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COMPARISON OF ORGANIC LIQUID SOAP MADE FROM PAPAYA-TURMERIC AND ALOE VERA-PIPER BETEL

Rahmat Juninho, Irfan Afandi Syamsudin, Ismudiati Puri Handayani, Memoria Rosi*, Hertiana Bethaningtyas Dyah Kusumaningrum, Yusup ABD Salam, Desti Umdatul Islamiah, Astrid Rinaldi

Department of Engineering Physics, School of Electrical Engineering, Telkom University , Bandung, West Java, Indonesia

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**Corresponding Author*
Email:
memoriarosi@telkomuniversity.ac.id
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ABSTRACT

In the wake of the COVID-19 pandemic, the imperative to mitigate pathogen transmission has catalyzed the innovation of soaps imbued with antimicrobial and antibacterial properties. Diverging from conventional reliance on synthetic chemicals, often associated with adverse dermatological reactions, this study explores the formulation of organic liquid soaps. These soaps leverage naturally occurring antibacterial and antimicrobial compounds from readily accessible plants, presenting a viable alternative to commercially available inorganic body washes predominantly manufactured by small to medium-sized enterprises. Specifically, this research harnesses papaya and aloe vera extracts for their antimicrobial attributes, augmented with turmeric and piper betel for enhanced antibacterial efficacy. Despite the recognized potency of turmeric and piper betel, variability in their effectiveness necessitates rigorous validation against the Indonesian National Standards (SNI) to ensure product quality and safety. This includes comprehensive evaluations of pH levels, density, Total Plate Count (TPC), and Mold and Yeast Count (MYC) to certify the soap's inhibitory capacity against bacterial and fungal proliferation. Employing maceration and hot processing techniques, the formulated papaya-based soap adhered to SNI 4085:2017 criteria for pH and MYC, although initially failing the TPC test. Subsequent incorporation of turmeric extract facilitated compliance with all SNI benchmarks. Conversely, aloe vera formulations only satisfied pH requirements under the SNI, even after adding piper betel. However, substituting piper betel with turmeric extract enabled the aloe vera soap to fulfill the requisite SNI parameters. These findings underscore turmeric extract's superior antibacterial properties, positioning it as a pivotal component in papaya and aloe vera soap formulations. Contrary to prevalent assumptions regarding piper betel's antimicrobial and antibacterial effectiveness, our investigation substantiates turmeric's superior role in bacterial growth inhibition within organic soap matrices.

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INTRODUCTION

The utilization of body soap, particularly those enhanced with antimicrobial and antibacterial agents, has significantly expanded to mitigate the transmission of pathogens. Amid the COVID-19 pandemic, handwashing with soap emerged as a pivotal recommendation to reduce infection rates [1]. Body soaps are

Conventionally employed for hygiene and safeguarding the skin against various issues, including dryness, aging, bacteria, germs, and several skin diseases [2]. Traditional soap manufacturing involves saponification, combining oils and strong alkalis to yield carboxylate salt (soap) and glycerol, often supplemented with fragrances and coloring agents [3-4].

With shifts towards a modern lifestyle, there has been a growing preference for liquid soaps, attributed to their ease of use, affordability, and additional moisturizing properties that prevent skin dryness [5-6]. However, commercial soaps containing sodium lauryl sulfate (SLS) are frequently associated with skin dryness and irritation [7], prompting a shift towards organic soaps. These soaps exclude harmful SLS chemicals in favor of alternative bio-surfactants, offering a safer option for body care and mitigating environmental impact [8-10].

Exploratory research has delved into numerous natural substances, including papaya, aloe vera, turmeric, and piper betel, for their skin-beneficial properties. Papaya, rich in antioxidants, combats free radicals and prevents skin damage while facilitating the removal of dead skin cells through its content of papain, flavonoids, alkaloids, and polyphenols, which exhibit antimicrobial potential [11-14]. Aloe vera, on the other hand, demonstrates the ability to inhibit the growth of Escherichia coli and various skin pathogens, underscored by its biocompatibility and active components like salicylic acid and mannose, known for their antioxidant, antifungal, antiviral, and antibacterial properties [15-17]. Similarly, turmeric, containing curcumin, is recognized for its antioxidant, antibacterial, antifungal, and anti-inflammatory activities [18-19], while piper betel is noted for phenols and derivatives that prevent germ and bacterial formation [20].

