JOURNAL OF NATURAL REMEDIES
DOI: 10.18311/jnr/2025/45897
RESEARCH ARTICLE

Cocoa Butter as an Effective Moisturizer for Topical Cream

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Abstract

Background: Cocoa Butter (CB) is rich in triglycerides and various types of fatty acids, which provides it with occlusive effect on the skin. However, it is not commonly used as a main ingredient in modern formulated topical moisturizing creams. Consequently, this study was to examine the impact of CB as the primary ingredient in skin moisturizing cream. **Aim:** To examine the occlusivity impact of CB as the principal component in skin moisturizer topical cream. **Methods:** To prepare the cream, the oil phase, containing the polyethene glycol (PEG) 200, beeswax, and CB, was heated to a molten state before being combined with the aqueous phase. The oil-in-water (o/w) emulsions were prepared by incorporating the excipients and applying high-speed homogenization. The developed products were then evaluated for pH, Sun Protection Factor (SPF), *in vitro* occlusivity, antioxidant activity, antimicrobial activity, spreadability as well as stability study. **Results:** The S14 formulation exhibited superior sun protection factor (SPF = 25.4 ± 0.51) and the lowest occlusion factor (F = 24.20 ± 2.62). Additionally, the spreadability was effortless (1.53 ± 0.19 cm). Among the selected formulations, S12 demonstrated the highest occlusivity effect (54.10 ± 3.41), enhanced *in vitro* antioxidant and superior antimicrobial properties (1.58 ± 0.02 cm, 2..12 ± 0.04 cm Zone of Inhibition for *E. coli* and *S. aureus*, respectively), and maintained stable pH, color, and phase integrity throughout the three-month stability study without significant variations. **Conclusion:** CB demonstrates significant potential as an innovative skin moisturizer, and a valuable component in the development of green cosmetic products. In the prepared cream formulation, CB played a central role due to its versatile and multifunctional properties.

Major Findings: CB shows great potential as an effective skin moisturizer and a key ingredient in eco-friendly cosmetics. Its properties enhance hydration and nourishment, supporting the demand for sustainable skincare solutions.

Keywords: Cocoa Butter, Emulsions, Green Product, Occlusivity, Sun Protection Factor, Spreadability, Stability Study

1. Introduction

The skin consists of three intracellular lipids, namely free sterols, free fatty acids and sphingolipids, which serve as protective barriers. These lipids retain water while preventing excessive water loss. Under normal conditions, water rises from the deeper epidermal layer and travels upwards to moisturize the cells of the outermost skin layer[1]. With the use of moisturizer, the water content in the skin can be maintained within

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Article Received on: 10.11.2024 Revised on: 09.12.2024 Accepted on: 09.01.2025

the normal range of 10% to 30%[2]. Typically, topical dosage forms that are available on the market, exist in the form of lotion, ointment, butter, oil, cream, and others. Among these dosage forms, the lotion-type moisturizer is the top seller due to its affordable cost, easy application and appealing texture[3]. However, they are less effective for individuals with dry skin or atopic dermatitis due to their high evaporation rate.

Currently, the moisturizers in the market are composed of different ingredients. CB is among the ingredients incorporated into moisturizer formulations. Although numerous investigations have been undertaken regarding the possible effect of CB on skin hydration, it is typically added as a complement cause rather than as the primary ingredient to provide a moisturizing effect[4–6]. Moreover, recently, researchers have also proven the extended hydration benefits with the application of oil-in-water (o/w) cream made of beeswax, sunflower oil, phenoxyethanol, CB, urea, and glycerol[7].

CB is a natural, plant-based ingredient. The moisturizing effect of CB is mainly attributed to its oil compositions such as alpha-linolenic acid, palmitoleic acid and oleic acid. Interestingly, vitamin E (β-tocopherol, α-tocopherol and γ-tocopherol) which acts as an antioxidant, is also present in CB[8,9]. With the presence of these compositions, CB exhibits promising potential as an occlusive agent in reducing the loss of water from the skin. This research aimed to examine the occlusivity impact of CB as the principal component in skin moisturizer through an *in-vitro* method. Besides, the study explored the effect of CB on other parameters such as pH, SPF, spreadability, antioxidant activity, antimicrobial activity as well as stability.

