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Liquid Soap with *Piper betle* L. Ethanolic Extract: Physical Stability over 28 Days at Different Extract Levels

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ABSTRACT

Liquid soap is widely used as a cleansing product because it is hygienic, practical, and easy to apply, while incorporation of plant-based bioactives is increasingly explored to enrich functional attributes of personal-care formulations. Ethanolic extract of betel leaf (*Piper betle* L.) contains multiple secondary metabolites, including flavonoids, alkaloids, steroids, saponins, tannins, and essential oils, which may contribute to formulation performance. This study evaluated the effect of *P. betle* ethanolic extract level (20%, 25%, and 30%; corresponding to 10.0, 12.5, and 15.0 g per 50 mL batch) on the physical stability of liquid soap during 28-day storage under ambient conditions. A laboratory experimental design was applied, and samples were stored at room temperature with periodic monitoring of temperature and relative humidity (27.2–31.1°C; 65–85%). Physical stability was assessed on days 0, 7, 14, 21, and 28 in triplicate (n = 3) using organoleptic evaluation, homogeneity, pH, foam height, foam stability, and specific gravity. Across the observation period, all formulations remained organoleptically acceptable and homogeneous, with pH and foaming characteristics maintained within acceptable ranges. Endpoint comparisons between day 0 and day 28 within each formulation did not show statistically significant differences for pH, foam height, foam stability, or specific gravity (paired t-test, $p > 0.05$). Overall, under the tested conditions, increasing the extract level from 20% to 30% did not indicate measurable deterioration of the liquid soap's physical stability over 28 days.

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ABSTRAK

Sabun cair merupakan produk pembersih yang banyak digunakan karena lebih higienis, praktis, dan mudah diaplikasikan, sementara pemanfaatan bahan bioaktif berbasis tanaman dalam sediaan perawatan diri terus dikembangkan untuk memperkaya karakteristik fungsional produk. Ekstrak etanol daun sirih hijau (*Piper betle* L.) diketahui mengandung metabolit sekunder seperti flavonoid, alkaloid, steroid, saponin, tanin, dan minyak atsiri yang berpotensi memengaruhi performa sediaan. Penelitian ini bertujuan mengevaluasi pengaruh variasi kadar ekstrak etanol daun sirih hijau (20%, 25%, dan 30%; setara 10,0; 12,5; dan 15,0 g per batch 50 mL) terhadap stabilitas fisik sediaan sabun cair selama penyimpanan 28 hari pada kondisi suhu ruang. Penelitian dilakukan secara eksperimental, dengan penyimpanan sampel pada suhu ruang disertai pemantauan suhu dan kelembaban relatif secara berkala (27,2–31,1°C; 65–85%). Evaluasi stabilitas fisik dilakukan pada hari ke-0, 7, 14, 21, dan 28 dengan tiga kali replikasi (n = 3) meliputi uji organoleptis, homogenitas, pH, tinggi busa, stabilitas busa, dan bobot jenis. Selama periode pengamatan, seluruh formula tetap homogen dan tidak menunjukkan perubahan organoleptik yang mengindikasikan ketidakstabilan, sedangkan pH dan karakteristik busa berada dalam rentang yang dapat diterima. Perbandingan endpoint antara hari ke-0 dan hari ke-28 pada masing-masing formula menunjukkan tidak terdapat perbedaan yang bermakna secara statistik untuk pH, tinggi busa, stabilitas busa, dan bobot jenis (uji t berpasangan, $p > 0,05$). Secara keseluruhan, pada kondisi uji ini, peningkatan kadar ekstrak 20–30% tidak menunjukkan penurunan stabilitas fisik sabun cair hingga hari ke-28.

Kata Kunci:
Sabun cair; *Piper betle* L.; Ekstrak etanol; Stabilitas fisik; Karakteristik busa; pH; Bobot jenis

1. Introduction

Hand hygiene remains a cornerstone of infection prevention because it interrupts the transfer of enteric and environmental microorganisms from contaminated surfaces to the oral route, thereby reducing the risk of gastrointestinal disease, including diarrhoeal episodes associated with *Escherichia coli* exposure [1],[2]. In community and institutional settings, compliance with hand hygiene is strongly influenced by the accessibility and usability of cleansing agents; consequently, liquid soap has gained prominence because it is perceived as more hygienic, convenient, and practicable, particularly for shared or public facilities where rapid and repeated use is required [3],[4]. Beyond the basic function of soil removal, contemporary personal-care formulations increasingly incorporate natural bioactive ingredients to enhance perceived efficacy and to respond to consumer demand for plant-derived components, including the inclusion of botanical extracts with reported antimicrobial potential [5],[6].

Among commonly utilised medicinal plants in Indonesia, green betel leaf (*Piper betle* L.) is widely recognised for its traditional use and reported antibacterial properties. Phytochemical investigations have indicated that *P. betle* leaves contain diverse secondary metabolites, including flavonoids, alkaloids, saponins, tannins, steroids, and essential oils, which may collectively contribute to antibacterial effects through mechanisms such as membrane perturbation, protein interaction, or interference with microbial metabolic processes [7],[8]. In the context of liquid soap development, prior work has reported that formulations incorporating 20%, 25%, and

30% ethanolic extract of green betel leaves exhibit inhibitory activity against *E. coli* [9]. However, these reports primarily emphasised antibacterial performance and provided limited evaluation of physical stability, even though stability constitutes a critical determinant of product quality and acceptability during storage and distribution.

