

Effects of Nutrient Sources and Incubation Time on Extract Yield and Antibacterial Activity of Sponge-Associated *Streptomyces* BTA 1-131

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Abstract

Streptomyces BTA1-131, a sponge-associated actinobacterium from Indonesia, has been reported as a potential producer of bioactive compounds. The bioactivity of BTA1-131 was influenced by the type of growth medium. Therefore, this current study aims to assess the effects of nutrient sources and time of incubation on the yield extract of BTA1-131 and their antibacterial activity against *Staphylococcus aureus* ATCC 13420. The study employed a Central Composite Design through Response Surface Methodology (RSM) approach, followed by the selection of six growth medium compositions derived from the RSM strategy, which was subsequently evaluated for their bioactivity using the agar plug method. The results have shown substantial effects of nutrients (yeast, starch and NaCl) and time of incubation, on the yield extract and antibacterial activity of sponge-associated *Streptomyces* BTA1-131. This finding contributes to marine bioprospecting, particularly in the discovery and development of (new) antimicrobials from potential indigenous strains.

Keywords: Bioactivity, Bioprospecting, RSM, *Streptomyces*, Indonesia

Introduction

The Indonesian archipelago has been reported as a vast source for the discovery of new marine-derived antimicrobial compounds (Hanif *et al.*, 2019; Nugraha *et al.*, 2023). Additionally, marine invertebrates from Indonesian waters, such as sponges and their associated bacteria, were recognized as prominent producers of antibacterial compounds (Atikana *et al.*, 2023; Dita *et al.*, 2017; Izzati *et al.*, 2021). Studies on the bioactivity of sponge-associated bacteria from Indonesia have been reported from Derawan Island (Sumarlin *et al.*, 2024), Lembeh Strait (Atikana *et al.*, 2023;

Paramita *et al.*, 2024), Samalona Island (Rante *et al.*, 2022), and Manado Bay (Sembiring *et al.*, 2021). Our previous study on the bioactivity of actinobacterium strain BTA1-131 associated with sponges *Melophlus sarasinorum* from Indonesia indicates the effects of growth media on its bioactivity against *Staphylococcus aureus* ATCC 13420 (Atikana *et al.*, 2023). The study further suggests the importance of Yeast-Starch (YS) fermentation medium in the process production of antibacterial compounds from marine *Streptomyces* (Atikana *et al.*, 2023).

Marine *Streptomyces* has been widely investigated, especially those focusing on the genomic potential and various biosynthetic gene

clusters (Eduardo, 2019; Jackson *et al.*, 2018; Xu *et al.*, 2019). Further investigation supports the significance of marine *Streptomyces* as potential producers of important metabolites, especially for biomedical applications, such as producers of anticancer compounds (Tangerina *et al.*, 2021) and silver nanoparticles (Elsilk *et al.*, 2022). Previous studies on marine *Streptomyces* from Indonesian water reported their potential as producers of important enzymes, such as xylanopectinolytic (Nadhifah *et al.*, 2023), lipase (Agustriana *et al.*, 2023), and beta-mannanase (Putri *et al.*, 2024). In addition to that, other studies also reported the potential of marine *Streptomyces* from Indonesian water as producers of antimicrobial and anticancer compounds (Atikana *et al.*, 2021; Atikana *et al.*, 2023), antibiofilms (Jimat *et al.*, 2024), and anti-NTM (Paramita *et al.*, 2024).

A study reported factors that influence bacterial fermentation and the process of production of bioactive metabolites, including medium composition (nutrient sources), time of incubation, temperature, pH, and oxygen (Sunaryanto & Nurani, 2019). Determining an appropriate fermentation strategy is crucial to determine growth stability, yield biomass, and bioactivity of the extract derived from potential bacteria (Barzkar *et al.*, 2023; Li *et al.*, 2023). Adopting a sustainable strategy will ensure efficiency in the fermentation process, thereby reducing cost and production time in synthesizing bacterial bioactive metabolites (Barzkar *et al.*, 2023). The importance of YS medium in determining the bioactivity of sponge-associated actinobacterium strain BTA1-131 has been reported previously (Atikana *et al.*, 2023). However, the impact of nutrient sources within the YS fermentation medium, as well as the time of incubation, on the yield of extracts and its antibacterial activity, was underexplored. Therefore, the current study aims to investigate factors that influence the yield extracts and antibacterial activity of the crude extracts derived from the sponge-associated actinobacterium strain BTA1-131. Several variables/parameters were investigated in this study, including time of incubation and nutrient sources within the medium YS, such as the concentration of yeast extract, starch, and NaCl within the fermentation medium. A Response Surface Methodology (RSM) approach was conducted to measure the impact of variables/parameters (i.e., time of incubation,

yeast extract, starch, and NaCl) on the responses (yield extracts and antibacterial activity).

