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CRAFTING UNIQUE BLENDS: EXPLORING COMBINATIONS OF ONION, GARLIC, WILD GARLIC AND LEEK

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Abstract

Due to their high content of phytonutrients, Allium plants are used both as food and in the treatment of many medical conditions. The increased interest in these plants is due to their powerful antioxidant properties. In this paper, the Barchart logarithmic diagram allowed us to identify the representative nutritional components for each investigated product (onion, garlic, wild garlic and leek plants), allowing us, at the same time, to identify potential mixtures of dehydrated powders to be recommended to the consumer according to his nutritional deficit. Based on the generalized model, the following potential powder mixes were highlighted and characterized by mathematical modeling in order to make food supplements: mix of garlic and wild garlic, mix of onion and wild garlic, mix of wild garlic and leek. In order to determine the moisture content, the total antioxidant capacity and the total polyphenol content of the leaves of wild garlic, onion bulbs and garlic, the following methods were used: thermogravimetric analysis, analysis of the total antioxidant capacity using the CUPRAC method, determination of the polyphenol content using the method Folin-Ciocalteu.

Key words*: Allium plants, food supplements, nutritional deficiency, powder mixes.*

INTRODUCTION

The genus *Allium* is highly diverse, encompassing approximately 1,100 taxa (Pandey, A. et al., 2022), of which 1,077 species names are currently accepted (POWO, 2025). These species are distributed almost exclusively in the Northern Hemisphere, including the Mediterranean region of Europe, Asia, North America, South America, and Sub-Saharan Africa (Vuković, S., Popović-Djordjević, J. B. et al., 2023).

The genus *Allium* holds significant economic and nutritional importance, as many of its species are consumed as vegetables, spices, or medicinal plants. Among these, *Allium cepa* and *Allium sativum* are the most widely used species, primarily serving as fundamental ingredients in various culinary preparations, as well as for medicinal purposes (Najeebullah, S. et al., 2021). Other nutritionally and economically important species include *Allium ampeloprasum* var. *porrum* (leek), *Allium fistulosum* (spring onion), *Allium tuberosum* (chinese chives), *Allium schoenoprasum* (chives), and *Allium ascalonicum* (shallots) (Vuković, S., Popović-Djordjević, J. B. et al., 2023; Poojary, M. M. et al., 2017). Most wild species are harvested by local populations and used as spices, vegetables, medicinal plants, and for ornamental purposes. These wild species constitute a valuable component of the daily human diet (Yousaf, Z. et al., 2004). Among the wild species, *Allium ursinum* is particularly noteworthy as a culinary and medicinal plant, having been used for centuries in traditional medicine. Known for its garlic-like odor, which gives it the common name "wild garlic," *A. ursinum* is appreciated for its milder flavor compared to common garlic (Piątkowska, E. et al., 2015). All parts of the plant are usable (Ivanova, A. et al., 2009), but its culinary applications are primarily limited to its leaves. The leaves are harvested early in spring, during March and April, before the plant blooms.

The edible portions of *Allium* species are versatile and can be consumed in a variety of ways, such as raw, cooked, frozen, pickled, canned, dehydrated, or incorporated into processed products (Vuković, S.; Popović-Djordjević, J. B. et al., 2023).

Most species produce significant amounts of cysteine sulfoxides, which are responsible for their characteristic aroma and flavor (Friesen, N. et al., 2006). These traits contribute to their widespread use across different fields. In the culinary domain, *Allium* species are highly valued as ingredients, commonly used as either vegetables or spices. Additionally, they are integrated into classic medicine as supplement components and have been traditionally utilized in folk medicine for the prevention and treatment of various ailments (Vuković, S.; Popović-Djordjević, J.B. et al., 2023).

