A NARRATIVE REVIEW OF ZINGIBERACEAE FAMILY AS ANTIMICROBIAL AGENT FOR TRADITIONAL MEDICATION BASED ON BALINESE LOCAL WISDOM

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ABSTRACT

Background: One of the native plants from Indonesia that have been widely used for traditional medication as an antimicrobial comes from the Zingiberaceae family. Based on Usada Bali, the Zingiberaceae family used to treat digestive, respiratory, and skin diseases. Objective: This literature review aimed to discuss antimicrobial activity from the Zingiberaceae family and see its validity as a traditional use as antimicrobial based on Balinese local wisdom medication method (Usada) with its scientific evidence. Methods: The method of this literature review is the study of literature from several scientific publications in national and international journals about the antimicrobial activity of the Zingiberaceae family. Results: Several studies showed that the Zingiberaceae family has an antimicrobial activity with various inhibitions depended on the type of bacteria. Conclusion: The Zingiberaceae family mentioned in Usada Bali has been scientifically proved to have antimicrobial activity, so it shows the validity as a traditional use as antimicrobial based on Usada with its scientific evidence.

Keywords: Zingiberaceae, antimicrobial, Usada

INTRODUCTION

Indonesian society is synonymous with local wisdom. Local wisdom is the result of certain societies based on their experiences that are not necessarily experienced by other societies. It may be called a cultural characteristic[1]. There is a lot of local knowledge about health such as medicines inherited by society from ancestors which recorded on the manuscript. Some tribes in Indonesia still maintain their traditional medication knowledge until this present. Balinese is one of those tribes which has a traditional medication method called Usada, the manuscript of traditional Balinese treatment that contains various methods of medication and ceremony in self-purification and written on papyrus with the Balinese language and script[2].

Various types of plants used as medicine in Usada. One of them comes from the Zingiberaceae family. The Zingiberaceae family is known as ginger plants with characteristics such as has rhizome, pseudo-stems, and single leaves. The characteristics of each genus and species of this family are its inflorescence that has a distinctive shape and colour. The rhizome of this family is used for medication because it contains aromatic compounds as a characteristic of each species in its use for local societies. Aromatic compounds are usually the result of secondary metabolites such as essential oils which contains a lot of benefits, for example as an antimicrobial[3].

Antimicrobial compounds are able to kill or inhibit bacterial growth or
metabolism. Based on its mechanism of action, it is divided into bacteriostatic and bactericidal. Bacteriostatic antibacterial is an antibacterial that in which able to inhibit bacterial growth and bactericidal is an antibacterial that able to kill bacteria[4]. According to Usada, plants from the Zingiberaceae family can be used to treat digestive, respiratory, and skin diseases which are generally caused by a bacterial infection. Therefore, the author wants to do a literature review about an antibacterial activity from the Zingiberaceae family and see its validity as a traditional use as antibacterial based on Balinese local wisdom medication method (Usada) with its scientific evidence.

METHODS

The articles used in this literature review were obtained through the internet with the keyword are “Aktivitas antibakteri tanaman Zingiberaceae” and “Antimicrobial activity of Zingiberaceae”. After screening articles, 29 international articles and 23 national articles were obtained.

RESULTS

The Zingiberaceae family mentioned in Usada Bali such as Curcuma longa, Alpinia galanga, Zingiber cassumunar, Curcuma xanthorrhiza, Kaempferia galanga, Zingiber officinale, and Boesenbergia pandurata were used for traditional medication as antibacterial. The types of Usada, usage, and how to use are shown in Tables 1 and 2.

Based on several studies, the Zingiberaceae family mentioned in Usada Bali has an antibacterial activity which can be seen in tables 3, 4, and 5. One method that may be used to determine antibacterial activity is the diffusion method by measuring the inhibition zone due to categorizing the strength of the antibacterial activity of the compound.

DISCUSSION

Diffusion method was used to determine the antibacterial activity, which consists of a cylinder, well, and paper disc methods.

