Journal of
Food and Pharmaceutical Sciences

Original Article

Optimization of Liquid Paraffin as an Emollient and Propylene Glycol as a Humectant in the Formulation of Body Lotion containing Alpha-Arbutin

Singgih Ardi Pradipta, Lilies Wahyu Ariani*, Wulan Kartika Sari
College of Pharmaceutical Sciences, Yayasan Pharmasi Semarang, Jl. Letjend Sarwo Edie Wibowo Plamongansari-Pucanggading, Semarang 50193, Jawa Tengah, Indonesia
*Corresponding author: Lilies Wahyu Ariani; email: lilieswahyuariani@gmail.com

Received: 20 November 2024; Revised: 8 March 2025; Accepted: 19 March 2025; Published: 31 March 2025

Abstract: Dry skin due to sun exposure can be prevented by using moisturizer. Moisturizer can be found in body lotion preparations in the form of emollients such as liquid paraffin and humectants such as propylene glycol. The purpose of this study was to determine the effect and optimum concentration of liquid paraffin and propylene glycol on the physical characteristics and moisturizing power of body lotion and to determine the antioxidant activity and physical stability of the optimum formula of alpha-arbutin body lotion. The comparison of liquid paraffin and propylene glycol concentrations was determined based on the design expert 10.0.1 simplex lattice design method. The formula for the comparison of liquid paraffin and propylene glycol is FI (8.5:10.5); FII (10:9); III (10:9); FIV (5.5:13.5); FV (7:12); FVI (4:15); FVII (4:15); FVIII (7:12). The test parameters used in determining the optimum formula are pH, viscosity, adhesion, spreadability and moisture. The results of the test using the T-test. Based on the results of the study, the optimum formula was obtained at a concentration of 10% liquid paraffin and 9% propylene glycol. The conclusion of this study is that liquid paraffin or propylene glycol increases pH, viscosity, spreadability, adhesion and moisture content while the combination of the two materials increases spreadability, adhesion, moisture content and decreases pH and viscosity. The results were validated by the T-test showing that all parameter results were not significantly different. The optimum antioxidant formula test produced an IC_{50} value of 159.09 ppm which is included in very weak antioxidants and after going through a cycling test, an increase in pH value, adhesion, spreadability and decreased viscosity were obtained but were still stable in color, odor and homogeneity.

Keywords: alpha-arbutin, body lotion. liquid paraffin, optimization, propyleneglycol.

1. INTRODUCTION

Human skin is the part of the body that is most frequently exposed to sunlight,, which not only causes the skin to become darker due to hyperpigmentation, continuous exposure to sunlight and heat can accelerate the skin aging, also at risk of being skin cancer and decreased immune response. because the skin is not moist [1][2] . Dry skin due to sun exposure can be prevented in several ways, such as using moisturizers [3]. Moisturizers that can moisturize the skin can be found in skin care cosmetic preparations such as emollients and humectants. People these day use some of skin care in various form and product, including body lotion. Lotion formulations consist of oil, moisturizer, emulsifier,

and water. Body lotion can be used daily as a skin moisturizer to prevent the skin from becoming too dry due to continuous sun exposure.

Skin moisturizers such as emollients and humectants that are easy to find and use are liquid paraffin and propylene glycol. In addition to being able to moisturize the skin, both of these ingredients are suitable for use in formulations because they are colorless and odorless [4]. So the combination of the two moisturizing components has great potential to be made into useful cosmetic preparations. The selection of moisturizer is an important factor because the quality and stability of the preparation are also influenced by the moisturizer used, in addition, moist skin also facilitates the absorption of active substances into the skin so that the therapeutic effect can be achieved [5]. Liquid paraffin is used in semi-solid formulations as an emollient that has a moisturizing effect as a material that prevents skin dryness by increasing the water content in the skin [6] and propylene glycol which functions as a humectant in semi-solid preparations that can attract water particles from the air to keep it moist. Based on this background, a study was conducted on liquid paraffin and propylene glycol formulated in a moisturizing body lotion preparation to determine the composition comparison of liquid paraffin and propylene glycol as a moisturizer in an alpha-arbutin body lotion preparation that provides the best or optimum physical characteristics and moisturizing power.

