

Phytochemical Plasticity in Sunflower Petals under Different Climate Conditions

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Abstract: The cultivated sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops globally, appreciated for its high linoleic acid content and nutritional value. Beyond its traditional use in food production, recent studies have highlighted the therapeutic potential of various sunflower-derived products, including triterpene glycosides and other bioactive compounds extracted from petals, tubular flowers, and pollen, which exhibit anti-inflammatory, antidiabetic, antiasthmatic, and antioxidant activities. However, despite this promising bioactivity, there is a notable lack of studies focusing specifically on the phytochemical composition of these reproductive structures and how environmental factors influence their biosynthesis. This study analyzed the volatile oil composition of sunflower petals collected from a single hybrid across three agro-ecological zones in the Republic of Moldova (Visoca, Pelinia, and Bacioi) during the flowering stage of 2022 - a year marked by high temperatures and a spring–summer precipitation deficit. Volatile oils obtained via steam distillation were analyzed by GC-MS, identifying 52 constituents. α -Pinene was dominant across all sites (66.71–77.62%), with the highest concentration in Bacioi, characterized by the highest values of temperatures and a significant rainfall peak (83 mm). In contrast, Visoca, characterized by moderate temperatures and the highest June rainfall (71 mm), showed relatively balanced profiles of α -pinene. Pelinia, which experienced lower precipitation throughout the period, displayed reduced levels of several minor volatiles, suggesting a possible drought-induced suppression of certain metabolic pathways. Regression analysis showed a strong positive correlation between α -pinene levels and both average temperature and total precipitation (excluding June rainfall, which was statistically insignificant). Several other major compounds, including α - and γ -terpinene, β -felandrene, and terpinen-4-ol, showed strong negative correlations with climate variables (Pearson $r = -0.83$ to -0.99), except for June precipitation quantity, which correlated positively ($r = 0.70$ – 0.82), suggesting biosynthetic modulation during early flowering. α -Gurjunene levels appeared climate-independent. Interestingly, June rainfall showed contrasting effects: 20 compounds correlated negatively with it, while 17 showed positive correlations, suggesting divergent moisture sensitivities during early phenological stages. These findings highlight the significant influence of climatic variables on volatile compounds accumulation, supporting the valorization of sunflower petals as a resource for pharmaceutical and cosmetic applications.

Keywords: Sunflower Volatile Oils; Climate Influence; α -Pinene Dominance; GC-MS Analysis; Agro-ecological Variation.

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