ABSTRACT

Supercritical Fluid Extraction Of Jasmine

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Jasmine, the key ingredient in many fine perfume formulations, has been conventionally extracted using a mixture of organic solvents and vacuum distillation. The use of supercritical fluid extraction using carbon dioxide as a solvent was investigated as an alternative to the traditional process.

This work established optimal extraction conditions for maximal yield of extract based on two parameters – pressure and temperature. This was done by choosing 36 conditions in a 6×6 replicate experimental design. The temperatures investigated were 35, 45, 55, 65, 75, and 85°C, while the pressures used were 100, 200, 300, 400, 500, and 550bars. Statistical analyses of replicate runs were used to evaluate the experimental results.

The quality of the extracts was determined by the use of gas chromatographic analysis, with the use of external standards for identification and quantitation of major fragrance components. The components benzyl acetate, geraniol, eugenol, jasmone, nerol, nerolidol, farnesol and benzyl acetate were

analysed as the major markers for establishing the quality of the extract. Duplicate analyses of the extracts were carried out, and statistical analyses done on the data generated.

It was proposed that the extraction mechanism for flavour and fragrance material with supercritical fluid extraction (SFE) involved a simultaneous internal and external mass transfer mechanism. To verify this hypothesis, an equation was developed based on internal diffusion theory and external mass transfer theory. The equation was solved on an elemental basis with the use of mathematical software packages and tools. The equation which used a diffusion coefficient (D) and a mass transfer coefficient (K) as its driving mechanisms were used to predict the extraction curves at various conditions and consequently determine the extent to which internal or external mass transfer mechanisms dominate the extraction process for a particular material. Besides being tested on the SFE results for jasmine, the equation was tested on SFE results for other materials such as nutmegs and orange peels, which were thought to have varying degrees of internal and external mass transfer occurring in their extraction processes.

Finally, an economic model and analysis was done. The economic model was developed for use as a screening process to identify possible profitable commercial crops for SFE processing. This model was based on external factors such as drying time, weight loss during drying, the need for size reduction, extraction yield, the price of the raw material and the price of the extract. The model gave a value for the Profitability Index (P.I.) of a particular material and served to determine whether further economic considerations should be given to

that particular crop. A subsequent mathematical equation based on regression analysis was derived in order to predict the P.I. of a material. Consequently, a detailed study of the economics of a potential 90L SFE processing plant, with jasmine as its main product, was undertaken to determine the feasibility of such a venture.

Based on these objectives, it was discovered that, with respect to jasmine, the optimal extraction conditions for a maximal yield of 0.382% occurred at 55°C and 550bars. It was also determined that even though the concentrations of the key fragrance compounds identified were high in this extract, they were even higher in the extracts obtained at lower temperatures.

The proposed equation based on the elemental analysis of the simultaneous internal/external mass transfer mechanism accurately predicted the extraction curves for the SFE of jasmine, as well as the SFE results for other materials such as nutmegs and orange peel. It was proved that jasmine had a dominant external mass transfer mechanism, with internal mass transfer making only a minor contribution. Different extents of dominance were found for nutmegs and orange peels. As a result of application of the model to the SFE results, values for diffusion coefficients and mass transfer coefficients were determined for an extensive range of pressures and temperatures in the case of jasmine. Such coefficients can be used for predicting extractions of other similar floral material.

The economic model accurately predicted jasmine as a commercially viable crop and the subsequent economic analysis confirmed that an industrial

SFE plant with jasmine as its major processing crop would have 39% return on investment over a ten-year life cycle.

KEYWORDS: Vernon Paltoo, supercritical fluid extraction, jasmine, carbon dioxide, GC analysis, mathematical modelling, internal mass transfer, external mass transfer, elemental analysis, diffusion coefficient, mass transfer coefficient, economic model, feasibility analysis.