2. MATERIALS AND METHODS

2.1. Materials

The materials used in this study were alpha-arbutin (Fruiterco), stearic acid (MKR), triethanolamine (petronas), liquid paraffin (MKR), propylene glycol (DOW), cetyl alcohol (BASF), DMDM hydantoin (Glydant), jasmine essence, aquadest, methylene blue, methanol p.a (Merck), DPPH (Aldrich), and ascorbic acid (Aldrich).

2.2. Identification of Alpha-arbutin

FTIR spectroscopy tests were carried out on the active substance alpha-arbutin, and then the FTIR absorbance spectra were measured at wave numbers 4000–400 cm^{-1}. The measurement results were analyzed to show whether the material used was indeed alpha-arbutin [7].

2.3. Optimization Design with Simplex Lattice Design

Table 1. Liquid Paraffin and Propylene Glycol Optimization Design

Material	FI	FII	FIII	FIV	FV	FVI	FVII	FVIII
Alpha-arbutin	1%	1%	1%	1%	1%	1%	1%	1%
Stearic acid	3%	3%	3%	3%	3%	3%	3%	3%
Triethanolamine	1%	1%	1%	1%	1%	1%	1%	1%
Liquid paraffin	8.5%	10%	10%	5.5%	7%	4%	4%	7%
Propylene glycol	10.5%	9%	9%	13.5%	12%	15%	15%	12%
Cetyl alcohol	2%	2%	2%	2%	2%	2%	2%	2%
DMDM Hydantoin	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%
Jasmine essence	6 drops	6 drops	6 drops	6 drops	6 drops	6 drops	6 drops	6 drops
Aquadest	up to 100%	up to 100%	up to 100%	up to 100%	up to 100%	up to 100%	up to 100%	up to 100%

Description: F1 = *Run* 1; FII = *Run* 2; FIII = *Run* 3; FIV = *Run* 4; FV = *Run* 5; FVI = *Run* 6; FVII = *Run* 7; FVIII = *Run* 8

2.4. Body Lotion Preparation

All the ingredients needed in making body lotion are weighed, stearic acid, cetyl alcohol and liquid paraffin are put in a porcelain cup (1) and melted in a water bath at a temperature of 70°C (oil phase), in another porcelain cup (2) triethanolamine, propylene glycol, DMDM hydantoin and aquadest are added and heated in a water bath at a temperature of 70°C (water phase). Little by little, while stirring, add the water phase (cup 2) to the oil phase (cup 1) to form a good body lotion base. Then jasmine essence is added to taste and alpha-arbutin into the body lotion base and stirred homogeneously.

2.5. Body Lotion Assay

2.5.1. Organoleptic

Organoleptic observations were carried out on the alpha-arbutin body lotion preparation that had been made using human senses, including observations of color, odor, and shape [8].

2.5.2. Type of Lotion

The preparation is made into a thin layer on the object glass, dripped with methylene blue. The object glass is covered with a cover glass, observed under a microscope and the lens magnification is adjusted. The O/W type emulsion will appear as white oil droplets with a blue base from methylene blue [9].

2.5.3. Viscosity

The viscosity of the preparation was measured using a Brookfield viscometer with spindle number 64 at a speed of 50 rpm. The viscosity value that meets the standard is in the range of viscosity values of 2000-50000 cp [10].

2.5.4. pH

The pH test of the alpha-arbutin body lotion preparation was carried out using a pH meter. Cosmetic preparations used on the skin must have a pH that matches the skin's pH, which ranges from 4.5-6.5 [11] or according to the requirements of SNI 16-4399-1996, which is in the range of 4.5-8.0.