Table 1. Traditional medication from Curcuma longa, Curcuma xanthorrhiza, and Alpinia galanga based on Usada Bali

| Plant Species | Usada            | Function                  | How to Use | References |
|---------------|------------------|----------------------------|------------|------------|
| **Curcuma longa** |                  |                            |            |            |
| Usada Tenung  | Tanyalara        | Asthma                     | Oral       | [5]        |
| Usada Upas    |                  | Cough                      | Oral       | [6]        |
| Usada Rare    |                  | Stomachache                | Topical    |            |
| Usada Taru    | Premana          | Fever                      | Oral       | [8]        |
| Usada Tiwas   | Punggung         | Cough                      | Topical    |            |
| Usada Tiwas   | Punggung         | Stomachache                | Topical    | [6]        |
| **Curcuma xanthorrhiza** |     | Fever                      | Topical    |            |
| Usada Tenung  | Tanyalara        | Stomachache                | Oral       | [5]        |
| **Alpinia galanga** |            |                            |            |            |
| Usada Rare    |                  | Fever                      | Topical    | [7]        |
| Usada Netra   |                  | Skin disease               | Oral       | [7]        |
| Usada Tenung  | Tanyalara        | Stomachache                | Topical    | [5]        |
| Usada Upas    |                  | Stomachache                | Oral       | [6]        |

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### Table 2. Traditional medication from Zingiber cassumunar, Kaempferia galanga, Zingiber officinale, and Boesenbergia pandurata based on Usada Bali

| Plant Species           | Usada          | Function            | How to Use | References |
|-------------------------|----------------|---------------------|------------|------------|
| **Zingiber cassumunar** |                |                     |            |            |
| Usada Netra             | Stomachache    | Topical             | [7]        |            |
| Usada Rare              | Skin disease   | Topical             | [7]        |            |
| Usada Upas              | Stomachache    | Topical             | [6]        |            |
| Usada Tenung Tanyalara  | Asthma         | Oral                | [5]        |            |
| Usada Netra             | Fever          | Oral                | [7]        |            |
| Usada Upas              | Vomiting       | Oral                | [6]        |            |
| **Kaempferia galanga**  |                |                     |            |            |
| Usada Netra             | Stomachache    | Topical             | [7]        |            |
| Usada Upas              | Cough          | Oral                | [6]        |            |
| **Zingiber officinale** |                |                     |            |            |
| Usada Netra             | Stomachache    | Topical             | [7]        |            |
| Usada Rare              | Skin disease   | Topical             | [7]        |            |
| Usada Tenung Tanyalara  | Fever          | Oral                | [5]        |            |
| Usada Tiwas Punggung    | Cough          | Oral                | [6]        |            |
| **Boesenbergia pandurata** |            |                     |            |            |
| Usada Tenung Tanyalara  | Asthma         | Oral                | [5]        |            |

### Table 3. Antibacterial activity from Curcuma longa and Curcuma xanthorrhiza

| Plant Species          | Chemical Compounds                        | Bacterial Species          | Inhibition Zone (mm) | Types of Action | References |
|------------------------|-------------------------------------------|----------------------------|----------------------|-----------------|------------|
| **Curcuma longa**      | Alkaloids, tannins, flavonoids, curcumin, and essential oils | *Escherichia coli*         | 5.64±0.25            | Moderate        | [9]        |
|                        |                                            | *Shigella dysenteriae*     | 10.30                | Strong          | [10]       |
|                        |                                            | *Salmonella thyphir*       | 12.10                | Strong          | [11]       |
|                        |                                            | *Escherichia coli*         | 7                     | Moderate        | [12]       |
|                        |                                            | *Bacillus cereus*          | 16.30±0.90           | Strong          | [13]       |
|                        |                                            | *Shigella dysenteriae*     | 10                    | Moderate        | [14]       |
|                        |                                            | *Staphylococcus aureus*    | 12                    | Strong          | [15]       |
|                        |                                            | *Staphylococcus aureus*    | 28±1                  | Very Strong     | [16]       |
|                        |                                            | *Bacillus subtilis*        | 13                    | Strong          | [17]       |
|                        |                                            | *Escherichia coli*         | 27                    | Very Strong     | [18]       |
|                        |                                            | *Staphylococcus aureus*    | 20                    | Strong          | [19]       |
|                        |                                            | *Bacillus cereus*          | 12                    | Strong          | [20]       |
| **Curcuma xanthorrhiza**| Alkaloids, flavonoids, saponins, curcumin, and essential oils (Xanthorrhizol) | *Escherichia coli*         | 3.94±0.01            | Weak            | [9]        |
|                        |                                            | *Salmonella thyphir*       | 15.50                 | Strong          | [11]       |
|                        |                                            | *Bacillus cereus*          | 9.64±0.45            | Moderate        | [21]       |
|                        |                                            | *Staphylococcus aureus*    | 8                     | Moderate        | [22]       |
|                        |                                            | *Escherichia coli*         | 9.40±0.35            | Moderate        | [23]       |
|                        |                                            | *Klebsiella pneumoniae*    | 9.68±0.58            | Moderate        | [24]       |
|                        |                                            | *Streptococcus mutans*     | 4                     | Weak            | [25]       |
Table 4. Antibacterial activity from *Alpinia galanga*, *Zingiber cassumunar*, and *Kaempferia galanga*