The RSM is a robust statistical tool that is generally applied to optimizing multiple parameters/variables and evaluating their interactions without the need to conduct an extensive experiment (Khuri & Mukhopadhyay, 2010). This approach has been reported as a potential strategy to increase the bioactive metabolites of *Streptomyces prasinopilosus* up to ninefold compared to the standard medium (Sunaryanto & Nurani, 2019). Implementation of the RSM strategy is crucial to identify important variables that influence the yield extracts and antibacterial activity, as well as to elucidate interaction between nutrient sources in the fermentation medium and the fermentation conditions. As such, the finding in this study can be further optimized to enhance the metabolite productivity of the marine actinobacterium strain BTA1-131. Furthermore, this study contributes to the bioutilization of indigenous *Streptomyces*, especially for biotechnology, pharmaceutical, and industrial applications.

Materials and Methods

Rejuvenation of strain BTA1-131. The isolate strain BTA1-131 was maintained in the medium YS-Agar (YSA), which contains yeast extracts (2 g/L), starch (10 g/L), and agar (18 g/L), following the DSMZ protocols (DSMZ, 2007), with the modification of additional NaCl (2%). Prior to the experiment, the strain BTA1-131 was incubated at a temperature of 28 °C, for 10 days of incubation.

Preculture of *Streptomyces* BTA1-131. The preculture of strain BTA1-131 was prepared by slicing approximately 1x1 cm³ of the 10-day-old BTA1-131 using a sterile disposable cutter. The 1x1 cm³ piece of BTA1-131 agar was further inoculated in 100 mL of medium YS Broth (YSB), with 2% NaCl. The culture was incubated in a shaker incubator at a temperature of 28 °C and agitation of 150 rpm for 10 days of incubation.

Optimization of fermentation conditions. The current study implements Response Surface Methodology (RSM) to determine factors that influence yield extracts and antibacterial activity of the strain BTA1-131. The RSM strategy was conducted following a published method (Ahsan

et al., 2017), with Central Composite Design (CCD) that was calculated using Design Expert Software. The input numeric factors for this experiment (Table 1) resulted in a total of 30 experimental runs for subsequent implementation (Table 2). The cultivation experiment, performed according to the composition provided by the CCD/RSM strategy, was conducted by inoculating 10% of the previously precultured strain BTA1-131 in a total of 100 mL of YSB medium. This culture was further incubated in a shaker incubator, at a temperature of 28 °C, with agitation of 150 rpm. The time of incubation for this culture was conducted accordingly, as specified in Table 2 for 6 days, 8 days, 10 days, 12 days, and 14 days. As a control standard, the strain BTA1-131 was also cultivated in YS medium.

Table 1. Input numeric factors of various variables/parameters for CCD

Variables	Level				
	1	-1	0	-2	2
Yeast Extract (gr)	0	0.1	0.2	0.3	0.4
Starch (gr)	0	0.5	1	1.5	2
NaCl (gr)	1	1.5	2	2.5	3
Time of Incubation (days)	6	8	10	12	14

Extraction of bioactive metabolite. The bioactive metabolites were extracted from all of the 30 experimental cultures of the strain BTA1-131, following a previously published protocol (Atikana *et al.*, 2023). Each liquid culture was centrifuged at a temperature of 4 °C, at 13000 rpm, for 20 min, to separate the pellet and supernatant. An equal volume of solvents (ethyl acetate : methanol = 1 : 1) was added to the pellet, and the mixture was incubated for 1 hour before sonication. The sonication procedure was conducted to extract the cell walls. Afterwards, the mixture was centrifuged at a temperature of 4 °C, in 13000 rpm, for 20 min, to separate the pellet and supernatant. The supernatant that contained the metabolites was removed, filtered, and stored in a new vial. The procedure was repeated three times, and the metabolites were pooled for further concentration using a vacuum concentrator, to obtain bacterial crude extracts for further experiments. The yield of each extract was measured as a response to each CCD treatment.