2.5.5. Adhesion

Weigh 0.5 g of the preparation placed in the middle of the object glass and covered with another object glass. A load of 250 grams is placed on the cover object for 5 minutes. Connect both ends of the cover glass and the end of the base glass with the test tool clamp, and remove the load support. The time for the two glasses to separate from the test tool is recorded as the binding time of the preparation. The requirement for good adhesion is 1 second or more [2].

2.5.6. Spreadability

Weigh 0.5 g of body lotion preparation and place it in the middle of a round glass base. A 50 g load is placed on the cover glass and left for 1 minute, after which the distribution diameter is measured and recorded. Give another 50 g load, leave for 1 minute, then measure and record the distribution again until at least one line shows a constant number for three consecutive measurements [2].

2.5.7. Moisture

Moisture testing was conducted for one week. Before the preparation was applied to the respondent's arm, the moisture of the respondent's arm skin was first measured using a skin analyzer. The test location was the respondent's arm skin with a diameter of 3 cm with the use of the preparation

every day after bathing. The number of respondents was 10 people [1]. Moisture measurement was carried out using a skin analyzer using the % parameter with a standard scale on the tool, namely dry 0-33, slightly dry 34-37, normal 38-42, slightly moist 43-46 and moist 47-100.

2.6. Determination of Optimum Formula

The determination of the optimum formula is based on the response parameters including adhesion test, spread test, viscosity test, pH test and humidity test. The selected optimum formula is then subjected to a validation test using T-test, an antioxidant test and a physical stability test.

2.6.1. Antioxidant Assay

Antioxidant activity testing using DPPH standard that has been dissolved using methanol p.a with ascorbic acid as a positive control. Ascorbic acid and optimum formula preparations of alpha-arbutin lotion were made in series of 10, 30, 50, 70 and 90 ppm.

Antioxidant measurements using a UV-Vis spectrophotometer at a wavelength of 517.00 nm with an operating time of 5 minutes. Each standard series was pipetted with 1 ml and mixed with 3 ml of 4 ppm DPPH solution. Furthermore, the absorbance data was calculated for the % inhibition value using the following equation,

$$\%\ inhibition = \frac{\text{DPPH control absorbance} - \text{absorbance of test solution}}{\text{DPPH control absorbance}}\ x\ 100\% \qquad (1)$$

The IC_{50} value is determined by creating a regression line equation for the relationship between % inhibition and the concentration of the test solution.

2.6.2. Physical Stability

Physical stability testing was carried out using the cycling test method. The samples were stored at 40°C for 24 hours and then stored at 4°C for 24 hours in a climatic chamber for 6 cycles or 12 days. Observation data including organoleptic, pH, spreadability, adhesiveness, and viscosity were analyzed using the paired sample T-test to determine whether there was a significant difference between the data before and after the cycling test [12].

3. RESULTS AND DISCUSSION

3.1. FTIR Assay Result

The peak wave of the test results was compared with the literature according to Rohman (2014) [13] and research by Khan et al. (2023) [14] who conducted FTIR testing on pure alpha-arbutin. Differences in wave peaks can be caused by several things, such as cluster shifts that can occur due to sample storage temperature, differences in sample preparation and other things.

