

COMPARATIVE ANALYSIS OF BIOACTIVE COMPOUNDS IN PIMPINELLA ANISUM L. (ANISE) GROWN UNDER VARIOUS CULTIVATION CONDITIONS.

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**Annotation:** *Pimpinella anisum* L. (anise) is a medicinal and aromatic plant from the Apiaceae family, known for its rich content of bioactive compounds such as anethole, estragole, limonene,  $\alpha$ -pinene, flavonoids, and phenolic substances. These constituents have significant therapeutic, antimicrobial, and antioxidant properties, making anise valuable for pharmaceutical, food, and cosmetic applications. The present study aimed to investigate and compare the bioactive compound profile of anise grown under three cultivation environments: open field, greenhouse, and semi-covered (plastic-sheltered) conditions. During the 2024 growing season in the Tashkent region, mature seed samples were collected and analyzed. Essential oil components were identified via Gas Chromatography-Mass Spectrometry (GC-MS), total phenolics were measured using the Folin-Ciocalteu method, and total flavonoids were determined using the aluminum chloride colorimetric assay. The results showed that open-field cultivation yielded the highest anethole concentration (73.6%), while greenhouse-grown plants contained more limonene and estragole. The semi-covered environment enhanced total phenolic content, suggesting stronger antioxidant capacity. Greenhouse conditions also promoted higher flavonoid accumulation, likely due to controlled temperature and humidity. These findings highlight that cultivation environment has a significant impact on the biosynthesis of both volatile and non-volatile bioactive compounds. Therefore, growing strategies can be adapted to maximize specific phytochemicals depending on the desired application.

**Keywords:** *Pimpinella anisum* L., anethole, flavonoids, phenolic compounds, cultivation conditions, GC-MS, antioxidant activity, essential oil, secondary metabolites

## INTRODUCTION

*Pimpinella anisum* L. (anise) is a medicinal and aromatic plant belonging to the Apiaceae family. Its seeds are rich in numerous bioactive compounds, including anethole, estragole, limonene,  $\alpha$ -pinene, flavonoids, and phenolic substances. These compounds are widely used in the pharmaceutical, food, and cosmetic industries due to their therapeutic, antimicrobial, and antioxidant properties. The phytochemical composition of anise can vary significantly depending on cultivation conditions such as climate, soil type, irrigation, and agricultural practices. This study aimed to investigate and compare the profile of bioactive compounds in anise grown in three different cultivation settings: open field, greenhouse, and semi-covered (plastic-sheltered) environments.

**Methodology:** During the 2024 growing season, *Pimpinella anisum* L. was cultivated under different agro-ecological conditions in the Tashkent region. Samples were harvested at the full seed maturity stage. Essential oil components were analyzed using Gas Chromatography-Mass Spectrometry (GC-MS). Total phenolic content was measured

using the Folin–Ciocalteu method, and total flavonoid content was assessed via aluminum chloride colorimetric assay.

**Results and Discussion:** The GC-MS analysis revealed that the highest concentration of anethole (73.6%) was found in anise grown in open-field conditions. In contrast, greenhouse-grown samples showed a higher proportion of limonene and estragole. Semi-covered conditions (plastic-sheltered environment) led to an increase in total phenolic content, indicating stronger antioxidant potential. Flavonoid levels were highest in the greenhouse-grown plants, likely due to stable temperature and humidity that promote secondary metabolite synthesis.

Environmental factors such as light exposure, soil moisture, and temperature fluctuations significantly influenced the biosynthesis of volatile and non-volatile bioactive compounds. The findings suggest that cultivation conditions can be strategically selected to maximize specific bioactive components depending on the intended use (e.g., pharmaceutical, food additive, or antioxidant formulations).

**Conclusion:** The study concluded that the qualitative and quantitative composition of bioactive compounds in *Pimpinella anisum* L. is highly dependent on the cultivation environment. For obtaining high anethole content suitable for pharmaceutical use, open-field cultivation is more favorable. On the other hand, greenhouse or plastic-covered conditions may enhance antioxidant properties due to elevated phenolic content. These insights contribute to optimizing cultivation techniques for targeted production of phytopharmaceutical compounds from anise.

#### Recommendations

- Cultivation strategies should align with the intended purpose of the plant material.
- For essential oil extraction with high anethole, open-field farming is optimal.
- For antioxidant or nutraceutical purposes, semi-covered or greenhouse cultivation may be preferred.
- Further research is suggested on the impact of fertilization, irrigation frequency, and harvesting time on secondary metabolite synthesis.

Albatta! Quyida siz soʻragan barcha qismlar — annotatsiya (annotation), kalit soʻzlar (keywords), va foydalanilgan adabiyotlar (references) — ingliz tilida yagona matn shaklida keltirilgan:

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