FORMULATION AND EVALUATION OF HAND CREAM USING COCOA FAT AND PASTE WITH THE ADDITION OF YLANG-YLANG (*Cananga odorata*) AND LILAC (*Syringa vulgaris*) ESSENTIAL OILS

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Abstract: Cocoa fat and paste have the potential to be used in cosmetic products, especially because they can moisturize and hydrate the skin. The addition of essential oils to cosmetic products, besides providing a natural aroma, also functions as an antioxidant. This research aims to formulate and evaluate the characteristics of a hand cream based on cocoa fat and paste with the addition of ylang-ylang and lilac essential oils, which can remain free from fungal growth contamination after being stored for more than 30 days. The research was carried out in two stages: heating the cocoa fats and paste to temperatures of 25°C, 80°C, 90°C, and 121°C, and formulating the hand cream by varying the concentration of cocoa fat (1%, 2%, 3%) and the type of essential oil ((no essential oil, ylang-ylang oil, lilac oil, a blend of ylang-ylang and lilac oils). The total plate count analysis of the cocoa fats and paste showed that no microorganisms were found in the cocoa fat from a heating temperature of 25°C, while in the cocoa paste, microorganisms were not found after heating at a temperature of 121°C. The antioxidant activity of the cocoa fats and paste ranged after heating from 65.23% to 82.66%. The hand cream's characteristics met the quality standards of SNI 16-3499-1996 and BPOM No. 17 of 2014 including homogeneous appearance, pH, and specific gravity. Essential oils can be an alternative to using cocoa paste for scenting hand cream, because heating cocoa paste to 121°C for 15 minutes to eliminate microorganisms can reduce its antioxidant activity.

Keywords: cocoa; essential oil; hand cream, heating, antioxidant

Abstrak: Lemak dan pasta kakao memiliki potensi untuk digunakan dalam produk kosmetik terutama karena dapat melembapkan dan menghidrasi kulit. Penambahan minyak atsiri dalam produk kosmetik selain memberikan aroma alami juga berfungsi sebagai antioksidan. Penelitian ini bertujuan untuk memformulasi dan mengevaluasi karakteristik *hand cream* berbasis lemak dan pasta kakao dengan penambahan minyak atsiri ylang-ylang (*Cananga odorata*) dan lilac (*Syringa vulgaris*). yang dapat tetap bebas dari kontaminasi pertumbuhan jamur setelah disimpan lebih dari 30 hari. Penelitian dilaksanakan dalam 2 tahap, yaitu pemanasan lemak dan pasta kakao, menggunakan suhu 25°C, 80°C, 90°C, 121°C, dan formulasi *hand cream* dengan memvariasikan konsentrasi lemak kakao (1%, 2%, 3%), dan jenis minyak atsiri (tanpa minyak atsiri, minyak ylang-ylang, minyak lilac, campuran minyak ylang-ylang dan lilac). Hasil

analisis *total plate count* (TPC) lemak dan pasta kakao menunjukkan bahwa pada lemak kakao sudah tidak ditemukan adanya mikroorganisme mulai suhu pemanasan 25°C, sedangkan pada pasta kakao, tidak ditemukan mikroorganisme setelah proses pemanasan pada suhu 121°C. Aktivitas antioksidan lemak dan pasta kakao setelah pemanasan berkisar 65,23% - 82,66%. *Hand cream* telah memiliki karakteritik sesuai syarat mutu SNI 16-3499-1996 dan BPOM No. 17 tahun 2014 yaitu penampakan homogen, pH (4,60–6,58), dan bobot jenis (0,95–1,05). Minyak atsiri dapat menjadi alternatif untuk menggantikan penggunaan pasta kakao sebagai sumber aroma pada *hand cream*, mengingat pemanasan pasta kakao pada suhu 121°C selama 15 menit dapat menurunkan aktivitas antioksidan dari pasta kakao.