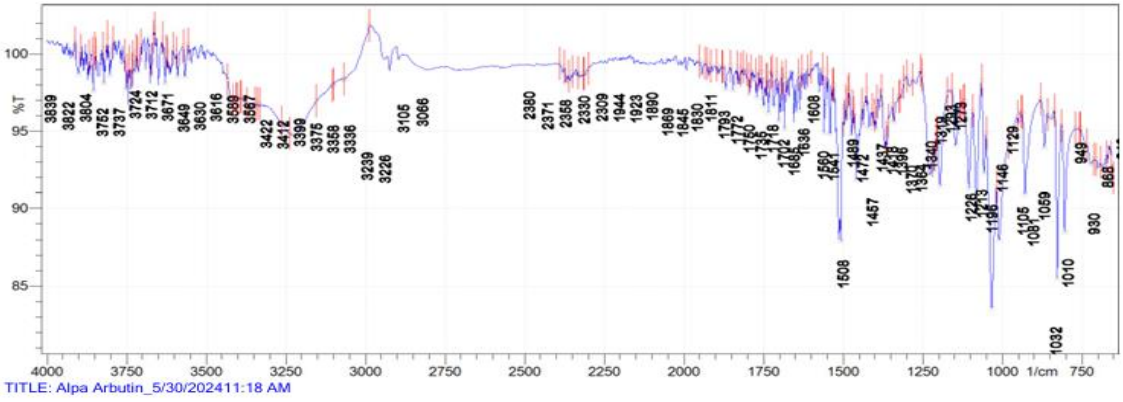

Figure 1. FTIR test results of alpha-arbutin samples

Table 2. FTIR Data Interpretation

Group	Rohman, 2014	Khan et al, 2023	Sample	Description
O-H	3650-3600 cm^{-1}	3368.06 cm^{-1}	3649 cm^{-1}	Contain O-H group
C-H	3000-2850 cm^{-1}	2999.32 cm^{-1}	3066 cm^{-1}	Contain C-H group
C-O	1300-1000 cm^{-1}	1217 cm^{-1}	1293 cm^{-1}	Contain C-O group
C=C aromatic	1600 dan 1475 cm^{-1}	1575 cm^{-1}	1608 cm^{-1}	Contain C=C aromatic group

3.2. Characteristic Assay Result

The results of the characteristic tests of the eight runs or formulations, including the homogeneity test, organoleptic test, lotion type test, pH test, viscosity test, adhesion test, spreadability test and humidity test of the alpha-arbutin body lotion preparation can be seen as follows.

Table 3. Characteristic Test Results

Test	Formula							
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**
Form	*Lotion*	*Lotion*	*Lotion*	*Lotion*	*Lotion*	*Lotion*	*Lotion*	*lotion*
Color	White	White	White	White	White	White	White	White
Odor	Jasmine scent	Jasmine scent	Jasmine scent	Jasmine scent	Jasmine scent	Jasmine scent	Jasmine scent	Jasmine scent
Homogeneity	Homogen	Homogen	Homogen	Homogen	Homogen	Homogen	Homogen	Homogen
Lotion type	O/W	O/W	O/W	O/W	O/W	O/W	O/W	O/W
pH	7.57	7.8	7.76	7.4	7.45	7.33	7.38	7.5
Viscosity (cp)	9165	9542	9439	8855	9027	5698	8494	8964
Spreadability (cm)	6.45	6.65	6.75	5.95	6.25	5.7	5.65	6.3
Adhesion (second)	1.43	1.56	1.54	1.25	1.36	1.12	1.19	1.41
Moisture (%)	17.8	18	18	17.7	17.9	17.5	17.6	17.8

The higher the content of liquid paraffin used, the higher the pH value will be more alkaline, while the higher the concentration of propylene glycol used, the lower the pH value will be more acidic. However, the difference in the combination of liquid paraffin and propylene glycol mixtures in each comparison used produces a pH value in the range that is in accordance with the pH requirements in SNI 16-4399-1996, namely 4.5 to 8.0.

Measurement of the viscosity of the alpha-arbutin body lotion preparation using a Brookfield viscometer with spindle number 64 and a spindle rotation speed of 50 rpm. The viscosity of topical preparations as sunscreen required by SNI 16-4339-1996 is 2.000-50.000 cp. The higher the concentration of liquid paraffin will increase the viscosity value of the alpha-arbutin body lotion preparation, conversely the higher the concentration of propylene glycol will decrease the viscosity value of the alpha-arbutin body lotion preparation produced. This occurs due to the possibility of a saponification reaction between stearic acid in liquid paraffin oil and triethanolamine base which can cause an increase in viscosity and a higher pH value compared to formulas with lower liquid paraffin content [11].