| Plant Species            | Chemical Compounds                          | Bacterial Species       | Inhibition Zone (mm) | Types of Action | References |
|--------------------------|---------------------------------------------|-------------------------|----------------------|-----------------|------------|
| *Alpinia galanga*        | Alkaloids, flavonoids, saponins, and essential oils | *Escherichia coli*      | 7                    | Moderate        | [26]       |
|                          |                                             | *Bacillus subtilis*     | 16±4.60              | Strong          | [27]       |
|                          |                                             | *Staphylococcus aureus* | 27.21±0.21           | Very Strong     | [28]       |
|                          |                                             | *Escherichia coli*      | 10.34                | Strong          | [29]       |
|                          |                                             | *Bacillus cereus*       | 11.80±2.80           | Moderate        | [13]       |
|                          |                                             | *Bacillus cereus*       | 10.30                | Strong          | [30]       |
|                          |                                             | *Staphylococcus aureus* | 16.67±1.15           | Strong          | [31]       |
|                          |                                             | *Staphylococcus aureus* | 22.33±0.58           | Very Strong     | [32]       |
|                          |                                             | *Bacillus cereus*       | 13                   | Strong          | [20]       |
| *Zingiber cassumunar*    | Alkaloids, flavonoids, saponins, tannins, and essential oils | *Escherichia coli*      | 7.50                 | Moderate        | [33]       |
|                          |                                             | *Staphylococcus aureus* | 11.33±0.57           | Strong          | [34]       |
|                          |                                             | *Bacillus cereus*       | 12.76                | Strong          | [35]       |
|                          |                                             | *Salmonella thyphi*     | 8                    | Moderate        | [36]       |
|                          |                                             | *Staphylococcus aureus* | 16.68±2.78           | Strong          | [37]       |
|                          |                                             | *Escherichia coli*      | 6.93                 | Moderate        | [38]       |
| *Kaempferia galanga*     | Flavonoids, phenols (ethyl p-methoxy cinnamate), tannins, saponins, and essential oils | *Escherichia coli*      | 18.33                | Strong          | [39]       |
|                          |                                             | *Bacillus subtilis*     | 8.66                 | Moderate        | [40]       |
|                          |                                             | *Staphylococcus aureus* | 12                   | Strong          | [41]       |
|                          |                                             | *Porphyromonas gingivalis* | 18.87±1.99           | Strong          | [42]       |
|                          |                                             | *Escherichia coli*      | 9.80±1.60            | Moderate        | [43]       |
|                          |                                             | *Staphylococcus aureus* | 11                   | Strong          | [44]       |
|                          |                                             | *Bacillus cereus*       | 10±0.41              | Moderate        | [45]       |
|                          |                                             | *Staphylococcus aureus* | 11                   | Strong          | [31]       |