Antibacterial activity. The antibacterial activity in this study was conducted using the Kirby-

Bauer Disc Diffusion Assay (Hudzicki, 2012) and the Agar Plug Diffusion Assay (Balouiri *et al.*, 2016). Prior to antibacterial activity screening, the test strain *Staphylococcus aureus* ATCC 13420 was rejuvenated from glycerol stock by inoculating 10 µL of the test strain to 20 mL of Nutrient Broth (NB) in a sterile 50 mL Falcon. This culture was incubated at 37 °C, with agitation at 150 rpm, overnight (± 16 hours). Afterwards, the culture optical density (OD) was measured using a spectrophotometer, following a previously published protocol (Atikana *et al.*, 2023), until it reached the standard $OD_{600\text{ nm}} = 0.02$, which is equal to 5×10^7 cfu/mL of bacteria. The test bacterial strain was inoculated in medium Nutrient Agar (NA) and incubated for 1 hour. The antibiotic vancomycin (1000 ppm) was used as an antibiotic control for *S. aureus* ATCC 13420, while the blank medium YSB was used as a negative control for the experiment.

Kirby-Bauer Disc Diffusion Assay. A sterile filter paper disc was placed on top of the agar with a lawn of *S. aureus* ATCC 13420. Afterwards, each of the crude extracts (10 µl) was placed on the sterile discs to test for their antibacterial potential. The plates was incubated at 37 °C for 24 h. The antibacterial activity was indicated as clear zones surrounding the discs after incubation and measured by digital calliper.

Agar Plug Diffusion Assay. Prior to agar plug assays, the strain BTA1-131 was cultivated in six selected treatments, in which the composition of the fermentation media had extreme nutrient concentrations (Table 3). The strain BTA1-131 of the selected six treatments, was incubated at 28 °C for 10 days of incubation. Pieces of agar ($1 \times 1\text{ cm}^2$) consisting of ten-day-old colonies of *Streptomyces* BTA1-131 were placed on top of the agar with a lawn of *S. aureus* ATCC 13420 to test the antibacterial activity. The antibacterial activity was indicated as clear zones surrounding the strain BTA1-131 agar after incubation and measured by digital calliper.

Statistical data analysis. Data analysis in this study was performed using statistical analysis ANOVA (analysis of variances) between all parameters (yeast extracts, starch, NaCl, and time of incubation) and responses (yield extracts and antibacterial activity). The influence of parameters on responses was considered significant at p-value < 0.05 .

Results and Discussion

Significant various nutrient sources and time of incubation to yield extracts and antibacterial activity of *Streptomyces* BTA1-131

In solid agar medium Yeast Extract Starch Agar (YSA) supplemented with 2% NaCl, the strain BTA 1-131 exhibited distinct morphological characteristics, as such colonies developed as dense, chalky to powdery growth, with an irregular spreading pattern across the agar surface (Figure 1). The colony surface appeared rough and dry, with abundant formation of aerial mycelium giving rise to a white to cream coloration, including a yellowish pigmentation that diffused into the surrounding medium. In several areas, the growth formed compact aggregates, while other regions showed discrete, circular colonies of varying sizes, indicating active sporulation and mycelial differentiation. These morphological features are characteristic of filamentous actinomycetes, particularly members of the genus *Streptomyces* (Barka *et al.*, 2016; Beroigui & Errachidi, 2023).



Figure 1. *Streptomyces* BTA1-131 maintained in the medium YSA+2% NaCl after 10 days of incubation.

This study employed an RSM optimization approach to determine the optimum medium composition and incubation time for the growth of *Streptomyces* BTA 1-131 to achieve maximal extract yield and antibacterial activity. Four factors known to affect secondary metabolite production were controlled in this study, namely the concentrations of yeast extract, starch, and NaCl, including time of incubation (Table 2). The response variables in this study evaluate the extract yield and the antibacterial activity, which are commonly used indicators of secondary metabolite production efficiency (Table 2). The data analysis indicates the highest yield and the highest antibacterial activity of *Streptomyces* BTA 1-131 were obtained using combination

treatment 12 (155 mg and 16.70 ± 0.14 mm, respectively).

