Assessment of the eco-biochemical composition of Raphanus sativus L. leaves grown in Uzbekistan

Ibragim Askarov[1] and *Nargiza* Atakulova[11]

[1] Andijan State University, Andijan, Uzbekistan

Abstract. This study characterizes the biochemical composition of *Raphanus sativus L.* (radish) leaf cultivars grown in Uzbekistan, with emphasis on their nutritional and ecological applications. The investigation encompasses botanical classification, geographical distribution, and analytical methodologies for phytochemical quantification. The quantity of macro- and microelements, water-soluble vitamins, and phenolic compounds was analyzed using HPLC methods. The results indicate that 'Andijan-9' radish leaves are rich in essential macronutrients such as potassium (625 g/100g) and calcium (1025 g/100g), as well as high concentrations of vitamin B1 (43.665 mg/100g), quercetin (74 mg/100g), and apigenin (74 mg/100g). These bioactive compounds not only offer nutritional value but also demonstrate potential as natural, environmentally safe additives in food and pharmaceutical industries. The ecological relevance of the study lies in promoting plant-based sources for safe, biodegradable compounds, thereby reducing dependence on synthetic chemical inputs. This research supports the sustainable utilization of agricultural biodiversity and emphasizes the environmental benefits of incorporating locally grown, resource-efficient crops into the value chain.

1 Introduction

The global scientific community recognizes the critical need to analyze plant chemical compositions to address pressing nutritional and therapeutic demands. Developing natural, eco-friendly food additives derived from plant sources represents a vital alternative to synthetic compounds. These plant-based additives contain biologically active compounds, essential minerals, and micronutrients with demonstrated potential for treating and preventing viral diseases, as documented in traditional medicine practices [1].

Epidemiological data indicate that peptic ulcer disease affects approximately 14-15% of the global population, with highest prevalence among males aged 20-40 years. Recent years have witnessed concerning increases in incidence rates among younger demographics, particularly school-aged children and university students [2,3]. This troubling pattern underscores the urgent need for innovative treatment approaches, especially those derived from plant-based sources.

[1] Corresponding author: nargizaatakulova456@gmail.com

Extensive research has investigated the biochemical properties of Raphanus sativus L. (radish), particularly its antioxidant, therapeutic, antiviral, and anti-inflammatory characteristics. Previous studies by Syn and Beaufetta Chang X., along with contributions from Gorkov V.A., Drabijev M.Yu., Azimova Yu.E., and Tabeeva G.R., have established foundational knowledge about this species. However, significant gaps remain in understanding the chemical composition and gastroprotective effects of Raphanus sativus L. cultivars grown in Uzbekistan.

This study aims to characterize the macro- and micronutrient profiles, vitamin content, and phenolic compounds of Raphanus sativus L. cultivars cultivated in Uzbekistan, with particular emphasis on their potential applications for gastrointestinal health.

Raphanus sativus L. (radish) is a widely distributed species that thrives in tropical and subtropical climates. While the plant originated in Latin America, it has become naturalized in Eastern Europe and Mexico. Currently, radish is cultivated globally as an important food crop. The species demonstrates significant adaptability to diverse growing conditions, making it suitable for agricultural production in various regions worldwide [4].

Gabrielle D. Velluti is an Italian scientist who has researched the genetic modification of *Raphanus sativus L.* from Damon, the creation of high yields, and disease-resistant varieties [5]. Scientists have done scientific work in the fields of creating *Raphanus sativus L.* agroecology and agroeconomics. In his work, Bravo studied the factors that influence the growth of the average yield of Raphanus sativus L. [5]. Other scientists have carried out scientific work on new selection methods to make the Raphanus sativus L. drought-resistant and effectively exploit the water resources of this plant [6].

