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Candidates for antimalarial compounds in secondary metabolites of *Streptomyces* sp. InaCC 1497 and AB8

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ABSTRACT. One effort to reduce the transmission of malaria is the provision of antimalarial drugs. However, the use of drugs that are not according to standards causes resistance to *Plasmodium*. This condition triggers the exploration of various natural compounds to prevent malaria. Secondary metabolites derived from *Streptomyces* sp. are known to have antimalarial activity. However, information related to secondary metabolites from *Streptomyces* sp. strains InaCC A497 and AB8 as antimalarials are not yet known. The purpose of this study was to determine the metabolite compounds secondary contained in *Streptomyces* sp. strains InaCC A497 and AB8 as antimalarial candidates. This research method is descriptive by testing secondary metabolites which are carried out through chemical compound tests, thin layer chromatography (TLC), fourier transform infra-red (FT-IR), and gas chromatography-mass spectroscopy (GC-MS). Test results of chemical compounds and FT-IR analysis of *Streptomyces* sp. InaCC A497 contains alkaloids, flavonoids, and triterpenoids, while *Streptomyces* sp. AB8 contains alkaloids and tannins. In the TLC test, *Streptomyces* sp. InaCC A497 produced an Rf value of 0.257 and *Streptomyces* sp. AB8 of 0.314. Based on the GC-MS test, *Streptomyces* sp. InaCC A497 produces acetic acid compounds, ethyl ester including the ester group, and 1,2-benzene dicarboxylic acid, dioctyl ester including the alkaloid group. *Streptomyces* sp. AB8 produces the compound 2-pentadecyn-1-ol which belongs to the aromatic alcohol group and cochlioquinone A belongs to the quinone group. Both compounds have antimalarial activity.

Keywords: Antiplasmodial; fourier transform infra-red; metabolites compound; *Streptomyces* sp.; thin layer chromatography

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INTRODUCTION

To reduce the incidence of malaria which is a public health problem that occurs in the tropics, in addition to various other more advanced approaches such as the development of nano insecticides (Borgheti-Cardoso *et al*., 2020). Exploration of various natural materials used to prevent malaria for example, papaya leaf extract contains alkaloids, flavonoids, tannins, and glycosides which can be efficacious as anthelmintics, antimalarials, antibacterials, and anti-inflammatories (McCarthy *et al*., 2019), while flamboyant tree bark extracts proved the presence of anti-inflammatory and antiseptic activities (Fatmawaty *et al*., 2017). Plants have deficiencies in the production of secondary metabolites, in addition, the use of bacterial extracts has advantages, one of which is a shorter life cycle time, whereas plants require a longer time to obtain their secondary metabolites (Vurukonda *et al*., 2018). An example of bacteria that is commonly used is *Streptomyces*. *Streptomyces* bacteria is a genus of actinomycetes that are widely distributed in nature and is most commonly found in soil (Yokoyama *et al*., 2019).

Streptomyces can produce bioactive compounds that are used as antibiotics, antifungal, anticancer, antiviral, antibacterial, and others (Mathew *et al*., 2020). Alkaloids from Actinobacteria were able to role of antiplasmodial drugs, such as diketopiperazines (De Rop *et al*., 2021). Gancidin W is diketopiperazine derived from *Streptomyces* sp. which has antimalarial activity tested on mice infected with *Plasmodium berghei* PZZI/100 (Zin *et al*., 2017). *Streptomyces aculeolatus* MS1-6 also

produced naphthoquinone terpenoids with good antiplasmodial besides antimicrobial activity (Kuncharoen *et al*., 2023). Not only eponemycin, but *S. hygroscopicus* also secreted isoquinoline alkaloids to inhibit the Plasmodium parasite (Nugraha *et al*., 2020). Other alkaloid groups such as pavettine, aurantioclavine, and 4-butyl diphenylmethane are reported to have antiplasmodial metabolites. The metabolomic technique is advised as a first step in tracking and identifying antimalarial metabolites before separation and purification (Ahmad *et al*., 2021).

Isolates *Streptomyces* sp. strain InaCC A497 and AB8, these strains have been tested for their enzyme activity including mannanase, cellulase, and lipase. However, information related to secondary metabolites from both *Streptomyces* sp. strains InaCC A497, and AB8 as antimalarials are not yet known, so this research was conducted to determine the secondary metabolites contained in *Streptomyces* sp. strains InaCC A497 and AB8 as antimalarial candidates.

