# Formulation and Testing of Ethanol Extract Ointment Preparation of Red Ginger (Zingiber Officinale Rhizoma) as Antidiabetic Foot

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**Abstract.** Diabetes Mellitus is a globally prevalent metabolic disease, with cases rising yearly. Currently, approximately 171 million individuals worldwide are affected, and projections suggest this will reach 366 million by 2030. Among them, 15–20% experience diabetic foot ulcers, with around 15% of these cases resulting in amputations annually in the United States. This study investigates the formulation stages and methods for creating an ethanol-based red ginger (Zingiber officinale) extract ointment intended for diabetic foot treatment. The research utilized a digestion maceration method, followed by comprehensive ointment evaluation, including pH, stability, organoleptic properties, spreadability, adhesion, homogeneity, and viscosity testing. The findings aim to contribute to alternative therapeutic options for diabetic foot management.

**Keywords:** Red ginger, Diabetes mellitus, Antidiabetic foot

## 1 Introduction

Diabetes mellitus (DM) is a significant global health concern. According to the International Diabetes Federation (IDF), the worldwide prevalence of diabetes has reached approximately 1.9%, making DM the seventh leading cause of death globally. In Indonesia, the Basic Health Research (Riskesdas) data from 2021 reported a DM prevalence of 2.1% among individuals over 15 years of age, with Semarang being one of the cities most affected, listing DM as the second most common non-communicable disease following hypertension. At Kedungmundu Public Health Center alone, DM cases reached 3,165 in 2021 [5].

Globally, the World Health Organization (WHO) reported that 8.5% of adults over 18 live with DM, with 1.5 million deaths in 2019 attributed to this condition and a significant portion of these deaths occurring before age 70. In 2021, IDF and WHO estimated that 537 million adults (aged 20-79), or roughly 1 in 10, live with DM, a number projected to rise. Among the most impacted countries, Indonesia ranks fifth, with an estimated 19.47 million people diagnosed with DM (World Health Organization, 2021).


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Diabetes mellitus leads to various severe complications, including diabetic foot ulcers (DFUs), which are highly susceptible to infections. These infections, caused by common pathogens like Staphylococcus aureus and Pseudomonas aeruginosa, significantly delay healing and often lead to limb amputations. Studies have shown that diabetic foot infections are among the most serious and common complications for DM patients, contributing to increased hospitalization and mortality rates [13].

In traditional medicine, red ginger (Zingiber officinale) has shown potential therapeutic effects for DM due to its active compounds with anti-inflammatory and antioxidant properties. The phenolic content in red ginger can reduce oxidative stress and inflammation, which are critical in DM management and complications like DFUs. Red ginger has been associated with improved insulin sensitivity, potentially aiding in blood sugar regulation [5].

This study aims to develop an ethanol-based red ginger extract ointment for diabetic foot care, exploring its production process and evaluating its effectiveness in managing diabetic foot complications. This research intends to contribute to alternative DM management solutions and examine red ginger's efficacy as an accessible, herbal-based intervention for diabetic patients with foot ulcers.

## 2 Literature Review

Ginger in Indonesia consists of three main types, namely elephant ginger, emprit ginger, and red ginger. Red ginger in particular is widely used in traditional medicine because of its high content of gingerol and shogaol, which provides a spicy taste as well as pharmacological effects such as anti-inflammatory, analgesic, and antifungal [11]. Ginger is a versatile spice that is used in a variety of sectors, from cooking to cosmetics. The production and trade of ginger as a raw material continue to increase, especially in the traditional medicine and food/beverage industries [7]. Indonesia is among the top five ginger-exporting countries in the world, with exports increasing by an average of 32.75% per year [14]. The main chemical content of red ginger includes flavonoids, phenols, essential oils, and tannins. Flavonoids function as antioxidants that help reduce inflammation and the risk of coronary heart disease, making them important in increasing life expectancy [7].

