ALKIMIA : Jurnal Ilmu Kimia dan Terapan

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Eyebrow Cream Preparation Formulation Based on Activated Carbon from *Elaeis guineensis* Jacq. Shells

Annisaa Siti Zulaicha[a]*, Deviana Safitri[b], Iwan Syahjoko Saputra[a], Wahyu Solafide Sipahutar[c], Yunita Fahni[d]

Abstract. This study aims to utilize palm kernel shell waste as a source of activated carbon for the formulation of safe and sustainable eyebrow cream. Activated carbon was obtained through pyrolysis and physical activation at 800°C, then characterized using proximate analysis, SEM-EDX, XRD, and FTIR to determine its structure, composition, and purity. The characterization results showed that the activated carbon had 100% carbon purity, a porous amorphous structure, and a predominance of C=C groups, indicating a non-polar surface with high adsorptive potential. The activated carbon was then formulated into four variations of eyebrow cream using the hot emulsification method and evaluated through organoleptic, homogeneity, pH, and smudge resistance tests. All formulas showed physical stability for four weeks, a semi-solid texture, homogeneity without granules, and increased color with increasing activated carbon concentration. The pH value of all formulas was 5, within the safe range for skin. This study shows that palm kernel shell activated carbon not only meets the characteristics of stable and safe cosmetic pigments but also provides a natural coloring alternative that supports the concepts of clean beauty, green cosmetics, and the circular economy. Thus, palm kernel shell waste activated carbon has great potential to be developed as an active ingredient in decorative cosmetics, particularly natural-based eyebrow creams.

Keywords : Activated charcoal, Eyebrow cream, Palm coconut shell, Cosmetic.

[a]*Department of Cosmetic Engineering, Faculty of Industrial Technology, Institut Teknologi Sumatera, Jl. Terusan Ryacudu, Way Huwi, Jati Agung, Lampung 35365, Indonesia*
[b]*Bachelor's Degree Student, Department of Cosmetic Engineering, Faculty of Industrial Technology, Institut Teknologi Sumatera, Jl. Terusan Ryacudu, Way Huwi, Jati Agung, Lampung 35365, Indonesia*
[c]*Department of Materials Engineering, Faculty of Industrial Technology, Institut Teknologi Sumatera, Jl. Terusan Ryacudu, Way Huwi, Jati Agung, Lampung 35365, Indonesia*
[d]*Department of Chemical Engineering, Faculty of Industrial Technology, Institut Teknologi Sumatera, Jl. Terusan Ryacudu, Way Huwi, Jati Agung, Lampung 35365, Indonesia*
Correspondence and requests for materials should be addressed to Annisaa Siti Zulaicha (email: annisaa.zulaicha@km.itera.ac.id).

Introduction

The global cosmetics industry is experiencing rapid growth with a market value estimated to reach USD 622 billion in 2023 and projected to continue increasing to more than USD 750 billion by 2026 [1-3]. In Indonesia, the growth of the cosmetics industry is supported by the productive age population, increasing awareness of appearance, and social media exposure. One segment that shows significant growth is decorative cosmetics [4]. Compared to other categories such as skincare or personal care, demand for decorative cosmetics is projected to experience a sharp increase in 2026 to 2027, along with the trend of beauty influencers, short video content, and the increasing interest of the younger generation in exploring makeup styles [5]. One of popular decorative cosmetic products is eyebrow cream, as it provides a more natural eyebrow effect and is easy to apply. However, most products currently available as eyebrow pencils containing synthetic dyes black carbon (CI 77266), which have the potential for toxicity with long-term use and are less environmentally friendly [6]. Furthermore, pencil-based preparations are susceptible to water and sweat, making them less suitable for tropical climates like Indonesia's, which tend to be humid. Consumers are increasingly demanding products that are not only aesthetically effective but also safe, based on natural ingredients, and sustainable. This trend is known as "clean beauty" or "green cosmetics," and is further strengthened by the Indonesian Food and Drug Authority (BPOM) regulations, which encourage the development of themed cosmetics based on local natural ingredients [7].

On the other hand, Indonesia is the 4th largest producer of palm oil in the world, with Sumatra as one of the main production centers. The palm oil processing process produces solid waste in the form of palm kernel shells, the volume of which can reach 5 million tons/year nationally [8]. This waste is largely not optimally utilized and causes environmental problems. In fact, structurally, palm kernel shells are rich in lignin and carbon, so they have great potential to be converted into activated carbon (AC) through pyrolysis and physical activation, an environmentally friendly process in accordance with principles of green chemistry because it does not require hazardous chemicals [8-9]. Activated carbon has a very high surface area (>1000 m^2/g), strong adsorptive properties, and a stable, deep black color, making it not only an adsorbent agent but also a safe and environmentally friendly natural colorant in decorative cosmetic formulations such as eyebrow cream [10]. Thus, the use of activated carbon from palm kernel shells not only reduces the waste load but also supports a circular economy and the development of natural-based cosmetics [11].

