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FINAL YEAR PROJECT 2 - RESEARCH PROJECT

INVESTIGATING PHYTOTOXICITY REMOVAL OF CHLOROGENIC ACID (CGA) AND CAFFEINE FROM SPENT COFFEE GROUND (SCG) USING CHEMICAL AND THERMAL PRETREATMENT

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ABSTRACT

INVESTIGATING PHYTOTOXICITY REMOVAL OF CHLOROGENIC ACID (CGA) AND CAFFEINE FROM SCG USING CHEMICAL AND THERMAL PRETREATMENT

Spent coffee grounds (SCG), a by-product of the global coffee industry, contain valuable organic matter and nutrients but are limited in agricultural applications due to the presence of phytotoxic compounds such as chlorogenic acid (CGA) and caffeine. These compounds can suppress plant growth and microbial activity in soil. This study investigates the removal of CGA and caffeine from SCG using two pretreatment methods: chemical (ultrasound-assisted extraction) and thermal (carbonisation), with the goal of reducing phytotoxicity and enabling safe reuse as soil amendments. Response Surface Methodology (RSM) was applied to optimise treatment parameters, particularly temperature and reaction time. The optimum condition for chemical pretreatment of spent coffee grounds was 80 °C for 10 min, while thermal pretreatment was optimized at 400 °C for 120 min. Following treatment, SCG samples were analysed using Fourier-transform infrared spectroscopy (FTIR), high-performance liquid chromatography (HPLC), ultraviolet-visible spectroscopy (UV-Vis), and inductively coupled plasma optical emission spectrometry (ICP-OES) to evaluate chemical composition, phytotoxic compound removal, and nutrient content. FTIR results for both chemical and thermal pretreatment indicated significant reductions in peaks at 1700 cm^{-1} (C=O) and 3200–3400 cm^{-1} (O–H), suggesting degradation of phytotoxic substances. Weaker aliphatic C–H signals (2850–2920 cm^{-1}) indicated partial caffeine removal. HPLC and UV-Vis confirmed reductions in CGA and caffeine, correlating with increased treatment severity. Elemental analysis of untreated SCG showed the presence of K (0.41 mg/g), Zn (0.26 mg/g), Cu (0.08 mg/g), and Fe (16.83 mg/g). Chemical treatment decreased metal content, while thermal treatment increased nutrients' concentrations due to organic matter loss, particularly enriching iron. The findings demonstrate that both pretreatment methods effectively reduce phytotoxicity in SCG. This supports the development of an affordable, sustainable detoxification process for SCG valorisation in agriculture.