The ointment is a semi-solid preparation that is easy to apply for topical use, where the active ingredient is dissolved or dispersed homogeneously in a suitable ointment base. Ointment formulations, usually fat-in-oil or oil-based formulations with water-in-oil or oil-in-water emulsifiers, can improve skin hydration occlusively. The main advantage of this preparation is its ability to exert a direct effect on local networks [12]. The ointment is used in the treatment of acute or chronic skin conditions for the penetration of the drug into the skin layers, providing the desired topical or systemic effect. This shape is preferred because it is easy to use, provides a softening and emollient effect, and maintains skin moisture [9]. The preparation also protects the skin from mechanical, heat, and chemical irritants and is stable in use and storage [2].

Diabetes mellitus (DM) remains a major health problem in modern society, with nearly half a billion people diagnosed with DM this year, and it is expected to reach 300 million people by 2025 [6]. One of the serious complications of diabetes is diabetic foot infection (IKD), which occurs due to the invasion of micro-organisms in body tissues, especially in the distal area of the foot malleolus. Predisposing factors that exacerbate this condition include neuropathy, vasculopathy, immunopathy, and foot biomechanical disorders [6]. IKD is closely related to high morbidity, decreased physical function, and quality of life of patients and is often the main cause of lower limb amputation in diabetics. The treatment of this infection requires proper diagnosis, selection of appropriate antibiotics, and planned surgical intervention [8]. Diabetic foot infections are often caused by both gram-positive and negative bacteria, with Staphylococcus aureus and Pseudomonas aeruginosa being the most commonly found bacteria [13]. Diabetic foot infections also increase the risk of amputation, with amputation rates in diabetic patients about 10 to 20 times higher than in the non-diabetic population. Over the past decade, the incidence of amputation in people with diabetes has ranged from 1.5 to 3.5 per 1000 people per year [4].

Staphylococcus aureus and Pseudomonas aeruginosa bacteria. Staphylococcus aureus is a bacterium that causes a variety of diseases with characteristic signs, such as inflammation and abscess formation. These infections can vary from mild conditions on the skin to serious illnesses, such as endocarditis, bacteremia, and pneumonia. One of the main problems in treatment is resistance to antibiotics, such as Methicillin Resistant Staphylococcus Aureus (MRSA) and Vancomycin Resistant Staphylococcus Aureus (VRSA), which complicate the handling of infections [3]. S. aureus can also colonize human skin and nose, and infection can occur through wounds or direct contact. Pseudomonas aeruginosa is a gram-negative bacterium that is often the cause of nosocomial infections, especially in patients with weakened immune systems. These bacteria are able to form biofilms, adapt to low-nutrient conditions, and survive at various temperatures, so they are often found in hospital medical equipment. P. aeruginosa infection can cause cystic fibrosis, respiratory tract infections, urinary tract infections, and wound infections, which pose challenges in treatment [9].

## 3 Methods

This research was carried out starting February 2024 at the FKKGIK UNPRI Laboratory. The instruments used include digital scales, magnetic stirrers, flasks, and hotplates, while the main ingredients include red ginger extract (Zingiber Officinale Rhizoma), solid paraffin, yellow vaseline, beeswax, stearyl alcohol, propyl paraben, and various other additives. The research method began with the manufacture of simplisia, in which red ginger was dried, sorted, and crushed into powder. Furthermore, the extraction is made through maceration of red ginger powder with 96% ethanol, which is then heated, filtered, and evaporated until a thick extract is obtained. Red ginger ointment preparations are formulated in four different bases: hydrocarbon, absorption, water-absorbent ointment,

and water-washable ointment, each with a customized composition and heating method. Evaluation of the preparation is carried out through a variety of tests, including pH, stability, organoleptic, dispersion, adhesion, homogeneity, and viscosity tests, to ensure the quality and stability of the resulting ointment.

## 4 Results

**Results of pH Test of Red Ginger Extract Ointment Formulation I** The pH test was carried out to ensure the safety of the ointment according to the pH of the skin (4.5–6.5), using red ginger extract (1%) as an antioxidant, paraffin, vaseline, beeswax, stearyl alcohol, and propyl paraben. The pH value of 6 indicates the safety of the product for the skin of diabetics.