The results of good spreadability testing range from 5-7 cm [15]. Based on Table 3, it can be seen that the increasing concentration of liquid paraffin can increase the spreadability of body lotion preparations. Liquid paraffin has an effect on increasing the spreadability of semi-solid preparations

[16]. The physical properties of liquid paraffin and propylene glycol make both materials able to increase the spreadability of both single and combined use.

From the tests produced, it can be seen that the higher the concentration of liquid paraffin, the longer the adhesive power produced, while the largest concentration of propylene glycol produces faster adhesive power. This is likely because liquid paraffin, including oil-soluble bases, will be stickier or stick longer when compared to propylene glycol which is soluble in water.

The moisture test aims to determine how much impact the use of alpha-arbutin body lotion has during use for a certain time to moisturize the skin. Measurement of skin moisture is carried out before use and after use of the alpha-arbutin body lotion preparation. Use is carried out for 7 consecutive days used according to the instructions for use.

Based on the test results, it can be seen that the increasing concentration of liquid paraffin, the better the moisturizing power of the alpha-arbutin body lotion preparation. Liquid paraffin is used in the formulation as an emollient that can prevent dry skin and is able to provide a moisturizing effect because it can increase the water content in the skin [6], while propylene glycol acts as a humectant where its working mechanism is more dominant in maintaining the moisture of the preparation by binding water in the air and preventing water from evaporating from the preparation.

Based on the design expert 10.0.1 program, an optimum formula for the alpha-arbutin body lotion preparation was obtained. The selected formula used as the optimum formula is a point with a concentration of 10% liquid paraffin and 9% propylene glycol with a desirability value of 0.912. The higher desirability value indicates that the preparation produced according to the program is approaching perfection (1). The optimum formula obtained results of pH 7.774, viscosity 9475.451 cP, spreadability 6.694 cm, adhesiveness 1.545 seconds and humidity 17.980%.

3.3. Validation Assay Result

Table 4. Alpha-arbutin Body Lotion Equivalence Verification

Parameter	Prediction	Test	significance	Conclusion
pH	7.774	7.7760	0.460	Not significantly different
Viscocity (cp)	9475.451	9423.600	0.135	Not significantly different
Spreadability (cm)	6.694	6.730	0.069	Not significantly different
Adhesion (second)	1.545	1.5620	0.429	Not significantly different
moisture (%)	17.980	18.080	0.111	Not significantly different

The table above shows that the experimental results of each parameter are not significantly different when compared to theoretical data with expert design data, resulting in a significance value of >0.05. So it can be concluded that the experimental results are consistent with the predicted results.

3.4. Antioxidant Assay

From the experimental results, a linear equation Y = 0.220927081X + 14.8516129 was obtained, where Y is the % inhibition and X is the concentration of the test solution, this equation is used to determine the IC_{50} value or antioxidant power of the body lotion sample.

The body lotion preparation samples were tested in the range of 10, 30, 50, 70 and 90 ppm. From this equation, the IC_{50} value was 159.09 ppm, this value is classified as a very weak antioxidant. According to Boo, et al. (2021) [17], arbutin is weak in preventing free radicals in DPPH compared to counteracting free radicals in ABTS and is more durable in counteracting free radicals in AAPH.