Kata kunci: kakao; minyak atsiri; krim; pemanasan; antioksidan

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Introduction

Cacao (*Theobroma cacao* L.) is a widely cultivated in tropical regions, including Indonesia (Sari et al., 2023), where annual production reaches approximately 667,300 tons (Badan Pusat Statistik Indonesia, 2022). Aceh Province, particularly Pidie Jaya Regency, is one of the important cacao-producing areas; however, local processing is still largely directed toward food products such as cocoa powder, chocolate beverages, and chocolate bars (Direktorat Jenderal Perkebunan, 2022; Adilla et al., 2024; Yusdiana et al., 2021). This condition indicates an opportunity to diversity cacao utilization into higher-value non-food products, particularly cosmetics.

Cocoa fat is rich in palmitic, stearic, and oleic, a composition that is compatible with skin lipids and allows it to function as an emollient and occlusive ingredient in topical products (Firmanto, 2018) Cocoa-based ingredients may also support skin moisture retention because of their lipid fraction and bioactive compounds (Yunita et al., 2021). Therefore, hand cream is an appropriate product from utilizing cocoa fat and paste, as hands are frequently exposed to water, detergents, chemicals, and environmental stressors that can cause dryness and barrier damage (Sampebarra, 2016; Rusiyantoro et al., 2021; Sinulingga et al., 2018).

A previous formulation of cocoa-based hand cream containing essential oils showed fungal growth after 30 days of storage at room temperature, which was suspected to be related to microbial contamination of raw cocoa materials and insufficient antifungal protection from the essential oils used (Afifah, 2023). In the present study, cocoa fat and paste were pre-heated to reduce microbial contamination. However, heating may also decrease antioxidant activity by degrading heat-sensitive bioactive compounds, creating a trade-off between microbiological safety and functional quality.

Ylang-ylang (*Cananga odorata*) and lilac (*Syringa vulgaris*) essential oils were selected because they contain antioxidant-related constituents such as linalool, geraniol, benzyl acetate, and phenolic compounds, while also providing floral aromas that are suitable for cosmetic products (Udayani et al., 2017; Pujiarti et al., 2016; Gecer, 2022). Floral fragrances are commonly associated with comfort, freshness, and elegance, and are highly preferred, especially by female consumers and young adults (Figueiredo & Eiriz, 2020). These consumer groups represent a major segment in the hand cream market (Harshitha, 2024). Their addition is expected to improve the sensory profile of cocoa-based hand cream, mask the strong cocoa aroma, and contribute antioxidant benefits that help protect skin from free-radical exposure (Hussen et al., 2025).

Although cocoa fat and paste have been studied as cosmetic ingredients, limited research has integrated heating treatment, microbiological safety, antioxidant retention, and hand cream formulation using selected essential oils. Therefore, this study aims to formulate and evaluate a cocoa fat- and paste-based hand cream enriched with ylang-ylang and lilac essential oils, and to assess its physical characteristics, antioxidant activity, and resistance to fungal contamination after 30 days of storage under room-temperature conditions.

Materials and Method

Materials

The materials used were cocoa fat and paste obtained from the Socolatte factory in Pidie Jaya, Aceh, along with glycerin (Pharmacy), lecithin (Pharmacy), cetyl alcohol (Pharmacy), polypropylene glycol (Pharmacy), carboxymethyl cellulose (CMC) (Pharmacy), stearic acid (Pharmacy) were pharmaceutical grade, ylang-ylang oil (Happy Green), lilac oil (Happy Green), 2,2-diphenyl-1-picrylhydrazyl (Aldrich), ethanol (Brataco), Plate Count Agar (Oxoid), and Sabouraud Dextrose Agar (Oxoid).

Research design

This research consisted of two stages. Stage 1: heating cocoa fat and paste. It utilized a two-factor design with: heating temperature at four levels: 25°C, 80°C, 90°C, 121°C, and type of material at two levels: cocoa fat, and paste. Each treatment was repeated three times, resulting in a total of 24 experimental units. Stage 2: hand cream formulation, using a two-factor design with: cocoa fat concentration at three levels: 1%, 2%, 3%, and type of essential oil at four levels: without essential oil, ylang-ylang oil, lilac oil, a blend of ylang-ylang and lilac oils. Each treatment was repeated three times, resulting in a total of 36 experimental units.

