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Research article

Effectiveness of ginger extract (Zingiber officinale Rosc) on reducing oral odor levels (Halitosis)

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Abstract: Bad breath (halitosis) is a common problem that often results from the decaying action of microorganisms on endogenous or exogenous proteins and peptides. Some factors that cause bad breath (halitosis) are smoking, alcohol consumption, diabetes, obesity, and periodontal disease. Ginger (Zingiber officinale Rosc.) is one of Indonesia's medicinal commodities and spices included in traditional medicine. Ginger contains compounds such as antimicrobials from the phenol group, flavonoids, terpenoids, and essential oils, a class of bioactive compounds that ginger can inhibit microbial growth. To determine the role of ginger extract (Zingiber officinale Rosc.) in reducing halitosis levels in Hasanuddin University dental students in Makassar City, South Sulawesi. The design of the research is Experimental. This research obtained a sample of 45 respondents. Data collection using Consecutive Sampling. Data processing and analysis techniques were performed with the Independent Sample T Test. The results showed a significant difference in halitosis values between before and after gargling with 2%, 4%, and 6% ginger concentration solutions; the most effective concentration to reduce halitosis levels was 6% ($p<0.05$). Ginger extract (Zingiber officinale Rosc.) can cause a decrease in oral odor (halitosis) levels.

Keywords: *Halitosis, Oral odor, Ginger (Zingiber officinale Rosc.)*

INTRODUCTIONS

Halitosis is a common problem that manifests as an unpleasant and bothersome odor emanating from the mouth. The unpleasant odor is mainly due to the decaying action of microorganisms on endogenous or exogenous proteins and peptides. *Halitosis* is an unpleasant condition affecting many of the human population. It often results in nervousness and social difficulties, such as a lack of confidence to approach and talk to others. Halitosis has become a concern for a

large proportion of the population. It is a complex problem to diagnose due to multi-factorial causes. [2] Halitosis affects approximately 15% to 60% of the human population worldwide.

The causes of pathological halitosis are diverse but can be classified as extra-oral and intra-oral halitosis. Factors contributing to halitosis include periodontal disease, dry mouth, smoking, alcohol consumption, dietary habits, diabetes, and obesity. Halitosis can also be affected by general body hygiene (i.e., dehydration, starvation, and high physical activity), advanced age, bleeding gums, decreased brushing frequency, and stress. [1]

Volatile Sulfur Compounds (VSCs) are found in the gingival crevice and are released mainly from deep periodontal pockets and where there is attachment loss. Volatile sulfur compounds (VSCs), such as hydrogen sulfide (H2S) and methyl mercaptan (CH3SH), are mainly responsible for the odor associated with intraoral halitosis. Dimethyl sulfide ([CH3]2S) is mainly associated with cases of extra-oral halitosis. The formation of VSCs in the oral cavity results from the degradation of organic substrates by anaerobic bacteria and may be influenced by saliva secretion, reduced oxygen concentration, and bacterial metabolism. The microflora of the tongue coating is thought to play an essential role in intra-oral halitosis, but the exact microbiological causative factor of intra-oral halitosis remains unclear.

A recent study showed that the metabolic profile of the tongue-coating microbiome of patients with intra-oral halitosis was significantly different from that of healthy controls. Branched-chain fatty acids (BCFAs), 3-fumaryl pyruvate, and acetyl phosphate are potential essential substances in intra-oral halitosis, with BCFAs, the primary metabolites in intra-oral halitosis, shown to underlie tongue coating formation possibly. In addition, acetyl phosphate has clear links to H2S-producing metabolic pathways and anaerobic metabolism. Evidence for the possible role of Candida species in intra-oral halitosis is conflicting, with some authors reporting a positive correlation between VSC measurements and Candida culture test results, whereas others report no association between Candida presence and oral halitosis.

Ginger (Zingiber officinale Roscoe) is one of Indonesia's medicinal commodities and spices included in traditional medicine. The use of ginger as a

medicinal plant in Indonesia has grown rapidly over time with the development of natural ingredients for treatment. Ginger contains anti-microbial compounds from the phenol, flavonoid, terpenoid, and essential oil groups, which are bioactive compounds that can inhibit microbial growth. Ginger also has active substances such as essential oils and gingerol, which have physiological actions and inhibit the development of microorganisms such as bacteria and fungi. Essential oils amount to 0.6%, 0-3% have antiseptic effects, and gingerol is ginger's most critical anti-oxidant active substance. Gingerol is a class of phenols that have the most effect as antibacterial and anti-fungal. According to research, ginger concentrations of 2%, 4%, and 6% provide practical anti-fungal and antibacterial effects against *Candida albicans*, *Streptococcus mutans*, and *Enterococcus faecalis*.[34]

Based on the efficacy of ginger as an antibacterial and anti-fungal, the author assumes that ginger likely reduces halitosis levels. The author proposes a study on the effectiveness of Ginger extract (Zingiber officinale Rosc.) in reducing levels of Oral Odor (Halitosis).