Some aspects of the Raphanus sativus L., such as ecological adaptation, waste treatment, phytotherapeutic and cosmetic properties, genetic resources, and its use in agriculture, have not yet been fully studied. There are great opportunities for new scientific research and technological approaches in these areas. Our goal is to conduct and analyze the physical and chemical analyses of the widespread areas where Raphanus sativus L. is grown in Uzbekistan. This research will help illuminate the nutritional benefits and potential applications of the *Raphanus sativus L.*, paving the way for innovations in health, agriculture, and sustainable practices. By exploring these properties, we aim to contribute valuable knowledge that can enhance both local farming techniques and broader ecological understanding. Furthermore, the findings could lead to improved crop management strategies, ensuring that farmers can maximize yield while maintaining soil health. Ultimately, this research may foster a deeper appreciation for the *Raphanus sativus L.* not only in Uzbekistan but also in global markets.

2 Methods

Experiment 1. Pre-dried, ground, and weighed on 0.001 g precision scales (Navigator OHAUS®), a sample of porcelain was subjected to a dry ash extraction method; ash was obtained by heating up to 50°C in a muffle oven (Nabertherm, Germany). In this, it was initially heated to 500°C at a speed of 100°C and held for 5 hours at a temperature of 500°C. The resulting ash was dissolved with 6 ml of concentrated $HHNO_3$ and 2 ml of 60% H_2O_2 of ICP-MS purity and heated on a heating plate in a fragile cupboard until the formation of white smoke was completed. The cooled solution was transferred to a polypropylene measuring flask with a volume of 100 ml and delivered to its line with ultra-pure water. The initial B_1, B_6, B_3, B_{12}, and B_9 were then removed from the vitamins by 200 µL, and a solution was prepared with a concentration of each vitamin of 14.286 mg/L. Thus, standard solutions from 7.143, 3.571, and 1.786 mg/l were prepared. Standard solutions of vitamin C with concentrations of 286, 143, 71.5, and 57.2 mg/l were also

prepared. Pure water was used for a concentration of 0 mg/l to construct a calibration graph in Table 1.

Experiment 2. The elimination Solutions of vitamins C (CAS 50-81-7), B_1 (CAS 59-43-8), B_6 (CAS 58-56-0), B_3 (CAS 59-67-6), B_{12} (CAS 68-19-9), and PP (CAS 98-92-0) are prepared by dissolving 50 ml of 0.1 N solution of 5 mg of each vitamin (100 mg/l). Standard solutions of vitamins B_2 (CAS 83-88-5) and B_9 (CAS 59-30-3) were prepared by dissolving 5 mg of these vitamins in a 50 mL 0.025% sodium hydroxide solution. The initial B_1, B_6, B_3, B_{12}, and B_9 were then removed from the vitamins by 200 µL, and a solution was prepared with a concentration of each vitamin of 14.286 mg/L. Thus, standard solutions from 7.143, 3.571, and 1.786 mg/l were prepared. Standard solutions of vitamin C with concentrations of 286, 143, 71.5, and 57.2 mg/l were also prepared. Pure water was used for a concentration of 0 mg/l to construct a calibration graph in Table 2.

Experiment 3. Standard solutions' preparation. Gallic acid (5.2 mg), salicylic acid (5.2 mg), rutin (5 mg), quercetin (5 mg), apigenin (5 mg), and Kempferol (5 mg) were dissolved in 96% ethanol in an ultrasonic bath for 20 minutes and transferred to a 50 ml flask and delivered to the line with ethanol. From each solution, a total of 4 different solutions were prepared, taking 200 µL and mixing them by peeling. Each solution was poured into the vial and used for analysis. Plant extract preparation. For the extraction of phenolic compounds, 1 g of the sample examined was weighed at an accuracy of 0.01 g on the NV222 brand scale produced by the OHAUS Company (USA), placed in a conical flask with a volume of 50 ml, and 25 ml of 96% ethanol was added. The mixture was extracted for 20 minutes in a GT SONIC-D3 (Chinese) branded ultrasonic bath at a temperature of 60°C. The mixture was then cooled, filtered, and brought to 25 mL with ethanol in a measuring flask. The amount of 1.5 ml of the extract is 7000 ayl in a mini-7 brand (BIOBASE, China) centrifuge. / min was centrifuged at speed and filtered through a 0.45 µm screw filter and used for analysis.

