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Mediterranean non-cultivated vegetables as dietary sources of compounds with antioxidant and biological activity

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ABSTRACT

Non-cultivated vegetables whose basal leaves have been traditionally consumed in Spain were evaluated for their potential in human nutrition, considering vitamin C, organic acids, tocopherols, phenolics and flavonoids, and antioxidant activity. As far as we know, this is the first report on organic acids and vitamin C of *Anchusa azurea* and *Apium nodiflorum*, on tocopherols of *Aazurea*, *Beta vulgaris*, *Chondrilla juncea*, *Rumex papillaris*, *Rumex pulcher*, *Silybum marianum* and *Taraxacum obovatum*, as well as on the antioxidant capacity of most of them. Data revealed that the mentioned non-cultivated vegetables are good sources of bioactive compounds. *R. pulcher*, *R. papillaris* and *Papaver rhoeas* are rich in vitamin C, *Sonchus oleraceus* and *R. papillaris* in tocopherols. *R. pulcher*, *P. rhoeas* and *A. azurea* showed promising antioxidant properties, which are related to their high levels of phenolic and flavonoids. Some species presented high levels of oxalic acid. Therefore, people with a trend of developing kidney calculus should avoid eating these greens (especially *S. marianum*, *S. oleraceus* and *Beta maritima*) and choose species with low oxalic acid content such as *T. obovatum* and *Cichorium intybus*. The traditional consumption of these species after boiling and rejecting the water may decrease the amount of oxalic acid.

1. Introduction

There is an increasing public awareness that nutrition and dietary components have a very relevant contribution to personal well-being and health (Biesalski et al., 2011). In the case of non-cultivated traditional vegetables, despite its intermingled nutritional and medicinal role has been widely documented (Carvalho & Morales, 2010; Etkin, 1996; Guarrera, 2003; Heinrich, Leonti, Nebel, & Peschel, 2005; Pardo-de-Santayana, Tardío, & Morales, 2005), there are regions where they are mainly seen as an inferior, low-calorie part of the diet (e.g., Poland, Łuczaj, 2010). On the contrary there are *herbophilous* regions, where people appreciate non-cultivated greens and even perceive their health benefits (Ishtiaq et al., 2007). This is the case of many Mediterranean countries, where these vegetables have been an important part of the Mediterranean diet (Parada, Carrió, & Vallès, 2011; Pieroni, 2001).

For instance, non-cultivated vegetables have been traditionally consumed in the Iberian Peninsula and have played a nutritional role in complementing agricultural foodstuff, especially during times of shortage (Tardío, Pardo de Santayana, & Morales, 2006; Carvalho & Morales, 2010). However, there is general trend of decline in the use of non-cultivated vegetables due to social and food habit changes (Carpenter et al., 2009) and only a few species are still widely consumed (Pardo-de-Santayana, Pieroni, & Puri, 2010). Specifically, there is an increasing scientific interest on studying the health benefits of these greens, since their nutritional properties and their richness in bioactive components such as antioxidants, have demonstrated health-promoting properties (Burton & Traber, 1990; Scalbert & Williamson, 2000).

Epidemiological evidences indicate a correlation between the intake of food rich in antioxidants and the reduction of certain chronic diseases. Furthermore, non-cultivated vegetables are rich in micronutrients and have been reported to address micronutrient malnutrition (Kennedy, Nantel, & Shetty, 2003). Vegetables (including non-cultivated plant foods) have interest for their micronutrient content, especially vitamins and minerals, but also

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for other phytochemical compounds with antioxidant properties (Scalbert & Williamson, 2000). These micronutrients are important in the prevention of various pathologies including degenerative, cardiovascular and neurological diseases (Shah & Channon, 2004), several kinds of cancer, as well as embryonic development (Valko, Rhodes, Moncol, Izakovic, & Mazur, 2006).

Vitamin C, both in the form of ascorbic acid (AA) and its oxidized one, dehydroascorbic acid (DHAA), is nutritionally important. It is an essential vitamin and has a high redox potential, alone or/and coupled to other antioxidants, either in food or in human body (Phillips et al. 2010). Recent research in the role of dietary antioxidants in general, and of specific food components have shown the need for accurate food composition data to facilitate epidemiological studies related to the intake of vitamin C, which is often underestimated by the measurement of exclusively AA form.

Another antioxidant of great interest is vitamin E (formed by tocopherols and tocotrienols), being an essential component of the human diet (Trumbo, 2002). Tocopherols are naturally occurring antioxidant nutrients that play important roles in health by inactivating free radicals produced through normal cellular activity and from various stressors. They act as antioxidants by donating a hydrogen atom to peroxyl radicals of unsaturated lipid molecules, forming a hydroperoxide and a tocopheroxyl radical, which reacts with other peroxyl or tocopheroxyl radicals forming more stable adducts (Traber, 2007). It has been reported that γ-tocopherol and its physiological metabolite 2,7,8-trimethyl-2-(β-carboxyethyl)-6-hydroxychroman (γ-CEHC), inhibit COX-2-catalyzed formation of PGE2, inducing anti-inflammatory properties (Barreira et al., 2009). Moreover, it is also believed that tocopherols and tocotrienols protect against degenerative processes, such as cancer and cardiovascular diseases (Burton & Traber, 1990; Kamal-Eldin & Appelqvist, 1996).

