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FORMULATION OF ANTIBACTERIAL SHOWER GEL INCORPORATING EXTRACTS FROM BITTER MELON (*MOMORDICA CHARANTIA* L.) AND TEA LEAVES ESSENTIAL OIL (*MELALEUCA ALTERNIFOLI* C.)

Nguyen Anh Dao[1], Pham Khanh Vy[2], Pham Nguyen Tuong Van[3*]

Abstract – *Cosmetics derived from natural sources have been receiving much research attention recently, especially specialized products that support moisturizing or antibacterial properties and contain medicinal herbs, such as bitter melon or tea tree essential oil. In Vietnam, bitter melon (Momordica charantia L.) is well-known and utilized for cosmetic and health-related use. In addition, the essential oil of tea leaves (Melaleuca Alternifoli C.) is known to have antibacterial qualities, making it appropriate for a variety of common dermatological problems, including acne. To create eco-friendly cosmetics derived from natural sources, the research team first created a shower gel with extracts from bitter melon and tea leaves essential oils. The ingredients included bitter melon extract (5.0%), tea tree essential oil (0.4%), hydroxypropyl methylcellulose (1.5%), cocamidopropyl betaine (4.0%), glycerin (3.0%), triethanolamine (0.4%), citric acid (0.1%), sodium benzoate (0.2%) and distilled water (q.s to 100%). The shower gel is light brown, homogeneous, smooth, transparent, and does not separate. It has a pleasant fragrance and satisfies the quality requirements for cosmetics. Additionally, the product is safe for human skin because its pH ranges from 4.5 to 6.*

Keywords: antimicrobial, bitter melon (Momordica charantia L.), cosmetics, shower gel, tea tree essential oils (Melaleuca Alternifoli C.).

[1,2,3]Tra Vinh University, Vietnam
*Corresponding author: pntvan@tvu.edu.vn
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I. INTRODUCTION

Cosmetics made with natural and organic materials have become more and more popular in recent years [1]. These products are believed to be more effective than synthetic ones because chemically created fake cosmetics may negatively affect skin conditions [2, 3]. Some medicinal plants contain antibacterial and anti-inflammatory qualities that can be used to treat skin conditions like acne and dermatitis when they are combined with cosmetic products [1, 2]. Using bitter melon and tea tree essential oil extracts, this research attempts to create a product with anti-inflammatory qualities, acknowledging the beneficial effects of natural cosmetics on consumer health. The study's goals are to create a showing gel using bitter melon extract and tea tree essential oil and assess the shower gel's quality standards.

II. LITERATURE REVIEW

Bitter melon (*Momordica charantia* L.) is widely cultivated in Vietnam, primarily for its fruit, which is a common and valued food source in traditional medicine for its cooling, non-toxic properties. Bioactive compounds, including sterols, terpenoids, phenolics, and flavonoids, have been identified in bitter melon, presenting potential applications in pharmaceuticals and cosmetics for their antibacterial, anti-inflammatory, and antioxidant activities [4]. While a few bitter melon-derived products are on the market, cleansing formulations remain limited [5]. Conversely, tea tree essential oil (*Melaleuca alternifoli* C.), with its broad-spectrum antibacterial efficacy, offers significant potential for

treating dermatological disorders and enhancing cosmetic formulations due to its antimicrobial, antifungal, and aromatic qualities [6, 7].

Bui Chi Cong et al. [8] combined bitter melon extract into cleansing gels with a formula consisting of bitter melon extract, hydroxylethyl cellulose, cocamidopropyl betaine, lauryl glucoside, glycerin, citric acid, and distilled water. This study aims to expand cosmetic product diversity by developing a shower gel containing *Momordica charantia* L. extract and tea tree essential oil. Duong Mong Hoa et al. [9] examined the chemical composition and application of tea tree oil (*Melaleuca alternifolia* C.) in the production of mouthwash for its antibacterial ability on strains of *Pseudomonas aeruginosa*, *Staphylococcus aureus*, equivalent to many commercial mouthwashes. Studies on the antibacterial properties of tea leaves essential oil have been carried out using strains Escherich coli, Bacillus subtilis, Candida albicans with inhibition diameters ranging from 8 to 18 mm [5].