METHODS

This research is a type of quasi-experiment research with the design used as a Pre-Test and Post-Test. The research sample comprised 45 female students of the Faculty of Dentistry at Hasanuddin University. The sampling method used was Consecutive sampling. Inclusion Criteria: 19-year-old women and men with no caries and intraoral and systemic diseases. The samples must not use prostheses/orthodontic devices, not eat food 2 hours before treatment, and be prohibited from fasting during the research. Respondents who are not willing to participate are exclusion criteria. Independent variable: Ginger Extract 2%, 4% and 6%. Effect variable: Amount of Volatile Sulfur Compound. Confounding variables: OH, oral flora, and food consumption treatment. Assessment Criteria of the effectiveness of ginger used in this study use a breath checker tool. A breath checker is a tool that can measure a person's breath odor by interpreting a person's halitosis on a scale of 0-4.

Table 1. Breath Checkers Baseus Assessment Criteria

Code	Criteria
0	No halitosis
1	Normal
2	Slight Halitosis
3	Moderate halitosis
4	Strong halitosis

MATERIALS AND METHOD

Breath checker (Baseus), handscoon (surgical gloves), plastic cup, measuring cup, stationery, masks, glass jar, rotary evaporator, aquades, and ginger. Research procedures in this study are:

Preparation of Ginger Extract Solution

The research stage to examine the effectiveness of consuming ginger extract solution to reduce halitosis is as follows:

1. Prepare 500 grams of ginger
2. Ginger washed and cleaned from the skin
3. Then the ginger is pulverized by grating
4. Then put it in a glass jar, put ethanol two liters, and keep it for one day.
5. Then, put it into a rotary evaporator to extract and separate the ethanol and ginger substances.
6. After that, put in aquadest; each extract contains 100 ml of aquades bottle. The first bottle contains 2 ml of ginger extract, the second bottle contains 4 ml of ginger extract, and the third bottle contains 6 ml of ginger extract. A ginger extract solution with a concentration of 2%, 4%, and 6% is formed in this process.

Sampling Procedure

Before each data collection, the sample was asked to avoid eating, drinking, brushing teeth, and gargling for two hours before data collection.

1. Prepare tools and materials.
2. The sample was given a brief explanation of the purpose and objectives of the study and signed an informed consent.

3. Before conducting the study, the sample was instructed not to eat and drink for 2 hours before the study.
4. Prepare ginger extract solution with 2% concentration
5. The sample was asked to blow through the mouth of the breath checker for 15 seconds. After that, record the score of the breath checker before the ginger extract solution treatment, which is recorded as the pretest score.
6. Then prepare a ginger extract solution with a concentration of 2%.
7. The sample was instructed to gargle with the solution for 15 seconds.
8. After that, the sample was instructed again to blow the breath checker through the mouth, and then the score of the breath checker was re-recorded after the treatment (posttest).
9. Prepare ginger extract solution with 4% concentration
10. The sample was asked to blow through the mouth of the breath checker for 15 seconds. After that, record the score of the breath checker before the ginger extract solution treatment, which is recorded as the pretest score.
11. Then prepare ginger extract solution with a concentration of 4%.
12. The sample was instructed to gargle with the solution for 15 seconds.
13. After that, the sample was instructed again to blow the breath checker through the mouth, and then the score of the breath checker was re-recorded after the treatment (posttest).
14. Prepare ginger extract solution with 6% concentration
15. The sample was asked to blow through the mouth of the breath checker for 15 seconds. After that, record the score of the breath checker before the ginger extract solution treatment, which is recorded as the pretest score.
16. Then prepare a ginger extract solution with a concentration of 6%.
17. The sample was instructed to gargle with the solution for 15 seconds.
18. After that, the sample was instructed again to blow the breath checker through the mouth, and then the score of the breath checker was re-recorded after the treatment (*posttest*).

RESULTS

Characteristics of sample

This study conducted research on the Effectiveness of Ginger Extract (*Zingiber Officinale Rosc*) in Reducing Oral Odor Levels (Halitosis). This research is a type of quasi-experiment research with the design used as a Pre-test and Post-test. The characteristics of respondents based on gender are as follows.

