SEASONAL VARIATION IN NUTRIENT CONTENT OF SOME LEAFY VEGETABLES FROM BANAT COUNTY, ROMANIA

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ABSTRACT
The aim of this study is to investigate the effect of seasonal variation of the moisture content and trace metal composition of spinach, butter lettuce and parsley leaves. The content of bioactive compounds in green leafy vegetables at harvest has beneficial effects on human health. It was found that moisture, macro and microelement content vary from one season to another. Water content measured by thermo-gravimetric method is presenting small variation during the seasonal change, revealing the lowest value for spinach, butter lettuce and parsley leaves, in June. Calcium, magnesium and potassium concentrations in leaves are decreasing in spinach, lettuce and parsley from April to September, but the variations are small. Copper is accumulating mostly in parsley leaves and less in lettuce and spinach. Knowing the concentration of important nutrients in different seasons helps do decide the harvesting period in according to the richness of the diet for each individual.

Keywords: seasonal variation, green leafy vegetables, moisture dehydration process, trace metals content

INTRODUCTION

Green Leafy Vegetables are principally known for their high nutritional content and are often consumed for their health and dietary benefits.

Spinach (*Spinacia oleracea*) is an edible flowering plant of Amaranthaceae family. Spinach is an important green leafy vegetable in temperate climates presenting high dietary value and being a good source of minerals and vitamins (PROTA4U DATABASE, a).

Spinach contains per 100 g of fresh leaves: 89.7% water, 2.8% protein, 0.8% fat, 1.6% carbohydrate, 2.1% dietary fibre, Ca 170 mg, Mg 54 mg, P 45 mg, Fe 2.1 mg, Zn 0.7 mg, carotene 3535 μg, thiamin 0.07 mg, riboflavin 0.09 mg, niacin 1.2 mg, folate 150 μg, ascorbic acid 26 mg (HOLLAND ET AL., 1991; PROTA4U DATABASE, a).

Sara Bergquist, 2006, found that flavonoids and ascorbic acid concentrations decrease usually during spinach plant growth. Carotenoids show relatively small increases or decreases, but plant growth presents the biggest impact on carotenoid concentration. Flavonoid concentration presents variable responses at different times of the season and at diverse growth stages. She also discovered that the baby spinach, when harvested a few days earlier, had higher ascorbic acid, exhibited improved visual quality and better nutritional value during storage (FAN, 2010).

Lettuce (*Lactuca sativa* L.) is an annual plant and belongs to the family Asteraceae (Compositae), the largest of the dicotyledonous families (FUNK ET AL., 2005), and is considered as the most important vegetable in the group of leafy vegetables (KŘÍSTKOVÁ ET AL., 2008).

According to the PROTA4U database lettuce leaves contain: 94.4 % water, 0.9% protein, 0.6% fat, 1.2% fiber, 0.7% ash per 100 g edible portion. According to HOLLAND ET AL.

(1991), in 100 g edible fresh lettuce high amounts of micronutrients are present: Ca 53 mg, Fe 1.5 mg, β-carotene 910 μg, thiamin 0.15 mg, riboflavin 0.03 mg, niacin 0.5 mg, folate 57 μg, ascorbic acid 7 mg (HOLLAND ET AL., 1991). There are significant differences in nutritional properties among lettuce types (PROTA4U DATABASE, b).
Headed types with a low chlorophyll content (light green leaves) have smaller amount micronutrients than leafy types; the dark green types have noticeably more carotene, Fe and vitamin C (PROTA4U DATABASE, b).
Parsley (***Petroselinum hortense***) is a species of *Petroselinum* in the family *Apiaceae*, widely cultivated as an herb, a spice and a vegetable (BORDEAN ET AL., 2012)
Dried parsley contains per 100 g: 9% water, 22.4% protein, 4.4% fat, 41.4% carbohydrates, 10.3% fiber, 12.5% ash. The micronutrients content found in 100 g dried parsley are: Ca 1.5 g, Fe 98 mg, Mg 249 mg, P 351 mg, K 3.8 g, Na 452 mg, Zn 4 mg, ascorbic acid 122 mg, thiamine 0.172 mg, riboflavin 1.23 mg, niacin 7.93 mg, vitamin B6 1.00 mg and vitamin A 23 340 IU. Fresh parsley loses 80-90% of its weight during drying (PROTA4U DATABASE, c).

