Studies on the optimization of ultrasound-aided enzymatic synthesis of caffeic acid phenethyl ester

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ABSTRACT

Phenolic acids are good radical scavengers for anti-inflammatory and anti-oxidant performances. Caffeic acid, one kind of phenolic acid, increase the solubility in oil-based formulas and emulsions is to esterify the compounds with alcohols and enhance anti-oxidant ability in the food and cosmetics applications. However, the reagents used in chemical synthesis of caffeic acid phenethyl ester (CAPE) are harmful to natural environmental. In contrast, enzymatic synthesis offers the advantages of specificity, milder reaction conditions, and minimization of side reactions and byproduct formation. Therefore, the value of using continuous ultrasound-assisted packed-bed bioreactor for the lipase-catalyzed processing should also permit an easier approach to producing commercial amount of CAPE. In this study, optimum conditions for the enzymatic synthesis of CAPE, catalyzed by immobilized lipase (NovozymR 435) were investigated. NovozymR 435 was used to catalyze caffeic acid and 2-phenyl ethanol in an isooctane system. 5-level-4-factor central-composite rotatable design (CCRD), Box-Behnken experiment design and response surface methodology (RSM) were employed to evaluate the effects of synthesis parameters on percentage conversion of CAPE by esterification for three part experiments. In the first part, immobilized enzymes were used to catalyze the esterification of caffeic acid with phenyl ethanol. The esterification improved the stability and hydrophobicity of phenolic acid. On the basis of ridge max analysis, the optimum conditions for synthesis were: reaction time 59 h, reaction temperature 69 oC, substrate molar ratio1:72, and enzyme amount 351 PLU. The molar conversion of predicted value was 91.86% and actual experimental value was 91.65±0.66%, respectively. In the second part, ultrasonication causes cavitations in the liquid medium. Subsequent collapses of the cavitation bubbles appear to cause a thorough mixing and stirring of the liquid solution, and the energy thus released should accelerate the enzymatic reactions. Ultrasound provides a very effective mixing and stirring in the reaction solution and increases the contacts between substrates and enzyme. The optimum condition for CAPE synthesis were reaction time 9.6 h, substrate molar ratio 1:71, enzyme amount 2938 PLU, and ultrasonic power 2 W/cm2. The molar conversion of predicted values and actual experimental values were 96.03% and 93.08±0.42%, respectively. In the third part, the ultrasound-acceleration synthesis of CAPE in a continuous packed-bed bioreactor was investigated. A three-level-three-factor Box-Behnken and RSM were employed on percent molar conversion of CAPE. The optimum conditions for synthesis CAPE were: reaction temperature of 72.66 ?C, flow rate of 0.046 mL/min, and ultrasonic power of 1.64 W/cm2. The molar conversion of predicted values and actual experimental values were 97.84% and 92.11±0.75%, respectively. This work demonstrates of lipase in a continuous ultrasound-acceleration packed-bed bioreactor for industrial production of CAPE. The use of continuous ultrasound-acceleration packed-bed bioreactor in NovozymR 435-catalyzed synthesis of CAPE from caffeic acid and 2-phenyl ethanol in isooctane was investigated. Compared with chemical synthesis was more natural and milder synthesis process reduced the environmental damage, while the synthesized product of CAPE was also relatively safe for food or cosmetic applications. According to our results, used the natural enzyme catalysis and ultrasound to accelerate improve time-consuming for synthesis CAPE. The value of using packed-bed bioreactors for the lipase-catalyzed processing should also permit an easier approach to producing commercial amount of the product.

Keywords : biocatalysis、bioreactor、caffeic acid phenethyl ester、lipase、optimization、phenolic acid、ultrasonication

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