3 Results and discussion

The micro- and macroelement content of medicinal plants is fundamentally determined by the geochemical composition of their growth substrate. The elemental profile of Raphanus sativus L. cv. 'Andijan-9' was quantitatively analyzed using inductively coupled plasma mass spectrometry (ICP-MS).

Table 1 presents the complete micro- and macroelement composition of the 'Andijan-9' radish variety, as determined by ICP-MS analysis. This high-precision analytical technique provides comprehensive elemental quantification, revealing the mineral accumulation patterns influenced by the local soil chemistry.

Table 1. The amount of macro-and microelements in the turnip leaf of the “Andijan - 9” variety is g/100g.

№	Macro and microelement	Content (mg/100 g dry weight) ± SD
1	Ca	895.56 ± 42.45
2	Fe	5.89 ± 0.05
3	K	698.45 ± 40.62
4	Mg	78.12 ± 0.26
5	Na	326.45 ± 40.43
6	P	45.23 ± 0.03
7	Zn	0.45 ± 0.01
8	Cu	0.36 ± 0.01
9	Mn	0.69 ± 0.01

10	Ag	0.26 ± 0.01
11	Au	0.26 ± 0.01
12	Se	0.32 ± 0.01

Table 1 presents the macro- and microelement composition of Raphanus sativus L. cv. 'Andijan-9' leaves cultivated in Uzbekistan. Analytical results demonstrate significantly higher mineral concentrations in the leaf tissues compared to other plant parts. Notably, the leaves contain substantial quantities of calcium 895.56±2.45 mg/100g, potassium 698.45±0.62 mg/100g, silver 0.26±0.01 mg/100g, and gold 0.32±0.01 mg/100g.

The most abundant minerals in radish were calcium and potassium, as found in the leaves. Calcium is required by children, pregnant and lactating women for the development of bones and teeth [7]. Calcium was recommended at 800 mg per day for children and 1,200 mg for adults and pregnant women. Radish also contains many other valuable minerals useful for human health, such as potassium, which controls hypertension in the body with high levels, captures iron absorption, and maintains body fluid balance functions [8-10].

The most abundant minerals in radish were calcium and potassium, as found in the leaves. Calcium is required by children, pregnant and lactating women for the development of bones and teeth. Calcium was recommended at 800 mg per day for children and 1,200 mg for adults and pregnant women. Radish also contains many other valuable minerals useful for human health, such as potassium, which controls hypertension in the body with high levels, captures iron absorption, and maintains body fluid balance functions.

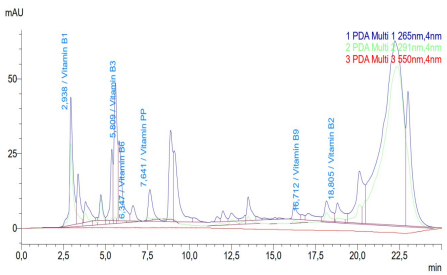

Fig. 1. Chromatogram for the determination of vitamins in radish leaf extract.

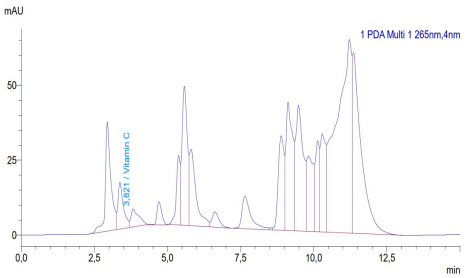

Fig. 2. Chromatogram for determining the amount of vitamin C in radish leaf extract.

Table 2. Radish Leaf the amount of vitamins in the extract and the Times of Capture.

