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Formulation and Characterization of Peel-Off Gel Mask Containing Secang (*Caesalpinia sappan* L.) Wood Extract with Strong Antioxidant Activity

[Formulasi dan Karakterisasi Masker Gel Peel-Off Mengandung Ekstrak Kayu Secang (*Caesalpinia sappan* L.) dengan Aktivitas Antioksidan yang Kuat]

Intan Martha Cahyani[1*], Tan Tanando Tanzaq[1], Ruth Ditya Agustina[1], Kemala Endar Setiawati[1]

[1]*School of Pharmaceutical Sciences, Pharmasi Foundation Semarang, Semarang, Central Java, 50192, Indonesia*

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ABSTRACT

Secang (*Caesalpinia sappan* L.) wood contains flavonoid compounds such as brazilin, 3'-O-methylbrazilin, sappanin chalcone, and sappan chalcone, which act as primary and secondary antioxidants. Antioxidants are substances that can inhibit oxidation reactions by neutralizing free radicals. Enhancing the antioxidant potential of *C. sappan* wood can be achieved by developing a topical dosage form. Peel-off gel masks are an ideal form due to their ability to improve skin health and provide ease and comfort in application. This study aimed to formulate a peel-off gel mask containing *C. sappan* extract and evaluate its physical properties and antioxidant activity. The formulations were prepared using 2.5%, 5%, and 7.5% extract with sodium carboxymethyl cellulose, polyvinyl alcohol, and propylene glycol as the base. The resulting masks were assessed for physical characteristics (pH, viscosity, spreadability, adhesiveness, and drying time) and antioxidant activity using the DPPH method. The results indicated that increasing the extract concentration significantly ($p < 0.05$) increased viscosity, adhesiveness, and drying time, while decreasing pH, spreadability, and IC_{50} value. All formulations demonstrated strong antioxidant activity (IC_{50} between 50–100 µg/mL), with IC_{50} values of 88.71 µg/mL, 81.58 µg/mL, and 79.04 µg/mL, respectively.

Kata kunci:

Caesalpinia sappan
Masker gel peel-off
Formulasi
Antioksidan
Karakteristik fisik

ABSTRAK

Kayu secang (*Caesalpinia sappan* L.) mengandung senyawa flavonoid seperti brazilin, 3'-O-metilbrazilin, sappanin chalcone dan sappan chalcone yang berfungsi sebagai antioksidan primer maupun sekunder. Antioksidan merupakan senyawa yang mampu menghambat reaksi oksidasi dengan menetralkan radikal bebas. Upaya peningkatan potensi antioksidan kayu *C. sappan* dapat dilakukan melalui pengembangan sediaan topikal. Masker gel peel-off merupakan bentuk sediaan yang sesuai karena dapat menjaga kesehatan kulit sekaligus memberikan kenyamanan dan kemudahan saat pemakaian. Penelitian ini bertujuan untuk merumuskan dan mengevaluasi masker gel peel-off yang mengandung ekstrak kayu *C. sappan* berdasarkan karakteristik fisik dan aktivitas antioksidannya. Formulasi dibuat dengan konsentrasi ekstrak 2,5%, 5%, dan 7,5% menggunakan natrium karboksimetil selulosa, polivinil alkohol, dan propilen glikol sebagai basis gel. Evaluasi dilakukan terhadap parameter fisik (pH, viskositas, daya sebar, daya lekat, dan waktu kering) serta aktivitas antioksidan menggunakan metode DPPH. Hasil menunjukkan bahwa peningkatan konsentrasi ekstrak secara signifikan ($p < 0,05$) meningkatkan viskositas, daya lekat, dan waktu kering serta menurunkan pH, daya sebar, dan nilai IC_{50}. Seluruh formula menunjukkan aktivitas antioksidan yang kuat (IC_{50} antara 50–100 µg/mL), dengan nilai IC_{50} berturut-turut sebesar 88,71 µg/mL, 81,58 µg/mL, dan 79,04 µg/mL.

