



Effectiveness of *Loranthus sp.* Liquid Soap in Improving Skin Moisture among Pregnant Women with Gestational Diabetes Mellitus

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Abstract

Gestational diabetes mellitus frequently causes skin dryness due to impaired microcirculation, peripheral neuropathy, and reduced sweat gland function, increasing the risk of skin infection and decreasing maternal quality of life. Natural topical products containing bioactive compounds may provide a safe alternative for improving skin hydration during pregnancy. This study aimed to determine the most effective concentration of *Loranthus sp.* liquid soap for improving skin moisture in pregnant women with gestational diabetes mellitus. A quasi-experimental study using a nonequivalent control group design was conducted at the Tilango Community Health Center, Gorontalo Regency, Indonesia. Thirty pregnant women with gestational diabetes mellitus were allocated into three intervention groups receiving *Loranthus sp.* liquid soap containing 5%, 10%, or 15% extract (n=10 per group). Participants used 500 mL of the assigned soap twice daily for seven consecutive days. Skin moisture was measured before and after the intervention using digital skin moisture analyzer EH900U. Within-group differences were analyzed using the Wilcoxon signed-rank test, while differences among intervention groups were assessed at a significance level of 0.05. Mean skin moisture increased from 34.6±3.1% to 37.1±5.1% in the 5% group, from 34.8±4.8% to 37.9±4.9% in the 10% group, and from 37.0±5.3% to 45.6±4.3% in the 15% group. Significant improvements were observed in all groups (p=0.041, p=0.026, and p=0.0001, respectively), with a significant difference among concentrations (p=0.0017). The 15% *Loranthus sp.* liquid soap demonstrated the greatest improvement in skin moisture and showed potential to improve skin moisture in pregnant women with gestational diabetes mellitus. Further studies with larger sample sizes, longer follow-up periods, and an appropriate control group are needed to confirm these findings.

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1. INTRODUCTION

Gestational diabetes mellitus (GDM) is one of the most common metabolic disorders during pregnancy and is characterized by glucose intolerance resulting from impaired insulin action or secretion that is first recognized during gestation (Schlichting et al., 2024). The global prevalence of GDM has increased substantially over the past decade, affecting approximately 2–25% of pregnancies depending on the diagnostic criteria and population studied (Shah et al., 2022). This growing burden has become an important public health concern because GDM is associated with adverse maternal and neonatal outcomes, including hypertensive disorders, cesarean delivery, fetal macrosomia, and long-term metabolic complications (Sica et al., 2022). In Indonesia, GDM remains a significant maternal health challenge in Gorontalo Province. In 2023, the prevalence of GDM in the Tilango Community Health Center working area was 15.0%, with 15 cases identified among 100 pregnant women. This finding highlights the need for appropriate prevention, early detection, and management of GDM in the local population.

Beyond metabolic complications, GDM frequently affects skin integrity (Adjei et al., 2022). Chronic hyperglycemia contributes to microvascular dysfunction, oxidative stress, and peripheral neuropathy, resulting in reduced sweat gland activity and disruption of the skin barrier (Lolok et al., 2020). Consequently, pregnant women with GDM commonly experience dry skin, pruritus, impaired wound healing, and an increased susceptibility to bacterial and fungal infections (Mzimba et al., 2023). Although the prevalence of xerosis specifically among pregnant women with GDM has not been well established, these skin changes may adversely affect comfort and quality of life. Maintaining adequate skin hydration is therefore an important component of supportive care to preserve skin barrier function and reduce the risk of secondary skin complications (Bradley et al., 2021).

Current management of skin complications in GDM primarily emphasizes patient education regarding skin care and the application of topical emollients, particularly urea-based creams (Kolonnage & Chew, 2023). Although these products have demonstrated effectiveness in relieving xerosis and pruritus, their use remains limited (Gao & Kannan, 2020). Urea-based formulations are generally recommended for localized treatment, particularly on the feet, and prolonged use may not be desirable for routine preventive care (Eumelen et al., 2023). Moreover, these products rely on synthetic chemical ingredients and are not specifically designed as whole-body cleansing agents capable of simultaneously maintaining skin hydration and reducing microbial colonization. These limitations highlight the need for safe, natural, and practical alternatives suitable for daily use throughout pregnancy (Sexton et al., 2024).

Medicinal plants have attracted increasing attention as complementary approaches to skin care because of their diverse biological activities and potential safety profiles (Fatchiyah et al., 2023). *Loranthus* sp. (mistletoe) is a medicinal plant containing bioactive compounds, including saponins, flavonoids, tannins, and other phytochemicals that may support skin hydration and skin barrier function (Abera et al., 2023). In particular, the presence of saponins and other hydrophilic compounds may contribute to the maintenance of skin moisture by supporting water retention at the skin surface. These properties suggest that *Loranthus* sp. has potential as a topical ingredient for maintaining or improving skin moisture (Oyekunle et al., 2021). However, evidence regarding the use of *Loranthus* sp. in liquid soap formulations for improving skin moisture among pregnant women with gestational diabetes mellitus remains limited (Richardson & Collins, 2023). Therefore, evaluating changes in skin moisture following the use of *Loranthus* sp. liquid soap may provide preliminary evidence regarding its potential application in skin care for this population.

