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Original Research Article

The content of selected minerals and vitamin C for potatoes (*Solanum tuberosum* L.) from the high Tiber Valley area, southeast Tuscany

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ABSTRACT

Potatoes (*Solanum tuberosum* L.) from the high Tiber valley area (TVA; Tuscany, Italy), have been sampled and analyzed for selected mineral content (Na, Mg, K, Ca, and Mn, Fe, Cu and Zn) and vitamin C, the year 2012; some samples from 2011 and 2013 crops were also collected and analyzed. The varieties were Daytona (DAY), Kennebec (KEN), Sifra (SIF) and Volare (VOL). Control samples consisted of mixed commercial varieties from the local market, namely C1, C2 and C3. The low content of sodium, especially for KEN (46 ± 3 mg/kg FD (freeze dry), year 2012) and SIF (47 ± 3) (VOL (55 ± 3) and DAY (61 ± 3) have a little higher values) is worth of note and in agreement with the scarce concentration of Na in the soil (291 ± 12 mg/kg DM). Magnesium was abundant in KEN (1434 ± 75 mg/kg FD, year 2012) and VOL (1334 ± 70). The content of K for DAY and KEN (13,147 ± 900 and 13,185 ± 900 mg/kg FD) was higher than for VOL and SIF; whereas Ca was in the range 340 ± 16–490 ± 28 mg/kg FD. The contents of Cu and Zn were higher in KEN (8.1 ± 0.3 and 25 ± 1 mg/kg FD) when compared to the other varieties and controls. The content of vitamin C is high for KEN and SIF and decreased significantly upon cooking (50% for KEN).

1. Introduction

Potato (*Solanum tuberosum* L.) spread to Europe from the Americas in the late 1500s (Camire et al., 2009) and immediately became very important for human nutrition in the "Old Word" as well. Nowadays, potatoes are cultivated in more than 160 countries (AAFC, 2007), with more than 4000 cultivars (Hils and Pieterse, 2007). As has been reported by Camire et al. (2009) "the potato now ranks third, behind rice and wheat, for human food, as the use of corn for bio-fuels and animal feed has lessened its human food application". Although the areas where potato cultivation is rapidly increasing are in Asia and Africa, specific areas in Europe and in the Americas might play a role for the production of particular varieties that are designed for assuring certain quality standards and dietary requirements. Because of this, more research on the concentration of certain nutrients such as macro- and microessential metals, antioxidants and vitamins in these tubers should be pursued in order to guarantee healthy human nutrition and successfully compete in global markets. Such research must be combined with study of the chemical nature of the soil along with the quality of the water used for irrigation, in order to maintain unpolluted areas and to strictly observe local, national and community regulations on food and the environment, and to select areas with proper solar irradiation and climate parameters. The efforts of several local and national governments are being oriented more and more towards "niche" local productions, and Tuscan regional authorities are taking the lead on this task in Italy (Expo Rurale Toscana, 2013).

Moreover, it is unfortunately very well known that agriculture has been – and in certain regions in the world still is – a significant contributor to the pollution of soil and surface water. Vast and indiscriminate use of fertilizers and pesticides, along with tractor

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cultivation, introduces essential and non-essential elements as well as toxic heavy metals, and large amounts of nitrate and phosphate into the environment, to mention just a few of the inorganic chemical species causing pollution (Reddy et al., 2013; Hang et al., 2009). These inorganic species, particularly the toxic metals but also nitrates and phosphates, that accumulate in the soils over long-term cultivation and that are subsequently taken up by the plant crops and that percolate into surface water systems, can pose serious problems to humans and animals, and they pollute the environment (Taylor and Percival, 2001; Thorburn et al., 2003).

In this paper we wish to report on the selected results from an analytical project on horticultural products from high Tiber Valley in Tuscany, Valtiberina (TVA, Province of Arezzo; Fig. 1). The data concern the concentration of selected minerals and vitamin C in four varieties of potato (*S. tuberosum* L.). The chemical nature of soils and waters from the cultivation lands were also investigated and reported. We felt that the products from certain varieties of *S. tuberosum* L. from that area, have specific nutritional qualities that deserve to be unveiled to the science community and to possible consumers. Selected minerals and vitamin C have been analyzed in the present study. Some of them are representative of the antioxidant potential of the product, like vitamin C and zinc, and some others might be risky for human nutrition, like sodium as a hypertensive contributor, or chromium, nickel, cadmium and lead when the respective concentrations exceed certain threshold values, even if just present in the environment (soils, irrigation waters).

2. Materials and methods

2.1. Reagents and solutions

Ultrapure ascorbic acid (vitamin C) was purchased from Sigma–Aldrich Chemical Co. (Milan, Italy). The ethanol (EtOH), methanol (MeOH) and acetonitrile (MeCN) solvents used for standard solution preparations and for chromatographic analysis, were HPLC grade (Sigma–Aldrich Chemical Co.; Milan, Italy).