Indonesia produces abundant palm kernel shell waste that can be converted into value-added activated carbon. This study modifies palm kernel shell–based activated carbon with Fe_3O_4 and triethoxyiphenylsilane (TEPS) to enhance adsorption capacity, separation efficiency, and surface functionality, with structural and surface changes characterized using UV–Vis, FTIR, XRD, SEM–EDX, and BET analyses [12]. Activated carbon coated with magnetite (ACA–Fe_3O_4) was synthesized from *Elaeis guineensis* Jacq through physical and chemical activation, followed by magnetite coating using $FeCl_3$–$FeSO_4$ coprecipitation. Characterization confirmed successful Fe_3O_4 coating and increased pore properties, resulting in high Ni(II) adsorption efficiency of 99.11% under optimal conditions. The adsorption followed a pseudo-second-order kinetic model and Langmuir isotherm, with desorption efficiency reaching 70.84% [13]. This study aims to evaluate the adsorption capability of magnetite-coated activated carbon (ACC-M) derived from oil palm shells for Cu(II) and Ni(II) ions. The successful Fe_3O_4 coating enhanced the adsorbent properties of activated carbon, as confirmed by SEM–EDX, XRD, FTIR, and BET analyses [14]. Decorative cosmetics such as lip cream often use synthetic dyes that may pose health risks, including Rhodamine B. This study aims to formulate a safe and stable lip cream using natural coloring from *senduduk* fruit extract, obtained through ethanol maceration, and to evaluate its physical and stability properties. The results showed that the formulation with a carnauba wax–microcrystalline wax ratio of 7.6:9.6 (F2) produced the most preferred color based on hedonic testing [15]. Another study, exposure to ultraviolet radiation can cause skin damage, which can be prevented through the use of sunscreen. This study aims to determine the optimal oil-in-water lotion formulation containing Orthosiphon aristatus leaf extract and evaluate its in vitro sunscreen activity by optimizing excipient composition using the Simplex Lattice Design method [16]. In contrast to conventional cosmetic pigments such as synthetic carbon black (CI 77266) or other inorganic colorants, which are predominantly derived from non-renewable sources, the activated carbon used in this study was synthesized from palm shell waste (*Elaeis guineensis* Jacq.) through a thermal activation process. To date, the application of biomass-derived activated carbon as a functional coloring agent in eyebrow cream formulations remains limited. Therefore, this study presents a novel approach by integrating waste valorization, green chemistry principles, and clean beauty concepts in decorative cosmetic development, while also examining the relationship between activated carbon material characteristics and the performance of the resulting eyebrow cream formulations. Based on the previous research, this research conducted to utilize palm kernel shell waste as a source of activated carbon for the formulation of safe and sustainable eyebrow cream. Activated carbon was obtained through pyrolysis and physical activation at 800°C, then characterized using proximate analysis, SEM-EDX, XRD, and FTIR to determine its structure, composition, and purity.

Experimental

This laboratory research aims to produce an activated carbon (AC)-based eyebrow cream formulation from palm oil shell waste. This research adopts the principles of green chemistry and sustainable cosmetic formulation, with the steps presented in **Figure 1**.

Material

The materials used in this study include: Activated carbon, Cera alba, Cetyl Alcohol, Triethanolamine (TEA), Ptopylen Glycol, Lanolin, Butylated hydroxytoluene (BHT), Silica dioxide, Propyl Paraben, Castor oil, Vitamin C (Tocopherol acetate), and Aquadest.

Activated Carbon Preparation

Palm kernel shells were obtained from PT AnakTuha Sawit Mandiri, Lampung. The shells were cleaned with water and then dried in the sun for 5 hours. Next, the carbonization process involved an environmentally friendly pyrolysis process. The carbonized product was ground using a grinder, sieved using a 100-µm sieve, and then physically activated using a furnace. The steps involved placing 160 grams of pyrolysis carbon in a furnace at 800°C for 1 hour. The activation temperature of 800°C was selected based on Zulaicha et al., 2024 [12] and the characteristics of palm kernel shell biomass. At this temperature, physical activation effectively removes volatile compounds and oxygen-containing functional groups, increasing carbon content and pore development while maintaining a predominantly amorphous structure without inducing graphite crystallization. In addition, chemical-free high-temperature activation aligns with green chemistry principles and ensures the safety of activated carbon for cosmetic applications. After being allowed to stand at room temperature for 24 hours, the resulting Physically Activated Carbon (PAF) was pro-