2. Materials and Methods

The materials used were unrefined raw CB (Biotek Abadi Sdn. Bhd, Malaysia), beeswax, cinnamon oil, ethyl alcohol (Fisher Scientific), mueller hinton agar powder (Difco), nutrient broth powder (Merck), poloxamer 188 solution (Sigma-Aldrich), poloxamer 407 powder (Sigma-Aldrich), polyethene glycol (PEG) 200 (RandM Chemicals), hydrogen peroxide (Systerm), potassium dihydrogen phosphate powder (Systerm), ortho-phosphoric acid (Emsure), sodium hydroxide powder (Emsure), sweet almond oil (International Collection) and vanillin (Acros Organics). The bacteria strains (*Escherichia coli* and *Staphylococcus aureus*) were cultured in the microbiology laboratory of UCSI University.

2.1 Preparation of Prototype Formulations

Procedures for preparing for primary emulsion were adopted from the published research works with some modifications[10]. In total, 15 prototype formulations were developed by adding the ingredients in predetermined proportions (data not shown). Among the formulations, 4 prototype formulations with reduced grittiness and a creamy consistency were selected for further characterization. The compositions of the prototype formulations were summarised in Table 1. The melted oil phase (PEG 200, CB and beeswax) was added to the heated aqueous phase (distilled water and poloxamer 188) at the same temperature in a 100 mL glass beaker. All the excipients were added accordingly, and the mixture was immediately subjected to high-speed homogenization at 4000 rpm for 15 minutes. The beaker was rotated continuously during homogenization to ensure proper mixing of the ingredients and formation of homogenized cream.

2.2 Physical Appearance and Organoleptic Properties

The visual appearance, colour, and homogeneity of the cream were assessed after it had settled in the container. A small quantity of sample was taken and compressed between the thumb and forefinger to evaluate the homogeneity and texture. The texture and homogeneity

Table 1. Composition of prototype formulations

Sample	S8	S12	S13	S14
Cocoa butter or CB (g)	5.0	5.0	3.0	2.0
Beeswax (g)	2.0	5.0	2.0	2.0
PEG 200 (mL)	10.0	2.0	2.0	1.0
Poloxamer 188 (mL)	2.0	2.0	2.0	2.0
Poloxamer 407 (g)	4.0	4.0	4.0	4.0
Cinnamon oil (mL)	1.0	1.0	0.5	0.3
Almond oil (mL)	5.0	5.0	5.0	1.0
Vanillin (g)	1.1	1.5	1.5	1.2
Distilled Water (mL)	10.0	10.0	10.0	16.5

*The unstable formulations were omitted from further evaluations (S1-S7 and S9 – S11)

were assessed on the formulation's consistency and the absence of coarse particulates[11].

2.3 pH Test

Before the initiation, the pH meter was calibrated with a standard buffer solution. 0.5 g of the prepared cream was taken and gently mixed with 50 mL of distilled water. The pH of the cream was subsequently examined at ambient temperature using the pH meter[12].

2.4 *In Vitro* Occlusivity Study

10 g of distilled water was placed in a 100 mL borosilicate glass beaker. Qualitative filter paper 102 (medium filter speed) with a pore size of 7 – 9 µm and an area of 12.5 cm ×12.5 cm was placed on the upper surface of the beaker. A small amount of sample (0.2g) was evenly distributed on filter paper and stored at a temperature of 37°C and 65% Relative Humidity (RH) for 48 hours. A negative control without the cream was prepared and kept under the same conditions. The setup was as portrayed in Figure 1.

The occlusive factor, F was calculated using the following formula[9]. The steps were repeated thrice.

$$F = \frac{A - B}{A} \times 100 \quad \text{----------(1)}$$

Whereas,

A = Water flux through uncovered filter (% of water loss)

B = Water flux through the filter when covered by formulation (% of water loss)

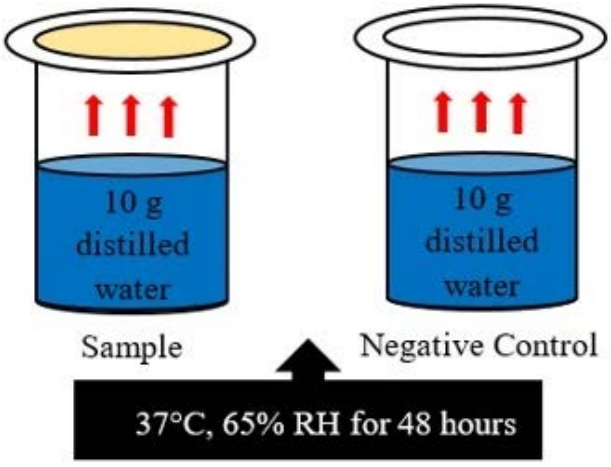


Figure 1. *In vitro* occlusivity study.