Liquid soap represents an attractive delivery system for herbal extracts because it can be applied to the entire body, is more hygienic than solid soap, reduces the risk of microbial contamination during use, and facilitates regular daily skin care (Leistner et al., 2023). Incorporating *Loranthus* sp. extract into liquid soap therefore offers a practical non-pharmacological strategy for improving skin moisture among pregnant women with GDM while providing additional antimicrobial protection (Chirani et al., 2021). Despite the promising pharmacological properties of *Loranthus* sp., evidence regarding its clinical effectiveness in improving skin moisture among pregnant women with GDM remains scarce (Puspawiningtiyas et al., 2021). Furthermore, the optimal concentration of *Loranthus* extract for topical application has not been established, particularly in liquid soap formulations intended for routine maternal skin care (Ross et al., 2023).

Previous studies have reported the potential of medicinal plant-derived compounds for supporting skin health, while research on herbal topical preparations has primarily focused on their phytochemical properties, antimicrobial activity, or general dermatological applications (VanderGiessen et al., 2023). However, evidence regarding the use of *Loranthus* sp. as a topical preparation specifically for improving skin moisture remains limited, particularly among pregnant women with gestational diabetes mellitus (Falciani et al., 2023). Furthermore, the concentration of *Loranthus* sp. extract that may provide the greatest improvement in skin moisture has not been clearly established (Sá-Leite et al., 2024). This gap is important because pregnant women with gestational diabetes mellitus may be particularly vulnerable to skin dryness and impaired skin barrier function, yet evidence-based topical interventions targeting skin moisture in this population remain scarce. Therefore, this study aimed to compare changes in skin moisture following the use of liquid soap containing 5%, 10%, and 15% *Loranthus* sp. extract among pregnant women with gestational diabetes mellitus, providing preliminary clinical evidence on the potential concentration associated with improved skin moisture. The findings are expected to contribute new evidence supporting the development of safe, natural, and cost-effective skin care interventions for pregnant women with GDM and to inform non-pharmacological maternal care practices. This study aimed to compare changes in skin moisture before and after the use of *Loranthus* sp. liquid soap at concentrations of 5%, 10%, and 15%, and to determine the concentration that provides the greatest improvement in skin moisture among pregnant women with gestational diabetes mellitus.

2. METHODS

This study employed a quantitative quasi-experimental pretest–posttest design with three intervention groups to evaluate changes in skin moisture following the use of *Loranthus* sp. liquid soap at different extract concentrations among pregnant women with gestational diabetes mellitus (GDM). The study was conducted at the Tilango Community Health Center, Gorontalo Regency, Indonesia. This design was selected because the study did not include a non-intervention control group, while the use of three intervention concentrations allowed comparison of changes in skin moisture following different concentrations of *Loranthus* sp. extract.

The study population consisted of all pregnant women diagnosed with GDM who attended antenatal care at the Tilango Community Health Center in 2023. Based on health center records, 42 pregnant women met the initial population criteria. The minimum sample size was calculated based on the expected difference and standard deviation obtained from previous research, using a 95% confidence level and 80% statistical power. The calculation yielded a minimum sample size of 27 participants. After adding a 10% allowance for potential attrition, the required sample size was increased to 30 participants.

The 30 participants were divided equally into three intervention groups, with 10 participants in each group.

Participants were recruited using purposive sampling based on predefined eligibility criteria. The inclusion criteria were pregnant women aged 20–35 years, diagnosed with GDM, willing to participate, and able to provide written informed consent. Women with dermatitis, chronic skin diseases, skin infections, known allergies to soap ingredients, or other dermatological conditions that could interfere with skin moisture assessment were excluded. Eligible participants were assigned sequentially to one of three intervention groups according to the order of enrollment until each group contained 10 participants. This allocation procedure was non-randomized. Group 1 received *Loranthus* sp. liquid soap containing 5% extract, Group 2 received liquid soap containing 10% extract, and Group 3 received liquid soap containing 15% extract.

Each participant received a 500 mL bottle of the assigned liquid soap and was instructed to use it twice daily during bathing for seven consecutive days. The seven-day intervention period was selected to evaluate the short-term change in skin moisture following repeated use of the topical formulation. The duration was also considered feasible for monitoring participant adherence and minimizing participant burden. The study was intended to evaluate short-term changes in skin moisture, and no long-term follow-up was conducted after the seven-day intervention period. Participants were instructed not to use other soaps, body washes, moisturizers, lotions, or other topical skin-care products during the intervention period.

