Reviving Malay Traditional Black Ink: Historical Recipes, Characteristics, and Reconstruction

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ABSTRACT

Malay traditional black ink, widely used in historical manuscripts, exemplifies durability, permanence, and a composition based on natural, locally sourced materials. This study reconstructs a historical recipe using indigenous ingredients such as soot, mangosteen charcoal, and cashew gum. The formulation process involved experimental procedures including soot combustion, gum extraction, and the incorporation of additives like black pepper and salt. Testing the ink's properties through scientific analysis—alongside accelerated ageing and light exposure experiments—demonstrated its strong colour stability, resistance to fading, and consistent penetration into paper substrates. Compared to several commercially available inks, the traditional formulation displayed favourable performance in terms of durability and environmental compatibility. Feedback from professional calligraphers confirmed the ink's practicality, with minor adjustments suggested to improve flowability and drying time. The findings highlight the cultural and material significance of Malay traditional black ink and contribute to the preservation of historical knowledge on ink preparation techniques in the Malay region.

1. Introduction

Malay manuscripts, created between the 16th and 19th centuries, are invaluable cultural artifacts encompassing religious texts, historical chronicles, and literary works. These manuscripts were predominantly written in Jawi script—a modified form of Arabic with distinctive regional stylistic characteristics, as described in paleographic studies[1] —and were typically inscribed on imported European, Chinese, or Indian paper. Black ink, a cornerstone of manuscript production, symbolised permanence, knowledge, and authority. However, the traditional knowledge of ink-making was confined to exclusive circles such as palace officials, Islamic scholars, and students in *pondok*[2] schools.

The inks—whether black or coloured—were traditionally produced using locally available natural resources. Ingredients included carbon sources (e.g., soot, burnt rice, charcoal, and mangosteen charcoal), binding media (e.g., cashew gum, young mangosteen skin latex, and cobwebs), and additives (e.g., salt, black pepper, and virgin coconut oil). This labour-intensive craft required meticulous preparation, including the collection and drying of raw materials under sunlight. Practical guidance on these preparatory processes was preserved in instructional resources on manuscript writing.[3]

The late 19th century saw a sharp decline in traditional ink production with the introduction of industrial inks and printing technologies. The adoption of lithographic presses by Malay/Muslim printers significantly impacted the manuscript tradition. Munshi Abdullah (Abdullah bin Abdul Kadir), widely regarded as a pioneer of Malay printing, learned printing techniques from the English missionary Walter Medhurst (1796–1857) in Melaka. He contributed to missionary publications as a translator and editor and authored new works intended specifically for print, becoming the first non-European writer to publish in Malay.

Despite the long-standing use of these inks, written documentation of traditional ink recipes and production techniques remains scarce, creating critical gaps in understanding their composition and preparation. This study seeks to reconstruct a historical formulation of traditional Malay black ink, evaluate its material properties, and explore its significance within the broader context of Malay manuscript culture and natural-material-based craftsmanship.

2. Reconstructing historical Malayan ink recipes

2.1. Source Research of Historical Ink Recipes

Malay manuscripts served various purposes, including religious instruction, governance, and poetry. Notable examples such as *Hikayat Abdullah*[4] and *Hikayat Raja Khandak*[5] illus-

1 Wan Ali (1987), pp. 57–61

2 "Pondok" originates from the Arabic word funduq*, meaning "a place" or "shelter." It can therefore be inferred that* sekolah pondok *(pondok schools) consisted of small buildings serving as temporary shelters for students. The earliest* sekolah pondok *began around 1450 in Malacca, but the system only spread more widely to other states such as Kelantan, Terengganu, and Kedah in the 19th century.*

3 Wan Ali (2012), pp. 24–33

4 Hikayat Abdullah *is a major literary work by Abdullah bin Abdul Kadir, a Malacca-born* munshi *(scribe and teacher) based in Singapore. Composed in the* hikayat *genre, the work is widely regarded as his autobiography, offering a personal yet perceptive account of Singaporean and Malaccan society in the early 19th century. See: Abdullah bin Abdul Kadir (1997), p. 37.*

5 Hikayat Raja Khandak *is a well-known Malay narrative set during the early Islamic wars, featuring the eponymous antagonist Raja Khandak—also known in* trate the cultural significance of these works. These texts were commonly written on imported European, Chinese, or Indian papers and composed in Jawi script—a modified form of Arabic.

Traditional black ink evolved through local ingenuity and external influences via trade with China, India, and the Arab world. The two primary types of black ink, ranging from deep black to various shades of brown, were:

- **Carbon-Based Ink:** Made from soot, burnt rice, or mangosteen charcoal, and mixed with plant-based binders such as cashew gum. This type of ink was widely used from the 14^{th} to the 19^{th} centuries, particularly in manuscripts that were frequently copied and recopied. *Professor emeritus of Malay Literature Choo Ming Ding*[6] *(National University of Malaysia) noted that this ink was a staple during the height of Malay manuscript production.*
- **Iron Gall Ink:** Derived from tannins and iron sulphate, this ink offered a chemical alternative to carbon-based inks. It required additional gum as a dispersion agent rather than solely as an adhesive and became prominent in the early 19^{th} century.