The chemical composition of plants in the *Allium* genus is highly complex. The most significant constituents are organosulfur compounds (OSCs), which are primarily responsible for the distinctive odor and flavor of these plants, as well as the majority of their biological activities (Fredotović, Ž., Puizina, J. 2019; Putnik, P. et al., 2019; Poojary, M. M. et al., 2017). Another notable group of bioactive compounds includes polyphenols, such as phenolic acids and flavonoids, which contribute to the characteristic pigmentation of onion bulbs (Fredotović, Ž., Puizina, J. 2019; Carotenuto, A. et al., 1996). Polyphenols are secondary metabolites in plants that play an essential role in defending against adverse environmental conditions. Their synthesis can be intensified under various stress factors (Czech, A. et al., 2022).

In addition, plants of the *Allium* genus are rich in phytosterols and steroidal saponins (Teotia, Deepti et al., 2024; Nishimura, T. et al., 2016), fatty acids and terpenoids (Vuković, S., Moravčević, D. et al., 2023; Fredotović, Ž., Puizina, J., 2019), as well as phytoestrogens, carotenoids (Oszmianski, J., 2013; Dubouzet, J.; Shinoda, K., 1999), vitamins (A, E, C, K, B1, B3, B6, B9), and essential minerals such as phosphorus, potassium, calcium, magnesium, zinc, manganese, sodium, iron, selenium, and copper (Vuković, S.; Moravčević, D. et al., 2023; Fredotović, Ž., Puizina, J., 2019; Putnik, P. et al., 2019).

The edible parts of onion plants are rich in carbohydrates, such as fructose and glucose, while the outer layers of onion bulbs contain arabinose and galactose (Fredotović, Ž., Puizina, J., 2019). The same authors highlight the presence of essential amino acids, including glutamic acid and arginine, which serve as valuable nitrogen reserves and enhance the nutritional profile of these species.

The use of *Allium* species in both traditional and official medicine is closely associated with their rich nutritional profiles and high concentrations of phytochemicals with notable therapeutic potential. Numerous studies highlight the pharmacological properties of these species, which are directly linked to their phytochemical composition.

Wild Garlic (*Allium ursinum*)

Traditional folk medicine recommends the use of wild garlic as a remedy for fever and gastrointestinal issues (Bârlă, G. F. et al., 2016; Pavlović, D. R., 2017).

Currently, *Allium ursinum* L. and its preparations play a significant role in the prevention and treatment of cardiovascular diseases. Scientific literature indicates that the consumption of wild garlic significantly reduces blood pressure, serum cholesterol, and triglycerides (Krivokapic, M et al., 2021). Furthermore, this wild plant inhibits platelet aggregation, owing to the presence of flavonoids, and prevents the progression of atherosclerosis (Hiyasat B. et al., 2009). Additionally, it has been reported that wild garlic demonstrates a greater blood pressure-lowering effect in rats compared to common garlic (Preuss H. G., 2001).

Numerous studies have also highlighted its antioxidant (Wu, H. et al., 2009), cytostatic, and antimicrobial properties (Ivanova, A., 2009), as well as its antifungal effects (Pârvu, M. et al., 2011). The potential health benefits of wild garlic are primarily attributed to its sulfur-containing compounds. High levels of volatile compounds such as sulfides and disulfides, identified in wild garlic, directly influence its quality as both a medicinal plant and a culinary spice (Preuss H. G., 2001).

Research conducted by Xu, X. Y. (2013) confirmed that the aqueous extract of *Allium ursinum* can inhibit proliferation and induce apoptosis in AGS gastric cancer cells, suggesting that diallyl sulfides are primarily responsible for this effect in most investigated cases (Xu X.Y., 2013). Due to its content of allicin, alliin, and other sulfur compounds, the plant exhibits vermicidal, fungicidal, and antibacterial properties (Giurgiu E., 2013; Ivanova A., 2009).

Additionally, certain studies have shown that flavonoids are responsible for inhibiting platelet aggregation in humans and possess significant antioxidant activity (Stajner D. et al., 2008). While all edible parts of wild garlic exhibit antioxidant properties, the leaves, due to their high flavonoid content, are considered the most significant in this regard (Stajner, D. et al., 2008; Oszmianski, J. et al., 2013). Consuming these vegetables, particularly in spring, can provide a beneficial supply of antioxidants.