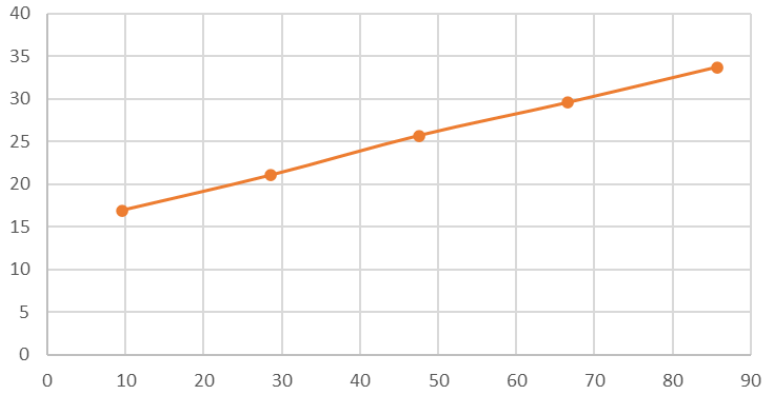

Figure 2. Equation Chart

In the body lotion preparation formula, a 1% alpha-arbutin concentration was reported to be effective in brightening the skin after one month of use [18], however, according to Boo et al. (2021), stronger or more effective antioxidants are expected to reduce oxidative stress in cells, in the study it was stated that a concentration of 1 mM (4.008%) is considered the limit concentration between safe and toxic. At concentrations above 4.008%, it was reported that toxicity occurred in the form of decreased cell function and even cell death.

3.5. Stability Assay

Table 5. Comparison of Physical Characteristics

Test	Before	After	Analysis
Color	White	White	No different
Odor	Jasmine scent	Jasmine scent	No different
Homogeneity	Homogen	Homogen	No different
pH	7.7733	7.8833	Significantly different
Viscocity	9458.6667 cp	7318.0000 cp	Significantly different
Spreadability	6.74167 cm	7.28333 cm	Significantly different
Adhesion	1.22667 second	1.36667 second	Not significantly different

The test results before and after the cycling test obtained a body lotion with stable color, odor and homogeneity. The pH of the alpha-arbutin body lotion preparation increased significantly. The viscosity of the alpha-arbutin body lotion preparation decreased significantly. The spreadability increased significantly. The adhesive power of the alpha-arbutin body lotion preparation increased insignificantly.

4. CONCLUSION

The influence of liquid paraffin and propylene glycol, as well as their interaction, significantly impacts the properties of alpha-arbutin body lotion. Both components individually increase pH, viscosity, spreading power, adhesion, and moisture power, but their interaction reduces pH and viscosity while enhancing adhesion, spreading power, and moisture power. A ratio of 10% liquid paraffin and 9% propylene glycol produces an optimal formulation with excellent physical characteristics and moisturizing power. This optimum formula has very weak antioxidant activity, with an IC_{50} value of 159.09 ppm. After cycling testing, significant changes were observed in pH,

viscosity, and spreadability, while adhesion and organoleptic properties remained stable. This highlights the balanced formulation of an effective alpha-arbutin body lotion.

References

[1] E. S. Noviani, "Formulasi Uji Kelembaban dan Efek Iritasi Lulur Beras Ketan Hitam," Akademi Farmasi Putra Indonesia Malang, 2023.

[2] M. Tazkya, "Formulasi dan Uji Stabilitas Fisik Hand and Body Lotion Halal Dari Ekstrak Rimpang Kunyit (Curcuma longa Linn)," Universitas islam Negeri Maulana Malik Ibrahim malang, 2022.

[3] M. E. T. Butarbutar and A. Y. Chaerunisaa, "Peran Pelembab dalam Mengatasi Kondisi Kulit Kering," *Maj. Farmasetika*, vol. 6, no. 1, pp. 56–69, 2020, doi: 10.24198/mfarmasetika.v6i1.28740.

[4] R. C. Rowe, P. J. Sheskey, and M. E. Quinn, *Handbook of Pharmaceutical Excipient Sixth Edition*, Sixth Edit. Pharmaceutical press, 2009.

[5] M. R. Perkin *et al.*, "Association of frequent moisturizer use in early infancy with the development of food allergy," *J. Allergy Clin. Immunol.*, vol. 147, no. 3, pp. 967-976.e1, 2021, doi: 10.1016/j.jaci.2020.10.044.

[6] N. N. Hudairiah, S. Rosalinda, and A. Widyasanti, "Formulasi Handbody Lotion (Setil Alkohol dan Karagenan) dengan Penambahan Ekstrak Delima Merah," *J. Teknotan*, vol. 15, no. 1, pp. 41–46, 2021, doi: 10.24198/jt.vol15n1.7.

