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POLYPHENOLIC CONTENT AND RADICAL SCAVENGING CAPACITY OF KOHLRABI SPROUTS AT DIFFERENT MATURITY STAGES

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Abstract. The vegetable and cereal sprouts' consumption is a modern, pleasant and low-cost way to ensure a healthy diet. The kohlrabi sprouts are particularly rich in antioxidants, especially in polyphenolic compounds. The present paper analyses the antioxidant properties reflected by total polyphenolics and radical scavenging capacity of edible kohlrabi sprouts at different maturity stages (5, 7 and 9 days old), in the purpose to suggest the optimal harvest time to produce sprouts with better health-promoting content. The obtained results recommend the harvest of 5-days sprouts, if the producer is interested in a high content of total polyphenolics and increased soluble dry matter. In the case that a product with higher radical scavenging capacity, no matter the nature of contained antioxidants, is required, then the harvest of kohlrabi at the stage of 7-days old sprouts is recommended.

Keywords: antioxidants, Brassicaceae, Brassica oleracea var. gongylodes L., Cruciferae, diet, germination, health-promoting, kohlrabi sprouts, optimal harvest time.

Introduction

Kohlrabi (*Brassica oleracea* var. *gongylodes* L.) is a vegetable from the family named *Brassicaceae* or *Cruciferae*. It originates in north-western Europe and is grown especially in Europe, North America and temperate parts of Asia, but also in subtropical Asia (India, China and northern Vietnam), and occasionally in eastern Africa. There is no information about it before 16th century [1]. Kohlrabi is grown for the flattened spherical stem (stem tuber), which is eaten cooked or raw (in salads). It contains 90 – 92 g/100 g water, 6 – 6.5 g/100 g carbohydrates (more dietary fibers than sugars), 1.5 – 2.0 g/100 g amino acids and proteins, and also minerals: potassium, sodium, calcium, magnesium, iron, manganese, selenium and phosphorus [2]. Kohlrabi is rich in antioxidants from the group of phenolic compounds with a total phenolic content of 2.733±0.026 g GAE/100 g [3] and also contains antioxidant vitamins. The most important content is vitamin C (60 – 65 mg/100 g) and less in vitamin E (around 0.5 mg/100 g). Other well represented water-soluble vitamins are: B1, B2, B3, B5, B6 and B9. The fat content is very small (0.1 g/100 g) and also other fat-soluble vitamins (e.g. vitamin A 2 µg/100 g).

Latest years became more and more popular a modern way to consume raw kohlrabi, not as mature vegetable, but in the phase of sprouts, namely, 5 - 10 days-old plants [4]. Except the very short production time, sprouts usually have the advantage of a greater content in nutrients and nutraceuticals than the same mature plant, and also, than the seeds. In this regard, Marton et al., stated that the biological value of the sprouts' proteins increase during germination, the digestibility was better and the quantity of the antinutritive materials decreased [5]. Li et al., found that in adzuki bean, the total free amino acid content of 3-days sprouts was less than that of 7-days sprouts [6]. Guo et al., studied mung bean sprouts and concluded that germination increased vitamin C content, reaching the higher content during day 8 of germination - up to 285 mg/100 g dry weight, almost 24 times bigger than the initial concentration in mung bean seeds. They found that the antioxidant activity was maximum also in day 8 (by 6 times higher), while the total phenolics and total flavonoids contents were maximum in day 9, being 4.5 and 6.8 times higher than in initial mung bean seeds, respectively [7].

It is well-known that phenolics from vegetables and fruits are antioxidants and health-promoting compounds useful in the prevention of cancer, cardio-vascular and many other degenerative diseases.

From the point of view of the phenolic compounds, in kohlrabi mature plants it was noticed a higher content in leaves than in the edible part of the plant, the stem tuber. The total phenolic compounds were found between 16.473 - 27.582 mg GAE/g extract in kohlrabi leaf, and 7.323 - 8.303 mg GAE/g extract in tuber [8]. In this context it is raised the question of the way that total phenolic content changes in the whole plant during the phases of its maturation.

