

Formulation of a 2-in-1 Conditioner-Shampoo Containing *Morus nigra* Ethanolic Extract with Surfactant Combination

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ABSTRACT: Black mulberry (*Morus nigra*) is rich in flavonoids and anthocyanins with antioxidant and conditioning properties that can improve hair health. However, its incorporation into a stable 2-in-1 conditioner-shampoo formulation remains limited. This study aimed to formulate and evaluate the physical stability of conditioner-shampoo preparations containing *M. nigra* ethanolic extract at concentrations of 5%, 10%, and 15% w/w using sodium lauryl ether sulphate (SLES) and cocamidopropyl betaine (CAPB) as surfactant bases. Each formulation was prepared by gradual mixing of aqueous and surfactant phases, followed by the addition of conditioning agents and active extract. Physical characteristics—including organoleptic properties, homogeneity, pH, foam height, and viscosity—were evaluated before and after six cycles of a stability test at 4 °C and 40 °C. All formulas exhibited homogeneous brown appearance with peppermint aroma and acceptable foam stability. The initial pH decreased with increasing extract concentration (F1 = 6.74; F2 = 5.95; F3 = 3.97) and slightly decreased after cycling (F1 = 6.21; F2 = 5.84; F3 = 3.61). Viscosity values ranged from 44,000 to 70,000 mPas and decreased after temperature cycling, whereas foam height remained within acceptable limits (≈ 1.5–2.3 cm). Among the tested formulations, F2 (10% extract) showed the most balanced properties in terms of pH, viscosity, and foam stability. In conclusion, a 10% *M. nigra* ethanolic extract conditioner-shampoo demonstrated good physical stability and potential as a natural antioxidant and conditioning hair-care product.

KEYWORDS: Antioxidant; Conditioner; Cycling Test; Shampoo.

1. INTRODUCTION

Hair is part of the scalp and has a complex structure of keratin epithelial cells. Hair is located in the epidermis of the scalp and effectively protects the scalp from the effects of direct sunlight, pollution, and other hair-cleaning products. Hair is a crown of pride for both women and men and has a very important role in a person's appearance, so the hair must be cared for so that it is always healthy, beautiful, and well-groomed [1]. Human hair has an average of around 100,000 follicles, which regulate the growth and differentiation of the epithelium and the hair growth cycle [2]. Therefore, we must do proper hair care every day to have clean and healthy hair. Unhealthy hair has certain characteristics, such as split ends, brittle hair, dull or shiny hair, unmanageable hair, oily hair, hair loss, and a reddish scalp [3].

The way to overcome hair problems is to use shampoo and conditioner. Shampoo is a preparation containing surfactants to clean grease, dirt, and hair and scalp problems [4]. After using shampoo, the conditioner functions as a hair protector so that hair feels soft, easy to manage, and shiny [5]. So, a combination of shampoo and conditioner is needed for maximum hair care to prevent hair damage and ensure hair remains healthy. One of the plants that can be used to make hair healthy is the mulberry plant. Several species of mulberry grow in Indonesia, including *M. cathayana*, *M. alba* (var. *kanva* and *lembang*), *M. multicaulis*, *M. nigra*, *M. australis*, and *M. macrora*. Six types of mulberries are developed and cultivated in harmony with sericulture. Mulberry cultivation is carried out by utilizing mulberry leaves as food for silkworms [6]. Indonesian mulberry plants can bear fruit all year round, so the prospects are very good. In the West Java region, the area of cultivation of this plant is 9,000 hectares, and the total area of mulberry cultivation in

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Indonesia is 45,085.5 hectares. Diversity is one of the supporting factors for plant production. Varieties that provide good results include the Nigra variety (5-8 tons per year), the Multicallis variety (10-12 tons per year), and the Alba variety (8-10 tons per year) [7].

The mulberry plant is a plant with various benefits in the field of medicine and the field of cosmetics; its use in the field of cosmetics can help treat hair loss and damaged hair [8]. Black mulberry fruit has a high nutritional content, including fatty and organic acids, minerals, vitamins (A, B, C, K, and E), proteins and amino acids, and carbohydrates (sugars and fiber). Black mulberry fruit has more flavonoids, anthocyanins, and antioxidant abilities than red or white mulberries. Black mulberry fruit has a high concentration of natural phenolic compounds, such as phenolic acids, flavonols, anthocyanins, and carotenoids, which exhibit various biochemical activities, including antioxidant, antihyperlipidemia, and anticancer properties [9].

