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A NARRATIVE REVIEW OF ZINGIBERACEAE FAMILY AS ANTIBACTERIAL 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 antibacterial 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 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 method of this literature review is the study of literature from several scientific publications in national and international journals about the antibacterial activity of the Zingiberaceae family. **Results:** Several studies showed that the Zingiberaceae family has an antibacterial activity with various inhibitions depended on the type of bacteria. **Conclusion:** The Zingiberaceae family mentioned in *Usada* Bali has been scientifically proved to have antibacterial activity, so it shows the validity as a traditional use as antibacterial based on *Usada* with its scientific evidence.

Keywords: Zingiberaceae, antibacterial, *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 antibacterial[3].

Antibacterial compounds are able to kill or inhibit bacterial growth or

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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 Cough Stomachache	Oral	[5]
	Usada Upas	Stomachache Fever	Topical Oral	[6]
	Usada Rare	Cough Diarrhea Stomachache	Oral	[7]
	Usada Taru Premana	Cough Diarrhea Skin disease	Topical Oral Topical	[8]
	Usada Tiwas Punggung	Stomachache	Topical	[6]
Curcuma xanthorrhiza	Usada Tenung Tanyalara	Fever Stomachache	Topical Oral	[5]
Alpinia galanga	Usada Rare	Fever Skin disease	Topical	[7]
	Usada Netra	Fever	Oral	[7]
	Usada Tenung Tanyalara	Skin disease Stomachache	Topical	[5]
	Usada Upas	Stomachache Cough	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]
Kaempferia galanga	Usada Tenung Tanyalara	Asthma Fever	Oral	[5]
	Usada Netra	Nausea Vomiting Stomachache Cough	Oral	[7]
	Usada Upas	Stomachache Cough	Oral	[6]
Zingiber officinale	Usada Netra	Stomachache	Topical	[7]
	Usada Rare	Fever Skin disease	Topical	[7]
	Usada Tenung Tanyalara	Fever Cough	Oral	[5]
	Usada Tiwas Punggung	Stomachache	Oral	[6]
Boesenbergia pandurata	Usada Tenung Tanyalara	Asthma Cough	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 dysentriae	10.30	Strong	[10]
		Salmonella thypi	12.10	Strong	[11]
		Escherichia coli	7	Moderate	[12]
		Bacillus cereus	16.30±0.90	Strong	[13]
		Shigella dysentriae	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 thypi	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]

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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 thypi	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[61].

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[62].

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.

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Tabel 5. Antibacterial activity from *Zingiber officinale* and *Boesenbergia pandurata*

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 thypi	20	Strong	[18]
		Staphylococcus aureus	16	Strong	[20]
		Escherichia coli	10.56	Strong	[49]
		Salmonella thypimurium	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 actinomycetem-comitans	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[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 medication 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 dysentriae*	Diarrhea
d.	*Salmonella thypi*	Salmonellosis
e.	*Salmonella thypimurium*	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[23].

The antibacterial activity of the Zingiberaceae family is caused by its secondary metabolites, such as alkaloids, flavonoids, polyphenols, saponins, tannins, and essential oils[23]. Each of 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[10]. 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[23]. 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[10]. 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[54]. Meanwhile, tannins act as antibacterial by damaging the bacterial cell membrane[23].

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

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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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