Combining two medicinal herbs, including bitter melon extract and tea tree oil, diversifies natural cosmetic products from nature. Aiming to create a shower gel product cleaning the body and enhancing the value of environmentally friendly medicinal herbs, the research developed a formula for antibacterial shower gel containing bitter melon extract and tea tree oil to intensively investigate factors, such as the ratio of gelling agent, thickening agent, and bitter melon concentrate and tea tree oil.

III. RESEARCH METHODS

A. Materials

Mateirals: Bitter melon extract (BME) prepared from the fruits of bitter melon (*Momordica charantia* L.) plated in Tra Vinh Province, Vietnam, tea leaves essential oil, hydroxypropyl methylcellulose (HPMC), cocamidopropyl betaine (CAPB), glycerin, triethanolamine (TEA), citric acid, sodium benzoate and distilled water meet cosmetic manufacturing standards.

B. Method

Preparation of BME

Preliminary processing: Fresh bitter melon (*Momordica charantia* L.) fruits free from pests are selected. The seeds are removed and the fruit is sliced thinly (about 3.0 mm). Slices are thoroughly rinsed with water, spread in a thin layer, and allowed to air dry for 24 hours. The slices are then dried in an oven at 50^oC until the moisture content falls below 10%. Dried slices are subsequently ground into a fine powder [10].

Extraction process: 300 grams of ground bitter melon is placed into a conical flask, to which distilled water is added in a 1:25 ratio (bitter melon). The mixture is heated to 90^oC for 60 minutes. After filtration, the filtrate is further concentrated under reduced pressure at approximately 60^oC to yield a high-concentration extract with a moisture content of less than 20% [8].

Formulation of shower gel

Preparation of gel base: The gel-forming agent, either HPMC or hydroxyethyl cellulose (HEC), is weighed and soaked in a sufficient quantity of distilled water for an hour, allowing full hydration. TEA is then added as a pH-adjusting agent, and the mixture is stirred until a slightly thickened consistency is achieved.

Incorporation of active ingredients: The thickened bitter melon extract is added to the gel base. CAPB, glycerin, and sodium benzoate are then incorporated, followed by tea tree essential oil, with continuous gentle stirring until a homogeneous gel is obtained. The final gel formulation is allowed to stabilize for 24 hours before assessment.

Evaluation of gel-forming agent, foaming agent, and extract ratios

Gel-forming agent: The concentration of the gel-forming agent directly affects the viscosity, stability, and texture of the product, impacting usability. Excessive viscosity can reduce ease of application, while inadequate viscosity may give a perception of poor efficacy [11].

Foaming agent: The foaming agent (surfactant) enhances cleansing, increases formula viscosity, and promotes foam production, which is benefi-

cial in cosmetic applications [2].

The components were formulated in variable ratios to determine the optimal balance for the desired product characteristics:

- Fixed ratios: BME (5.0%), tea tree essential oil (0.4%), TEA (0.4%), glycerin (3.0%), citric acid (0.1%), sodium benzoate (0.2%), and distilled water (q.s to 100%)

- Gel-forming agent ratios: HEC was tested at 0.5%, 1.0%, and 1.5%, while HPMC was evaluated at 1.0%, 1.5%, and 2.0%.

- Foaming agent ratios: CAPB was tested at 3.0%, 4.0%, and 5.0%.

The formulas for examining the proportions of excipients are presented in Table 1 and Table 2.

Evaluation criteria: Formulations were assessed on sensory attributes, stability, pH, foaming ability and foam stability, and viscosity.

Sensory attributes: Formulations were evaluated for desirable properties, including viscosity, clarity, absence of phase separation, minimal air bubbles, and mild fragrance. Scoring was binary: Pass (+) or Fail (–) [12].

Stability: Stability testing was conducted by placing 10 ml of the formulation in a falcon tube, followed by centrifugation at 4000 rpm. A stable formulation, recorded as stable (+) or phase separation (–), showed no phase separation [2].

pH: pH was measured to ensure skin compatibility, with an ideal range of 5–6. Scoring was binary: Pass (+) for pH within 5–6 or Fail (–) for values outside this range [12].