Table 2. Frequency Distribution of Respondents Based on Gender

Gender	Frequency	Percentage (%)
Male	16	35,6
Female	29	64,4
Total	**45**	**100,0**

Frequency Distribution of Pre-test and Post-test after treatment with ginger extract concentrations of 2%, 4% and 6% based on Halitosis Category

Based on the study results, there were pre-test and post-test halitosis levels with ginger water gargle treatment with a concentration of 2%, 4%, and 6% conducted on 45 respondents with these three treatments. The frequency distribution based on the value of the breath checker scale 0 = No VSCs odor, 1 = Normal Odor, 2 = Less Halitosis, 3 = Moderate Halitosis, and 4 = Strong Halitosis.

Table 3. Frequency Distribution of Pre-test and Post-test with 2%, 4%, and 6% Concentration

Scale Breath Checker	2% Solution Concentration				4% Solution Concentration				Solution Concentration 6%			
	Pre-test	%	Post-test	%	Pre-test	%	Post-test	%	Pre - test	%	Post-test	%
No no VSCs odor	0	0	9	60	0	0	10	66,7	0	0	12	80
Normal Odor	0	0	6	40	0	0	5	33,3	0	0	3	20
Less halitosis	0	0	0	0	0	0	0	0	0	0	0	0
Halitosis Medium	5	33,3	0	0	5	33,3	0	0	4	26,7	0	0
Halitosis Strong	10	66,7	0	0	10	66,7	0	0	11	73,3	0	0
Total	**15**	**100**	**15**	**100**	**15**	**100**	**15**	**100**	**15**	**100**	**15**	**100**

Source: *IBM SPSS Statistical Output Version 24, 2023*.

Table 2 shows that at a concentration of 2% solution before treatment, ten people had a strong halitosis category with a percentage of 66.7%, and five people had a moderate halitosis category with a percentage of 33.3%. Then, after the intervention of ginger mouth rinse solution with a concentration of 2% was given, nine people had a category of No VSCs odor with a percentage of 60%, and six people with a normal odor category with 40%.

At a concentration of 4%, before treatment, ten people had a strong halitosis category with a percentage of 66.7%, and five people had a moderate halitosis category with a percentage of 33.3%. Then, after the intervention of ginger mouthwash solution with a concentration of 4% was given, ten people had the category no odor of VSCs with a percentage of 66.7%. Moreover, five people have a normal odor category with a percentage of 33.3%.

At a concentration of 6%, before treatment, 11 people had a strong halitosis category with a percentage of 73.3%, and four people had a moderate halitosis category with a percentage of 26.7%. Then, after the intervention of ginger mouthwash solution with a concentration of 6% was given, 12 people had the category No odor of VSCs with a percentage of 80%, and three people had a normal odor category with a percentage of 20%. Difference between *Pre-Test* and *Post-Test* Halitosis Mean Values of Gargling with Ginger Solution at 2%, 4% and 6% Concentration.

The difference in the average value of halitosis is used to determine the value before (pre-test) and after (post-test) given a solution concentration of 2%, 4%, and 6%. There is also a difference in the average value, which can be seen in the following table:

Table 4. Frequency distribution of pre-test and post-test halitol categories with 2%, 4%, and 6% Concentration

Concentration	Group	Mean	*P-Value* (Sig.)
2%	Before	3,67	**0,000***
	After	0,40	
4%	Before	3,67	**0,000***
	After	0,33	
6%	Before	3,73	**0,000***
	After	0,20	

Table 5.3 shows the difference in the average value of overall halitosis before and after being given the intervention of gargling with ginger solution with a concentration of 2%, 4%, and 6%. As contained in Table 5.3, it can be explained that the value of halitosis before being given the intervention, the average value is 3.67. However, after being given the intervention of gargling with 2% ginger solution, the average value of halitosis decreased to 0.40.

At 4% concentration, it can be explained that the halitosis value before the intervention was given an average value of 3.67. However, after the intervention of gargling with 4% ginger solution, the average halitosis value decreased to 0.33.
At a concentration of 6%, it can be explained that the value of halitosis before the intervention was an average value of 3.73. However, after the intervention of gargling with 6% ginger solution, the average halitosis value decreased to 0.20.

Based on the statistical test results, each concentration obtained a p-value of $0.000 < \alpha$ (0.05). This shows a significant difference in halitosis value before gargling with 2%, 4%, and 6% concentration solution and after gargling with a ginger solution with 2%, 4%, and 6% concentration.

