

ABSTRAK

PENGARUH LAMA FERMENTASI TERHADAP AKTIVITAS ANTIBAKTERI *ECO-ENZYME* KULIT JERUK NIPIS (*CITRUS AURANTIIFOLIA*) SEBAGAI SUMBER BELAJAR KIMIA HIJAU

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Meningkatnya limbah organik rumah tangga yang belum dimanfaatkan secara optimal serta meningkatnya resistensi bakteri terhadap antibakteri sintesis mendorong pengembangan antibakteri alami yang ramah lingkungan. *Eco-enzyme* berbahan limbah kulit jeruk nipis (*Citrus aurantiifolia*) berpotensi sebagai antibakteri, tetapi pengaruh lama fermentasi terhadap aktivitas antibakterinya belum banyak dianalisis berdasarkan karakterisasi senyawa yang terbentuk. Penelitian ini bertujuan menganalisis pengaruh lama fermentasi terhadap aktivitas antibakteri *eco-enzyme* kulit jeruk nipis terhadap *Escherichia coli*. Penelitian menggunakan metode eksperimen dengan variasi lama fermentasi satu, dua, dan tiga bulan. Karakterisasi dilakukan melalui pengamatan fisik, pengukuran pH, analisis FTIR, identifikasi senyawa menggunakan GC-MS, serta uji aktivitas antibakteri dengan metode difusi sumuran. Data dianalisis secara deskriptif dengan menggunakan uji One-Way ANOVA yang dilanjutkan dengan uji Tukey. Hasil menunjukkan bahwa semakin lama fermentasi menyebabkan pH menurun, warna dan aroma berubah, serta terjadi perubahan senyawa dominan dari asam lemak, triterpenoid, menjadi ester. Aktivitas antibakteri pada konsentrasi 100% meningkat dari bulan ke-1 sebesar $5,3 \pm 2,52$ mm, bulan ke-2 sebesar $14,6 \pm 0,58$ mm, dan bulan ke-3 sebesar $23,6 \pm 0,58$ mm. Hasil uji hipotesis menunjukkan bahwa lama fermentasi berpengaruh signifikan terhadap aktivitas antibakteri *eco-enzyme* ($p < 0,05$), sedangkan uji Tukey menunjukkan adanya perbedaan nyata antar setiap lama fermentasi. Dengan demikian, semakin lama fermentasi menghasilkan karakteristik senyawa dan aktivitas antibakteri yang semakin baik.

Kata kunci: aktivitas antibakteri, *eco-enzyme*, fermentasi, GC-MS, kulit jeruk nipis

ABSTRACT

EFFECT OF FERMENTATION DURATION ON THE ANTIBACTERIAL ACTIVITY OF LIME PEEL (CITRUS AURANTIIFOLIA) ECO-ENZYME BASED ON COMPOUND CHARACTERIZATION AS A GREEN CHEMISTRY LEARNING RESOURCE

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The increasing amount of household organic waste that has not been optimally utilized, along with the growing bacterial resistance to synthetic antibacterial agents, has encouraged the development of environmentally friendly natural antibacterial products. Eco-enzyme produced from lime peel (Citrus aurantiifolia) waste has the potential to be used as a natural antibacterial agent; however, the effect of fermentation duration on its antibacterial activity based on compound characterization has not been widely investigated. This study aimed to analyze the effect of fermentation duration on the antibacterial activity of lime peel eco-enzyme against Escherichia coli. An experimental research design was employed using fermentation periods of one, two, and three months. Characterization was conducted through physical observation, pH measurement, Fourier Transform Infrared Spectroscopy (FTIR), Gas Chromatography–Mass Spectrometry (GC-MS), and antibacterial activity testing using the well diffusion method. The data were analyzed using descriptive statistics and inferential statistics through One-Way ANOVA followed by Tukey's post hoc test. The results showed that prolonged fermentation decreased pH, altered the color and aroma, and changed the dominant compounds from fatty acids to triterpenoids and esters. At a concentration of 100%, the inhibition zone against E. coli increased from 5.3 ± 2.52 mm to 14.6 ± 0.58 mm and 23.6 ± 0.58 mm after one, two, and three months of fermentation, respectively. The hypothesis test indicated that fermentation duration had a significant effect on the antibacterial activity of eco-enzyme ($p < 0.05$), while Tukey's test revealed significant differences among all fermentation periods. Therefore, longer fermentation improved both the compound characteristics and the antibacterial activity of lime peel eco-enzyme.

Keywords: antibacterial activity, eco-enzyme, fermentation, GC-MS, lime peel