Foaming ability and stability: 1.0 ml of shower gel was placed in a 250 ml measuring cylinder, diluted with 50 ml distilled water, sealed with paraffin film, and shaken vigorously 10 times [8]. The total foam volume and foam quality were recorded immediately after shaking. Foam stability was assessed by recording the foam column volume after four minutes. Foam stability was calculated using the Formula (1).

$$V(\%) = V1/V0 \times 100 \quad (1)$$

V0 is the foam volume at 0 minutes (ml).

V1 is the foam volume at 4 minutes (ml).

The foam produced should be fine, and foam stability should be over 90%.

Foaming ability was assessed at three levels, including very little foam (+), moderate foam (++), and a lot of foam (+++).

Viscosity: Viscosity was determined by using a Portable RM100 viscometer. The required viscosity is between 2400–3000 cP [8].

Evaluation of product quality indicators

Conduct repeat modulation three times the best formula. After that, evaluate product quality criteria, including sensory attributes, stability, pH, foaming ability and stability, viscosity, microbial contamination limits, heavy metal limits, and skin irritation on rabbits according to the standards applicable to cosmetics prescribed under the guidance of the Ministry of Health on cosmetic management issued on March 16, 2021 [12]. Evaluation of product quality indicators is based on the average results of three different product bathes.

Sensory attributes: The gel should be thick, clear, not separate, have minimal air bubbles, and a mild fragrance. The evaluation was at two levels: Pass (+) or Fail (–) [10].

Stability: 10 ml of shower gel was placed in a Falcon tube and centrifuged at 4000 rpm. The gel must not separate. The evaluation was at two levels: Stable (+) or phase separation (–) [2].

pH: The pH should be suitable for skin, with a pH between 5–6. The evaluation was at two levels: Pass (+) for pH 5–6 or Fail (–) for pH out of the 5–6 range [10].

Foaming ability and stability: The foam produced should be fine, and foam stability should be over 90% [8].

Viscosity: Viscosity measurements were performed with a portable RM100 viscometer, aiming for a viscosity range of 2400–3000 cP to ensure appropriate consistency and usability [8].

Microbial contamination limits: the total aerobic microbial count should be $\leq$ 1000 CFU/g; *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Candida albicans*: should not be present. This was conducted according to the Ministry of Health's guidelines on cosmetic management issued on March 16, 2021 [12].

Heavy metal limits: Mercury $\leq$ 1.0 μg/g; Arsenic $\leq$ 5.0 μg/g; Lead $\leq$ 20.0 μg/g. This was

Table 1: Ratio of the composition of shower gel formulations containing bitter melon extract and tea tree essential oil with HEC from E1–E9

Components	Ratio (% w/w)								
	E1	E2	E3	E4	E5	E6	E7	E8	E9
HEC	0.5	0.5	0.5	1.0	1.0	1.0	1.5	1.5	1.5
CAPB	3.0	4.0	5.0	3.0	4.0	5.0	3.0	4.0	5.0
BME	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Tea tree essential oil	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Glycerin	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
TEA	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Citric acid	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sodium benzoate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Aquadest q.s	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 2: Survey of the composition of shower gel formulations containing bitter melon extract and tea tree essential oil with HPMC from F1–F9

Components	Ratio (% w/w)								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
HPMC	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0
CAPB	3.0	4.0	5.0	3.0	4.0	5.0	3.0	4.0	5.0
BME	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Tea tree essential oil	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Glycerin	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
TEA	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Citric acid	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sodium benzoate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Aquadest q.s	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

conducted according to the Ministry of Health's guidelines on cosmetic management issued on March 16, 2021 [12].

Skin irritation on rabbits: conducted based on Decision No. 3113/1999/QD-BYT dated October 11, 1999, by the Minister of Health [13].

Antibacterial activity: The samples were evaluated for antibacterial activity against two bacterial strains, *Staphylococcus aureus and Escherichia coli*. The antibacterial activity of the shower gel from bitter melon extract and tea tree essential oil was assessed based on the inhibition zone created on the petri dish [14].

IV. RESULTS AND DISCUSSION

A. Formulation of antibacterial shower gel containing bitter melon extract and tea tree essential oil

Preparation of BME

Specialized bitter melon obtained from the extract of juice with moisture and extraction efficiency is presented according to Table 3.