Further research has demonstrated that *Allium ursinum* has a stronger effect in increasing high-density lipoprotein (HDL) levels, reducing total cholesterol, and lowering systemic blood pressure (Preuss H. G., 2001).

Thus, *Allium ursinum* extract holds significant potential for use in both the food and pharmaceutical industries.

Garlic (*Allium sativum*)

Numerous studies have demonstrated that garlic consumption significantly reduces total cholesterol (TC) and low-density lipoproteins (LDL), with more pronounced effects observed at lower doses over extended periods, particularly in individuals with cardiovascular diseases (Li S. et al., 2023). Raw garlic, as well as garlic extracts in the form of oil or powder, can be utilized as both functional and therapeutic foods. Substantial evidence supports the preventive and therapeutic roles of garlic in strengthening the immune system (Vuković S., Popović-Djordjević et al., 2023), exhibiting antitumor properties (Sasaki J.I. et al., 2007), and providing antioxidant activity that protects the body from free radicals (Cheng H. et al., 2020).

A balanced diet rich in functional foods incorporating garlic has been linked to numerous health benefits. Garlic has been shown to enhance the function of various organs, particularly those in the respiratory and digestive systems (Lee G.Y. et al., 2015). Both preclinical and clinical studies indicate that garlic consumption contributes significantly to antihypertensive (Hussein H.J. et al., 2017), antidiabetic (Mutlu-Ingok A. et al., 2022), immunomodulatory (Kumari N. et al., 2022), and hypolipidemic effects (Perez-Rubio K.G. et al., 2022), offering substantial benefits for both medical and surgical treatments (Daharia A. et al., 2022).

Currently, garlic is widely used worldwide as a prophylactic agent and for the treatment of various diseases, including acute and chronic infections such as pneumonia, dysentery, typhoid fever, cholera, gastritis, tuberculosis, diabetes mellitus, heart disease, and hypertension (Sashank Srivastava, S. S., & Pathak, P. H., 2012).

Onion *(Allium cepa)*

Allium cepa is commonly used to treat hypertension, bronchitis, migraines, coronary diseases, hypercholesterolemia, cataracts, and diabetes (Vuković, S., Popović-Djordjević et al., 2023).

Leek (*Allium ampeloprasum*)

Although its therapeutic effects are less pronounced compared to other *Allium* species, leek (*Allium ampeloprasum*) has been used since ancient times to treat a wide range of ailments. The scientific literature highlights notable health benefits of *Allium ampeloprasum*, including antibacterial, antifungal, antioxidant (Garcia-Herrera P. et al., 2014), vermifuge and antihypertensive (Guarrera P. M., Savo V., 2013).

Other studies have revealed its antitoxic, anti-inflammatory, and immunostimulatory properties (Dey P., & Khaled K.L., 2015). Leek also helps reduce the risk of gastrointestinal diseases and protects the skin from damage (Strati I.F. et al., 2018).

The aim of the study was to characterize the main bioactive compounds in onion, leek, garlic and wild garlic plants in order to obtain new data and information that would lead to highlighting the phytopharmaceutical potential of these plants. Another objective was to characterize potential mixes of dried plants through mathematical modeling in order to create food supplements.

MATERIALS AND METHODS

Allium cepa, Allium ampeloprasum and *Allium sativum* used in the experiments were sourced from gardens located in an unpolluted region of Timiș County, while *Allium ursinum* was harvested from a hilly area.

All reagents were of analytical grade.

All analysis were performed in triplicate.

The performed analyses were: thermogravimetric analysis, total antioxidant capacity based on CUPRAC method, and total polyphenol content based on Folin-Ciocalteu method.

Thermogravimetric analysis

The moisture content was determined using the Sartorius thermobalance monitoring the dehydration process of the studied plant material through continuous weighing.

