Food Chemistry 177 (2015) 29–36

Contents lists available at ScienceDirect

Food Chemistry

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

# Elemental characterization of wild edible plants from countryside and urban areas

Massimiliano Renna [a], Claudio Cocozza [b], Maria Gonnella [a,*], Hamada Abdelrahman [b,c], Pietro Santamaria [d]

[a] Institute of Sciences of Food Production, CNR – National Research Council of Italy, Via G. Amendola 122/O, 70126 Bari, Italy
[b] Dipartimento di Scienze del Suolo, della Pianta e degli Alimenti (DISSPA), University of Bari "Aldo Moro", Via Amendola 165/A, 70126 Bari, Italy
[c] Soil Science Dept., Faculty of Agriculture, Cairo University, Giza 12613, Egypt
[d] Dipartimento di Scienze Agro-Ambientali e Territoriali (DISAAT), University of Bari "Aldo Moro", Via Amendola 165/A, 70126 Bari, Italy

ARTICLE INFO

*Article history:*
Received 20 October 2014
Received in revised form 15 December 2014
Accepted 16 December 2014
Available online 26 December 2014

*Chemical compounds studied in this article:*
Iron (PubChem CID: 23925)
Magnesium (PubChem CID: 5462224)
Manganese (PubChem CID: 23930)
Calcium (PubChem CID: 5460341)
Nickel (PubChem CID: 935)
Cadmium (PubChem CID: 23973)
Lead (PubChem CID: 5352425)

*Keywords:*
Nutritional value
Essential elements
ICP-OES
Local habit
Food risk
EC regulation

ABSTRACT

Thirteen elements (Na, K, Ca, Mg, Fe, Mn, Cu, Zn, Cr, Co, Cd, Ni and Pb) in 11 different wild edible plants (WEP) (*Amaranthus retroflexus*, *Foeniculum vulgare*, *Cichorium intybus*, *Glebionis coronaria*, *Sonchus* spp., *Borago officinalis*, *Diplotaxis tenuifolia*, *Sinapis arvensis*, *Papaver rhoeas*, *Plantago lagopus* and *Portulaca oleracea*) collected from countryside and urban areas of Bari (Italy) were determined. *B. officinalis* and *P. rhoeas* could represent good nutritional sources of Mn and Fe, respectively, as well as *A. retroflexus* and *S. arvensis* for Ca. High intake of Pb and Cd could come from *P. lagopus* and *A. retroflexus* (1.40 and 0.13 mg $kg^{-1}$ FW, respectively). WEP may give a substantial contribution to the elements intake for consumers, but in some cases they may supply high level of elements potentially toxic for human health. Anyway, both ANOVA and PCA analyses have highlighted the low influence of the harvesting site on the elements content.



## 1. Introduction

Wild edible plants (WEP) are a favorite delicacy in many countries and have always represented an important food source for the rural communities of the Mediterranean basin (Hadjichambis et al., 2008). Several studies have demonstrated their relevant role in the traditional Mediterranean diets (Heinrich et al., 2005) and their nutritional value even after cooking processes (Boari et al., 2013). Therefore, a lot of people harvest WEP also because of their substantial contribution to the diet in terms of healthy compounds such as minerals, antioxidants and vitamins. So, in Italy and other European countries, the tradition of eating spontaneous plants is not only still alive but is increasing since the WEP are considered natural and healthy foods (Pereira, Barros, Carvalho, & Ferreira, 2011; Renna & Gonnella, 2012; Sánchez-Mata et al., 2012).

In Apulia region (Southern Italy) there are about 2500 wild herbaceous species of which over 500 may be consumed as food (Bianco, Mariani, & Santamaria, 2009). Thus, inhabitants of Apulia harvest WEP as a local habit and many people pick plants from both countryside and near highway of urban areas.

The WEP represent an extraordinary source of food that may be used to diversify and enrich modern diet with many colours and flavours, while providing essential elements such as Ca, K, Mg and Fe. Nevertheless, the information on elements content of WEP are scarce especially as regard the presence of potentially toxic ones. As reported by some authors (Alloway, 2004; Clark, Brabander, & Erdil, 2006; Shinn, Bing-Canar, Cailas, Peneff, & Binns, 2000), vegetables grown in urban and peri-urban areas are generally exposed to a higher level of pollutants including heavy metals. Thus, the traditional practice of Apulia inhabitants to harvest WEP not only in the countryside but also near highway of urban areas could increase human health risks. Effectively, various studies have revealed that consuming vegetables from polluted

* Corresponding author. Tel./fax: +39 080 5929306/9374.
*E-mail address:* maria.gonnella@ispa.cnr.it (M. Gonnella).

http://dx.doi.org/10.1016/j.foodchem.2014.12.069
0308-8146/

sites can lead to serious public health problems (Hough et al., 2004; Kachenko & Singh, 2006; Pruvot, Douay, Hervé, & Waterlot, 2006; Qadir, Ghafoor, & Murtaza, 2000; Sharma, Agrawal, & Marshall, 2007). In this context, the potential contemporary presence in the WEP of beneficial and toxic elements could lead to doubt about their dietary value and health benefits. However, while many Authors have reported the elements content of wild mushrooms harvested from different sites (Gençcelep, Uzun, Tunçtürk, & Demirel, 2009; Mendil, Uluözlü, Hasdemir, & Çaglar, 2004; Ouzouni, Veltsistas, Paleologos, & Riganakos, 2007; Yamaç, Yıldız, Sarıkürkcü, & Halil Solak, 2007), to our best knowledge the literature lacks information with regard to the WEP.