In this research, an innovation of shampoo with a combination of conditioner was made where in society, shampoo and conditioner are usually used separately; this combination is done to make it easier for people to use it more practically. The shampoo preparation itself consists of several components. The main components in shampoo usually consist of basic ingredients, namely primary surfactants and secondary surfactants (co-surfactants); primary surfactants function as foam-forming agents and scalp or hair cleansers, while secondary surfactants function as auxiliary surfactants, which can increase detergency and foaming properties and maintain hair condition [10].

In Risiana's research, the emulsification method was used in making ethanol extract shampoo from kirinyuh leaves, using a combination of surfactants, namely sodium lauryl sulfate (SLS) and Cocamidopropyl betaine (CAPB). In the research formula, the addition of CAPB as a secondary surfactant can reduce skin irritation caused by SLS; in addition, it can function to increase foam and viscosity in shampoo [11]. Therefore, this research carried out an update by replacing SLS with its derivative compound, namely SLES (Sodium lauryl ether sulfate), which has a much milder skin irritation effect and is more water soluble than SLS [12]. In addition, this research also carried out an update by comparing the effect of thick black mulberry fruit extract using the emulsification method on 3 variations of shampoo formulas containing conditioners with a combination of surfactants, namely SLES and CAPB.

2. MATERIALS AND METHODS

2.1. Materials and tools

Black mulberry fruit powder (*Morus nigra* L.) was obtained from local producers in Malang, East Java, Indonesia. Ethanol 96% (Merck, Germany), hydrochloric acid 2 M (Merck, Germany), sodium hydroxide 2 M (Merck, Germany), sulfuric acid p.a. (Merck, Germany), Mayer reagent (Sigma-Aldrich, USA), Dragendorff reagent (Sigma-Aldrich, USA), sodium hydroxide 10% (Merck, Germany), ferric chloride 1% (Merck, Germany), and Liebermann-Burchard reagent (Sigma-Aldrich, USA) were used for phytochemical screening. sodium lauryl ether sulfate (SLES; Kao Chemicals, Japan), cocamidopropyl betaine (CAPB; BASF, Germany), sodium chloride (Merck, Germany), salicylic acid (Brataco, Indonesia), stearyl alcohol (Croda, UK), Polyquaternium-7 (Dow Chemical, USA), dimethicone (Shin-Etsu, Japan), propylene glycol (Dow Chemical, USA), vegetable glycerin (Wilmar, Indonesia), methylparaben and propylparaben (Nippon Shinyaku, Japan), citric acid (Merck, Germany), panthenol (DSM Nutritional Products, Switzerland), pearl concentrate (Guangzhou Tinci Materials, China), peppermint oil (PT Indesso Aroma, Indonesia), triethanolamine (Dow Chemical, USA), and distilled water (produced in-house, Indonesia).

Analytical balance (Shimadzu AY220, Japan), maceration jar (Iwaki, Japan), measuring cylinder (Pyrex, UK), black glass bottle (Duran, Germany), horn spoon and glass stirring rod (Iwaki, Japan), rotary evaporator (Heidolph Laborota 4000, Germany), macerator (IKA, Germany), glass funnel (Pyrex, UK), and Whatman filter paper no. 3 (GE Healthcare, UK). hot plate with magnetic stirrer (IKA C-MAG HS7, Germany), homogenizer (IKA T25 Digital Ultra-Turrax, Germany), Brookfield viscometer (DV-E, AMETEK Brookfield, USA), pH meter (Mettler Toledo SevenCompact, Switzerland), and glass slides (Matsunami, Japan).

2.2. Procedure

2.2.1 Preparation of *Morus nigra* Extract with Kinetic Maceration Method

Mulberry fruit dry powder was macerated with 96% ethanol solvent for 3x24 hours with occasional stirring. The ratio of dry powder to the solvent used was 1:10. The maceration method used was kinetic

maceration. Kinetic maceration is an extraction technique with continuous stirring for 6 hours after which it was left in a dark cupboard away from light or sunlight for 18 hours. This process is called static maceration. The maceration results were filtered to separate the filtrate and residue with the Whatman No.3 filter paper. The filtrate obtained was then thickened using a rotary evaporator at a temperature of 40°C to reduce the ethanol content in the extract. The resulting thick extract was left at room temperature in the dark until all the ethanol solvent evaporated. The extract that had been obtained was weighed, and its yield was calculated [13].