MATERIAL AND METHODS

Moisture content and measurements of the mineral concentrations (Ca, Mg, K, Fe, Mn, Zn, Cu, Ni, Cr, Cd and Pb) were carried out in our laboratory (Environmental Research Test Laboratory, Banat`s University of Agricultural Sciences and Veterinary Medicine from Timisoara, Romania).
Water content (%) was determined using Sartorius semi-micro analytical thermo balance, which allows monitoring of the dehydration process by continuous weighing during the evolution process. The measuring accuracy is 0.1% for samples with a mass greater than > 1 g and 0.02% for those larger than 5 g.
The mineral concentrations in the filtrate were determined by flame atomic absorption spectrophotometry with high resolution continuum source (Model ContrAA 300, Analytik Jena, Germany). The process was carried out in triplicates by weighing out 5.0 g

Samples collection and preparation

The study was carried out on three green leafy vegetables (lettuce, spinach and parsley) in the months April, June and September of 2011. Samples were freshly harvested from the same village vegetable farm. All samples were separated and rinsed in distilled water to remove potential impurities.
The samples were washed with double distilled water and spread on clean plastic trays to allow the water to drain off. 5 g of each sample was analyzed for moisture content using thermo-gravimetric method. 200 g of each assortment samples were packed into labeled paper brown envelops and oven dried at a temperature of 65ºC for 4 days. The dried samples were crushed with a mortar (Isolab SL-1372), passed through a 2 mm sieve, and kept for further analysis in self-sealing sterile paper pouches at room temperature (t = 22°C). The analysis of trace metal content was performed as described by Bordean et al 2012.

Reagents and solutions

Powdered samples were used in all the determinations, except in moisture content analysis where 5 g fresh samples were oven dried at 110°C to constant weight using thermo-gravimetric method.

The samples were weighed on an analytical balance (model TP-214, Denver Instrument Gmbh, Göttingen, Germany) to the nearest 0.1 mg. All reagents used in the present study were of analytical grades and double distilled water was used throughout the analyses. The digestion solutions (HNO_3 0.5 N) were prepared from Merck`Suprapur` nitric acid (65%, ρ = 1.39 g/cm^3, Merck KGaA, Darmstadt, Germany).

Statistical analysis and graphical representations

The data were statistically analyzed and graphically represented using Microsoft Office Excel 2007. Star charts plot the values of each category along a separate axis that starts in the center of the chart and ends on the outer ring (MICROSOFT EXCEL, 2007) and represent a useful way to display multivariate observations with an arbitrary number of variables (CHAMBERS ET AL., 1983).

RESULTS AND DISCUSSIONS

The seasonal variations of moisture and mineral nutrients are presented in *Figures 1, 2 and 3*.

Water content measured by thermo-gravimetric method is presenting small variation during the seasonal change, revealing the lowest value in June for all three studied green leafs. Each value in the graphics is an average of 3 replicates. The moisture content in September is lower than in April for spinach and butter lettuce, but higher for parsley leafs (*Figure1*). The obtained values are in accordance with the literature: spinach 89.7% (HOLLAND, B., ET AL., 1991); lettuce 94.4% (HOLLAND, B., ET AL., 1991) and parsley (PROTA4U DATABASE, C and BORDEAN ET AL., 2012).

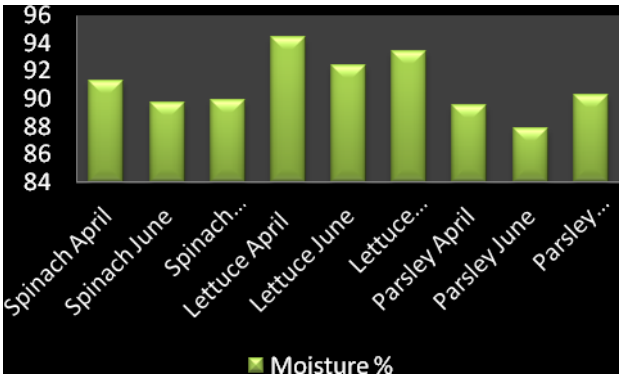

Figure 1. Moisture seasonal variation in green leafy vegetables

Calcium, magnesium and potassium concentrations in leaves are decreasing in spinach, lettuce and parsley from April to September, but the variations are small. Iron content is increasing from April to September for all three studied vegetable leaves (*Figure 2*).

As we can observe, high variation of Mn and Zn (*Figures 3* and *4*) are specific for lettuce leaves which present the highest concentration in September (65.12 ppm Mn and 68.00 ppm Zn) compared to April (27.37 ppm Mn and 22.53 ppm Zn). Mn and Zn concentrations in spinach and parsley follow the same trend, but the variation is smaller. Chromium is accumulating more in parsley leafs (highest accumulation in September) and is absent in spinach. A small amount of Cr is present in lettuce being detected only in the harvested leafs of month September. Cuopper is accumulating mostly in parsley leafs and less in lettuce and spinach (*Figure 5*).