Table 3: Moisture and high extract efficiency from bitter melon

Method	The mass of medicinal herbal powder (g)	High volume of medicinal materials obtained (g)	Efficiency (%) (w/w)	Moisture bitter melon extract (%)
Hot extraction method	300	87.74	31.69	19.22

The hot extraction method gives an extraction yiel of 19.22 for bitter melon, however, it is necessary to control the temperature and time to avoid decomposition of active ingredients that are sensitive to temperature.

Evaluation of gel-forming agent, foaming agent, and extract ratios

The results of the evaluation of the survey indicators, including the composition and concentration of substances in the formulas from E1 to E9, are presented in Table 4.

Table 4: Evaluation of pH, stability, and sensory properties of the compositions from E1–E9

Formula	Sensory	Stability	pH value	Foaming Ability and Stability (cP)	Viscosity (%)
E1					
E2					
E3					
E4					
E5					
E6					
E7	+	-	6.0	+ 88.59 ± 0.56%	2702 ± 0.20%
E8	+	-	5.5	+ 90.11 ± 0.44%	2789 ± 0.15%
E9	+	-	5.5	++ 93.56 ± 0.32%	2890 ± 0.25%

Note: ■ Evaluation of the indicators could not be performed due to the formulation's failure to form a gel

The results presented in Table 4 for the formulas E1 to E9, which use HEC as the gelling agent, indicate that none of the formulations meet the required criteria. HEC is typically employed as a thickening agent in formulations and is considered safe for health. The study evaluated HEC at concentrations ranging from 0.5% to 1.5%, revealing that the viscosity of the formulation depends on the concentration of the thickening agent and the pH of the formulation. In the study of Bui Chi Cong et al. [8], HEC was used as a gelling agent at a ratio of 1.5% to create a complete gel. However, in this study, none of the HEC-based formulations were successful, and the resulting formulas did not meet the evaluation criteria.

The results of the evaluation of the components and their concentrations in the formulas from F1 to F9 are presented in Table 5.

Table 5: Evaluation of pH, stability, and sensory properties of the compositions from F1–F9

Formula	Sensory	Stability	pH value	Foaming Ability and Stability (cP)	Viscosity (%)
F1	+	-	6.12 ± 0.02	+ 86.47 ± 0.2	2130 ± 0.21%
F2	+	-	5.53 ± 0.02	+ 89.15 ± 0.15	2016 ± 0.32%
F3	+	-	5.54 ± 0.03	++ 91.54 ± 0.11	2237 ± 0.28%
F4	+	-	5.51 ± 0.04	+ 87.56 ± 0.12	2401 ± 0.40%
F5	+	+	5.59 ± 0.02	+++ 96.15 ± 0.45	2519 ± 0.30%
F6	+	+	5.46 ± 0.01	+++ 92.20 ± 0.54	2590 ± 0.26%
F7	+	-	5.7 ± 0.03	+ 88.59 ± 0.56	2702 ± 0.50%
F8	+	-	5.59 ± 0.04	+ 90.11 ± 0.13	2789 ± 0.27%
F9					

Note: ■ Evaluation of the indicators could not be performed due to the formulation's failure to form a gel

The results of the evaluation with HPMC as the thickening agent, presented in Table 5 for formulas F1 to F9, show that all formulations meet the sensory and pH criteria. However, regarding stability, only formulas F5 and F6 achieved phase stability without separation. Both formulas F5 and F6 also exhibited good foam stability and viscosity within the required range. Formula F5 produced more foam compared to Formula F6. Therefore, Formula F5 was selected as the most suitable formulation.

Furthermore, the foaming agent is a crucial component of a skin cleansing product. In this study, CAPB was chosen to develop the shower gel due to its advantages, including being a zwitterionic surfactant derived from fatty acids (coconut oil). Compared to sodium lauryl sulfate, CAPB is considered to have a lower potential for skin irritation [8]. Increasing the concentration of CAPB in the formula enhances foaming but may also increase the pH, which could affect the gel's consistency. The final shower gel formula containing 4.0% CAPB demonstrated good foaming

ability with fine and stable foam. An additional 0.1% citric acid (0.01 M) was used to stabilize the gel's pH. Additionally, a combination of bitter melon (*Momordica charantia* L.) fruit extract and tea tree essential oil, at 5.0% and 0.4%, respectively, created a complete shower gel with a brownish-yellow color and a pleasant tea tree essential oil scent that masks the bitter aroma of the bitter melon fruit

B. Evaluation of product quality indicators

The average test results of three batches are presented in Table 6.

