRACT

Fresh-cut vegetables are a successful convenient healthy food. Nowadays, the presence of new varieties of minimally processed vegetables in the market is common in response to the consumers demand for new flavours and high quality products. Within the most recent fresh-cut products are the aromatic herbs. In this work, the objective was to evaluate the nutritional quality and stability of four fresh-cut aromatic herbs. Several physicochemical quality characteristics (colour, pH, total soluble solids, and total titratable acidity) were monitored in fresh-cut chives, coriander, spearmint and parsley leaves, stored under refrigeration (3 ± 1 °C) during 10 days. Their nutritional composition was determined, including mineral composition (phosphorous, potassium, sodium, calcium, magnesium, iron, zinc, manganese and copper) and fat- and water-soluble vitamin contents. Total soluble phenolics, flavonoids and the antioxidant capacity were determined by spectrophotometric methods. The aromatic herbs kept their fresh appearance during the storage, maintaining their colour throughout shelf-life. Their macronutrient composition and mineral content were stable during storage. Coriander had the highest mineral and fat-soluble vitamin content, while spearmint showed the best scores in the phenolic, flavonoid and antioxidant capacity assays. Vitamins and antioxidant capacity showed some variation during storage, with a differential behaviour of each compound according to the sample.

1. Introduction

Fresh-cut vegetables are minimally processed healthy products that have gained the consumer's preference for its convenience and due to the growing awareness of the benefits of a balanced diet. An “optimal nutrition” could provide the required amount of nutrients (carbohydrates, proteins, fats, vitamins, and minerals) and also promote health, improve wellbeing and reduce the risk of developing diseases (presence of antioxidant compounds) (Francis et al., 2012; Viuda-Martos, Ruiz-Navajas, Fernández-López, & Pérez-Álvarez, 2010). Fresh vegetables are an important part of a balanced diet and the minimally processed fresh-cut vegetables are an option that can easily fit the busy lifestyle of today's consumers (Tomás-Callejas, Boluda, Robles, Artés, & Artés-Hernández, 2011). The fresh-cut industry is continuously evolving and pursuing new varieties and innovations to meet consumer expectations in terms of convenience, freshness, new flavours and quality (Martínez-Sánchez et al., 2012). Fresh-cut aromatic herbs are becoming a successful option within the fresh-cut market mainly due to their intense flavour and convenience. They are minimally processed (washed, cut and packaged at chilling temperatures) to assure the safety and maintenance of their freshness, tenderness and uniformity of green colour for a longer period (Barrett, Beaulieu, & Shewfelt, 2010). Microbiological safety is essential and is one on the most studied quality parameters in these products (Caleb, Mahajan, Al-Said, & Opara, 2013; Jacxsens, Devlieghere, Ragaert, Vanneste, & Debevere, 2003). Nevertheless, nutritional quality is also gaining the consumer's attention that are now favouring the healthy and convenient food products (Alarcón-Flores, Romero-González, Martínez Vidal, Egea González, & Garrido Frenich, 2014; Fan & Sokorai, 2008).

The use of aromatic herbs in the human nutrition has been described for centuries and has a place in all the cultures. Traditionally, herbs can be used fresh, dried, whole, chopped or ground, and are used to give flavour to food and beverages, reducing the need for salt and fatty condiments (Salgueiro, Martins, & Correia,

* Corresponding author. Tel.: +351 220 428 500; fax: +351 226 093 390.
E-mail address: beatoliv@ff.up.pt (M. Oliveira).

http://dx.doi.org/10.1016/j.lwt.2014.05.019
0023-6438/

2010; Viuda-Martos et al., 2010; Wong & Kitts, 2006). Certain aromatic herbs are also listed as "medicinal plants" and are believed to provide the organism with extra antioxidant compounds, improve digestion, and have some antibacterial, anti-inflammatory, antiviral and anti-carcinogenic activities (Charles, 2013). Phenolic acids, flavonoids, sterols and coumarins are the most-referred bioactive compounds in aromatic herbs with functional properties (Charles, 2013). Due to their antioxidant and antimicrobial properties, aromatic herbs are also used as preservative agents, playing an important role in the conservation of foods and beverages (Salgueiro et al., 2010; Wong & Kitts, 2006).

Minimally processed and individually packed fresh-cut aromatic herbs did not had the initially success reported for other fresh-cut products, due to the high perishability of these leaves (Luo, McEvoy, Wachtel, Kim, & Huang, 2004). Nevertheless, fresh aromatic herbs have clear advantages over the dried product as they retain more aroma (Curutchet, Dellacassa, Ringuelet, Chaves, & Viña, 2014). Minimal processing increases the vegetables respiratory rate, which can lead to a more promptly onset of senescence signs on the fresh-cut leaves and consequently loss of quality (Junqueira-Gonçalves et al., 2012; Martínez-Sánchez, Allende, Cortes-Galera, & Gil, 2008). Although there are several works concerning the nutritional composition and microbiological safety of fresh-cut aromatic herbs (Almeida, Mezzomo, & Ferreira, 2012; Alves-Silva et al., 2013; Hao et al., 2011; Junqueira-Gonçalves et al., 2012; Kamat, Pingulkar, Bhushan, Gholap, & Thomas, 2003; Luo et al., 2004; Ninfali, Mea, Giorgini, Rocchi, & Bacchiocca, 2005; Rosa, Sapata, & Guerra, 2007; Trigo et al., 2009), studies on their stability and nutritional quality during shelf-life are scarce (Curutchet et al., 2014). Therefore, the main aim of this work was to study the stability of nutritional quality during refrigerated storage of minimally processed chives, coriander, parsley and spearmint leaves, which are within the most used aromatic herbs in the gastronomy of the European countries (Almeida et al., 2012; Hao et al., 2011; Junqueira-Gonçalves et al., 2012; Rosa et al., 2007). Nutritional analysis focused on the evolution of their macronutrient composition, vitamins and minerals during shelf-life. Antioxidant capacity and phenolic and flavonoids content of the studied herbs were also assessed. Several physicochemical characteristics, more related to the evolution of the leaves appearance and flavour, as colour, total soluble solids (TSS), total titratable acidity (TTA) and pH, were monitored during refrigerated storage.