2.2.2 Identification of Chemical Content of *Morus nigra* Extract

Results Phytochemical screening tests were carried out on *Morus nigra* extract by adding reagents to each sample to be tested by observing changes in the color and shape of the liquid being tested. The compounds tested in this study were [14]

a. Anthocyanin Compound Test

1 mL of *Morus nigra* extract was put into a tube, then 2 mL of 2 M HCl was added and heated at 100°C for 5 minutes. If there is a color change from purple to red, it means the sample contains anthocyanin. Then 1 mL of extract was added with 2 mL of 2 M NaOH; if positive, the red color will change to blue-green and fade.

b. Flavonoid Compound Test

The extraction results were put into 2 tubes, each containing 1 mL of extract. Tube one was added with 2 mL of 10% NaOH, and tube two was added with 2 mL of H₂SO₄ p. The results were declared positive if tube one changed from yellowish green to brownish green while tube two changed from yellowish red to blackish red.

c. Alkaloid Compound Test

The extraction results were put into 2 tubes, each containing 1 mL of extract. Tube one was added with 2 mL of Mayer's reagent, and tube two was added with 2 mL of Dregendorff's reagent. Positive results are indicated by the formation of white precipitates in Mayer's reagent and orange precipitates in Dragendorff's reagent.

d. Polyphenol Compound Test

1 mL of extract is put into a tube then 2 mL of 1% FeCl₃ solution is added. Positive results if there are green, red, purple, dark blue, blue and blackish blue or blackish green precipitates.

e. Steroid and Terpenoid Compound Test

1 mL of extract is put into a tube then 2 mL of Liebermann burchard solution (5 drops of H₂SO₄ p and 3 drops of anhydrous acetic acid) are added. Positive terpenoids result if a red or purple color is formed, and positive steroids if a green color is formed

f. Tannin Compound Test

1 mL of extract is diluted with sufficient distilled water, then put into a tube, and 2 mL of iron (III) chloride is added. Positive results if the sample turns blue or blackish green.

g. Saponin Compound Test

A total of 1 mL of extract is put into a tube then mixed with hot water and cooled, then shaken until foam appears and 1 drop of 2 N HCl is added. Positive results if there is a lot of foam and it lasts a long time.

2.2.3 Conditioner Shampoo Formulation

Made in 3 formulations that are distinguished by the concentration of black mulberry fruit ethanol extract with varying concentrations, namely 5%, 10%, and 15%. The ingredients used in making shampoo consist of 2 phases, namely the water phase and the oil phase, using the emulsification method. Each is 300 grams in the same base composition. Furthermore, sodium chloride is dissolved with sufficient distilled water until completely dissolved. Pearl concentrate is dissolved with the remaining distilled water until dissolved.

The oil phase is made by melting stearyl alcohol, dimethicone, propylparaben, and propylene glycol until completely melted on a hotplate at 60°C (phase I). Then, the water phase is made by heating SLES, CAPB,

salicylic acid, polyquartener 7, methylparaben, panthenol, triethanolamine, and vegetable glycerin on a hotplate at 60°C (phase II).

Phase I is mixed into phase II and homogenized using a homogenizer at a speed of 300 rpm for 10 minutes. Then add the NaCl solution, dissolved pearl concentrate, thick black mulberry fruit extract, and peppermint oil, and stir until homogeneous. Add citric acid to adjust the pH [15]. Then, the mulberry fruit conditioner shampoo preparation was tested for evaluation, put into a 100 mL bottle, and tested for stability for 6 cycles or 12 days.