In pharmaceutical and cosmetic sciences, stability is generally conceptualised as the capacity of a preparation to maintain its intended physical characteristics and performance attributes throughout its shelf life, ensuring consistent quality, safety, and functional reliability [10]. For liquid soap, physical stability is typically reflected in parameters such as organoleptic attributes (colour, odour, and appearance), homogeneity, pH, and foaming behaviour, alongside density-related properties that can indicate structural or compositional changes during storage [11],[12]. Instability may manifest as phase separation, perceptible changes in odour or colour, altered foaming capacity, or shifts in pH that can affect user comfort and product performance. Such changes may be modulated by external stressors (temperature fluctuation, humidity, oxygen exposure, and microbial contamination) and internal formulation variables, including the concentration of extractives and surfactants, which can influence interfacial phenomena and overall system integrity [11],[12].

Although variations in active-ingredient concentration are frequently associated with changes in pH, homogeneity, and foam characteristics in liquid formulations, systematic evidence focusing on the physical stability of green-betel-leaf-extract liquid soap across different extract levels remains limited. Therefore, this study was designed to evaluate the effect of *P. betle* ethanolic extract level (20%, 25%, and 30%) on the physical stability of liquid soap during 28-day storage at room temperature, using repeated observations for organoleptic properties and homogeneity, as well as quantitative assessment of pH, foam height, foam stability, and specific gravity.

2. Methods

Study Design and Storage Conditions

This study employed a laboratory experimental design to evaluate the effect of *Piper betle* L. ethanolic extract level (20%, 25%, and 30%) on the physical stability of liquid soap during 28-day storage. Stability observations were conducted on days 0, 7, 14, 21, and 28 under ambient room-temperature conditions. Temperature and relative humidity were monitored periodically throughout storage (27.2–31.1°C; 65–85% RH).

Materials and Instruments

Materials included ethanolic extract of green betel leaves, olive oil, stearic acid, butylated hydroxyanisole (BHA), Na-CMC, KOH, ethanol (70% and 96%), sodium lauryl sulfate (SLS), and distilled water. Instruments included a calibrated pH meter, pycnometer, analytical balance, standard glassware, blender, 20-mesh sieve, and water bath.

Plant Material Preparation and Ethanolic Extraction

Green betel leaves (*Piper betle* L.) were dried at 50°C for 24 h, milled, and sieved using a 20-mesh sieve. Extraction was performed by maceration using 70% ethanol: 400 g of powdered plant material was macerated in 2 L solvent, followed by re-maceration using 1 L solvent. Combined filtrates were concentrated using a water bath until a thick extract was obtained.

Formulation of Liquid Soap Containing *Piper betle* Extract

Liquid soap was formulated at three extract levels (F1: 20%, F2: 25%, F3: 30%), as presented in **Table 1**. Olive oil was mixed with 40% KOH and heated at 70°C until a

soap paste formed. Separately, Na-CMC was dispersed in hot distilled water, stearic acid was dissolved in 96% ethanol, SLS was dissolved in distilled water, and BHA was dissolved in 50% ethanol. These components were added sequentially into the soap paste with continuous mixing until a uniform base was obtained. The *Piper betle* ethanolic extract was then incorporated according to the intended concentration (20%, 25%, or 30%) and mixed until homogeneous. Finally, distilled water was added q.s. to obtain a final batch volume of 50 mL [9].

Table 1. Composition of liquid soap formulations containing *Piper betle* L. ethanolic extract

Ingredient	Function	F1 (20%) (g)	F2 (25%) (g)	F3 (30%) (g)
Piper betle L. ethanolic extract	Active ingredient	10.0	12.5	15.0
Olive oil	Fatty acid source (soap base)	15.0	15.0	15.0
KOH 40% (w/w)*	Alkali (saponification agent)	8.0	8.0	8.0
Na-CMC	Thickener/viscosity modifier	0.50	0.50	0.50
SLS	Surfactant and foaming agent	0.50	0.50	0.50
Stearic acid	Foam stabilizer/consistency agent	0.25	0.25	0.25
BHA	Antioxidant	0.50	0.50	0.50
Distilled water (q.s. ad 50 mL)**	Solvent and dispersing medium (Na-CMC)	q.s.	q.s.	q.s.

Note:
** KOH 40% (w/w): prepared as an aqueous solution containing 40 g KOH pellets per 100 g final solution.*
*** q.s. ad 50 mL: distilled water was added in sufficient quantity to obtain a final batch volume of 50 mL after complete mixing of all components.*

Physical Property Evaluation

All measurements were performed in triplicate (n = 3) at each observation time point unless stated otherwise.

Organoleptic Evaluation

Organoleptic properties (appearance/form, colour, and odour) were assessed by direct visual and sensory observation [13].

Homogeneity Test

Approximately 0.1 g of sample was placed on a glass slide and examined for the presence of coarse particles or non-uniform dispersion [13].

pH Measurement

One gram of sample was dispersed in 10 mL distilled water, and pH was measured using a pH meter [14].