MATERIALS AND METHODS

The material used in this study was *Streptomyces* sp. strains InaCC A497 and AB8, International *Streptomyces* Project media (ISP) 1 (5 g tryptone, 3 g yeast extract, 20 g agar, 1000 mL H_2O), and ISP 4 media for production (Arifiyanto *et al*., 2023), yeast starch agar (YSA) medium for rejuvenation, ethyl acetate and methanol solvents for dissolving metabolite extracts, 70% alcohol was used as a disinfectant to avoid contamination, Whatman filter paper number 40 was used for the filtering process to separate the natant and supernatant, and a silica gel 60 F254 for thin layer chromatography (TLC) plate was used to see the appearance of stains.

Growth media preparation. *Streptomyces* sp. isolate strains InaCC A497 and AB8 using YSA media were prepared by adding 2 g of yeast extract, 10 g of starch, and 15 g of agar and then adding it to 1 L of distilled water. After that, it was sterilized in the autoclave for 15 minutes. *Streptomyces* AB8 strain was grown on ISP 4 media prepared by adding 10 g soluble starch, 1 g K2 HPO_4, 1 g $MgSO_4$, 1 g NaCl, 2 g ammonium sulfate, 2 g $CaCO_3$, and 20 g agar, then put in 1 liter of distilled water and then sterilized in an autoclave for 15 min (Setiawati *et al*., 2022).

Bacterial sub-culturing. Isolate InaCC A497 *S. hygroscopicus* subsp Jinggangensis is a collection of Indonesian Culture Collection (InaCC) LIPI Cibinong, while *Streptomyces* sp. isolates AB8 strains constitute collection from Laboratory of Microbiology, Universitas Lampung. *Streptomyces* sp. isolate strain InaCC A497 was sub-cultured on YSA media, while *Streptomyces* sp. AB8 strain was sub-cultured on ISP 4 media. Both isolates were incubated in an incubator at 37℃ for 3 days.

Starter production. The fermentation medium used for *Streptomyces* sp. strain InaCC A497 is ISP 1 media. ISP 1 media was prepared by adding 5 g tryptone, 20 g agar, and 3 g yeast extract into 100 mL distilled water and sterilized using an autoclave for 15 minutes. Then inoculated *Streptomyces* sp. isolate. strain InaCC A497 and incubated for 7 days in an incubator shaker. After 7 days, the starter was put into 900 mL of media (Arifiyanto *et al*., 2021). *Streptomyces* sp. isolate strain AB8 uses ISP 4 as a fermentation medium. The starter was made by adding 10 g soluble starch, 10 g K_2 HPO_4, 1 g $MgSO_4.7H_2O$, 1 g NaCl, 1 g $(NH_4)2SO_4$, and 2 g $CaCO_3$ then put into 100 mL of distilled water and then sterilized using an autoclave for 15 minutes. Then isolate *Streptomyces* sp. AB8 strain was inoculated and incubated for seven days in the shaker incubator. After 7 days, the starter is put inside 900 mL of media (Lestari *et al*., 2022).

Production of metabolite. The fermented product of *Streptomyces* sp. 1 L of InaCC A497 and AB8 strains were incubated in an incubator shaker at 32℃ for 7 days. The two isolates were filtered using Whatman filter paper to obtain the natant and supernatant. The supernatant was dissolved in 500 ml ethyl acetate and 500 mL methanol was added. The filtrate was evaporated for 30 minutes in the evaporator to concentrate secondary metabolite products. Secondary metabolite products are stored in the refrigerator (Arifiyanto *et al*., 2021).

Chemical compound test. A chemical compound test is a qualitative test to find out the chemical content in the form of secondary metabolites in the sample. Test chemical compounds consisting of

alkaloids, flavonoids, saponins, tannins, terpenoids, and glycosides. The results of the chemical compound test will show the compounds detected in the secondary metabolites of the *Streptomyces* sp. extract. Tests were carried out to determine potential antimalarial candidates. Test the chemical compounds of *Streptomyces* sp. extract. using the Farnsworth method (Arifiyanto *et al*., 2022; Riyanto *et al*., 2021).

Thin layer chromatography (TLC) test. A 4×2 cm TLC plate was prepared with underlines and lines above 1 cm each. The mobile phase was prepared with different solvent mixtures and at different ratios, and the mobile phase was tested until the best separation was obtained. The eluent system used was n-hexane: acetone with a ratio of 6:4. 1 µL of the extract was applied to the TLC plate using a capillary tube. Then it is dried before being put into a vessel containing the mobile phase. After the mobile phase reached the specified limit, the TLC plate was removed and viewed under ultraviolet light, and stained with cerium (IV) sulfate. Then the Rf value is calculated (Wutsqa *et al*., 2021).