Potential confounding factors affecting skin moisture were controlled as far as feasible through standardized instructions and measurement procedures. Participants were instructed to use only the assigned liquid soap during the intervention, maintain their usual fluid intake and bathing routine, and avoid additional topical skin-care products. They were also advised to avoid prolonged exposure to excessive heat or direct sunlight during the intervention period. Water temperature was kept at a comfortable level and participants were instructed to use their usual bathing water temperature throughout the study. Skin moisture measurements were performed under comparable conditions using the same instrument and standardized procedures. Baseline characteristics, including parity, gestational age, occupation, body mass index, and blood glucose level, were recorded to describe factors that could potentially influence skin moisture.

Skin moisture was measured before the intervention (pretest) and after seven days of intervention (posttest) using the Skin Analyzer Digital Test System EH900U. Measurements were performed on the volar aspect of the forearm, using the same anatomical site for all participants. The measurement site was cleaned and allowed to dry before measurement, and participants were instructed not to apply any topical product to the measurement area before assessment. Skin moisture was expressed as a percentage (%). According to the manufacturer's reference values, moisture levels were categorized as $\leq 33\%$ (very dry skin), 34–37% (dry skin), 38–42% (normal skin), and 43–46% (moist skin). The same instrument, anatomical site, and measurement procedures were used for all participants at both assessment points to improve measurement consistency.

Following recruitment and written informed consent, baseline demographic and clinical data were collected and pre-intervention skin moisture measurements were performed. Participants then received the assigned *Loranthus* sp. liquid soap together with standardized instructions regarding its use. Compliance was monitored through daily telephone or WhatsApp communication during the seven-day intervention period. During each follow-up contact, participants were asked whether the soap had been used twice daily as instructed, whether any other soap or topical product had been used, and whether any adverse skin reactions had occurred. Participants were also reminded to follow the

study instructions. At the end of the seven-day intervention, participants returned to the health center for post-intervention skin moisture measurement using the same instrument, anatomical site, and measurement procedures.

Safety was monitored throughout the intervention. Participants were instructed to report any adverse skin reactions, including redness, itching, burning, irritation, rash, swelling, or other allergic reactions following use of the assigned liquid soap. Any reported adverse events were documented and evaluated by the research team. No adverse skin reactions, including redness, itching, burning, irritation, rash, or swelling, were reported during the seven-day intervention period.

Descriptive statistics were used to summarize participant characteristics and skin moisture values. Continuous variables were presented as mean $\pm$ standard deviation, whereas categorical variables were presented as frequencies and percentages. The normality of the skin moisture data was assessed using the Shapiro–Wilk test. Because the data did not meet the assumption of normality, changes in skin moisture between pretest and posttest within each intervention group were analyzed using the Wilcoxon signed-rank test. Differences in the magnitude of skin moisture changes among the three intervention groups were analyzed using the Kruskal–Wallis test, which was selected as the appropriate non-parametric alternative to one-way ANOVA. When the Kruskal–Wallis test showed a statistically significant difference, Dunn's post hoc test with Bonferroni adjustment was performed to identify differences between individual concentration groups. Effect size for the Wilcoxon signed-rank test was calculated using $r = Z/\sqrt{N}$, where Z represents the standardized test statistic and N represents the number of paired observations. For the Kruskal–Wallis test, epsilon-squared (ϵ^2) was calculated to estimate the magnitude of differences among the three intervention groups. Effect sizes were interpreted together with p-values to provide information on the statistical and practical magnitude of the observed changes. Statistical significance was set at $p < 0.05$. All statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA).

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Health Research Ethics Committee of Poltekkes Kemenkes Gorontalo (No.DP.04.03/KEPK/0140/2026). Written informed consent was obtained from all participants before enrollment. Participants were informed that participation was voluntary, that they could withdraw from the study at any time without consequences to their healthcare, and that all personal information would be kept confidential and used solely for research purposes.

3. RESULTS AND DISCUSSION

The baseline characteristics of the participants are presented in Table 1. These characteristics include selected demographic and clinical variables that may influence skin moisture and are described to provide an overview of the participants in each intervention group.

Table 1. Baseline characteristics of participants.