CUPRAC Antioxidant Reduction Method

The method is based on the protocol described by Apak et al., 2004. The method is applicable to both hydrophilic and lipophilic antioxidants (unlike Folin and DPPH tests) and presents selective action towards antioxidant compounds without affecting sugars and citric acid, which are commonly present in food products. The method has the advantage of linearity across a broader concentration range and can also determine the antioxidant activity of substances containing sulfhydryl (-SH) groups, such as proteins (unlike FRAP) (Apak R., 2007). The CUPRAC reagent does not involve any radical reagent, making it insensitive to several physical parameters such as temperature, sunlight, pH, humidity, etc., and it can be adsorbed onto a cation-exchange membrane to construct a sensor with a linear antioxidant response (Bener M. et al., 2010).

Determination of Total Phenolic Content (TPC)

The method is a colorimetric method described by Folin-Ciocalteu. with slight modifications. As standard was used Gallic acid, and the results were expressed as mg gallic acid equivalents (GAE) per 100 mL of extract (Nuncio-Jáuregui N., 2015).

The experimental determinations were performed on 50% alcohol extracts obtained from wild garlic leaves, garlic bulbs, and onion bulbs, slowly dehydrated at temperatures between 40-60°C.

Creation of a compositional database based on literature data, in order to identify the main patterns of garlic, wild garlic, onion and leek, nutritional and phytopharmaceutical compounds.

Statistical processing

The interpretation of the obtained data was carried out using: simple and logarithmic Barchart diagrams, cluster analysis, linear correlation r and mathematical modeling. The generalized linear model was carried out using the PAST and MVSP software.

RESULTS AND DISCUSSIONS

The results are presented in Table 1 and Figure 1.

Table 1. Samples analysis results

Dehydrated samples	Moisture [%]	TAC [mg TE.100 g^{-1} d.w.]	TPC [mg TE.100 g^{-1} d.w]
Wild garlic	89.02	433.2	361.2
Onion	65.52	523.4	302.7
Garlic	27.33	632.6	265.5
Leek	63.85	588.8	295.6

From Table 1, it is observed that the highest moisture content (U%) and total polyphenol content (TPC) are found in wild garlic leaves, while garlic exhibits the highest total antioxidant capacity (TAC), data that are also confirmed by the scientific literature (Bârlă G.F., 2016; Ivanova A., 2009; Piątkowska E., 2015; Sobolewska D., 2015).

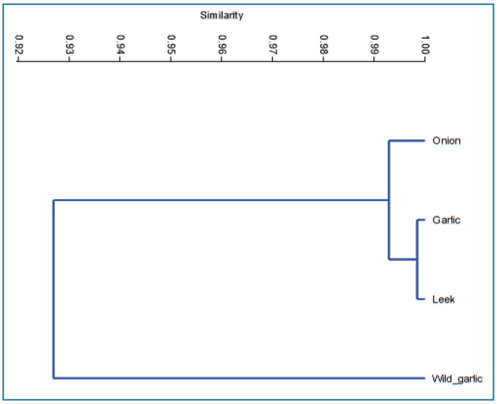


Figure 1. Cluster analysis of data

The cluster analysis applied to the experimental data highlights a correlation coefficient of 0.8052 (Figure 1).

The cluster analysis based on the associated grouping algorithm and similarity correlation highlights a high similarity of the analyzed extracts. It is observed that the extract from garlic and leek shows a greater similarity than those of onion and wild garlic.

This high correlation demonstrates a strong similarity among the samples concerning their nutritional and phytopharmaceutical properties.

Fingerprinting (Figure 2) using the MVSP software highlights the particularities of the wild garlic alcoholic extract, which can stabilize alcoholic extracts based on onion or garlic.