Suprapur® mother standard solutions for the metals that contained 1.000 g/L of the elements Mg, Ca, Cr, Mn, Ni, Cu, Zn, Cd, Pb, were purchased from Merck (Darmstadt, Germany). The mother standard solution of Fe was previously prepared by starting from ultrapure iron rods (Merck, Darmstadt, Germany) stored under grease. The rods were cleaned on the surface by scraping them with Whatman® Schleicher & Schuell filter paper, sandpaper, filter paper, in the listed order, to remove possible particles grease, iron oxides, silica. Then the cleaned rods were weighed (0.1000 g) and dissolved in ultrapure HNO_3 (1 M, Merck) and finally brought to volume (100 mL) with ultrapure water. Standard solutions of Na and K were prepared by dissolving 0.2912 g of ultrapure and dry $Na_2C_2O_4$ (primary standard, Merck) and 0.3762 g of ultrapure and dry $K_2Cr_2O_7$ (primary standard, Merck), respectively, in 100 mL of ultrapure HNO_3 (1 M, Merck) and diluted in Milli-Q water (mqw; Advantage A10 system, Millipore, Milan, Italy). The Fe, Na and K standard solutions were recently tested by using Merck standard solutions: the titre was confirmed with an error below 1%. Suprapur® H_2O_2 (Perhydrol® 30%) and HCl (37%) were also purchased from Merck. Water was mqw ultrapure quality and ultrapure gasses were from SolGroup (Milan, Italy).

All the glassware used in the work were Duran-Schott (DURAN Productions GmbH & Co. KG, Mainz, Germany). Glassware, Teflon vessels for microwave, Kartell® line of premium plastic laboratory were used after cleaning and storage in aqueous ultrapure HNO_3 (1%, v/v) for at least 12 h and then rinsed three times with mqw.

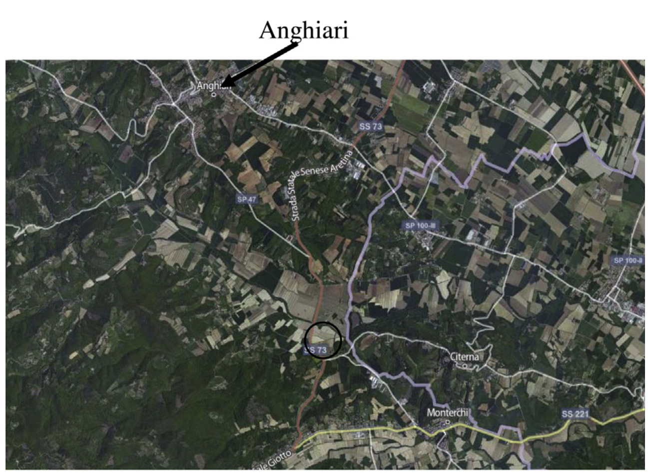

Fig. 1. Detail of the Michelin map showing the Tiber valley area (TVA, Tuscany, Italy) near the towns of Anghiari (shown, 43.5418° N, 12.0605° E) and Sansepolcro (not shown, off map the corner at the upper right) of interest for the work. The sampling fields are located within the black circle (43.5030° N, 12.0868° E) close to the Tuscany (left) – Umbria regional border (pale violet line). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

2.2. Sampling methods

Samples for each variety were collected in cultivated flat, nearly rectangular fields ~0.5 ha in area, through an almost random selection method. Specifically, 4 plants each variety were selected located about ¼ and ¾ the length of two diagonal lines. The tubers of all the plants collected were mixed and the few that were smaller than 3 cm (in at least one dimension) were discarded. The average sizes of the tubers are shown in Fig. S1.

To summarize, the samples collected were as follows: (a) samples 2011 (harvest September 1st), Kennebec (KEN) and Sifra (SIF); (b) samples 2012 (seeds, March) KEN, SIF and Volare (VOL); samples 2012 (June) SIF; samples 2012 (July) Daytona (DAY), KEN, SIF and VOL; samples 2012 (harvest August 30th – September 1st) DAY, KEN, SIF and VOL; (c) samples 2013 (harvest September 1st), KEN and SIF. Control samples consisted of mixed commercial varieties from the local markets in the geographical area close to the sampling fields (namely C1, C2 and C3).

The biological variability for the size of the varieties was estimated as ~15% for KEN and SIF and 25% for DAY and VOL as regards the samples collected within two days before the regular harvest time. The biological variability was not taken into account when the sampling was performed significantly earlier than regular harvest (in June and July). The final whole samples were subsequently treated as follows. Three average sized tubers (~0.5 kg) for each variety from the whole pool were gently rinsed on the surface with faucet water and then dried with filter paper. Next they were peeled using stainless steel knives; a layer of about 0.5 cm was removed from the surface of each tuber. The collection of a second sample was performed in the same way. The pulps of the tubers were then cut into slices 0.5 cm thick using a stainless steel knife and subsequently ground in a Moulinex DPA141, Moulinette knife mill (Groupe SEB, Moulinex International, Ecully Cedex, France).

The homogenate was collected and three portions (100 g each) for each variety were collected and analyzed as follows. Two portions were frozen at -20 ± 1 °C for 12 h in the dark and then were transferred to a freeze-dry machine (XO-12N Ordinary Model Lyophilization Machine with a four-layer compartment; Shanghai Beiyi BioEquip Information Co. Ltd, Shanghai, China) and submitted to lyophilization process for 48 h at -50 °C and pressure <15 Pa. The