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Formulation and evaluation of virgin coconut oil (VCO) lotion: Effect of variation in emulsifier type and concentration

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KEYWORDS

Cream lotion
Emulsifier concentration
Span 80
Tween 80
Virgin coconut oil

ABSTRACT

Indonesia is a tropical country rich in agricultural commodities, such as coconut. One of the derived products from coconut is virgin coconut oil (VCO), which widely used as ingredient in cosmetic lotion products. This study aimed to evaluate the effects of variations in the addition of emulsifiers to VCO cream lotion. Two emulsifiers were used, including Tween 80 and Span 80 with concentrations of 5% without essential oil, 5%, 4%, 3%, and 2%. Quality parameters analyzed were homogeneity, specific gravity, stability, pH, and organoleptic. The data were statistically analyzed using the Kruskall-Wallis test. The results showed that Tween 80 and Span 80 emulsifiers significantly affected physicochemical and organoleptic characteristics, except pH value. The selected best formulation was cream lotion with the addition of 2% emulsifier formulation. This VCO lotion had a quality value according to SNI 16-4399-1996 and had organoleptic characteristics most preferred by the panelists.

Introduction

Coconut (*Cocos nucifera*) is one of Indonesia's most widely grown plantation crops, with high economic value (Alouw and Wulandari, 2020; Hebbar et al., 2022. Based on Indonesian Plantation Statistics, coconut production in 2020 reached 2.8 million tons across approximately 3.3 million hectares of land (Directorate General of Plantations, 2021). One of the main products obtained from coconut flesh is Virgin Coconut Oil (VCO) (Sundrasegaran and Mah, 2020; Darmawan et al., 2022). It comprises of more than 90% of saturated fatty acids in its composition (i.e., lauric acid, myristic acid, caprylic acid, palmitic acid, capric acid, and stearic acid) (Ng et al., 2021; Mohammed et al., 2021; Divya et al., 2023). VCO also contains unsaturated fatty acids, namely oleic and linoleic acid (Mohammed et al., 2021; Sabahannur and Alimuddin, 2022). These fatty acids, especially lauric acid, are crucial as humectant agents in maintaining human's skin moisture (Pereira et al., 2022; Poljšak et al., 2022; Ainurofiq et al., 2023). VCO can be used to moisturize wrinkled, rough skin, aid in removing dead skin cells, and enhance skin elasticity and strength (Tumbelaka et al., 2019).

Derivative products of VCO hold high added value, one of which is used as the primary cosmetic compound in lotion making (Anggraini and Ritonga, 2020; Rulhisham and Razak 2021; Jose et al., 2022). Cream lotion is a semi-solid emulsion used as an emollient or skin protector (Mawazi et al., 2022). It must meet specific requirements, including being easy to clean, non-rancid, non-irritating, free of sharp and hard particulates, easily spreadable on the skin, and homogenous (Ministry of Health of the Republic of Indonesia, 1979). Cosmetics encompass materials or preparations used topically or orally (on teeth and/or the mucous membrane of the mouth), serving as cleansers, fragrances, enhancers of appearance, improvers of body odor, and body protectors to promote a better overall condition (Almukainzi et al., 2022; Dey and Dubey, 2023).

According to research by Amaliyah et al. (2020), the production of VCO using the mixer method produces the highest yield, with the addition of a VCO:water ratio of 3:1.71 resulting in lotion quality that meets the Indonesian National Standard (SNI 16-4399-1996) and hedonic organoleptic criteria for texture, color, fragrance, and spreadability as assessed by panelists.

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Adejokun and Dodou (2020) used VCO as one of the ingredients in making oil-in-water cream lotions. Their study reported that the resulting creams had a good shelf-life when stored at 25 ºC, with no changes in color or odor. Mahbub et al. (2022) found that VCO from *Kopyor* coconut has the potential for making cream lotions. The addition of 5% concentration produced lotion with a pleasant physical appearances and sensory atributes. Azmi et al. (2020) demonstrated that adding VCO into *Ficus deltoidea* extract did not show irritation or was toxic to normal skin. They reported that the formulation could be used to treat skin damage caused by Ultraviolet B (UVB), yet in-depth investigation is critical. Hashim et al. (2023) claimed that combining VCO with neem extract could produce lotions with good moisture and stability, as indicated by no layer appearance, color changes, or granules formulation. However, this research suggests a need for evaluation regarding fragrance, which still retains a strong coconut scent. Therefore, it is recommended to incorporate essential oils that provide a lasting and pleasant aroma.

In making skincare creams or lotions, emulsifiers are often added to enhance the emulsion process, thus improving it stability and physochemical characteristics (Alam et al., 2020; Anggraini and Ritonga, 2020; Setyaningsih and Aminingsih, 2021; Huynh et al., 2021; Palefsky, 2022;). Two widely used emulsifiers are Tween 80 (a hydrophilic emulsifier) and Span 80 (a lipophilic emulsifier) (Faghmous et al., 2021; Zhang et al., 2022; Yousefi et al., 2023). Tween 80 is an emulsifier derived from polyethoxylated sorbitol anhydride and oleic acid, with high efficacy in reducing interfacial tension and producing a more stable emulsion (Zhang et al., 2020). Tween 80 is a food-grade emulsifier that is cheap, non-toxic, easy to find, and affordable; therefore, it is widely used in food or non-food applications (Bu et al., 2020; Kumar et al., 2022). Span 80 is also known as sorbitan mono oleate (SMO, widely applied as an emulsion binder (Sahasrabudhe et al., 2021). It is a biodegradable surfactant-based emulsifier, easy to handle, and can be used as water-in-oil emulsifier (Anarakdim et al., 2020; Faghmous et al., 2021). Therefore, Span 80 is also suitable for various applications, such as cosmetics, textiles, etc.