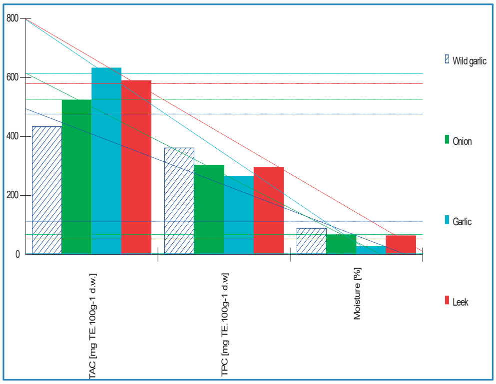


Figure 2. Fingerprint of wild garlic, onion, and garlic alcoholic extracts

The laboratory results were completed with the study of literature data to create a complex database of chemical and nutritional parameters of the analyzed plants (garlic, wild garlic, onion and leek) and the results were graphically represented in Figures 3 and 4. The interpretation of the results were carried out using PAST software.

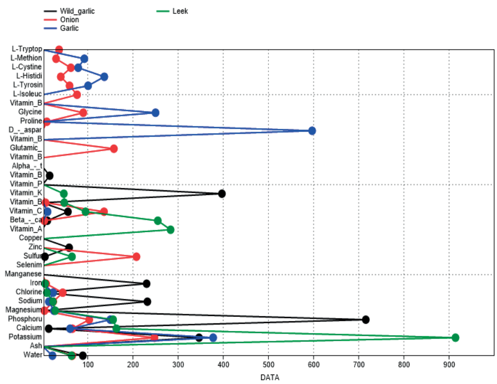


Figure 3. Graphical representation of the investigated data values

Figure 3 shows that wild garlic (*Allium ursinum*) has the highest content of water, vitamin K1, B2, iron, sodium, phosphorus, and zinc. Onion (*Allium cepa*) has the highest content of chlorine, sulfur, vitamin C, glutamic acid, L-isoleucine, and L-tryptophan. Garlic (*Allium sativum*) is characterized by its high selenium content, vitamin B6, D-aspartic acid, glycine, and the highest levels of amino acids (L-Tyrosine, L-Histidine, L-Cysteine, L-Methionine). Leek (*Allium ampeloprasum*) is recommended for its highest content of potassium, calcium, magnesium, vitamin A, and vitamin C.

The Barchart diagram (Figure 4) allows us to identify the nutritional components representative for each product investigated (black for wild garlic, red for onion, blue for garlic, and green for leek).

This method enables us to create dehydrated powder mixtures based on the nutritional deficiencies of the consumer. Specifically, individuals with an amino acid deficiency can consume a product with a high content of garlic powder, while those with a deficiency in minerals and vitamins are recommended a mixture of leek and wild garlic powders.

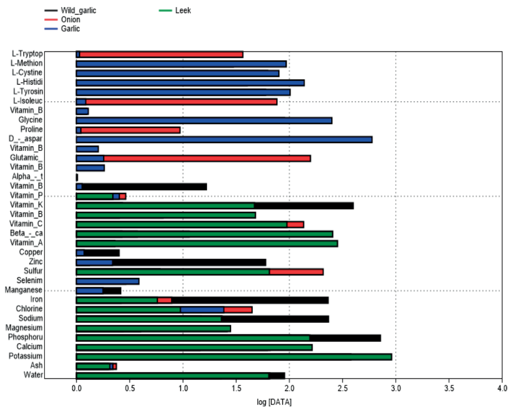


Figure 4. Barchart diagram of the phytopharmaceutical characteristics

To further understand the positioning of wild garlic (*Allium ursinum*) in comparison to garlic (*Allium sativum*), onion (*Allium cepa*), and leek (*Allium ampeloprasum*) in terms of their physicochemical characteristics, a correlation analysis (r) was performed (Table 2). The purpose of the correlation analysis is to provide insights into the strength and direction of the linear relationship between two variables, which is crucial for identifying the most suitable formulations based on specific nutrient profiles (https://www.dummies.com/education/math/statistics/how-to-interpret-a-correlation-coefficient-r/)