The cylinder method is a method that place a several-cylinder glass or stainless steel on the bacteria inoculated media. Each cylinder place to stand on the media and filled with the tested solution then incubated. Furthermore, bacterial growth will observe by measuring the inhibition zone around the cylinder. The well method is to make wells on the bacteria inoculated media. It adjusted with the number and position of wells due to the research objective. Each of well is filled by the tested solution then incubated. Right after, the bacterial growth will observe by measuring the inhibition zone around the well. The paper disc method is to soak a paper disc in the tested solution and placed on the bacteria inoculated media. Furthermore, bacterial growth will observe by measuring the inhibition zone around the paper disc. The strength of antibacterial activity from a compound can be seen from a diameter of the inhibition formed zone. Bigger diameter shows the stronger antibacterial activity. The category of antibacterial activity based on the diameter of the inhibitory zone consist of four types of action.

Based on tables 3, 4, and 5, the results of studies from the Zingiberaceae family can be categorized according to the level of its antibacterial activity. *Curcuma longa* has antibacterial activity with moderate, strong, and very strong responses.
| Plant Species       | Chemical Compounds                           | Bacterial Species          | Inhibition Zone (mm) | Types of Action | References |
|---------------------|---------------------------------------------|----------------------------|----------------------|-----------------|------------|
| Zingiber officinale | Flavonoids, phenols, saponins, and essential oils. | Escherichia coli          | 18                   | Strong          | [46]       |
|                     |                                             | Staphylococcus aureus     | 6                    | Moderate        | [47]       |
|                     |                                             | Bacillus subtilis         | 13.60±0.27           | Strong          | [48]       |
|                     |                                             | Escherichia coli          | 12.50±1.20           | Strong          | [13]       |
|                     |                                             | Salmonella thyphi         | 20                   | Strong          | [18]       |
|                     |                                             | Staphylococcus aureus     | 16                   | Strong          | [20]       |
|                     |                                             | Escherichia coli          | 10.56                | Strong          | [49]       |
|                     |                                             | Salmonella thyphimurium   | 8                    | Moderate        | [50]       |
|                     |                                             | Bacillus subtilis         | 6.05±0.05            | Moderate        | [51]       |
|                     |                                             | Streptococcus mutans      | 6                    | Moderate        | [25]       |
|                     |                                             | Staphylococcus aureus     | 10.30±0.07           | Strong          | [52]       |
|                     |                                             | Bacillus cereus           | 10.33±0.76           | Moderate        | [53]       |
|                     |                                             | Aggregatibacter actinomycetecomitans | 11.10                 | Strong          | [54]       |
| Boesenbergia pandurata | Essential oils (1,8-cineol, geraniol) | Bacillus cereus           | 14                   | Strong          | [20]       |
|                     |                                             | Streptococcus mutans      | 6.70                 | Moderate        | [55]       |
|                     |                                             | Streptococcus mutans      | 10.46±0.29           | Strong          | [56]       |
|                     |                                             | Streptococcus mutans      | 1.85                 | Weak            | [57]       |
|                     |                                             | Pseudomonas aeruginosa    | 13.85                | Strong          | [58]       |
|                     |                                             | Staphylococcus aureus     | 13.60                | Strong          | [59]       |
|                     |                                             | Streptococcus pyogenes    | 7                    | Moderate        | [60]       |

Curcuma xanthorrhiza has antibacterial activity with weak, moderate, and strong responses. Alpinia galanga has antibacterial activity with moderate, strong, and very strong responses.

Table 6. Category of antibacterial activity\cite{62}

| Type of Action | Inhibition Zone (mm) |
|----------------|----------------------|
| Weak           | <5                   |
| Moderate       | 5 – 10               |
| Strong         | 10 – 20              |
| Very Strong    | >20                  |

Zingiber cassumunar has antibacterial activity with moderate and strong responses. Kaempferia galanga has antibacterial activity with moderate and strong responses. Zingiber officinale has antibacterial activity with moderate and strong responses. Boesenbergia pandurata has antibacterial activity with weak, moderate, and strong responses. The difference in antibacterial activity caused by the type of bacteria that was inhibited which can be seen in table 7.