This emulsifier acts as stabilizer for the oil and water phase during lotion production, necessitating careful attention to increase the concentration to prevent them from mixing into smaller particles (Venkataramani et al., 2020). The production of lotion is simple and influenced by several factors such as temperature, emulsifier type and concentration, active ingredients added, etc. (Widiputri et al., 2020; Putri and Sailah, 2022) . This research aimed to evaluate the effects of emulsifier type and concentration on the quality and sensory attributes of VCO lotion and to compare the results with SNI 16-4399-1996..

Research and methods

Materials

Materials used in this research include aquadest, benzoic acid, cetyl alcohol, glyceryl monostearate, lavender essential oil, sodium metabisulfite, span 80, stearic acid, triethanolamine, tween 80, and VCO.

Procedure of VCO lotion production

The steps in making VCO lotion are presented in Figure 1, modified from previous study (Tumbelaka dkk., 2019). The formulation used to make VCO lotion is shown in Table 1. The lavender essential oil was added to create a pleasant sensory sensation in the lotions.

Parameters analysis

The quality parameters of VCO lotion were analyzed, including homogeneity, specific gravity, stability, pH determination, and organoleptic tests.

Homogeneity test

According to the Ministry of Health of the Republic of Indonesia (1979), the homogeneity examination of preparations involves rubbing the mentioned preparation onto an object glass to demonstrate its homogeneous composition and resulting granules.

Stability test

According to the Ministry of Health of the Republic of Indonesia (1979), the stability of a pharmaceutical preparation is assessed based on the presence of color, taste, odor changes, and emulsion separation during storage. Stability testing involved storing the lotion in an enclosed container and observing it for eight weeks for any signs of emulsion separation, phase separation, color, and odor changes.

pH test

According to the Ministry of Health of the Republic of Indonesia (1979), pH determination of preparations is conducted using pH indicator strips. The pH of lotion preparation conforming to the SNI 16-4399-1966 is expected to fall within the range of 4.5-8.0. Changes in the color of the pH strips awere monitored over eight weeks.

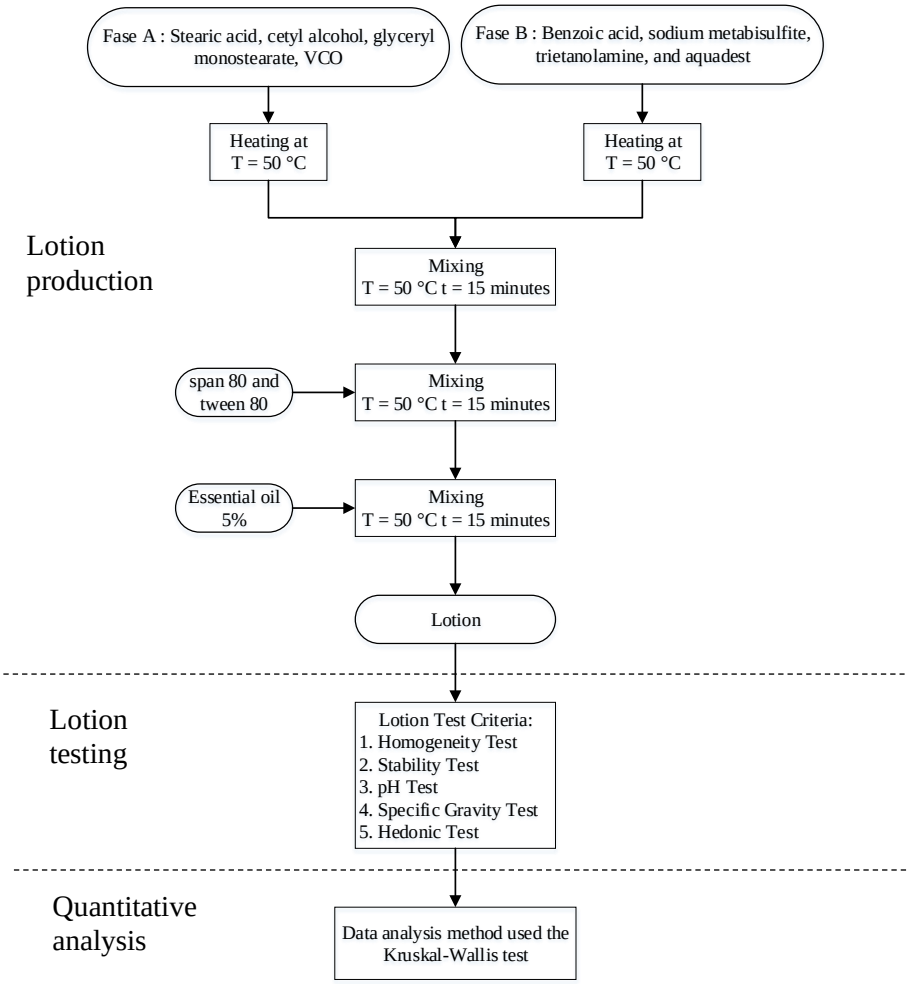

Figure 1. VCO lotion production

Table 1. Formulation in the VCO lotions

Ingredients	Formulation (Concentration in %)				
	A	**B**	**C**	**D**	**E**
Glyceryl Monostearate	4				
Stearic Acid	4				
Cetyl Alkohol	2				
Virgin Coconut Oil (VCO)	60				
Trietanolamine (TEA)	1				
Span 80	0.5	0.5	0.4	0.3	0.2
Tween 80	4.5	4.5	3.6	2.7	1.8
Sodium Metabisulfite	0.2				
Benzoic Acid	0.4				
Lavender Essential Oil	0	5	5	5	5
Aquadest a.d	100	100	100	100	100

