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SEASONAL INFLUENCE ON PHENOLIC COMPOUNDS OF Eugenia punicifolia ASSESSED BY NMR-BASED METABOLOMICS

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Eugenia punicifolia DC., popularly known as "vegetable insulin," is a medicinal plant native to the Amazon and widely used in traditional medicine for the treatment of type 2 diabetes. Its pharmacological properties are mainly associated with its content of flavonoids and other bioactive phenolics, whose biosynthesis can be modulated by environmental factors. This study investigated the influence of seasonality on the chemical profile of *E. punicifolia* leaf extracts obtained with a methanol:ethanol:water (3:1:1) mixture, using ^{1}H NMR spectroscopy integrated with multivariate analysis. Samples were collected monthly over a 12-month period, enabling the correlation of metabolic profiles with climatic data (temperature, precipitation, relative humidity, and solar radiation). Principal Component Analysis (PCA) and Partial Least Squares Discriminant Analysis (PLS-DA) revealed groupings corresponding to rainy, dry, and transitional periods, with robust models ($R^2 > 0.85$; $Q^2 > 0.85$). Quercetin, myricetin, gallic acid, catechin, and epigallocatechin were identified as the main seasonal markers. Quercetin production showed a positive correlation with solar exposure ($r = 0.60$) and negative correlations with relative humidity ($r = –0.59$), precipitation ($r = –0.62$), and the number of rainy days ($r = –0.64$). Gallic acid exhibited the opposite pattern, being favored by high humidity ($r = 0.66$), greater precipitation ($r = 0.62$), and more rainy days ($r = 0.74$), while being reduced by increased solar radiation ($r = –0.56$). Catechin and epigallocatechin maintained relatively stable levels, with a slight increase between September and November, the months with the highest average temperature. Our findings suggest one way in which seasonality may modulate the biosynthesis of flavonoids and phenolic acids in *E. punicifolia*, consistent with adaptive responses to environmental stresses such as fluctuations in UV radiation, water availability, and biotic pressure. The integration of NMR-based metabolomics and climatic data proved to be an effective approach for understanding how abiotic factors may influence the secondary metabolism of this species. This study provides a scientific basis for management strategies and the optimization of harvest timing to maximize the pharmacological potential of *E. punicifolia*, thereby contributing to the sustainable use of medicinal plants from Amazonian biodiversity.

Keywords: *Eugenia punicifolia, metabolomics, NMR, seasonality, flavonoid.*