Further analysis of variances indicates the significant effects of nutrient concentration (yeast extracts and NaCl) on both the yield of extracts and the antibacterial activity of *Streptomyces* BTA 1-131 (Table 3). Moreover, concentration of starch is only significant for yield extracts, while time of incubation is only significant for antibacterial activity of *Streptomyces* BTA 1-131 (Table 3).

Table 3. Effects of different concentration of nutrients and time of incubation to yield extracts and antibacterial activity of *Streptomyces* BTA 1-131

Parameters	Yield Extracts		Antibacterial activity	
	F-value	P-value	F-value	P-value
Yeast Extract	81.86	< 0.01*	42.2	< 0.01*
Starch	26.40	< 0.01*	3.24	0.092
NaCl	7.11	0.018*	12.52	< 0.01*
Time of incubation	3.88	0.068	8.37	0.011*

*significant at P-value < 0,05

Further antibacterial activity of the *Streptomyces* BTA 1-131 was conducted using agar plug assay, in which the strain BTA1-131 was cultivated in agar medium with extreme composition, as suggested by the Software Design Expert (Table 4). The strain was incubated for 10 days prior to the antibacterial activity screening. The colonies of *Streptomyces* BTA 1-131 under different culture conditions showed visible variations in their growth (Figure 2). Plates (a–g) exhibited distinct patterns, in which reduced bacterial growth was evident, characterized by fewer and smaller colonies in medium without yeast extract (a) to dense bacterial growth with numerous colonies in medium with yeast extract (b–g). Plate (h), serving as the negative control, showed no bacterial growth.

The differences in medium composition not only influence the growth of *Streptomyces* BTA1-131 but also its bioactivity screening (Table 4). The antibacterial activity of *Streptomyces* BTA1-131 in several extreme conditions is generally higher than the antibacterial activity of the control antibiotic vancomycin (1000 ppm), indicating the prominence of *Streptomyces* BTA1-131 in developing as a producer of antibacterial compounds. The lowest antibacterial activity was observed in treatment 18, with the highest concentration of yeast extract (13.20 ± 0.14). The analysis of variances indicates the

significant effect of yeast extracts and starch on the antibacterial activity of *Streptomyces* BTA1-131 in extreme conditions (Table 5). However, the effect of the concentration of NaCl on the

antibacterial activity of *Streptomyces* BTA1-131 in extreme conditions was not significant (Table 5).

Table 2. Responses (Yield extracts and antibacterial activity) of *Streptomyces* BTA1-131 in the 30 treatments liquid medium YS with variables/parameters: concentration of nutrients and different times of incubation. Treatment with the highest yield extract and antibacterial activity was written in bold.

Treatments	Variables/Parameters				Responses	
	Nutrient concentration				Yield Extract (mg)	Antibacterial activity (mm)
	Yeast Extract (g/L)	Starch (g/L)	NaCl (%)	Time of Incubation (days)		
1	0.1	0.5	1.5	8	34.6	8.10 ± 0
2	0.3	0.5	1.5	8	55.8	7.30 ± 0,14
3	0.1	1.5	1.5	8	34.8	0
4	0.3	1.5	1.5	8	111	10.85 ± 0.07
5	0.1	0.5	2.5	8	30.4	0
6	0.3	0.5	2.5	8	55	7.85 ± 0.07
7	0.1	1.5	2.5	8	50	0
8	0.3	1.5	2.5	8	118.2	10.20 ± 0.28
9	0.1	0.5	1.5	12	28.8	7.80 ± 0.14
10	0.3	0.5	1.5	12	114.6	11.05 ± 0.07
11	0.1	1.5	1.5	12	96.6	14.55 ± 0.21
12	0.3	1.5	1.5	12	155	16.70 ± 0.14
13	0.1	0.5	2.5	12	20.4	0
14	0.3	0.5	2.5	12	69.4	11.15 ± 0.49
15	0.1	1.5	2.5	12	42.4	0
16	0.3	1.5	2.5	12	120.2	15.10 ± 0.14
17	0	1	2	10	18.2	0
18	0.4	1	2	10	151.4	10.50 ± 0
19	0.2	0	2	10	43.2	10.55 ± 0.07
20	0.2	2	2	10	90.2	14.65 ± 0.07
21	0.2	1	1	10	76.6	14.15 ± 0.35
22	0.2	1	3	10	32.0	8.20 ± 0.14
23	0.2	1	2	6	35.2	7.85 ± 0.21
24	0.2	1	2	14	35.6	9.80 ± 0.28
25	0.2	1	2	10	61.6	9.80 ± 0.14
26	0.2	1	2	10	38.4	10,40 ± 0.28
27	0.2	1	2	10	35	8,60 ± 0
28	0.2	1	2	10	36.4	8,85 ± 0.21
29	0.2	1	2	10	38.6	9,15 ± 0.21
30	0.2	1	2	10	69.8	12.35 ± 0.07