*Corresponding author:
Intan Martha Cahyani (intanmartha@stifar.ac.id)

1. INTRODUCTION

Air pollution has increased significantly in recent years, with levels rising by up to 20%, and has been identified as a major contributor to various health problems due to prolonged exposure (Wahdaningsih et al., 2015). One of the primary mechanisms through which pollution causes harm is oxidative stress, a condition arising from an overproduction of free radicals in the body. These reactive species can damage biological molecules, highlighting the importance of antioxidants in neutralizing free radicals and preventing oxidative damage, particularly in the skin (Widowati, 2011).

Flavonoids are natural compounds widely recognized for their antioxidant properties. They are capable of scavenging a variety of free radicals, including hydroxyl, peroxide, alkoxyl, superoxide anions, singlet oxygen, and hydrogen peroxide (Utari, 2017). One promising source of flavonoids is the wood of secang (*Caesalpinia sappan* L.), which contains active constituents such as brazilin, 3'-O-methylbrazilin, sappanin, and chalcone. These compounds act as both primary and secondary antioxidants. Among them, brazilin has shown particularly strong antioxidant activity, reportedly exceeding that of synthetic antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) (Sugiyanto et al., 2013). In previous studies, the extract of *C. sappan* demonstrated strong antioxidant potential with an IC_{50} value of 74.44 µg/mL (Tanzaq et al., 2019).

Facial masks are among the most popular cosmetic products for skin care. However, traditional mask types are often considered less practical due to lengthy application and removal processes. Peel-off gel masks have emerged as a more efficient alternative, offering ease of use, user comfort, and the ability to deliver active ingredients effectively without requiring rinsing (Rahmawanty et al., 2015). Furthermore, peel-off gel formulations have been shown to enhance antioxidant efficacy when natural extracts are incorporated. Successful applications have been reported using extracts such as *Paederia foetida* (Eka et al., 2022), areca seed (*Areca catechu*) (Dwi Mulyani et al., 2023), red spinach (*Amaranthus tricolor*) leaves (Welly et al., 2022), and mangrove (*Avicennia marina*) leaves (Hasibuan et al., 2024).

Despite its promising properties, the application of *C. sappan* extract in peel-off gel mask formulations remains underexplored. Therefore, the aim of this study was to formulate and evaluate a peel-off gel mask containing *C. sappan* extract, with a focus on its physical characteristics and antioxidant activity. This formulation is expected to serve as a natural, effective skincare solution by maximizing the antioxidant potential of *C. sappan* in a user-friendly topical preparation.

2. METHOD

2.1. Materials and Equipment

The materials used in this study included *C. sappan* (secang) wood, 96% ethanol (Merck), sodium carboxymethyl cellulose (CMC-Na), polyvinyl alcohol (PVA), propylene glycol, vitamin C, and 1,1-diphenyl-2-picrylhydrazyl (DPPH).

The instruments employed were a rotary evaporator (Heidolph), standard laboratory glassware (Pyrex), pH meter (Hanna Instruments pH 210 Microprocessor), viscometer (Brookfield DV-I Prime), and UV-Vis spectrophotometer (Shimadzu UV-1240 Mini).

2.2. Extraction of *C. sappan* Wood

Secang wood was extracted by maceration. The wood powder was soaked in 96% ethanol at a ratio of 1:10 (w/v) for 72 hours. The extract was filtered and concentrated using a rotary evaporator until a thick extract was obtained (Tanzaq et al., 2019).

Table 1. Composition of Peel-Off Gel Mask Formulations Containing *C. sappan* Extract

Ingredient	Formula I (%)	Formula II (%)	Formula III (%)
C. sappan extract	2.5	5.0	7.5
Sodium CMC (CMC-Na)	1.26	1.26	1.26
Polyvinyl alcohol (PVA)	6.74	6.74	6.74
Propylene glycol	4.0	4.0	4.0
Distilled water (ad)	100	100	100

2.3. Formulation of Peel-Off Gel Mask

The peel-off gel mask was formulated using *C. sappan* extract at concentrations of 2.5%, 5%, and 7.5%, as shown in **Table 1**. The gel base consisted of polyvinyl alcohol (PVA), sodium carboxymethyl cellulose (CMC-Na), and propylene glycol. PVA and CMC-Na were dispersed in distilled water heated to 80°C until fully swollen. Afterward, propylene glycol was added and the mixture was stirred until homogeneous. The ethanol extract of *C. sappan* was then incorporated gradually into the base while stirring, and distilled water was added to reach 100% total weight. The final mixture was stirred continuously to ensure uniformity (Cahyani et al., 2025).

