I. INTRODUCTION

I.I Background

An antibiotic is a substance in form of small bioactive molecules that are naturally produced by microorganism like bacteria and fungi during their secondary metabolism or semisynthetic compound derived from microorganisms when present in small amounts, either kills or stops the growth of other microorganisms (Schlegel, 2003; Russell, 2004; Denyer et al., 2005; Etebu and Ibemologi Arikekpar, 2016). Some antibiotics are obtained from various microorganisms that grow in extreme environments, such as high-temperature areas, low-temperature areas, deep sea, deserts, ice layers, hot springs, and oil (Sulistiyaningsih, 2006; Yuliati, 2015). Antibiotics have become the foundation of microbes infections treatment and one of the comerstones of modern medicine (Adriaenssens et al., 2011; Fomnya et al., 2021). Antibiotics are also utilized as prevention and treatment for diseases, as the number of disease cases rises. Most antibiotics that are commercially used are synthetic antibiotics that have a tendency to cause resistance in pathogens particularly bacteria (Ruhe et al., 2005).

Antimicrobial resistance is the main health concern of the twenty-first century. The likelihood of a post-antibiotic era is increased by the increasing occurrence of multidrug-resistant bacteria (World Health Organization, 2017). Standard medicines are less efficient at treating common bacterial infections due to the growing frequency of antibiotic resistance worldwide, which poses a significant issue. One of

the major public health issues of the twenty-first century is bacterial antibiotic resistance, which makes medications ineffective in treating infections (O'Neill, 2022). Methicillin-resistant S. aureus (MRSA), vancomycin-resistant S. aureus (VRSA), and vancomycin-resistant Enterococci (VRE) are among the drug-resistant bacteria that have been becoming more common (Kaur et al., 2015). Acinetobacter, Pseudomonas, and certain Enterobacteriaceae, including K. pneumoniae, E. coli, and Enterobacter spp., are important priority bacteria. These organisms can cause serious and frequently deadly infectious illnesses like pneumonia and bloodstream infections, and they are resistant to some medications (Breijyeh et al., 2020).

The finding for additional sources of antibiotics is still occurences in an effort to stop the spread of pathogens that are resistant to them, particularly bacteria that have adapted to survive in environments with high salinity, low water availability, high temperatures, and pH, all of which may be sources of new bioactive compounds. Under such circumstances, microbial metabolites are abundant sources of novel, potentially bioactive substances (Moawad et al., 2004; Elazm et al., 2020; Abd El-Rahim et al., 2020). Nonetheless, the capacity of extremophilic microbes to generate such compounds remains to be harnessed. Indonesia has various areas of extreme conditions, such as geothermal areas, hydrothermal vents and hot springs which are habitats for extremophilic microorganisms (Akhmaloka et al., 2006; Grégoire et al., 2011; Febriani et al., 2024). Extremophilic microorganisms potentially produce metabolites, such as antibiotics, that have unique characteristics due to their ability to adapt to extreme conditions. Bacteria thermophile have certain

potentials which are can produce enzyme, antibiotics, anti-algae component and anti-cancer compounds (Rudolf et al., 1998).

Many studies have been conducted on the utilizing of thermophilic bacteria as agents producing antibacterial substances that have activity against pathogen microbes including gram-positive and gram-negative bacteria. The research by Alkhalili et al., (2016) shows that, an antibacterial substance known as Z-geobacilin, a class-I lantipeptide that is produced from lantipeptides by the thermophilic bacterium Geobacillus sp. ZGt-1. Two class I lantibiotics, Lan A (Lan AI and Lan AII), are present in G. kaustophilus HTA426. The base length of Lan A from Geobacillus sp. ZGt-1-geobacillin is 100% comparable to that of Lan AI. The antibacterial agent bacteriocin is antagonistic towards Salmonella typhimurium. According to the research from Febriani et al., (2024), conducted that Thermo-Halophilic Bacterium PLS 76 isolate from Pria Laot Sabang, Indonesia, produced an antibiotic of the polypeptide group that resembled polymyxin B2. The antibiotic activity was evaluated using the Kirby-Bauer method, and the inhibition zone against Staphylococcus aureus and Escherichia coli was approximately 12 mm.

Some studies also report antibiotics productions from microorganisms living in extreme conditions. Bacteriocin antibiotics are produced by Geobacillus toebiii, which was isolated from a 60°C environment (Başbülbül and Biyik, 2011). Bacillus atrophaeus produces antibiotics that are stable between 4° and 100°C and stop Bacillus subtilis from growing. It is known that the thermo-halophilic bacteria of PLS 80 produce β-Lactam antibiotics in the ethyl acetate fraction (Iqbalsyah et al.

2019). Those statements also supported that thermophilic bacteria belonging to the Actinomycetes can obtain bioactive compounds in the form of antimicrobial which can be utilized in pharmacology and biotechnology fields (Limaye et al., 2017).

Based on the description, thermophilic microbes are suspected to have the potential to produce antimicrobial compounds in the form of antibiotics. Therefore, further research is needed to combat the increasing prevalence of antibiotic resistance by microorganisms. Antibiotics that produced by thermophilic bacteria in geothermal areas or hot springs are still relatively rare to study, so the research on thermophilic bacteria isolated from Aia Angek Batu Bajanjang, Padang Dama, and Garara, Solok Regency, has the potential to be antibiotic producers.

1.2 Formulation of The Problem

Based on the background of the problem above, the problem can be formulated in this study, namely:

1. Whether thermophilic bacteria obtained from the hot springs of Garara, Padang Dama, and Batu Bajanjang are capable of producing antibiotic compounds?
2. How the macroscopic and microscopic characteristics of thermophilic bacteria from the hot springs of Garara, Padang Dama, and Batu Bajanjang support their potential as antibiotic producers?

1.3 Purpose of the Research

The objectives of this study are:

1. To obtain thermophilic bacterial isolates suspected of producing antibiotic compounds from the Hot Springs in the Cupak and Batu Bajanjang areas, Solok Regency.

2. To identify the macroscopic and microscopic characteristics of thermophilic bacteria with the potential to produce antibiotics from the Hot Springs of Garara, Padang Dama, and Batu Bajanjang.

1.4 Benefits of the Research

The expected benefit of this research is to add a collection of thermophilic bacteria producing antibiotics, to obtain the character of thermophilic bacterial isolates from Garara, Padang Dama, and Batu Bajanjang Hot Springs and to contribute in the field of science.