Despite the recognized benefits of turmeric and piper betel, variability in their antibacterial effectiveness necessitates further validation to meet Indonesian National Standards (SNI). Previous studies have evaluated turmeric's efficacy based on the diameter of inhibition zones without addressing colony numbers as mandated by SNI [12-16]. A similar approach has been applied to Piper Betel [21-22], indicating the need for a comprehensive evaluation of their antibacterial capabilities in organic soap formulations.

This study aims to synergize the advantages of selected plants, combining papaya with turmeric and aloe vera with piper betel, to develop liquid body soaps. These plants are readily available in urban and rural settings. The study follows a methodology where a basic liquid soap formulation is enriched with varying volumes of antimicrobial (papaya/aloe vera) extracts and further enhanced with antibacterial (turmeric/piper betel) extracts. The final products undergo rigorous testing for pH, density, Total Plate Count (TPC), Mold and Yeast Count (MYC), and other parameters as per SNI 4085:2017 [23]. Contrary to previous findings [20-22], our research posits that turmeric surpasses piper betel in antibacterial efficacy within both aloe vera and papaya-based organic soap formulations, achieving TPC and MYC levels below 10 colonies/mL, thus aligning with SNI standards.

METHODS

The experimental methodology was systematically designed to encompass the extraction of antimicrobial and antibacterial agents, formulation of organic liquid soap, integration of extracts into the soap matrix, and comprehensive quality testing. This sequential approach was guided by established protocols [24] for extract preparation and soap formulation, with subsequent quality evaluations adhering to the SNI 4085:2017 standard [15]. The Total Plate Count (TPC) and Mold and Yeast Count (MYC) tests were specifically conducted to assess the efficacy of piper betel and turmeric as bacterial inhibitors in papaya and aloe vera-based organic liquid soaps.

1. Materials

Raw materials, including papaya, aloe vera, turmeric, and piper betel, were sourced from Bandung, Indonesia. Supplementary components such as virgin coconut oil deionized (DI) water, ethanol, potassium hydroxide (KOH), Carboxy Methyl Cellulose (CMC), stearic acid, and citric acid were procured from local marketplaces within Indonesia. Ethanol was selected as the solvent due to its demonstrated superiority in extract yield compared to alternative solvents [25-26].

2. Preparation of Antimicrobial and Antibacterial Extracts

The extraction process for obtaining antimicrobial and antibacterial agents from papaya, aloe vera, turmeric, and piper betel employed the maceration technique. Initially, 500 grams of each plant were thoroughly cleaned, sliced, and finely crushed. These plant materials were then combined with 96% ethanol in a mass ratio 1:3. The mixture was agitated continuously for three days to ensure optimal extraction. After the maceration period, the mixture underwent filtration and was subjected to evaporation at 180°C. This process was maintained until a concentrated liquid extract was achieved and ready for incorporation into the organic soap formulations.

3. Manufacture of Organic Liquid Soap

The formulation of the organic liquid soap utilized the hot process method. This began with heating 15 ml of coconut oil to 70°C, adding 0.25 g of stearic acid. This oil-acid mixture was then combined with 8 ml of a 40% KOH solution maintained at the same temperature and stirred continuously until a uniform paste was achieved. The pH of the resultant soap base was assessed using litmus paper. After that, the mixture was enriched with 25 ml of DI water, 6 ml of citric acid, and 0.5 g of CMC at 50°C to finalize the liquid soap base. To this base, antimicrobial extracts of papaya and aloe vera were incorporated in varying concentrations (1.5, 3, and 4.5 ml) at 40°C, followed by the introduction of antibacterial extracts of turmeric and piper betel in differing amounts (0.1, 0.2, and 0.3 g), to enhance the soap's antimicrobial and antibacterial properties.