2.4. Evaluation of Physical Characteristics

The physical characteristics of the peel-off gel masks were evaluated to assess their suitability as topical cosmetic formulations. Organoleptic properties including color, odor, and

consistency were observed visually, while homogeneity was examined by spreading a small sample of the gel on a glass slide to check for uniform dispersion of components (Syam et al., 2021).

The pH of each formulation was measured by immersing the electrode of a calibrated digital pH meter into the gel and recording the stabilized value (Andini et al., 2017). Viscosity was determined using a Brookfield viscometer equipped with spindle number 64, operated at a speed of 1 rpm. A viscosity range of 2000–50000 cps is considered acceptable for peel-off gel masks (SNI 16-4399-1996).

To evaluate spreadability, 0.5 g of the formulation were placed at the center of a glass plate, then covered with another glass plate of known weight. The diameter of the spread was measured, and additional weight was added incrementally until the diameter stabilized. Adhesiveness was assessed by placing a 0.25 g sample between two glass slides, applying a 100 g load for five minutes, and measuring the time it took for the plates to separate after load removal (Syam et al., 2021).

The drying time was tested by applying 0.1 gram of gel to a 2.5 × 2.5 cm area on the inner forearm. The time required for the film to dry completely at room temperature was recorded. An ideal drying time for peel-off gel masks ranges from 15 to 30 minutes (Silvia et al., 2021).

2.5. Antioxidant Activity Test Using DPPH Method

The antioxidant activity of the peel-off gel mask formulations was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging method. Initially, the maximum absorbance wavelength (λmax) of the DPPH solution (30 µg/mL) was determined using a UV-Vis spectrophotometer within the 400–800 nm range. The optimal reaction time was also established by reacting a 1:1 volume ratio of vitamin C (as the standard antioxidant) with the DPPH solution and measuring the absorbance over a 60-minute period.

Each sample (0.05 g) was dissolved in methanol and diluted to 50 mL. From this stock solution, working concentrations of 60, 70, 80, 100, and 120 µg/mL were prepared. Equal volumes of the sample solution and DPPH solution (30 µg/mL) were mixed, incubated at room temperature for the predetermined optimal time, and their absorbance measured at the previously identified λmax. The same procedure was applied to vitamin C standard solutions at concentrations of 2, 4, 6, 8, and 10 µg/mL.

The percentage inhibition of DPPH radicals was calculated for each concentration, and the IC_{50} value—the concentration required to inhibit 50% of the DPPH radicals—was determined by linear regression analysis of the inhibition percentage versus sample concentration (Maharani et al., 2022).

2.6. Data Analysis

The evaluation of the peel-off gel mask formulations was conducted using descriptive analysis. Observational data such as organoleptic characteristics and homogeneity were assessed qualitatively. Physical parameters including pH, viscosity, spreadability, adhesiveness, and drying time were compared across formulations to identify trends related to increasing concentrations of *C. sappan* extract. Similarly, antioxidant activity data were interpreted by comparing the IC_{50} values of each formulation. The significance of observed changes was discussed in terms of their relative magnitude and consistency rather than based on formal statistical tests.

3. RESULTS AND DISCUSSION

3.1. Physical Characteristics of Peel Off Gel Mask Containing *C. sappan* Extract

Caesalpinia sappan has traditionally been recognized for its therapeutic properties, including antibacterial, anti-inflammatory, antidiabetic, and antioxidant effects. The ethanol extract of *C. sappan* contains flavonoid compounds such as brazilin, 3'-O-methylbrazilin, sappanin, and chalcone, which contribute to its strong antioxidant profile (Ngamwonglumlert & Devahastin, 2023). In this study, peel-off gel mask formulations containing *C. sappan* extract at concentrations of 2.5%, 5%, and 7.5% were developed and evaluated for their physical properties.

