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METHODOLOGICAL JOURNAL**<http://mentaljournal-jspu.uz/index.php/mesmj/index>**VITAMIN PROPERTIES OF ANETHUM GRAVEOLENS L****Nilufar Suyunova***Master's student at Karshi State Technical University*[nilufarhanim2002@gmail.com](mailto:nilufarhanim2002@gmail.com)*Karshi, Uzbekistan***Uchkun Jomurodovich Ishimov***Associate Professor, Karshi State Technical University**Karshi, Uzbekistan***Bahodir Kholmurodov***Associate Professor, Karshi State Technical University*[Bahodirxolmurodov1994@gmail.com](mailto:Bahodirxolmurodov1994@gmail.com)*Karshi, Uzbekistan***ABOUT ARTICLE**

**Key words:** Anethum graveolens L.; dill; medicinal plants; chemical composition; essential oils; water-soluble vitamins; HPLC; therapeutic effect; biological activity.

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**Abstract:** This article is devoted to a comprehensive analysis of the beneficial, therapeutic, and physiological properties of Anethum graveolens L. (dill) based on scientific literature and experimental studies. Within the scope of the research, the historical use, morphological characteristics, chemical composition, and biological activity of dill were systematically investigated. The analysis of scientific literature demonstrated that the plant is rich in essential oils, phenolic compounds, flavonoids, vitamins, and mineral substances. In particular, carvone and limonene present in the essential oil were identified as the main biologically active components.

In addition, the content of water-soluble vitamins in Anethum graveolens was determined and quantitatively evaluated using high-performance liquid chromatography (HPLC). The obtained results showed that riboflavin (vitamin B<sub>2</sub>) was present in the highest amount, while ascorbic acid (vitamin C),

pyridoxine (vitamin B<sub>6</sub>), and folate (vitamin B<sub>9</sub>) were detected at moderate levels. In contrast, thiamine (vitamin B<sub>1</sub>) and niacin (vitamin B<sub>3</sub>) were found in very low amounts. The results were compared with previously published scientific studies, and similarities as well as differences were analyzed.

The obtained scientific data confirm that *Anethum graveolens* exhibits antimicrobial, antioxidant, anti-inflammatory, hypolipidemic, and metabolism-regulating properties. Overall, *Anethum graveolens* L. can be considered a promising natural raw material for applications in phytotherapy, pharmaceuticals, and the development of functional food products.

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## Introduction

Medicinal plants have played an important role in the history of human civilization since ancient times and have developed in close connection with food, medicine, and culture. The earliest healing remedies obtained from nature by humans were primarily based on plants, and even today their significance continues to increase in modern pharmacology and phytotherapy [1]. One such medicinal plant is *Anethum graveolens* L. (dill), which belongs to the Apiaceae family, is an annual, essential oil-rich, and widely used plant [2].

The earliest historical records of dill date back to ancient Egypt, Greece, and Rome. In ancient Egyptian papyri, dill was mentioned as a digestive aid and a calming agent [3]. Greek physician Hippocrates and Roman scholar Dioscorides described dill as a plant useful for relieving intestinal spasms and treating colds [4]. During the Middle Ages, dill was widely used in folk medicine throughout Europe and Asia, particularly for gastrointestinal disorders, insomnia, and stimulation of lactation [5].

Modern scientific studies indicate that the chemical composition of *Anethum graveolens* L. is extremely rich in biologically active compounds. Research has demonstrated the presence of essential oils, monoterpenes, phenolic compounds, flavonoids, vitamins, and minerals in the seeds and aerial parts of the plant. In particular, carvone and limonene have been identified as the major components of the essential oil, accounting for more than 60–70% of its total composition [6].

Modern analytical techniques such as gas chromatography (GC), gas chromatography–mass spectrometry (GC–MS), high-performance liquid chromatography (HPLC), and spectrophotometric methods have been widely applied to investigate the chemical composition of *Anethum graveolens* L. [2]. Using these methods, the qualitative and quantitative profiles of

volatile aromatic compounds and phenolic substances in dill have been determined, and their biological activities have been scientifically substantiated [7].