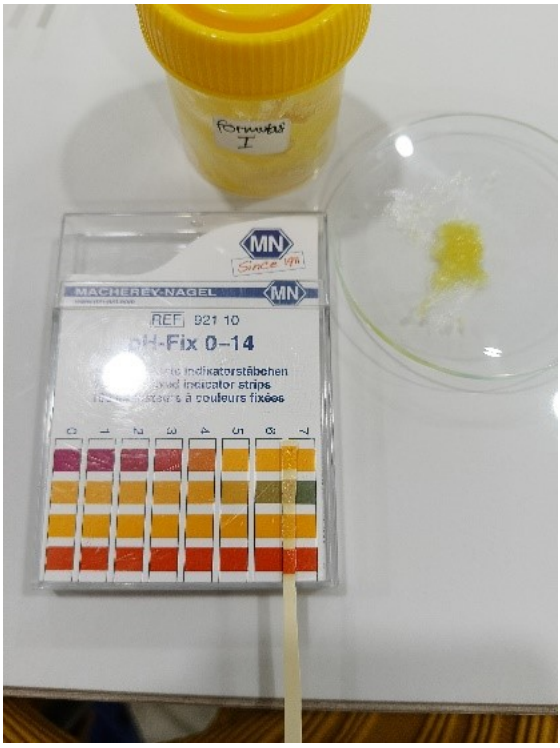


**Fig. 1.** Formulation I pH Test Results

Formulation II The main ingredients include red ginger (1%), adeps lanae, stearyl alcohol, beeswax, vaseline, and aquaades. The pH test on this formulation also produces a value of 6, in accordance with the skin pH standard, so it is safe to use.


**Fig. 2.** Formulation II pH Test Results

Formulation III The combination of red ginger extract, sodium lauryl sulfate, stearyl alcohol, propylene glycol, Vaseline, and aquaades results in a pH of 6, suitable for the skin. This formulation provides a protective effect without causing irritation

Formulation IV Contains red ginger (1%), PEG 4000, and PEG 400. The test showed a pH of 6, confirming the product's compatibility with the skin's natural pH and ensuring user comfort.

**Organoleptic Test Results**

Organoleptic testing on red ginger extract ointment assesses the shape, aroma, and color of various formulations:

The results of these organoleptic tests show that formulation variations provide a noticeable difference in consistency or viscosity, while aroma and color tend to be uniform across formulations.

### 4.1 Dispersion Test Results

The ointment spreadability test aims to measure the ability of the ointment to spread when subjected to a certain pressure, which is important for consistency and comfort of use. A total of 0.5 grams of ointment is placed in a petri dish,

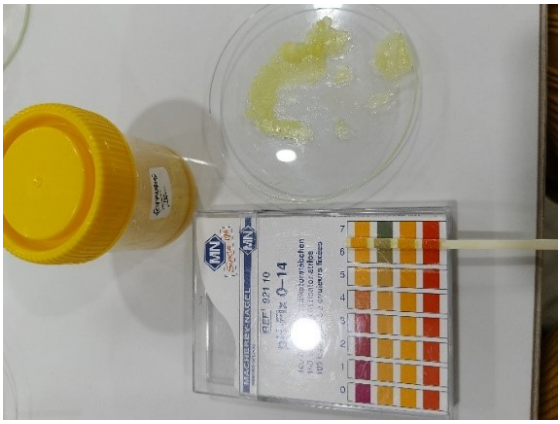


**Fig. 3.** Formulation III pH Test Results


**Fig. 4.** Formulation IV pH Test Results

**Table 1.** Organoleptic Test Results

| Shape | Organoleptic Test Results |
|---|---|
| **Formulation 1** | Thick and thick |
| **Formulation 2** | Thick |
| **Formulation 3** | Viscous but watery |
| **Formulation 4** | Overcrowded |
| **Construction** | All red ginger flavored formulations |
| **Color** | All formulations are yellow |

then covered with a gradual weighting ranging from 50 to 250 grams. After one minute, the diameter of the spread is measured. Based on [14], the ideal spread power ranges from 5-7 cm.

**Table 2.** Dispersion Test Results

| Formulation | Spread Test Results |
|---|---|
| I | 4.5 cm |
| II | 5 cm |
| III | 5 cm |
| IV | 2.5 cm |

### 4.2 Homogeneity Test Results

The homogeneity test ensures an even distribution of ingredients in the ointment without coarse particles, following the method from the research of Rinaldi [10]. Each formulation is tested by applying it evenly on the glass surface, and then samples are taken from the top, middle, and bottom to ensure the consistency of the composition of the active and excipient ingredients, which is essential for the effectiveness of the ointment. The following are the results of homogeneity tests for each formulation.

