LWT - Food Science and Technology 50 (2013) 320–325

Contents lists available at SciVerse ScienceDirect

LWT - Food Science and Technology

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

Effect of technological processing upon the antioxidant capacity of aromatic and medicinal plant infusions: From harvest to packaging

Maria S. Gião [a], Cláudia I. Pereira [a], Manuela E. Pintado [a], F. Xavier Malcata [b,c,d,*]

[a] CBQF/Escola Superior de Biotecnologia, Universidade Católica Portuguesa, Rua Dr. António Bernardino de Almeida, P-4200-072 Porto, Portugal
[b] Department of Chemical Engineering, University of Porto, Rua Dr. Roberto Frias, P-4200-465 Porto, Portugal
[c] CEBAL – Centro de Biotecnologia Agrícola e Agro-alimentar do Baixo Alentejo e Litoral, Rua Pedro Soares, Apartado 6158, P-7801-908 Beja, Portugal
[d] CICECO – Centre for Research in Ceramics & Composite Materials, University of Aveiro, P-3810-193 Aveiro, Portugal

ARTICLE INFO

Article history:
Received 13 December 2008
Received in revised form
13 April 2012
Accepted 9 May 2012

Keywords:
$ABTS^{\bullet+}$
Total phenolics
Fresh plant
Frozen plant
Packed plant
Stored plant

ABSTRACT

Antioxidants are secondary metabolites in plants, designed to protect them from abiotic stress; however, they may also improve one's general health, following regular ingestion. Since most foods from plant origin are consumed only after processing and formulation, the final activity exhibited by their antioxidants may be rather different from that in the original plant.

Ten plants empirically used in Portugal in traditional medicine were accordingly studied – agrimony (*Agrimonia eupatoria*), eucalyptus (*Eucalyptus globulus*), walnut-tree (*Juglans regia*), myrtle (*Myrtus communis*), raspberry (*Rubus idaeus*), sage (*Salvia* sp.), savory (*Satureja montana*), sweet-amber (*Hypericum androsaemum*), thyme (*Thymus vulgaris*) and yarrow (*Achillea millefolium*), for total antioxidant capacity and total phenolic content. Significant variations were found between fresh and frozen forms: most plants decreased those features by 30–80 %. However, weather conditions prevailing during plant growth also had a significant impact, besides postharvest storage conditions – especially in the case of antioxidant capacity. Typically, a decrease occurred throughout processing and storage, which was maximum for myrtle and minimum for yarrow.

The results of this research are useful in attempts to preserve the antioxidant content of plant-derived foods, or of plant additives in foods, via rational manipulation of processing conditions after harvest and throughout storage.

1. Introduction

Besides classical preservation features imparted to foods, antioxidants have been increasingly sought for incorporation in human diets because of their claimed benefits as tools in preventive health. Antioxidants are indeed compounds able to protect cells against oxidative stress – which might otherwise lead to cell damage (Buhler and Miranda, 2000; Fennema, 1996; Rivero-Pérez et al., 2005; Valls-Bellés, Muñiz, González, González-Sanjosé, & Beltrán, 2002). Coronary heart diseases, ulcers, cancers and neurodegenerative diseases (e.g. Parkinson's and Alzheimer's) – further to overall ageing, are but a few examples of pathologies that can be prevented (or, at least, delayed) via regular and balanced inclusion of antioxidants in one's diet (Bamforth, 2002; Baxter, 2001).

Several higher plants, both in their leaves and their fruits, contain high levels of antioxidant compounds; their original physiological function is to provide protection against harmful Reactive Oxygen Species (ROS) formed e.g. during photosynthesis or respiration. Shiow and Zheng (2001) have shown that the environmental temperatures prevailing during plant growth affect the phenolic content and the corresponding antioxidant capacities of several fruits. In order to cope with heat stress, plants do resort to various alternative mechanisms – including maintenance of membrane stability, scavenging of ROS, and production of antioxidants concomitant with tannin oxidation. However, the antioxidant capacity after plant harvesting also changes as a function of technological processing – e.g. drying, freezing and storage.

The active roles of several plant infusions upon disease prevention, control or reduction have been attributed – at least in part, to antioxidant features of liposoluble constituents, e.g. vitamins A and E; water-soluble components, e.g. vitamin C; and several amphipathic molecules, broadly termed phenolic compounds (Ivanova, Gerova, Chervenkov, & Yankova, 2005).

* Corresponding author. Department of Chemical Engineering, University of Porto, Rua Dr. Roberto Frias, P-4200-465 Porto, Portugal. Tel.: +351 96 8017411.
E-mail addresses: fmalcata@ismai.pt, fmalcata@docentes.ismai.pt (F.X. Malcata).

0023-6438/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.lwt.2012.05.007

Phenolics include chiefly flavonoids, anthocyanins and lignins – and are probably the most important class of secondary metabolites in plants, in which they play a variety of roles in coping with unfavourable, externally imposed conditions leading to oxidative stress. In particular, flavonoids in plants are important actors in their physiology; besides their function as pigments in flowers and fruits aimed at attracting pollinator insects and seed disperser birds, flavonoids also participate in scavenging of UV-mediated radicals, while contributing to fertility and resistance to disease. Although some plants contain high levels of specific flavonoids, others possess only low concentrations thereof (Schijlen, Ric de Vos, van Tunen, & Bovy, 2004). Anthocyanins – which are a subclass within flavonoids, are greatly modulated by temperature in plant tissues: the higher the prevailing temperature, the lower their concentration in buds and fruits. One of the causes underlying this observation is their lower rate of synthesis and stability at higher temperatures (Wahid, Gelani, Ashraf, & Foolad, 2007).