Table 2. SPF calculation (normalized product functions)

Wavelength (λ nm)	EE x I (normalized)
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.0180
Total	1

2.5 Sun Protection Factor (SPF)

The method employed in evaluating the SPF of o/w emulsion containing Greek red saffron was adapted to evaluate the SPF of skin moisturizer containing CB in our study[13]. Specified quantities (0.5 g) of prototype formulations were weighed into the 100 mL beaker and diluted with 99% ethyl alcohol. Dilution were made, and the absorbance was measured at the wavelength range of 290 – 320 nm at 5 nm interval using the UV spectroscopy. Three replicates were obtained, and the average was calculated. The SPF value was determined using the Mansur equation stated as follows along with the normalized product functions in Table 2[14].

$$SPF = CF \times \sum_{320}^{290} [EE(\lambda) \times I(\lambda) \times abs(\lambda)] \text{ -----(2)}$$

Whereas,

CF = Correction factor (10)

EE (λ) = Erythmogenic effect of radiation at wavelength λ,

I (λ) = Intensity of solar light at wavelength λ,

abs (λ) = Absorbance of wavelength λ by a solution of the preparation

2.6 Spreadability Study

The procedure has been adopted and modified from the published studies[15,16]. A circle of 1 cm diameter was pre-marked on the glass side, and 0.5g of the formulation was added to it. Another glass slide was placed on top to cover the sample. A standard weight of 100 g (used to calibrate the weighing balance) was placed on the upper plate for 2 minutes (Figure 2). Spreadability was indirectly evaluated by the measuring area covered by the fixed amount of cream tested on a glass slide. An

increase in the diameter as a result of uniform spreading was recorded. The procedure was repeated three times, and the average increase in diameter was calculated.

2.7 *In Vitro* Antioxidant Activity (Hydrogen Peroxide Method)

The ability of the formulated cream to inhibit the generation of Reactive Oxygen Species (ROS) was evaluated using the method of Ruch *et al.,* with slight modification[17]. This method is commonly used to evaluate the SPF values, as hydrogen peroxide is a strong oxidizing agent, and its decreases correlated well with the presence of scavenging compounds[18]. 1 mL of each sample of concentration (100, 90, 80, 70, 60, 50, 40, 30, 20, 10, 1, 0.5, 0.25 µg/mL) was added to 0.6 mL of 40 mM hydrogen peroxide solution and 2.4 mL of phosphate buffer solution. The absorbance of hydrogen peroxide at 230 nm was measured 10 minutes after mixing with a blank solution for each concentration. The absorbance of the control, which consisted of phosphate buffer with hydrogen peroxide (absence of sample) was measured against a blank after 10 minutes of mixing. Three replicates were obtained for each concentration and the average absorbance value was determined.

$$\%\text{Antioxidant activity} = \frac{\text{Absorbance of Sample}}{\text{Absorbance of control}} \times 100 \quad ---(3)$$

2.8 Antimicrobial Activity

The antimicrobial activity of the moisturizing cream was accessed using the disc diffusion susceptibility method against a Gram-negative strain (*Escherichia coli*) and a Gram-positive strain (*Staphylococcus aureus*). The bacterial broth solution was first swabbed onto the nutrient agar using sterile cotton buds. Next, the dried sterile discs containing the sample were placed on the nutrient agar. Subsequently, the bacteria were incubated at a temperature of 37°C for 24 hours. The diameter of the clear Zone of Inhibition (ZOI)