4. Soap Quality Testing

The produced soaps were subjected to rigorous quality assessments aligned with SNI 4085:2017 standards, particularly focusing on the Total Plate Count (TPC) and Mold and Yeast Count (MYC). The pour plate method was employed for these tests, using Plate Count Agar (PCA) for TPC and Sabouraud Dextrose Agar (SDA) for MYC, with the media prepped at 40-45°C. The SDA media was supplemented with 100 mg/1000 mL of chloramphenicol antibiotic for MYC assessments to inhibit bacterial growth. The soap samples were homogenized, plated, and allowed to solidify before being incubated at 37°C for 1-7 days for MYC and 1-3 days for TPC, with the resultant colony growth quantified in CFU/mL. SNI 06-4085-1996 specifications conducted density evaluations. These quality tests were carried out at the Analytical Service Laboratory STFI in Bandung, Indonesia, except for pH measurements, which were performed in the materials laboratory at Telkom University.

RESULTS AND DISCUSSION

1. Visualization and Yield of Extracts

The visual representation and quantitative assessment of extract yields play a crucial role in formulating and refining organic liquid soaps. These soaps transcend traditional roles by integrating natural extracts, embodying aesthetic appeal and therapeutic functionality. Figure 1 serves as a visual testament to this intricate development process, offering an insightful glimpse into the myriad of samples generated during the experimental phase. This section aims to delve deeper into the initial stages of soap formulation, where the visual characteristics and extraction yields of natural antimicrobial and antibacterial agents are meticulously analyzed. The journey from a basic soap base to a product enriched with the essences of papaya and aloe vera epitomizes the transformative power of natural extracts regarding soap coloration and texture and the enhanced dermatological benefits they confer.

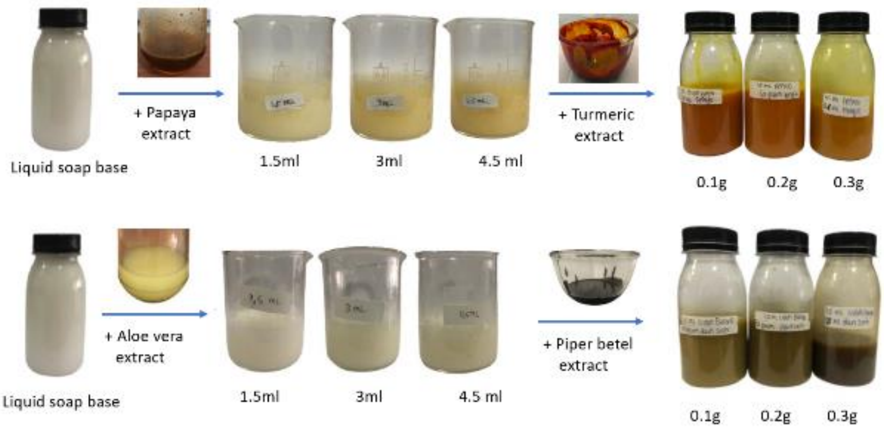

Figure 1. The produced liquid soap base, many plant extracts, organic liquid soap-based papaya-turmeric soap, and aloe vera-piper betel soap.

In stark contrast, the antibacterial agents sourced from turmeric and piper betel are introduced with a significantly higher concentration. Turmeric, with its vibrant golden hue, is renowned for its curcumin content, offering potent antibacterial and anti-inflammatory benefits. Although less commonly known, Piper betel brings a rich historical context of medicinal use, particularly for its antibacterial properties [26]. These concentrated extracts amplify the soap's ability to fend off bacterial pathogens and contribute to the sensory experience through their distinct colors and potential aromatic profiles.

