Antimicrobial Properties of *Pliek U* as Traditional Acehnese Fermented Spices

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ABSTRACT

The high prevalence of antimicrobial resistance globally has increased the burden of disease. The phenomenon demands urgency to explore new antimicrobial drugs, one of which is sourced from natural ingredient, spices. *Pliek U*, as one of the spices traditionally processed by Acehnese, has attracted researchers to explore its potential source for antimicrobial substances. The objective of this literature review is to explore the characteristic, production, chemical composition, and antimicrobial mechanism of *Pliek U*. A literature search was carried out on PubMed, Science Direct, Springer Link, and Google Scholar using the keywords "Pliek U", “Coconut Flesh”, and “Antimicrobial”. The articles obtained were then screened based on predetermined criteria. The results of the analysis were displayed in tabular and narrative form. The final result was 8 main articles and 10 additional articles after screening 65 articles obtained from the database. *Pliek U* powder is traditionally produced and has unique characteristics that make it easy to recognize. *Pliek U* mechanism of action based on the chemical composition and the role of lactic acid bacteria in the fermentation process. Analysis shows that *Pliek U* is a promising antimicrobial source, so it needs to be researched and developed further in the pre-clinical to clinical phases.


ABSTRAK


1. Introduction

Antimicrobial resistance (AMR), a phenomenon of changes in microbes that cause a reduction in the effectiveness of drugs used to treat infectious diseases, has emerged and is one of the biggest public health threats in this century. According to the 2019 Antimicrobial Resistance Collaborators prediction, AMR would be the cause of 4.95 million deaths across 204 countries and territories [1]. As many as 10 million deaths worldwide could result from AMR by 2050, according to a 2016 review of the subject [2]. AMR has a significant disease burden, hence research and development of novel medications must be started right away [1]. Spices are one of the natural products that are rich in active substances and have been widely studied to assess their potential antimicrobial activity in the context of discovering new antimicrobial drugs [3].

Spices hold a crucial place in human food habits and are integrated into the culinary customs of all cultures worldwide [3]. Over time, aromatic herbs and spices have been utilized as natural preservers, flavor boosters, coloring elements, and dietary additions to promote well-being and better health [4]. According to reports, the populations of more than 80% of World Health Organization (WHO) member states use herbal and natural products [5]. Based on their possible health benefits, between 5 and 10% of adult Americans utilize botanical supplements such as spices [4]. In Indonesia, almost 80% of people utilize medicinal herbs to prevent and treat illness [6].

Plek U (Acehnese language) is one of the spices whose health benefits have been extensively studied. A traditional spice blend known as "Plek U" is used in Acehnese cooking, an Indonesian culinary style exclusive to the Aceh area of northern Sumatra. *Plek U* is made by fermenting coconut meat (Cocos nucifera L.) for a few days [7-10]. Acehnese have traditionally utilized *Plek U* and its oil for cooking (rujak seasoning, chili sauce, vegetables) and medicinal purposes (reduces fever, promotes wound healing, eases joint stiffness, eases stomach pain, and allays headaches) [8]-[12].

Previous preclinical studies have demonstrated *Plek U*’s antimicrobial properties, including its ability to operate as an antibacterial [8], antifungal [13], and antiviral [14,15]. Additionally, several earlier researchers created the antimicrobial preparation *Plek U* as a functional food [8,13] and topical ointment [16,17]. Although many studies have examined the antimicrobial effects of *Plek U*, there is a lack of comprehensive information on the characteristics of *Plek U* and how it is produced, its chemical composition, and its mechanism of action as an antimicrobial. Therefore, this literature review aims to explore the characteristics, production, chemical composition, and antimicrobial mechanisms of *Plek U*, to provide a foundation for future *Plek U*-related research and development.

2. Methods

The literature search was carried out using PubMed, Science Direct, Springer Link, and Google Scholar databases in January 2024 using the keywords “Plek U”, “Coconut Flesh”, and “Antimicrobial”. The inclusion criteria used in this study were articles discussing the antimicrobial activity of *Plek U*, published in the last 10 years. Meanwhile, the exclusion criteria were articles that were incomplete and did not use Indonesian or English. Researchers then carried out screening and overall reading of articles. The results of the main article analysis obtained are displayed in tabular form. Other information related to the topic is presented in narrative form.

3. Result and Discussion

![Figure 1. Article Screening Flow](image-url)
The literature search process resulted in 65 articles. Based on the final results of screening articles according to inclusion and exclusion criteria, 8 main articles and 10 additional articles were obtained. The article screening flow can be seen in Figure 1. The results of the main article analysis can be seen in Table 1, while the analysis of additional articles is described in narrative form in several subheadings below.