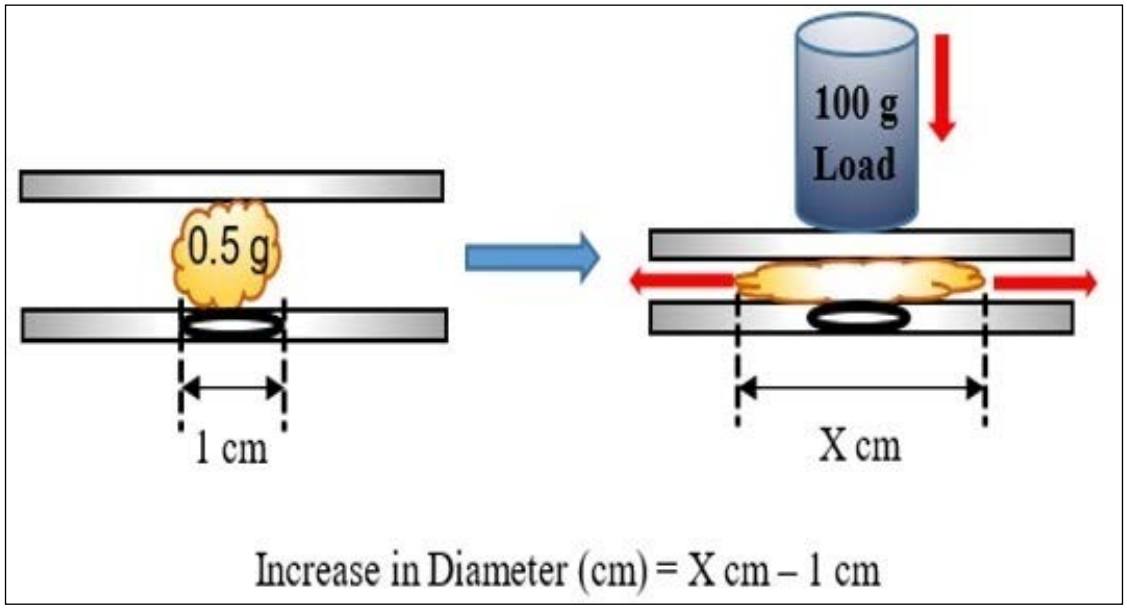


Figure 2. Spreadability study.

Table 3. Physical appearance, organoleptic properties and pH

Formulation code	Appearance and Homogeneity	Colour	Oiliness and Phase separation	pH value
S8	Homogeneous appearance	Light yellow	Very oily cream. No phase separation	5.17 ± 0.06
S12	Homogeneous appearance	Whitish yellow	Less oily cream. No phase separation	5.20 ± 0.10
S13	Homogeneous appearance	Whitish yellow	Oily cream. No phase separation	5.17 ± 0.06
S14	Homogeneous appearance	Whitish yellow	Less oily cream. No phase separation	5.07 ± 0.06

surrounding the discs was measured. Ampicillin disc was used as a control[19].

2.9 Stability Study

The formulation, S12 was selected for stability testing and subjected to the conditions of a refrigerator (1.7°C to 3.3°C) and room temperature (29.5°C to 32.6°C with relative humidity of 65% to 90%)[20]. The appearance, pH, and phase separation were observed for 3 months.

3. Results

3.1 Physical Appearance, Organoleptic Properties and pH

The selected cream formulations were evaluated for their physical appearance, including colour, texture, phase separation, homogeneity, consistency, and grittiness. The results of these assessments, along with the organoleptic properties and pH value of formulations S8, S12, S13 and S14 are summarized in Table 3. Notably, formulations S12 and S14 exhibited a less oily and homogenous appearance, all the selected formulations aligning with an acceptable skin pH range.

Table 4. Occlusion factor, sun protection factor and spreadability

Formulation code	Occlusion Factor (F)	SPF	Spreadability (cm)
S8	36.40 ± 2.55	21.20 ± 0.20	1.52± 0.08
S12	54.10 ± 3.41	24.72 ± 0.59	0.97± 0.03
S13	51.47 ± 1.96	24.73 ± 0.11	0.93± 0.06
S14	24.20 ± 2.62	25.40 ± 0.51	1.53± 0.19

Table 5. Antimicrobial activity

Sample	Increase in diameter of ZOI (cm)	
	E. coli	***S. aureus***
Ampicillin	1.02 ± 0.03	3.58 ± 0.06
S8	1.53 ± 0.03	1.87 ± 0.03
S12	1.58 ± 0.02	2.12 ± 0.04
S13	1.28 ± 0.03	1.53 ± 0.03
S14	1.17 ± 0.06	1.33 ± 0.03

3.2 *In Vitro* Occlusivity, Sun Protection Factor and Spreadability Studies

The selected cream formulations were comprehensively evaluated through *in vitro* studies to assess their occlusivity, spreadability and SPF validation. The results of this evaluation are detailed in Table 4. Among the tested formulations, S12 demonstrated the highest occlusivity effect, signifying its exceptional ability to form a protective barrier and minimize transdermal water loss. Formulation S12, S13 and S14 exhibited notable SPF values indicating their effectiveness in providing sun protection. Furthermore, formulations S8 and S14 showcased the highest spreadability highlighting superior ease of application.