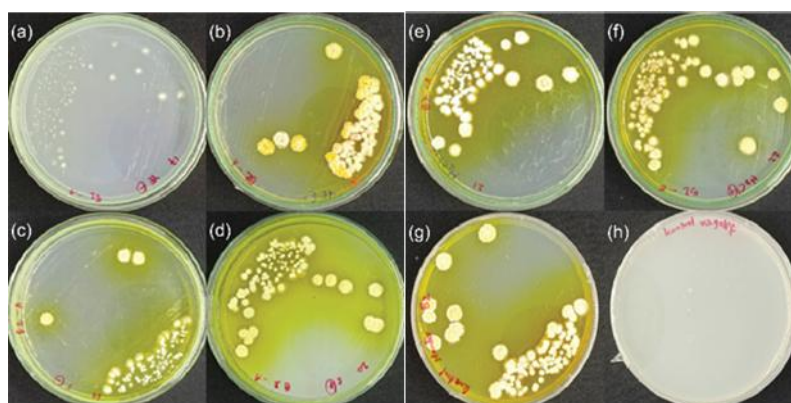


Figure 2. The *Streptomyces* BTA1-131, after 10 days of incubation, in various medium composition of treatments 17 (a), 18 (b), 19 (c), 20 (d), 21 (e), and 22 (f), while (g) Control standard composition*, and (h) Control negative*** (empty medium YSA + 2% NaCl).

Table 4. The antibacterial activity of *Streptomyces* BTA1-131 on fermentation media with extreme composition concentrations that incubated for 10 days. The bioactivity was evaluated using an agar plug assay.

Treatments	Nutrients concentration		Antibacterial activity	
	Yeast Extract (g/L)	Starch (g/L)	NaCl (%)	(mm)
17	0	1	2	22.98 ± 0.39
18	0.4	1	2	13.20 ± 0.14
19	0.2	0	2	22.08 ± 0.26
20	0.2	2	2	20.75 ± 0.29
21	0.2	1	1	22.15 ± 0.33
22	0.2	1	3	23.10 ± 1.54
Control standard*	0.2	1	2	22.60 ± 0.57
Control antibiotic**	Antibiotic <i>Vancomycin</i> 1000 ppm			19.58 ± 0.3
Control negative***	YSA + 2% NaCl without culture			0

*Control *Streptomyces* BTA1-131 in medium YSA standard, **control antibiotic consist of vancomycin 1000 ppm, ***control negative consist of only medium YSA+ 2% NaCl

Table 5. Effects of different nutrients to the antibacterial activity of *Streptomyces* BTA 1-131 on fermentation media with extreme composition concentrations, tested using an agar plug assay

Parameters	F-value	P-value
Yeast Extract	272.40	<0.01*
Starch	8,07	<0.01*
NaCl	2.01	0,164

*significant at P-value < 0,05

Surface plot analysis on interaction of all variables (yeast extract, starch, NaCl, and time of incubation) indicates its effects/influences to yield extract and antibacterial activity of the *Streptomyces* BTA 1-131 (Figure 3, Figure 4). The interaction between yeast extract and starch showed that increasing the concentration of yeast extract, following by increasing the concentration of starch, will increase yield extract and antibacterial activity (Figure 3a, 4a). The interaction between yeast extract and NaCl showed that increasing the concentration of yeast extract, following by decreasing the concentration of NaCl, will increase the yield extract and antibacterial activity (Figure 3b, 4b). The interaction between yeast extract and time of incubation showed that increasing the concentration of yeast extract, following by longer time of incubation, will increase the yield extract and antibacterial activity (Figure 3c, 4c). The interaction between starch and NaCl showed that increasing concentration of starch, following by decreasing the concentration of NaCl, will increase the yield extract and antibacterial activity (Figure 3d, 4d). The interaction between starch and time of incubation showed the increasing concentration of starch, following by longer time of incubation, will increase the yield extract and antibacterial activity (Figure 3e, 4e). The interaction between NaCl and time of incubation showed that

decreasing the concentration of NaCl, following by longer time of incubation, will increase the yield extract and antibacterial activity (Figure 3f, 4f).

