Enriching beta-carotene from palm oil using scale-up supercritical CO2 continuous countercurrent fractional column

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Abstract

Beta-carotene is the essential group member of the natural carotenoids. It is a vibrant and reliable source of provitamin A precursors and a powerful antioxidant, which plays a critical role in human health. Though beta-carotene can be chemically synthesized, naturally occurring β-carotene is growing in demand. Among the beta-carotene natural resources, Crude palm oil (CPO) is the richest natural plant source of beta-carotene, which contains around 0.05%. Many methods have been developed to concentrate β-carotene, among which the Molecular distillation procedure was often applied. However, CPO was often required to be transformed to the fatty acid esters by the transesterification process, and could not be applied in food again. Therefore, it is highly desired to isolate beta-carotene without destroying original molecular structure of CPO. In this work, we present enriching beta-carotene directly from CPO without transesterification process using a continuous countercurrent supercritical CO2 extraction-distillation process. A lab and scale-up plants with the fractional column, filled with packing, have been developed. The lab-fractional column is 6000 mm in height and 50 mm in diameter. The scale-up one is 12000 mm in height and 100 mm in diameter. The maximum working pressure is 50 MPa. There are four heating zones along with the column. The influences of the process parameters (pressure, temperature, CO2 and feeding ratio) on the beta-carotene content and the yield were investigated in detail. The content of the beta-carotene reached 0.5% in the first phase and 5% in the second stage in the CPO at the suitable conditions. The content was finally increased 100 times, comparing that of the CPO raw. Based on the lab results, processing capacity being of 1 kg/hr, we scale up to more than 10 kg/hr. The process parameters, such as pressure, temperature, and CO2-to-feed ratio significantly impact the concentrating efficiency as that in lab plant. The similar results were obtained at the optimum conditions. It suggests that the scaling effect is small for supercritical CO2 countercurrent extraction-distillation process and this technique can be potentially scaled up to industrial production. Furthermore, this approach can find wide applications in enriching and purifying other compositions used in nutraceutical, pharmaceutical & cosmetic fields, et al.