3.3 *In Vitro* Antioxidant Activity (Hydrogen Peroxide Method)

Figure 3 presents the antioxidant activity data for all four selected formulations (S8, S12, S13, S14). The results indicate a general trend in all four formulations where the percentage of antioxidant activity increases as the sample concentration increases.

3.4 Antimicrobial Activity

The outcome of the antimicrobial study is shown in Figure 4 and Table 5. It was obvious that the average

Table 6. Stability study results of S12 formulation (3 months)

Duration (Months)	Conditions	Colour	pH	Phase Separation
Initial	Room temperature	Whitish yellow	5.0±0.06	None
	Refrigerator	Whitish yellow	5.1±0.07	None
1	Room temperature	Whitish yellow	5.1± 0.06	None
	Refrigerator	Whitish yellow	5.1± 0.10	None
2	Room temperature	Whitish yellow	5.0± 0.08	None
	Refrigerator	Whitish yellow	5.1±0.07	None
3	Room temperature	Whitish yellow	5.2 ± 0.06	None
	Refrigerator	Whitish yellow	5.1 ±0.04	None

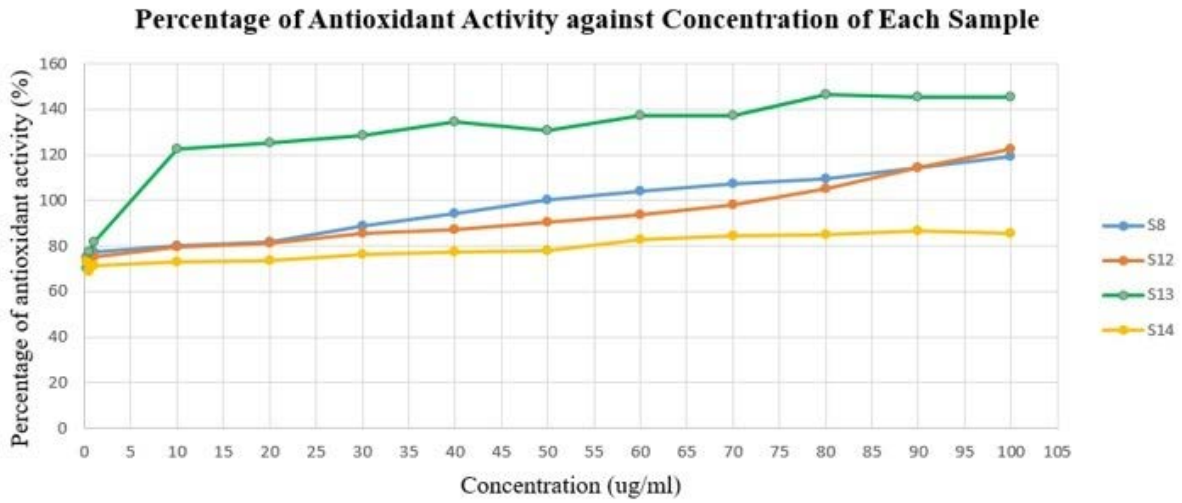


Figure 3. Antioxidant activity of prototype formulations.