Other important nutritional compounds are organic acids. However, there is a lack of data about their profile in non-cultivated vegetables. These compounds are photosynthetic intermediates, mainly produced in mitochondria through the tricarboxylic acid or Krebs cycle and to a lesser extent in the glyoxysome as part of the glyoxylate cycle. Some organic acids may have biological activity, and thus a significant impact on human health. Tartaric, malic, citric or succinic acids have shown positive health benefits as antioxidants due to their ability to chelate metals (López-Bucio, Nieto-Jacobo, Ramírez-Rodríguez, & Herrera-Estrella, 2000; Seabra et al., 2006). As the available data about nutrients and bioactive compounds composition of many non-cultivated edible vegetables are still scarce, and with the aim of improving the knowledge on their nutritional value, the present study provides new data about the content of some compounds with biological activity, such as vitamin C (ascorbic and dehydroascorbic acid), organic acids, vitamin E (tocopherols), phenolics, as well as the *in vitro* measurement of the overall antioxidant capacity of eleven non-cultivated leafy species traditionally used in Spain.

2. Material and methods

2.1. Sampling of plant material

According to their high cultural relevance shown in a previous ethnobotanical review (Tardío, Pardo-de-Santayana, & Morales, 2006), eleven different species of non-cultivated vegetables traditionally used in Spain were chosen (Table 1): *Anchusa azurea* Mill., *Beta maritima* L., *Cichorium intybus* L., *Chondrilla juncea* L., *Papaver rhoeas* L., *Rumex papillaris* Boiss. & Reut., *Rumex pulcher* L., *Scolymus hispanicus* L., *Silybum marianum* (L.) Gaertn., *Sonchus oleraceus* L. and *Taraxacum obovatum* (Willd.) DC. Their basal leaves were harvested and their non-edible portion was eliminated. All these species are usually gathered before flowering (sterile specimens), when they look similar to other species. Therefore a deep knowledge about their vegetative stages and morphological features is needed for a correct identification of the desired species. Fertile material was collected at later date and a herbarium voucher of flowered plants from each studied species and each population was mounted to make easier and to confirm the identification.

Table 1
Edible and medicinal uses of the non-cultivated vegetables surveyed, according to several ethnobotanical studies carried out in the Iberian Peninsula (Benítez, González-Tejero, & Molero-Mesa, 2008; Carvalho, 2010; Carvalho & Morales, 2010; Tardío, 2010).

Species	Edible use	Medicinal uses
Anchusa azurea	Cooked	Gastralgia, cold, kidney stones, pain, skin problems and so on
Beta maritima	Cooked	Digestive disorders, burns and throat pains and anaemia
Papaver rhoeas	Raw and cooked	Nervousness, insomnia, digestive and respiratory disorders, baldness, eye infection, as well as for measles treatment
Rumex papillaris	Raw in salads	–
Rumex pulcher	Cooked	–
Chondrilla juncea	Raw in salads	–
Cichorium intybus	Raw and cooked	Digestive disorders such as laxative, diuretic and invigorative, hypoglycaemic, depurative, disinfectant of urinary tract, hepatoprotective, and in skin diseases
Sonchus oleraceus	Raw and cooked	As depurative and diuretic, in contusions and burns, and also to prevent haemorrhoids
Taraxacum obovatum	Raw in salads	Hepatoprotective, in kidney diseases, malfunction, and asthenia
Scolymus hispanicus	Boiled and fried in olive oil with garlic; raw in salads	Digestive disorders as gastralgias, in Malta fever and in eye infection
Silybum marianum	Boiled and fried in olive oil with garlic; raw in salads.	Liver diseases, gall-blander infection and haemorrhoids

The whole leaves were used in most of the species, except for the two thistles (*S. hispanicus* and *S. marianum*), whose leaves were peeled removing their spines and leaving only the fleshy midribs. The samples were prepared with at least twenty five specimens of each species randomly chosen, gathered in springtime from the middle of March to late May. From each sample, a minimum of 500 g of edible portion was gathered, cleaned by removing soil particles and damaged parts, packed in plastic bags and carried to the laboratory in a cold system within the day. All the samples of the selected species presented a healthy external appearance. Vitamin C and organic acid contents were measured in fresh samples (immediately after collection and transport to the laboratory), whereas tocopherols and antioxidant assays were performed in freeze-dried samples (stored at −20 °C until analysis, less than two years). Moreover, moisture was analyzed in all samples according to Method 925.09 (AOAC, 2005).

In order to have representative samples that take into account the geographical and environmental variability, each studied species was collected from two different wild populations of Central Spain and during at least two years from 2007 to 2009 (three years in some cases). Therefore, the number of surveyed samples for each species was 4 or 6, depending on a two year or three year period of gathering.

Physicochemical, vitamin C and organic acids analyses were performed in all the independent samples and three replicates were used. So the number of measures varied between 12 and 18 according to two or three periods of gathering (e.g. 4 or 6 samples