The yields obtained from these extracts indicate the efficiency of the maceration method employed. The percentages—34.10% for papaya, 29.54% for aloe vera, 6.72% for turmeric, and 10.63% for piper betel—reflect the relative success in extracting the active compounds from the plant materials. These yields, calculated as the weight ratio of the extract to the original plant material, highlight the variability in extractability among different botanicals. Despite papaya and aloe vera offering more substantial yields, the lower yields of turmeric and piper betel are counterbalanced by their potent antibacterial concentrations [14]. The maceration technique, chosen for its simplicity and cost-effectiveness, reveals a trade-off between ease of execution and extraction efficiency. While it facilitates the extraction process without sophisticated equipment, the method's inherent limitations in extracting a more significant portion of the desired compounds become apparent. This outcome prompts contemplation of the method's scalability and effectiveness, especially in maximizing the therapeutic potential of the extracts for soap formulation.

2. Color Transformation

In the cosmetic and personal care industry, the visual attributes of products significantly influence consumer preferences and perceptions. The color of soap, in particular, serves not only as an aesthetic feature but also as an indicator of its compositional nature and potential dermatological benefits. Within the context of organic liquid soap development, the integration of natural extracts plays a pivotal role not only in conferring antimicrobial and antibacterial properties but also in effectuating color transformations. These alterations in hue are not merely superficial but are indicative of the underlying chemical interactions between the natural pigments in the extracts and the soap's base. This narrative aims to elucidate the mechanisms and implications of color changes observed in organic liquid soap formulations post-infusion with selected botanical extracts, underscoring the symbiosis between visual appeal and chemical composition in enhancing the product's sensory appeal [9].

Continuing from the exploration in Table 1 and as depicted in Figure 2, the dynamic shifts in the coloration of liquid soap by adding natural extracts provide a vivid illustration of the soap's transformative journey. The transition from a simple white base to a spectrum of hues enriches the product's aesthetic appeal and signifies the complex chemical reactions at the heart of this metamorphosis.

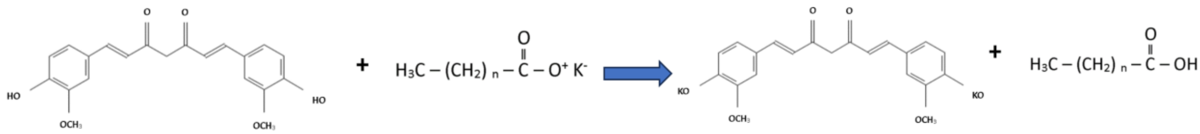

Figure 2. The proposed mechanism of color transformation of antibacterial soap of curcumin

Table 1. The result of different soap composition

Compound	Antimicrobial	Antibacterial	Result
Liquid soap base (50 ml)	-	-	White
Liquid soap base (50 ml)	Papaya extract (1.5; 3 and 4.5 ml)	-	Light orange
Liquid soap base (50 ml)	Aloe vera (1.5; 3 and 4.5 ml)	-	Dull white
Liquid soap base (50 ml)	Papaya extract (1.5 ml)	Turmeric (0.1; 0.2; 0.3 g)	Deep yellow
	Aloe vera (1.5 ml)	Piper betel (0.1; 0.2; 0.3 g)	Deep green

The acid-base reactions catalyzed by incorporating antibacterial pigments into the alkaline soap base underscore a critical facet of natural product integration into consumer goods. The interaction between curcumin and the soap's alkaline environment, leading to a visually distinct yellow coloration, exemplifies natural extracts' potential to alter everyday products' physical characteristics profoundly. As detailed in Figure 2, this mechanism, where the curcumin's engagement results in a significant color shift, elucidates the underlying scientific principles driving these changes. The presence of phenolic groups (-OH) in the resulting soap composition highlights the chemical complexity of these reactions and points to the therapeutic potential of these modifications. The ability of curcumin to act as an antimicrobial and antibacterial agent while simultaneously imparting aesthetic enhancements to the soap illustrates the dual utility of such natural compounds in product development [27].

This holistic approach to soap formulation, wherein natural extracts serve functional and decorative purposes, reflects a growing trend in consumer goods towards incorporating organic and natural elements. The visual differentiation afforded by these color transformations provides a tangible connection between the product and its natural origins, aligning with increasing consumer demand for authenticity and transparency in product composition.