Vitamin	Retention time (s)	Concentration (mg/L)	Content per 100 g (mg)
Vitamin (B_1)	2,938	17,466	43,665
Vitamin (B_3)	5,809	11,423	28,558
Vitamin (PP)	7,641	6,698	16,745
Vitamin (B_9)	16,712	0,738	1,845
Vitamin (B_2)	18,805	2,932	7,330
Vitamin (B_6)	6,347	0,093	0,233
Vitamin (C)	3,821	5,894	14,735

Tables 1-2 present chromatographic profiles of radish leaf extracts. Table 2 specifically quantifies vitamin content and retention times in the leaf extracts.

Table 6 demonstrates that 100 g of radish leaves contain:

Vitamin B1 (thiamine): 43.665 mg

Vitamin B3 (niacin): 28.558 mg
Vitamin PP (nicotinamide): 16.745 mg
Vitamin C (ascorbic acid): 14.735 mg
Vitamin B9 (folate): 1.845 mg
Vitamin B6 (pyridoxine): 0.233 mg
Thiamine (vitamin B1) plays several critical physiological roles:
Facilitating growth and development
Maintaining cellular function
Catalyzing energy metabolism through food conversion

As a water-soluble vitamin (along with other B-complex vitamins and ascorbic acid), thiamine exhibits heat stability but requires daily dietary intake due to the body's limited storage capacity. The recommended daily allowance is 1.2 mg for men and 1.1 mg for women. Thiamine deficiency can lead to beriberi, emphasizing the importance of regular consumption through dietary sources.

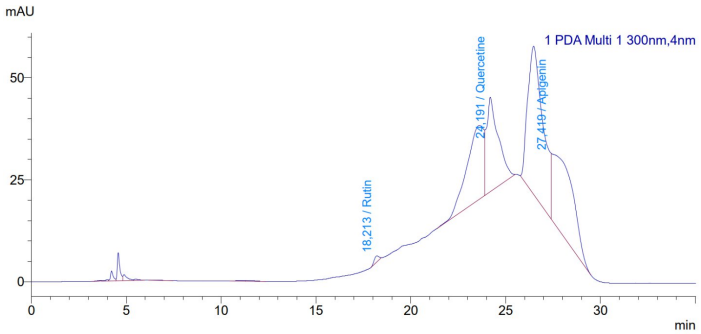

Fig. 3. Chromatogram for the determination of polyphenols in radish leaf extract.

Table 3. Radish Leaf the amount of polyphenols in the extract and the capture Times.

Phenolic compound	Retention time (s)	Concentration (mg/L)	Content per 100 g (mg)
Rutin	18,213	2,02	5,050
Quercetin	24,191	29,742	74,355
Apigenin	27,419	29,995	74,988

Figure 3 displays the HPLC chromatogram of polyphenol compounds identified in radish leaf extracts, with corresponding quantification data and retention times presented in Table 3. The analysis revealed that 100 g of radish leaves contain substantial amounts of quercetin (74.355 mg) and apigenin (74.988 mg), along with smaller quantities of rutin (5.05 mg).

Quercetin demonstrates multiple beneficial health effects, primarily due to its strong antioxidant properties. Current research indicates this flavonoid contributes to reducing inflammation, supporting cardiovascular health, and potentially exhibiting anticancer activity. Additional studies suggest quercetin may help mitigate allergic reactions and enhance immune system function. The significant concentrations of these bioactive polyphenols in radish leaves underscore their potential nutritional and therapeutic value.

Apigenin, on the other hand, is a natural flavonoid and is found in many plants, including parsley, celery, chamomile, and other greens. It has several beneficial properties for health, including antioxidant, anti-inflammatory, and anticancer effects. Apigenin protects cells from free radicals and oxidative stress. This process helps to slow down the

processes of cardiovascular disease and aging. It can prevent chronic inflammatory-related diseases by suppressing inflammatory mediators, such as arthritis and asthma. Apigenin inhibits the growth and proliferation of cancer cells. It is particularly active against breast, ovarian, prostate, and lung cancer. Apigenin has neuroprotective properties that reduce the risk of nervous system diseases such as Alzheimer's. In addition, it can have a calming effect and improve sleep quality. Apigenin interacts with estrogen receptors in women to help maintain hormonal balance and reduce symptoms during menopause.