3.1 Pliek U Characteristics

Pliek U is a common powder from Aceh Province, Indonesia, used in traditional recipes. It may be kept for a long time before use and is prepared from dried, fermented coconut (Cocos nucifera L.) endosperm [18]. As a traditional dish blended with the main meal, Pliek U is quite popular among the Acehnese [9,19]. "Patarana" is an additional term for Pliek U that is used [20]. This is easily recognizable because of its dark color, strong scent, rancid smell, slight sour, and taste [13,21]. Figure 2 shows the shape of the Pliek U.

![Figure 2. Pliek U](image)

3.2 Pliek U Production

To prepare Pliek U, old or semi-old coconuts must be split (not open) and incubated for four to five days at room temperature (29 to 36 °C). Then, the shredded coconut meat must be incubated for four to five days in a closed container without light exposure. The meat then be dried in the sun and pressed for more than five days using a special hydraulic pressure tool called “Peneurah” that separates the oil from the meat. The final products are Pliek U oil (also known as Minyeuk Simplah or Minyeuk Reutek) and coarse Pliek U powder. The Pliek U processing procedure generally takes 15 to 20 days [15,19,22]. This food has undergone spontaneous (accidental) fermentation or is preserved without the use of a starting culture [7,8,9,10,13]. Different modifications that arise throughout the fermentation process lead to different metabolites that are created from the original components or as a result of fermentation and may be discovered in the final product [10]. Figure 3 shows the production scheme for Pliek U.

![Figure 3. Pliek U Production Scheme](image)

3.3 Pliek U Chemical Composition

Pliek U has the potential to be exploited as a therapeutic source due to its unique chemical composition [14]. One of natural substance that serves as a source of fatty acids is Pliek U. Gas Chromatography-Mass Spectrometry (GC-MS) study was performed on the Pliek U extract to ascertain the composition of different fatty acids. These include lauric acid (C12), capric acid (C10), caprylic acid (C8),...
palmitic acid (C16), myristic acid (C14), oleic acid (C18), palmitoleic acid (C16), linoleic acid (C18),
tetradecanediol acid, 7-10-13-hexadecanediol acid, 9-12-15-octadecanediol acid, along with esters and
alcohols. Among these, lauric acid is the most prevalent [9,14,23]. According to Arpi in [15], each of them
belongs to the medium-chain fatty acids (MCFA) category.

As an antibacterial, antifungal, antiprotozoal, and antiviral, lauric acid is significant [14,16]. Because
it may be changed into monolaurate in the bodies of humans and other animals, lauric acid (C12), an MCFA,
has a crucial purpose. Antiviral, antibacterial, and antiprotozoal properties are shared by monolaurate. This
substrate is essential for the production of monoglycerides as antibacterials due to its extremely high amount
of medium- and short-chain saturated fatty acids [10,16].

Several things contribute to Pliek U's high fatty acid content, one of which is the method of
processing it—breaking the coconut apart during the fermenting process. The more coconut is opened, the
more it is exposed to contamination from microorganisms, particularly mold, which produces high levels of
free fatty acids, and from drying it in the sun or other light source, which starts the oxidation process that
produces short-chain free fatty acids and ketones. A hydrolysis process also occurs in tandem with this event.
The breakdown of fat into glycerol and free fatty acids can be sped up by light [15].

Many of the health advantages associated with coconut eating are assumed to be attributable to
phytochemical components found in meat and coconut oil extracts, which were tested for phytochemical
compounds. These chemicals included flavonoids, carotenoids, phenolic acids, saponins, glycosides, tannins,
alcohols. Among these, lauric acid is the most prevalent [9,14,23]. According to Arpi in [15], each of them
includes organic acids, diacetyl, hydrogen peroxide, and bacteriocins. During the fermentation, LAB produces metabolites
inhibition zone of none, 7,2 mm, 7,5 mm, 8,6 mm, 8,4 mm.

3.4 Lactic Acid Bacteria In Pliek U Fermentation
Lactic acid bacteria (LAB) are a group of microbes that play an important role in the fermentation
process of various types of traditional food [8]. During the fermentation, LAB produces metabolites
including organic acids, diacetyl, hydrogen peroxide, and bacteriocin which will cause changes in taste and
shape and can inhibit destructive bacteria and pathogens [8,13].

3.5 Pliek U Antimicrobial Activity
A compilation of previous preclinical studies evidence on the topic of Pliek U's antimicrobial activity can be
seen in Table 1 as follows.