2. Material and methods

2.1. Chemicals

All chemicals used were of analytical reagent grade. Distilled and ultrapure water was from a Milli-Q system (Millipore, Bedford, MA, USA). Vitamins standards (purity >99.0%), namely, ascorbic acid (C), thiamine hydrochloride (B_1), riboflavin (B_2), nicotinamide (B_3), D-calcium pantothenate (B_5), pyridoxine (B_6), folic acid (B_9), α-tocopherol (E) and β-carotene (provitamin A) were from Sigma–Aldrich (Madrid, Spain), as the internal standards (hippuric acid and trans-β-Apo-8′-carotenal), the triethylamine (TEA), the butylated hydroxytoluene (BHT) and the nitric acid (65%). Minerals standard solutions (1000 mg/l) of potassium, calcium, magnesium, iron, manganese, zinc and copper were from Panreac Quimica SA (Barcelona, Spain). Phosphorous standard solution was made from potassium dihydrogen phosphate (Riedel-de Haën, Seelze, Germany) and the sodium from sodium chloride from Merck (Darmstadt, Germany). Ammonium acetate and acetic acid were from Panreac (Barcelona, Spain) and Scharlau (Sentmenat, Spain), respectively. Methanol (MeOH), methyl tert-butyl ether (MTBE), ethyl acetate were HPLC-grade from Lab-Scan (Gliwice, Sowinskiego, Poland). Folin–Ciocalteau reagent, sodium carbonate (Na_2CO_3), sodium nitrate ($NaNO_2$) and ethanol were acquired from Merck (Darmstadt, Germany). Gallic acid, catechin, trolox, 2,2-diphenyl-1-picrylhydrazyl (DPPH), TPTZ (2,4,6-Tris(2-pyridyl)-s-triazine), ferrous chloride and ferrous sulphate were supplied by Sigma–Aldrich (Madrid, Spain).

2.2. Samples

Fresh-cut chives (*Allium schoenoprasum* L.), coriander (*Coriandrum sativum* L.), parsley (*Petroselinum crispum* (Mill.) Nym.) and spearmint (*Mentha spicata* L.) leaves were obtained from a commercial producer (Odemira, Portugal) one day after minimally processed (washed, cut and packed). Due to very different formats and sizes of leaf samples, chives were cut in small pieces, while coriander, parsley and spearmint leaves were packed whole. Upon arrival to the laboratory the fresh-cut aromatic herbs were separated in two different groups. The first group was prepared for analyses and the second stored under refrigerated conditions (3 ± 1 °C) for 10 days. A subsample of fresh leaves from each set (about 200 g), at day 1 and day 10, was used for colour, TSS, TTA, pH and macronutrient determinations (protein, fat, ash and dietary fibre determinations). The remaining leaves were freeze-dried (Telstar Cryodos-80, Terrassa, Barcelona), reduced to a fine powder in a knife mill (GM 200, RETSCH, Haan, Germany) and stored protected from light, oxygen and heat until analyses (vitamins, minerals, total soluble phenolics, flavonoids and antioxidant capacity).

2.3. Quality analyses

2.3.1. Physicochemical characteristics

Leaves colour parameters L^*, a^* and b^* were determined with a tristimulus colorimeter (CR-400Chroma Meter, Konica Minolta, Japan), where L^* defines the lightness ($0 < L^* < 100$). Parameters a^* define red (+) to green (−) and b^*, blue (−) to yellow (+) chromaticity and were used to calculate chroma value ($C^* = (a^{*2} + b^{*2})^{1/2}$). The equipment was set up for illuminant D65 with 10° observer angle and calibrated using a standard white plate. Thirty to forty measurements were made in different leaves at each sampling day. Total soluble solids (TSS) were determined on juice, obtained by grinding 10 g of fresh leaves in a knife mill, in a Digital Refractometer (°Brix, HI 9680, Hanna Instruments, EUA). The pH was measured with a pH-meter (Crison Instruments, Barcelona, Spain) in 10 g of leaves homogenized in 20 mL of deionised water (AOAC, 2000). Total titratable acidity (TTA) was determined by titration a suspension of 10 g of fresh leaves homogenized in 100 mL of deionized water, with 0.1 mol/l NaOH to pH value of 8.1 (AOAC, 2000). The results were expressed as mg of citric acid/100 g fresh weight (f.w.) product. The TSS, pH and TTA were determined in triplicate for the two sampling days.

2.3.2. Nutritional composition

Water, protein (factor of 6.25), fat, ashes and total dietary fibre contents were determined according to the AOAC (2000) methods, in the samples from the two groups (day 1 and day 10). Protein content was assessed by a Kjeldahl method, fat by a Soxhlet extracting method, the ash content was determined by incineration at 600 ± 15 °C and dietary fibre by an enzymatic gravimetric method. All values were presented as g/100 g (f.w.) product, being carbohydrates calculated by difference. All proximate composition analyses were done, at least, in triplicate for each sampling day.

Mineral composition was evaluated by a High Resolution-Continuum Source Atomic Absorption Spectroscopy (HR-CS-AAS) method optimized by Santos, Oliva-Teles, Delerue-Matos, and Oliveira (2014). Briefly, 150 mg of freeze dried sample was digested