Stage 1: Heating of cocoa fat and paste

Heating of the cocoa fat and paste was carried out by varying the temperature: 25°C, 80°C, 90°C, and 121°C, each for 15 minutes. The heating process at 80°C and 90°C used a hot plate, while heating at 121°C used an autoclave. After heating

was complete, the cocoa fat and paste were analyzed for total plate count (TPC) (Ningrat et al., 2024), yeast-mold count (Maa'idah et al., 2020), and antioxidant activity (Rodina et al., 2016).

Stage 2: Hand cream formulation

The procedure for making the hand cream followed the method by (Rodina et al., 2016), with the formula detailed in Table 1. First, the oil-phase ingredients (cetyl alcohol, stearic acid, polypropylene glycol, lecithin), and the water-phase ingredients (glycerin, CMC, distilled water) were heated separately on a hot plate at 70°C for 10 minutes. The water-phase ingredients were slowly added to the oil-phase ingredients while being stirred with a Geeben hand blender (SG-3400M) at 22,000 rpm for 5 minutes until a cream base formed. Cocoa fat (1%, 2%, 3%), and 1% cocoa paste were then added, and the mixture was stirred again for another 5 minutes. Finally, 0.25% of essential oil (no essential oil, ylang-ylang oil, lilac oil, or a mixture of ylang-ylang and lilac oils) was added to the hand cream and stirred for another 5 minutes. The finished hand cream was then placed into sterilized 50 g dark glass jars and stored for 30 days at room temperature.

Table 1. The formulation of hand cream

Materials	**F1 (%)**	**F2 (%)**	**F3 (%)**
Cocoa fat	1.00	2.00	3.00
Cocoa paste	1.00	1.00	1.00
Essential oil	0.25	0.25	0.25
Stearic acid	9.65	9.55	9.45
Glycerin	9.65	9.55	9.45
Propylene glycol	0.77	0.76	0.75
Cetyl alcohol	0.97	0.96	0.95
Lecithin	2.32	2.29	2.27
Carboxymethyl cellulose	0.77	0.76	0.75
Aquadest	73.62	72.88	72.13

In the present formulation, most ingredients such as cocoa fat, glycerin, lecithin, and stearic acid are widely used in cosmetic products and are generally considered safe for topical application (Sabre, 2024; Azilah & Nur, 2022; Johnson et al., 2020; Becker et al., 2019). However, essential oils, including ylang-ylang and lilac essential oils, contain volatile compounds such as linalool and geraniol, which have been reported to potentially cause mild skin irritation or allergic contact dermatitis in susceptible individuals, particularly those with sensitive skin (Gąsecka et al., 2023; Sarkic & Stappen, 2018).

In this study, skin irritation or allergenicity testing was not performed; therefore, the dermatological safety of the formulation cannot be fully confirmed. This limitation highlights the importance of further studies involving skin irritation tests, patch testing, and controlled clinical evaluations to assess product safety and support future clinical and commercial applications.

The hand cream, after being stored for 30 days, was analyzed for pH (Wulandari et al., 2023), spreadability (Rachmatillah et al., 2021), specific gravity (Ariani & Wulandari, 2020), and antioxidant activity (Rodina et al., 2016).

Statistical analysis

The data were analyzed using analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at a 1% significance level when significant differences among treatments were detected.

Results And Discussion

Research stage 1: Effect of heating temperature and material type on cocoa fat and paste characteristics

The research results showed that the interaction between temperature and material type had a highly significant effect ($P<0.01$) on the total plate count (TPC) and antioxidant activity values of both cocoa fat and cocoa paste (Table 2).

Table 2. The total plate count and antioxidant activity of cocoa fat and paste

Temperature (°C)	Materials	Total plate count (log CFU/ml)	Antioxidant activity (%)
25	Cocoa fat	0.00 ± 0.00^{a}	82.66 ± 0.20^{f}
25	Cocoa paste	5.38 ± 0.29^{d}	82.18 ± 0.20^{f}
80	Cocoa fat	0.00 ± 0.00^{ab}	77.79 ± 0.54^{e}
80	Cocoa paste	4.70 ± 0.11^{c}	77.39 ± 0.29^{de}
90	Cocoa fat	0.00 ± 0.00^{ab}	67.74 ± 0.25^{b}
90	Cocoa paste	3.55 ± 0.12^{b}	77.15 ± 0.51^{d}
121	Cocoa fat	0.00 ± 0.00^{ab}	65.23 ± 0.15^{a}
121	Cocoa paste	0.00 ± 0.00^{ab}	73.21 ± 0.29^{c}

Note:
Values are presented as mean ± standard deviation. Numbers followed by different superscript letters within the same column indicate significant differences according to Duncan's Multiple Range Test (DMRT) at a 1% significance level ($\alpha = 0.01$). Values sharing the same letter or overlapping letters are not significantly different.