Specific gravity test

According to the National Standardization Agency (1998), specific gravity or density is a parameter associated with free volume, diffusivity, and permeability of solution. Specific gravity of the lotion sample was measured using a pycnometer, following these steps:

1. Weigh an empty, clean, and dry pycnometer with the cap on and record the weight.
2. Fill the pycnometer with the liquid whose specific gravity is to be measured, ensuring it is completely filled and free of air bubbles.
3. Close the pycnometer and clean if any liquid has leaked out.
4. Weigh the enclosed pycnometer and record the weight.
5. Calculate the result using the following equation.

$$Lotion\ specific\ gravity\ (\%) = \frac{\frac{m_1 - m_2}{V}}{water\ specific\ gravity} \quad \text{.....(1)}$$

Description:
m_1 : mass of pynometer with lotion
m_2 : mass of empty pycnometer
V : pynometer volume
Water specific gravity : 0,996 g cm^{-3}

Organoleptic Characteristics

The hedonic organoleptics test parameters consisted of texture, fragrance, color, and spreadability, rated on a scale from 1 (strongly disliked) to 7 (strongly liked). The respondents used in this study were 15 untrained panelists, and they were required to provide their preference over VCO lotion and commercial lotion (brand 'X').

Statistical data analysis

The statistical data analysis used was the *Kruskal-Wallis* test, followed by the *Mann-Whitney* test, performed using IBM SPSS Statistics software. The results of the organoleptic test were tested using *Duncan's Multiple Range* test with a significance of 5%, as follows:

Normality Assumption
H_0 : Data is normally distributed
H_1 : Data is nor normally distributed
α : 5%

If the significance value < α (=5%), then H_0 is rejected and H_1 is accepted. If the significance value > α (=5%), then H_1 is rejected and H_0 is accepted.

Results and Discussion

Homogeneity

The homogeneity test results provided in Table 2 indicate that all lotion formulations (A, B, C, D, and E) exhibited no granules and showed no significant differences in effect. It can be concluded that all lotion preparations were homogeneous. This suggests that the temperature and mixing time of the formulation (50 ℃ for 15 minutes) were ideal. Lotion formulations primarily consisted of oil and water phases, stabilized with emulsifiers such as Tween 80, which is soluble in water, and Span 80, which is soluble in oil. These differences stem from the Hydrophilic-Lipophilic Balance (HLB) value of each solution. Tween 80 has an HLB value of 15, whereas Span 80 has an HLB value of 4.5 (Putri et al., 2018).

Furthermore, Rosly et al. (2020) stated that the addition of Tween 80 and Span 80 mixture could formed a stable emulsion (i.e., no breaking or swelling) with HLB value of 5.3. According to Liu et al. (2020), emulsifiers with HLB values ranging from 3.4 – 8.0 show good formation and stabilization in emulsion process. However, their study also found that increased HLB values to ~14 could improve the droplet curvature and facilitate more emulsion stability. This variation in HLB values of the emulsifiers ensures homogeneity between the two phases, resulting in the absence of granules or phase separation. The findings confirmed that HLB values are related to emulsion stability. Such phenomena were reported due to a decreased particle size and increased zeta potential value (Liu et al., 2020). Furthermore, other factors affecting the HLB values and emulsion stability are particle size distribution, pH values, polydispersity index (PDI), interfacial tension, and interfacial behavior (Alam et al., 2020; Park and Kim, 2021; Wang et al., 2023; Yan et al., 2023).

Specific gravity

.The specific gravity test results as shown in Table 3 indicated that all formulations met the SNI 16-4399-1996, with values ranging from 0.95 to 1.05. The data was processed with Shapiro-Wilk test of normality using IBM SPSS Statistics software. The test revealed that formulations A, B, D, and E had significance values of ($p > 0.05$), indicating normal distribution. Meanwhile, the formulation of C showed a significance value of ($p < 0,.05$), indicating a non-normal distribution. Levene's test for homogeneity also yielded a significance value of $p < 0.05$, indicating non-homogeneity. Since the initial statistical analysis revealed non-normally distributed and non-homogenous data, transformations in the form of changing values into log, sqrt, and ln were applied, but did not alter the normality and the data homogeneity. Hence, one-way *ANOVA* analysis was not feasible, and the *Kruskal-Wallis* test was conducted as an alternative non-parametric test.

A significance value of $p = 0.000$ ($p < 0.05$) was obtained from the *Kruskal-Wallis* test, indicating significant differences between specific gravities. A follow-up test of *Mann-Whitney* was conducted to identify differences between treatments. The *Mann-Whitney post hoc* test results indicated that formulation A had the highest average specific gravity value at 1.0403838, while formulation E had the lowest value at 1.0254351. Formulation A significantly differed from other formulations, suggesting its potential as a lotion-making alternative.

