Kajian In Vitro dan In Vivo Bromelain Terenkapsulasi Pada Matriks Kitosan-Alginat-Pektin Sebagai Alternatif Untuk Mengobati Hiperkolesterolemia dan Inflamasi = In Vitro and In Vivo Study of Bromelain Encapsulated in Chitosan-Alginate-Pectin Matrix As An Alternative Formula to Treat Hypercholesterolemia and Inflammation

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Abstrak

Prevalensi penyakit akibat inflamasi di Indonesia dilaporkan cukup tinggi, dengan dampak jangka panjang seperti kanker, gangguan saraf, dan masalah peredaran darah. Salah satu faktor penyebab inflamasi adalah kolesterol tinggi dalam darah, yang meningkatkan risiko penyakit jantung dan stroke. Hiperkolesterolemia, kondisi di mana kadar kolesterol total, LDL, dan trigliserida dalam darah terlalu tinggi, merupakan masalah kesehatan yang signifikan. Bromelain, enzim dari buah nanas, telah terbukti memiliki sifat antiinflamasi dan antikolesterol. Meskipun bromelain dapat diserap dengan baik di usus halus, pemberian secara oral menghadapi tantangan asam lambung yang dapat mendenaturasi enzim ini, mengurangi efektivitasnya. Oleh karena itu, diperlukan enkapsulasi untuk melindungi bromelain dari asam lambung dan memastikan khasiatnya tetap terjaga. Penelitian ini telah mengkaji enkapsulasi bromelain dalam matriks kering beku kitosan-alginat-pektin, yang diharapkan dapat memungkinkan pelepasan lambat di lambung dan pelepasan kumulatif tinggi di usus halus. Kapsul HPMC dengan matriks kitosan-alginat-pektin menurunkan pelepasan bromelain sebesar 19% dalam SGF dan 17% dalam SIF, melindungi enzim dari degradasi asam dan memastikan lebih banyak bromelain aktif mencapai usus halus. Dalam pengujian aktivitas antiinflamasi, kapsul bromelain menunjukkan IC50 untuk inhibisi denaturasi protein pada 66,999 ppm, mendekati natrium diklofenak dan lebih efisien daripada ekstrak bromelain. Pada konsentrasi 100 µg/ml, efisiensi matriks bromelain mencapai 106%, lebih efektif daripada natrium diklorofenak. Pada konsentrasi tertinggi (1000 µg/ml), efisiensi adalah 84%, menunjukkan efektivitas pada konsentrasi menengah hingga tinggi. Dalam pengujian antikolesterol, matriks bromelain mencapai IC50 pada 33,18 ppm, lebih efektif dibandingkan ekstrak bromelain. Pada konsentrasi tertinggi (1000 µg/ml), efisiensi inhibisi mencapai 83%, menunjukkan bahwa pada konsentrasi tinggi, matriks bromelain hampir seefektif simvastatin. Pengujian in vivo menunjukkan matriks bromelain memiliki potensi signifikan dalam efek antiinflamasi dan antikolesterol, setara atau lebih tinggi dari ekstrak bromelain, didukung oleh hasil in vitro yang menunjukkan peningkatan stabilitas dan aktivitas enzimatik melalui enkapsulasi.

.....The prevalence of inflammation-related diseases in Indonesia is reported to be quite high, with long-term impacts such as cancer, nerve disorders, and circulatory problems. One contributing factor to inflammation is high blood cholesterol, which increases the risk of heart disease and stroke. Hypercholesterolemia, a condition where total cholesterol, LDL, and triglyceride levels in the blood are excessively high, is a significant health issue. Bromelain, an enzyme from pineapple, has been proven to have anti-inflammatory and anti-cholesterol properties. Although bromelain is well absorbed in the small intestine, oral administration faces the challenge of stomach acid that can denature this enzyme, reducing its effectiveness. Therefore, encapsulation is needed to protect bromelain from stomach acid and ensure its efficacy. This study has examined the encapsulation of bromelain in a freeze-dried chitosan-alginate-pectin matrix, which

is expected to allow slow release in the stomach and high cumulative release in the small intestine. HPMC capsules with a chitosan-alginate-pectin matrix reduced bromelain release by 19% in SGF and 17% in SIF, protecting the enzyme from acid degradation and ensuring more active bromelain reaches the small intestine. In anti-inflammatory activity testing, bromelain capsules showed an IC50 for protein denaturation inhibition at 66.999 ppm, close to that of diclofenac sodium and more efficient than bromelain extract. At a concentration of 100 µg/ml, the efficiency of the bromelain matrix reached 106%, more effective than diclofenac sodium. At the highest concentration (1000 µg/ml), the efficiency was 84%, indicating effectiveness at medium to high concentrations. In anti-cholesterol testing, the bromelain matrix achieved an IC50 at 33.18 ppm, more effective than bromelain extract. At the highest concentration (1000 µg/ml), the inhibition efficiency reached 83%, indicating that at high concentrations, the bromelain matrix is almost as effective as simvastatin. In vivo testing shows that the bromelain matrix has significant potential in anti-inflammatory and anti-cholesterol effects, comparable to or higher than bromelain extract, supported by in vitro results showing increased stability and enzymatic activity through encapsulation.