Total plate count

The TPC values for cocoa fat and paste ranged from 0 to 5.38±0.29 log CFU/ml, with an average value of 1.70±0.07 log CFU/ml. No microorganisms were detected in cocoa fat at all temperatures, which may be attributed to its very low moisture content (Soares & Oliveira, 2022; Edo et al., 2023), and lipid-dominant composition that do not support microbial growth. The cocoa fat has natural antimicrobial properties due to its fatty acid content, such as oleic, stearic, and palmitic acids. These fatty acids can disrupt bacterial cell membranes and lead to cell death (Scapagnini et al., 2014; Ramlah et al., 2020). Flavonoids and phenolic compounds in cocoa also have antimicrobial properties that can suppress the growth of microorganisms (Rossi et al., 2025).

In contrast, cocoa paste showed high microbial contamination at 25°C, likely due to the presence of proteins and carbohydrates that can serve as nutrients for microorganisms (Scapagnini et al., 2014). Increasing the heating temperature reduced microbial counts, and no microorganisms were detected in cocoa paste after heating at 121°C. This result indicates that heating at 121°C was effective in achieving microbiological safety and met the SNI 3749:2009 requirement for cocoa mass.

Mold and yeast count

No mold or yeast growth was detected in cocoa fat or cocoa paste at all heating temperatures. Therefore, both materials met the microbiological requirement of SNI 3749:2009 for cocoa mass, which sets the maximum mold and yeast count at 50 colonies/g.

Antioxidant activity

The antioxidant activity of the cocoa fat and paste ranged from 65.23%±0.15 to 82.66%±0.20, with an average value of about 75.42%±0.30. The highest inhibition values were observed at 25°C, indicating that antioxidant compounds were better retained without high-temperature treatment. Increasing the heating temperature decreased antioxidant activity, particularly in cocoa fat. This reduction may be caused by thermal degradation, oxidation, and structural changes of heat-sensitive phenolic and flavonoid compounds, such as catechin, epicatechin, and procyanidins (Acosta-Otálvaro et al., 2022; Nurhayati et al., 2018; Attahmid et al, 2020). Epicatechin is particularly susceptible to thermal degradation and may undergo oxidation, epimerization, and polymerization at elevated temperatures, resulting in reduced radical scavenging capacity (Hurst et al., 2011; Nurhayati et al., 2018). Cocoa paste retained higher antioxidant activity than cocoa fat, probably because of its higher polyphenol content (Rachmatullah et al., 2021). These results indicate a trade-off between microbial safety and antioxidant retention.

Based on these results, unheated cocoa fat was selected for the second stage because it was free from microbial contamination and retained the highest antioxidant activity. Cocoa paste heated at 121°C was selected because this treatment eliminated microbial contamination, although it reduced antioxidant activity.

Research Stage 2: Effect of cocoa fat concentration and essential oils addition on hand dream characteristics

The characteristics of the hand cream can be seen in Table 3. The analysis of variance results showed that the interaction between cocoa fat concentration and essential oil type had a significant effect ($P \leq 0.05$) on the hand cream's pH value, specific gravity, spreadability, and antioxidant activity.