Table 2. The results of VCO lotion homogeneity

Key	Formulation	Homogeneity	Specific Gravity
1.	A	No particles detected	$1.0404^{a} \pm 0.0057$
2.	B	No particles detected	$1.0315^{b} \pm 0.0061$
3.	C	No particles detected	$1.0281^{bc} \pm 0.0105$
4.	D	No particles detected	$1.0272^{bc} \pm 0.0020$
5.	E	No particles detected	$1.0254^{c} \pm 0,0047$

Note: The same letter indicates a value that is not significantly different at 5%

Table 3. The results of specific gravity VCO lotion in *Kruskall-Wallis* and *Mann-Whitney*

Kruskall-Wallis

The Difference Between Concentrations		*p-value*	Significance
A	B	0.004	Significant
	C	0.003	Significant
	D	0.000	Significant
	E	0.000	Significant
B	C	0.622	Not Significant
	D	0.117	Not Significant
	E	0.023	Significant
C	D	0.348	Not Significant
	E	0.350	Not Significant
D	E	0.362	Not Significant

Mann-Whitney

Formulation	Mean		
	A	**B**	**C**
A	1.0303838		
B		1.0314592	
C		1.0281124	1.0281124
D		1.0272200	1.0272200
E			1.0254351

According to Devi et al. (2019), adding Tween 80 and Span 80 affects lotion consistency—the higher the concentration, the stronger the bonds between the water and oil phases. In this research, a 5% emulsifier concentration produced VCO lotion with a thicker consistency than lower emulsifier concentrations (4%, 3% and 2%), which produced less thick lotions but remained within the standard limit. Rahmandari et al. (2021) reported that specific gravity is related to the thickness or viscosity of lotion. Therefore, the addition of emulsifiers had impact on improving this value, where increasing the emulsifier concentration parallels to an increase in specific gravity. Similarly, Buzzo et al. (2021) reported that emulsifier type and concentration affect the sunscreen emulsion's physicochemical properties and stability, as shown by the specific gravity and viscosity values. Putri and Sailah (2022) stated that ingredients added to the lotion mixture impact the specific gravity values. Add carbohydrate-based materials (i.e., salt and sugar) can increase the specific gravity value, in contrast to fat-and ethanol-based materials. In this study, some of those ingredients were added, impacting the characteristics of the VCO lotion.

Stability

Based on the stability test results presented in Table 4, each formulation exhibited no changes in color, fragrance, and consistency during eight-week storage period. This indicated that the formula remained stable and the final products were not impaired. Descriptive statistical analysis revealed that if there were no changes in color, fragrance, and consistency, the corresponding value would be zero (0). All five formulations yielded similar results, indicating no significant differences in their effects.

Several factors affected emulsion stability on lotions, i.e., mechanical, temperature, and procedural factors. Each lotion preparation remained stable due to the same ingredients, optimal mixing temperature, and appropriate mixing duration (Ersalina et al., 2020; Putri and Sailah, 2022). Instability in emulsion preparations occurs when creaming, flocculation, or coalescence is present. Creaming involves the formation of globules due to different specific gravities between two unstable phases. Flocculation happens when formed droplets congregate into a larger particle but dispersed completely upon agitation. Coalescence refers to the merging of two

different phases of emulsion into a single globule (Wang et al., 2021; Low et al., 2020).

The results of these stability tests were also affected by the formulation of added emulsifiers. The color of the lotions remained unchanged, as the formulation did not contain any color-altering ingredients, even though essential oils were present. The essential oils used in this research were stored in dark glass bottles at the appropriate temperature to maintain their properties. The difference in fragrance produced between each formulation was insignificant, as the concentration of added Span 80 did not deviate significantly from others. Higher concentrations of Span 80 resulted in lighter fragrances as it would bind and mix with the essential oils smoothly. A similar concept applies to homogeneity, wherein lotion stability was caused by differences in the HLB values of Span 80 and Tween 80. The test result indicated stable consistency because no phase alterations or separations occurred.

pH

Table 4 shows that all pH values of the preparations met the SNI 16-4399-1996and remained stable for eight consecutive weeks. This result was achieved by using stable and safe ingredients in the preparations. Descriptive statistic results showed no significant differences between the effects of each lotion preparation.

The pH value of the VCO lotion was determined to be 6, which remained stable for eight weeks, aligning with the SNI 16-4399-1996. The use of safe and stable ingredients ensured this stability . However, emulsifiers may influence pH values, as reactions between acidic essential oils and non-ionic emulsifiers can occur. The value of pH was also affected by environmental conditions. A higher or lower pH value can spoil the product during storage, whereas a pH value lower than 4.5 may lead to skin irritation and a pH higher than 8.0 can result in dry and scaly skin (Chen et al., 2016; Putri and Sailah, 2022; Syafitri et al., 2023). This is because the ideal pH value according to SNI 16-4399-1996 is ranging from 4.5 - 8; therefore, any lotion product must meet this requirement. Furthermore, the results indicated that formulation, emulsifiers type and concentration have no significant impact on pH values. Similarly, Wulandari dkk. (2022) claimed that the addition of Tween 80 and Span 80 (at concentrations of 1, 3, and 5%) had no impact on pH, viscosity, adhesiveness, and dispersion of basil leaves extract cream. Also, Rulhisham and Razak (2021) found that addition of emulsifier at concentration ranging from 1-5% had the same effect on the pH of VCO cream. However, Syafitri et al. (2023) reported that adding Tween 80 and PEG 400 mixture significantly affected the pH of rice bran oil emulsion as skin antioxidant. Furthermore, Putri and Sailah (2022) reported that the addition of active ingredients influences the pH of lotions. This is because pH is one of the critical parameters on the adsorption capacity of lotion into the skin. Furthermore, Chen et al. (2016) added that the pH of normal skin ranges from 5.0-6.0. Therefore, the VCO lotions from this study are well within the requirement for normal skin. As Lukić et al. (2021) stated, skin pH is critical to be used as foundation to develop and produce ‘skin health maintenance’ cosmetic products, such as creams and lotions.

