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Optimization of Ultrasound-Assisted Extraction of Oil from Spent Coffee Grounds Using a Central Composite Rotatable Design

Authors : Malek Miladi, Miguel Vegara, Maria Perez-Infantes, Khaled Mohamed Ramadan, Antonio Ruiz-Canales, Damaris Nunez-Gomez

Abstract : Coffee is the second consumed commodity worldwide, yet it also generates colossal waste. Proper management of coffee waste is proposed by converting them into products with higher added value to achieve sustainability of the economic and ecological footprint and protect the environment. Based on this, a study looking at the recovery of coffee waste is becoming more relevant in recent decades. Spent coffee grounds (SCG's) resulted from brewing coffee represents the major waste produced among all coffee industry. The fact that SCGs has no economic value be abundant in nature and industry, do not compete with agriculture and especially its high oil content (between 7-15% from its total dry matter weight depending on the coffee varieties, Arabica or Robusta), encourages its use as a sustainable feedstock for bio-oil production. The bio-oil extraction is a crucial step towards biodiesel production by the transesterification process. However, conventional methods used for oil extraction are not recommended due to their high consumption of energy, time, and generation of toxic volatile organic solvents. Thus, finding a sustainable, economical, and efficient extraction technique is crucial to scale up the process and to ensure more environment-friendly production. Under this perspective, the aim of this work was the statistical study to know an efficient strategy for oil extraction by n-hexane using indirect sonication. The coffee waste mixed Arabica and Robusta, which was used in this work. The temperature effect, sonication time, and solvent-to-solid ratio on the oil yield were statistically investigated as dependent variables by Central Composite Rotatable Design (CCRD) 23. The results were analyzed using STATISTICA 7 StatSoft software. The CCRD showed the significance of all the variables tested ($P < 0.05$) on the process output. The validation of the model by analysis of variance (ANOVA) showed good adjustment for the results obtained for a 95% confidence interval, and also, the predicted values graph vs. experimental values confirmed the satisfactory correlation between the model results. Besides, the identification of the optimum experimental conditions was based on the study of the surface response graphs (2-D and 3-D) and the critical statistical values. Based on the CCDR results, 29 ºC, 56.6 min, and solvent-to-solid ratio 16 were the better experimental conditions defined statistically for coffee waste oil extraction using n-hexane as solvent. In these conditions, the oil yield was >9% in all cases. The results confirmed the efficiency of using an ultrasound bath in extracting oil as a more economical, green, and efficient way when compared to the Soxhlet method.

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