The result of literature studies from several research journals showed that the type of bacteria that was inhibited by compounds in the Zingiberaceae family are bacteria that cause digestive, respiratory, and skin infections so that shows the validity between traditional use from the Zingiberaceae family as an antibacterial

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based on Balinese local wisdom mediation method (*Usada*) with its scientific evidence.

### Table 7. The type of bacteria that was inhibited by Zingiber

| Bacterial Species | Types of Diseases          |
|-------------------|----------------------------|
| **Gram-Positive Bacteria** |                     |
| a. *Bacillus cereus* | Diarrhea                  |
| b. *Bacillus subtilis* | Diarrhea                  |
| c. *Staphylococcus aureus* | Diarrhea                |
| d. *Streptococcus mutans* | Dental decay             |
| e. *Streptococcus pyogenes* | Throat and skin infections |
| **Gram-Negative Bacteria** |                     |
| a. *Aggregatibacter actinomycetem comitans* | Periodontal diseases |
| b. *Escherichia coli* | Diarrhea                  |
| c. *Shigella dysenteriae* | Diarrhea                  |
| d. *Salmonella typhi* | Salmonellosis             |
| e. *Salmonella typhimurium* | Salmonellosis            |
| f. *Klebsiella pneumoniae* | Respiratory tract infection |
| g. *Porphyromonas gingivalis* | Periodontal diseases |
| h. *Pseudomonas aeruginosa* | Skin infection |

Gram-positive bacteria and gram-negative bacteria have different cell wall structures that affect their sensitivity to antibacterial. The difference is in the content of peptidoglycan and lipids from gram-positive and gram-negative bacteria. Gram-positive bacteria contain approximately 70% of peptidoglycan from the dry mass of cell wall which causes the cell wall thick and stiff and gram-negative bacteria contain approximately 10% of peptidoglycan from the dry mass of cell wall which causes the cell wall thinner. Moreover, gram-negative bacteria have porin proteins and high lipid levels. Porin proteins act as a pathway for the entry of active substances into bacterial cells. Active substances in the bacterial cell can damage the enzyme activity in the cell and causing cell damage. Meanwhile, high lipid levels in the bacterial cells potentially increase the permeability of active substances into cells.

The antibacterial activity of the Zingiberaceae family is caused by its secondary metabolites, such as alkaloids, flavonoids, polyphenols, saponins, tannins, and essential oils. Each compound has different inhibition mechanism. In general, the mechanism of antibacterial action compound is based on the bacterial structure and composition, such as an enzyme, nucleic acid, cytoplasmic membrane, and cell wall. If one of the structures and composition damage, it will be the beginning of the changes that cause cell death.

Essential oils act as antibacterial because they contain hydroxyl and carbonyl functional groups which are derivatives of phenol. Phenol derivatives will interact with bacterial cell walls, then absorbed and penetrated bacterial cells. This will cause the precipitation and denaturation of proteins that can lyse the bacterial cell membrane. Xanthorrhizol is an active compound from *Curcuma xanthorrhiza* essential oils that can affect cell wall morphology by attacking cell membrane, nucleic acid, and bacterial metabolism. Curcumin is an active compound from *Curcuma longa* rhizome which is polyphenols compound. Curcumin acts as an antibacterial by inhibiting the proliferation of bacterial cells. Alkaloids and flavonoids act as antibacterial by denaturing protein and then damage the bacterial cell wall. Saponins act as antibacterial by disturbing permeability of bacterial cell wall. Meanwhile, tannins act as antibacterial by damaging the bacterial cell membrane.

**CONCLUSION**

Based on the result of several studies shows the Zingiberaceae family mentioned in *Usada* Bali to treat digestive, respiratory, and skin diseases have been scientifically proved to have antibacterial activity with various inhibitions from weak to very
strong depended on the type of bacteria. So, it shows the validity as a traditional use as antibacterial based on Balinese local wisdom medication method (Usada) with its scientific evidence.

**CONFLICT OF INTEREST**
No conflict of interest in this paper. This paper was written independently without being affiliated by another party.

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