Journal of Health and Nutrition Research
Vol. 5, No. 1, 2026, pg. 258-265, https://doi.org/10.56303/jhnresearch.v5i1.756
Journal homepage: https://journalmpci.com/index.php/jhnr/index

e-ISSN: **2829-9760**

Efficacy of a Pineapple Core-Based Hand Sanitizer in Reducing Bacterial Contamination and Infection Risk in Diabetic Foot Ulcer Care: A True Experimental Study

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ORIGINAL ARTICLES

Submitted: 29 August 2025

Accepted: 16 January 2026

Keywords:
Diabetes Mellitus, Diabetic Foot Ulcer, Pineapple Core, Hand Sanitizer, Wound Care DFU

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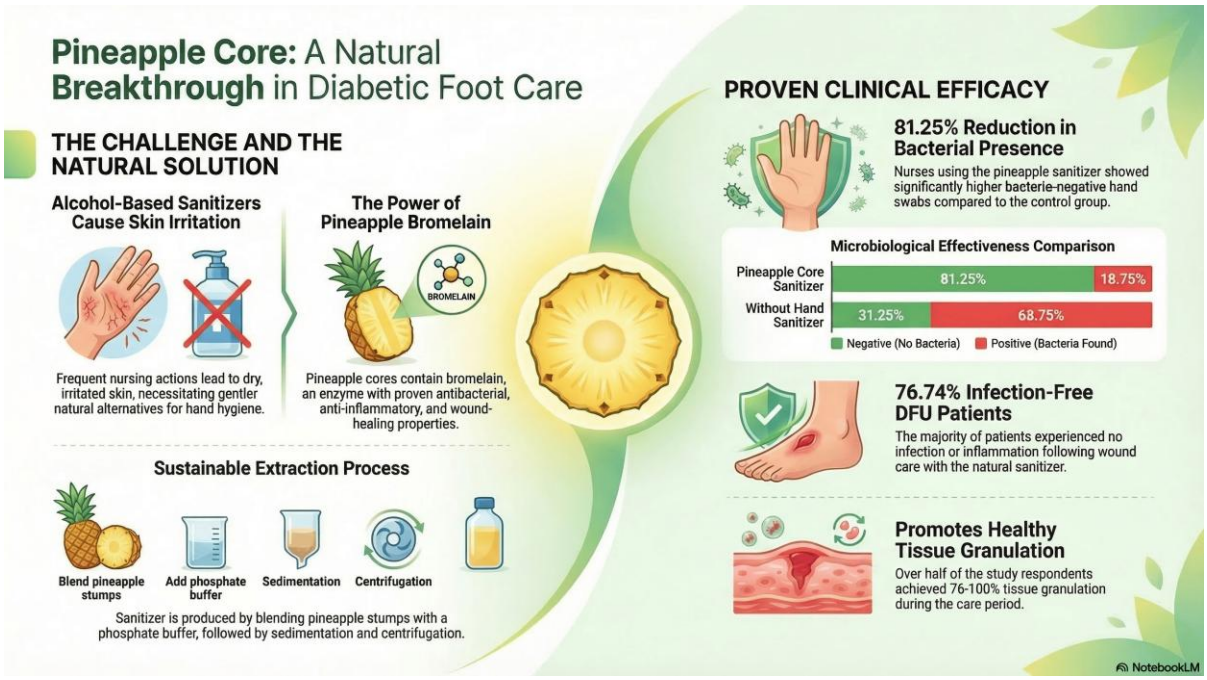
ABSTRACT

This study evaluated the efficacy of a natural hand sanitizer derived from pineapple core extract as an alternative to alcohol-based agents for reducing bacterial contamination and infection risk during diabetic foot ulcer (DFU) care. Using a true experimental design, the researchers conducted microbiological assessments of 16 nurse hand swabs and clinical observations of 43 DFU patients between February and April 2025. Microscopic results revealed a significant reduction in bacterial presence: only 18.75% of swabs tested positive for gram-positive cocci with the pineapple-based sanitizer, compared to 68.75% in the control group. Furthermore, clinical findings indicated that 76.74% of patients remained infection-free following wound care procedures employing the extract. The study concludes that pineapple core extract possesses potent antimicrobial and anti-inflammatory properties, largely attributed to the enzyme bromelain, making it a viable, eco-friendly, and cost-effective alternative for infection control in specialized wound care settings.