Coloured inks, including red and yellow, were also used to emphasise important text such as Qur'anic verses, poetry, or chapter headings. For instance, red ink highlighted key sections within continuous texts, as observed in *Hikayat Raja Khandak* (Fig. 1).[7] The use of vibrant coloured inks, particularly red, reflects a broader tradition of manuscript embellishment, as extensively documented in major collections such as those of the British Library.[8] Marsden's *History of Sumatra* documented the use of soot mixed with egg white for ink production, suggesting regional variation in techniques and materials. Such accounts reflect the diversity of methods and ingredients based on locally available resources.

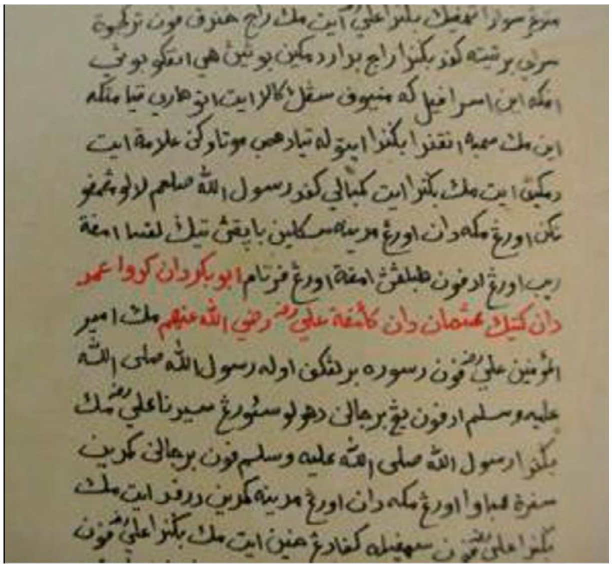

Fig. 1: *A continuous text in* Hikayat Raja Khandak *and* Raja Badar *(Or.16128) written in black and partially in red ink. Image reprinted with kind permission of the British Library.*

Primary sources, including *Hikayat Abdullah* and William Marsden's *History of Sumatra*, were reviewed. William Marsden, a British administrative officer stationed in Bengkulu (then Bangkahulu), remarked that the ink used by the Malays was made from a mixture of soot and egg white.[9] The oral transmission of ink-making knowledge highlights the challenges in documenting traditional practices.

some versions as Raja Handak or Raja Handik—and his son Raja Badar, who battle against the forces of the Prophet. The story was widely popular and exists in multiple regional adaptations, including Javanese, Sundanese, Acehnese, and Makassarese versions. See: Ding (1992), pp. 9–11.

6 Ding (1992), pp.9-11

7 See above note on Hikayat Raja Khandak

8 Gallop (1991), p. 172

9 Marsden (1811), p. 28

According to Munsyi Abdullah, his grandmother supplied him with writing ink made from rice that had been burnt to cinders. Unfortunately, no further information about the ingredients or preparation process was provided. Munshi Abdullah's account noted:[10]

"By the will of Allah, the disease was cured, and my body recovered and returned to normal. Then, my grandmother gave me a toy, which was a stick of reed pen and a wooden board, along with a little rice ink. She said: 'This is what you play with every day. If you play with soil or go out in the sun, I will punish you.'"

This quote underscores the early use of rice-based ink as a carbon source, although it does not detail the preparation process.

Scholars such as Ding, Wan Ali, and Siti Hawa have documented numerous indigenous Malay ink-making formulations, mostly preserved through oral traditions.[11] These records—though fragmented—highlight three core components as follows:

- **Colouring Agent** – carbon or other pigments
- **Adhesive** – cashew gum, mangosteen latex
- **Additives** – black pepper, salt

2.2. Preparation of Ingredients

The preparation of Malay traditional black ink involved the careful selection and processing of natural, locally available ingredients, following practices derived from historical sources. This process reflects a combination of indigenous artisanal knowledge and systematic experimentation, aimed at reconstructing the ink in a manner faithful to its traditional composition and use. The materials used were selected based on documented historical references, oral traditions, and ethnographic accounts. Key materials included:

- **Soot:** Soot was produced through the controlled combustion of kerosene, ensuring consistent particle size and purity to contribute to the ink's intense pigmentation and smooth texture. It was traditionally collected from kerosene lamps (pelita ayam), cobwebs in Malay kitchens, and soot deposits on cooking pots (Fig. 2).

Fig. 2: *Preparation of soot by burning kerosene oil. (Image from the author's personal collection.)*

- **Mangosteen Charcoal:** Derived from the dried rind of Garcinia mangostana, mangosteen charcoal is valued for its high carbon content and pigmentation, which provide both stability and richness in colour. Its use demonstrates the resourcefulness in utilising locally abundant materials (Fig. 3).