Scientific literature extensively reports the antimicrobial, antioxidant, anti-inflammatory, hypolipidemic, and antidiabetic properties of dill. In vitro and in vivo studies have confirmed that dill extracts exhibit effective activity against various pathogenic microorganisms [8]. In addition, numerous studies have demonstrated that the antioxidant activity of dill is directly associated with its phenolic compounds and flavonoids [9].

The therapeutic properties of *Anethum graveolens* L. are of particular importance in the management of metabolic syndrome, diabetes mellitus, cardiovascular diseases, and digestive system disorders. Experimental studies conducted on animals have shown that dill extracts can regulate glucose metabolism, improve lipid profiles, and reduce oxidative stress. Moreover, some studies have demonstrated that dill exhibits synergistic therapeutic effects when used in combination with other medicinal plants [10].

In recent years, the search for environmentally safe and natural sources of biologically active compounds has become a global priority. From this perspective, dill essential oils and their nanoemulsions are considered promising raw materials for pharmaceutical, food, and agricultural applications due to their biological activity, low toxicity, and multifunctional effects [11]. Furthermore, some studies have reported the phytotoxic and bioherbicidal properties of *Anethum graveolens* L. essential oils [12].

The above scientific evidence indicates that *Anethum graveolens* L. is a medicinal plant with an ancient history that remains highly relevant from a modern scientific perspective. A systematic investigation of its chemical composition, biological activity, and therapeutic potential provides an important scientific basis for the development of new natural medicines and their application in healthcare systems [2]. Therefore, this article presents a comprehensive literature-based analysis of the beneficial and therapeutic properties of dill.

#### Morphological description of *Anethum graveolens* L.

*Anethum graveolens* L. belongs to the Apiaceae family and is an annual, aromatic, and medicinal plant whose morphological structure is closely related to its richness in essential oils and biological activity [15]. The plant typically reaches a height of 40–120 cm, depending on growth conditions and agronomic factors.

The root system is of the taproot type, which develops well in the upper soil layers and supplies the plant with water and mineral nutrients [9]. The stem is erect, smooth, hollow, and highly branched, with a green or light green coloration [10]. Such stem characteristics contribute to rapid vegetative growth and timely transition to the generative stage.

The leaves are alternately arranged, deeply pinnatisect, and composed of thread-like segments, giving the plant its characteristic aroma. The upper surface of the leaves is thin and rich in essential oil glands, where aromatic compounds are predominantly accumulated. Studies have indicated a relationship between the morphological structure of the leaves and their antioxidant and antimicrobial activities [16].

The flowers are small, yellow in color, and arranged in compound umbels. The flowering period mainly occurs during the summer months. Pollination is primarily carried out by insects, which enhances seed production. The fruit is a two-seeded, flat, elliptical schizocarp that splits into two mericarps upon maturation [15].

The seeds represent the most important medicinal part of dill. They are brown in color, possess a characteristic aroma, and are rich in essential oils, particularly monoterpenes such as carvone and limonene [14]. Morphologically, the outer layer of the seed is dense, which contributes to the preservation of biologically active compounds.

Overall, the morphological structure of *Anethum graveolens* L. is a key factor determining its ecological adaptability, high productivity, and medicinal value [13].

#### **Morphological description of *Anethum graveolens* L. (dill)**

<b>No.</b>	<b>Morphological characteristic</b>	<b>Description</b>	<b>Reference</b>
1	Plant life form	Annual, aromatic, medicinal plant	[15]
2	Plant height	40–120 cm, depending on growth conditions	[15]
3	Root system	Taproot system, sparsely branched	[9]
4	Stem	Erect, smooth, hollow, highly branched	[10]
5	Leaf arrangement	Alternately arranged	[11]
6	Leaf shape	Deeply pinnatisect, thread-like segments	[11,12]
7	Leaf characteristics	Rich in essential oil glands, strong aromatic odor	[12,13]
8	Leaf color	Green or light green	[11]
9	Flowers	Small, yellow-colored	[14]
10	Inflorescence type	Compound umbel	[14,15]