Fourier transform infra-red (FT-IR) analysis. Samples were weighed using an analytical digital balance of 0.2 mg and then analyzed by infrared (IR) spectroscopy (Nicolet iS 10 FT-IR Spectrometer)(Mohammadi *et al*., 2019).

Gas chromatography-mass spectroscopy (GC-MS) analysis. Samples were analyzed using GC-MS (Shimadzu 2010 QP). Sample as much as 1 µL injected into GC-MS which was operated using an Rtx5MS column (5% diphenyl/95% dimethyl polysiloxane) and Carbowax (Polyethylene glycol) and the mobile phase used was helium (Variani *et al*., 2021).

Data analysis. The data obtained from the positive chemical compound test results for active compounds were presented in tabular form and analyzed descriptively by looking at the color changes formed. Then the TLC results were analyzed descriptively based on the formation of stains. FT-IR data results are shown in graphical form and then discussed descriptively based on the size and type of the absorption peak. GC-MS results are presented in the form of GC and MS chromatograms and then discussed descriptively based on retention time, area percentage, molecular structure, and molecular weight (Pratiwi & Dewi, 2022).

RESULTS AND DISCUSSION

Chemical compound test. Based on the test results of chemical compounds showed that *Streptomyces* sp. InaCC A497 contains three secondary metabolites including alkaloids, flavonoids, and triterpenoids, while *Streptomyces* sp. AB8 contains two secondary metabolites, namely alkaloids and tannins. Test results of chemical compounds on *Streptomyces* sp. InaCC A497 and AB8 are presented in Table 1.

Table 1. Test results for chemical compounds extracted from *Streptomyces* sp. InaCC A497 and AB8

Chemical compounds tested	Reactor	Results	
		Streptomyces sp. InaCC A497	*Streptomyces* sp. AB8
Alkaloid	Dragendroff Mayer	+	+
Flavonoid	Pb Acetat 10%	+	-
	NaOH 20%	+	-
Saponin	Aquades	-	-
Tanin	$FeCl_3$	-	+
Triterpenoid	Acetic Acid + Anhidrat	+	-
Glycosides	Concentrated H2SO4 NaOH 1N	-	+

Note: (-): not detected, (+): detected

Test results for chemical compounds extracted from *Streptomyces* sp. InaCC A497 the presented in Table 1. and Fig. 1. The positive test for alkaloids was indicated by the formation of an orange precipitate given the Dragendroff reagent and a yellow precipitate after Mayer's reagent which can be seen in Fig. 1A. Test positive for flavonoids as indicated by the formation of a yellow precipitate (Fig. 1B). The positive test for triterpenoids is indicated by a violet color change in the test solution

which can be seen in Fig. 1C. Test results for chemical compounds extracted from *Streptomyces* sp. AB8 is presented in Table 1. and Fig. 1. The tannin-positive test is indicated by a change in color to black-green in the test solution (Fig. 2A). The positive alkaloid test is indicated by the formation of an orange precipitate and a yellow precipitate which can be seen in Fig. 2B.

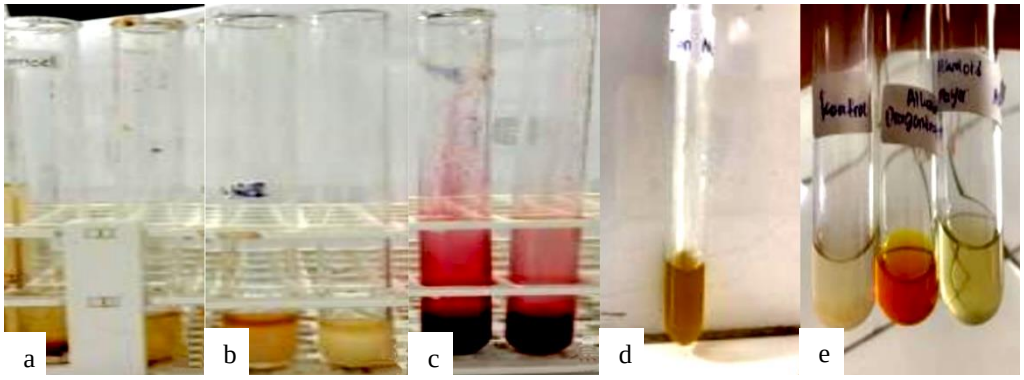


Fig. 1. Test results for chemical compounds extracted from *Streptomyces* sp. InaCC A497: a. Alkaloid positive test; b. flavonoid positive test; c. Triterpenoid positive test; d. Test results for chemical compounds extracted from *Streptomyces* sp. AB8: positive test for tannins; e. positive test for alkaloids