Characteristic	Loranthus sp. soap 5%	Loranthus sp. soap 10%	Loranthus sp. soap 15%
Parity			
One child	2	2	2
Two children	2	2	1

Three children	4	5	6
≥ Four children	2	1	1
Occupation			
Unemployed	6	7	8
Employed	4	3	2

A total of 30 pregnant women diagnosed with gestational diabetes mellitus completed the study. Participants were allocated into three intervention groups receiving *Loranthus* sp. liquid soap containing 5%, 10%, or 15% extract (n = 10 per group). Baseline characteristics of the participants are presented in Table 1. The characteristics assessed included parity, gestational age, and occupational status. Most participants were multiparous and in the third trimester of pregnancy, while the majority were unemployed. The distribution of these characteristics was described for each intervention group to provide an overview of the baseline characteristics of the study participants. Because participants were allocated using a non-randomized procedure, the groups were not assumed to be homogeneous solely on the basis of their descriptive characteristics. Therefore, the baseline characteristics were considered when interpreting differences in skin moisture outcomes among the three intervention groups.

As shown in Table 1, parity characteristics indicated that in the 5% *Loranthus* liquid soap group, the majority of participants had three children (4 participants; 40.0%), while those with one child, two children, and four or more children each accounted for 2 participants (20.0%). In the 10% *Loranthus* liquid soap group, most participants also had three children (5 participants; 50.0%), whereas participants with one child and two children each represented 2 participants (20.0%), and only 1 participant (10.0%) had four or more children. Similarly, in the 15% *Loranthus* liquid soap group, the majority of participants had three children (6 participants; 60.0%), while 2 participants (20.0%) had one child, and 1 participant (10.0%) each had two children and four or more children.

Regarding gestational age, most participants in the 5% *Loranthus* liquid soap group were in the third trimester (5 participants; 50.0%), followed by the second trimester (3 participants; 30.0%) and the first trimester (2 participants; 20.0%). In the 10% group, participants were predominantly in the second and third trimesters, with 4 participants (40.0%) in each trimester, while 2 participants (20.0%) were in the first trimester. In the 15% group, the majority were also in the third trimester (5 participants; 50.0%), followed by the second trimester (2 participants; 20.0%) and the first trimester (2 participants; 20.0%). With respect to occupational status, most participants in the 5% *Loranthus* liquid soap group were unemployed (6 participants; 60.0%), while 4 participants (40.0%) were employed. Likewise, in the 10% group, 7 participants (70.0%) were unemployed and 3 participants (30.0%) were employed. In the 15% group, the majority were also unemployed (8 participants; 80.0%), whereas only 2 participants (20.0%) were employed. The baseline characteristics of participants were relatively comparable across the three intervention groups. Most participants were multiparous, in the third trimester of pregnancy, and unemployed, indicating that the groups were generally homogeneous at baseline and reducing the likelihood of confounding factors influencing the study outcomes.

Table 2. Skin moisture before and after seven days of intervention.

Intervention	Before (Mean ± SD)	After (Mean ± SD)	Mean Change	95% CI
<i>Loranthus</i> sp. soap 5%	34.6 ± 3.1	37.1 ± 5.1	+2.5	-1.58 to 6.58

<i>Loranthus</i> sp. soap 10%	34.8 ± 4.8	37.9 ± 4.9	+3.1	-1.84 to 8.04
<i>Loranthus</i> sp. soap 15%	37.0 ± 5.3	45.6 ± 4.3	+8.6	4.55 to 12.65

The largest improvement in skin moisture was observed in participants receiving the 15% *Loranthus* extract formulation, with a mean increase of 8.6 percentage points after the intervention. As shown in Table 2, the mean skin moisture level among pregnant women with gestational diabetes mellitus in the 5% *Loranthus* liquid soap group increased from 34.6 ± 3.1% before the intervention to 37.1 ± 5.1% after seven days of treatment. This finding indicates an improvement in mean skin moisture following the use of 5% *Loranthus* liquid soap. In the 10% *Loranthus* liquid soap group, the mean skin moisture level increased from 34.8 ± 4.8% before the intervention to 37.9 ± 4.9% after seven days of treatment. These results suggest that the 10% *Loranthus* liquid soap effectively improved skin moisture among pregnant women with gestational diabetes mellitus compared with baseline values.

Meanwhile, participants receiving the 15% *Loranthus* liquid soap demonstrated the greatest improvement in skin moisture. The mean skin moisture increased from 37.0 ± 5.3% before the intervention to 45.6 ± 4.3% after seven days of treatment, representing the largest increase among the three intervention groups. Overall, all concentrations of *Loranthus* liquid soap resulted in increased skin moisture following the seven-day intervention. The greatest improvement was observed in the 15% *Loranthus* liquid soap group, indicating that this concentration showed the highest potential effectiveness in improving skin moisture compared with the 5% and 10% formulations.

Table 3. Individual changes in skin moisture.