Key Messages:

- The healing process of Diabetic Foot Ulcers (DFU) is greatly influenced by infection control during wound care. Pineapple stems in the form of hand sanitizer can be an alternative antibacterial agent during wound care procedures

GRAPHICAL ABSTRACT



INTRODUCTION

Diabetes Mellitus (DM) is a chronic disease that is a public health problem in the world with a very high (1). Indonesia are ranked 7th in Southeast Asia with the largest number of sufferers and the percentage of deaths due to diabetes in Indonesia is the second highest (2). One type of complication experienced by DM sufferers is *Diabetic Foot Ulcer (DFU*) (3). The risk of DFU in DM patients is stated to be 85.7% (4). Sufferer DM with *neuropathy* own risk tall For become DFU and among them experience amputation (5). Diabetes experts estimate 50% to 75% Amputation incidents can be avoided with good foot care (6). The key to treating DFU is recognizing and treating diabetes before complications occur (7). More than a Half of all leg ulcers will become infected and require hospitalization and 20% from infection extremities lower will end with amputation (5). DFU treatment will have a significant impact on preventing the occurrence of complications chronicle foot diabetic like ulcer or even gangrene (8). The importance of comprehensive diabetic foot care that is effort overcome, remove or reduce infection until woundhealed total (9). Nurses provided by health workers in hospitals are expected to fulfill various aspects, one of which is patient safety, including preventing patients from infections that occur in hospitals (10)(11)(12).

Good hand hygiene is a very important infection control measure resulting from person-to-person contact (13)(14). Hand hygiene is essential to prevent the spread of infectious diseases and is an infection control measure (15)(16). Long-term side effects of use of alcohol on the skin is considered can cause skin irritation skin, dry skin so need necessitating a more gentle and natural alternative (17). The utilization of pineapple fruit is generally limited to the flesh of the fruit only and other parts such as the crown, skin, and pineapple stem have not been optimally utilized and are even thrown away even though these parts contain the enzyme compound bromelain which has an effect on healing cuts (18). However, the use of pineapple stems as a hand sanitizer in DFU wound care to reduce the risk of infection has never been studied before.

Previous research using pineapple skin as a disinfectant spray to reduce the number of germs on the dining table with the result of a decrease in the number of germs on the dining table after using a disinfectant spray from pineapple skin extract (19). In addition, another study that utilizes pineapple skin extract made into nano spray gel against the growth of Staphylococcus epidermidis bacteria in Ulcers with the results of antibacterial activity against Staphylococcus epidermidis at a concentration of 75% (20). Therefore, this study aimed to develop and evaluate the antimicrobial effectiveness of a hand sanitizer derived from Pineapple Core and to assess its preliminary utility in preventing infections during the care of diabetic foot ulcers.

https://doi.org/10.56303/jhnresearch.v5i1.756

METHODS

The research design using *true experiment* with a quantitative descriptive approach. This study was conducted at the Hospital of Muhammadiyah Palembang from 1st February to 25th April 2025 with a population of all DM patients in the internal medicine surgery room with the total 588 patients. The study was conducted in two phases: first, a microbiological assessment of hand swabs from 16 nurses with and without the use of the pineapple stump sanitizer. The second, a single-arm observational cohort assessment of infection incidence in 43 patients with DFU following wound care where the sanitizer was used. The inclusion criteria DFU Patients' were : (1) DM patients with a duration of DM ≤ 10 years; (2) Having Diabetic Foot Ulcers; and (3) Willing to be respondents. While the exclusion criteria were DM patients with severe complications such as heart disease and stroke. The sampling technique uses purposive sampling by selecting intentionally to adjust the research objectives (21).

Tools and materials used is pineapple stump, 0.1 M phosphate buffer pH 7, gram staining, microscope, oil immersion, blender, and centrifuge. Procedure Work making hand sanitizer from pineapple stem, namely: a pineapple stump that has cleaned up cut small pieces, adding 0.1 M phosphate buffer pH 7, ground with using a blender , the blender results are squeezed, the results squeeze saved at temperature room for 24 hours so that settle , take results sediment Then centrifuged with speed 3500 rpm for 15 minutes obtained filtrate containing extract pineapple stump (22) . Procedure Work gram staining is made stock review above the object glass then fixed above bunsen, then dripped with crystal violet then left alone for 1-2 minutes. the rest substance color thrown away, then rinsed with running water. All preparation dripped with solution lugol and let for 30 seconds. Throw away solution lugol and rinse with running water. Preparation dispelled with alcohol 96% to all substance color fade, and soon wash with running water. Dripping with substance safranin color, let it for 2 minutes Then rinse with running water Then left alone dry (23). Procedure Work inspection bacteria in a way microscopic namely: observing below microscope with enlargement lens objective 100x use emersion. Staphylococcus aureus is gram-positive bacteria and cocci form clusters (24). The data of Characteristics of Patients using the Medical record data and to assess infection of wound characteristics' using the Diabetic observation sheet Foot Ulcer Assessment Scale (DFUAS) Concurrent, construct, and predictive validity tests have been conducted on DFUAS. The reliability test of DFUAS is stated to be reliable with an Alpha value Cronbach 0.654

Data processed in a way analysis descriptive based on results positive found bacteria. Inspection results done analysis in a way descriptive based on results microscopic found bacteria (25). For infection incidence, data analysis using univariate analysis in the form of frequency distribution and percentage produced the distribution of wound characteristics and severity of DFU (26).