Each microorganisms has been reported to have a specific type and amount of carbon and nitrogen sources to grow. The integration of carbon and nitrogen metabolic pathways involves complex regulatory mechanisms, such as post-translational modifications, allosteric regulation, and changes in gene expression levels, which modularly coordinate key metabolic functions (Yu *et al.*, 2024). Secondary metabolite production, for example in the genus *Streptomyces*, is induced by nutrient limitations, including nitrogen (Krysenko, 2023). Thus, optimization of culture conditions is a critical strategy to enhance the production of secondary metabolites in *Streptomyces*, as variations in nutrient composition and incubation parameters was directly influence metabolic pathways and bioactive compound biosynthesis (Hu *et al.*, 2024; Sweetline & Usha, 2021). Carbon and nitrogen sources such as starch and yeast extract have been reported to significantly regulate growth, morphological differentiation, and antibiotic production in *Streptomyces* sp., while salinity and incubation duration further modulate metabolite yield and bioactivity (Hu *et al.*, 2024; Sweetline & Usha, 2021).

The current study suggest the importance of nutrient sources (starch, yeast extract, and NaCl) and time of incubation for metabolite production/yield extract and its antibacterial activity (Table 2, Table 3, Table 4, Table 5, Figure 3, Figure 4). Selection of yield extract as a response parameter is important for estimating the quantity of secondary metabolites produced, and it has been reported to exhibit a positive relationship with antibacterial activity, where

higher yields increase the likelihood of enhanced bioactivity (Hu *et al.*, 2024; Sweetline & Usha, 2021).

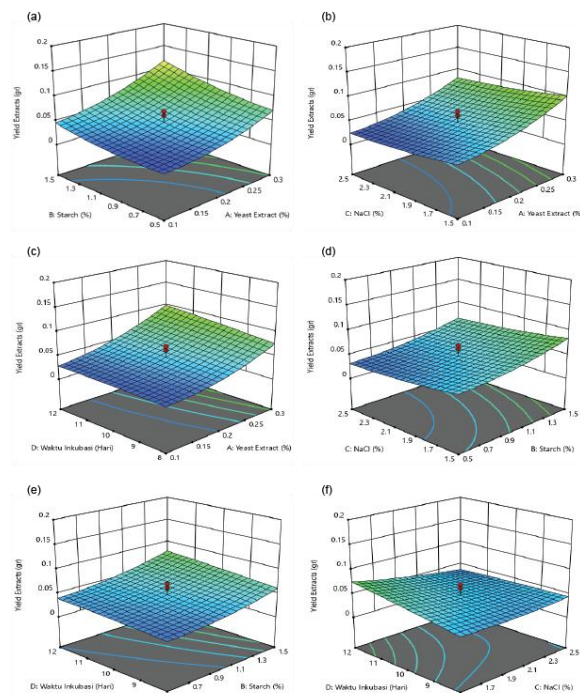


Figure 3. Surface plots of the response of extract yield derived from *Streptomyces* BTA 1-131. (a) Effect of the interaction between yeast extract and starch on yield extract. (b) Effect of the interaction between yeast extract and NaCl on yield extract. (c) Effect of the interaction between yeast extract and incubation time on yield extract. (d) Effect of the interaction between starch and NaCl on yield extract. (e) Effect of the interaction between starch and incubation time on yield extract. (f) Effect of the interaction between NaCl and incubation time on yield extract.