Table 1. Black Mulberry Fruit Extract Shampoo Formula Design

Ingredients	Uses	Formulas (%)		
		F1	F2	F3
Black Mulberry Fruit Extract	Active Ingredients	5	10	15
Sodium Lauryl Ether Sulfate (SLES)	Anionic Surfactants	5.5	5.5	5.5
Cocamidopropyl Betaine (CAPB)	Foam Booster	5.5	5.5	5.5
Sodium Chloride	Thickening Agent	3.5	3.5	3.5
Stearyl Alcohol	Emolient and Emulsifier	5	5	5
Polyquartener 7	Conditioning agent	1	1	1
Dimethicone	[8], [11], [15]Emollient and Anti foaming	0.5	0.5	0.5
Salicylic Acid	Anti Dandruff	2	2	2
Propylene glycol	Humectant	10	10	10
Vegetable Glycerine	Humectant	5	5	5
Pathenol	Hair Conditioning Agents; Skin Conditioning Agents	0.4	0.4	0.4
Methyl Paraben	Preservative	0.18	0.18	0.18
Propyl Paraben	Preservative	0.02	0.02	0.02
Citric Acid	Buffer	0.3	0.3	0.3
Peppermint Oil	Aromatic	0.1	0.1	0.1
Pearl Concentrate	Pearlizing Agent	1	1	1
Triethanolamine	Alkalizing Agent	0.5	0.5	0.5
Aquadest	Solvent	ad 300 mL	ad 300 mL	ad 300 mL

2.2.4 Shampoo Conditioner Preparation Evaluation Test

a. Stability Test

Carried out using the cycling test method. The preparation is stored at a temperature of 4°C for 24 hours in a closed condition and protected from light and then transferred to an oven at a temperature of 40°C for 24 hours. This treatment is 1 cycle. The stability test was carried out in 6 cycles for 12 days. After that, it was observed for physical changes in organoleptic tests, homogeneity tests, pH tests, foam height tests and viscosity tests [16].

b. Organoleptic Test

The test is carried out visually by observing the shape, odor, and color of the preparation [8].

c. Homogeneity Test

The test is carried out visually by weighing the preparation, which can be as much as 0.5 grams, smearing it on a glass slide, and then covering it with another glass slide. The preparation must show a homogeneous composition, and no coarse grains must be visible [15].

d. pH Test

The test is carried out with a pH meter by calibrating it with buffer solutions 4 and 7. Then, the electrode is cleaned with distilled water and dried. The pH meter electrode is dipped until the tip is completely immersed in the preparation [17].

e. Viscosity Test

The viscosity test is carried out using a Brookfield viscometer. The conditioner shampoo preparation is put into a viscosity glass cup, the spindle to be used is prepared, and a number of spindles are tested from the smallest to the largest rpm. The numbers read on the viscometer are recorded, and then the viscosity value is calculated [17].

f. Foam Height Test

We weighed 100 mg of the preparation dissolved in 10 mL of water, which was then put into a test tube, closed, and shaken for 20 minutes. Then, the height of the foam formed was measured [8].

3. RESULTS

3.1. Extraction Results

Table 2. Results of Black Mulberry Fruit Extract Yield

Weight of Dry powder (g)	Solution (Liter)	Thick Extract (g)	Yield (% b/b)
500	5	120.2	24.04

3.2. Phytochemical Screening Test Results

Table 3. Phytochemical Screening Test Results for Black Mulberry Fruit Extract

Testing	Reagent Name	Results	Explanation
Anthocyanin	HCl 2 M	+	No fading of red color
	NaOH 2 M	+	The blue green color fades slowly
Flavonoids	NaOH 10%	+	Red to green brownish yellow
	H ₂ SO ₄	+	Red to yellowish red to blackish red
Alkaloids	Mayer	+	Formation of white precipitate
	Dragendorff	+	Formation of orange precipitate
Polyphenols	FeCl ₃ 1%	+	Green, red, purple, dark blue, blue, blackish blue, or blackish green precipitate
Steroids	Liebermann	-	No green color is formed, and remains red.
Triterpenoids	Burchard	+	Red or purple color is formed
Tannin	FeCl ₃	+	The sample turns blue or blackish green.
Saponin	HCl 2 N	+	The sample contains a lot of foam and is long lasting

Explanation: (+) positive, (-) negative

3.3. Evaluation Results of Shampoo Conditioner Preparations Before Cycling Test

Table 4. Results of Evaluation of Conditioner Shampoo Preparations Before Cycling Test

Test Parameter	Formulations		
	F1	F2	F3
Organoleptic			
a. Color	Brown +	Brown ++	Brown +++
b. Texture	Thick +	Thick ++	Thick +++
c. Odour	Mint Odour	Mint Odour	Mint Odour
Homogeneity	Homogeneous	Homogeneous	Homogeneous
pH	6.74	5.95	3.97
Foam Height	2 cm	2.3 cm	2.2 cm
Viscosity	45,333 cps	70,222 cps	79,388 cps