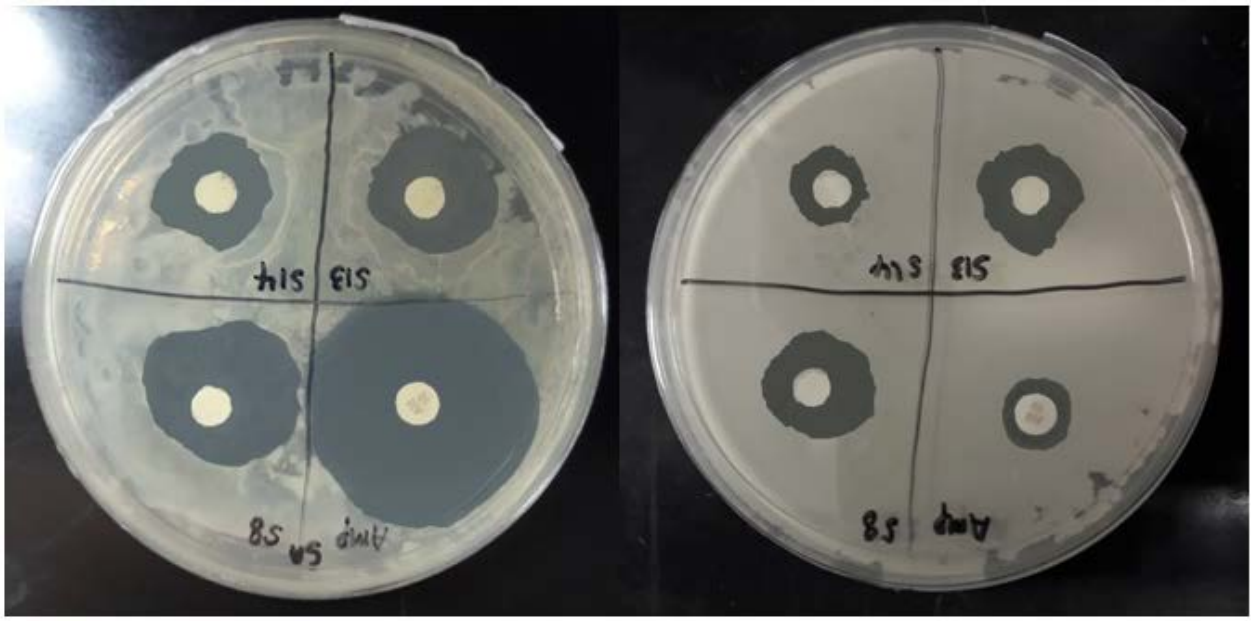


Figure 4. Antimicrobial activity (zone of inhibition for *S. aureus* (right) and *E. coli* (left).

diameter of ZOI against *S. aureus* was greater than *E. coli* for all four selected formulations.

3.5 Stability Study

The results of the stability study, as presented in Table 6 demonstrated that the selected formulation, S12 was stable for 3 months under both refrigerator and room temperature. Over the 3 months, there was no obvious change in the colour and pH of the formulation as well as absence of phase separation.

4. Discussion

4.1 Selection of Prototype Formulations

In our study, the oil phase consisted of PEG 200, CB and beeswax, while the aqueous phase contained poloxamer 188 and distilled water. Beeswax was added to improve the moisturizing effect of the cream, as several studies had claimed its ability to prevent moisture loss[21–24]. PEG 200 was added as a wetting agent to reduce the contact angle of the particles at the interface of the oil and water

phases. To further improve the stability of the samples, poloxamer 188 was selected to act as the emulsifier due to its amphiphilic property, contributed by the hydrophilic polyethene oxide parts and hydrophobic polypropylene oxide parts[25]. This ensured that the oil globules were uniformly distributed and hence prevented coalescence. In addition, poloxamer 407 was added as the thickener to enhance the homogeneity of the cream. As a well-known skin conditioning agent, almond oil was included in the formulation to improve skin complexion and reduce UV damage[23]. Finally, cinnamon oil was used as an antimicrobial agent and vanillin was added to mask the pungent smell of cinnamon oil. Among the prototype formulations, S12 and S14 appeared to be the best formulations due to their homogeneity, less oiliness and whiter cream texture. The reason for less oiliness could be associated with the reduction in the amount of oil phase ingredients, such as PEG 200, cinnamon oil and almond oil. Besides, the smell was less pungent compared to the others because of the increase in vanillin amount and reduction in cinnamon oil.

4.2 Physical Appearance, Organoleptic Properties and pH

All the selected formulations demonstrated desirable cream characteristics, including excellent consistency, homogeneity, appealing appearance, a pH within an acceptable range of skin application and no signs of phase separation. However, an exception was noted with the S8 formulation, which exhibited an oily texture. The prototype formulations showed pH values of 5.07 to 5.20, which were within the skin pH range (4.0 - 6.0). This indicated that the samples were less likely to cause skin irritation. According to the study, the average skin pH was around 4.7 and this was optimum for the growth of skin flora[26]. A pH that is either higher or lower pH would disrupt the balance of skin flora.

4.3 *In Vitro* Occlusivity

Occlusivity was determined by comparing the percentage of water loss after 48 hours with samples to the percentage of water loss in the negative control. The weight of water evaporation in the negative control should be theoretically higher than that in the samples. This is because the filter paper lacked an occlusive agent to act as a barrier for water evaporation. It was found that S12 had the highest occlusion factor (F = 54.10 ± 3.41) whereas the occlusion factor of S14 was lowest (F = 24.20 ± 2.62) among the selected prototype formulations (Table 4). Higher CB concentration in the formulation S12 provides better occlusivity which leads to a lower amount of water loss. Formulation S14 had a smaller occlusion factor than S13 and S8. The CB, which is rich in triglycerides, palmitic acid, stearic acid, oleic acid and linoleic acid contributed to the hydrophobicity of the cream, allowing the formation of an occlusive layer on the skin surface[27,28]. Our findings corroborated with another study that concluded that adding CB to the cream could provide a longer-lasting hydration effect[7].