Exploring these color changes, rooted in the chemical interactions between natural pigments and the soap matrix, invites further investigation into other natural compounds with similar transformative potentials. It opens avenues for future research on harnessing these natural properties for their aesthetic contributions, health, and therapeutic benefits.

3. pH Analysis

The pH level of soap constitutes a pivotal parameter influencing its compatibility with human skin. Maintaining an optimal pH is imperative for preserving the skin's natural barrier, which mitigates dryness and irritation, ensuring effective cleansing. The formulation of organic liquid soaps, especially those augmented with natural antimicrobial extracts, demands rigorous assessment of pH levels to ascertain compliance with health and safety norms and provide therapeutic advantages. This segment delves into an exhaustive analysis of the pH fluctuations manifested within organic liquid soap formulations upon integrating natural extracts. The objective is to highlight the criticality of sustaining an appropriate pH equilibrium in skincare commodities, ensuring they are conducive to skin health and integrity [4,12].

Figure 3(a) systematically documents the investigation into the physicochemical properties of organic liquid soap formulations; particular attention is dedicated to the pH metric, a critical determinant of soap compatibility with human skin. Figure 3(a) meticulously records the pH levels of a foundational liquid soap base in its pure form alongside variations incorporating antimicrobial extracts derived from papaya and aloe vera, spanning multiple concentrations. Initially, the soap base, absent of any antimicrobial additives, demonstrated a pH of 8.7, which not only falls within but surpasses the SNI stipulated standards, dictating a pH range of 8-10. This pH range is paramount for maintaining skin integrity and averting the adverse effects of dryness and irritation [20].

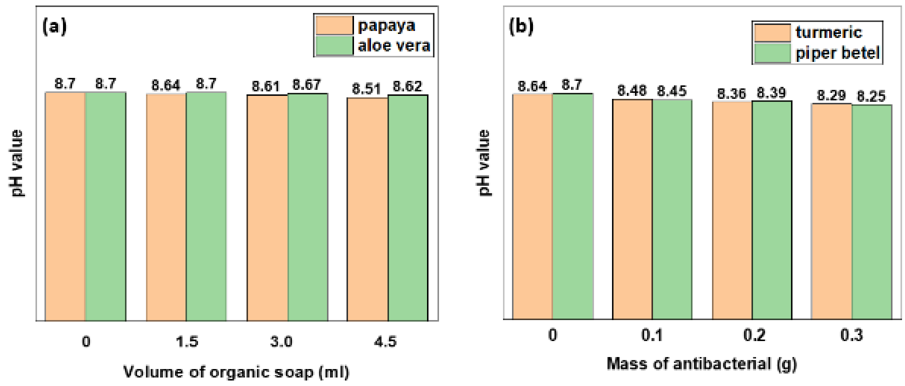

Figure 3. pH value of various (a) volume of organic soap and (b) mass of antibacterial extracts

As delineated in Figure 3(a), a discernible trend emerges: the pH level experiences a proportional decline with incremental additions of papaya and aloe vera extracts. This phenomenon can predominantly be attributed to the intrinsic acidic characteristics of papaya and aloe vera extracts. In light of these observations, a strategic selection was made to focus on a specific concentration—1.5 ml of papaya/aloe vera extract—aiming to refine the formulation through the incorporation of antibacterial extracts, namely turmeric and piper betel, introduced in quantities of 0.1, 0.2, and 0.3 g. The subsequent pH values, specifically for the soap formulations enhanced with papaya-turmeric and aloe vera-piper betel, are depicted in Figure 3(b). This further exploration unveiled a consistent pattern: integrating antibacterial extracts prompts a marginal reduction in pH levels, albeit not to the extent that compromises the soap formulations' overall alkalinity.