Foam Height

One gram of sample was placed in a measuring cylinder containing 10 mL distilled water. The cylinder was covered and shaken vertically for 20 s, after which foam height was measured [13].

Foam Stability

Foam was generated as described in Section 2.5.4. Foam stability was determined by recording foam height after 5 min and expressing it as a percentage of the initial foam height. Foam was considered acceptable when it remained within 60–70% of the initial volume after 5 min [13].

Specific Gravity (Pycnometer Method)

Specific gravity (relative density) was determined using a calibrated pycnometer at 25°C. The clean and dry empty pycnometer was weighed (W0). The

pycnometer was then filled with distilled water, equilibrated at 25°C for approximately 10 min, wiped dry on the outside, and weighed (W1). After emptying and drying, the pycnometer was filled with the liquid soap sample, equilibrated under the same condition, wiped dry externally, and weighed (W2). All weighings were performed using an analytical balance, and measurements were conducted in triplicate (n = 3).

Specific gravity (SG, dimensionless) was calculated using the standard pycnometric relationship [15]:

$$SG = \frac{W_2 - W_0}{W_1 - W_0}$$

where W0 is the mass of the empty pycnometer, W1 is the mass of the pycnometer filled with water, and W2 is the mass of the pycnometer filled with sample (all in grams).

If density is required (ρ, g/mL), it was obtained by multiplying SG by the density of water at the measurement temperature [16]:

$$\rho_{\text{sample}} = SG \times \rho_{\text{water},25^\circ C}$$

where $\rho_{\text{water},25^\circ C}$ is the density of water at 25°C (g/mL).

Stability Testing Protocol

Stability testing was conducted by storing the formulated liquid soap samples at room temperature and observing organoleptic properties, homogeneity, pH, foam height, foam stability, and specific gravity over 28 days (days 0, 7, 14, 21, and 28) under monitored ambient conditions (27.2–31.1°C; 65–85% RH) [17].

Statistical Analysis

Quantitative data are presented as mean ± SD (n = 3). For endpoint-focused comparison, day-0 and day-28 values within each formulation were analysed using paired t-tests (SPSS), with statistical significance set at $p < 0.05$.

3. Results and Discussion

Formulation Overview and Visual Characteristics

The prepared liquid soap formulations were designed as an aqueous surfactant system generated through saponification of a lipid phase (olive oil) with KOH, followed by structural stabilisation using a polymeric thickener (Na-CMC), an anionic surfactant and foam former (SLS), and a foam-stabilising fatty component (stearic acid), with BHA included to mitigate oxidative deterioration during storage. Within this formulation logic, the measured stability attributes (organoleptic appearance, homogeneity, pH, foaming performance, and density-related behaviour) represent practical physicochemical surrogates for the integrity of the dispersed/micellar system and its resistance to time-dependent changes that can compromise product quality and user acceptability [18],[19]. The incorporation of *Piper betle* L. ethanolic extract at three concentration levels (F1 20%, F2 25%, and F3 30%) was adopted based on previous formulation work in which these extract loadings were utilised in liquid soap matrices [20].

As shown in **Figure 1**, the freshly prepared products (day 0) presented as thick, slightly fluid liquid soaps with a characteristic brownish-green coloration and a distinctive *P. betle* odour, with the highest extract formulation (F3) exhibiting a more

intense colour and a visibly higher apparent viscosity than the lower-extract counterparts. This concentration-dependent visual intensification is mechanistically plausible because botanical extracts introduce a complex mixture of polar and semi-polar constituents (including polyphenolic compounds and other extractives) as well as amphiphilic components such as saponins and volatile fractions (essential-oil components), all of which can modulate colour, odour intensity, and interfacial behaviour in surfactant-based systems [11],[12]. Consequently, although the three formulations were visually compatible at initial preparation, systematic stability evaluation over 28 days under ambient storage (27.2–31.1°C; 65–85% RH) was required to determine whether increasing extract loading (20–30%) would precipitate time-dependent physicochemical drift, phase instability, or performance deterioration within the liquid soap matrix [11],[12].

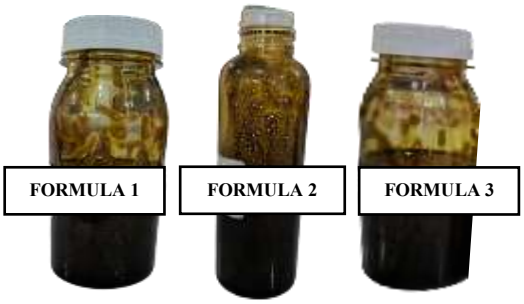

Figure 1. Visual appearance of liquid soap formulations containing *Piper betle* L. ethanolic extract at different extract levels: F1 (20%), F2 (25%), and F3 (30%) (day 0)

Organoleptic Stability (Colour, Odour, and Texture)

Organoleptic evaluation represents an early and clinically relevant indicator of physical stability because perceptible changes in colour, odour, and texture may signal oxidative processes, compositional imbalance, or incipient phase instability, and such changes can reduce user acceptability even before quantitative parameters demonstrate measurable drift [21]. In the present study, organoleptic stability was monitored on days 0, 7, 14, 21, and 28 in accordance with standard physical-evaluation procedures for liquid and semi-solid preparations [13],[22]. At baseline (day 0), all formulations exhibited a brownish-green appearance and a characteristic *Piper betle* odour, with a thick, slightly fluid texture. A concentration-dependent baseline difference was evident, wherein the formulation containing the highest extract level (F3, 30%) displayed a darker colour intensity and a relatively thicker texture compared with F1 (20%) and F2 (25%). This observation is analytically plausible because a higher extract loading introduces a greater amount of dissolved and colloidal extractives that may intensify colour and increase apparent viscosity, without necessarily indicating instability.