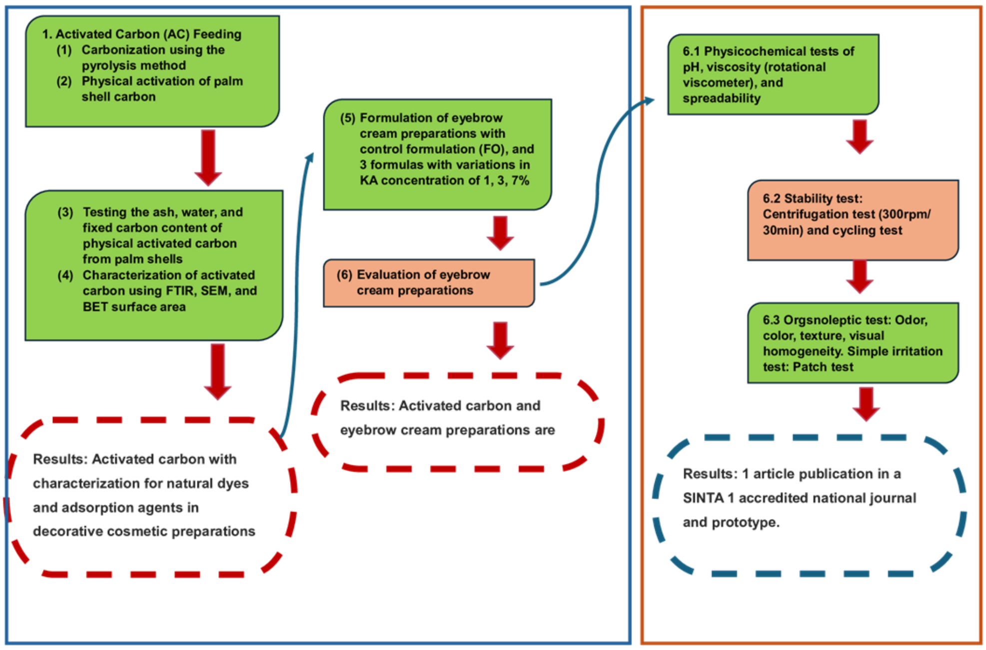

Figure 1. Research Flowchart

duced [17].

Activated Carbon Characterization

The characterization in this study began with identifying the water, ash, and fixed carbon content using the thermogravimetric method. Furthermore, functional groups were identified using FTIR, and the surface morphology and composition of the activated carbon (KAF) were analyzed using SEM-EDX. The surface area and pore volume were determined using the BET surface area method [18].

Eyebrow Cream Formulation

The eyebrow cream formulation design is presented in **Table 1**. The activated carbon concentrations in formulations F1–F3 were selected to systematically evaluate their effect on color intensity, physical stability, and usability of the eyebrow cream. F1 represents a low concentration for basic coloring and homogeneity assessment, F2 an intermediate concentration for balanced performance, and F3 a high concentration to determine the maximum stable loading. This stepwise approach ensures systematic evaluation and improves the reproducibility of the study.

Activated Charcoal EC Preparation

Eyebrow cream is prepared using the heat emulsification method, where the encapsulated material is separated into two phases: an oil phase and an air phase. The mixing process is carried out at a temperature of 65–70°C until the emulsion is completely formed. Afterward, the active ingredient (activated carbon) is added and stirred until homogeneous [19-20].

Working Principle of Activated Carbon EC Production and In Process Control (IPC)

Activated Carbon EC Production and In Process Control (IPC) as shown in **Figure 2**.

Evaluation of Activated Charcoal EC Preparation

Organoleptic visualization includes: shape, color, and odor. A smooth consistency, no granules, a homogeneous preparation, and a pleasant aroma are the required specifications for eyebrow cream. Homogeneity testing uses a glass slide. A small amount of the preparation is applied to the slide, spread evenly, and the cream is observed for coarse granules. The pH test uses a pH indicator, absorption test, and smudge resistance test.

Result and Discussion

Characteristics of Activated Carbon (AC) from Palm Kernel Shells

Activated carbon (AC) synthesized from palm kernel shells has been characterized as a raw material for cosmetic pigments and adsorbents. SEM micrographs (**Figure 3**) show that the AC particles exhibit a fragmented, angular, and non-uniform morphology. The dense macroscopic structure of

Table 1. Formulation of eyebrow cream preparation using activated carbon from palm shells

		Formulas			
Material	**Function**	**F0 (%)**	**F1 (%)**	**F2 (%)**	**F3 (%)**
Activated carbon	Natural dyes and adsorption agents	0	1	3	7
Cera alba	Binder	20	20	20	20
Cetyl alcohol	Emulsifier	5	5	5	5
Triethanolamine (TEA)	Emulsifier	4	4	4	4
propylene glycol	Solvent	5	5	5	5
Lanolin	Solvent	5	5	5	5
Butylated hdroxytoluene (BHT)	Antioxidant	0.1	0.1	0.1	0.1
Silica dioxide	Waterproof agent and sebum absorber	1	1	1	1
Propyl paraben	Preservative	0.2	0.2	0.2	0.2
Castor oil	emollient, gives shine, and viscosity	5	5	5	5
Vitamin E (Tocopherol acetate)	Antioxidant	0.5	0.5	0.5	0.5
Aquadest ad	Solvent	qs ad 100	qs ad 100	qs ad 100	qs ad 100

