HYDROPHILIC CAROTENOIDS FROM *CROCUS SATIVUS* L.: BIOCHEMICAL PROPERTIES, GEOGRAPHIC VARIATION, AND FUTURE INNOVATIONS

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Abstract. *Carotenoids are essential bioactive compounds for human health, commonly found in yellow, orange, and red-pigmented plants. While most carotenoids are lipophilic and insoluble in water, this limits their application in certain pharmaceutical and food systems. However, the rare occurrence of naturally water-soluble, or hydrophilic, carotenoids in specific plant species presents a unique opportunity for broader bioavailability and formulation flexibility. Hydrophilic carotenoids such as crocin are notable for their potent antioxidant, antimicrobial, and anti-inflammatory properties, making them promising candidates for pharmaceutical development. This study investigates the biochemical characteristics and bioactivity of crocin and related carotenoids extracted from the stigmas of Crocus sativus L. cultivated in Iran, Turkey, and Kashmir. High-performance liquid chromatography (HPLC) analysis revealed significant geographic variation, with Iranian saffron showing the highest crocin concentration (11414.67±516.34 μg/g DW). Antioxidant capacity was evaluated using the DPPH assay, while antimicrobial activity was tested via the disc diffusion method against Staphylococcus epidermidis. The results confirm crocin's efficacy as both an antioxidant (IC_{50} = 283.918±3.934 μg/mL) and an antimicrobial agent, with notable inhibition zones at concentrations of 100 μg/mL. Given its bioactivity, crocin is proposed as a candidate active pharmaceutical ingredient (API) for therapeutic applications. In light of land availability and cultivation limitations, future research will explore in vitro culture and metabolic engineering approaches to enhance crocin production through biotechnological means. These findings position hydrophilic carotenoids from saffron as valuable natural resources with commercial and medical relevance.*

Keywords. *Crocus sativus L., crocin, hydrophilic carotenoids, bioactive compounds, natural pigments, geographic variation.*