<table>
<thead>
<tr>
<th>No</th>
<th>Author</th>
<th>Intervention</th>
<th>Method</th>
<th>Microbe</th>
<th>Control</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>[7]</td>
<td>LAB isolated from Pliek U (Lactobacillus plantarum) with a colony count of $6.8 \times 10^8$ CFU/g</td>
<td>Identification of bacterial species by 16SrRNA gene amplification, antimicrobial activity using disc diffusion method (in vitro)</td>
<td>Escherichia coli (E. coli) dan Staphylococcus aureus (S. aureus)</td>
<td>Positive: Ciprofloxacin, Negative: None</td>
<td>a. E. coli isolate: E1, E2, E3, E4, E5 show inhibition zone of 7,5 mm, 8 mm, 7,2 mm, 7 mm, 6,8 mm. b. S. aureus isolate: E1, E2, E3, E4, E5 with inhibition zone 13 mm, 13,3 mm, 10 mm, 8,6 mm, 8,4 mm.</td>
</tr>
<tr>
<td>2</td>
<td>[14]</td>
<td>Fatty acids (lauric, capric, linoleic, caprylyc, myristic, palmitic, oleic)</td>
<td>Molecular docking</td>
<td>Sars Cov-2 protein and Enzym</td>
<td>None</td>
<td>For 3CLpro (6LU7), E Protein (5X29), Plpro (6WX4), Spike Ectodomain Structure (6VYB), RdRp (6MT1), and Plpro (6VXX), linoleic acid has the greatest interaction with the receptors with the lowest binding affinity of -4,9; -4,7; -5,8; -5,3; -4,3 and -5,5 kcal/mol.</td>
</tr>
<tr>
<td>3</td>
<td>[8]</td>
<td>LAB isolated from Pliek U</td>
<td>Diffusion method (in vitro)</td>
<td>Candida albicans (C. albicans), S. Aureus, E. coli</td>
<td>None</td>
<td>a. S. aureus isolates: SP1, SP2, SP3, SP4, SP5 show inhibition zone of none, 7 mm, 7,7 mm, 0.25 mm, 0.25 mm. b. E. coli isolates: SP1, SP2, SP3, SP4, SP5 with an inhibition zone of 2,5 mm, 1,5 mm, none, none, 28 mm.</td>
</tr>
<tr>
<td>No</td>
<td>Author</td>
<td>Intervention</td>
<td>Method</td>
<td>Microbe</td>
<td>Control</td>
<td>Results</td>
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<tr>
<td>4</td>
<td>[9]</td>
<td>Pliek U crude extract (Solvent Ethanol, Hexane, Ethanol Residue)</td>
<td>Diffusion method (in vitro)</td>
<td>Salmonella typhi</td>
<td>Positive: Amoxicillin 10 µg, Negative: Aquades</td>
<td>Pliek U ethanol extract (EEP) shows an inhibition zone of 17.2 mm, Pliek U hexane extract (EHP) 0 mm, residual ethanol extract (EERP) 17.4 mm, positive control 25.6 mm, negative Control 0 mm</td>
</tr>
<tr>
<td>5</td>
<td>[16]</td>
<td>Pliek U ethanol extract ointment 5mg/ml</td>
<td>Diffusion method (in vitro)</td>
<td>S. aureus</td>
<td>Positive: none, Negative: ointment base</td>
<td>The inhibition zone: ointment base (P0) 0 mm, Pliek U extract 5mg/ml of 26 mm, Pliek U extract ointment 5mg/ml of 15 mm</td>
</tr>
<tr>
<td>6</td>
<td>[13]</td>
<td>Pliek U crude extract (Solvent hexane, ethanol residue, ethanol)</td>
<td>Diffusion method (in vitro)</td>
<td>B. cereus, B. subtilis, S. aureus, C. albicans</td>
<td>None</td>
<td>Average Inhibition Zone a. Ethanol: B. cereus 6.67±0.47 mm; B. subtilis &amp; S. aureus none, C. albicans 17.33±0.94 mm b. Ethanol residue: B. cereus 19.67±0.47 mm; B. subtilis 10.33±0.94 mm, S. aureus 18.33±0.47, C. albicans none.</td>
</tr>
<tr>
<td>7</td>
<td>[17]</td>
<td>Pliek U ethanol extract and hexane residue extract, cream formulation</td>
<td>Diffusion method (in vitro)</td>
<td>S. aureus</td>
<td>Positive: Clyndamic in., Negative: ethanol solvent and cream base</td>
<td>Ethanol Pliek U extract with average inhibition zone of 8.66±0.57 mm, Hexane residue extract and cream: none</td>
</tr>
<tr>
<td>8</td>
<td>[10]</td>
<td>Pliek U ethanol extract cream</td>
<td>Diffusion method (in vitro)</td>
<td>S. aureus</td>
<td>Positive: Krim Bevalex, Negative: Aquades</td>
<td>The average inhibition zone: F1 (3%) 12.65 mm, F2 (5%) 14.9 mm and F3 (7%) 12.92 mm.</td>
</tr>
</tbody>
</table>

### 3.6 Pliek U Antimicrobial Mechanism

Some of the antimicrobial mechanisms of Pliek U are as follows

#### 3.1.1. Antibacterial

**a. Fatty acids**

When saturated fatty acids function as antibacterials, they often harm target cell membranes by acting directly on them [16]. Aside from that, suppression of the formation of cell walls is another inhibitory mechanism against bacteria [8].