DISCUSSION

The main components of halitosis are volatile sulfide compounds (VSCs), mainly hydrogen sulfide (H2S), methyl mercaptan (CH3SH), and dimethylsulfide [(CH3)2S1. VSCs have been considered the main compounds responsible for halitosis originating from the oral cavity. However, amines (cadaverine, putrescine, and indole) and short-chain fatty acids (isobutyric and isovaleric acids) also contribute to halitosis. VSCs include hydrogen sulfide, methyl mercaptan, and dimethyl sulfide and produce different kinds of unpleasant odors. Methyl mercaptan is believed to be the most malodorous compound and has been shown to correlate closely with organoleptic ratings. VSCs are generated through enzymatic modification of sulfur-containing amino acids (cysteine and methionine), which become available after proteolytic degradation of proteins. Both processes mainly involve anaerobic Gram-negative bacteria located on the tongue surface, in the interproximal region, and at subgingival sites within the oral cavity. [20]

At this time, a highly sensitive and specific gas chromatographic method was adapted to measure volatile sulfur compounds in saliva and breath directly. Initial studies with saliva were developed. With the addition of substrate and enzyme inhibitors, it was determined that VSC was the primary substance responsible for the foul odor of decomposing saliva. In the 1970s, gas chromatography was the most sensitive instrument used in clinical research. Gas chromatography made it possible to directly identify and measure the individual VSC components (H2S - hydrogen sulfide, CH3SH methanethiol, and CH3SCH3-dimethylsulfide) in halitus. [22]

This results in the release of volatile sulfur compounds (VSCs). Oral microbiota have been investigated as bacteria play a crucial role in halitosis. Oral micro-biota associated with halitosis are predominantly Gram-negative anaerobes, as their final metabolic product is volatile sulfur compounds (VSCs). The tongue coating comprises concentrated saliva, bacteria, exfoliated epithelial cells, food debris, and debris on the tongue dorsum. The tongue coating is also responsible for halitosis, and anatomical variations of the tongue, such as chapped tongue, hairy tongue, and ulcerated tongue, can contribute to worsening halitosis. [22]

Ginger (Zingiber officinale Rosc.) is a spice plant that is widely used throughout the world. Besides being used in food and beverages, ginger has anti-inflammatory, analgesic, antipyretic, and antibacterial effects. Ginger can inhibit growth in pathogenic bacteria, such as Staphylococcus aureus, Streptococcus viridans, Bacillus cereus, and Salmonella. Elephant ginger (Z. officinale var. Officinarum) contains essential oils that may be antibacterial. Essential oils consist of active compounds, such as *β-farnesene, β-Bisabolene, zingiberene, sesquiphellandrene, zingerone, oleoresin, kamfena, limonene, borneol, sineol*, *citral, zingiberol, felandren*, vitamins A, B, and C, as well as *flavonoids* and *polyphenols*. These active compounds work by disrupting the coagulation process of bacterial cells and damaging the plasma membrane of bacterial cells. [21]

The gingerol content of red ginger is higher than that of other ginger. Ginger's characteristic smell and aroma come from a mixture of *zingerone, shogaol,* and volatile oil compounds with a range of 1-3% in fresh ginger. *Zingeron* has a lower pungency and gives a sweet taste. The pungency of ginger is due to the

presence of *non-volatile phenylpropanoid derivatives* such as *gingerol* and *shogaol.* These phenolic components contribute to the flavor of ginger. Gingerol is very unstable in the presence of heat and, at high temperatures, will turn into *shogaol.*

Some plants can be used as alternatives to treat halitosis conditions, namely plants that contain essential oils. Research by Pangesti et al. (2018) explained that essential oils effectively reduce halitosis conditions. The essential oil in question is lipophilic in liquid form and derived from plants. The content causes a bactericidal effect that can cause plaque reduction and gingivitis from halitosis. Gingerol has an antibacterial activity on the mouth and gums (Miri, Bae, and Lee, 2008). Flavonoids are antibacterial and anti-fungal, so they are used as natural antibiotic drugs (Duke, 2000).

Ginger is an herbal plant with chemical compounds beneficial in various disease treatments, such as anti-inflammatory, gastroprotective, and anti-ulceration. These effects are caused by bioactive components contained in ginger, such as zingerone, zingiberenes, gingerols, and shogaol. Flavonoids can interfere with bacterial cell integration or can damage bacterial cell membranes by causing bacterial cell walls to be damaged so that nucleotides and amino acids come out and prevent the entry of other active ingredients needed by bacteria into cells, which can cause bacteria to lysis or die.