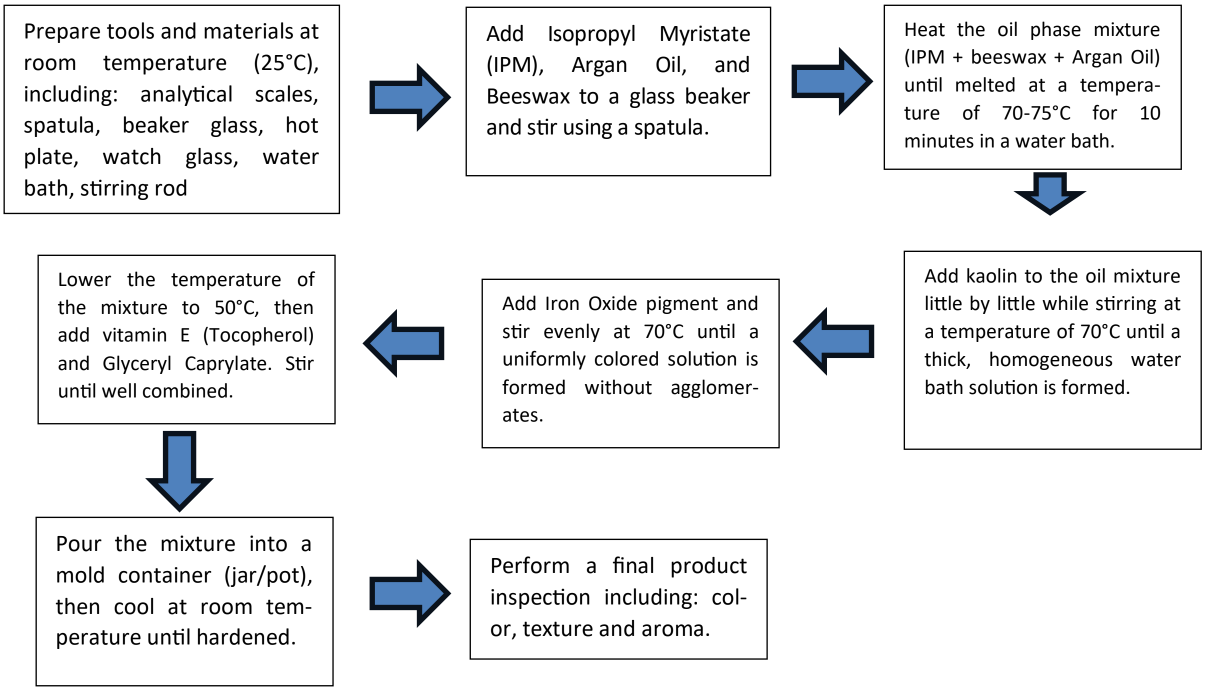

Figure 2. Activated Carbon EC Production and In Process Control (IPC)

the biomass feedstock is destroyed through thermal and activation processes, resulting in particles with distinct fracture boundaries. This results in the formation of abundant porosity and a homogeneous distribution across the particle surface. These pores are observed as circular to elliptical cavities with a variable size spectrum. This visualization strongly supports the success of the physical activation stage at 800°C, where volatiles are eliminated and the internal walls of the carbon are eroded, significantly increasing the specific surface area. These open pore channels indicate functional diffusion pathways, which are essential for adsorbate mass transfer.

The surface topology of KAF observed in **Figure 3** directly supports the material's potential as an adsorbent. A high level of porosity is a prerequisite for achieving adequate specific surface area, thus determining adsorption performance than carbon non activation. The detoxification capabilities of KAF include the ability to adsorb oil, sebum, and dirt that clog skin pores. This is in line with other studies on palm oil waste (empty fruit bunches) which show that effective activity produces an efficient pore structure for mass transfer, which is essential for adsorption performance. The large-dimensional pores (mesopores to macropores) that are visible also function as transport channels. These channels are important to allow large adsorbate molecules such as skin dirt or formulation molecules to quickly access the micropores within the carbon matrix.

EDX Analysis

Based on the EDX analysis of the KTA sample shown in **Table 2**, carbon (C) was identified as the dominant element with a weight percentage of 78.93%, while oxygen (O) accounted for 21.07%.

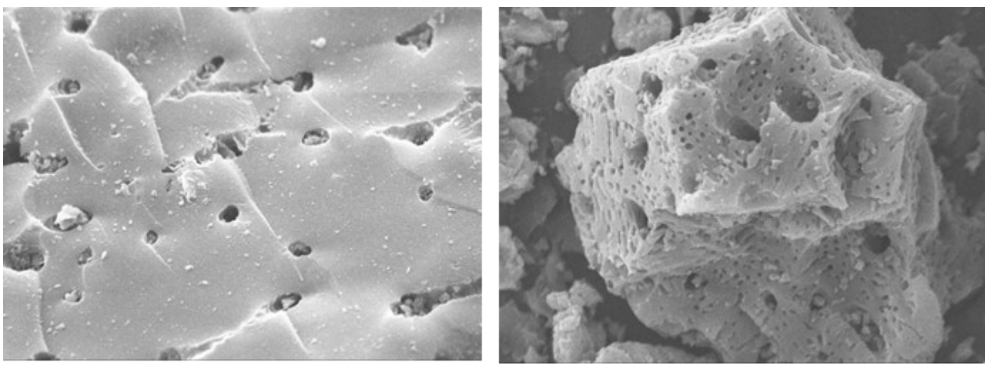

Figure 3. SEM micrograph of a) carbon non activation and b) activated carbon (KAF)

Tabel 2. EDX Analysis adsorben (a) Unactivated Carbon (KTA) dan (b) Activated carbon (KAF)

Elemen	Carbon (C) [WT.%]	Oxygen (O) [WT.%]	Iron (Fe) [wt.%]	Nitrigen (N) wt.%]	Total [wt.%]
KTA	78.93	21.07	0.00	0.00	100.00
KAF	99.20	0.80	0.00	0.00	100.00

Despite undergoing pyrolysis, the presence of oxygen indicates residual oxygen-containing functional groups, such as hydroxyl and carbonyl groups, as well as volatile components that were not completely removed during the initial carbonization process. After physical activation at 800°C, the activated carbon (KAF) sample exhibited a substantial increase in carbon content, reaching approximately 99 wt.%, with only a trace amount of oxygen detected within the sensitivity limits of the EDX technique. This result indicates a carbon-dominant composition rather than absolute elemental purity. This high increase in carbon purity is caused by the activation process which is very effective in removing the remains of volatile substances and mineral residues (ash), as evidenced by the loss of the Oxygen element which was previously at 21.07%. This increase in purity confirms the optimal success of purification and is very crucial, because 99.2% C purity guarantees the quality of KAF as a cosmetic pigment Carbon Black which is stable and has minimal risk of inorganic element contamination. The success of this activity is also proven by studies on other palm oil waste (empty bunches) which report that the activation process can increase the percentage of carbon elements and produce an efficient pore structure.