The organoleptic and homogeneity observations showed that all formulations had a consistent orange color, a characteristic *C. sappan* odor, and a smooth, thick consistency. Each gel was visually homogeneous, indicating even distribution of ingredients throughout the formulation.

Figure 1 illustrates the physical properties of the three formulations. The pH values decreased slightly as the extract concentration increased. This trend is attributed to the acidic nature of *C. sappan* extract (Muslimin et al., 2024), which becomes more influential as the proportion of extract rises. The viscosity of the gels increased progressively with extract concentration, affecting other parameters such as spreadability, adhesiveness, and drying time. A higher viscosity reduced spreadability but enhanced adhesiveness and prolonged the drying time. These relationships are evident in the trends presented in Figure 1.

Such changes in physical characteristics are consistent with the structural influence of extract constituents and the thickening effect they exert in the gel base. Although no statistical tests were applied, the consistent trends across all parameters support the influence of *C. sappan* extract concentration on the physical performance of the peel-off mask.

3.2. Antioxidant Activity of Peel-Off Gel Mask Containing *C. sappan* Extract

The antioxidant activity of the peel-off gel mask formulations was evaluated using the DPPH free radical scavenging assay. All formulations demonstrated strong antioxidant capacity, with IC_{50} values within the range of 50–100 µg/mL, indicating effective radical scavenging potential.

As shown in **Figure 2**, the IC_{50} values decreased with increasing extract concentration: 88.71 µg/mL for Formulation I (2.5%), 81.58 µg/mL for Formulation II (5.0%), and 79.04 µg/mL

for Formulation III (7.5%). This trend suggests that higher concentrations of *C. sappan* extract contribute to enhanced antioxidant performance, likely due to increased levels of flavonoid compounds such as brazilin.

Although statistical testing was not applied, the progressive decrease in IC_{50} values clearly indicates the influence of extract concentration on antioxidant activity. These results are consistent with the literature, which identifies *C. sappan* as a potent natural antioxidant source (Tanzaq et al., 2019). Compared to its pure extract IC_{50} value of 74.44 µg/mL, the formulated gels retained high antioxidant potential. However, when compared to vitamin C (IC_{50} = 3.04 µg/mL), the formulations were less potent, which is expected given the superior radical scavenging efficiency of pure ascorbic acid.

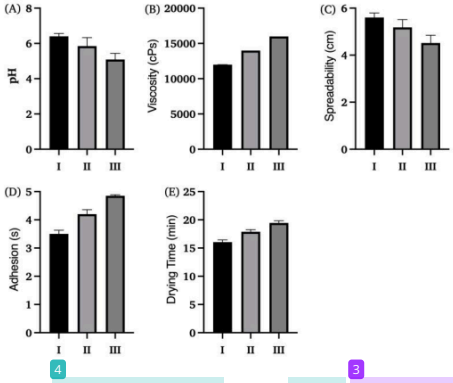

Figure 1. Physical characteristics of peel-off gel mask containing *C. sappan* extract in Formulation I (2.5%), Formulation II (5.0%), and Formulation III (7.5%): (a) pH, (b) viscosity, (c) spreadability, (d) adhesiveness, and (e) drying time.

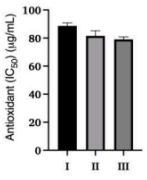

Figure 2. IC_{50} values of peel-off gel mask containing *C. sappan* extract in Formulation I (2.5%), Formulation II (5.0%), and Formulation III (7.5%).

CONCLUSION

This study demonstrated that peel-off gel masks containing *C. sappan* extract can be effectively formulated using polyvinyl alcohol, sodium carboxymethyl cellulose, and propylene glycol as base components. Increasing the extract concentration from 2.5% to 7.5% affected the physical properties of the formulation by increasing viscosity, adhesiveness, and drying time, while decreasing pH and spreadability. All formulations exhibited strong antioxidant activity, with IC_{50} values ranging from 88.71 to 79.04 µg/mL, indicating that higher extract concentrations enhance antioxidant performance. Overall, the 7.5% extract formulation showed the most favorable combination of physical characteristics and antioxidant activity, supporting its potential as a natural, effective peel-off gel mask for skin health applications.

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