Based on the present state of knowledge, this study analyses the antioxidant properties, reflected by total phenolic content and radical scavenging capacity of edible kohlrabi sprouts at different maturity stages (5-, 7- and 9-days old), with the purpose to recommend the optimal harvest time to produce sprouts with better health-promoting properties. The sprouts younger than 5-days cannot be considered, because of their very small dimensions and accumulated mass, while after 9-days are too large to be considered as sprouts.

Materials and methods

The "Gigant" kohlrabi seeds from Agrosel, Romania were sterilised with 0.07% NaOCl. The germination was performed in laboratory conditions at 22 - 24 °C and relative air humidity 65 - 70%, for 5, 7, and 9 days.

The soluble dry matter was determined from whole sprouts, at 18 - 20 °C, using Zeiss portable refractometer. Results were expressed as °Bx.

The polyphenols were extracted from whole sprouts, using 70% ethanol acidified with 0.01% HCl following the two-steps procedure described by Patras et al. [9].

The total phenolic content of kohlrabi extracts (TPC) was determined by Folin - Ciocâlțeu method according to Cristea et al. [10]. Results were calculated from a calibration curve with gallic acid and expressed as mg gallic acid equivalents reported to fresh weight (mg GAE/100 g FW). Another method used to quantify total phenolic content was the direct measurement of sample absorbance at 280 nm (after appropriate dilution). It is a faster alternative to Folin - Ciocâlțeu method and results were expressed as total polyphenol

index (I_{280}). The value of I_{280} for each sample was given as the absorbance multiplied by the proper dilution rate [11].

The radical scavenging capacity (RSC) of kohlrabi extracts was measured by reaction with 2,2-diphenyl-1-picrylhydrazyl radical (DPPH[•]), according to the method of Brand - Williams et al. [12], modified by Patras et al. [9]. The results were expressed as percent of DPPH[•] inhibition by the extract [13].

All spectrophotometric measurements employed the Analytik Jena Specord 200 Plus spectrophotometer.

The results were obtained in 3 parallel experiments and are expressed as means \pm standard deviations. Statistical analysis was performed using IBM SPSS Statistics 21 (Tukey HSD test). Differences at $p < 0.05$ were treated as significant.

Results and discussions

The highest content of soluble dry matter was registered for 5-days sprouts (3.4 °Bx), while for 7-days was the lowest one (2.7 °Bx). Still, the differences among all the obtained values are not statistically significant (Figure 1). These slight changes are due to the fluctuations in sugars content during the development of sprouts.

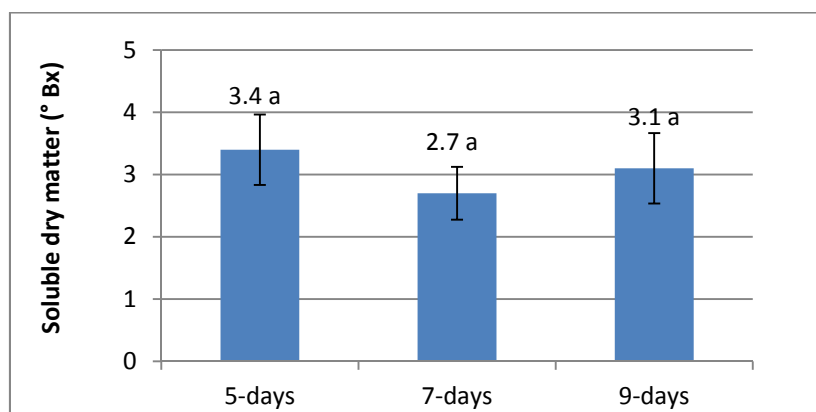


Figure 1. The soluble dry matter (expressed in °Bx) of kohlrabi sprouts at different stages of maturity (5-days old, 7-days old and 9-days old).

Results are means of 3 determinations and error bars represent standard deviation. Same letter (a) denotes statistically insignificant differences between obtained values (Tukey HSD test, $p < 0.05$).