Description:

F1: Formula containing 5% black mulberry fruit extract

F2: Formula containing 10% black mulberry fruit extract

F3: Formula containing 15% black mulberry fruit extract

3.4. Evaluation Results of Conditioner Shampoo Preparations After Cycling Test

Table 5. Results of Shampoo Conditioner Preparation Evaluation After Cycling Test

Test Parameter	Formulas		
	F1	F2	F3
Organoleptic			
a. Color	Brown +	Brown ++	Brown +++
b. Texture	Thick +	Thick ++	Thick +++
c. Odour	Mint Odour	Mint Odour	Mint Odour
Homogeneity	Homogeneous	Homogeneous	Homogeneous
pH	6.21	5.84	3.61
Foam Height	1.47 cm	1.5 cm	1.63 cm
Viscosity	38,629 cps	55,841 cps	60,925 cps

Description:

F1: Formula containing 5% black mulberry fruit extract

F2: Formula containing 10% black mulberry fruit extract

F3: Formula containing 15% black mulberry fruit extract

4. DISCUSSION

4.1. Black Mulberry Fruit Thick Extract

Black mulberry fruit dry powder was extracted using the maceration method for 3 days using 5 liters of 96% ethanol solvent. The working principle of the maceration method is the process of dissolving active substances based on their solubility properties in a solvent (like dissolved like). The maceration method was chosen because the flavonoid compounds in black mulberry fruit are not heat resistant (thermolabile) and are easily oxidized at high temperatures; in addition, the equipment used is simple, the processing process is easy to apply, the operational costs are relatively low, and the solvent is more economical. The extraction results of 500 grams of black mulberry fruit dry powder were 120.2 g of thick extract with a yield of 24.04%. In the extraction process, several factors affect the extraction results, namely preparation of materials before extraction, particle size, solvent, ratio of materials to solvents, methods used in extraction, time, temperature, and the process of separating solvents from the extraction results. In addition, the ratio of materials to solvents affects the extraction process because the more solvents used, the more compounds can be extracted [18].

4.2. Phytochemical Screening of Black Mulberry Fruit Extract

From the phytochemical test results, it can be seen that black mulberry fruit contains secondary metabolites in the form of anthocyanin, flavonoid, alkaloid, polyphenol, terpenoid, saponin, tannin compounds and does not contain steroids. Polyphenol and flavonoid compounds such as anthocyanins are known to have antioxidant activity to stabilize free radicals. Terpenoid and steroid compounds have properties as anti-inflammatory, antioxidant, and astringent.

4.3. Shampoo Conditioner Evaluation Test Before Cycling Test

Organoleptic Test

Organoleptic tests were conducted to determine the physical stability of the shampoo conditioner preparation, such as color, shape, and aroma. In formulas I, II, and III, the resulting preparation was brown and thick. The higher the extract concentration value, the higher the intensity of the brown color and the thickness of the resulting preparation. Formulas I, II, and III have a mint aroma.

Homogeneity test

A homogeneity test is conducted to see whether or not the shampoo conditioner preparation contains coarse particles. In formulas I, II, and III, the results are homogeneous. Judging from the color of the shampoo, the conditioner preparation was produced evenly, and there were no coarse particles during the observation.

pH Test

The pH test is carried out to determine the safety of the shampoo conditioner preparation when used and to ensure that the preparation made has the right pH value and does not harm the scalp. According to SNI, a good pH for the scalp is around 4.5-6.5. When the pH of the shampoo conditioner is too acidic, it will cause scalp irritation, and if it is too alkaline, it can cause the skin to become scaly [19]. In the process of making shampoo conditioner, initially a preparation is obtained that is alkaline, then citric acid is added to adjust the pH to approach the hair pH so as not to irritate the scalp and damage the hair. In formulas I, II, and III, the higher the concentration of mulberry fruit extract, the lower the measured PH value. The decrease in PH is due to the addition of mulberry fruit extract, which contains acidic antioxidants.