Table 3. The characteristics of hand cream

Cacao fat (%)	Essential oils	pH	Specific gravity	Spreadability	Antioxidant activity
1	No essential oil	5.53±0.49^{ab}	0.9779±0.02^{a}	4.00±0.14^{a}	76.09±3.82^{c}
1	Ylang-ylang oil	6.58±0.18^{b}	0.9609±0.01^{a}	5.60±0.29^{bc}	77.98±3.74^{c}
1	Lilac oil	6.29±0.25^{b}	1.0306±0.01^{b}	6.27±0.39^{c}	80.91±2.36^{d}
1	Ylang-ylang + Lilac oil	6.15±0.44^{b}	0.9836±0.01^{ab}	6.57±0.25^{c}	68.11±4.29^{a}
2	No essential oil	5.35±0.19^{a}	0.9584±0.00^{a}	4.47±0.33^{ab}	77.29±2.84^{c}
2	Ylang-ylang oil	6.22±0.46^{b}	0.9903±0.00^{ab}	5.30±0.49^{bc}	78.84±2.17^{c}
2	Lilac oil	6.06±0.20^{b}	0.9627±0.01^{a}	5.13±0.17^{b}	82.08±1.76^{d}
2	Ylang-ylang + Lilac oil	5.40±0.35^{a}	0.9642±0.01^{a}	4.15±0.05^{ab}	73.00±4.17^{b}
3	No essential oil	4.60±0.18^{a}	0.9627±0.01^{a}	4.10±0.37^{ab}	78.42±3.46^{c}
3	Ylang-ylang oil	5.45±0.26^{a}	0.9621±0.01^{a}	5.20±0.22^{bc}	80.79±2.03^{d}
3	Lilac oil	5.78±0.55^{ab}	1.0189±0.01^{b}	6.37±0.40^{c}	83.09±2.12^{d}
3	Ylang-ylang + Lilac oil	5.09±0.51^{a}	1.0294±0.01^{b}	6.13±0.74^{c}	75.83±1.93^{c}

Note:
Values are presented as mean ± standard deviation. Numbers followed by different superscript letters within the same column indicate significant differences according to Duncan's Multiple Range Test (DMRT) at a 1% significance level ($\alpha = 0.01$). Values sharing the same letter or overlapping letters are not significantly different.

pH value

The pH values of the hand cream ranged from 4.60 ± 0.18 to 6.58 ± 0.18, with an average of 5.71 ± 0.45, indicating that all formulations were within the acceptable range for topical preparations. These values comply with SNI 16-3499-1996 and BPOM Regulation No. 17 of 2014, which require the pH of skin moisturizing products to be within 4.5–8.0. Indian Standard Skin Creams Specification (2004) states that the pH of the cream should be between 4-9. Croatian Institute of Public Health (2019) states that the products staying in prolonged contact with the skin may have a pH value 3.0 to 8.0. The relatively stable pH suggests that cocoa fat, cocoa paste, and essential oils were chemically compatible in the emulsion system.

According to studies by Rusiyantoro et al. (2021) and Diba et al. (2023), natural ingredients like cocoa fat and essential oils do not significantly affect the pH of an emulsion when used in low concentrations. This is due to the interaction between volatile compounds and fatty acids that helps balance the pH. Similarly, (Azila & Azilah, 2022) explained that while cocoa fat is slightly acidic, it tends to maintain pH stability in water-based systems as long as no strong acidic or basic components are added.

Specific gravity

The specific gravity of the hand cream ranged from 0.9609 ± 0.01 to 1.0306 ± 0.01, with an average of 0.9835, which met the quality requirements of the Indonesian National Standard (SNI 16-3499-1996). These values indicate that the cream formulations had acceptable density and physical consistency. Formulations containing essential oils tended to show slightly higher specific gravity, which may

be related to the chemical composition and molecular weight of the volatile compounds present in ylang-ylang and lilac oils.

Specific gravity is an important parameter in emulsion-based creams because it reflects the density balance between the oil and water phases and indirectly indicates emulsion stability (Lachman et al., 1991; Tadros, 2013). A stable specific gravity supports uniform texture, spreadability, and a lower risk of phase separation during storage (Barel et al., 2014). In this study, hand creams containing essential oils tended to show slightly higher specific gravity than those without essential oils, which may be related to the chemical composition of the oils, particularly the presence of oxygenated terpene compounds such as linalool in lilac oil (Gecer, 2022; Eslahi et al., 2017).

Spreadability

The spreadability of the hand cream ranged from 4.00±0.14 to 6.57±0.25 cm with an average of 5.31±0.43. Most formulations were within or close to the desirable spreadability range of 5-7 cm (Nurfita et al., 2021). The addition of essential oils generally increased spreadability, probably by reducing cream viscosity and improving the distribution of the oil phase. Higher cocoa fat concentrations combined with essential oils also tended to improve spreadability, indicating better ease of application on the skin.