With almost one million inhabitants, the metropolitan area of Bari (Apulia region) represents a big share of the population potentially susceptible both to the risks and benefits of an indiscriminate harvesting of WEP. In this area the harvesting of WEP is a time-honored custom, moreover several species represent the essential ingredient to prepare traditional dishes (Bianco et al., 2009).

Starting from these remarks the aims of the present study were: (i) to assess the concentration of selected elements in several WEP collected from the inner countryside and from fields near the highways of the metropolitan area of Bari (Apulia region); (ii) to understand the benefits and risks of consuming the WEP coming from countryside sites, perceived safe, and from sites close to the highways, considered potentially polluted.

## 2. Materials and methods

### 2.1. Plant material and harvesting sites

Botanical and common names of the WEP selected for the investigation are reported in supplementary information, together with main traits of their use as food. The choice of the 11 WEP was made according to the local habit and to several ethnobotanical surveys conducted in the Mediterranean area (Bianco, Santamaria, & Elia, 1998; Bianco et al., 2009).

The plants were collected from the metropolitan area of Bari, Apulia region, Italy, between winter and spring of 2011. The harvesting area included countryside sites and urban sites, the second ones normally exposed to the vehicular traffic (Fig. 1). Therefore, the collected samples were classified and evaluated into two harvesting areas: near road (NR) area and inner part of countryside (IPC) area. The distances from the road were 0–20 m for samples from the NR area and beyond 1000 m for samples from the IPC area. The plants were harvested manually and a minimum of 30

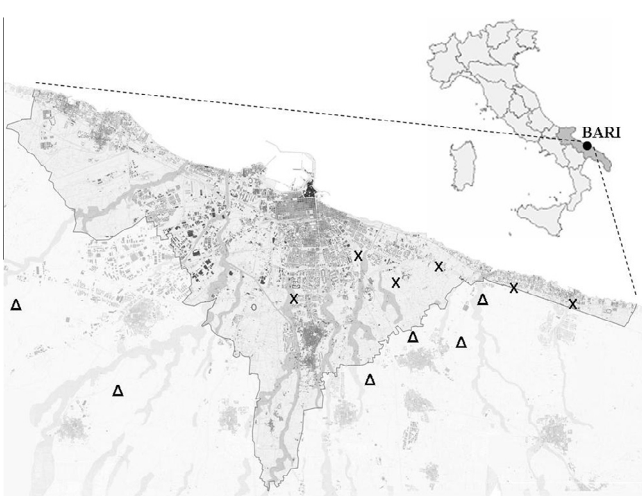


**Fig. 1.** Map of the study area with the harvesting sites: near road of urban area (X); inner part of countryside (Δ).

samples for each replication were pooled to form a single bulk. Each sample was immediately preserved in a portable refrigerator and transported to the laboratory within 2 h from harvest. Samples of each species were gathered according to local consumers practices and preferences in the Apulia region in the season when WEP are most suitable for consumption.

### 2.2. Sample preparation and dry matter determination

The collected plants were gently cleansed and separated into the edible and the waste portion. The latter generally consisted of the older leaves and stems that are removed during the normal dish preparation. The processed sample of each species for each site was divided into two equal portions of 300 g each. One portion (subdivided into three replicates of 100 g each) was dried in a forced air oven at 105 °C until reaching a constant mass for the determination of the dry weight (DW) content. Results were expressed as g 100 $g^{-1}$ fresh weight (FW). The other portion (equally in triplicate of 100 g each) was dried at room temperature and gently ground in an agate mortar to be used for the elemental analysis.

### 2.3. Elemental analysis

Major and trace elements of the selected WEP were analyzed in 132 samples (11 species × 2 harvesting area × 6 replications).

Approximately 0.3 g of each homogenized sample were weighted into a Teflon digestion tube. A mixture of high purity grade concentrated $HNO_3$, HCl and $H_2O_2$ (6:1:1) was added and the tube was heated in an Anton Paar Multiwave 3000 microwave oven. The samples digestion occurred in four steps: the first one started raising the oven power to 800 W in 8 min and keeping it for another 8 min; the second step occurred increasing the power to 1000 W in a period of 8 min and keeping it for another 7 min; during the third phase, the power of 1200 W was reached in 6 min and kept constant for another 6 min; finally, the cooling phase occurred in 25 min. Several blanks were obtained with each batch of samples.

Digested samples were transferred into 50 mL volumetric flasks, diluted with Milli-Q water, filtered through ashless Whatman 42 and stored in polypropylene tubes. All glassware and plastic were cleaned using a 6 M HCl solution and then rinsed with ultra-pure water (18.2 MΩ $cm^{-1}$). The latter was obtained from a Milli-Q Element system (Millipore, Molsheim, France) and used to prepare all solutions.

The concentration of the elements (K, Ca, Mg, Na, Fe, Mn, Cu, Zn, Cd, Cr, Co, Ni and Pb) in the WEP was assessed by inductively coupled plasma optical emission spectroscopy (ICP-OES) measurements using an iCAP 6000 Series ICP-OES Spectrometer, Thermo

**Table 1**
Detection limits of the ICP spectrometer.

| Element | Detection limit (μg $L^{-1}$) |
|---|---|
| Na | 0.0595 |
| K | 0.1557 |
| Ca | 0.0558 |
| Mg | 0.0145 |
| Fe | 0.2385 |
| Mn | 0.0794 |
| Cu | 0.0785 |
| Zn | 0.0760 |
| Cr | 0.2858 |
| Co | 0.1646 |
| Cd | 0.0739 |
| Ni | 0.3065 |
| Pb | 0.8211 |