Thin layer chromatography (TLC) test. Based on the results of the TLC test observed under 366 nm UV light, it is known that *Streptomyces* sp. strain InaCC A497 has an Rf value of 0.257, while *Streptomyces* sp. strain AB8 of 0.314 as shown in Fig. 2. The results of this test also obtained the best eluent, namely n-hexane: acetone (6:4). This is because the stains provide a fairly good separation pattern (Fig. 2).

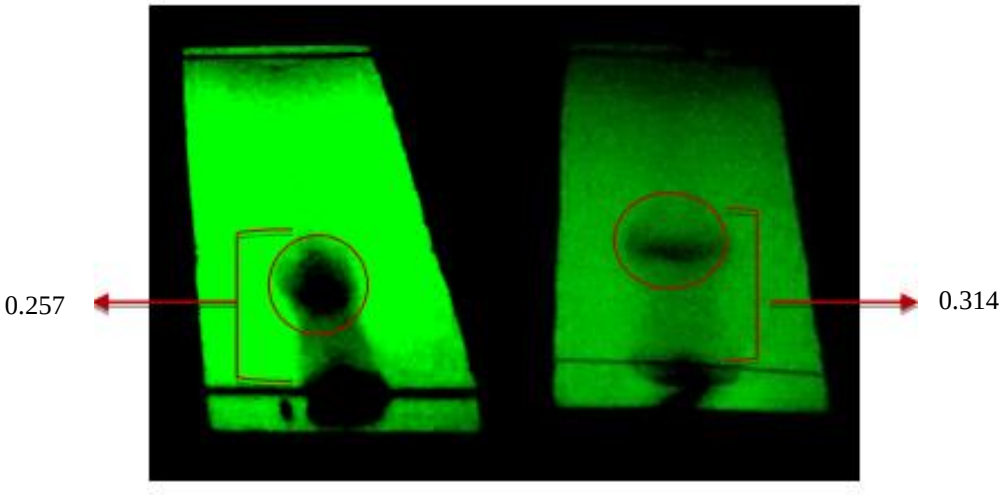


Fig. 2. Visualization of TLC plates on UV 366 nm *Streptomyces* sp. strain InaCC A497 (left) and *Streptomyces* sp. AB8 strains (right)

Fourier transform infra-red (FT-IR) analysis. Analysis using FT-IR showed that *Streptomyces* sp. strain InaCC A497 contains functional groups such as O-H in wave number 3.350 cm^{-1} with a widening absorption band which produces hydroxyl groups strengthened by the presence of a wave number vibration of 1,077 cm^{-1} which indicates a stretching vibration of the CO group. The wave number of 2.957 cm^{-1} indicates the presence of aliphatic C-H groups. The absorption peak at wave number 1.577 cm^{-1} indicates the presence of a group (C=O) that conjugates with C=C. This can be seen in Fig. 3.