Despite including antibacterial extracts, all formulated soaps steadfastly adhered to the SNI guidelines concerning pH levels, regardless of the precise degree of extract amalgamation. This exhaustive analysis of pH fluctuations across a spectrum of soap formulations accentuates the nuanced interplay between incorporating natural extracts and maintaining an optimal pH balance [18]. Such a balance is crucial, not solely for aligning with regulatory benchmarks but also for harnessing the therapeutic potentials of natural extracts, thereby amplifying the final organic soap product's dermatological virtues and consumer appeal. This careful orchestration of ingredients, underscored by a commitment to both quality and efficacy, illustrates the pivotal role of pH optimization in developing skin-friendly organic soaps.

4. Density Analysis

Figure 4(a) elucidates the impact of incorporating various antimicrobial extracts on the density of liquid soap formulations. The density, a fundamental property in the formulation process, is directly influenced by the volume of antimicrobial extract integrated into the soap base. Conducting density tests is an essential step in the development process, enabling formulators to determine the compatibility of solid materials with other components, thereby facilitating the efficient creation of the soap. The data reveal a distinct trend: as the concentration of antimicrobial extract increases, there is a corresponding decrease in the density of the soap. This observation can be attributed to the relatively dilute nature of the antimicrobial extracts, as illustrated in Figure 1.

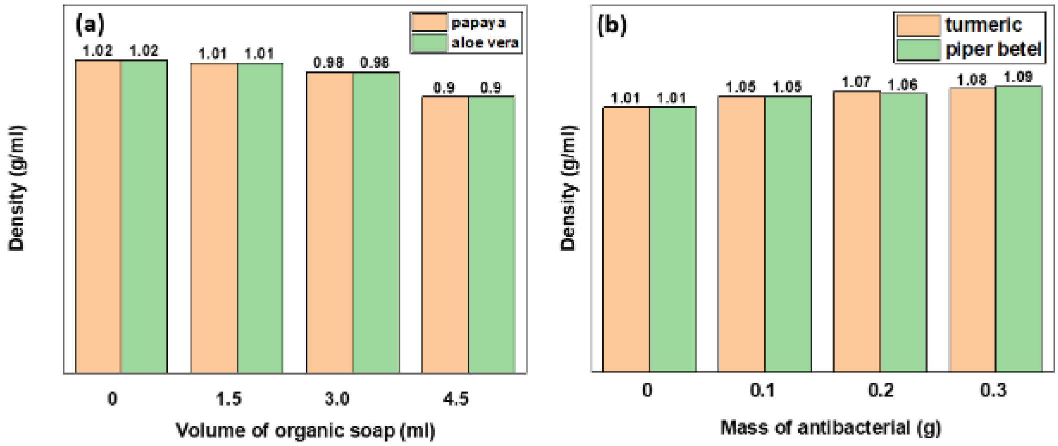

Figure 4. Density of various (a) volume of organic soap and (b) mass of antibacterial extracts

The Standard Nasional Indonesia (SNI) specifies that the acceptable density range for liquid soap is between 1.01 and 1.1 g/ml. In this context, formulations containing 1.5 ml of papaya and aloe vera extracts align with the SNI's density criteria. Interestingly, upon integrating antimicrobial agents into the papaya/aloe vera soap base, a notable increment in density is observed, elevating from 1.01 to 1.09, as depicted in Figure 4(b). This phenomenon underscores the principle that adding higher masses of antibacterial agents, such as turmeric and piper betel, increases the soap's density [19].

Remarkably, all soap variants augmented with turmeric and piper betel successfully meet the SNI standards concerning density, signifying the meticulous balance achieved between the desired therapeutic properties and the physicochemical requirements of the final product. This alignment with SNI standards emphasizes carefully calibrating ingredient proportions to ensure product quality and consumer safety. The detailed analysis presented in Figures 4(a) and 4(b) provides valuable insights into the formulation strategy and highlights the importance of adhering to established standards to deliver a product that is both efficacious and compliant with regulatory guidelines [27-28].