Terpenoids can interfere with the formation of bacterial cell walls by interfering with the entry of essential ions in bacterial cells, and terpenoids can bind to fats and carbohydrates, which will cause the permeability of the bacterial cell wall to be disrupted. Phenols can damage the bacterial cell wall into lysis by denaturing proteins in bacteria, so bacterial cells will experience damage due to a decrease in the permeability of the bacterial cell wall, which causes cell growth to be inhibited, and bacterial cells will experience death. Essential oils can interfere with forming bacterial cell walls using essential oils, which can cause bacterial cell membranes to be hypertonic, inhibiting the preparation of bacterial cell walls so that cells are only limited by thin cell membranes. [23]

Overall, the results showed that red ginger water can reduce the level of VSCs in samples with various concentrations. This suggests that red ginger water can be used as an alternative treatment for halitosis. However, further studies with

more samples and more controlled research methods are needed to confirm these results.

Studies on the effectiveness of ginger extract (Zingiber officinale Rosc) in reducing halitosis levels have been conducted by several researchers. These studies revealed that ginger can help reduce halitosis through several mechanisms. One study conducted by researchers in India showed that ginger can reduce halitosis by inhibiting the growth of bacteria that cause halitosis. Ginger contains compounds such as gingerol, shogaol, and zingerone that have antibacterial properties. These compounds can kill halitosis-causing bacteria such as Streptococcus mutans, Prevotella intermedia, and Porphyromonas gingivalis. Another study conducted in Japan showed that ginger can also help improve digestive system function and prevent halitosis caused by stomach acid. Ginger can help stimulate the production of digestive enzymes and help reduce excessive stomach acid production.

A study by Nuraini et al. (2019) showed that ginger extract can significantly reduce halitosis levels after seven days of use. The study was conducted on 25 people with halitosis, divided into two groups. The first group was given ginger extract applied to the gums for seven days, while the second group was given a placebo. The results showed that the group given ginger extract experienced a significant decrease in halitosis levels compared to the placebo group. According to Refika et al. (2021), previous research stated that the administration of red ginger decoction extract (Zingiber officinale Rosc.) at a concentration of 10%.[30]

Research conducted by Widhi (2015) has a relationship between red ginger extract and bacteria that cause halitosis. The study states that the bacteria that cause halitosis, namely Streptococcus mutans and Staphylococcus aureus, which are aerobic bacteria that increase acid and by-products in the form of alcohol, which is a means of halitosis can be inhibited by the presence of red ginger extract (Zingiber officinale Rosc.) which contains essential oil with a total inhibitory value. The higher the concentration obtained, the higher the total inhibition value[31] .

In another study, according to Jung and Nam (2014), adding red ginger extract (Zingiber officinale Rosc.) in vitro can reduce the production value of hydrocarbons from lipid links that cause the lipid oxidation process of these hydrocarbons. Oxidized hydrocarbons can cause an increase in the value of 1-

propanol, heptanal, hexanal, pentanal, and 2-butanone, which causes the origin of the increased value of Volatile Sulfur Compounds (VSCs). Previous research also mentioned that the presence of red ginger extract contained metabolites that significantly suppressed the value of Volatile Sulfur Compounds (VSCs) when compared to untreated, which produced one of its by-products in the form of aldehydes, ketones and alcohols whose results were not very significant with a value of $p < 0.05$. [32]

Red ginger (Zingiber officinale Rosc.) has secondary metabolites such as terpenoids and phenols that can destroy the walls and damage the metabolism of bacteria that cause halitosis. In addition, ginger can also help improve blood circulation and help neutralize microbes. Good oral care (such as brushing teeth, cleaning the tongue, and gargling with mouthwash) is also critical to maintain oral health and prevent halitosis.

Overall, the results showed that ginger extract can reduce halitosis levels through several mechanisms, such as inhibiting the growth of halitosis-causing bacteria and improving digestive system function. Red ginger (Zingiber officinale Rosc.) also has secondary metabolites such as terpenoids and phenols that can destroy the walls and damage the metabolism of bacteria that cause halitosis. However, further research is needed to evaluate the effectiveness of ginger in treating halitosis in humans.

CONCLUSION

1. Ginger extract (Zingiber officinale Rosc.) can cause a decrease in halitosis levels,
2. Ginger extract concentration (Zingiber officinale Rosc.), which is effective in reducing halitosis levels, is a concentration of 6% ($p<0.05$).

SUGGESTIONS

1. It is recommended that further research be carried out to determine the effectiveness of ginger in reducing halitosis with more samples, different methodologies, and different concentration variants.
2. The need for research with adequate samples and selection to get good results.

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