Kinetics and modeling during phenolics extraction from grape pomace

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Grape pomace is the winery waste originated during the production of must by pressing whole grapes. Nine million tons of this waste are produced per year in the world, which constitutes about 20% w/w of the total grapes used for wine production (Teixeira et al., 2014). Grape pomace constitutes a source of phenolic compounds. Its phenolic content mainly include anthocyanins (e.g., malvidin, peonidin), flavan-3-ols (e.g., catechin, proanthocyanidins), flavonols (e.g., quercetin, myricetin), stilbenes, and phenolic acids (Negro et al., 2003; Makris et al., 2007). Based on its polyphenolic content, several studies have reported its high antioxidant activity (Rockenbach et al., 2011). Therefore, the recovery of phenolic compounds from grape pomace is of great importance, not only because of their significant properties, but also because it could exploit a large amount of the wine industry wastes, which are mainly used today as cattle feed or for soil conditioning or they are trucked away to disposal sites (Louli et al., 2004).

The traditional extraction technique for polyphenols from plant materials or food industry wastes is solid-liquid extraction (maceration), but it has been linked with various disadvantages, such as time-consuming procedures, thermal degradation of phenolic compounds, use of less eco-friendly organic solvents, and low extraction yield. In the last two decades, innovative extraction techniques have been proposed that use added energy such as ultrasound and microwave irradiation in order to tackle the aforementioned drawbacks (Chemat et al., 2011).

In addition, optimization of extraction processes is an essential step in translating the research into an industrial reality. The new trend in food and bioprocess technology requires the development of low cost tailor-made products. To reduce development costs during design and scale up of processing equipment, numerical modeling has proven to be an effective tool, reducing development time and costs by avoiding development through trial-and-error. Modeling is a very broad term and encompasses analytical, statistical, kinetic, computational fluid dynamics (CFD), response surface methodology (RSM), neural network models among others.

In this work, the phenolics extraction from grape pomace was modeled and the effects of the independent variables on the extraction kinetics were examined. Two present extraction techniques, microwave-assisted extraction (MAE) and ultrasound-assisted extraction (UAE) have been selected and used in comparison with conventional maceration extraction (CME). In ultrasound-assisted extraction, extraction temperature (20-60 °C), solvent type (0-100% aqueous ethanol), amplitude level (20-60%), and solvent/solid ratio (8-24 mL/g) were the factors investigated. In the case of microwave extraction, the effects of solvent type (0-100% aqueous ethanol), solvent/solid ratio (8-24 mL/g), and microwave power (100-600 Watt) were studied. In both methods, the extracts were collected at time intervals of 2, 5, 10, 20, and 30 min.

Three different mathematical approaches were selected for the kinetic modelling, namely, the first order kinetic model, the mass transfer model, and the Peleg's model. The values of the adjusted correlation coefficient, the root mean square error (RMSE), the mean bias error (MBE), and the reduced chi-square (χ^2) were used to evaluate the goodness of fit and to select the best model for a given experimental data set.

References

Chemat, F., Huma, Z., & Khan, M. K. (2011). Applications of ultrasound in food technology: Processing, preservation and extraction. Ultrasonics Sonochemistry, 18, 813–835.

Louli, V., Ragoussis, N., & Magoulas, K. (2004). Recovery of phenolic antioxidants from wine industry by-products. Bioresource Technology, 92, 201–208.

Makris, D. P., Boskou, G., & Andrikopoulos, N. K. (2007). Polyphenolic content and in vitro antioxidant characteristics of wine industry and other Agri-food solid waste extracts. Journal of Food Composition and Analysis, 20, 125–132.

Negro, C., Tommasi, L., & Miceli, A. (2003). Phenolic compounds and antioxidant activity from red grape marc extracts. Bioresource Technology, 87, 41–44.

Rockenbach, I. I., Gonzaga, L. V., Rizelio, V. M., Goncalves, A. E.., Genovese, M. I., & Fett, R. (2011). Phenolic compounds and antioxidant activity of seed and skin extracts of red grape (Vitis vinifera and Vitis labrusca) pomace from Brazilian winemaking. Food Research International, 44 (4), 897–901.

Teixeira, A., Baenas, N., Dominguez-Perles, R., Barros, A., Rosa, E., Moreno, D. A., & Garcia-Viguera, C. (2014).Natural bioactive compounds from winery by-products as health promoters: A Review. International Journal of Molecular Sciences, 15, 15638–15678.