Table 6: Evaluation results of the quality indicators for the shower gel product containing BME and tea tree essential oil

No.	Criteria	Requirements	Results
1	Sensory Evaluation	The gel is thick, clear, and not separated, with few air bubbles, with a light fragrance	Passed
2	Stability	The gel does not separate when centrifuged at 4000 rpm	Passed
3	pH	Suitable for human skin with pH values ranging from 5 to 6	Passed (pH = 5.5)
4	Foaming Ability and Foam Stabilit	Foam should be fine with foam stability above 90%	Passed
5	Viscosity	2400–3000 cP	Passed
6	Microbial limits	Total aerobic microorganisms ≤ 1000 CFU/g; *Pseudomonas aeruginosa, Staphylococcus aureus, Candida albicans*: not allowed	Passed
7	Heavy metal limit	Mercury ≤ 1.0 µg/g; Arsenic ≤ 5.0 µg/g; Lead ≤ 20.0 µg/g	Passed
8	Skin irritation on rabbits	Minimal or no irritation	No irritation
9	Antibacterial activity	Ability to inhibit bacterial growth, demonstrated by the width of the inhibition zone on petri dishes	Passed

The Formula F5, identified as the most suitable, was selected as the optimal formulation, comprising the following components: 5.0% concentrated bitter melon extract, 0.4% tea tree essential oil, 1.5% HPMC, 4.0% CAPB, 3.0% glycerin, 0.4% TEA, 0.1% citric acid, 0.2% sodium benzoate, and distilled water to make up the remainder to 100%. Subsequent analyses were conducted to evaluate various quality parameters of the product. The findings demonstrated that the shower gel, containing bitter melon extract and tea tree essential oil, conformed to all required cosmetic standards. The product exhibits a mild and distinctive fragrance derived from tea tree essential oil and bitter melon extract.

Fig. 1: Shower gel product formulated from bitter melon extract and tea tree essential oil

V. CONCLUSION

Experiments are conducted to ascertain the proportion of foaming agents, geling agents, and a high percentage of bitter melon and tea tree essential oil from which to build a satisfactory shower gel to get the most appropriate shower gel formula.

A foaming agent is an important ingredient for a skin cleansing product. In this study, Capb was selected to conduct a formula for bathing. Compared to sodium lauryl sulfate, CAPB is said to be less likely to cause skin irritation [15]. The increase in the CAPB in the formula will increase the foaming but at the same time increase the pH which can affect the comparison of the gel. The complete formula of 4% CAPB shower gel shows the ability to create foam quite well, smooth foam, durability, and a suitable pH without irritating the skin of the user. In addition, the HPMC thick substance is surveyed at many different ratios of 1%, 1.5% and 2% to create formulas with comparison and pH change. With this study, the rate of using HPMC 1.5% in shower gel achieved a sense of comparison and appropriate pH.

The change in the combination ratio of extract from the bitter melon extract (*Momordica Charantia* L.) with tea tree essential oil at different concentrations also forms a gel with dark yellow to dark brown. At the same time, if the concentration of tea tree essential oil is increased from 0.2% to 0.4%, the typical smell of bitter melon in the shower gel will reduce, and instead, the pleasant aroma of tea tree essential oil will be present. Besides, thanks to the good antibacterial ability of bitter melon and tea tree essential oil, the shower gel containing bitter melon extract and tea tree essential oil is well resistant to two strains of bacteria permanently residing on human skin, *S. aureus* and *E. coli*.

In short, the study successfully developed a shower gel formulation incorporating bitter melon extract and tea tree essential oil. The resulting product is a transparent, brownish-yellow gel with a mild fragrance characteristic of tea tree essential oil and a balanced pH, making it suitable for topical application. The product met all evaluated criteria, including sensory properties, pH balance, foaming ability, viscosity, antibacterial efficacy, heavy metal limits, and microbial limits. Additionally, it showed no signs of irritation in rabbit skin tests.

The evaluation criteria for the shower gel formulation were conducted in accordance with the guidelines issued by the Ministry of Health on Cosmetic Management, dated March 16, 2021.

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