CODE OF HEALTH ETHICS

This study has been tested ethically at Universitas Muhammadiyah Ahmad Dahlan Palembang with the number: 000316/KEP IKesT Muhammadiyah Palembang/2025.

RESULTS

Table 1. The presentation results in a way microscopic on hand swab, the nurse who uses Pineapple Core hand sanitizer is positive (18.75%) and negative (81.25%), while without hand sanitizer is positive (68.75%) and negative (31.25%).

Table 1. Microbiological Results of Nurses' Hand Swabs with and without use of Pineapple Core Hand Sanitizer (n=16 samples per group).

Variable	n	%
Pineapple Core Hand Sanitizer		
Positive (+)	3	18.75
Negative (-)	13	81.25
Without Hand Sanitizer		
Positive (+)	11	68.75
Negative (-)	5	31.25

https://doi.org/10.56303/jhnresearch.v5i1.756

Table 2. Characteristics of Patients with DFU (43)

Variables	n	%
Age (year)		
≤ 60	19	44.1
>60	25	55.9
Type Sex		
Male	16	37.2
Female	27	62.8
Education		
No education	8	18.6
Elementary school	14	32.6
Junior high school	5	11.6
Senior high School	12	27.9
College	4	9.3
Occupation		
No work	19	44.2
Trader	7	16.3
Farmer	2	4.7
Employee Country	2	4.7
Self-employed	13	30.2
Long Suffering Diabetes Mellitus		
< 5 Year	18	41.9
5-10 Year	25	58.1

The demographic and clinical data presented in Tables 2 and 3 indicate a study population predominantly composed of elderly individuals (55.9% >60 years old) and females (62.8%), the majority of whom have managed diabetes for 5 to 10 years. Despite the severity of the participants' conditions—with 58.14% of wounds penetrating the subcutaneous or dermal layers and 88.37% of ulcers classified as significantly wide—the clinical outcomes following the application of the pineapple core extract were remarkably positive. Specifically, 76.74% of patients showed no signs of infection, 55.81% exhibited high levels of tissue granulation (76–100%), and 48.84% presented with healthy, pink wound edges. These results suggest that the antimicrobial and anti-inflammatory properties of the pineapple extract, likely driven by the enzyme bromelain, effectively stabilized the wound environment by preventing secondary infections and promoting tissue regeneration, even in high-risk elderly patients with deep diabetic ulcers.

Table 3. Characteristics of Wound on Respondents after wound care (n=43)

Wound Characteristics'	n	%
Depth of wound		
Unite	2	4.65
Layer outside/epidermis	1	2.33
Subcutaneous / dermis	25	58.14
Tendon	5	11.63
Tissue fascia, muscle or bone	6	13.95
Unstage	4	9.30
Size of wound		
≤ 1 cm^2	2	4.65
1 $cm^2 < x \leq 4$ cm^2	10	23.26
4 $cm^2 < x \leq 9$ cm^2	8	18.60
9 $cm^2 < x \leq 16$ cm^2	6	13.95
16 $cm^2 < x \leq 25$ cm^2	3	6.98
25 $cm^2 < x \leq 36$ cm^2	1	2.33
36 $cm^2 < x \leq 49$ cm^2	2	4.65
49 $cm^2 < x \leq 64$ cm^2	4	9.30
> 64 cm^2	7	16.28
Evaluation of wound		
Enough wide	38	88.37
Wide	5	11.63
Inflammation/ infection		
No	33	76.74
Sign inflammation	5	11.63
Sign infection	3	6.98

https://doi.org/10.56303/jhnresearch.v5i1.756

Wound Characteristics'	n	%
Osteomyelitis	1	2.33
Osteomyelitis and local infection	1	2.33
Comparison oftissue granulation		
No	1	2.33
76- 100%	24	55.81
51- 75%	10	23.26
26- 50%	3	6.98
11- 25%	2	4.65
≤ 10%	3	6.98
Wound Edge Type		
The edges are joined together	2	4.65
The edges of the wound are pink	21	48.84
Hyperkeratosis or lining	6	13.95
Wound edges colored red	3	6.98
Not yet formed	11	25.58