Intervention	Improved	Unchanged	Decreased
<i>Loranthus</i> sp. soap 5%	4 (40%)	5 (50%)	1 (10%)
<i>Loranthus</i> sp. soap 10%	6 (60%)	4 (40%)	0
<i>Loranthus</i> sp. soap 15%	10 (100%)	0	0

As shown in Table 3, among pregnant women with gestational diabetes mellitus who used 5% *Loranthus* liquid soap, the majority of participants (5 participants; 50.0%) showed no change in skin moisture, while 4 participants (40.0%) experienced an increase in skin moisture and 1 participant (10.0%) experienced a decrease. In the 10% *Loranthus* liquid soap group, most participants (6 participants; 60.0%) demonstrated increased skin moisture, whereas 4 participants (40.0%) showed no change. No participants experienced a decrease in skin moisture after the intervention. In contrast, all participants in the 15% *Loranthus* liquid soap group (10 participants; 100%) experienced an improvement in skin moisture, with no participants showing either unchanged or decreased skin moisture following seven days of treatment. These findings indicate that higher concentrations of *Loranthus* liquid soap were associated with a greater proportion of pregnant women with gestational diabetes mellitus experiencing improved skin moisture. The 15% formulation produced improvements in skin moisture in all participants, suggesting superior effectiveness compared with the 5% and 10% formulations.

Table 4. Statistical analysis of skin moisture changes.

Comparison	Statistical Test	p-value
Pretest vs Posttest (5%)	Wilcoxon Signed-Rank Test	0.041
Pretest vs Posttest (10%)	Wilcoxon Signed-Rank Test	0.026
Pretest vs Posttest (15%)	Wilcoxon Signed-Rank Test	0.0001
Difference among concentrations	One-way ANOVA	0.0017

As shown in Table 4, the results of the Wilcoxon signed-rank test demonstrated statistically significant improvements in skin moisture within all intervention groups. The 5%, 10%, and 15% *Loranthus* liquid soap groups yielded p-values of 0.041, 0.026, and 0.0001, respectively, indicating significant changes in skin moisture following the intervention. To compare the magnitude of skin moisture improvement among the three *Loranthus* liquid soap concentrations, an additional statistical analysis was performed. The analysis yielded a p-value of 0.0017, indicating a statistically significant difference in skin moisture improvement among the three intervention groups ($p < 0.05$). These findings demonstrate that different concentrations of *Loranthus* liquid soap produced significantly different effects on skin moisture improvement in pregnant women with gestational diabetes mellitus. Descriptively, the 15% *Loranthus* liquid soap formulation produced the greatest improvement in skin moisture compared with the 5% and 10% formulations.

DISCUSSION

Skin moisture in pregnant women with gestational diabetes mellitus.

Gestational diabetes mellitus (GDM) is a glucose metabolism disorder that first develops during pregnancy as a result of increased insulin resistance. Persistent hyperglycemia during pregnancy can affect multiple organ systems, including the skin (Pandey et al., 2023). Elevated blood glucose levels contribute to microvascular dysfunction, increased oxidative stress, and peripheral nerve damage, leading to diabetic neuropathy (Mussagy et al., 2023). Neuropathy impairs sweat gland function, resulting in reduced sebum and sweat production (Azme et al., 2023). Consequently, the skin loses its natural moisture barrier, becoming dry, rough, cracked, itchy, and more susceptible to infection (Rahmi et al., 2017).

In addition to GDM, several factors may influence skin moisture in pregnant women, including parity, gestational age, and occupational status (Todd et al., 2010). The majority of participants in this study were multiparous women. Repeated pregnancies may reduce skin elasticity and increase hydration requirements because of recurrent stretching of skin tissues (Yogesh et al., 2024). As the number of pregnancies increases, the skin's ability to maintain elasticity and moisture may decline, making appropriate skin care increasingly important (Byrka & Kaminska, 2022).

Gestational age also influences skin condition. Most participants were in the third trimester of pregnancy, during which elevated levels of estrogen, progesterone, and human placental lactogen alter body fluid metabolism and increase the skin's hydration requirements (Schlichting et al., 2024). Furthermore, enlargement of the uterus and increased maternal body weight contribute to stretching of the abdominal skin, making the epidermis more prone to transepidermal water loss (Shah et al., 2022). Consequently, pregnant women in the third trimester are more likely to experience dry skin than those in earlier stages of pregnancy (Sica et al., 2022).

Occupational status may also affect skin moisture (Adjei et al., 2022). Most participants in this study were unemployed. Although their physical workload was relatively low, household activities frequently expose them to water, detergents, soaps, and other cleaning agents that may remove the skin's natural lipid barrier when used repeatedly

(Lolok et al., 2020). Therefore, using a cleansing product containing natural moisturizing agents may help maintain skin barrier integrity among pregnant women with GDM (Mzimba et al., 2023).

The present study demonstrated that baseline skin moisture levels were relatively low across all intervention groups (Bradley et al., 2021). Following seven consecutive days of *Loranthus* sp. liquid soap application, skin moisture increased in all groups, although the magnitude of improvement varied according to the concentration of the herbal extract (Kolonnage & Chew, 2023). These findings suggest that *Loranthus* sp. liquid soap has the potential to improve skin hydration in pregnant women with gestational diabetes mellitus (Eumelen et al., 2023).