Across the 28-day storage period, no organoleptic deterioration was observed in any formulation. Specifically, there were no progressive colour changes suggestive of degradation, no emergence of off-odour, and no textural alterations consistent with phase separation or macroscopic breakdown. Importantly, the darker colour and thicker texture of F3 remained stable across time and should therefore be interpreted as an intrinsic attribute of the higher extract concentration rather than a manifestation of deterioration, particularly because it was not accompanied by other visible instability phenomena. Overall, these findings indicate that, under the tested storage condition,

variation in *P. betle* ethanolic extract level (20–30%) did not compromise organoleptic stability over 28 days, supporting the compatibility of the extract within the liquid soap matrix at the studied concentrations [11],[13].

Table 2. Organoleptic evaluation of liquid soap formulations containing *Piper betle* L. ethanolic extract during 28-day storage (room temperature)

Day	F1 (20%)	F2 (25%)	F3 (30%)
0	Brownish-green; characteristic *P. betle* odour; thick, slightly fluid	Brownish-green; characteristic *P. betle* odour; thick, slightly fluid	Darker brownish-green; characteristic *P. betle* odour; thicker, slightly fluid
7	No observable change vs day 0	No observable change vs day 0	No observable change vs day 0
14	No observable change vs day 0	No observable change vs day 0	No observable change vs day 0
21	No observable change vs day 0	No observable change vs day 0	No observable change vs day 0
28	No observable change vs day 0	No observable change vs day 0	No observable change vs day 0

Homogeneity and Phase Integrity

Homogeneity is a fundamental indicator of physical stability for liquid cleansing systems because it reflects the uniform dispersion of all constituents and the absence of macroscopic incompatibility phenomena such as sedimentation, creaming, or phase separation, which can emerge when botanical extractives interact unfavourably with the surfactant–thickener network [11]. In the present work, homogeneity was evaluated microscopically on a glass slide to detect coarse particles and non-uniform dispersion, and the results were tracked longitudinally on days 0, 7, 14, 21, and 28 [13]. As summarised in **Table 3**, all formulations (F1–F3) were homogeneous at baseline and remained homogeneous throughout the 28-day storage period, with no visible coarse particles, layering, or sediment formation. This persistent homogeneity supports the inference that the *Piper betle* ethanolic extract at 20–30% was compatible with the liquid soap matrix under the tested conditions, and that the combined structuring roles of Na-CMC (viscosity enhancement and dispersion stabilisation) together with the surfactant system (SLS) were sufficient to maintain phase integrity over time [11]. These findings also provide a coherent physical basis for interpreting subsequent stability outcomes (pH, foaming behaviour, and density-related measures), because stable dispersion reduces the likelihood that temporal changes are driven by segregation rather than by genuine physicochemical drift [11],[13].

Table 3. Homogeneity test of liquid soap formulations containing *Piper betle* L. ethanolic extract during 28-day storage

Formulation	Day 0	Day 7	Day 14	Day 21	Day 28
F1 (20%)	+	+	+	+	+
F2 (25%)	+	+	+	+	+
F3 (30%)	+	+	+	+	+

Note: (+) homogeneous; (–) non-homogeneous.

pH Profile and Safety Relevance

pH is a critical quality attribute for liquid soap because it is directly linked to user tolerability and potential irritation risk, while also reflecting the chemical equilibrium of the soap–surfactant system during storage [12]. In this study, pH was measured after calibrating the pH meter using standard buffer solutions (pH 4.01 and 6.86) to ensure analytical reliability prior to sample reading [23]. At baseline (day 0), the pH values of F1–F3 were within the alkaline range specified by SNI 06-4085-1996 for liquid soap products (pH 8–11), indicating that the formulations met the national quality requirement at the time of preparation [24]. This profile is also consistent with prior work on *Piper betle* extract-based liquid soap that reported pH values within a comparable range [9].

Table 4. pH of liquid soap formulations containing *Piper betle* L. ethanolic extract at day 0 and day 28

Formula	Day 0 (pH)	Day 28 (pH)	Sig. (2-tailed)
F1 (20%)	8.83 ± 0.05	8.60 ± 0.05	0.091
F2 (25%)	8.92 ± 0.06	8.55 ± 0.06	0.068
F3 (30%)	9.20 ± 0.18	8.58 ± 0.03	0.056

Over 28 days of ambient storage, all formulations exhibited only modest numerical shifts in pH, and the measured values remained within the SNI-referenced acceptable range throughout the observation window. Endpoint comparison between day 0 and day 28 using paired t-tests showed no statistically significant differences for any formulation ($p > 0.05$), suggesting that increasing extract level from 20% to 30% did not produce a detectable deterioration of pH stability under the tested condition (**Table 4**). From a formulation-stability perspective, the absence of a significant endpoint change supports the inference that the system maintained a relatively stable alkaline environment during storage, and that extract incorporation at the studied levels did not introduce progressive acidifying/alkalising drift that would be meaningful for product performance or tolerability [12],[25].