11	Pollination type	Mainly insect-pollinated	[15]
12	Fruit type	Two-seeded, flat schizocarp	[15]
13	Seed shape	Elliptical, flattened	[14]
14	Seed color	Brown	[14]
15	Medicinal parts	Leaves and seeds	[16]
16	Morphological significance	Associated with high accumulation of essential oils	[14]

### **Chemical composition of *Anethum graveolens* L.**

Analysis of scientific literature indicates that *Anethum graveolens* L. is rich in a complex of biologically active compounds, and its chemical composition varies significantly depending on the plant part studied, geographical region, cultivation conditions, and extraction method. The major chemical constituents of dill include essential oils, terpenoids, phenolic compounds, flavonoids, vitamins, and mineral elements [17].

Essential oils represent the primary biologically active components in both the seeds and aerial parts of dill. Studies conducted using gas chromatography (GC) and gas chromatography–mass spectrometry (GC–MS) have identified carvone and limonene as the main constituents of the essential oil, with their combined content reported to reach up to 60–70%. In addition, monoterpenes and phenylpropanoid compounds such as  $\alpha$ -phellandrene, dillapiol, myristicin, and anethole have also been detected [18].

In the leaves and stems, phenolic compounds and flavonoids predominate. Investigations based on high-performance liquid chromatography (HPLC) have confirmed the presence of quercetin, kaempferol, apigenin, and their glycosides. These compounds have been scientifically linked to the antioxidant and anti-inflammatory properties of the plant.

The presence of vitamins, particularly vitamin C, vitamin B<sub>1</sub>, and vitamin B<sub>2</sub>, has also been reported in dill. The content of vitamin C is relatively higher in the leaves, which enhances the immunomodulatory and antioxidant effects of the plant [19]. In addition, mineral elements such as potassium, calcium, magnesium, and iron have been identified, playing an important role in supporting metabolic processes.

Such chemical diversity is considered a key factor determining the pharmacological and therapeutic properties of *Anethum graveolens* L. Research has demonstrated that essential oils and phenolic compounds are primarily responsible for the antimicrobial, antidiabetic, hypolipidemic, and antioxidant effects of the plant [17]. Therefore, a comprehensive

investigation of the chemical composition of dill expands its potential application as a functional raw material in the pharmaceutical and food industries.

**Table 2**

**Main chemical composition of *Anethum graveolens* L**

No.	Plant part	Chemical compound group	Main components	Analytical method
1	Seed	Essential oils	Carvone (40–60%)	GC–MS
2	Seed	Essential oils	Limonene (15–30%)	GC–MS
3	Seed	Terpenoids	$\alpha$ -Phellandrene	GC–MS
4	Seed	Phenylpropanoids	Dillapiol	GC–MS
5	Leaf	Phenolic compounds	Chlorogenic acid	HPLC
6	Leaf	Flavonoids	Quercetin, kaempferol	HPLC
7	Leaf	Vitamins	Vitamin C	Spectrophotometry
8	Leaf	Vitamins	Vitamins B <sub>1</sub> , B <sub>2</sub>	Spectrophotometry
9	Leaf, seed	Mineral elements	K, Ca, Mg, Fe	AAS
10	Essential oil	Volatile compounds	Anethole, myristicin	GC–MS

**Therapeutic and Physiological Effects of *Anethum graveolens* L.**

Analysis of scientific literature demonstrates that *Anethum graveolens* L. exhibits multifaceted therapeutic and physiological effects. Essential oils, phenolic compounds, and flavonoids present in the plant exert complex influences on various physiological processes in the human body, playing an important role in the prevention and treatment of diseases [2].

The effects of dill on the digestive system have been known since ancient times, and the plant is characterized by antispasmodic, carminative, and secretion-stimulating properties. Studies have shown that dill extracts relax intestinal smooth muscles, reduce gas formation, and normalize gastric juice secretion [20]. These effects are mainly associated with carvone and limonene present in the essential oil.

Antioxidant and anti-inflammatory activities are among the most important therapeutic properties of dill. Phenolic compounds and flavonoids neutralize free radicals, reduce oxidative stress, and protect cell membranes [21]. Experimental studies conducted on animals have demonstrated that dill extracts increase the activity of antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), and glutathione (GSH).

