DEVELOPMENT OF VALORIZED PRODUCTS FROM FLORAL WASTE USING INTERGRATED APPROACH AND THEIR POTENTIAL APPLICATIONS

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ABSTRACT

Wasted flowers from religious places, as well as cultural celebrations, end up in landfills and waterways, where they pose a threat to wildlife and human health. Therefore, alternative processes have been devised to turn these wastes into valuable resources and build a circular economy in close loop system for environmental management and construction of zero waste approach. This research focuses on recovering and reusing valuable components from two flower waste: marigold (*Tagates erecta*) and rhododendron (*Rhododendron arboreum*). The primary goal of this study was to record several methods of drying food to increase its shelf life and various methods of extracting bioactive compounds for use in food. In addition to being used in a closed-loop system for waste water treatment, the wastes were also put to use in the manufacture of biochar by slow pyrolysis. The physicochemical properties of the floral wastes were evaluated before any applications were carried out. This included testing for moisture, ash, volatiles, CHNS, crude fibre, and mineral content. Both biomasses were found to have a volatile concentration of more than 85 wt.%, making them ideal candidates for biochar applications targeting the elimination of poisonous dyes and heavy metals. The phosphorus content in marigolds (30386.5 µg/g) and rhododendrons (24752.65 µg/g) were found to be much greater than those of other minerals. Dried flower scraps were analyzed for their ability to retain TPC (Total phenolic content), TFC (Total flavonoid content), and antioxidant characteristics. Infrared drying at 250W preserved the most phytochemical and antioxidant qualities out of three drying methods (infrared drying, microwave drying, and hot air drying). Microwave drying at high temperatures of 600W for shorter durations reduces phytochemical concentrations and antioxidant qualities in floral biomass, in contrast to prolonged drying times at lower temperatures. The following results were found for the TPC, TFC, DPPH, and FRAP of infrared-dried marigold flowers at 250 W: GAE/g = 57.51mg, QE/g = 68.96mg, IC_{50} = 35.52mg/ml, and Fe^{2+}/g = 165.51mg/g. Once infrared dried at 250 W, rhododendron showed highest values of 67.14 mg GAE/g, 240.24 mg QE/g, 25.95 IC_{50} g/ml, and 159.53 mg Fe^{2+}/g for TPC, TFC, DPPH, and FRAP.

The infrared dried floral petals were utilized for extraction of bioactives using microwave and ultrasound aid. Bioactive compounds and antioxidants are found in abundance in flower biomass. Here are the conditions for microwave-assisted extraction that yielded the best results from spent marigold flowers: TPC: 119.51 mg/100g, TFC: 145.18 mg GAE/g, DPPH: 34.39 IC_{50} g/ml, and FRAP: 569.15 mg Fe^{2+}/g; microwave power: 310W; yield recovery: 74.22%; TCC: 119.51 mg/100g. The expected results for UAE under ideal conditions (amplitude: 30%; sonication time: 12 min; solvent volume: 150 ml) were 42.61 % for yield recovery, TPC: 139.83 mg GAE/g, TFC: 374.45 mg QE/g, DPPH: 45.51 IC_{50} g/ml, FRAP: 474.97 mg Fe^{2+}/g, and TCC: 100.21 mg/100g. Similarly, for rhododendron floral wastes extracted with ideal microwave aided conditions (microwave power: 300W; time: 7 min; solvent volume: 211.10 ml), the expected values for yield recovery, TPC, TFC, DPPH, FRAP, and TAC were as follows: Results: 86.45%, 208.84 mg GAE/g, 826.11 mg QE/g, 29.38 IC_{50} g/ml, 586.94 mg Fe^{2+}/g, and 230.73 mg/g. The expected values for the yield recovery, TPC, TFC, DPPH, FRAP, and TAC of UAE under ideal conditions (sonication time: 15 minutes; solvent volume: 150 ml; amplitude: 29.6%) are: 70.84%, 193.00 mg GAE/g, 523.86 mg QE/g, 35.17 IC_{50} g/ml, 504.61 mg Fe^{2+}/g, and 139.41 mg/100g. When processing rhododendron and marigold, MAE drastically shortened treatment time compared to UAE, cutting it from 5 minutes to 8 minutes while still maintaining bioactive component preservation and improving extraction efficiency.

An antioxidant-fortified product was developed by combining microwave-assisted marigold (ME) and rhododendron extract (RE) with three unique oils: sesame, peanut, and mustard. The peroxide value (PV), acid value (AV), and iodine value (IV) were measured to determine the efficacy of the flower extract in comparison to the synthetic antioxidant (BHT 200 ppm) when added to groundnut, sesame, and mustard oil at concentrations of 200, 400, 600, 800, and 1000 ppm. Primary and secondary oxidation products were both significantly reduced at the maximum ME dose compared to the control. Extracts with concentrations of 600 ppm or above suppress lipid oxidation more effectively than BHT at 200 ppm. The shelf life of all three oils was increased by about 50-60 days as a result of this improvement, and at some concentrations, the oils could be stored for over 100 days. In light of these results, it seems reasonable to consider ME and RE as potential organic replacements for synthetic antioxidants. In order to get a bird's-eye view of the sample variations and spot behavioural patterns, we used a modest number of principle components (PC) to decrease the initial variables. PC1 and PC2 components accounted for 96.84 % and 1.87 %, respectively, of the total variance in groundnut oil with ME. 69.53 and 32.89 percent of the variance in groundnut oil, 98.21 and 1.07 % in sesame oil, and 98.2 and 1.52 % of the variance in mustard oil could be accounted for by ME.

Slow pyrolysis at 400 °C, 500 °C, and 600 °C for 60 min was used to convert the depigmented biochar residue into a green bioabsorbent. After completion of the pyrolysis processes, the physicochemical analysis of the rhododendron residue derived biochar (RRB), marigold residue derived biochar (MRB) and marigold husk derived biochar (MHB) was investigated by proximate, ultimate and different instrumental analysis like XRD, SEM, FTIR and BET studies. Low volatile matter (from 13.54 to 20.5 %) and high fixed carbon (from 81.85 to 85.16 %) were observed in RRB, MRB, and MHB samples at a range of pyrolytic temperatures (from 400 to 600 °C), demonstrating compliance with the requirements for biochar production. Biochar obtained at 600 °C had higher quality for further uses, as determined by studying the biochar yields and physicochemical evaluations. In addition, it was shown that the specific surface area of RRB is the largest (412.00 m^2 g^{-1}) compared to MRB (6.21 m^2 g^{-1}) and MHB (17.09 m^2 g^{-1}). All of the biochar samples were found to be significantly porous, with the creation of pores, cracks, and ridges on the structure, as determined by both the structural analysis and the morphological evaluation by SEM analysis. This study's findings lend credence to the idea that biochar, thanks to its high surface area (particularly RRB), porosity, and surface functional groups, can be used in wastewater treatment processes such, for example, the degradation of dyes and the accumulation of heavy metals. When compared to biochar made from marigolds, which was tested for its ability to remove Congo red (CR) and methylene blue (MB) dyes from aqueous solutions at a fixed initial concentration of 50 mg/L, rhododendron-derived biochar showed significantly higher removal percentages (91.60 % for CR and 88.30 % for MB). Modelling their absorption behaviour and surface homogeneity with the Langmuir isotherm provided more confirmation. The primary idea is "waste to wealth and circular economy," which lays emphasis on closing the loop between the efficient avoidance, recycling, and utilization of floral waste for its potential use in the food business and the environmental remediation sector in India and around the world.