Foaming Capacity (Foam Height)

Foaming capacity is a functional performance attribute of liquid soap because foam formation is strongly associated with consumer perception of cleansing efficacy and is mechanistically governed by surfactant concentration, interfacial tension reduction, and the stability of air–liquid films generated during agitation [26]. In the present study, foam height was measured using a standardised shaking procedure at defined sample mass and dilution volume, thereby enabling comparative interpretation across formulations prepared under identical conditions [27]. At baseline (day 0), foam height values differed slightly across extract levels, with the higher-extract formulation (F3, 30%) tending to produce a greater foam column than the lower-extract formulations. This pattern is mechanistically plausible because *Piper betle* ethanolic extract may introduce amphiphilic constituents (notably saponins) that can contribute to surface activity and foam formation in aqueous systems, potentially augmenting the foaming performance of the base surfactant matrix when incorporated at higher loading [28].

Table 5. Foam height of liquid soap formulations containing *Piper betle* L. ethanolic extract at day 0 and day 28

Formula	Day 0 (cm)	Day 28 (cm)	Sig. (2-tailed)
F1 (20%)	6.60 ± 0.10	6.40 ± 0.10	0.112
F2 (25%)	6.70 ± 0.20	6.50 ± 0.10	0.097
F3 (30%)	7.50 ± 0.30	7.30 ± 0.20	0.085

During 28-day storage, foam height remained within an acceptable functional range for liquid soap and did not demonstrate a statistically detectable endpoint decline within each formulation. Paired t-test comparisons between day 0 and day 28 indicated no significant differences for F1–F3 ($p > 0.05$), suggesting that extract incorporation at 20–30% did not compromise foaming capacity over the observation period (**Table 5**). Collectively, these results imply that the surfactant–thickener architecture of the formulation remained sufficiently stable to preserve foam generation characteristics during storage, and that any extract-related enhancement of foaming (particularly in F3) was maintained without evidence of performance deterioration [12],[29].

Foam Stability

Foam stability reflects the persistence of the foam structure over time and is determined by the strength and elasticity of the air–liquid interfacial film, drainage rate, and resistance to bubble coalescence and collapse. In liquid soap systems, foam stability is influenced not only by the primary surfactant (e.g., SLS), but also by formulation components that reinforce the lamellar structure of the foam film, including fatty-acid derivatives and structuring agents such as stearic acid, which may increase film robustness and delay foam decay [12]. In the present study, foam stability was evaluated as the percentage of foam height retained after 5 min relative to the initial foam height generated under standardised shaking conditions [13].

Table 6. Foam stability of liquid soap formulations containing *Piper betle* L. ethanolic extract at day 0 and day 28

Formula	Day 0 (%)	Day 28 (%)	Sig. (2-tailed)
F1 (20%)	66.0 ± 2.0	65.0 ± 1.0	0.109
F2 (25%)	66.0 ± 2.0	67.0 ± 2.0	0.084
F3 (30%)	69.0 ± 1.0	68.0 ± 2.0	0.134

As presented in **Table 6**, all formulations maintained foam stability values within the commonly cited acceptable range of 60–70% foam retention at 5 min, indicating adequate foam persistence for practical use [13]. Although slight numerical variation was observed across extract levels, endpoint paired t-tests comparing day 0 and day 28 did not reveal statistically significant differences for F1–F3 ($p > 0.05$). These findings suggest that, under the tested storage condition, increasing *Piper betle* ethanolic extract concentration from 20% to 30% did not induce measurable destabilisation of the foam film. Mechanistically, this outcome is consistent with a formulation in which the surfactant–fatty component balance (SLS with stearic acid as a foam stabiliser) remained sufficiently preserved over time, thereby sustaining film strength and limiting progressive drainage or coalescence that would otherwise manifest as declining foam retention during storage [30].

Density (Pycnometer-Derived)

Density or specific gravity is a useful supporting indicator of physical stability in liquid formulations because it can reflect changes in total dissolved/colloidal solids, microstructural organisation, and overall system integrity during storage. In surfactant-based cleansing systems, density may be influenced by the concentration of extractives, the extent of solubilisation within micellar structures, and the viscosity-modifying effect of polymeric thickeners, whereas substantial time-dependent shifts may signal compositional drift or phase-related instability [11]. In the present study, density was determined using a pycnometer at controlled temperature, and values were reported in g/mL (mean ± SD, n = 3) [15],[16].

Table 7. Density (pycnometer-derived) of liquid soap formulations containing *Piper betle* L. ethanolic extract at day 0 and day 28

Formula	Day 0 (g/mL)	Day 28 (g/mL)	Sig. (2-tailed)
F1 (20%)	1.034 ± 0.010	1.007 ± 0.010	0.093
F2 (25%)	1.047 ± 0.006	1.004 ± 0.006	0.064
F3 (30%)	1.086 ± 0.015	1.005 ± 0.010	0.062

As shown in **Table 7**, baseline density values increased with higher extract levels, with F3 (30%) exhibiting the highest density at day 0 compared with F1 (20%) and F2 (25%). This pattern is mechanistically plausible because higher extract loading introduces additional dissolved and dispersed constituents that increase the mass fraction of non-volatile solids within the formulation, thereby elevating density. During 28-day storage, density values for all formulations showed only modest numerical variation and remained within a comparable range, and paired t-test comparisons between day 0 and day 28 did not demonstrate statistically significant differences ($p > 0.05$). Collectively, these findings indicate that incorporation of *Piper betle* ethanolic extract at 20–30% did not cause a measurable density drift suggestive of instability under the tested condition, and the preserved density profile is coherent with the observed maintenance of homogeneity and organoleptic integrity across the study period [11], [15], [16].