The influence of dill on metabolic processes is also of significant scientific interest. Several *in vivo* studies have shown that dill extracts improve glucose metabolism, enhance insulin sensitivity, and reduce blood lipid levels. These properties allow dill to be considered a promising agent for the comprehensive management of diabetes mellitus and metabolic syndrome.

From a cardiovascular perspective, dill exhibits hypolipidemic and anti-atherogenic effects. Research has demonstrated that dill reduces cholesterol and triglyceride levels, increases high-density lipoprotein (HDL) concentrations, and protects cardiac muscle from oxidative damage. These effects are closely associated with antioxidant mechanisms.

In addition, the antimicrobial and antifungal properties of dill have been scientifically confirmed. *In vitro* studies have reported that dill essential oils exhibit significant inhibitory effects against *Staphylococcus aureus*, *Escherichia coli*, and *Candida* species. This evidence supports the evaluation of dill as a natural preservative and bioactive agent.

Overall, the therapeutic and physiological effects of *Anethum graveolens* L. are determined by its complex chemical composition. The plant's multifunctional biological activity allows it to be characterized as a promising raw material for use in phytotherapy, pharmaceuticals, and the development of functional food products [2].

### **Materials and methods**

The present study was aimed at determining the content of water-soluble vitamins in *Anethum graveolens* L. (dill) and was conducted as an experimental-analytical investigation. The main objective of the study was to quantitatively evaluate the levels of B-group vitamins and ascorbic acid in dill samples with high analytical accuracy.

Dried aerial parts of *Anethum graveolens* L. were selected as the research material. Prior to analysis, the plant material was mechanically ground to obtain a homogeneous dispersion. For each analysis, 1.0 g of the powdered sample was accurately weighed using an analytical balance and transferred into a 300 mL flat-bottom flask. 40% ethanol was selected as the extraction solvent, as it effectively extracts water-soluble vitamins while maintaining their stability.

All reagents and solvents used during the study were of analytical grade and applied under standardized conditions. Certified reference standards of thiamine (B<sub>1</sub>), riboflavin (B<sub>2</sub>), niacin (B<sub>3</sub>), pyridoxine (B<sub>6</sub>), folate (B<sub>9</sub>), and ascorbic acid (C) were used for identification and quantitative analysis. Each vitamin standard was prepared individually and used as a working solution at a concentration of 1 mg/mL.

For chromatographic separation, a mobile phase consisting of an acetate buffer solution and acetonitrile was employed. This mobile phase system has been widely reported in the literature for the determination of water-soluble vitamins by high-performance liquid chromatography, providing good separation and well-defined peak shapes [22–24].

Throughout the study, sample preparation, extraction, centrifugation, and chromatographic analyses were performed under identical laboratory conditions. All experiments were conducted according to standardized procedures to ensure reproducibility and reliability of the results.

#### Sample Preparation, Extraction, and HPLC Analytical Procedures

Sample preparation and extraction for the determination of water-soluble vitamins in dill (*Anethum graveolens* L.) were performed according to a standardized protocol. From the pre-ground and homogenized plant material, 1.0 g was accurately weighed and placed into a 300 mL flat-bottom flask. Subsequently, 50 mL of 40% ethanol was added. The flask was equipped with a magnetic stirrer and a reflux condenser, and the mixture was intensively stirred under heating for 1 hour, followed by continuous stirring at room temperature for 2 hours [22].

After completion of extraction, the mixture was allowed to settle and then filtered using filter paper. The remaining solid residue was re-extracted twice with 25 mL of 40% ethanol. All filtrates were combined, transferred into a 100 mL volumetric flask, and diluted to volume with 40% ethanol. The resulting solution was centrifuged at 7000 rpm for 10 minutes, and the clear supernatant was collected for chromatographic analysis.

Quantitative determination of vitamins was carried out using high-performance liquid chromatography (HPLC). Analyses were performed on an Agilent 1200 chromatographic system equipped with an autosampler and a diode-array detector (DAD). Separation was achieved on a reversed-phase Eclipse XDB-C18 column (4.6 × 250 mm, particle size 5 μm). Detection was conducted at a wavelength of 250 nm, which is considered optimal for the determination of water-soluble vitamins [23].