[7] E. S. Suckristiana, N. L. D. Aryani, and R. Sumiyani, "Pengaruh Komposisi Molar terhadap Karakteristik dan Stabilitas Fisikokimia Komplek Inklusi Alfa Arbutin dengan Hidroksipropil Beta Siklodekstrin Menggunakan Metode Kneading," *MPI (Media Pharm. Indones.*, vol. 2, no. 3, pp. 153–164, 2019, doi: 10.24123/mpi.v2i3.1700.

[8] S. Rohmani and T. R. Putri, "Formulasi Anti-Aging Cream Potassium Azeloyl Diglycinate Terhadap Stabilitas Fisika-Kimia Krim dengan Variasi Konsentrasi Trietanolamin Sebagai Emulgator," *J. Ilm. Ibnu Sina*, vol. 7, no. 2, pp. 310–319, 2022, doi: 10.36387/jiis.v7i2.974.

[9] R. Agustin, Y. Oktadefitri, and H. Lucida, "Formulasi Krim Tabir Surya dari Kombinasi Etil p–Metoksisinamat dengan Katekin," in *Prosiding Seminar Nasional Perkembangan Terkini Sains Farmasi dan Klinik*, 2013, pp. 184–198.

[10] Dewan Standarisasi Nasional, *Standar Nasional Indonesia Sediaan Tabir Surya*, vol. 16, no. 4399. 1996.

[11] A. Wulanawati, C. Epriyani, and E. Sutanto, "Analisis Stabilitas Lotion Menggunakan Emulsifier Hasil Penyabunan Minyak Dan Alkali," *J. Farmamedika*, vol. 4, no. 1, pp. 23–28, 2019, doi: 10.47219/ath.v4i1.51.

[12] S. A. Mardikasari, A. N. T. A. Mallarangeng, W. O. S. Zubaydah, and E. Juswita, "Formulasi dan Uji Stabilitas Lotion dari Ekstrak Etanol Daun Jambu Biji (Psidium guajava L.) Sebagai Antioksidan," *J. Farm. Sains, dan Kesehat.*, vol. 3, no. 2, pp. 28–32, 2017.

[13] A. Rohman, *Spektroskopi Vibrasional: Teori dan Aplikasinya Untuk Analisis Farmasi*. Gadjah Mada University Press, 2014.

[14] H. M. S. Khan, N. Tanveer, T. Arshad, F. Rasool, M. N. Uddin, and M. Kazi, "Encapsulation of alpha arbutin, a depigmenting agent, in nanosized ethosomes: Invitro and invivo human studies," *Heliyon*, vol. 9, 2023, doi: 10.1016/j.heliyon.2023.e19326.

[15] D. Dominica and D. Handayani, "Formulasi dan Evaluasi Sediaan Lotion dari Ekstrak Daun

Lengkeng (Dimocarpus Longan) sebagai Antioksidan," *J. Farm. Dan Ilmu Kefarmasian Indones.*, vol. 6, no. 1, pp. 1–7, 2019, doi: 10.20473/jfiki.v6i12019.1-7.

[16] C. K. Nugraheni, E. D. Ikasari, and L. Kusmita, "Optimasi Basis Krim Ekstrak Etanol Daun Kawista (Limonia acidissima L.) sebagai Antibakteri Staphylococcus aureus," *Media Farm. Indones.*, vol. 11, no. 1, pp. 993–1003, 2020.

[17] Y. C. Boo, "Arbutin as a Skin Depigmenting Agent with Antimelanogenic and Antioxidant Properties," *Antioxidants*, vol. 10, no. 7, pp. 1–22, 2021, doi: 10.3390/antiox10071129.

[18] H. Widjaja and A. S. R. D. B. Butar, "Optimasi Kombinasi Cetyl Stearyl Alcohol dan Stearic Acid Sebagai Emulgator Pada Lotion Pemutih Mengandung Alpha Arbutin," *J. Syntax Fusion*, vol. 2, no. 8, pp. 730–739, 2022.