Table 4. The results of VCO lotion stability

Key	Formulation	Week of-	Stability			pH
			Colors	Fragrance	Consistency	
1	A	1	-	-	-	6
		3	-	-	-	6
		5	-	-	-	6
		8	-	-	-	6
2	B	1	-	-	-	6
		3	-	-	-	6
		5	-	-	-	6
		8	-	-	-	6
3	C	1	-	-	-	6
		3	-	-	-	6
		5	-	-	-	6
		8	-	-	-	6
4	D	1	-	-	-	6
		3	-	-	-	6
		5	-	-	-	6
		8	-	-	-	6
5	E	1	-	-	-	6
		3	-	-	-	6
		5	-	-	-	6
		8	-	-	-	6

Table 5. The results of VCO lotion organoleptics

Key	Formulation	Texture	Color	Fragrant	Spreadability
1.	A	3.93^{d}	5.73^{b}	2.07^{d}	3.27^{e}
2.	B	5.67^{a}	5.53^{bc}	5.8^{ab}	5.27^{cd}
3.	C	5.6^{bc}	5.67^{b}	5.73^{b}	5.07^{c}
4.	D	5.4^{c}	5.53^{bc}	5.6^{c}	5.3^{bc}
5.	E	5.53^{c}	5.67^{b}	5.7^{b}	5.6^{b}
6.	Commercial	6.13^{a}	6.7^{ab}	6.4^{a}	5.8^{ab}

Note: The same letter indicates a value that is not significantly different at 5%

Organoleptic characteristics

Table 5 shows that the commercial lotion had the most favored texture among the panelists. Lotion B closely resembled the texture of the commercial lotion compared to other formulations. This result indicated that the commercial lotion and lotion B were preferred due to its softer and silkier texture. While lotion A was scored neutral because of its heavier texture. The panelists associated this heavier texture with longer absorbance time and a perceived oiliness.

The color parameter testing results in Table 5 indicated that commercial lotion was preferred due to its warm and trendy lilac color compared to other white-colored lotion formulations. Despite this, some panelists considered that color did not affect the lotions' benefit and perceived minimal differences among the other formulations' colors.

In terms of fragrance, Table 5 shows that the commercial lotion emerged as the preferred choice, with lotion B exhibited a similar scent profile. Both were favored for their more pungent fragrance, believed by panelists to last longer. Conversely, lotion A was the least preferred due to the absence of scent since no essential oil was added.

The spreadability testing results in Table 5 revealed that the commercial lotion was the most preferred spreadability by the panelists, with lotion E closely resembling its properties compared to other formulations. These results indicated that the commercial lotion and lotion E were favored for their higher spreadability, resulting in a lighter, less greasy feel. In contrast, lotion A was the least preferred due to its lower spreadability, resulting in a thicker feel. The panelists believed that lotions with lower spreadability lead to slower absorption into the skin.

In general, the results indicated that variations in the added emulsifier in the production of the VCO lotion led to differences in texture, color, fragrance, and spreadability. The panelists favored the lavender-scented commercial lotion, with Formulation E being the closest to the commercial one. This Formulation E contained an added concentration of 2% emulsifier and 5% essential oils.

Furthermore, this study's findings confirmed that different types and concentrations of emulsifers imrpoved the organoleptic characteristics of VCO lotion and have good panelists' preferences. Similarly, Putri and Sailah (2022) reported a good level of customer preference (i.e., customer satisfaction index of 69%) for suncreen skin lotion with addition of green tea (10%), chitosan (10%), and lemon (10%). Rahmandari et al. (2021) also reported that adding gelatin at a concentration of 5-9% with the beeswax, olive oil, and vaselin enhances the organoleptic characteristics of body cream. Syafitri et al. (2023) stated that combining Tween 80 and PEG400 to make nano-emulsion for skin antioxidant could enhance the organoleptic characteristics. Yin et al. (2024) found that the addition of α-mangostin or kojic acid (KA) on the nano-emulsion of skincare product increases the preference score for aroma, thickness, and spreadability. Their study found that the resulting skincare cream was comparable with a commercial cream, hence it is potential for further application in the cosmetics industry.

Conclusions

The panelists'most preferred formulation of the VCO lotion, which adhered to the SNI was the one with a concentration of 2% emulsifier. This lotion exhibited homogeneity, stable color, fragrance, and consistency for eight consecutive weeks with a specific gravity of 1.0254 and a stable pH value of 6 for eight weeks. The organoleptic characteristics of this lotion were closely resembled those of the commercial lotion. The difference of this lotion formulation compared to others was the concentrations of Tween 80 and Span 80 emulsifiers. These two emulsifiers contributed different characteristics that ensured lotion's stability and prevented phase separation.

Declarations

Conflict of interests The authors declare no competing interests.