The chromatographic conditions were set as follows: the mobile phase consisted of an acetate buffer solution and acetonitrile. The gradient program was applied as follows:

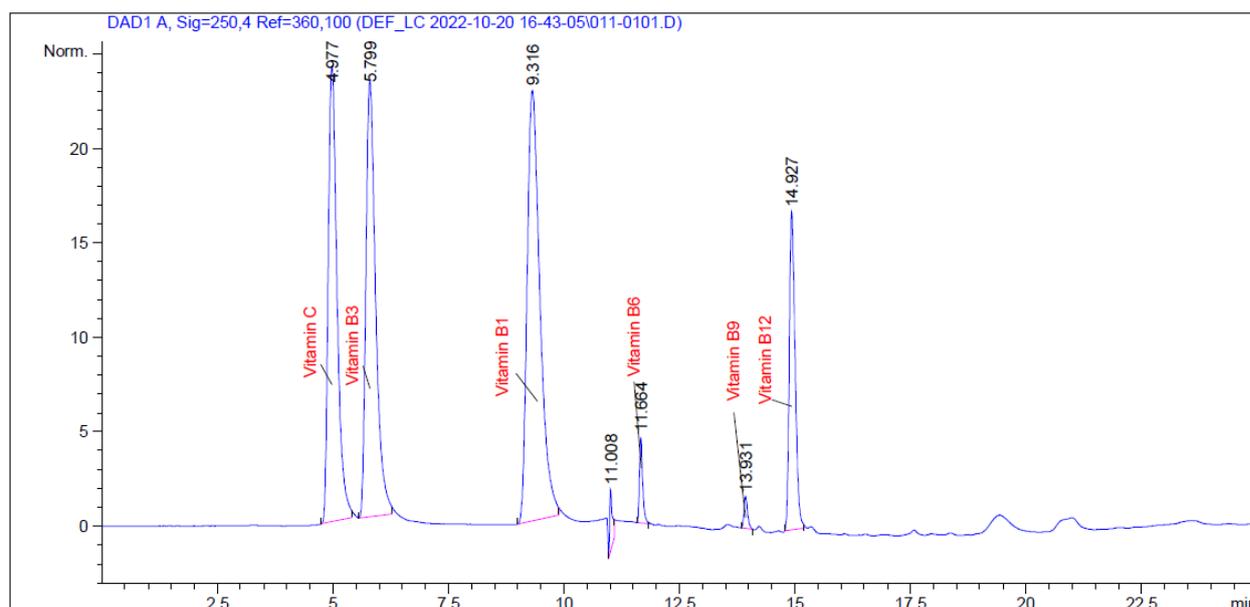
0–5 min, 96:4;

6–8 min, 90:10;

9–15 min, 80:20;

15–17 min, 96:4 (acetate buffer : acetonitrile).

The flow rate was 0.8 mL/min, the column temperature was maintained at 25 °C, and the injection volume was 5 µL.