Foam Height Test

A foam height test was conducted to determine the ability of surfactants to form foam in mulberry fruit conditioner shampoo preparations. In formulas I, II, and III, the foam height meets the requirements because, according to SNI 06-2692-1992, it is in the range of 1.3-22 cm. The foam obtained is not too much because the product made is a conditioner shampoo containing dimethicone. Dimethicone is used as an emollient (softener) and can also be used as an anti-foaming which can reduce the foam produced by surfactants. The surfactants used in the three formulas are sodium lauryl ether sulfate and cocamidopropyl betaine. It can be seen in the three formulas that the higher the concentration of extract contained in the preparation, the higher the foam produced. This can happen because the higher the amount of extract in the conditioner shampoo preparation, one of the secondary metabolite compounds, which is a natural ingredient that produces foam, namely saponin, will also increase [20].

Viscosity Test

Viscosity test to determine the level of thickness of a preparation. The higher the viscosity value, the greater the resistance to flow [21]. From the results of the viscosity test of the conditioner shampoo preparation, it can be observed that there is a relationship, namely the higher the use of mulberry fruit extract in the formula, the viscosity of the shampoo preparation increases. Formulas I, II, and III do not meet the viscosity requirements because mulberries have a high water content. Based on the research journal [22] it states that perfectly ripe mulberries have a high water content of 84.4 to 89.7%. Another factor is that chloride, which is used as a thickener, uses low concentration sodium so that it is less efficient in increasing the viscosity of the conditioner shampoo preparation. In a study conducted [23], it can be concluded that the addition of 10% NaCl salt gives better results compared to the addition of 5% NaCl salt because the higher the concentration of this chloride salt, the higher the salinity, which reduces the viscosity value so that the fluid will flow more easily.

4.4. Shampoo Conditioner Evaluation Test After Cycling Test

From the results of the cycling test for 6 cycles or 12 days. In cycles 1 to 2, the mulberry extract conditioner shampoo preparation did not experience any physical changes. However, in cycles 3 to 6, there were physical changes. This shows that the mulberry extract conditioner shampoo preparation is not stable at extreme temperature changes, namely 4°C and 40°C. In the organoleptic test, the color and aroma of the shampoo conditioner preparation in formulas I, II, and III did not change, but the form of the preparation during the cycling test changed. Namely, the shampoo conditioner preparation became more liquid. In the homogeneity test of formulas I, II, and III, during the cycling test, there was no change; all preparations remained homogeneous.

During the pH test during the cycling test, formulas I, II, and III changed, and the pH value decreased day by day. This decrease can occur because the storage temperature is less stable for the shampoo conditioner preparation, and the longer the storage time, the lower the pH value will be. In the foam height test of formulas I, II, and III during the cycling test, the foam height decreased. This was due to the thinning of the film layer and coalescence (lack of surfactant used) so that the foam broke. Another factor that affects foam stability is the testing method used, where the weakness of the method is that it depends on the strength of the shaking. However, all the formulas of the shampoo conditioner preparations are still in the foam height range that meets the requirements, namely 1.3-22 cm.

In the viscosity test of formula I, II and III during the cycling test, the viscosity value decreased. So, it can be concluded that temperature and viscosity are inversely proportional because if the preparation is at a high or hot temperature, the viscosity of the emulsion will decrease, and if at a low or cold temperature, the viscosity of the emulsion will increase.

4. CONCLUSION

The 2-in-1 conditioner-shampoo containing black mulberry (*Morus nigra*) ethanolic extract was successfully formulated using SLES and CAPB surfactants. All formulas met the basic physical stability requirements after six temperature cycles. Increasing extract concentration lowered pH and viscosity, with the 10% extract (F2) showing the most balanced properties for scalp application. Thus, the F2 formulation is considered optimal and has potential as a natural antioxidant and conditioning hair-care product.