References

Adejokun, D. A., and Dodou, K. (2020) 'A novel method for the evaluation of the long-term stability of cream formulations containing natural oils', *Cosmetics*, 7(4), pp. 1-17

Ainurofiq, A., Haya, A. F. F. D., Safitri, A. N., Solihatin, I. Z., Nusriya, S. B., and Nugroho, T.S. (2023) 'Characterization and application of moisturizer in skin treatment: A review', *Journal of Pakistan Association of Dermatologists*, 33(4), pp. 1602-1613

Alam, S., Algahtani, M.S., Ahmad, M.Z. and Ahmad, J. (2020) 'Investigation utilizing the HLB concept for the development of moisturizing cream and lotion: In-vitro characterization and stability evaluation', *Cosmetics*, *7*(2), pp. 1-12

Almukainzi, M., Alotaibi, L., Abdulwahab, A., Albukhary, N., and El Mahdy, A. M. (2022) 'Quality and safety investigation of commonly used topical cosmetic preparations', *Scientific reports*, 12(1), pp. 1-11

Alouw, J. C., and Wulandari, S. (2020) 'Present status and outlook of coconut development in Indonesia', *IOP Conference Series: Earth and Environmental Science*, pp. 1-10

Amaliyah, P. R., Tensiska, T., and Mardawati, E. (2020) 'Pengaruh Beberapa metode isolasi terhadap rendemen dan karakteristik virgin coconut oil (VCO) serta aplikasinya pada lotion (The influence of several isolation methods on the yield and characteristics of virgin coconut oil (VCO) and its application in lotions)', *Jurnal Teknologi Pertanian*, 21(3), pp. 203–210 [In Indonesian]

Anarakdim, K., Gutiérrez, G., Cambiella, Á., Senhadji-Kebiche, O., and Matos, M. (2020) 'The effect of emulsifiers on the emulsion stability and extraction efficiency of Cr (VI) using emulsion liquid membranes (ELMs) formulated with a green solvent', *Membranes*, 10(4), pp. 1-13

Anggraini, T., and Ritonga, N. B. (2020) 'Making skin lotion from virgin coconut oil with adding several natural plants extract as a skin protector', *IOP Conference Series: Earth and Environmental Science*, pp. 1-6

Azmi, N. A. N., Hasham, R., Ariffin, F. D., Elgharbawy, A. A. and Salleh, H. M. (2020) 'Characterization, stability assessment, antioxidant evaluation and cell proliferation activity of virgin coconut oil-based nanostructured lipid carrier loaded with *Ficus deltoidea* extract', *Cosmetics*, 7(4), pp. 1-15

Bu, X., Wang, X., Dai, L., Ji, N., Xiong, L., and Sun, Q. (2020) 'The combination of starch nanoparticles and Tween 80 results in enhanced emulsion stability', *International Journal of Biological Macromolecules*, 163, pp. 2048-2059

Buzzo, C. M. V. C., Converti, A., Silva, J. A., and Apolinário, A. C. (2021) 'Quality by design enabled the development of stable and effective oil-in-water emulsions at compounding pharmacy: The case of a sunscreen formulation', *Pharmaceutical Development and Technology*, 26(10), pp. 1090-1101

Chen, M. X., Alexander, K. S., and Baki, G. (2016) 'Formulation and evaluation of antibacterial creams and gels containing metal ions for topical application', *Journal of Pharmaceutical Sciences*, 2016, pp. 1–10

Chen, Z., Li, Y., Chen, C., Sun, X., and Liu, W. (2021) 'Aggregation behavior of asphalt on the natural gas hydrate surface with different surfactant coverages', *The Journal of Physical Chemistry C*, 125(30), pp.16378-16390

Darmawan, M. A., Siregar, K., and Gozan, M. (2022) 'Coconut oil', *Biorefinery of Oil Producing Plants for Value-Added Products*, 1, pp. 99-122

Devi, I. G. A. S. K., Mulyani, S., and Suhendra, L. (2019) 'Pengaruh nilai hydrophile-liphophile balance (HLB) dan jenis ekstrak terhadap karakteristik krim kunyit-lidah buaya (*Curcuma domestica* val.-*Aloe vera*) (The influence of the hydrophile-liphophile balance (HLB) value and the type of extract on the characteristics of turmeric-aloe vera cream (Curcuma domestica val.-Aloe vera))', *Jurnal Ilmiah Teknologi Pertanian Agrotechno*, 4(2), pp. 54-61 [In Indonesian]

Dey, A., and Dubey, S. K. (2023) 'Cosmetics science and skin care: History and concepts' in Draelos, Z. D (eds.) *Nanocosmetics*. Florida: CRC Press, pp. 1-15

Directorate General of Plantations. (2021) *Statistik Perkebunan Unggulan Nasional 2019-2021 (National Leading Plantation Statistics 2019-2021)* [Online]. Available at: https://ditjenbun.pertanian.go.id/template/uploads/2021/04/BUKU-STATISTIK-PERKEBUNAN-2019-2021-OK.pdf (Accesed: 20 April 2022) [In Indonesian]

Divya, P. M., Roopa, B. S., Manusha, C., and Balannara, P. (2023) 'A concise review on oil extraction methods, nutritional and therapeutic role of coconut products', *Journal of Food Science and Technology*, 60(2), pp. 441-452

Ersalina, E. B., Abdillah, A. A., and Sulmartiwi, L. (2020) 'Potential of *Caulerpa racemosa*

extracts as sunscreen creams', *IOP Conference Series: Earth and Environmental Science*, pp. 1-7

Faghmous, N., Bouzid, D., Boumaza, M., Touati, A. and Boyron, O. (2021) 'Optimization of chitosan-coated W/O/W multiple emulsion stabilized with Span 80 and Tween 80 using Box–Behnken design', *Journal of Dispersion Science and Technology*, 42(10), pp. 1566-1578