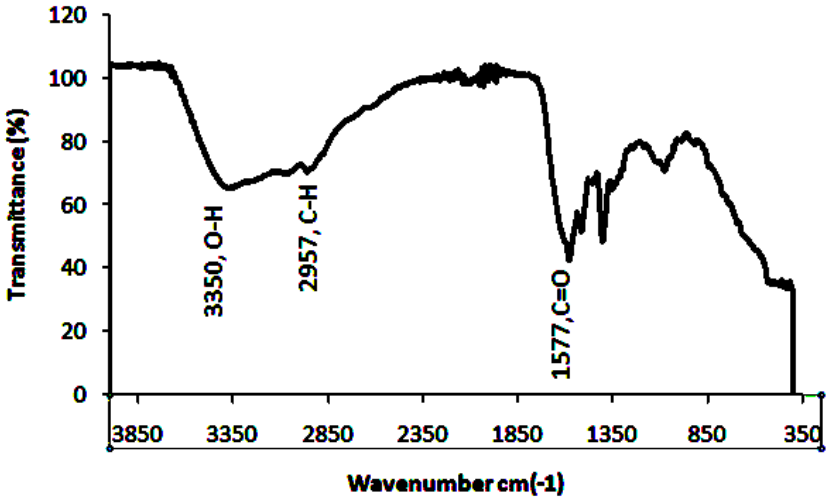


Fig. 3. IR Spektrum of *Streptomyces* sp. strain InaCC A497

FT-IR analysis of secondary metabolites contained in *Streptomyces* sp. AB8 strain is known to have a widened band on the wave number region of 3.272 cm^{-1} which is thought to be a stretching vibration of the hydroxyl group. Low absorption in the wave region of 2929 cm^{-1} which is identified as the aliphatic C-H functional group. The wave number of 1.636 cm-1 shows the absorption peak for the aliphatic olefin (C=O) group. Absorption at wave number 1.431 cm^{-1} indicates the presence of C=C (aryl) sp groups 2. IR spectra of secondary metabolites in *Streptomyces* sp. AB8 strain can be seen in Fig. 4.

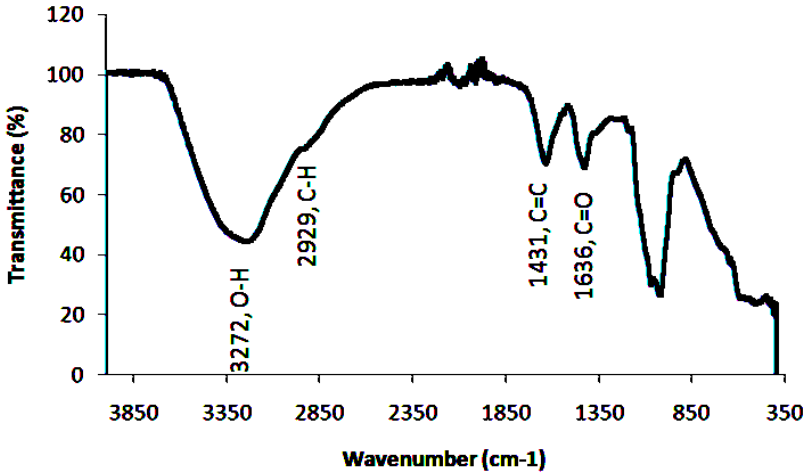
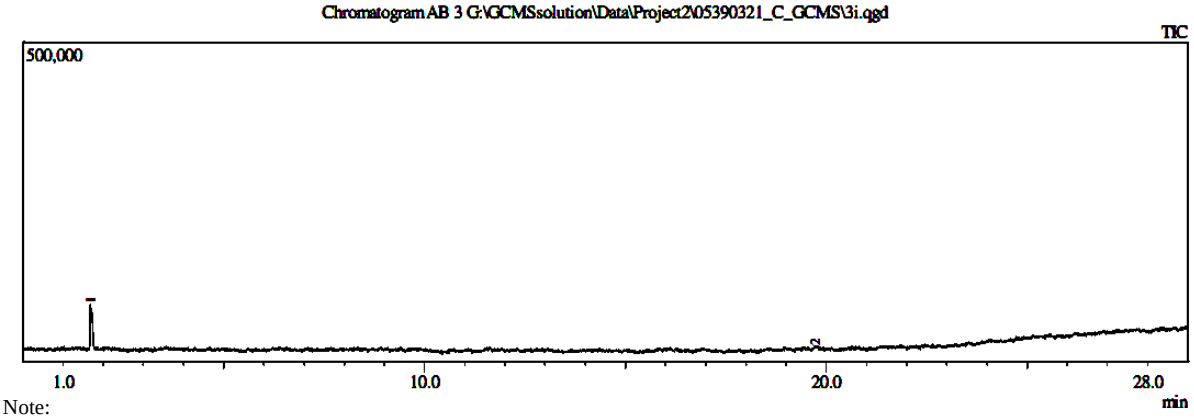


Fig. 4. IR Spektrum of *Streptomyces* sp. strain AB8

Gas chromatography-mass spectroscopy analysis. Secondary metabolite compounds in *Streptomyces* sp. InaCC A497 and AB8 strains were analyzed using GC-MS. GC-MS analysis can separate volatile and semivolatile compounds and can provide information on compound structure, retention time, percentage of similarity, molecular weight, and area percentage according to the available database. The database used is Willey 7 Library. The results of the GC-MS analysis of the secondary metabolites of *Streptomyces* sp. strain AB8 produced two peaks on the GC chromatogram (Fig. 5).