The addition of essential oils may reduce cream viscosity, resulting in easier application and higher spreadability (Nurhaini et al., 2022). In this study, formulations with higher cocoa fat concentrations and essential oils tended to show greater spreadability, consistent with Cahyani et al. (2020), who reported that cocoa fat improved cream spreadability by producing a less thick and more easily absorbed texture. This indicates that the interaction between fat and oil components contributes to the physical properties of the cream (Aydemir, 2019; Aydemir & Atalar, 2019).

Antioxidant activity

The antioxidant activity of the hand cream ranged from 68.11% ± 4.29 to 83.09% ± 2.12, with an average of 77.70% ± 3.74. Formulations containing lilac oil showed the highest inhibition values at all cocoa fat concentrations, with the highest activity observed in the formulation containing 3% cocoa fat and lilac oil. This may be related to the presence of oxygenated terpene compounds in lilac oil, such as linalool, α-terpineol, and geraniol, which can contribute to free radical scavenging activity. In contrast, the mixture of ylang-ylang and lilac oils showed lower antioxidant activity, possibly due to non-synergistic interactions among their bioactive compounds.

The addition of lilac and ylang-ylang essential oils generally increased the antioxidant activity of the hand cream compared to formulations without essential oils. However, the mixture of both oils showed lower percent inhibition, possibly due to non-synergistic or indifferent interactions among their bioactive compounds

(Sakinah & Subroto, 2021). The higher antioxidant activity of formulations containing lilac oil may be related to its oxygenated terpene compounds, such as linalool, α-terpineol, and geraniol, which contain functional groups that contribute to free-radical scavenging activity (Gecer, 2022; Charlton et al., 2023).

Cocoa fat showed no microbial growth even without high-temperature treatment, likely due to its low moisture content, lipid-dominant composition, and antimicrobial fatty acids such as oleic, stearic, and palmitic acids (Edo et al., 2023; Hurst et al., 2011; Ramlah et al., 2020). In contrast, cocoa paste required heating at 121°C to eliminate microorganisms because its protein and carbohydrate contents can support microbial growth (Scapagnini et al., 2014; Madigan et al., 2009). However, higher heating temperatures reduced antioxidant activity due to the thermal degradation of heat-sensitive phenolic and flavonoid compounds, indicating a trade-off between microbiological safety and antioxidant retention (Nurhayati et al., 2018; Attahmid et al., 2020).

Overall, the results show that cocoa fat is microbiologically stable without high-temperature treatment, whereas cocoa paste requires heating at 121°C to eliminate microbial contamination. However, high-temperature treatment reduces antioxidant activity, indicating the need to balance safety and functional quality. The addition of essential oils, particularly lilac oil, improved the antioxidant properties and sensory potential of the hand cream. Therefore, the formulation containing 3% cocoa fat and lilac oil can be considered the most promising formulation based on its antioxidant activity and acceptable physical characteristics.

Conclusion

This study successfully formulated cocoa-based hand cream enriched with ylang-ylang and lilac essential oils that met the required quality parameters for topical cream and remained free from visible fungal contamination after 30 days of storage at room temperature. The formulation containing 3% cocoa fat and lilac essential oil was identified as the most promising treatment, as it showed the highest antioxidant activity (83.09%) while maintaining acceptable physical characteristics, including homogeneous appearance, suitable pH, specific gravity, and spreadability. Unheated cocoa fat was suitable for formulation because it showed no detectable microbial contamination and retained high antioxidant activity, whereas cocoa paste required heating at 121°C to ensure microbiological safety, although this treatment reduced its antioxidant activity. These findings provide practical guidance for developing value-added cocoa-based hand cream by selecting processing conditions that balance microbiological safety, antioxidant retention, and product quality. Further studies involving irritation tests, patch testing, longer storage stability, and consumer sensory evaluation are recommended to support clinical and commercial application.

Conflict of interest

The authors declare that there is no conflict of interest. Contributions to this research were distributed equally among all authors, thus justifying co-authorship. All authors contributed equally to the conceptualization, methodology, validation, data analysis, evaluating, writing draft, and review.

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