DISCUSSION

The results of this study indicate that hand sanitizer from pineapple stem extract as an antibacterial has a negative result of 81.25%, while for the control group, the negative result was only 31.25%. The difference with previous studies, hand sanitizers were made using aloe vera extract and betel leaves with the addition of 70% alcohol and there were also those who used betel leaves and lime, using a filtration process (27)(28). Pineapple Cores contain very beneficial compounds, namely the enzyme bromelain which has been proven in various studies to have an effect on healing cuts (20). Studies have also been done on the effectiveness of antimicrobial hand sanitizers made from natural *Piper battle L* and *Aloe vera* (29). Natural hand sanitizers are more in demand by the public and have added value because they are considered safer than chemical hand sanitizers in general and are easily obtained in the wider community environment (30).

In this study, inflammation showed no infection (76.74%). It is a condition in which there are pathogenic microorganisms that grow in wounds which cause the wound to change color to reddish, swollen, painful, and purulent (31). The previous studies about DFU stated that the presence of infection can increases the risk of lower limb amputation by up to 50% compared to DFU without infection (32). Moreover, again on wound which due to by 2 or more pathogen (*combined infection*) can own risk which increasing. Matter this in accordance with study previously Which shows that the wound with *combined infection* 11.39 time higher risk of amputation (33). Depth wound on study This show that most of respondents have wound characteristics with subcutaneous/dermis depth (58.14%). The study explains that the risk of major amputation is 7.5 times higher when the wound penetrates or reaches the depth of the bone (6)(32). This is because the more in wound prevalence of pathogens anaerob will increase. *Diabetic foot infection* often time happen on wound with depth reach tendon and capsule on joints (34). The severity of the wound is also influenced by the size of the wound (35). The results showed that more respondents had wound characteristics with a size of $1\ cm^2 < x \leq 4\ cm^2$ than other sizes. The size of the wound will affective on long healing and risk amputation (36). Similarity to the characteristics of wound size, wound assessment is used to predict the length of wound healing. In addition, the wider the wound, the more Wounds are at greater risk of becoming a place for microorganisms to grow which can cause infection (32).

Pineapple peel has the potential to be used for wound healing because it contains compounds such as the enzyme bromelain, flavonoids, tannins, and saponins, which have anti-inflammatory and antimicrobial effects and support the formation of new skin tissue. Research shows that pineapple peel extract can accelerate wound healing, including burns and cuts, and is often formulated as a gel for easy absorption (21). Other studies using pineapple peel eco-enzyme solution have shown it contains secondary metabolites in the form of tannins and saponins. Tannins function as astringents that can deposit proteins on cell surfaces with low permeability. This causes skin pores to shrink and can stop leakage and bleeding, thus accelerating the wound healing process. The saponins contained in the eco-enzyme solution are

https://doi.org/10.56303/jhnresearch.v5i1.756

growth factors that can accelerate the re-epithelialization of epidermal tissue and the infiltration of inflammatory cells in the wound area (19)(21)

Based on the study results, it can be concluded that some DFU patients do not experience infection when using an alternative antiseptic hand sanitizer, pineapple stump, and active maintenance of the DFU wound. The presence of signs of infection, such as exudative fluid, can affect the occurrence of maceration. Maceration is damage to the skin around wounds caused by continuous exposure to moisture/exudate (36). However, the study found that respondents' own characteristics were more strongly associated with maceration than those of other categories. Maceration can be prevented by proper wound care, such as using a dressing that absorbs exudate. If maceration occurs, it will result in damage to skin integrity and prolong the healing period of wounds (33).

CONCLUSION

This study demonstrates that pineapple stem extract exhibits significant antibacterial activity when formulated into a hand sanitizer. Microscopic analysis showed that the pineapple-based sanitizer effectively reduced bacterial presence on nurses' hands (81.25% negative for bacteria), comparable to standard hygiene outcomes. Furthermore, its application in diabetic foot ulcer (DFU) care demonstrated promising safety, with most patients maintaining infection-free wounds. Instead of relying solely on alcohol-based agents, this natural formulation offers a viable, eco-friendly, and cost-effective alternative for infection control, particularly in resource-limited settings. Future research should focus on conducting randomized controlled trials (RCTs) with larger sample sizes and specific bacterial cultures to further establish its clinical efficacy and stability.

FUNDING

The funding in this study was supported by the Research Center of Muhammadiyah Foundation Batch VIII.

ACKNOWLEDGMENTS

The author thanked the participants in this study and the nurse managers who supported the data collection process.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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