Integrated Interpretation and Statistical Statement

Collectively, the stability dataset indicates that incorporation of *Piper betle* L. ethanolic extract at 20–30% was compatible with the liquid soap matrix under the tested storage condition. Across 28 days, all formulations retained stable macroscopic quality attributes, evidenced by preserved organoleptic characteristics (**Table 2**) and sustained homogeneity without visible phase separation (**Table 3**). Quantitative endpoint comparisons further supported this interpretation: pH remained within the SNI-referenced acceptable range for liquid soap (pH 8–11) and showed no statistically significant day-0 versus day-28 differences ($p > 0.05$; **Table 4**) [24]. Similarly, functional foaming performance was maintained, as indicated by stable foam height and foam retention with no significant endpoint change within each formulation ($p > 0.05$; **Tables 5–6**) and with foam stability values remaining within the commonly cited acceptable range of 60–70% after 5 min [13]. Finally, density (pycnometer-derived) showed only modest numerical variation and no statistically detectable endpoint drift ($p > 0.05$; **Table 7**), aligning with the maintained phase integrity reflected in the homogeneity findings [11],[15],[16]. Taken together, these results suggest that, within the scope of this study, increasing extract level from 20% to 30% did not produce measurable deterioration of physical stability over 28 days at room temperature, and

that the formulation design (saponified base with Na-CMC thickening and SLS–stearic acid foaming system) was sufficiently robust to accommodate the botanical extract load [11], [12].

From an interpretive standpoint, it is also noteworthy that concentration-dependent baseline differences—particularly the darker colour and higher apparent viscosity/density in the 30% extract formulation—should be viewed as intrinsic formulation attributes attributable to the increased load of dissolved and colloidal extractives, rather than indicators of instability, because these differences did not evolve unfavourably over the storage period and were not accompanied by off-odour formation, phase separation, or foaming deterioration [11]. Accordingly, the present findings provide a coherent stability narrative in which extract incorporation modifies initial sensory and physicochemical profiles in a concentration-related manner, while the storage trajectory remains stable under the applied condition.

Limitations of the Study

Several limitations should be acknowledged to contextualise the interpretation and to guide future work. First, although stability observations were conducted at multiple time points (days 0, 7, 14, 21, and 28), the inferential statistics in this manuscript were based on endpoint comparisons (day 0 vs day 28). While such endpoint testing provides a practical screening of net change, it may be less sensitive to non-linear temporal patterns; therefore, future studies should apply repeated-measures modelling (e.g., repeated-measures ANOVA or linear mixed-effects analysis) to quantify time effects, formulation effects, and time × formulation interactions across the full observation trajectory. Second, the storage condition was limited to ambient room temperature with monitored humidity; consequently, accelerated stability protocols (e.g., elevated temperature storage, freeze–thaw cycling, and centrifugation stress testing) would be valuable to more rigorously challenge the formulation and to support longer-term shelf-life prediction. Third, the present work emphasised physical stability parameters; microbiological quality was not assessed, and future investigations should consider preservative efficacy and microbial limit testing in alignment with cosmetic microbiological standards where applicable. Collectively, addressing these limitations would strengthen evidence for product robustness beyond the present 28-day ambient-condition window and improve the translational relevance for real-world storage and distribution.

4. Conclusion

This study demonstrated that liquid soap formulations containing *Piper betle* L. ethanolic extract at 20%, 25%, and 30% remained physically stable during 28-day storage under ambient conditions (27.2–31.1°C; 65–85% RH). All formulations maintained acceptable organoleptic characteristics and preserved homogeneity without visible phase separation throughout the observation period. Quantitative endpoint comparisons between day 0 and day 28 indicated no statistically significant changes ($p > 0.05$) in pH, foam height, foam stability, or pycnometer-derived density within each formulation, and the pH values remained within the SNI-referenced acceptable range for liquid soap (pH 8–11). Overall, within the tested storage condition and observation window, increasing the extract level from 20% to 30% did not indicate measurable deterioration of physical stability, supporting the compatibility of *P. betle* ethanolic extract with the liquid soap matrix at the studied concentrations.

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Conflict of Interest:
The authors declare no conflict of interest related to this study.