### 4.3 Viscosity Test Results

Testing the viscosity of red ginger extract ointment using a digital viscometer yielded the following data: Formulation 1: Has a low viscosity with a torque of 37.0%, showing sufficient consistency but thinner than other formulations.

**Antibacterial Test Results**


**Fig. 5.** Formulation 2: Viscosity increased to 1775 mPa.s with 44.4% torque, resulting in a more concentrated consistency.


**Fig. 6.** Formulation 3: Highest viscosity of 1792 mPa.s and torque of 44.8%, indicating good stability for optimal dispersion.


**Fig. 7.** Formulation 4: Not measurable (over), indicating viscosity is too high for topical application and requires adjustment.


**Fig. 8.** These results show that the viscosity variation between formulations with Formulation 4 requires re-evaluation.

**Table 3.** Homogeneity Test Results

| Formulation | Homogeneity Test Result |
|---|---|
| Formulation 1 | Homogeneous |
| Formulation 2 | Homogeneous |
| Formulation 3 | Homogeneous |
| Formulation 4 | Homogeneous |

Antibacterial tests on Staphylococcus aureus and Pseudomonas aeruginosa showed that formulation 3 had the highest inhibitory zone in both bacteria and in both replicates. In Staphylococcus aureus, formulation 3 yielded an inhibition zone of 21.64 mm on the first repeat and 21.23 mm on the second replicate, which was higher than the positive comparator of chloramphenicol ointment with 8.32 mm

For Pseudomonas aeruginosa, formulation 3 achieved an inhibition zone of 26.72 mm in the first iteration and 20.26 mm in the second iteration, also surpassing the chloramphenicol ointment, which was only 16.41 mm. Formulation 1 showed fairly high antibacterial activity in the first test but decreased in the second replicate, while Formulations 2 and 4 showed low antibacterial activity or no activity at all.

## 5 Discussion

he pH test aims to ensure that the ointment preparation is in accordance with the pH of the skin (4.5–6.5) to prevent irritation. In formulations I, II, III, and IV, the test results showed a pH value of 6, which is within the ideal range of skin pH. This shows that all formulations are safe to use on the skin, especially in diabetics who have sensitive skin [9].

Physical stability testing was carried out through the freeze-thaw cycling method for six cycles. The results showed differences in consistency between formulations. Formulations I and II maintain a viscous consistency, while formulation III tends to be more liquid, and formulation IV is too dense. This indicates that formulations I and II have better physical stability than others.

Organoleptic observations include shape, aroma, and color. The entire formulation has a distinctive aroma of red ginger and a consistent yellow color. However, there is variation in consistency, where formulation III is more liquid, and formulation IV is too dense to be less than ideal in terms of application comfort.

The spread of formulation I (4.5 cm) is below the minimum standard of 5 cm [10], while formulations II and III reach 5 cm so that they meet comfort standards. In contrast, formulation IV has a low spreading power (2.5 cm), which is inadequate for topical application.

