

INTISARI

Jahe merah (*Zingiber officinale* var. *rubrum* Theilade) berpotensi sebagai obat herbal karena mengandung metabolit sekunder yang berperan penting dalam kesehatan. Produksi metabolit sekunder dapat dikembangkan melalui kultur *in vitro* karena metode ini mampu menghasilkan bahan tanaman yang seragam, bebas patogen, dan berpotensi meningkatkan akumulasi senyawa bioaktif. Penelitian ini bertujuan untuk membandingkan perbedaan total fenolik, flavonoid, aktivitas antioksidan, profil metabolit, dan aktivitas anti-*Salmonella* sp. pada ekstrak rimpang, suspensi sel tanpa elisitor, dan suspensi sel dengan elisitor *Fusarium oxysporum*. Kultur *in vitro* dilakukan melalui induksi kalus dari eksplan tunas rimpang jahe merah yang memiliki aktivitas antioksidan terbaik yaitu sampel LK dari Lendah-Kulonprogo. Eksplan ditumbuhkan pada media Murashige and Skoog dengan penambahan 2,4-D dan kinetin untuk induksi kalus, kemudian kalus remah ditransfer ke media cair untuk kultur suspensi sel dan diberikan elisitasi dengan *F. oxysporum*. Ekstrak suspensi sel tanpa dan dengan elisitor diuji aktivitas fitokimiawi dan antibakterinya terhadap *Salmonella* sp. Hasil penelitian menunjukkan bahwa ekstrak kalus menunjukkan nilai total fenolik yang lebih tinggi (204,793 µg/mg) dibandingkan ekstrak rimpang (130,770 µg/mg). Elisitasi dengan *F. oxysporum* meningkatkan nilai total fenolik dan flavonoid dibandingkan ekstrak rimpang (130,770 dan 6,744 µg/mg) maupun suspensi sel tanpa elisitor (80,195 dan 3,721 µg/mg). Namun, aktivitas antioksidan terbaik berdasarkan uji IC₅₀ DPPH (1,1-difenil-2-pikrilhidrazil) dan FRAP (*Ferric Reducing Antioxidant Power*) ditunjukkan oleh ekstrak rimpang (10,016 dan 54,517 µg/mg). Analisis LC-HRMS menunjukkan bahwa jumlah metabolit terdeteksi paling tinggi terdapat pada ekstrak rimpang (181 jenis), diikuti oleh suspensi sel dengan elisitor (129 jenis), dan suspensi sel tanpa elisitor (121 jenis). Perbedaan komposisi metabolit memengaruhi aktivitas anti-*Salmonella* sp. pada tiap ekstrak. Ekstrak rimpang dan suspensi sel dengan elisitor 0,250 x 10⁻³ % mampu menghambat pertumbuhan *Salmonella* sp. pada konsentrasi rendah yaitu 15,625 mg/mL. Sementara itu, ekstrak suspensi sel dengan elisitor 0,125 x 10⁻³ % menunjukkan aktivitas pada konsentrasi 500 mg/mL, sedangkan suspensi sel dengan elisitor 0,500 x 10⁻³ % dan suspensi sel tanpa elisitor aktif pada konsentrasi 1000 mg/mL. Hasil tersebut menunjukkan bahwa elisitasi dengan *F. oxysporum* berpotensi meningkatkan aktivitas anti-*Salmonella* sp. serupa dengan ekstrak rimpang jahe merah meskipun komposisi metabolitnya tidak bisa menyamai metabolit pada ekstrak rimpang. Senyawa yang diduga terkait anti-*Salmonella* sp. pada ekstrak rimpang dan suspensi sel tanpa elisitor adalah gingerol dan shogaol, sedangkan pada suspensi sel dengan elisitor diduga adalah 2-amino-1,3,4-oktadekanetriol dan (-)-karyofilen oksida. Perbedaan komposisi senyawa tersebut mengindikasikan adanya pengaruh elisitasi terhadap produksi senyawa pada kultur *in vitro* jahe merah.

Kata kunci: anti-*Salmonella* sp. elisitor, *Fusarium oxysporum*; LC-HRMS; *Zingiber officinale*

ABSTRACT

Red ginger (*Zingiber officinale* var. *rubrum* Theilade) has considerable potential as a herbal medicinal plant due to its secondary metabolites. The production of metabolites can be enhanced through *in vitro* culture, as this approach enables the generation of uniform, pathogen-free plant materials with the potential to accumulate bioactive compounds. This study aimed to compare total phenolic and flavonoid contents, antioxidant activity, metabolite profiles, and anti-*Salmonella* sp. activity among rhizome extract, non-elicited, and *Fusarium oxysporum*-elicited cell suspension extract. *In vitro* culture was initiated by inducing callus from rhizome bud explants from Lendah-Kulonprogo (LK), which exhibited the highest antioxidant activity. The explant were cultured on Murashige and Skoog medium supplemented with 2,4-D and kinetin. Friable calli were subsequently transferred into liquid medium to establish cell suspension cultures and were elicited with *F. oxysporum*. The extracts were evaluated for phytochemical characteristics and antibacterial activity against *Salmonella* sp. The results showed that callus extract had a higher total phenolic content (204,793 µg/mg) than rhizome (130,770 µg/mg). Elicitation increased total phenolic and flavonoid contents compared to rhizome extract (130,770 and 6,744 µg/mg, respectively) and non-elicited cell suspension extract (80,195 and 3,721 µg/mg, respectively). However, the strongest antioxidant activity, based on DPPH radical-scavenging IC₅₀ and FRAP assay, was observed in the rhizome extract (10,016 and 54,517 µg/mg, respectively). LC-HRMS analysis revealed the highest number of detected metabolites in the rhizome extract (181 compounds), followed by elicited cell suspension extract (129 compounds), and non-elicited cell suspension extract (121 compounds). Differences in metabolite composition influenced the anti-*Salmonella* sp. activity of each extract. Rhizome extract and cell suspension extract elicited with 0,250 x 10⁻³ % *F.oxysporum* inhibited *Salmonella* sp. growth at a low concentration of 15,625 mg/mL. In contrast, the extract elicited with 0,125 x 10⁻³ % showed activity at 500 mg/mL, whereas the extract elicited with 0,500 x 10⁻³ % and the non-elicited cell suspension extract were active only at 1000 mg/mL. These findings indicate that *F. oxysporum* elicitation has the potential to enhance anti-*Salmonella* sp. activity to a level comparable to rhizome extract, even though the metabolite composition is different. The compounds putatively associated with anti-*Salmonella* sp. in rhizome extract and non-elicited cell suspensions were gingerol and shogaol, whereas those detected in elicited cell were 2-amino-1,3,4-octadecanetriol and (-)-caryophyllene oxide. These differences in metabolite composition indicate that elicitation influenced metabolite production in the *in vitro* culture of red ginger.

Keywords: anti-*Salmonella* sp. elicitor, *Fusarium oxysporum*; LC-HRMS; *Zingiber officinale*