The obtained total phenolic content (TPC) was high in all samples (Figure 2), being between 81.7 – 112.3 mg GAE/100 g FW, which is in concordance with previous results. For example, Lim et al., proved that among a series of 7 different sprouts, kohlrabi hold a top place after radish.

They stated that the TPC of different sprouts species decreased in the order: radish > kohlrabi > rape > red radish > tah tasai > cabbage > broccoli sprouts [14].

The highest total phenolic content was obtained for 5-days old sprouts (112.28 mg GAE/100 g FW) and it is statistically different compared to TPC of 7- and 9-days old sprouts. The 9-days old kohlrabi sprouts revealed the lowest TPC (81.68 mg GAE/100 g FW), and it is not significantly different compared to 7-days sprouts (82.70 mg GAE/100 g FW).

The total phenolic content measured by Folin – Ciocalteu method is considered an indicator of the total antioxidant capacity.

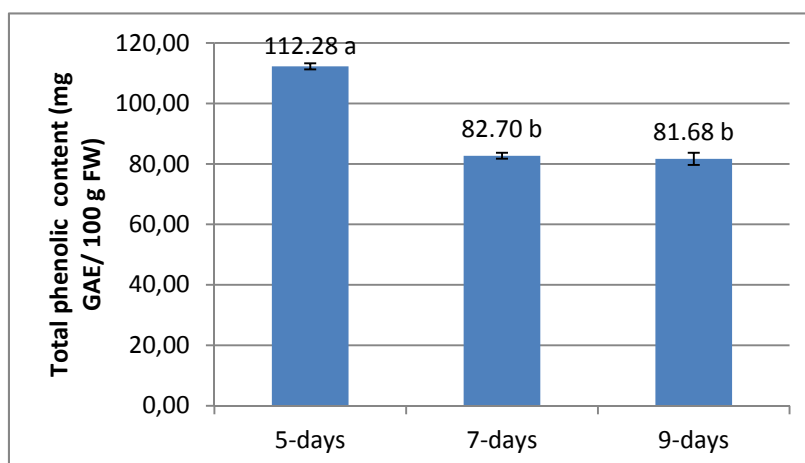


Figure 2. The total phenolic content (expressed in mg GAE/100 g fresh weight) of kohlrabi sprouts at different stages of maturity (5-days old, 7-days old and 9-days old). Results are means of 3 determinations and error bars represent standard deviation. Different letters denote statistically significant differences between obtained values (Tukey HSD test, $p < 0.05$).

The total polyphenol index (I_{280}) has exactly the same variation with sprouts age (Figure 3), as TPC. The highest I_{280} was obtained for 5-days sprouts (6.49), and its value decreased gradually to 7-days (4.59) and 9-days old sprouts (4.36), all differences being statistically significant.

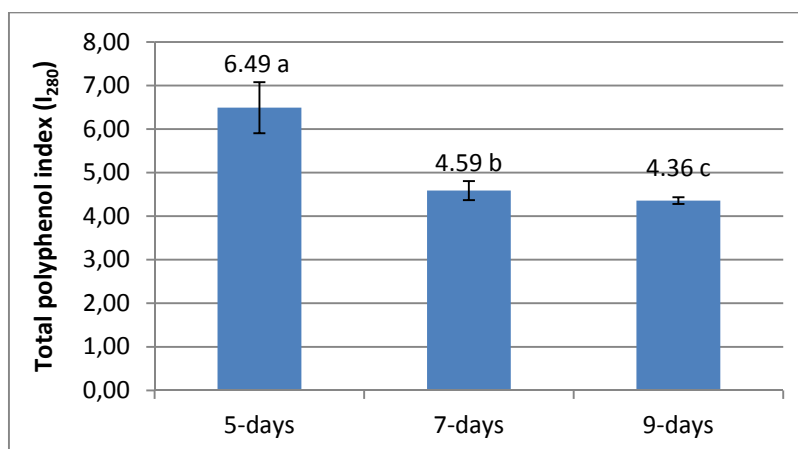


Figure 3. The total polyphenol index (I_{280}) of kohlrabi sprouts at different stages of maturity (5-days old, 7-days old and 9-days old). Results are means of 3 determinations and error bars represent standard deviation. Different letters denote statistically significant differences between obtained values (Tukey HSD test, $p < 0.05$).