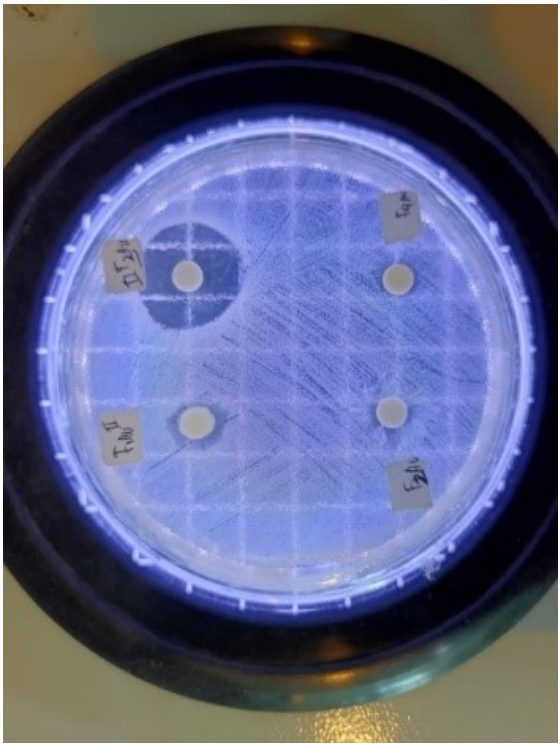

**Fig. 9.** Staphylococcus Aureus Antibacterial Test Results Repeat 1

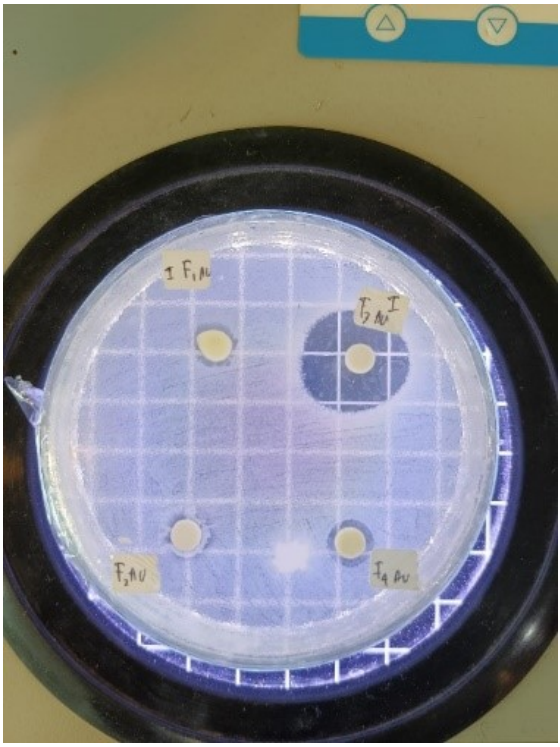

**Fig. 10.** Staphylococcus Aureus Antibacterial Test Results Repeat 2

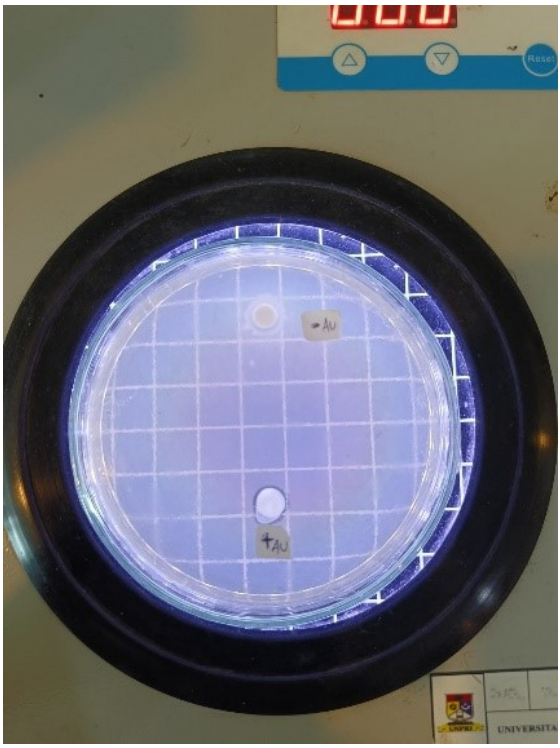

**Fig. 11.** Positive and Negative Comparative Test Results of Chloramphenicol Ointment Against Staphylococcus aureus

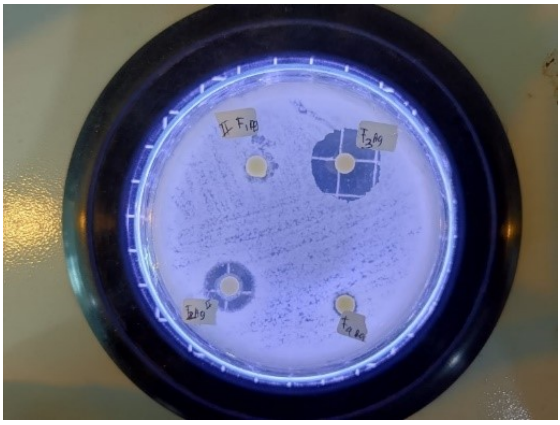

**Fig. 12.** Antibacterial Test Results of Pseudomonas Aureus Repeat 1

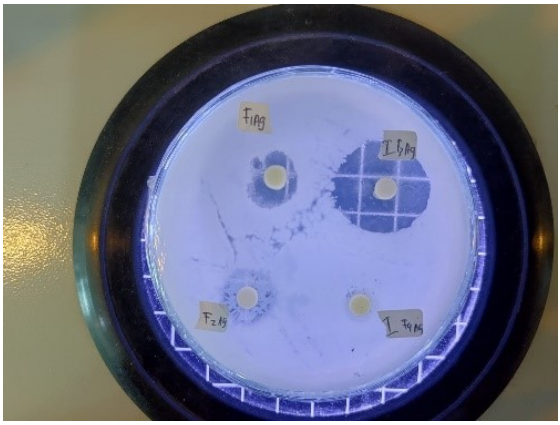

**Fig. 13.** Results of Pseudomonas Aureus Antibacterial Test Repeat 2

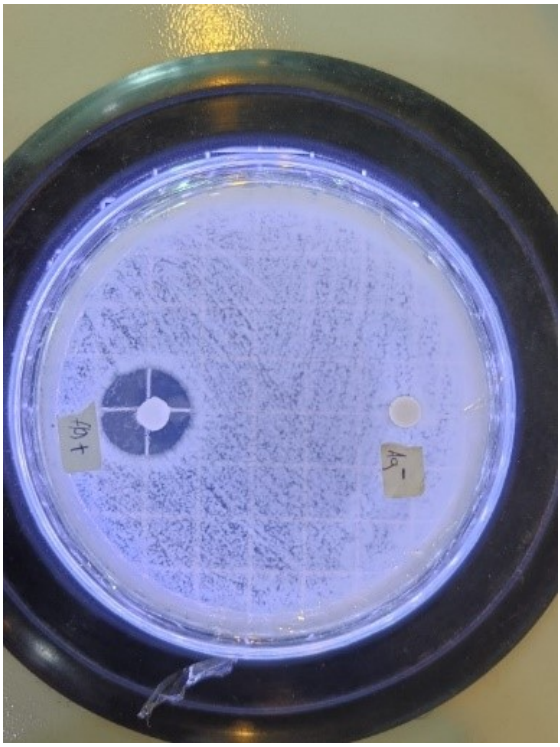

**Fig. 14.** Positive and Negative Comparative Test Results of Chloramphenicol Ointment Against Pseudomonas Aureus

All formulations meet the homogeneity criteria in the absence of coarse particles. This homogeneity is important to ensure an even distribution of active ingredients and excipients in the preparation, so that its effectiveness can be maintained [13].

Viscosity measurements showed that formulations I to III had viscosity levels that were still within the ideal range, but formulation IV had a very high viscosity and was beyond the detection limits of viscometers. The high viscosity of formulation IV indicates potential discomfort in its use on the skin.

In the antibacterial test, formulation III showed the largest inhibition zone (21.64 mm), indicating the highest antibacterial effectiveness. Formulations I and IV also showed antibacterial activity with inhibition zones of 9.98 mm and 8.89 mm, respectively, while formulation II showed no antibacterial activity.

Overall, formulation III has advantages in dispersibility, homogeneity, physical stability, and antibacterial effectiveness, although it is slightly more liquid. This formulation has the potential to be an optimal choice for topical application in diabetics.

## 6 Conclusion

Formulation 3 proved to be the most effective and optimal as an antidiabetic foot ointment based on the evaluation of various parameters. This formulation has the highest antibacterial activity, good spreadability, a suitable pH for the skin, and consistency suitable for topical use. Each formulation has different characteristics: all formulations show pH 6, safe for the skin; Consistent aroma and color stability, although formulations 3 and 4 are less than optimal in consistency; Formulations 2 and 3 meet the 5 cm spread power standard; all homogeneous formulations; and the viscosity of formulation 4 is too high to be difficult to spread. formulation 3 also showed the best antibacterial activity against Staphylococcus aureus and Pseudomonas aeruginosa, even exceeding chloramphenicol ointment.

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