As a primary carbon source, starch is hydrolyzed by enzymes and metabolized by microbes to generate energy for bacterial growth. Increasing carbon concentration and longer duration of fermentation will stimulate microbial metabolic activity and reproduction. Thus, enhances the production of primary and secondary metabolites. A starch-based fermentation indicates that extended time and substrate availability will increase metabolite yield (Li *et al.*, 2024; Tagami, 2024). While, the presence of NaCl in the medium creates extreme environmental conditions that induce the secretion of secondary metabolites. At higher concentrations and longer incubation times, there is an increase in the accumulation of secondary compounds such as phenolics and flavonoids in plants, as well as physiological

changes in bacteria (Hawrylak-Nowak *et al.*, 2021; Rodrigues *et al.*, 2024). Nitrogen is utilized by microbes for the biosynthesis of cellular components during the exponential phase. Increased nitrogen source concentration supports microbial growth and subsequently promotes secondary metabolite production during the transition phase as nutrients decline (Krysenko, 2023). The stationary and late growth phases are when secondary metabolite secretion often peaks due to environmental stress and nutrient depletion. At this stage, although growth slows, secondary metabolism becomes intense, consistent with the characteristics of the idiophase (Krysenko, 2023).

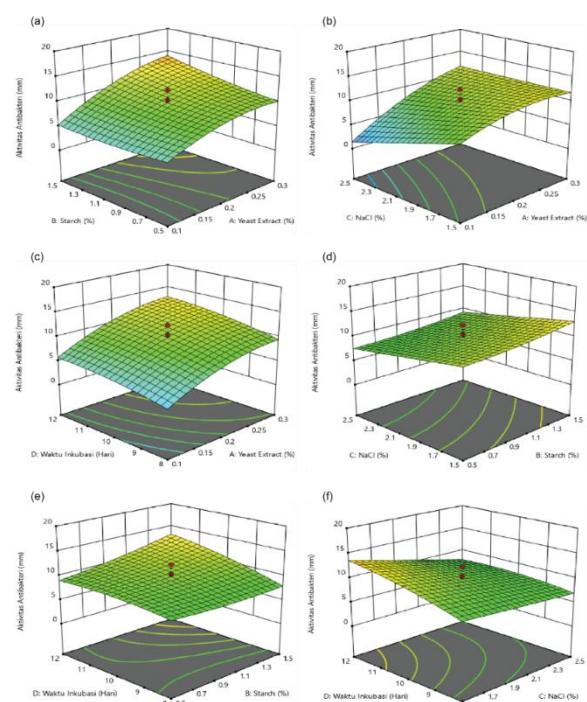


Figure 4. Surface plots of the response of antibacterial activity of *Streptomyces* BTA 1-131. (a) Effect of the interaction between yeast extract and starch on antibacterial activity. (b) Effect of the interaction between yeast extract and NaCl on antibacterial activity. (c) Effect of the interaction between yeast extract and incubation time on antibacterial activity. (d) Effect of the interaction between starch and NaCl on antibacterial activity. (e) Effect of the interaction between starch and incubation time on antibacterial activity. (f) Effect of the interaction between NaCl and incubation time on antibacterial activity.

Conclusions

Nutrient sources (yeast extracts, starch, and NaCl) and time of incubation have a significant

impact on the yield of extracts and the antibacterial activity of sponge-associated *Streptomyces* BTA1-131. The agar plug assay suggests that the antibacterial activity of sponge-associated *Streptomyces* BTA1-131 in media with extreme composition concentrations that were incubated for 10 days was more prominent than the control antibiotic vancomycin.

Conflict of Interest

Given their role as members of editorial boards in the journal of *Annales Bogorienses*, Akhirta Atikana and Puspita Lisdiyanti had no involvement in the peer review of this article. Additionally, they have no access to information regarding its peer review, and full responsibility for the editorial process for this article was delegated to another journal editor.

Declaration of generative AI

The author declares the use of AI tools (ChatGPT, Ms. CoPilot, Quillbott, and SciSpace) during the preparation of this work for paraphrasing sentences, search of relevant literatures, and improve structures/grammar. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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Data availability

The isolate *Streptomyces* BTA1-131 has been deposited in the Indonesian Culture Collection BRIN (InaCC) under accession number InaCC A1205. The 16S rRNA gene nucleotide sequence has been deposited in the NCBI GenBank accession no. MT280129.1.

Ethical approval

No endangered and/or protected species were involved in this study.

Author contribution

Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft: AA, LS. Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Software: R, FN. Supervision, Project administration: AA, LS, FHS, PL. Resources, Investigation: AA, LS, SRK. All authors contributes to Writing – review & editing.

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