VII International Congress "Engineering, Environment and Materials in Processing Industry", Jahorina, 17.-19.03.2021.

GREEN EXTRACTION APPROACH FOR THE RECOVERY OF BIOACTIVE COMPOUNDS FROM TOBACCO WASTE

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INTRODUCTION

Recent trends in the separation techniques have been largely focused on the green extraction techniques. The conventional extraction techniques require the high energy "input", including the consumption of harmful organic solvents, prolonged extraction time and utilization of high temperatures, and consequently degradation of thermolabile components occur. The novel extraction techniques such as supercritical CO_2 extraction, ultrasound assisted extraction, high voltage electric discharge assisted extraction and subcritical water extraction avoid or reduce these disadvantages and improve extraction efficiency. The aim of this paper is to give an overview of our results in the recovery of bioactive compounds from tobacco waste, with special attention to dominant bioactive compounds in tobacco waste, nicotine and chlorogenic acid respectively.

MATERIALS AND METHODS

Three types of tobacco waste (scrap, dust and midrib) and *Virginia* leaf blend (composed by 73.3% *Virginia* and 26.7% oriental tobaccos) as starting material were obtained from tobacco factory "Fabrika duhana Sarajevo" and subjected to different extraction techniques and process conditions.

ANALYSIS:

- Gas Chromatography coupled to Mass Spectrometry (GC-MS)
- Gas Chromatography with Flame-Ionization Detection (GC-FID)
- High Performance Liquid Chromatography (HPLC)
- Spectrophotometric analysis
- Total phenols contents (Folin-Ciocalteu assay)
- Antioxidant activity (DPPH method)
- Statistical analysis and experimental design using response surface methodology (Design Expert)

SUBCRITICAL WATER EXTRACTION (SWE)

Tested variables	Time (min)	Temperature (°C)	Solvent/solid ratio (mL/g)
Experimental range	5-25	150-250	10-30
Detected compounds	Phenolic compounds, carbohydrates, chlorogenic acid, rutin, nicotine, 3,4 DHBA, nicotinic acid, nicotinamide, 5-HMF, furfural and 5-MF		
Activity	Antioxidant activity		
Optimal conditions	Scrap: 150 °C, 23 min, 28 mL/g	Dust: 160 °C, 20 min, 10 mL/g	Midrib: 150 °C, 25 min, 30 mL/g

RESULTS

EXTRACTION WITH DEEP EUTECTIC SOLVENTS (DES)

Tested variables	Time (min)	Temperature (°C)	Water content (%)
Experimental range	30-90	30-70	10-30
Detected compounds	Phenolic compounds, chlorogenic acid, rutin		
Activity	Antioxidant activity		
Optimal conditions	Type: scrap, 30 min, 70°C, 29.99 % water Eutectic solvent: Choline chloride: Etan-1,2-diol		

HIGH VOLTAGE ELECTRIC DISCHARGE-ASSISTED EXTRACTION (HVED)

Tested variables	Time (min)	Frequency (Hz)	Solvent/solid ratio (mL/g)
Experimental range	15-45	30-70	300-700
Detected compounds	Phenolic compounds, chlorogenic acid, rutin, nicotine		
Activity	Antioxidant activity		
Optimal conditions	Scrap: 41 Hz, 16.3 min, 692 mL/g	Dust: 73 Hz, 15 min, 700 mL/g	Midrib: 40 Hz, 41 min, 689 mL/g

SUPERCRITCICAL CO_2 EXTRACTION (SC-CO_2)

Tested variables	Pressure (bar)	Temperature (°C)	Time (min)
Experimental range	100-300	40-80	5-120
Detected compounds	Fatty acids, nicotine, volatile organic compounds		
Optimal conditions	Type: scrap, 120 min, 300 bar and 61.22 °C		

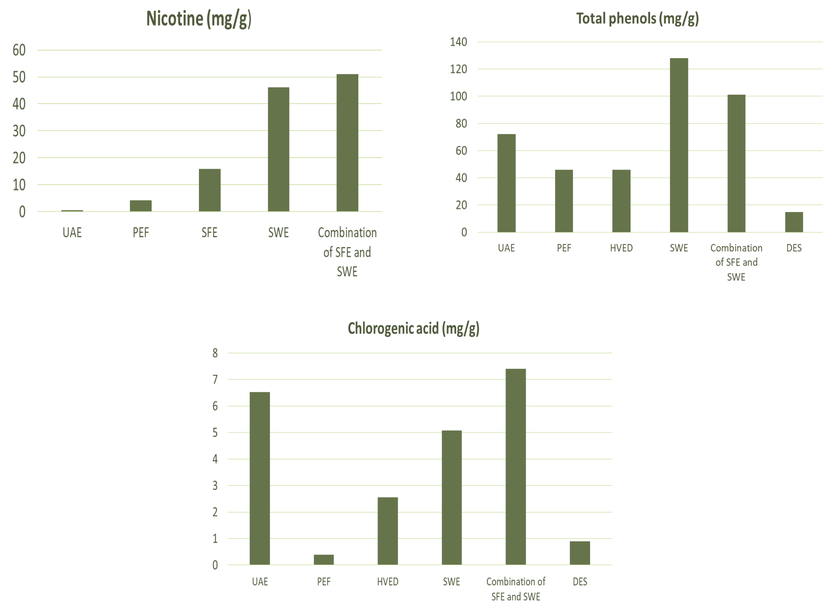

Figure 1. Comparison of different methods in extraction of bioactive compounds from tobacco waste

ULTRASOUND-ASSISTED EXTRACTION (UAE)

Tested variables	Time (min)	Temperature (°C)	Solvent/solid ratio (mL/g)	ethanol-water ratio (%)
Experimental range	30-90	30-70	10-30	40-80
Detected compounds	Phenolic compounds, chlorogenic acid, rutin, solanesol, caffeic acid, nicotine, volatile organic compounds, neophytadiene, 4,8,13-duvatriene-1,3-diol			
Activity	Antioxidant activity			
Optimal conditions for polar compounds	Scrap: 46.69 °C, 15.19 min, 10 mL/g, 40% ethanol-water ratio	Dust: 53.59 °C, 38.31 min, 10 mL/g, 55.43% ethanol-water ratio	Midrib: 69.27 °C, 38.31 min, 11 mL/g, 44.83% ethanol-water ratio	
Optimal conditions for non-polar compounds	Scrap: 70 °C, 50 min, 12.74 mL/g	Dust: 70 °C, 45 min, 10 mL/g	Midrib: 70 °C, 20.19 min, 10 mL/g	

CONCLUSIONS

Results showed that supercritical CO_2 extraction has advantages in extracting fatty acids and volatile organic compounds. Subcritical water extraction enabled high extraction yield, but some degradation products (furfurals) occurred on higher temperatures (above 200 °C). Ultrasound assisted extraction and high voltage electric discharge assisted extraction provided satisfying concentration of phenolic compounds (chlorogenic, acid and rutin). All tobacco waste types contained similar compounds as leaf blend but in lower concentrations.

Treatment of tobacco waste such as recycling and reusing are an imperative today due to rigorous environmental protection legislation. Studied green extraction techniques in this paper provided advantages over conventional extraction methods, such as being "greener", faster and more efficient.

ACKNOWLEDGEMENT

This work has been supported by Croatian Science Foundation under the project "Application of innovative techniques of the extraction of bioactive components from by-products of plant origin" (UIP-2017-05-9909)

HrZZ Croatian Science Foundation
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