The present study demonstrated that baseline skin moisture levels were relatively low across the three intervention groups. Following seven consecutive days of using *Loranthus* sp. liquid soap, skin moisture increased in all groups, although the magnitude of improvement differed according to extract concentration. The mean increase was 2.5 percentage points in the 5% group, 3.1 percentage points in the 10% group, and 8.6 percentage points in the 15% group. This pattern suggests a possible concentration-related change in skin moisture. However, because the study did not include a non-intervention control group, these findings should be interpreted as short-term changes associated with the intervention rather than definitive evidence of treatment efficacy.

The observed increase in skin moisture may be related to the combined effects of the liquid soap base and the *Loranthus* sp. extract. Repeated application of a topical cleansing formulation may influence hydration of the superficial skin layer, while constituents of *Loranthus* sp. may contribute to maintaining moisture at the skin surface. The progressively greater improvement with increasing extract concentration provides a possible concentration-response pattern. Nevertheless, because the study did not separately evaluate the effect of the soap base, the specific contribution of *Loranthus* sp. extract to the observed improvement cannot be determined with certainty.

These findings are generally consistent with previous research indicating that plant-derived topical formulations may contribute to maintaining or improving skin hydration. However, direct comparison with previous studies should be made cautiously because differences in plant species, formulation composition, extract concentration, application frequency, measurement instruments, and intervention duration may influence the magnitude of skin-moisture changes. The present study therefore provides preliminary clinical evidence regarding the use of different concentrations of *Loranthus* sp. liquid soap for improving skin moisture in pregnant women with GDM.

Effect of 5% *Loranthus* sp. liquid soap on skin moisture.

The Wilcoxon signed-rank test demonstrated a significant improvement in skin moisture following the use of 5% *Loranthus* sp. liquid soap ($p = 0.041$). Although several participants experienced improved skin moisture, most showed no measurable change, and one participant exhibited decreased skin moisture after the intervention (Sexton et al., 2024). The observed improvement may be attributed to the presence of saponins, which function as natural humectants by retaining water within the epidermis (Fatchiyah et al., 2023). In addition, coumarins may reduce skin irritation and promote epidermal regeneration (Abera et al., 2023). However, the relatively low concentration of bioactive compounds in the 5% formulation may have limited its moisturizing efficacy, resulting in only modest improvements in skin hydration (Oyekunle et al., 2021).

The Wilcoxon signed-rank test demonstrated a significant improvement in skin moisture following the use of 5% *Loranthus* sp. liquid soap ($p = 0.041$). The mean skin moisture increased by 2.5 percentage points after seven days. Although this change was

statistically significant, the magnitude of improvement was relatively modest compared with the higher-concentration formulations. This finding suggests that the 5% formulation may be associated with a small short-term improvement in skin moisture.

The modest improvement may be related to the lower amount of *Loranthus* sp. extract present in the formulation. However, this explanation should be interpreted cautiously because the study did not quantify individual active compounds in the final liquid soap or directly evaluate a dose-response mechanism. In addition, because no non-intervention control group was included, the observed change may also have been influenced by the soap base, bathing routine, environmental conditions, or natural variation in skin moisture.

Effect of 10% *Loranthus* sp. liquid soap on skin moisture.

The 10% *Loranthus* sp. liquid soap also significantly increased skin moisture compared with baseline ($p = 0.026$). Most participants experienced improved skin hydration, and none demonstrated a reduction in skin moisture after the intervention. The greater improvement observed in this group may be explained by the higher concentration of phytochemical constituents compared with the 5% formulation. Flavonoids and tannins possess antioxidant and antimicrobial properties that may reduce oxidative stress associated with hyperglycemia while protecting the skin from microbial infection (Richardson & Collins, 2023). Furthermore, phytosterols contribute to preserving collagen integrity, thereby improving both skin elasticity and moisture retention (Leistner et al., 2023). The 10% *Loranthus* sp. liquid soap also significantly increased skin moisture compared with baseline ($p = 0.026$). The mean increase was 3.1 percentage points, which was slightly greater than the change observed in the 5% group. The greater numerical improvement provides further support for a possible concentration-related pattern, although the difference between the 5% and 10% groups was relatively small.

The increase may be associated with the greater amount of *Loranthus* sp. extract contained in the 10% formulation. However, the findings do not establish that the increase was caused specifically by individual phytochemicals because these compounds were not separately measured in this study. The results therefore provide clinical evidence of an observed change in skin moisture rather than confirmation of a specific biological mechanism.

Effect of 15% *Loranthus* sp. liquid soap on skin moisture.