Hashim, N., Abdullah, S., Hassan, L.S., Abdullah, N., and Abdullah, A. H. (2023) 'Development and stability enhancement of neem-based lotion', *Materials Today: Proceedings*, pp. 1-5

Hebbar, K. B., Abhin, P. S., Sanjo Jose, V., Neethu, P., Santhosh, A., Shil, S., and Prasad, P. V. (2022) 'Predicting the potential suitable climate for coconut (*Cocos nucifera* L.) cultivation in India under climate change scenarios using the MaxEnt model', *Plants*, 11(6), pp. 1-23

Huynh, A., Garcia, A. G., Young, L. K., Szoboszlai, M., Liberatore, M. W., and Baki, G. (2021) 'Measurements meet perceptions: Rheology–texture–sensory relations when using green, bio-derived emollients in cosmetic emulsions', *International Journal of Cosmetic Science*, 43(1), pp. 11-19

Jose, D., Muenmuang, C., Kitiborwornkul, N., Yasurin, P., Asavasanti, S., Tantayotai, P., and Sriariyanun, M. (2022) 'Effect of surfactants and Co-surfactants in formulation of noni fruit extract in virgin coconut oil-based emulsion', *Journal of the Indian Chemical Society*, 99(10), pp. 1-7

Kumar, A., Kanwar, R., and Mehta, S. K. (2022) 'Development of Phosphatidylcholine/Tween 80 based biocompatible clove oil-in-water nanoemulsion as a green nanocarrier for controlled herbicide delivery', *Environmental Pollution*, 293, pp. 1-14

Liu, Y., Wei, Z. C., Deng, Y. Y., Dong, H., Zhang, Y., Tang, X. J., Li, P., Liu, G., and Zhang, M. W. (2020) 'Comparison of the effects of different food-grade emulsifiers on the properties and stability of a casein-maltodextrin-soybean oil compound emulsion', *Molecules*, 25(3), pp. 1-17

Low, L. E., Siva, S. P., Ho, Y. K., Chan, E. S., and Tey, B. T. (2020) 'Recent advances of characterization techniques for the formation, physical properties and stability of Pickering emulsion', *Advances in colloid and interface science, 277,* pp. 1-24

Lukic, M., Filipovic, M., Pajic, N., Lunter, D., Bozic, D., and Savic, S. (2021) 'Formulation of topical acidic products and acidification of the skin–Contribution of glycolic acid', *International Journal of Cosmetic Science*, 43(4), pp. 419-431

Mahbub, K., Octaviani, I. D., Astuti, I. Y., Sisunandar, S., and Dhiani, B. A. (2022) 'Oil from kopyor coconut (*Cocos nucifera* var. Kopyor) for cosmetic application', *Industrial Crops and Products*, 186, pp. 1-6

Mawazi, S. M., Ann, J., Othman, N., Khan, J., Alolayan, S. O., Al thagfan, S. S., and Kaleemullah, M. (2022) 'A review of moisturizers; history, preparation, characterization and applications', *Cosmetics*, 9(3), pp. 1-19

Ministry of Health of the Republic of Indonesia. (1979). *Farmakope Indonesia* (Edisi 3) (Indonesian Pharmacopoeia (Edition 3)). Jakarta: Ministry of Health of the Republic of Indonesia [In Indonesian]

Mohammed, N. K., Samir, Z. T., Jassim, M. A., and Saeed, S. K. (2021) 'Effect of different extraction methods on physicochemical properties, antioxidant activity, of virgin coconut oil', *Materials Today: Proceedings*, 42, pp. 2000-2005

National Standardization Agency, (1996) *SNI 16-4399-1996, Sediaan Tabir Surya (SNI 16-4399-1996, Sunscreen Preparations)* [Online]. Available at: https://pesta.bsn.go.id/produk/detail/4816-sni16-4399-1996 (Accesed: 20 Agustus 2023) [In Indonesian]

National Standardization Agency. (1998) *Kodeks Kosmetika Indonesia: SNI 16-0218.2-1998 (Indonesian Cosmetics Codex: SNI 16-0218.2-1998)* [Online]. Available at: https://pesta.bsn.go.id/produk/detail/516-sni16-02182-1998 (Accesed: 20 September 2022) [In Indonesian]

Ng, Y. J., Tham, P. E., Khoo, K. S., Cheng, C. K., Chew, K. W., and Show, P. L. (2021) 'A comprehensive review on the techniques for coconut oil extraction and its application', *Bioprocess and biosystems engineering*, 44(9), pp. 1807-1818

Palefsky, I. (2022) 'Creams and Ointments' in Draelos, Z. A. (eds.) *Cosmetic Dermatology: Products and Procedures*. New Jersey: John Wiley & Sons Ltd. pp.101-105.