5. Density, Total Plate Count (TPC), and Mold and Yeast Count (MYC) Assessments

The microbiological integrity of organic soap formulations, augmented with specific concentrations of antimicrobial and antibacterial extracts, was rigorously evaluated through Total Plate Count (TPC) and Mold and Yeast Count (MYC) tests. These assessments were meticulously aligned with soap formulations previously optimized for pH and density values, specifically incorporating 1.5 ml of antimicrobial and 0.3 g of antibacterial extracts. As illustrated in Table 2, the primary aim of TPC testing is to quantitatively assess the prevalence and proliferation of aerobic bacteria within the soap mixtures. The infusion of papaya and aloe vera extracts precipitated an increase in TPC values, intimating either the entrainment of extraneous microbial entities or the manifestation of the natural microbial burden harbored by the extracts. In stark contrast, including turmeric extract as an antibacterial constituent significantly diminished TPC values to beneath the 10 colonies/ml benchmark, emphatically affirming its bactericidal efficacy. Conversely, the introduction of 0.3 g of piper betel into the aloe vera-based soap culminated in a TPC value of 1.5 x 10^7 colonies/ml, thus exceeding the permissible limits established by the SNI standards and manifesting a pronounced deficiency in bacterial suppression [29].

Table 2. The TPC and MYC of the produced organic soap

Samples	TPC (colonies/ml)	MYC (colonies/ml)
Liquid soap base	5.0×10^4	10
Liquid soap base + 1.5 ml papaya	5.0×10^6	20
Liquid soap base + 1.5 ml aloe vera	2.5×10^5	<10
Liquid soap base + 1.5 ml papaya + 0.3 g turmeric	< 10	<10
Liquid soap base + 1.5 ml aloe vera + 0.3 g piper betel	1.5×10^7	<10
Liquid soap base + 1.5 ml aloe vera + 0.3 g turmeric	< 10	< 10

Prompted by turmeric's demonstrable success in attenuating bacterial populations, a strategic pivot was made to substitute piper betel with turmeric in the aloe vera soap composition. This modification precipitated a decline in TPC values to less than 10 colonies/ml, robustly substantiating turmeric's unparalleled antibacterial prowess. This outcome resonates with extant scholarly discourse that extols turmeric's antimicrobial virtues. Parallel to the TPC evaluations, MYC testing emerged as an instrumental diagnostic tool in gauging the levels of fungal contaminants, entities that potentially compromise human health. Remarkably, all variations of the soap formulations adhered to the MYC criteria delineated by the SNI, with contaminant counts receding to below 10 colonies/ml after integrating aloe vera, turmeric, and piper betel. This decline in fungal proliferation is likely attributable to the antifungal moieties—saponins and flavonoids—endemic to the utilized natural extracts [30].

This exhaustive investigation not only accentuates the aesthetic and olfactory enhancements bestowed by natural extracts upon organic soaps but also highlights their pivotal role in bolstering the microbial safety profile of these products. Turmeric, in particular, is spotlighted as a formidable antagonist against bacterial and fungal adversaries, heralding new trajectories for research and developing organic soap formulations to advance hygienic and dermatological well-being.

CONCLUSION

Organic liquid soaps have been produced using papaya and aloe vera in various combinations with turmeric and piper betel. The pH values of the soaps, across all concentrations of 1.5 ml, 3 ml, and 4.5 ml of papaya/aloe vera, were found to comply with SNI standards. However, only the formulations containing 1.5 ml of papaya/aloe vera met the density requirements set by the SNI. Regarding the Mold and Yeast Count (MYC) testing, the soap with 1.5 ml of papaya/aloe vera aligned with the SNI criteria, yet it failed to meet the SNI standards for Total Plate Count (TPC) testing. The papaya soap's total microbial count (TMC) significantly decreased upon adding turmeric, an effect not observed with piper betel. Substituting piper betel with turmeric led to a reduction in the TMC value. In conclusion, turmeric has demonstrated greater efficacy in bacterial reduction than piper betel. Based on these findings, we advocate for including turmeric in the formulation of organic soaps derived from papaya and aloe vera extracts.

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