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REFERENCES

- [1] Y. Nia et al., "Formulasi Dan Evaluasi Sediaan Shampoo Dengan Bahan Dasar Ekstrak Bunga Chamomile (*Matricaria Chamomilla*): Literature Review Article," *J. Ilm. Wahana Pendidik.*, vol. 9, no. 16, hal. 594–600, 2023, [Daring]. Tersedia pada: <https://doi.org/10.5281/zenodo.8260304>
- [2] P. Astiningsih Diah, G. Dolih, H. Rini, dan M. Resmi, "Review: Formulasi Dan Evaluasi Sampo Berbagai Herbal Penyubur Rambut," *Maj. Farmasetika*, vol. 6, no. 2, hal. 152, 2021, doi: 10.24198/mfarmasetika.v6i2.27629.
- [3] J. Nova dan Y. Mimi, "Kelayakan Kulit Jeruk Manis (*Citrus sinensis*) Sebagai Hair Tonic Perawatan Rambut Rontok," *J. Beauty Cosmetol.*, vol. 4, no. 2, hal. 2023, 2023.
- [4] S. A. Mu'thi, T. Muhammad, P. Mahdalena Sy, A. Julianty, dan D. Endah Nurrohwindi, "Formulasi Sampo Kombinasi Ekstrak Seledri (*Apium graveolens*) dan Ekstrak Kayu Manis (*Cinnamomum burmanii*) Serta Uji Aktivitasnya pada Jamur," *Jambura J. Chem.*, vol. 3, no. 2, hal. 84–90, 2021, doi: 10.34312/jambchem.v3i2.11199.
- [5] E. Solikah Ana, S. Anugerah, dan K. Vita, "EVALUATION OF CONDITIONERS WITH VARIETY OF *Alpinia*