Crystal Structure Analysis (X-Ray Diffraction-XDR)

In the KTA (inactivated Carbon) sample, the diffractogram pattern (a) displays a very broad and weak diffraction band in the angle range of 2θ = 10° to 30°, with a faint amorphous structure peak (see **Figure 4**). This structure is a characteristic of amorphous carbon formed after the biomass carbonization process. This pattern indicates the presence of randomly arranged polycyclic aromatic hydrocarbons. After high-temperature physical activation at 800°C, the KAF sample in the diffractogram pattern (b) retains this amorphous phase but with slightly stronger band intensity. The KAF diffraction pattern shows two broad peaks typical of amorphous carbon at 2θ ≈ 26° and 43° which represent the (002) and (100) reflection planes of the carbon structure, respectively. The amorphous structure may contribute to the development of defect sites and pore formation, which are beneficial for adsorption. Increasing the temperature to 800°C causes the carbon atoms to have energies exceeding the activation energy. This drives a diffusion process, where atoms move to new positions or move into vacant lattice spaces (substitution), thereby increasing imperfections or amorphous sites on the surface, but not to the point of forming a pure graphite structure. The XRD patterns confirm that both KTA and KAF samples exhibit predominantly amorphous carbon structures. No sharp diffraction peaks characteristic of crystalline graphite was observed, indicating that graphitization did not occur under the applied activation temperature of 800°C. The observed broad peaks correspond to disordered or turbostratic carbon domains rather than true graphite structures.

Surface Functional Group Analysis (Fourier Transform Infrared – FTIR)

The FTIR pattern (**Figure 5**) of a KTA (inactivated Carbon) sample, a freshly carbonized lignocellulosic precursor material, is characterized by strong stretching vibrations of oxygen-containing functional groups. The broad absorption band in the high-wavenumber region, from 3444 cm^{-1} to 3407 cm^{-1} in the KTA spectrum, reflects the stretching vibrations of O-H bonds. The presence of these O-H bonds indicates the presence of alcohol, phenol, or

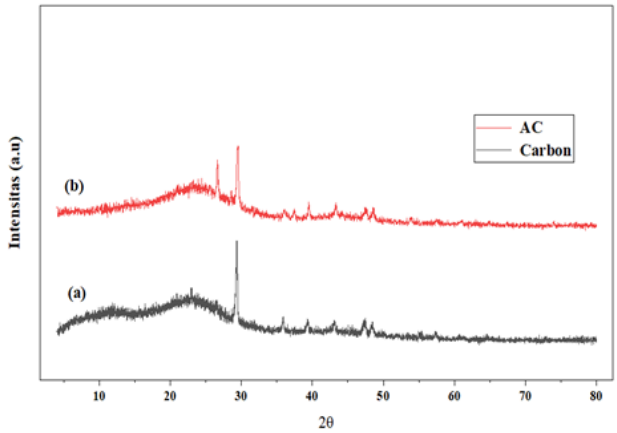

Figure 4. Diffractogram Patterns of (a) KTA and (b) KAF

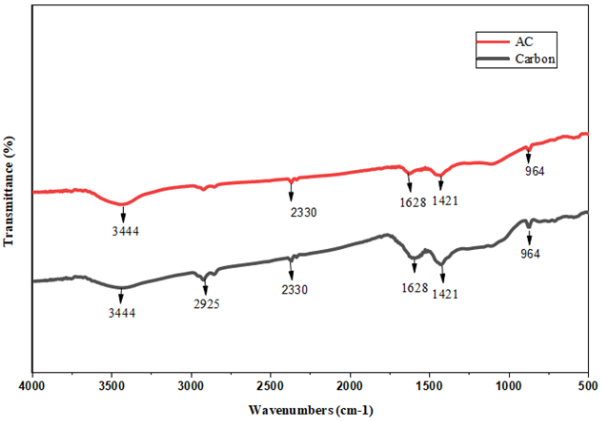

Figure 5. FTIR spectrum of KTA and KAF samples

water groups adsorbed on the material's surface. Furthermore, stretching vibrations of C-O and C=O bonds (which represent carboxyl or ketone groups) were also detected in the range 1087 cm^{-1} to 1628 cm^{-1}. These polar groups provide hydrophilic surface properties consistent with a high oxygen content [21].

In the KAF (Physically Activated Carbon) sample (pattern (b)) that had undergone thermal activation at 800°C, there was a significant decrease in the intensity of all oxygen-containing absorption bands. The peaks at 3444 cm^{-1} (O-H bond) and 1087 cm^{-1} are caused by the elimination of most polar groups and volatile substances due to the high activation temperature. This is in line with the EDX results which show 99.2% purity of carbon, where the band at around 1628 cm^{-1} associated with C=C vibrations indicates the presence of conjugated aromatic carbon domains. However, this formation does not indicate the formation of regular crystalline graphite, but rather represents an irregular or turbostratic aromatic carbon structure, as confirmed by XRD results that do not show the sharp diffraction peaks characteristic of crystalline graphite.