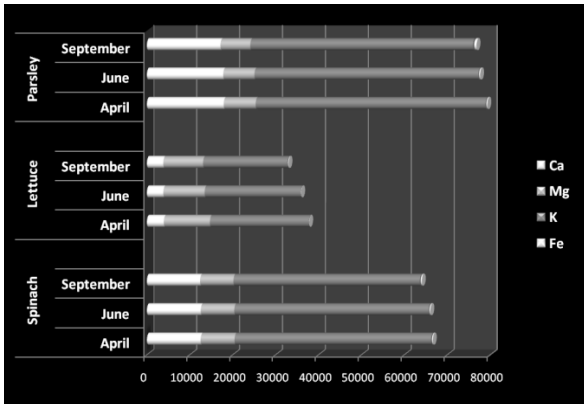

Figure 2. Seasonal variations of Ca, Mg, K and Fe in leafy vegetables
[mg trace metal/kg leafs dry weight]

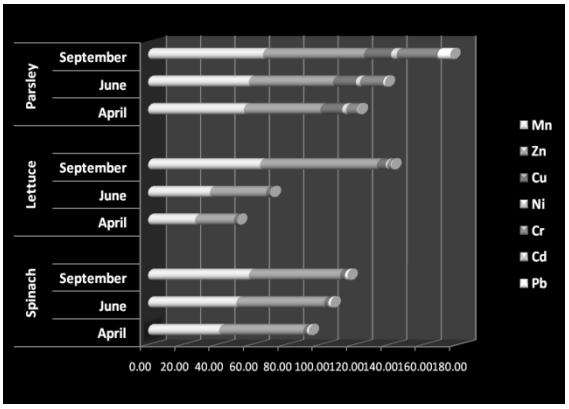

Figure 3. Seasonal variations of Mn, Zn, Cu, Ni, Cr, Cd and Pb in leafy vegetables
[mg trace metal/kg leafs dry weight]

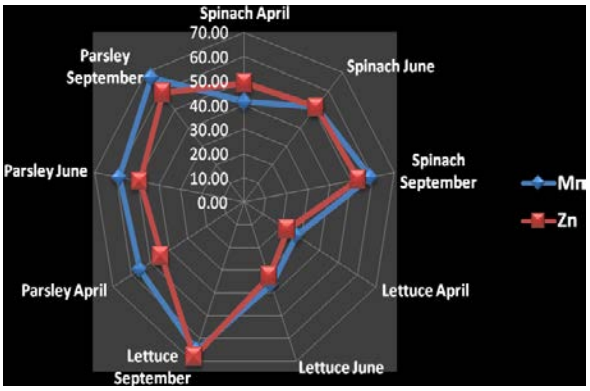

Figure 4. Star graphical representation of seasonal variations of Mn and Zn in vegetables leafs
[mg trace metal/kg leafs dry weight]

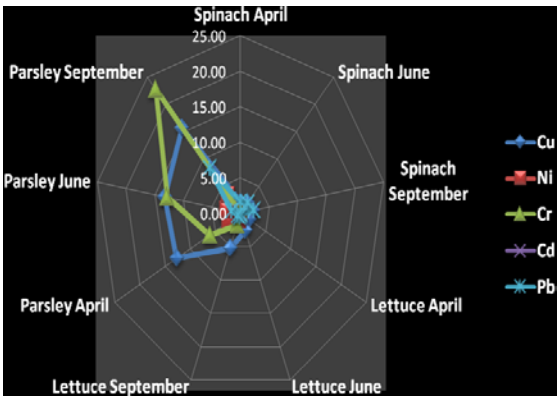

Figure 5. Star graphical representation of seasonal variations of Cu, Ni, Cr, Cd and Pb in vegetables leafs
[mg trace metal/kg leafs dry weight]

CONCLUSIONS

The moisture percent, macro and microelement content vary from one season to another. Knowing the concentration of important nutrients in different seasons helps do decide the harvesting period in according to the richness of the diet for each individual. Knowing the content of bioactive compounds in vegetables at harvest may not only have beneficial effects on human health, but may also reduce post-harvest losses of fresh produce.

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PROTA4U DATABASE, c http://www.prota4u.org/protav8.asp?h=M11,M12,M4&t=Petroselinum,hortense,petroselinum&p=Petroselinum+crispum#Description