Note:
1 : *2-pentadecyn-1-ol*
2 : *cochlioquinone A*

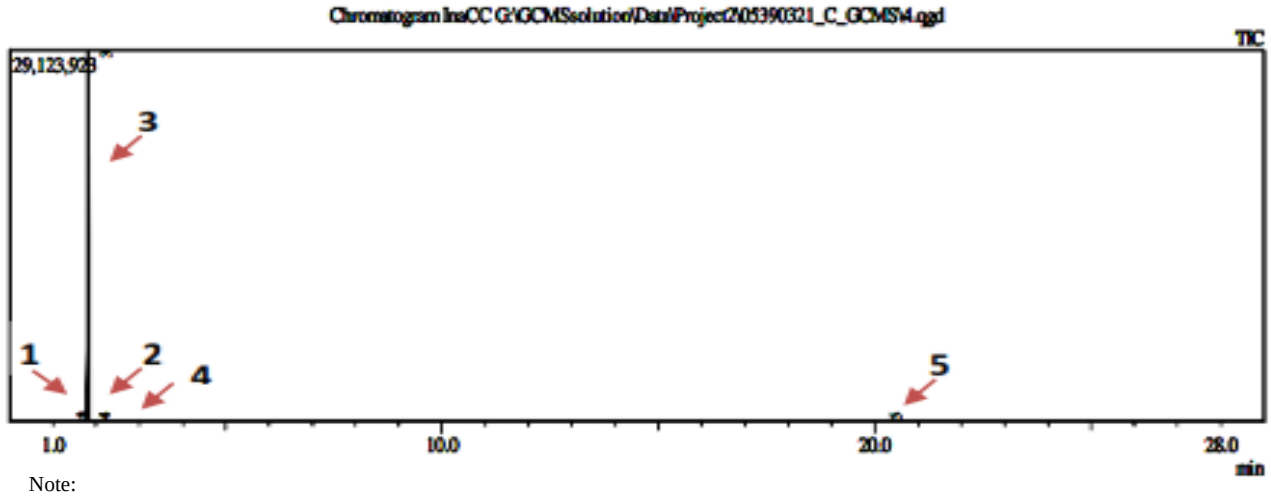
Fig. 5. GC chromatogram of *Streptomyces* sp. AB8

The identified compounds, namely 2-pentadecyn-1-ol at time retention 1.683 and cochlioquinone A at retention time 19.717. 2pentadecyn-1-ol has the highest peak with an area of 68.58% and a molecular weight of 224 m/z. Details can be seen in Table 2.

Table 2. GC-MS data of *Streptomyces* sp. AB8 strains extract

Sample	Retention time	Compounds	Structure	Molecular weight	Area (%)
Streptomyces sp. AB8	1.683	2-pentadecyn-1-ol	$C_{15}H_{28}O$	224	68.5
	19.717	cochlioquinone A	$C_{30}H_{44}O_8$	532	31.4

The results of the GC-MS analysis of the secondary metabolites of *Streptomyces* sp. InaCC A497 strain produced five peaks on the GC chromatogram (Fig. 6).



Note:
1 : *2-methyl-2-(alpha-thienyl)-1,3-dithiolane*
2 : *propanal, 2deutero*
3 : *acetic acid, ethyl ester*
4 : *toluene*
5 : *1,2-benzene dicarboxylic acid*

Fig. 6. *Streptomyces* sp. InaCC A497 produces five peaks at GC chromatogram

The compounds identified were 2-methyl-2-(alpha-thienyl)-1,3dithiolane, propanal, 2-deutero, toluene, 1,2-benzene dicarboxylic acid, and acetic acid, ethyl ester. Compound the dominant compound is acetic acid, ethyl ester is present at a retention time of 1,811 which has an area of 99.35%

and a molecular weight of 88 m/z. GCMS data of *Streptomyces* sp. strain InaCC A497 can be seen in Table 3.