Table 2. Linear correlation r

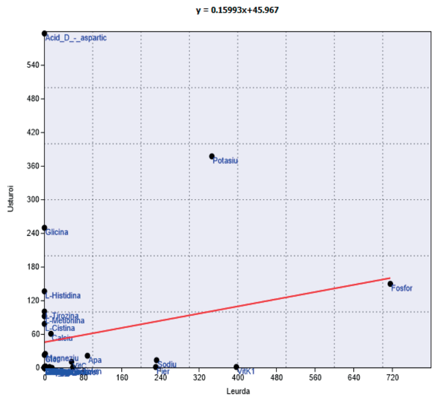
Product	Wild Garlic	Onion	Garlic	Leek
Wild Garlic	0	0.1023	0.2623	0.0482
Onion	0.2807	0	0.0921	0.0045
Garlic	0.1947	0.2892	0	0.0627
Leek	0.3363	0.4686	0.3179	0

From the perspective of phytopharmaceutical and nutritional characteristics, bear's garlic leaves show a positive correlation with garlic (0.2623), indicating an ascending relationship between the two.

y = 0.159993x+45.967

x = amount of wild garlic [mg]

y = quantity of garlic [mg]



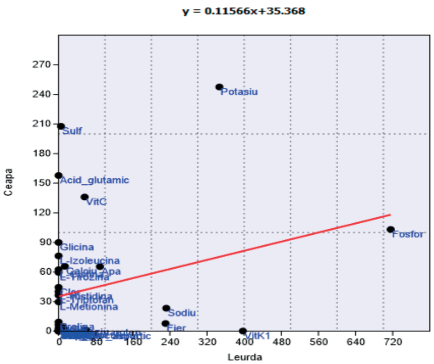
5.1. Garlic and wild garlic mix

The product is characterized by a high content of Phosphorus, Potassium, and Aspartic Acid.

y= 0.11566x+35.368

x= amount of wild garlic [mg]

y= amount of onion [mg]



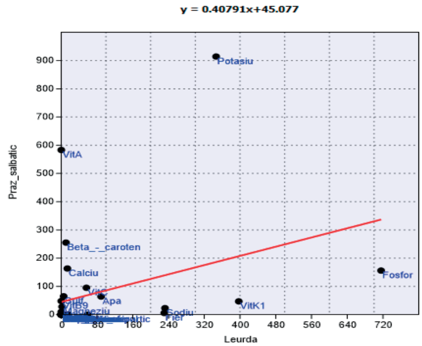
5.2. Onion and wild garlic mix

The mix of wild garlic and onion is characterized by a high content of Phosphorus, Potassium, and Sulphur.

y= 0.40791x+45.077

x= amount of wild garlic [mg]

y=quantity de wild leek[mg]



5.3. Wild leek and wild garlic mix

The mix is characterized by a high content of Phosphorus, Potassium, and Vitamin A,

Figure 5. Characterization of potential dried plant mixtures through mathematical modeling

The generalized linear model was created using the PAST program based on the normal distribution and the identity function, with the estimation of the phi coefficient.

The application of generalized linear models highlights the following potential powder mixtures for the formulation of dietary supplements (Figure 5).

CONCLUSIONS

The analysis of the nutritional composition of the investigated species yielded several significant observations:

- *Allium ursinum* (wild garlic) exhibited the highest levels of water, vitamin K_1, vitamin B_2, iron, sodium, phosphorus, and zinc among the studied samples.
- *Allium cepa* (onion) was notable for its elevated content of chlorine, sulfur, vitamin C, glutamic acid, L-isoleucine, and L-tryptophan.
- *Allium sativum* (garlic) was distinguished by its particularly high concentrations of selenium and vitamin B_6, as well as D-aspartic acid and glycine. Furthermore, it contained the greatest overall abundance of amino acids, including L-tyrosine, L-histidine, L-cysteine, and L-methionine.
- *Allium ampeloprasum* (leek) demonstrated the highest levels of potassium, calcium, and

magnesium, and was also a valuable source of vitamins A and C.

- The bar chart analysis, which facilitated the identification of the predominant nutritional constituents of each species, provides a practical framework for the development of functional dehydrated powder blends tailored to individual nutritional needs. For example, garlic-based powders may be particularly suitable for individuals with amino acid deficiencies, while mixtures incorporating leek and wild garlic powders are recommended for those with insufficient mineral and vitamin intake.

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