4 Conclusion

The Ministry of Health has established State Standard requirements for edible plant parts, with particular emphasis on ash content, moisture levels, and vital nutritional components including minerals, fiber, vitamins, phenolic compounds, and antioxidants. Radish leaves possess significant medicinal value due to their rich phytochemical composition, offering various health benefits. Analytical studies reveal calcium and potassium as the predominant minerals in first-year leaves, while quercetin and apigenin represent the major flavonoid constituents. The leaves' high content of water-soluble vitamins helps meet daily nutritional requirements through exogenous vitamin intake.

This article presents comprehensive data on the 'Andijan-9' radish cultivar (Raphanus sativus L.), including botanical classification, geographical distribution, and analytical methodologies for chemical characterization. Quantitative analysis via the Yussch method determined:

Macronutrient content: Potassium (625 g/100g), Calcium (1025 g/100g)

Vitamin concentration: Thiamine (43.665 mg/100g)

Flavonoid levels: Quercetin (74 mg/100g), Apigenin (74 mg/100g)

These findings position radish leaves as a nutritionally rich, natural food source capable of reducing reliance on artificial additives. The demonstrated phytochemical profile supports the classification of radish leaves as a functional food ingredient, offering significant potential for innovation in food product development while maintaining natural nutritional value.

References

1. R. Goyeneche, et al., Chemical characterization and antioxidant capacity of red radish (Raphanus sativus L.) leaves and roots. Journal of functional foods **16**, 256-264 (2015), http://dx.doi.org/10.1016/j.jff.2015.04.049
2. M.M. Cowan, Plant Products as Antimicrobial Agents. Clinical Microbiology Reviews, **32(4),** e00068-19 (2019), https://doi.org/10.1128/cmr.12.4.564
3. A. Bouchereau, P. Guénot, F. Larher. Analysis of amines in plant materials. Journal of Chromatography B: Biomedical Sciences and Applications **747**.1-2, 49-67 (2000). http://dx.doi.org/10.1016/S0378-4347(00)00286-3
4. S.S. Beevi, et al., Polyphenolics profile and antioxidant properties of Raphanus sativus L Nat Prod Res. **26(6),** 557-63 (2012) .https://doi.org/10.1080/14786419.2010.521884
5. P. Ansari, et al. Plant-based diets and phytochemicals in the management of diabetes mellitus and prevention of its complications: A review. Nutrients **16**.21, 3709 (2024). https://doi.org/10.3390/nu16213709
6. H. Sakakibara, Cytokinin Biosynthesis and Transport for Systemic Nitrogen Signaling. Annual Review of Plant Biology **72**, 173–196 (2021) https://doi.org/10.1111/tpj.15011

7. A.E. Pegg, Toxicity of polyamines and their metabolic products. Chem. Res. Toxicol. **26**, 12, 1782–1800 (2013) https://doi.org/10.1021/tx400316s
8. V. Nguyen, et.al., Glucosinolates: Natural Occurrence, Biosynthesis, Accessibility, Isolation, Structures, and Biological Activities. Molecules, **25** (19), 4537 (2020) https://doi.org/10.3390/molecules25194537
9. A. Grover, Plant chitinases: genetic diversity and physiological roles. Critical reviews in plant sciences **31**.1, 57-73 (2012). http://dx.doi.org/10.1080/07352689.2011.616043
10. R. Oxunov, et al. Research on the effect of the type of raw material on the physical and mechanical properties of the fabric obtained by the circular needle jacquard knitting machine. AIP Conference Proceedings **3045**. 1 (2024). http://dx.doi.org/10.1063/5.0197292