4.4 Sun Protection Factor (SPF)

The SPF was determined using the UV spectrophotometric method. According to the American Academy of Dermatology (AAD)[29] and the American Cancer Society, SPF 15 can block 93% of ultraviolet B rays (UVB rays) whereas SPF 30 can block 97% of UVB. The SPF values of samples (S12, S13 and S14) were around 25, except for the S8 formulation (Table 4). SPF value of 25, the formulation is expected to block 95% of UVB rays. Therefore, we concluded that the formulation provided a certain degree of photoprotection, although it was insufficient to reach the minimum SPF level of 30 recommended by AAD. It was believed that the photoprotective activity was attributed to the flavonoids and flavones in the CB. These components can reduce the inflammation and erythema caused by sunlight radiation. In addition, there is growing evidence that the polyphenols in natural substances might be beneficial in preventing sunburn[30]. Phenolics prevent the lipid peroxidation and production of oxygen-free radicals caused by UV[31].

4.5 Spreadability Study

Spreadability is significant in ensuring uniform application of the cream on the skin and patient compliance[32]. Based on a study, the beeswax improved the stability of the formulation but the sample with a lower concentration of beeswax spread more easily than the sample with a higher concentration of beeswax[33]. This was demonstrated in Table 4, where the average increase in diameter of S8 was 1.52 ± 0.08 cm but was 0.97 ± 0.03 cm for S12 under the same

load. The spreadability results also showed that the S14 had higher spreadability (1.53 ± 0.19cm) than other formulations. The amount of other ingredients such as PEG 200 and various oils might also play a considerable role in affecting the cream's spreadability as well.

4.6 *In Vitro* Antioxidant Activity (Hydrogen Peroxide Method)

The hydrogen peroxide method was used to investigate the total antioxidant activity in our samples, as H_2O_2 is the simplest peroxide with an oxygen-oxygen single bond[18]. Due to its structure, H_2O_2 is a strong oxidizing agent that accepts electrons to decompose into oxygen (O_2) and water (H_2O)[34]. Figure 3, anti-oxidant data revealed an unspecific tendency for all four formulations (S8, S12, S13, S14) to increase the percentage of antioxidant activity as sample concentration increased. This pattern suggests a concentration-dependent antioxidant effect, highlighting the potential of these formulations to scavenge free radicals more effectively at higher concentrations. The slight fluctuation in S13 at 50 µg/ml could be explained by the time delay in measuring the absorbance after the addition of hydrogen peroxide into the phosphate buffer and samples. CB had antioxidant activity due to the presence of flavonoids, epicatechin, catechin and procyanides. The phenolic quinoids tautomerism allowed electron delocalization on the aromatic rings of flavonoids, leading to increased stability of the molecules by resonance effect[35]. The cocoa polyphenol, especially flavanol was a very strong antioxidant as it neutralized the ROS, hence protecting the endothelium from oxidative stress and inhibiting lipid peroxidation. Apart from this, cocoa also interfered with the cellular antioxidant pathway, by inhibiting enzymes such as xanthan oxidase, NADPH oxidase, tyrosine kinase and protein kinase[36].