The dominance of C=C bonds and the reduction of polar groups cause the KAF surface to become more non-polar or hydrophobic. This hydrophobic property has important implications in cosmetic applications. A more hydrophobic surface tends to have better interactions with non-polar organic compounds, such as oils, sebum, and lipophilic components in cream formulations. This has the potential to increase the adsorption capacity of excess oil on the skin, so it can be used in skin care products to control shine and excess sebum. From a cosmetic safety perspective, the reduction of reactive oxygen groups on the carbon surface can also reduce the potential for irritation caused by active chemical interactions with the skin. A more stable structure dominated by aromatic carbon networks tends to be inert, thereby improving compatibility with the skin. In addition, moderate hydrophobic properties can support better dispersion in oil-based cream matrices or water-in-oil emulsions, as carbon particles are more compatible with the lipophilic phase than highly hydrophilic carbon.

EC Evaluation of Palm Kernel Shell Activated Charcoal

The quantitative evaluation (**Table 4**) shows clear differences among formulations F1–F3 with increasing activated carbon concentration. Colour intensity increased progressively from F1 to F3, confirming the effectiveness of activated carbon as a cosmetic colorant. Spreadability values ranged from 11.8 to 12.5 cm, with F2 exhibiting the best balance between ease of application and physical stability. Smudge resistance also improved with higher activated carbon content, with F3 showing the lowest pigment fading (<10%). The improved performance of the eyebrow cream is closely correlated with the characteristics of the activated carbon. The amorphous structure and high porosity observed in SEM and XRD analyses enhance pigment adsorption and uniform dispersion within the cream matrix. Furthermore, the dominance of C=C groups and reduced polar functional groups identified by FTIR result in a more hydrophobic surface, improving affinity with the oil phase and pigment adhesion to the skin. This correlation explains the increased color intensity and smudge resistance observed at higher activated carbon concentrations.

Organoleptic

Visualization was conducted to determine changes in color, aroma, and texture over four weeks. The cream's specifications were semi-solid, grain-free, homogeneous, and fragrant. The organoleptic test (**Table 3**) were conducted from the first to the fourth week, where F1 showed white cream as the weeks progressed, while F3 showed a change in cream color to black, then the product remained semi-solid, with no changes in odor. The color intensity of the product varied depending on the concentration of the active ingredient used. The higher the concentration, the more intense or concentrated the color [19].

Homogeneity

The homogeneity parameter (**Figure 6a**) of an eyebrow cream preparation is known as the ab-

Table 3. Evaluation of Palm Kernel Shell Activated Charcoal Eyebrow Cream

Category	F0	F1	F2	F3	Parameter
Organoleptic	White in color, argan scented, with semi-solid form	Slightly black in color, argan scented, with semisolid form	Black in color, argan scented, with semisolid form	Very black in color, argan scented, semi-solid in form	Stable, clear with semi-solid concentration
Homogeneity	No coarse particles	No coarse particles	No coarse particles	No coarse particles	There's no fibers and particles
pH	5	5	5	5	The pH requirement for skin is in the range of 4.5-7.
Spread Power	The spread is 12.5 cm, still within a good range and easy to spread.				Ideal Range: <5cm (too thick) 5-10cm (fairly good) 10-15cm (very good and easy to spread)
Smudge Resistance	The eyebrow cream still looks intact, the color is thick, and there is no visible spread of pigment to the surrounding area.				The pigment must adhere firmly to the skin and not move easily.
Smudge Resistance 3x Tap Tissue	There is some fading, but the main pigment remains attached to the skin.				Smudge Resistance Score: Fading <30% → Score 2 (fair) Fading <10–20% → Score 3 (good–very good)

Table 4. Quantitative evaluation of eyebrow cream formulations

Parameter	F1	F2	F3
pH	5.0 ± 0.0	5.0 ± 0.0	5.0 ± 0.0
Spreadability (cm)	11.8 ± 0.3	12.5 ± 0.2	12.2 ± 0.3
Color intensity (visual score*)	2.1 ± 0.2	3.4 ± 0.2	4.6 ± 0.3
Smudge resistance (fading, %)	22.5 ± 1.8	15.3 ± 1.5	8.7 ± 1.2

*Visual score: 1 (very light) – 5 (very dark)

sence of palpable grains and separated particles. The test was performed by spreading the preparation evenly on a glass slide. If no grains were found, it was considered homogeneous. All formulas showed homogeneity (**Table 3**), indicated by the absence of grains when applied [19-20].

Preparation pH

The test was conducted to determine its suitability to the skin's pH (4.5-6.5), to ensure there was no irritation during use. Irritation occurs if the pH is low or acidic, while skin drying occurs if the pH is too high. Based on the EC test results (**Table 3**) for palm shell activated charcoal, the formulation has the same pH, which was pH 5 (**Figure 6b**).

Spreadability Test

The spreadability test was conducted to determine the speed at which the cream spreads on the skin when applied. Based on observations (Table 3), the spreadability evaluation yielded a spreadability of 12.5 cm (**Figure 6c**), which meets the existing parameter requirements, indicating good spreadability due to easy spreadability with the ideal range: <5 cm (too thick), 5-10 cm (quite good), 10-15 cm (very good and easy to spread).