References

[1] R. Liandari, "Association between hand hygiene and intestinal parasite contamination among elementary-level students at Islamic boarding school X, Surabaya (2018)," *Medical Technology and Public Health Journal (MTPH J)*, vol. 5, no. 1, pp. 75–84, 2021. [Online]. Available: https://lppm.unusa.ac.id/mtphj/

[2] D. Ningtias, I. Faridah, and R. S. Sari, "Association between handwashing with soap behavior and diarrhea among grade-5 students at SDN Nagrog, Tangerang (2024)," *Gudang Jurnal Ilmu Kesehatan*, vol. 2, no. 2, pp. 329–333, 2024. [Online]. Available: https://gudangjurnal.com/

[3] M.-F. King *et al.*, "Bacterial transfer to fingertips during sequential surface contacts with and without gloves," *Indoor Air*, vol. 30, no. 5, pp. 993–1004, 2020. [Online]. Available: https://doi.org/10.1111/ina.12682

[4] M. A. Rifqi *et al.*, "Effect of handwashing on the reduction of *Escherichia coli* on children's hands in an urban slum in Indonesia," *Journal of Water and Health*, vol. 21, no. 11, pp. 1651–1662, 2023. [Online]. Available: https://doi.org/10.2166/wh.2023.121

[5] S. R. D. Ariani, L. Rahmawati, and A. N. Prasetyawati, *Monograph: Innovation of Transparent Bath Soap Products Enriched with Essential Oils of Local Flowers*. East Java, Indonesia: Uwais Inspirasi Indonesia, 2024. [Online]. Available: https://www.google.com/books

[6] L. Y. Yusan, Y. Nailufa, and Suryadhi, *Handwash Production: Improving UMKM Soap Quality*. Surabaya, Indonesia: Scorpindo Media Pustaka, 2022. [Online]. Available: https://www.google.com/books

[7] N. Marfu'ah, Sha'sha, Luthfiana, and Ichwanuddin, "Antibacterial potential test against *Staphylococcus aureus* of green betel leaf (*Piper betle* L.) ethanol extract," *Pharmaceutical Journal of Islamic Pharmacy*, vol. 5, no. 2, pp. 1–10, 2021. [Online]. Available: https://media.neliti.com/media/publications/520775-uji-daya-hambat-ektrak-etanol-daun-sirih-53aed492.pdf

[8] H. H. Sadiah, A. I. Cahyadi, and S. Windria, "A review of green betel leaf (*Piper betle* L.) as an antibacterial agent," *Jurnal Sain Veteriner*, vol. 40, no. 2, pp. 128–138, 2022. [Online]. Available: https://journal.ugm.ac.id/jsv/article/view/58745

[9] R. Rahmadina, *Formulation and Antibacterial Activity Test of Liquid Soap Containing Ethanol Extract of Betel Leaf (Piper betle L.) Against* Escherichia coli*. Yogyakarta, Indonesia: STIKes Akbidyo. [Online]. Available: https://doi.org/10.24252/al-kimia.v11i1.34386

[10] C. Huda and A. S. Tri, *Textbook of Solid Dosage Form Technology*. Malang, Indonesia: Media Nusa Creative. [Online]. Available: https://www.google.com/books

[11] C. M. Sativareza, I. Tivani, and A. A. Barlian, "Physical stability evaluation of liquid soap containing pineapple peel extract (*Ananas comosus* L. Merr.)," 2021.

[Online]. Available: https://journal.stifera.ac.id/index.php/jfsi/article/download/67/66

[12] M. Dhrik and R. T. Sawji, "Optimization of sodium lauryl sulfate (SLS) and stearic acid in a liquid-soap formulation containing green betel leaf (*Piper betle* L.) ethanol extract," *Jurnal Ilmiah Mahaganesha*, vol. 2, no. 1, pp. 1–10, 2023. [Online]. Available: https://jurnalfkip.unram.ac.id/index.php/JPM/article/download/4940/3061/21911

[13] R. Rinaldi, F. Fauziah, and R. Mastura, "Formulation and inhibition activity test of liquid soap containing citronella (*Cymbopogon nardus* L.) ethanol extract against *Staphylococcus aureus*," *Jurnal Riset Kefarmasian Indonesia*, vol. 3, no. 1, pp. 45–57, 2021. [Online]. Available: https://doi.org/10.33759/jrki.v3i1.115

[14] E. L. Ariyanti, R. P. Handayani, and E. S. Yanto, "Formulation of antioxidant serum from tomato extract (*Solanum lycopersicum* L.) and cinnamon extract (*Cinnamomum burmannii*) for skin care," *Journal of Holistic Health Science*, vol. 4, no. 1, pp. 50–57, 2020. [Online]. Available: https://doi.org/10.51873/jhhs.v4i1.80

[15] H. P. Hutauruk, P. V. Y. Yamlean, and W. Wiyono, "Formulation and antibacterial activity test of a cream containing celery herb (*Apium graveolens* L.) ethanol extract against *Staphylococcus aureus*," *Pharmacon*, vol. 9, no. 2, pp. 73–81, 2020. [Online]. Available: https://doi.org/10.35799/pha.9.2020.29275

[16] C. G. Gamas, D. B. R. E., and M. K. Putri, "Formulation and antibacterial test of liquid soap containing ylang-ylang flower (*Cananga odorata*) ethanol extract with citrus peel scrub (*Citrus reticulata* Blanco) against *Staphylococcus aureus*," *Jurnal Ilmu Kesehatan*, vol. 2, no. 2, pp. 34–49, 2023. [Online]. Available: https://doi.org/10.35335/midwifery.v12i3.1668