4.7 Antimicrobial Activity

This finding indicates that the all-tested formulations exhibited greater antimicrobial activity against *S. aureus*, suggesting their potential efficacy in targeting Gram-positive bacteria (Figure 4). Conversely, the relatively smaller ZOI observed for *E. coli* highlights a comparatively lower activity against Gram-negative bacteria, likely due to differences in cell wall structure and permeability between the two bacterial strains. Cinnamon oil and its constituents such as cinnamaldehyde and eugenol, have antimicrobial activity as mentioned in previous studies[37]. When comparing our results with other studies, it was noted that our samples showed lower effects on the bacteria[38]. However, the antimicrobial effect against *S. aureus* was greater than that of *E. coli*, which is aligned with the results of other researchers[39]. *E. coli* is a Gram-negative bacterium which had a thick lipopolysaccharide outer cell wall, causing the bacteria to be resistant to hydrophobic substances. Conversely, *S. aureus* is a Gram-positive bacteria possessing a single layer of peptidoglycan that allows lysis to happen more easily[40]. When cinnamaldehyde entered the cells, it caused damage to the membrane permeability, thus interfering with cellular processes in the nitrogen-containing structures such as protein and nucleic acid[41]. Compared to the standard drug Ampicillin, all 4 prototype formulations exhibited a greater ZOI against *E. coli* but demonstrated lower ZOI against *S. aureus*. Among the samples, S12 displayed the greatest diameter of the ZOI against both bacterial strains, attributed to their highest cinnamon oil content (1 mL), which was doubled to that of S13 (0.5 mL) and nearly triple that of S14 (0.3 mL). However, the inhibitory effect in our study was not significantly different between the samples, which could be due to the relatively lower concentration of cinnamon oil than in the reported study[39]. Among the samples, S8 and S12 exhibited the largest ZOI against both bacterial strains, attributed to their higher cinnamon oil content (1 mL), which was double that of S13 (0.5 mL) and nearly triple that of S14 (0.3 mL).

CB moisturizer cream also contributes to maintaining healthy skin. Dry skin is often prone to acne due to a damaged barrier, allowing bacterial intrusion. CB, with its excellent occlusive properties, hydrates the skin and locks in moisture. Its antioxidant properties aid in the healing process and protect the damaged skin barrier from free radicals. Additionally, CB cream demonstrated significant effectiveness against *S. aureus,* a primary acne-causing bacterium. Its sun protection and antioxidant benefits work together to safeguard skin collagen, offering anti-ageing advantages as well. The primary ingredient of this cream, CB, is produced from cocoa beans, a natural, plant-derived fat that adheres to sustainability and eco-friendliness principles. Its sourcing does not involve

synthetic chemicals (except emulsifiers), making it a more environmentally responsible choice. Highlight that using naturally occurring ingredients in the topical cream reduces its ecological footprint compared to synthetic alternatives. Substantiate the use of "green product" as a keyword highlighting the product's multifunctional properties, consumer benefits and the inclusion of low-cost ingredients.

4.8 Stability Study

After evaluating various factors, S12 was chosen for further stability studies due to its potent *in vitro* antioxidant activity, compliance with minimally recommended SPF value, and importantly, the highest occlusion factor among the prototype formulations. There were no apparent chemical reactions between the ingredients and thus S12 was physically stable (Table 6). The absence of liquefaction or phase separation indicated that the formulation would be relatively stable when stored under well-closed container[32]. The pH range was also within the skin pH (4.0-6.0), indicating the optimum pH for the growth of skin flora. Moreover, homogenization speed could affect the stability of the cream as supported by various studies[42]. Since there was no phase separation, this indicated that the homogenization speed selected was suitable for our formulation. Given the promising results, additional *in vivo* studies are needed to confirm that there are no skin irritations.

5. Conclusion

CB demonstrates significant potential as a primary ingredient in moisturizers, owing to its lipophilic structure, which acts as an effective occlusive agent, minimizing water loss from the skin. Our study confirmed that the pH of the CB cream closely matches the natural pH of the skin, an essential factor in reducing skin irritation. Additionally, the formulation exhibited the highest occlusion factor, optimum SPF and *in vitro* antioxidant activity, as well as antibacterial activity, enhancing its value as a multifunctional skin moisturizer. In conclusion, cosmeceuticals can benefit from incorporating natural and sustainable CB as a key ingredient, reducing reliance on harmful chemicals while promoting environmentally friendly practices. Further research should delve deeper into the broader application and benefits of CB in the cosmetic industry, further establishing its role as a versatile and sustainable component in skincare formulation.

6. Acknowledgment

The study's authors express their gratitude to the Faculty of Pharmaceutical Sciences, UCSI University, Cheras - 56000, Kuala Lumpur, Malaysia.

7. Author Contribution

Conceptualization, A.K.J. and V.K.P.; methodology, and investigation, T.J.W, V.K.P, and A.K.J.; formal analysis, T.J.W, S.K., T.S.M.S., and H.S.J.C.; data curation, S.K., T.S.M.S.; validation, H.S.J.C, M.A.; writing—review and editing, T.J.W, M.A., V.K.P, and A.K.J.; supervision, A.K.J. All authors have read and agreed to the published version of the manuscript.

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