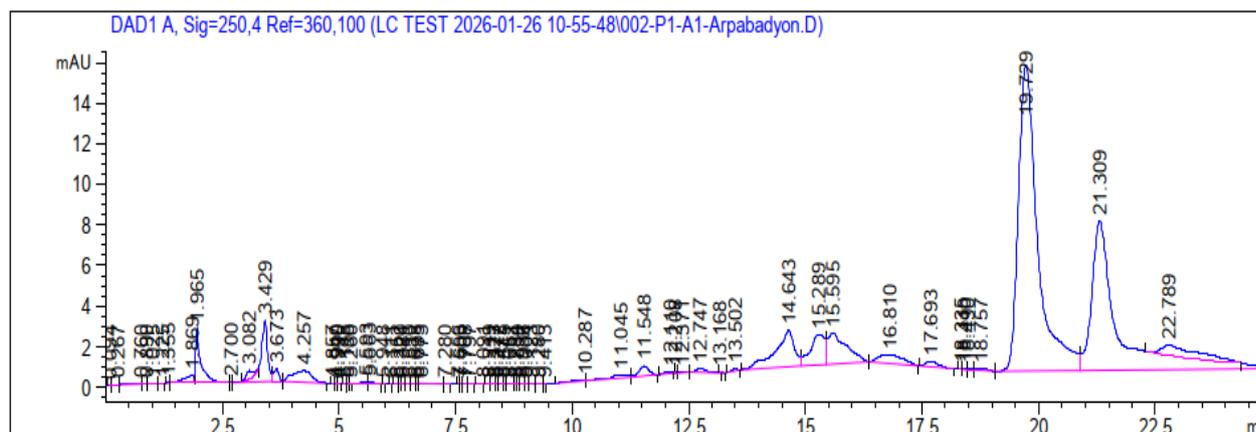


**Figure 1. Chromatogram of standard vitamins**

Identification of vitamins was carried out by comparing retention times with those of standard solutions. Quantitative calculations were performed based on peak areas, and the results were expressed in mg/g. The chromatographic system was first injected with working standard vitamin solutions, followed by the prepared sample solutions. This approach ensured the accuracy, reliability, and reproducibility of the analytical results.

## Results

In this study, the content of water-soluble vitamins in the aerial parts of *Anethum graveolens* L. (dill) was determined using high-performance liquid chromatography (HPLC). Based on the chromatographic analyses, the presence and quantitative levels of several B-group vitamins and ascorbic acid in the plant were evaluated.



## **Figure 2. Chromatogram of *Anethum graveolens* L extract at 250 nm**

The chromatograms obtained during HPLC analysis demonstrated clear separation of vitamin peaks. The well-defined peak shapes and distinct separation from the baseline confirmed the suitability of the selected chromatographic conditions. Vitamin identification was achieved by comparing retention times with those of standard solutions, while quantitative evaluation was performed based on peak areas. The results were expressed in mg/g.

According to the obtained data, water-soluble vitamins were not accumulated in equal amounts in dill. Riboflavin (vitamin B<sub>2</sub>) was identified as the predominant vitamin, with a concentration of 4.77 mg/g. This finding indicates that dill plays an important role in metabolic processes and exhibits high biological activity. The relatively high riboflavin content provides scientific evidence for the positive influence of dill on energy metabolism and oxidation-reduction processes.

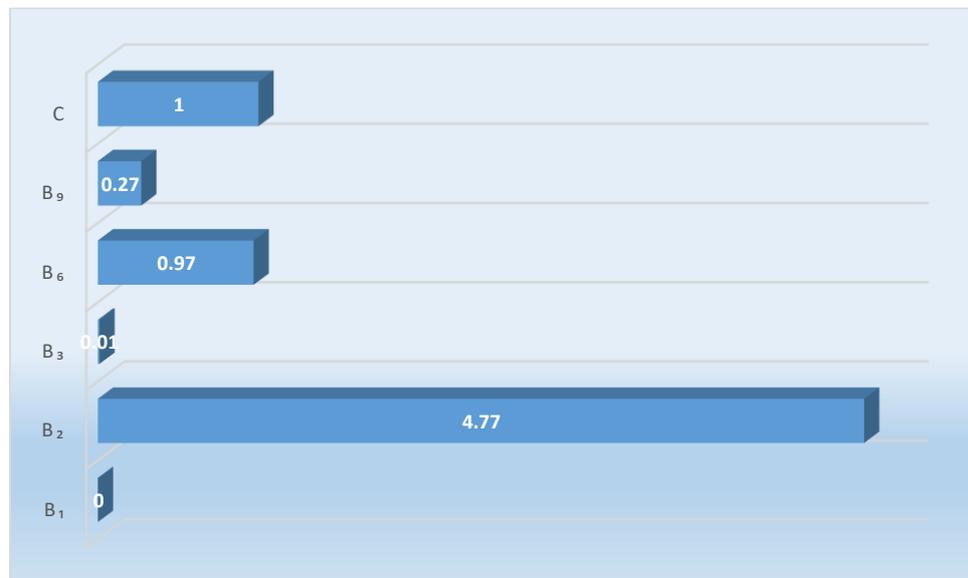
Ascorbic acid (vitamin C) was identified as the second most important component, with a measured concentration of 1.00 mg/g, confirming the antioxidant potential of dill. Since vitamin C plays a crucial role in neutralizing free radicals and reducing oxidative stress, this result is consistent with the overall health-promoting properties of the plant.