[17] Y. P. Tanjung, T. Akmal, and H. Virginia, "Formulation of hand cream containing basil (*Ocimum basilicum*) leaf essential oil," *Indonesian Journal of Pharmaceutical Science and Technology*, vol. 1, no. 1, pp. 33–40, 2022. [Online]. Available: https://doi.org/10.24198/ijpst.v1i1.41529

[18] S. Ainun, N. Sylvia, Zulnazri, R. Dewi, and I. Kamar, "Effect of NaOH variation on the quality of rosemary aromatherapy transparent soap based on VCO and olive oil," *Chemical Engineering Journal Storage*, vol. 5, no. 4, pp. 618–632, 2024. [Online]. Available: https://doi.org/10.29103/cejs.v4i5.15280

[19] F. D. Pertiwi, F. Rezaldi, and R. Puspitasari, "Activity test and formulation of a liquid body wash containing butterfly pea (*Clitoria ternatea* L.) ethanol extract as an antibacterial agent against *Staphylococcus epidermidis*," *Jurnal Ilmiah Kedokteran dan Kesehatan*, vol. 1, no. 1, pp. 53–66, 2022. [Online]. Available: https://doi.org/10.55606/klinik.v1i1.257

[20] A. J. Yustisi, S. Wahyuningsih, and N. Auliah, "Antibacterial activity test of liquid soap containing pomelo peel essential oil (*Citrus maxima*)," *Jurnal Riset Kefarmasian Indonesia*, vol. 5, no. 2, pp. 228–244, 2023. [Online]. Available: https://jurnalfarmasi.or.id/index.php/jrki/article/view/355/200

[21] I. Arman, H. J. Edy, and K. L. R. Mansauda, "Formulation and physical stability test of peel-off gel mask containing miana leaf (*Coleus scutellarioides* (L.) Benth.) ethanol extract with different bases," *Jurnal Farmasetis*, vol. 4, no. 1, pp. 36–43, 2021. [Online]. Available: https://doi.org/10.35799/pmj.4.1.2021.34523

[22] P. I. Sari, S. Malahayati, and D. Kurniawati, "Formulation and stability of liquid soap containing lime peel extract (*Citrus aurantifolia*) as an antiseptic," *Jurnal*

Surya Medika, vol. 10, no. 3, pp. 149–156, 2024. [Online]. Available: https://doi.org/10.33084/jsm.v10i3.9007

[23] R. Tiwari and G. S. Mahalpure, "A detailed review of pH and its applications," *Journal of Pharmaceutical and Biopharmaceutical Research*, vol. 6, no. 2, pp. 492–505, 2025. [Online]. Available: https://doi.org/10.25082/jpbr.2024.02.001

[24] Badan Standardisasi Nasional, *Liquid Bath Soap Standard: SNI 06-4085-1996*. Jakarta, Indonesia: BSN, 1996. [Online]. Available: https://sispk.bsn.go.id/SNI/DetailSNI/11876

[25] Syamsu, I. Suparlan, M. Yusuf, Arfiani, and D. Maruf, "Formulation and activity test of liquid bath soap containing kapok leaf (*Ceiba pentandra* (L.) Gaertn) ethanol extract against *Staphylococcus aureus*," *SEHATMAS: Jurnal Ilmiah Kesehatan Masyarakat*, vol. 1, no. 1, pp. 92–104, 2022. [Online]. Available: https://doi.org/10.55123/sehatmas.v1i1.53

[26] N. K. Pareda, H. J. Edy, and J. S. Lebang, "Formulation and antibacterial activity test of liquid soap combining teak leaf (*Tectona grandis* Linn.f.) ethanol extract and cat-tail leaf (*Acalypha hispida* Burm.f.) ethanol extract against *Staphylococcus aureus*," *Pharmacon*, vol. 9, no. 4, pp. 558–570, 2020. [Online]. Available: https://ejournal.unsrat.ac.id/v2/index.php/pharmacon/article/view/31366

[27] D. R. Fitri, H. Mustikawati, and D. T. Afianty, "Formulation of liquid bath soap containing jackfruit (*Artocarpus heterophyllus* Lam.) ethanol extract," *ISTA Online Technology Journal*, vol. 1, no. 1, pp. 26–32, 2020. [Online]. Available: https://doi.org/10.62702/ion.v1i1.25

[28] Y. Rasyadi, R. Yenti, and A. P. Jasril, "Formulation and physical stability test of liquid bath soap containing cardamom fruit (*Amomum compactum* Sol. ex Maton) ethanol extract," *Pharmacy: Jurnal Farmasi Indonesia*, vol. 16, no. 2, pp. 188–198, 2019. [Online]. Available: https://doi.org/10.30595/pharmacy.v16i2.5675

[29] T. H. Sutarna *et al.*, "Formulation of liquid soap containing cow's milk from a micro/small enterprise in Cimahi," *Indonesian Journal of Pharmaceutical Science and Technology*, vol. 9, no. 1, pp. 9–16, 2022. [Online]. Available: https://doi.org/10.24198/ijpst.v1i1.28901

[30] A.-L. Fameau, J. Ventureira, B. Novales, and J.-P. Douliez, "Foaming and emulsifying properties of fatty acids neutralized by tetrabutylammonium hydroxide," *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, vol. 403, pp. 87–95, 2012. [Online]. Available: https://doi.org/10.1016/j.colsurfa.2012.03.059