Park, Y. H., and Kim, H. J. (2021) 'Formulation and stability of horse oil-in-water emulsion by HLB system', *Food Science and Biotechnology*,30(7), pp. 931-938

Pereira, G., Fernandes, C., Dhawan, V., and Dixit, V. (2022) 'Preparation and development of nanoemulsion for skin moisturizing', *Nanotechnology for the Preparation of Cosmetics Using Plant-Based Extracts*, 2022, pp. 27-47

Poljšak, N., and Kočevar Glavač, N. (2022) 'Vegetable butters and oils as therapeutically and cosmetically active ingredients for dermal use: A review of clinical studies', *Frontiers in Pharmacology*, 13, pp. 1-17

Putri, F. L. A., Nugroho, A. K., and Setyowati, E. P. (2018) 'Optimization of HIB value combination of tween 60 and span 80 on cream formulation of ethanol extract of green tea leaves (*Camellia Sinensis* L.)', *Majalah Obat Tradisional*, *23*(3), pp. 124-130

Putri, F. R., and Sailah, I. (2022) 'Formulation natural ingredients combination and consumer preference

product sunscreen lotion', *IOP Conference Series: Earth and Environmental Science*, pp. 1-13

Rahmandari, F., Swastawati, F., and Kurniasih, R. A. (2021) 'Quality characteristics of body cream with the addition of gelatin from tilapia (*Oreochromis niloticus*) scales as an emulsifier', *IOP Conference Series: Earth and Environmental Science*, pp. 1-10

Rosly, M. B., Jusoh, N., Othman, N., Rahman, H. A., Sulaiman, R. N. R., and Noah, N. F. M. (2020) 'Stability of emulsion liquid membrane using bifunctional diluent and blended nonionic surfactant for phenol removal', *Chemical Engineering and Processing-Process Intensification*, 148, pp. 1-13

Rulhisham, N. S., and Razak, A. H. A. (2021) 'Optimisation of droplet size and pH for cosmeceutical cream containing virgin coconut oil (VCO)', *Progress in Engineering Application and Technology*, 2(1), pp. 27-37

Sabahannur, S., and Alimuddin, S. (2022) 'Identification of fatty acids in virgin coconut oil (VCO), cocoa beans, crude palm oil (CPO), and palm kernel beans using gas chromatography', *IOP Conference Series: Earth and Environmental Science*, pp. 1-7

Sahasrabudhe, G., DeIuliis, G., and Galvin, K. P. (2021) 'Hydrophobization of minerals by sorbitan mono oleate (Span® 80): Selectivity of a novel agglomeration process', *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 630, pp. 1-12

Setyaningsih, D., and Aminingsih, T. (2021) 'Application of MAG (monoacyl glycerol) as emulsifier with red palm oil in body cream product', *IOP Conference Series: Earth and Environmental Science*, pp. 1-8

Sundrasegaran, S., and Mah, S. H. (2020) 'Extraction methods of virgin coconut oil and palm-pressed mesocarp oil and their phytonutrients', *EFood*, 1(6), pp. 381-391

Syafitri, E., Saputro, A. H., Fauziyya, R., Aziz, S., and Sukrasno, S. (2023) 'The effect of surfactant and co-surfactant ratio on physical stability of rice bran oil based-nanoemulsion (organoleptic and pH parameters)', *AIP Conference Proceedings*, 2623(1), pp. 1-9

Venkataramani, D., Tsulaia, A., and Amin, S. (2020) 'Fundamentals and applications of particle stabilized emulsions in cosmetic formulations', *Advances in Colloid and Interface Science*, 283, pp. 1-6

Wang, Q., Zhang, H., Han, Y., Cui, Y., and Han, X. (2023) 'Study on the relationships between the oil HLB value and emulsion stabilization', *RSC advances*, 13(35), pp. 24692-24698

Wang, Y., Hartel, R. W., and Zhang, L. (2021) 'The stability of aerated emulsions: Effects of emulsifier synergy on partial coalescence and crystallization of milk fat', *Journal of Food Engineering*, 291, pp. 1-11

Widiputri, D. I., Wijaya, S., and Kusumocahyo, S. P. (2020) 'Development of skin lotion containing antioxidant extract from coffee pulp and study on its stability', *IOP Conference Series: Materials Science and Engineering*, pp. 1-6

Wulandari, F., Syaputri, F. N., and Jannah, N. R. (2022) 'The effect of various concentrations of the addition of emulsifier tween 80 and span 80 on the stability of cream formulation ethanolic extract of basil leaves (*Ocimum Americanum* L)', *Lumbung Farmasi: Jurnal Ilmu Kefarmasian*, 3(2), pp. 197-203

Yan, G., Wang, S., Li, Y., He, L., Li, Y., and Zhang, L. (2023) 'Effect of emulsifier HLB on aerated emulsions: Stability, interfacial behavior, and aeration properties', *Journal of Food Engineering*, 351, pp. 1-8

Yin, H. A., Wahab, R. A., Rehman, G. U., Abidin, M. H. Z., and Wong, K. Y. (2024) 'A novel water-in-oil-in-water double nanoemulsion of α-mangostin and kojic acid for topical applications', *Arabian Journal for Science and Engineering*, pp.1-15

Yousefi, S., Rajaei, P., Nateghi, L., Nodeh, H. R., and Rashidi, L. (2023) 'Encapsulation of sesamol and retinol using alginate and chitosan-coated W/O/W multiple emulsions containing Tween 80 and Span 80', *International Journal of Biological Macromolecules*, 242, pp. 1-11

Zhang, N., Liu, C., Jin, L., Zhang, R., Siebert, H. C., Wang, Z., Prakash, S., Yin, X., Li, J., Hou, D., and Sun, B. (2020) 'Influence of long-chain/medium-chain triglycerides and whey protein/tween 80 ratio on the stability of phosphatidylserine emulsions (O/W)', *ACS omega*, 5(14), pp.7792-7801.

Zhang, X., Song, R., Liu, X., Xu, Y., and Wei, R. (2022) 'Fabrication of vitamin D3 nanoemulsions stabilized by Tween 80 and Span 80 as a composite surface-active surfactant: Characterization and stability', *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 645, pp. 1-10