- purpurata K. Schum. EXTRACT," *Pharm. J. Islam. Pharm.*, vol. 5, no. 2, hal. 41–49, 2021, [Daring]. Tersedia pada: <https://ejournal.unida.gontor.ac.id/index.php/pharmasipha/issue/archive>
- [6] A. Chandra Dyah, M. Yeni, dan Y. Fathul, "POTENSI EKSTRAK DARI LIMBAH KULIT KAYU DAN BATANG MURBEI (*Morus alba* var. *kanva*) SEBAGAI ANTIBAKTERI *Enterococcus faecalis* ATCC 29212," vol. 9, no. 1, hal. 51–56, 2019.
 - [7] M. Selly, S. Melissa, dan Yuliani, "RESPON PERTUMBUHAN STEK TANAMAN MURBEI (*Morus alba* L.) TERHADAP ZPT ALAMI EKSTRAK TAUGE DAN EKSTRAK BAWANG MERAH," *Pro-STek*, vol. 6, no. 1, hal. 50–64, 2024, [Daring]. Tersedia pada: <https://jurnal.unsur.ac.id/pro-stek/article/view/4276>
 - [8] Y. Novena Adi, "Formulasi dan Uji Aktivitas Anti Ketombe P. Ovale Shampo Ekstrak Etanol Daun Murbei (*Morus Alba* L.)," *J. Mhs. Ilmu Farm. dan Kesehatan*, vol. 2, no. 1, hal. 116–125, 2024, [Daring]. Tersedia pada: <https://doi.org/10.59841/jumkes.v1i3>
 - [9] M. Mariana S, G. Ana C, A. Gilberto, dan S. Luís R, "Blackberries and Mulberries: Berries with Significant Health-Promoting Properties," *Int. J. Mol. Sci.*, vol. 24, no. 15, 2023, doi: 10.3390/ijms241512024.
 - [10] H. Mutiara, D. Fitrianti, dan S. Anan, "Kajian Bentuk-Bentuk Sediaan Farmasi sebagai Pedikulisida," *Bandung Conf. Ser. Pharm.*, vol. 2, no. 2, hal. 352–358, 2022, doi: 10.29313/bcsp.v2i2.4187.
 - [11] R. Faridatul, H. Wahida, dan P. Eskarani Dwi, "Optimasi Formula Sediaan Sampo Ekstrak Etanol Daun Kirinyuh (*Chromolaena odorata*) dengan Kombinasi Surfaktan," *Sasambo J. Pharm.*, vol. 2, no. 1, hal. 1–16, 2021, [Daring]. Tersedia pada: <https://doi.org/10.29303/sjp.v6i1.264>
 - [12] A. Nabila Rizki dan D. Heny, "Pra-Rancangan Pabrik Shower Gel Dari Sodium Lauryl Ether Sulfate Dengan Penambahan Minyak Sakura Pada Kapasitas 75.000 Ton/Tahun," *DISTILAT J. Teknol. Separasi*, vol. 8, no. 4, hal. 952–964, 2023, doi: 10.33795/distilat.v8i4.485.
 - [13] S. Enceng, R. M. Gilang, dan D. Irna Dwi, "Menentukan nilai rendemen pada proses ekstraksi daun murbei (*morus alba*.) dengan pelarut berbeda," *J. Ilm. Ilm. dan Teknol. Rekayasa*, vol. 4, no. September, hal. 36–41, 2022, doi: 10.31962/jiitr.vvii.66.
 - [14] R. Sandra Amalia et al., "Pewarnaan Preparat Apus Tipis Malaria (*Plasmodium vivax* Dan *Plasmodium falcifarum*) Menggunakan Ekstrak Murbei Sebagai Pengganti Eosin Pada Komposisi Giemsa," *Chempublish J.*, vol. 6, no. 2, hal. 75–89, 2021.
 - [15] P. Andri, H. Lungguk, dan K. Nabila Prihantini, "Formulasi Sediaan Kondisioner Rambut Sebagai Pelembab Rambut dari Minyak Inti Sawit (Palm Kernel Oil)," *Lumbung Farm. J. Ilmu Kefarmasian*, vol. 4, no. 1, hal. 129–134, 2023, [Daring]. Tersedia pada: <http://journal.ummat.ac.id/index.php/farmasi/article/view/11484>
 - [16] S. Ade Irma dan R. Eneng Ikrimah, "Uji Aktivitas Sediaan Sampo Antiketombe Ekstrak Daun Ketepeng Cina (*Cassia alata* L) Terhadap Jamur *Pityrosporum ovale*," *J. Syifa Sci. Clin. Res.*, vol. 5, no. 3, hal. 411–423, 2024, doi: 10.37311/jsscr.v5i3.24310.
 - [17] H. Febri, H. Iin, dan N. Kiki Indah, "FORMULASI DAN UJI EFEKTIVITAS SEDIAAN SAMPO DARI LENDIR BEKICOT (*Achatina fulica*)," *ISTA Online Technol. J.*, vol. 2, no. 1, hal. 51–56, 2021, doi: 10.62702/ion.v2i1.36.
 - [18] P. I Kadek Widhiana, P. G.P. Ganda, dan W. Luh Putu, "Pengaruh Perbandingan Bahan dengan Pelarut dan Waktu Maserasi terhadap Ekstrak Kulit Biji Kakao (*Theobroma cacao* L.) sebagai Sumber Antioksidan," *J. Rekayasa Dan Manaj. Agroindustri*, vol. 8, no. 2, hal. 167, 2020, doi: 10.24843/jrma.2020.v08.i02.p02.
 - [19] A. Dewi dan W. Abdul Rohman, "Formulasi Sampo Cair Transparan dari Sari Buah Jeruk Nipis dan Wortel," *Pros. Semin. Nas. Teknol. Ind. Lingkungan. dan Infrastruktur*, vol. 6, hal. A2.1-A2.13, 2023.
 - [20] G. Neni Sri, H. Himyatul, L. Bintang, dan A. Putri, "Formulasi Sediaan Sampo Antiketombe Ekstrak Etanol Daun Jambu Air (*Syzygium aqueum* (Burm.f.) Alston)," *Pharm. Biomed. Sci. J.*, vol. 5, no. 1, hal. 53–65, 2023, doi: 10.15408/pbsj.v5i1.29851.
 - [21] S. Dwi Kurniawati dan S. Siti, "Formulasi dan Aktifitas Sampo (*Cassia alata* Linn.) Sebagai Antiketombe Terhadap *Candida albican*," *J. Homepage*, hal. 1–7, 2021.
 - [22] S. Duangkamon, R. Sauwanee, dan J. Sirisopa, "Nutrition composition and anthocyanin content of mulberry fruits (*Morus alba* L.) by different ripening stage grown in the south of Thailand, applicants in sorbet and sherbet ice-cream and analysis of physical, chemical and sensory evaluation," *Emirates J. Food Agric.*, vol. 35, no. 2, hal. 130–138, 2023, doi: 10.9755/ejfa.2023.v35.i2.2943.
 - [23] H. Lindia, H. Andrea, dan K. Dinar Hananto, "Investigasi Eksperimental Pengaruh Kandungan Kimia Air Pada Penurunan Viskositas Minyak Mentah Berat Dengan Emulsifikasi," *PETRO J. Ilm. Tek. Perminyakan*, vol. 12, no. 4, hal. 280–292, 2023, doi: 10.25105/petro.v12i4.18178.