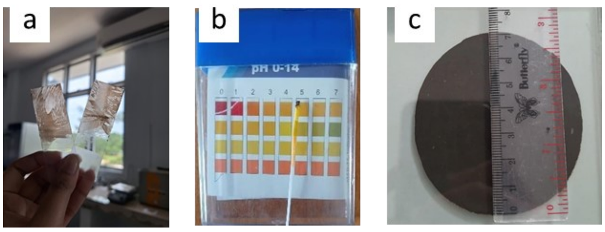

Figure 6. a. Homogenitas; b. pH;, and c. Spreadability of Eyebrow Cream

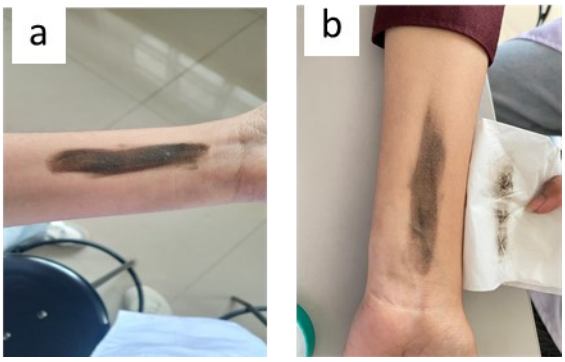

Figure 7. (a) Smudge Resistance Test Results and (b) Smudge Resistance Test Results after 3 taps using tissue

The spread is 12.5 cm, still within a good range and easy to spread.

Smudge Resistance Test

The results of the smudge resistance test (**Table 3**) showed that the formulated eyebrow cream had good friction resistance. The colour remained (see **Figure 7**) vivid after three wipes with a tissue, experiencing only slight fading without completely disappearing. This durability is influenced by the stable texture of the preparation, demonstrated by its 12.5 cm spreadability, and the combination of wax and film-forming components in the formula, which maintains the pigment's adherence to the skin. Therefore, the smudge test results were in the good category and met the smudge resistance criteria.

Conclusion

This study concluded that activated charcoal from palm kernel shells can be formulated into an eyebrow cream with a uniform level of homogeneity and a pH value that matches the skin's neutral pH of 5. This is supported by the activated charcoal characterization data using FTIR, XRD, and SEM-EDX, which demonstrate the detoxification capabilities of KAF, including the ability to absorb oil, sebum, and dirt that clog skin pores.

Acknowledgements

Thank you to the Institute for Research and Community Service of the Sumatra Institute of Technology for supporting this research through the 2025 Research Funding with Contract Number: 1999ar/IT9.2.1/PM.01.01/2025.

Figure 8. Eyebrow Cream Product Formulation

Author Contributions

Annisa Siti Zulaicha has contributed sufficiently to this research, from coming up with the idea, collecting the data, supervising, and producing the paper, Deviana Safitri conducted the research in the lab and collected the data, Iwan Syahjoko Saputra conducted to edit the manuscript, Wahyu Solafide Sipahutar conducted the analysis in the lab, and Yunita Fahnid conducted the analysis in the lab.

References

[1] Mouraiya, M.M., Dave, S.M., Gangurde, H.H., Kadam, K.A., and Bhalerao, A.A., "Cultivating Beauty: Formulation and Assessment of a Novel Herbal Cream For Eyebrow Growth Enhancement,' European Journal of Biomedical and Pharmaceutical Sciences., vol. 10(9), pp. 285-290, 2023, DOI: https://doi.org/10.52622/jisk.v2i2.26

[2] Wang, Z., Yuan, G., Sun, M., Fan, W., Fan, X., Lai, B., Leng, X., Zheng, G., and Dong, Z., "Deorative Cosmetics and Skincare Products Contribute Significantly to Short-Chain Perfluoroalkyl Carboxylates Exposure,' Journal of Hazardous Materials., vol. 495(2025), pp. 138846, 2025, DOI: https://doi.org/10.1016/j.jhazmat.2025.138846

[3] Mouraiya, M.M., Dave, S.M., Gangurde, H.H., Kadam, K.A., and Bhalerao, A.A., "Cultivating Beauty: Formulation and Assessment of a Novel Herbal Cream For Eyebrow Growth Enhancement,' European Journal of Biomedical and Pharmaceutical Sciences., vol. 10(9), pp. 285-290, 2023, DOI: https://doi.org/10.52622/jisk.v2i2.26

[4] Wang, Z., Yuan, G., Sun, M., Fan, W., Fan, X., Lai, B., Leng, X., Zheng, G., and Dong, Z., "Deorative Cosmetics and Skincare Products Contribute Significantly to Short-Chain Perfluoroalkyl Carboxylates Exposure,' Journal of

Hazardous Materials., vol. 495(2025), pp. 138846, 2025, DOI: https://doi.org/10.1016/j.jhazmat.2025.138846

[5] Jaini, A., Quoquab, F., Mohammad, J., and Hussin, N., "I Buy Green Products, do yo..?" The Moderating Effect ofeWOM on Green Purchase Behavior in Malaysian Cosmetics Industry,' International Journal of Pharmaceutical and Healthcare Marketing., vol. 11(1), pp. 89-112, 2020, DOI: https://doi.org/10.1108/IJPHM-02-2019-0017

[6] Buhani, Dewi, J. S., Fajriyah, N.S., Rilyanti, M., Suharso, Sumadi, and Elwakeel, K. Z., "Modification of Non-Activated Carbon from Rubber Fruit Shells with 3-(Aminopropyl)- Triethoxysilane and Its Adsorption Study on Coomassie Brilliant Blue and Methylene Blue in Solution,' Water, Air & Soil Pollution., vol. 234, pp. 578, 2023, DOI: https://doi.org/10.1007/s11270-023-06506- 2