Table 3. GC-MS data of *Streptomyces* sp. strain InaCC A497 extract

Sample	Retention time	Compounds	Structure	Molecular weight	Area (%)
Streptomyces sp. InaCC A497	1.811	acetic acid, ethyl ester	$C_4H_8O_2$	88	99.35
	1.679	2-methyl-2-(alpha-thienyl)-1,3-dithiolane	$C_8H_{10}S_3$	202	0.47
	1.724	propanal, 2-deutero	C_3H_5DO	58	0.10
	2.194	benzene, methyl- (CAS) toluene methylbenzene	C_7H_8	92	0.04
	20.480	1,2benzenedicarboxyic acid, dioctyl ester (CAS)	$C_{24}H_{38}O_4$	390	0.03

Based on the test results of chemical compounds, *Streptomyces* sp. strain InaCC A497 is known to contain alkaloids, flavonoids, and triterpenoids, while *Streptomyces* sp. the AB8 strain contains alkaloids and tannins. The four compounds are potential as antimalarial candidates (Arifiyanto *et al*., 2021), alkaloid and phenolic compounds found in *Streptomyces* sp. strain AB8 can inhibit *Plasmodium* with an IC50 value of 17.56 g/mL. Our previous study, Setyaningrum *et al*., (2021) showed *Streptomyces* sp. contains triterpenoid compounds that have the potential as antimalarials because they can inhibit ring formation and trophozoite stages in *Plasmodium falciparum* strain 3D7. In addition, *S. hygroscopicus* contains alkaloid compounds (tryptanthrine), fatty acids (hexadecanamide), flavonoids (flavanone), and aromatic alcohol (2phenylethanol). The tryptanthrine compound in *S. hygroscopicus* has antimalarial activity (Fitri *et al*., 2019; Nugraha *et al*., 2020)

Streptomyces sp. TPU1401A contains flavonoid compounds (genistein). Flavonoid compounds (genistein) have the potential as antimalarial candidates because they can inhibit parasite growth in two ways, namely by inhibiting hemoglobin catabolism and hem detoxification and interfering with transportation. *Streptomyces* sp. TPU1401A contains flavonoid compounds (genistein). Flavonoid compounds (genistein) have the potential as antimalarial candidates because they can inhibit parasite growth in two ways, by inhibiting hemoglobin catabolism and hem detoxification and interfering with the transportation of nutrients needed by parasites (Alkandahri *et al*., 2019). Besides having antimalarial activity, *Streptomyces* sp. has other biological activities, as has been reported by Mentari *et al*., (2019) that the phenol, flavonoid, and terpenoid compounds identified in *Streptomyces* sp. GMR 22 has toxicity to BHK-21 cells.

Some eluent mixtures consisting of polar, semi-polar, and non-polar have been tried in TLC, to separate the chemistry of the components on the extract of *Streptomyces* sp. InaCC strains A497 and AB8. The results of this test obtained the best eluent, namely n-hexane: acetone with a ratio of 6:4. A good eluent is an eluent that separates many compounds which are characterized by spots that appear, round spots, the stains are tailless, and the stains are separated (Nur *et al*., 2022).The n-hexane:acetone eluent mixtures have different polarities. N-hexane is non-polar, while acetone is polar, causing the mobile phase to tend to be non-polar. *Streptomyces* sp. strain InaCC A497 has an Rf value of 0.257, while *Streptomyces* sp. strain AB8 has an Rf value of 0.314. *S. hygroscopicus* extract contains alkaloid compounds with an Rf value of 0.24 (Ariel *et al*., 2021). Compounds contained in the two bacterial extracts belong to the class of polar compounds. Compounds that have Rf values greater tend to have low polarity and vice versa. This is because the stationary phase is polar. More polar compounds will be strongly held in the stationary phase so they have a low Rf (Uli *et al*., 2016). Flavonoids are polar compounds. Flavonoid compounds (flavanones) found in *S.*

hygroscopicus show antimalarial activity (Czechowski *et al*., 2019; Setyaningrum *et al*., 2021). Prenylated flavonoid compounds from plant extracts of *Artocarpus champeden* (Moraceae) have the potential as potent antimalarials in vitro (Hidayati *et al*., 2020). Several factors can affect the Rf value, including the chemical structure of the compound being separated, the saturation of the chromatographic vessel, temperature, and equilibrium (Naibaho *et al*., 2021)). Based on observations of stains observed under a UV lamp, there is only one stain and it does not appear colored. It is suspected that the compound is not pure, so it is necessary to continue the column chromatography test or vacuum liquid chromatography.