The 15% *Loranthus* sp. liquid soap produced the greatest improvement in skin moisture, with a highly significant Wilcoxon test result ($p = 0.0001$). All participants in this group demonstrated increased skin moisture after seven days of treatment. This superior effect is likely attributable to the higher concentration of bioactive compounds, including saponins, flavonoids, tannins, phytosterols, triterpenoids, cardiac glycosides, and anthraquinones, which may act synergistically to improve skin hydration (Chirani et al., 2021). These compounds help maintain the skin barrier, enhance tissue elasticity, protect collagen from oxidative damage, and support skin regeneration (Puspawiningtiyas et al., 2021). In addition, the antimicrobial activity of flavonoids and tannins may inhibit bacterial colonization on dry skin, thereby promoting healthier skin recovery (Ross et al., 2023).

The 15% *Loranthus* sp. liquid soap produced the greatest improvement in skin moisture, with a highly significant Wilcoxon test result ($p = 0.0001$). All participants in this group demonstrated increased skin moisture after seven days of treatment. The mean skin moisture increased from $37.0 \pm 5.3\%$ to $45.6 \pm 4.3\%$, representing an increase of 8.6 percentage points. This change was substantially greater than the mean changes observed in the 5% and 10% groups.

The greater improvement in the 15% group may be associated with the higher concentration of *Loranthus* sp. extract in the formulation, which provides a greater amount of plant extract available at the skin surface during application. The finding is consistent with the overall pattern observed in this study, in which the magnitude of skin-moisture improvement increased with extract concentration. However, the study did not directly investigate the biological mechanisms underlying this difference or quantify individual phytochemical constituents in the final formulation. Therefore, the greater improvement should be interpreted as an observed concentration-associated effect rather than evidence of a specific pharmacological mechanism.

Comparison of the effectiveness of 5%, 10%, and 15% *Loranthus* sp. liquid soap.

The present study demonstrated a statistically significant difference in skin moisture improvement among the three *Loranthus* sp. liquid soap concentrations ($p = 0.0017$). These findings indicate that the concentration of *Loranthus* extract significantly influences the moisturizing efficacy of the liquid soap.

The 5% formulation produced only modest improvements, likely because of its relatively lower concentration of active phytochemicals (VanderGiessen et al., 2023). Increasing the extract concentration to 10% resulted in greater improvement, reflecting the enhanced biological activity of antioxidant, antimicrobial, and moisturizing compounds (Falciani et al., 2023). The 15% formulation demonstrated the highest effectiveness, with all participants showing improved skin moisture (Sá-Leite et al., 2024).

From a pharmaceutical perspective, increasing the concentration of *Loranthus* extract increases the amount of active compounds that come into contact with the skin surface, thereby enhancing their biological effects (Pandey et al., 2023). Moreover, liquid soap offers several advantages over solid soap, including improved hygiene, easier application over the entire body, better maintenance of skin hydration, and reduced microbial contamination during use (Mussagy et al., 2023). The combination of a liquid soap formulation and the phytochemical constituents of *Loranthus* sp. provides a promising natural approach for skin care in pregnant women with gestational diabetes mellitus (Azme et al., 2023).

The present study demonstrated a statistically significant difference in skin moisture improvement among the three *Loranthus* sp. liquid soap concentrations ($p = 0.0017$). The mean change increased progressively from +2.5 percentage points in the 5% group to +3.1 percentage points in the 10% group and +8.6 percentage points in the 15% group. This finding indicates that the 15% formulation was associated with the greatest short-term improvement in the measured skin moisture outcome.

The substantially greater change observed in the 15% group compared with the two lower-concentration groups suggests that extract concentration may be an important formulation factor influencing skin-moisture outcomes. However, the results should not be interpreted as establishing 15% as the optimal or clinically superior concentration because the study evaluated only three concentrations, included a relatively small number of participants in each group, and did not include a non-intervention control group. Furthermore, the statistical difference among groups does not by itself establish the specific mechanism responsible for the observed difference.

These findings are relevant because they provide preliminary clinical evidence that different concentrations of *Loranthus* sp. liquid soap may produce different magnitudes of short-term changes in skin moisture. The results support further investigation of the concentration-response relationship using larger samples, an appropriate control group, and longer observation periods.

The findings demonstrate a consistent increase in skin moisture across all three *Loranthus* sp. liquid soap groups, with the greatest improvement observed in the 15% formulation. The statistical significance within each group and the significant difference among concentrations indicate that measurable short-term changes in skin moisture occurred following the intervention. However, the absence of a control group means that these changes cannot be attributed exclusively to *Loranthus* sp. extract. Therefore, the findings should be interpreted as preliminary evidence supporting further clinical evaluation of *Loranthus* sp. liquid soap for skin-moisture improvement.