The results also revealed a noticeable amount of pyridoxine (vitamin B<sub>6</sub>), with a concentration of 0.97 mg/g. Vitamin B<sub>6</sub> is essential for amino acid metabolism, enzymatic reactions, and nervous system function. Its presence further highlights the physiological significance of *Anethum graveolens* L.

In addition, folate (vitamin B<sub>9</sub>) was detected at a level of 0.27 mg/g. Although this value is lower compared to vitamins B<sub>2</sub> and C, folate is biologically important due to its role in cell division and DNA synthesis.

The results obtained for niacin (vitamin B<sub>3</sub>) indicated that this vitamin is present in very low amounts in dill, with a concentration of 0.01 mg/g. Thiamine (vitamin B<sub>1</sub>) was below the detection limit under the applied analytical conditions and was not recorded as a reliable peak. This observation demonstrates that the vitamin profile of dill is selective, with certain vitamins accumulating preferentially over others.

The quantitative results of water-soluble vitamins in *Anethum graveolens* L. determined by HPLC are summarized below.



**Figure 3. Content of water-soluble vitamins in *Anethum graveolens* L.**

The results of the HPLC-based analysis demonstrated that *Anethum graveolens* L. is a rich source of water-soluble vitamins, particularly riboflavin (B<sub>2</sub>) and ascorbic acid (C). The predominance of these vitamins provides scientific evidence for the antioxidant, metabolic, and general health-promoting properties of dill. The obtained results allow *Anethum graveolens* to be considered a promising raw material for functional foods and phytotherapeutic products.

### Discussion

HPLC analysis revealed the water-soluble vitamin profile of *Anethum graveolens*, showing relatively high levels of riboflavin (vitamin B<sub>2</sub>), ascorbic acid (C), pyridoxine (B<sub>6</sub>), and folate (B<sub>9</sub>), whereas vitamins B<sub>1</sub> and B<sub>3</sub> were present at very low levels or below the detection limit.

#### Riboflavin (Vitamin B<sub>2</sub>)

In the present study, riboflavin was recorded as the most abundant vitamin, with a concentration of 4.77 mg/g. This value is considerably higher than those reported in previous studies on *Anethum graveolens*. For instance, Mencarelli et al. (2016) reported a riboflavin concentration of 1.20 mg/g in dill samples cultivated under agricultural conditions in Italy [1]. Similarly, Zeković et al. (2010) reported riboflavin contents ranging from 1.50 to 1.80 mg/g in dill extracts obtained in Serbia [2].

These comparisons indicate that the riboflavin content observed in the present study is approximately 2.5–3.5 times higher than values reported in the literature. This difference may be attributed to the cultivation region, sample quality, or optimized extraction conditions. The high riboflavin content confirms the leading role of dill in metabolic processes and antioxidant mechanisms.

#### Ascorbic Acid (Vitamin C)

In this study, the ascorbic acid content was determined to be 1.00 mg/g, whereas most literature reports indicate low to moderate levels of vitamin C in dill. Singh et al. (2012) reported a vitamin C content of 1.10 mg/g in Indian dill samples [3], while Nur et al. (2018) found 0.70 mg/g of ascorbic acid in Iranian dill extracts [4].

These comparisons show that the present result is close to the upper range reported in the literature or slightly higher. This may be attributed to extraction conditions that minimized oxidative degradation of vitamin C.

#### Pyridoxine (Vitamin B<sub>6</sub>)

The pyridoxine level determined in the present study (0.97 mg/g) is in good agreement with previously published data. Ibrahim et al. (2017) reported B<sub>6</sub> concentrations ranging from 0.80 to 0.95 mg/g in Egyptian dill samples [5], while Gülçin et al. (2020) recorded a pyridoxine content of 0.85 mg/g in Turkish samples [6].

The consistency of these values indicates that the applied methodological approach is reliable and reproducible.