[7] Zulaicha, A.S., Buhani, and Suharso., "Modification of Activated Carbon from Elaeis Guineensis Jacq Shell with Magnetite (Fe3O4) Particles and Study Adsorption-Desorption on Ni(II) Ions in Solution,' Journal of Physics: Conference Series., vol. 175, pp. 1-11, 2021, DOI: https://doi.org/10.1088/1742-6596/1751/1/012086

[8] Zulaicha, A.S., Nusantari, C.S., and Setiajaya, A., "Functionalization Magnetite Activated Carbon Coatinng With Silane Agent as Adsorbent for Crystal Violet and Methyl Oange Dyes,' Analit: Analytical and Environmental Chemistry., vol. 9(2), pp. 56-67, 2024, DOI: https://doi.org/10.23960/analit.v9i02.209

[9] Buhani, Halimah, S.N., Suharso, and Sumadi., "Utilization of Activated Carbon from Candlenut Shells (Aleurites Moluccana) as Methylene Blue Adsorbent,' Rasayan Journal of Chemistry., vol. 15, pp. 124-131, 2022, DOI: https://doi.org/10.31788/RJC.2022.1516538

[10] Zulaicha, A.S., Saputra, I.S., and A. Setiajaya., "Formulasi Sediaan Kosmetik Dekoratif dengan Zat Warna Alami dari Ekstrak Buah Senduduk (Melastoma malabathricum),' Prosiding Sains Nasional dan Teknologi., vol. 13(1), pp. 84-94. 2023.

[11] Zulaicha, A.S., Saputra, I.S., Buhani, B., and Suharso, S., "Magnetite Particle Coating to Activated Carbon of Oil Palm Shells as Adsorbent of Cu(II) and Ni(II) Cation,' Journal of the Iranian Chemical Society., vol. 19(12), pp. 4777–4787, 2022, DOI: https://doi.org/10.1007/s13738-022-02641-5

[12] Zulaicha, A.S., Nusantari, C.S., Setiajaya, A., "Functionalization Magnetite Activated Carbon Coatinng With Silane Agent As Adsorbent For Crystal Violet And Methyl Orange Dyes,' Analit: Analytical and Environmental Chemistry, pp. 56-67. 2024.

[13] Zulaicha, A.S., Buhani, Suharso., "Modification of Activated Carbon from Elaeis Guineensis-Jacq Shell with Magnetite (Fe3O4) Particles and Study Adsorption-Desorption on Ni(II) Ions in Solution,' Journal of Physics: Conference Series. DOI: https://doi.org/10.1088/1742-6596/1751/1/012086

[14] Zulaicha, A.S., Saputra, I.S., Buhani, B. et al., "Magnetite Particle Coating to Activated Carbon of Oil Palm Shells as Adsorbent of Cu(II) and Ni(II) Cation,' J Iran Chem Soc, vol. 19, pp. 4777–4787. 2022. DOI : https://doi.org/10.1007/s13738-022-02641-5

[15] Zulaicha, A. S., Munawaroh, K., Saputra, I. S., and Setiajaya, A., "Utilization of Senduduk Fruit Extract (Melastoma malabathricum) for Natural Color in Lip Cream,' Walisongo Journal of Chemistry, vol. 6(2), pp.215–223. 2023. DOI: https://doi.org/10.21580/wjc.v6i2.18427

[16] Yasir, A.S., Suryaneta, Putri, T., Saputra, I., Handayani, K., Zulaicha, A., et al., "Optimization of Formula and In Vitro Activity Testing of O/W Lotion Cosmetic Formulations Containing Ethanol Extract of Cat's Whiskers Leaves (Orthosiphon aristatus) as Sunscreen,' Indonesian Journal of Cosmetics, vol. 2(1), pp. 10-25. 2023.

[17] Mokhtar, H.F., Zainal, A.H., and Mohd, R., "Application of FTIR and SEM in Characterization of Plant-Derived Cosmetic Base Materials,' Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy., vol. 259, pp. 119892, 2022.

[18] Singh, J., Brar, P.M., Dhillon, A.N., and Sarma, S.S., "Evaluation of Organoleptic and Physical Properties of Semisolid Herbal Formulations,'

Journal of Herbal Medicine., vol. 25, pp. 100422, 2021.

[19] Rico, F., Mazabel, A., Egurrola, G., Pulido, J., Barrios, N., Marquez, R., and Garcia, M., "Meta- Analysis and Analytical Methods in Cosmetics Formulation: A Review,' Cosmetics., vol, 11(1), pp. 1, 2024, DOI: https://doi.org/10.3390/cosmetics11010001

[20] Budiman, I., Amirta, A., Yuliansyah, Widyaningrum, A.A., and Fatriasari, W., "Activated Carbon for Cosmetics Applications. In Biomass-based Cosmetics,' Springer Nature Singapore., pp. 217–237, 2024, DOI: https://doi.org/10.1007/978-981-97-1908-2_10

[21] Iskandar, B., Liu, T.W., Mei, H.C., Kuo, I.C., Surboyo, M.D.C., Lin, H.M., and Lee, C.K., "Herbal Nanoemulsions in Cosmetic Science: A Comprehensive Review of Design, Preparation, Formulation, and Characterization,' Journal of Food and Drug Analysis., vol. 32(4), pp. 428– 458. 2024, DOI: https://doi.org/10.38212/2224-6614.3526