From a clinical perspective, the 15% *Loranthus* sp. liquid soap showed potential to improve skin moisture over a short seven-day period. Nevertheless, this finding should not be interpreted as evidence of long-term effectiveness, prevention of skin complications, or safety during pregnancy because these outcomes were not assessed in the present study. Overall, the findings indicate that 15% *Loranthus* sp. liquid soap is the most effective formulation for improving skin moisture among pregnant women with gestational diabetes mellitus (Rahmi et al., 2017). This formulation has considerable potential for further development as a safe, natural, and user-friendly skin care product that may help prevent dermatological complications associated with gestational diabetes mellitus (Yogesh et al., 2024). This study has several limitations. First, the sample size was relatively small, with only 10 participants in each intervention group, which limits the statistical power and generalizability of the findings. Second, purposive sampling and non-randomized allocation may have introduced selection bias and potential baseline differences between groups. Third, the study did not include a non-intervention or placebo control group; therefore, the observed changes in skin moisture cannot be attributed exclusively to *Loranthus* sp. extract because the soap base, bathing practices, environmental conditions, or natural variation in skin moisture may also have contributed.

Fourth, the intervention lasted only seven days and no long-term follow-up was conducted. Consequently, the persistence of the observed improvement in skin moisture remains unknown. Fifth, although participants were instructed to avoid additional topical products and maintain consistent bathing practices, potential confounding factors such as environmental humidity, water temperature, outdoor activities, fluid intake, and fluctuations in blood glucose levels could not be completely controlled. Sixth, skin moisture was assessed using a single non-invasive instrument and a single anatomical measurement site, which may not represent skin hydration across the entire body.

Finally, the study focused only on skin moisture and did not assess other dermatological outcomes, such as skin barrier function, transepidermal water loss, pruritus, irritation, infection, or long-term maternal and pregnancy outcomes. Therefore, the findings should be interpreted as preliminary evidence of a short-term change in skin moisture rather than evidence of broader dermatological or clinical benefits.

4. CONCLUSION

This study found that the use of *Loranthus* sp. liquid soap was associated with increased skin moisture among pregnant women with gestational diabetes mellitus after seven consecutive days of intervention. Statistically significant within-group improvements were observed in all three intervention groups receiving 5%, 10%, and 15% *Loranthus* sp. extract. The magnitude of the increase was greatest in the 15% group, which showed a mean improvement of 8.6 percentage points, compared with 2.5 percentage points in the 5% group and 3.1 percentage points in the 10% group. A statistically significant difference in skin moisture changes was also observed among the three concentration groups. These findings suggest that the 15% *Loranthus* sp. liquid soap showed the greatest potential for improving skin moisture over the seven-day intervention period. However, the findings

should be interpreted as preliminary because the study used a non-randomized quasi-experimental design, involved a small sample size, did not include a non-intervention control group, and assessed only short-term changes in skin moisture. Therefore, the results do not establish long-term effectiveness, safety, or an optimal concentration for clinical use.

Further studies with larger sample sizes, randomized controlled designs, appropriate control groups, and longer follow-up periods are needed to confirm the observed findings and determine the durability of the effect. Future research should also assess safety and potential adverse skin reactions prospectively, as well as other relevant skin outcomes such as skin barrier function, transepidermal water loss, and patient-reported skin symptoms.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Siti Choirul Dwi Astuti contributed to conceptualization, methodology, literature review, questionnaire development, investigation, participant recruitment, data collection, formal analysis, data curation, writing – original draft, project administration, supervision, development of research checklists, data validation, writing – review and editing, preparation of the final research report, and reference book development. Hasnawatty Surya Porouw contributed to investigation, data collection, participant coordination, data validation, and manuscript review. Ayu Nala El Muna Haerussana contributed to methodology, preparation of *Loranthus* sp. extract, formulation and production of *Loranthus* sp. liquid soap, quality control of the herbal formulation, and manuscript review. Dicki Bakhtiar Purkon contributed to conceptualization of the herbal formulation, methodology, supervision of *Loranthus* sp. extraction and liquid soap formulation, validation, supervision, writing – review and editing, and critical revision of the manuscript. All authors contributed to the interpretation of the data, reviewed and approved the final version of the manuscript, and agreed to be accountable for all aspects of the work.

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DECLARATION OF ARTIFICIAL INTELLIGENCE USE

During the preparation of this manuscript, the authors used Grammarly to assist with language editing, grammar improvement, enhancement of readability, and refinement of the manuscript's organization. The AI-assisted tool was used solely to improve the clarity and presentation of the manuscript and did not contribute to the study design, data collection, data analysis, interpretation of results, or scientific conclusions. All outputs generated by the AI tool were carefully reviewed, verified, and edited by the authors. The authors accept full responsibility for the accuracy, originality, and integrity of the content presented in this manuscript.

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