**b. Lactic acids as a result of LAB metabolism**

During the LAB metabolic process, lactic acid accumulation of primary metabolites can enter microbial cells and at higher intracellular pH levels, dissociate to produce hydrogen ions. This lowers intracellular pH and interferes with the function of vital metabolites, substrate translocation, and oxidative phosphorylation. By neutralizing or expelling protons, bacterial cells will attempt to
maintain the pH of their internal environment. Bacteria need their growth energy to release protons, therefore this attempt will slow down their growth. The cytoplasmic pH will drop and the cell burden will be high if the extracellular acid concentration is high and the external pH is low. Cells of bacteria will perish. [8,9].

c. Bacteriocin as a LAB metabolic result
The existence of secondary metabolites in the form of bacteriocin compounds, can stop peptidoglycan production in its entirety, weakening the bacterial cell wall and causing lysis in the bacterial cell [8].

d. Compound polarity of the solvent in the extract
The compound's polarity may contribute to its antibacterial action. The active chemical components of Pliek U are extracted by Jalma & Zachreini in [9], using an ethanol solvent. The polar active chemicals are supposed to dissolve in the polar solvent like ethanol. Hydrophilic (polar) and lipophilic (non-polar) characteristics determine the polarity of antibacterial substances and influence the hydrophobic (non-polar) balance of bacterial cell walls. Bacterial cells will be impacted by this imbalance in two ways: directly, through membrane damage, and indirectly, through increased membrane permeability.

e. Phytochemical content
The efficiency of several antimicrobial methods of action has been explored, and it is contingent upon the type of phytochemical molecule involved. These mechanisms include blocking the synthesis of nucleic acids by interfering with the activity of bacterial DNA gyrase and topoisomerase IV, blocking the function of the cytoplasmic membrane, blocking the synthesis of cell envelopes, blocking energy metabolism, blocking the synthesis of cell walls, blocking efflux pumps in bacteria, blocking virulence dependent on bacterial enzymes, and blocking membrane-disrupting activities [25].

3.1.2. Antifungal
Sterols bond to antimicrobial agents, causing harm to fungal cell walls. Chitin, cellulose, β-glucan, mannnan, chitosan, protein, lipids, and inorganic ions make up the cell walls of Candida albicans. Chitin production is often inhibited by antimicrobial substances that can also affect the development of fungal cell walls. Antimicrobials can also cause damage to microbial cell membranes by denaturing the proteins and lipids that comprise these membranes, which interferes with the germs' ability to exchange essential chemicals. Macrophages and ions exit the cell when the cytoplasmic membrane's integrity function is compromised, resulting in cell injury [8].

3.1.3. Antivirus

![Figure 4. Summary of Pliek U Antimicrobial Properties](image-url)
According to Khairan et al. in [14] molecular docking analysis, linoleic acid exhibits the best interaction with receptors, having the lowest binding affinity towards each of the following: PLpro (6WX4), E protein (5X29), RdRp (6M71), 3CLpro (6LU7) and Spike protein (6VXX). According to these data, linoleic acid binding to SARS-CoV2 proteins and enzymes may interfere with the virus's ability to bind to host cells, decreasing the virus's ability to infect COVID-19 patients. A summary of Plike U’s Antimicrobial Properties can be seen in Figure 4.

4. Conclusion

Plike U powder is easy to recognize because it has unique characteristics in the form of dark color, strong aroma, rancid odor, slightly sour, and taste after being produced by traditionally fermenting coconut flesh for 15-20 days. This powder is rich in fatty acids, phytochemical compounds, and lactic acid bacteria produced during the fermentation process with its metabolites. Prior studies have proven that Plike U has antibacterial, antifungal, and antiviral effects. The active ingredient works as an antimicrobial by damaging microbial cell walls, changing intra-extracellular pH or polarity, disrupting cell function, and preventing invasion of host cells. Based on the evidence, Plike U can be encouraged as a source of antimicrobials and it needs to continue to be developed and researched from preclinical to clinical trials.

References