Other *Brassica* sprouts (broccoli and cauliflower) proved different variation of phenolic content during germination. In the previous study, TPC measured by same methods decreased in broccoli from 5-days to 7-days old and then increased to 9-days sprouts, but remained less important than in 5-days sprouts. In cauliflower, TPC increased insignificantly in 7-days sprouts, compared to 5-days and decreased significantly in 9-days sprouts, which revealed the lowest content [9].

The DPPH radical scavenging capacity (RSC) registered the highest value in 7-days sprouts, 71.58%, but statistically insignificant compared to 5-days sprouts (70.64%). The lowest RSC was obtained in 9-days sprouts (69.44%) and this value was statistically significant different (Figure 4).

Exactly the same type of variation was obtained for cauliflower sprouts and similar result was obtained also for broccoli 9-days sprouts [9]. So, all these 3 Brassica sprouts revealed the lowest DPPH radical scavenging activity in 9-days old sprouts and higher RSC in 5- and 7-days sprouts with insignificant differences among the last two.

The important decrease of TPC in 7-days kohlrabi sprouts, which is not accompanied by the decrease of RSC (but, even contrary), prove that from the 5th to 7th day of germination, other antioxidants are synthesised (such as antioxidant vitamins, glucosinolates etc.), while the phenolic compounds are used in different metabolic processes.

The 7-days sprouts have also the advantage of a more important accumulated mass (data not shown).

The 9-days kohlrabi sprouts are not recommended to be produced because of lower content of phenolic compounds and decreased antioxidant capacity, despite the higher accumulated mass.

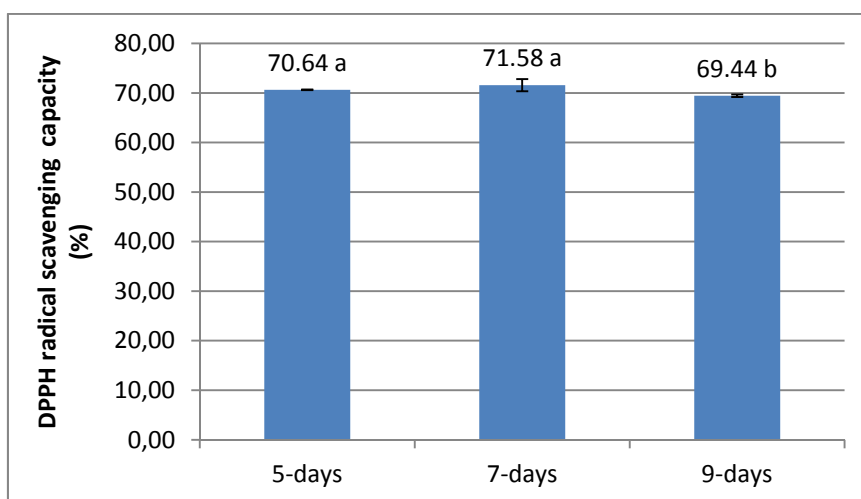


Figure 4. The DPPH radical scavenging capacity (expressed in %) of kohlrabi sprouts at different stages of maturity (5-days old, 7-days old and 9-days old).

Results are means of 3 determinations and error bars represent standard deviation. Different letters denote statistically significant differences between obtained values (Tukey HSD test, $p < 0.05$).

Conclusions

The kohlrabi sprouts were analysed in dynamics during germination (5-, 7- and 9-days old) from the point of view of total phenolic content and radical scavenging capacity. This study recommends the harvest after 5 days of germination if a high content in phenolics is specifically required, and this maturity stage assures also, an increased soluble dry matter. In case that the producer is interested in a product with higher radical scavenging capacity (and superior mass), no matter the nature of contained antioxidants, then the harvest of kohlrabi at the stage of 7-day old sprouts is recommended.

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