IR Spectrum of *Streptomyces* sp. Extract strain InaCC A497 which is presented in Figure 17. Producing functional groups OH, CH aliphatic, C=O, and C-O alcohol. The functional group of *Streptomyces* sp. strain InaCC A497 showed similarities in functional groups to triterpenoids, flavonoids, and alkaloids. This is confirmed by Mayanti *et al*., (2023), the n-hexane extract of Kepuh leaves contain triterpenoid compounds with the functional groups OH, CH aliphatic, C=O, and C-O alcohol. Another study by Putri & Fatmawati, (2019) said that the flavonoid compound of the ethyl acetate extract of *Chromolaena odorata* leaves has functional groups OH, C-H aliphatic, carbonyl groups (C=O), and aromatic C=C. IR spectrum of *Streptomyces* sp. the AB8 strain presented in. It is suspected that it contains tannins and alkaloids which are strengthened by the presence of OH groups, aliphatic C-H, C=O esters, and C=C groups. The ester group strengthens the presence of hydrolyzed tannin compounds because hydrolyzed tannin bonds are formed due to ester bonds between the hydroxy groups on glucose and the carboxyl groups of phenolic acids (Kumar & Goel, 2019). Functional group OH, aliphatic C-H, C=O ester, C=C aromatic, C-O-H, and C-OC ethers are the specific peaks of tannin compounds, especially hydrolyzed tannins (Sari *et al*., 2015). Alkaloid group compounds have the N-H functional group which is characteristic of alkaloids, C=O, and aliphatic CH. Phenolic and alkaloid compound derived from *Streptomyces* sp. AB8 has antimalarial activity (Arifiyanto *et al*., 2021).

The results of the GC-MS analysis of *Streptomyces* sp. known AB8 strains yield 2 compound peaks. Each of the compounds was identified to have various biological activities. The compound 2pentadecyn-1-ol is an aromatic alcohol group compound. 2pentadecyn-1-ol is known to have antioxidant, antimicrobial, and anti-inflammatory activities (Mirsonbol *et al*., 2022). *Streptomyces* sp. strain AB8 also contains the compound cochlioquinone A. The compound cochlioquinone A is a quinone compound derivative. Quinone group compounds in 70% ethanol extract of Sembung leaves are known to have antimalarial activity. The antimalarial activity of quinone compounds can occur by inhibiting the action of the glutathione reductase enzyme on parasites (Marozienė *et al*., 2019).

Based on the results of the GC-MS analysis, the main components of *Streptomyces* sp. strain InaCC A497 which is an acetic acid compound. This can be caused by the GC-MS tool which can only identify volatile compounds (de Lima *et al*., 2023). Acetic acid is an ester compound that is volatile and polar (Ne *et al*., 2018). This study uses ethyl acetate solvent so that only certain components that have the same properties as ethyl acetate solvent can be identified. Hence, the content of the compound acetic acid is the largest component in *Streptomyces* sp. strain InaCC A497. The content of *Streptomyces* sp. extracts compounds. the non-volatile InaCC A497 strain needs to be further identified using liquid chromatography mass spectrometer (LC-MS). Ester group compounds are carboxylic acid derivatives, the structure of the ester is similar to the structure of carboxylic acids but the acidic hydrogen is replaced by an alkyl group. Esters have important bioactivity, for example, they have antimalarial potential against *P. falciparum* (Nyandwaro *et al*., 2020). Acetic acid is known to have antibacterial and antifungal activity as reported by Al-Dhabi *et al*. (2019), *Streptomyces* sp. Al-Dhabi-2 contains the compounds benzene acetic acid, acetic acid, methoxy-, 2-phenylethyl ester which have the potential as antifungal and antibacterial. *Streptomyces* sp. InaCC A497 also contains the compound 1,2-benzene dicarboxylic acid, dioctyl ester. This compound belongs to the group of alkaloids. The alkaloid compounds contained in *S. hygroscopicus* have antimalarial activity (Nugraha *et al*., 2020). The antimalarial activity of alkaloid compounds can occur through the mechanism of

inhibiting the growth of *Plasmodium* parasites, namely inhibiting protein synthesis or forming bonds with DNA (Blasco *et al*., 2017).

CONCLUSION

It was concluded that *Streptomyces* sp. InaCC A497 contains alkaloids, flavonoids, and triterpenoids, while *Streptomyces* sp. AB8 contains alkaloids and tannins. The results of the GC-MS test showed that the content of ester group compounds (acetic acid, ethyl esther) and alkaloid groups (1,2 benzenedicarboxylic acid) in *Streptomyces* sp. InaCC A497 and the content of quinone group compounds (cochlioquinone A) in *Streptomyces* sp. AB8 is a potential antimalarial candidate.

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