In all aforementioned cases, maximization of the antioxidant activity retained in plant extracts can be attempted via technological improvement of the extraction process; however, only a portion of the actual activity will be kept, so a major issue still remains pertaining to the inventory of antioxidants in the original plant material itself (prior to extraction and further processing). The main goal of this research effort was thus to assess the variation in total antioxidant capacity and total phenolic content, throughout processing and storage, of ten medicinal plants grown and collected in two consecutive years.

2. Materials and methods

2.1. Plant material, treatment and extraction

Agrimony (*Agrimonia eupatoria*, Rosaceae), eucalyptus (*Eucalyptus globulus*, Myrtaceae), walnut-tree (*Juglans regia*, Juglandaceae), myrtle (*Myrtus communis*, Myrtaceae), raspberry (*Rubus idaeus*, Rosaceae), sage (*Salvia* sp., Lamiaceae), savory (*Satureja montana*, Lamiaceae), sweet-amber (*Hypericum androsaemum*, Clusiaceae), thyme (*Thymus vulgaris*, Lamiaceae) and yarrow (*Achillea millefolium*, Asteraceae) were selected, following a preliminary screening for antioxidant capacity (Gião et al., 2007). These aromatic plants, frequently used in traditional medicine in Portugal, were provided by ERVITAL (Castro Daire, Portugal) – and were all produced via organic farming in the open air, under sufficiently standardized culturing conditions to allow market specifications to be met; the specific parts used of each such plant were described in detail elsewhere (Gião et al., 2007).

Plant samples were supplied at different stages of processing; fresh (1), frozen (2) and dehumidified/packed (3), in two consecutive years (2006 and 2007) – thus producing true experimental replicates; the assays were also obtained as duplicates or triplicates, so analytical replicates were provided as well – and all were used to estimate experimental variability. Furthermore, walnut-tree, sage, savory, sweet-amber and thyme were, after dehumidification under controlled relative humidity, maintained for one year in a dark room not above 25 °C – so as to assess the effect of storage (4). The whole manufacture process is depicted in detail in Fig. 1. Following harvest (1), plants were first cut using a guillotine – in order to increase their surface area, and so accelerate drying in the open air (at room temperature under good ventilation); eventually all plants were frozen to −18 °C by a pulse of cold air, and kept as such in bulk storage (2) before packaging. Upon thawing, dehumidification of condensates was by venting with clean air. At this stage, the plant material was either packaged in bags made of PVC and heat-sealed under vacuum (3), or else stored in a well-ventilated dark room not above 25 °C. In the latter situation, said plant material was again frozen and thawed (without any relevant storage interval in between) and dehumidified before being final packaging (4); this cascade of operations was aimed at decreasing

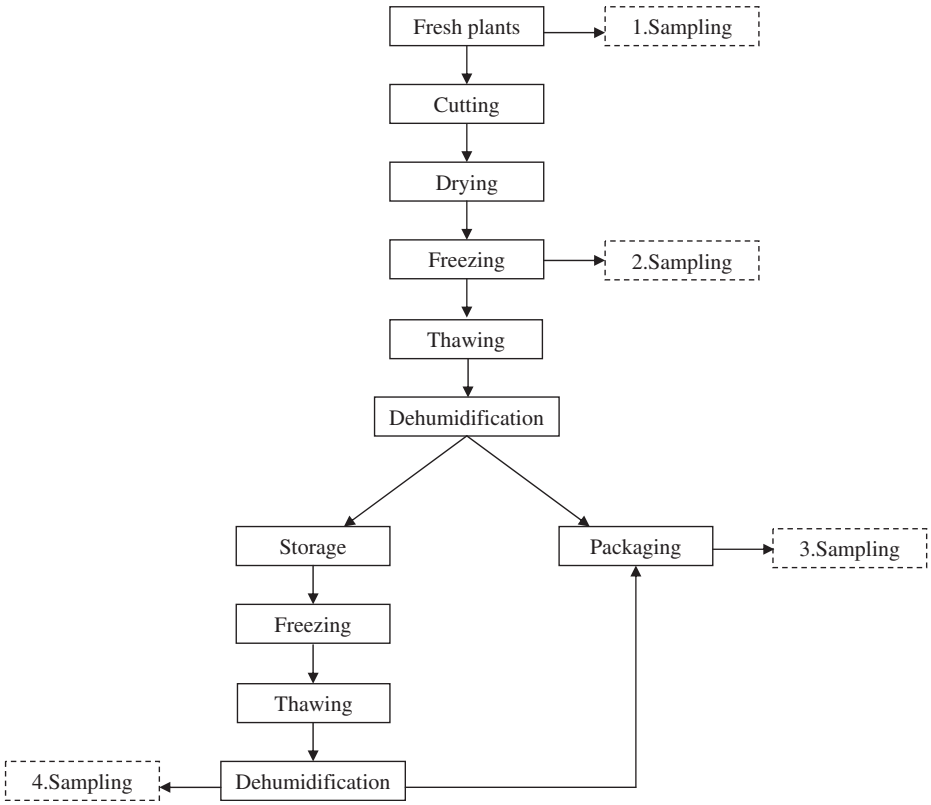

Fig. 1. Flowchart of typical plant processing, from harvest to packaging, with indication of points of sampling for experimental characterization.