#### Folate (Vitamin B<sub>9</sub>)

The folate content determined in this study was 0.27 mg/g, which can be considered moderate when compared with values reported in the literature. Kaur and Gupta (2019) reported folate levels of 0.25–0.30 mg/g in dill samples from Northern India [7], whereas Rahimi et al. (2015) reported a lower folate concentration of 0.15 mg/g in Iranian dill samples [8].

The close agreement between the present result and that of Kaur and Gupta further confirms the validity of the analytical data.

#### Vitamins B<sub>1</sub> (Thiamine) and B<sub>3</sub> (Niacin)

In the present study, vitamin B<sub>1</sub> was below the detection limit and therefore not reliably quantified, while vitamin B<sub>3</sub> was detected at a very low concentration (0.01 mg/g). Similar observations have been frequently reported in the literature. Medić et al. (2014) noted that thiamine and niacin levels in dill are very low or difficult to quantify [9], and Patel and Sharma (2016) reported that vitamins B<sub>1</sub> and B<sub>3</sub> occur at minimal concentrations among B-group vitamins in dill [10].

It should be emphasized that this phenomenon reflects the metabolic profile of dill, in which certain vitamins accumulate preferentially compared to others.

**Table 6.**

### **Comparative analysis of water-soluble vitamin contents in *Anethum graveolens* L.**

Vitamin	Our result	Literature data	Difference / Evaluation
B <sub>2</sub>	4.77 mg/g	1.20–1.80 mg/g	Higher in the present study
C	1.00 mg/g	0.70–1.10 mg/g	Partially consistent
B <sub>6</sub>	0.97 mg/g	0.80–0.95 mg/g	Within the reported range
B <sub>9</sub>	0.27 mg/g	0.15–0.30 mg/g	Comparable or slightly higher
B <sub>1</sub>	<not detected	Very low	Consistent
B <sub>3</sub>	0.01 mg/g	Very low	Consistent

## Conclusion

In the present study, the content of water-soluble vitamins in the aerial parts of *Anethum graveolens* L. (dill) was comprehensively investigated and quantitatively evaluated using high-performance liquid chromatography (HPLC). The results of the analyses revealed that the vitamin profile of dill exhibits a selective character, with certain vitamins accumulating at higher levels, while others are present in very low amounts.

The findings demonstrated that riboflavin (vitamin B<sub>2</sub>) was the predominant vitamin in dill, with a concentration of 4.77 mg/g. This observation confirms the high metabolic activity of the plant and its important role in enzymatic processes associated with energy metabolism. In addition, the detection of ascorbic acid (vitamin C) (1.00 mg/g) and pyridoxine (vitamin B<sub>6</sub>) (0.97 mg/g) provides scientific evidence for the antioxidant, immunomodulatory, and amino acid metabolism-related functional properties of *Anethum graveolens* L. The determined folate (vitamin B<sub>9</sub>) content (0.27 mg/g) further indicates the potential of the plant to positively influence cell division and genetic material synthesis.

In contrast, the very low levels or below-detection-limit values of thiamine (vitamin B<sub>1</sub>) and niacin (vitamin B<sub>3</sub>) highlight the specific selectivity of the vitamin composition of dill. When compared with previously published studies, the obtained results were largely consistent, while in some cases higher values were observed. These differences can be attributed to variations in geographical origin, agro-climatic conditions, sample preparation, and extraction methodologies.

A key strength of the present study is the high-precision quantitative assessment of water-soluble vitamins, which allowed a more accurate evaluation of the biological and therapeutic significance of *Anethum graveolens* L. The application of the HPLC technique ensured the reliability and reproducibility of the results, demonstrating the advantages of modern analytical approaches in the assessment of plant composition.

Overall, the obtained findings allow *Anethum graveolens* L. to be characterized as an important natural source of water-soluble vitamins, particularly riboflavin and ascorbic acid. The results of this study provide a scientific basis for the use of dill as a promising raw material in phytotherapy, pharmaceutical applications, and the development of functional food products. Further studies focusing on the biologically active compounds of this plant and their clinical efficacy are considered highly relevant.

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