10 Abdullah bin Abdul Kadir (1997), p. 37
11 Ding (1986); Ding (2004); Ding (2015); Wan Ali (1987); Wan Ali (2012); Siti Hawa Salleh (1995)

Fig. 3: *Preparation of mangosteen charcoal: (a) Natural sun-drying of mangosteen skins (3 days)*
(b) Use of coconut coir as fire starter
(c) Charcoaling process
(d) Fully carbonised mangosteen rinds

- **Cashew Gum:** Cashew gum, extracted from the bark of the Anacardium occidentale tree, served as a natural binding agent. It imparts both adhesion and viscosity to the ink. According to Paula & Rodrigues[12], the exudate is a branched acidic heteropolysaccharide, traditionally used as a substitute for gum Arabic and applied in pharmaceuticals, adhesives, and emulsifiers (Fig. 4).

Fig. 4: *Preparation of cashew gum:*
(a) Gum exudates collected from cashew tree bark
(b) Moisture removed by drying at 105°C overnight
(c) Dried gum
(d) Ground cashew gum passing through 0.55 mm sieve
(e) Final powdered form

- **Additives:** Black pepper, salt, and virgin coconut oil were added to enhance the ink's flow, viscosity, and durability.

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12 Paula/Rodrigues (1995), pp. 171–181

These ingredients also improved microbial resistance and drying properties, contributing to the longevity and usability of the ink in manuscripts and artwork.

Each of these ingredients was processed using methods reconstructed from historical recipes, field interviews, and ethnographic notes. This preparatory phase established the material basis for the subsequent ink-making and performance testing described in the following sections.

2.3. Ink Making

2.3.1 Traditional Ink Recipes

Several recipes and techniques for making traditional Malay black ink were documented by Wan Ali[13] and are summarised in Table 1 below.

Boiling was the most commonly used method to homogenise and emulsify ink ingredients. Sustained heating ensured proper distribution and binding of the components. In some recipes, fermentation was employed, though this method required caution due to the potential release of flammable gases.

Table 1

Traditional Malay Black Ink Recipes

Methods	Ingredients	Procedures
Method 1 (Boiling–Drying)	5 cups of soot/lamp black Fistful ground cashew gum Exiguous mangosteen skin charcoal 1 teaspoon of ground black pepper 5 liter of pure water A pinch of salt A bit of virgin coconut oil	Cashew gum and black pepper were ground into powder. All dry ingredients were added to water in a vessel. Salt and coconut oil were added, and the mixture was boiled while stirring until homogenised. The ink was dried into cakes and rehydrated with water for use.
Method 2 (Fermentation)	Old cobwebs Thin mangosteen rind charcoal Charcoal from young rambutan skin Charcoal-infused fruit Pure water	All ingredients were combined in a vessel with water and virgin coconut oil. The mixture was fermented for several days until ready for use.
Method 3 (Boiling)	Charcoal Ground cashew gum Ground glutinous rice Pure water	Charcoal and cashew gum were ground separately. Mixed with water and boiled until homogenised. The ink was strained through coarse linen for use.

Fig. 5: *Step-by-step visual guide to the preparation process of Malay traditional black ink, highlighting both its artisanal roots and scientific logic.* (Image generated using AI tools.)

13 Wan Ali (1987), pp. 57–61

3.3.2 Ink Formulation

The ink was formulated through an iterative experimental process using the One-Factor-At-a-Time (OFAT) method to optimise the proportions of primary ingredients based on flow, pigmentation, and overall handling. Through a series of controlled trials, a 2:1 ratio of soot to cashew gum was identified as optimal for achieving a balanced formulation with strong black colouration, acceptable viscosity, and stable adhesion to paper substrates.

Additives such as black pepper, salt, and virgin coconut oil were gradually incorporated and adjusted to improve drying time, flowability, and general ink performance, while staying faithful to materials mentioned in historical recipes. The experimental approach allowed for systematic refinement of the formula, ensuring consistency and reproducibility across batches. For a 100 ml ink preparation, the standard additive composition was as follows:

- Black pepper: 0.5 g
- Salt: 0.1 g
- Virgin coconut oil: 0.5 ml

The initial reproduction of traditional Malay black ink, referred to as T1R1 (Test 1 for Recipe 1), was based on standardised metric conversions of qualitative descriptions found in oral and written sources. This approach enabled controlled experimentation while respecting the ink's traditional roots. The final composition is detailed in Table 2.

Table 3 lists the materials used for the ink formulation. Traditional descriptions such as "5 cups per 5 litres" or "fistfuls" were translated into standardised metric quantities to ensure reproducibility. For instance, soot and mangosteen charcoal were each approximated to 20 g per litre, while cashew gum was estimated at 50 g per litre.

Table 2

Initial Estimation of Traditional Malay Black Ink (T1R1) Using Metric System

Component	Traditional Black Ink Recipe (T1R1)
Lamp black/soot	2 g
Mangosteen charcoal	2 g
Cashew gum	1 g
Black pepper	0.5 g
Virgin coconut oil	0.5 ml
Salt	0.1 g
Distilled water	100 ml

Table 3

Materials Used in the Preparation of Traditional Malay Black Ink

Material	Description
	Soot (carbon source) Collected from controlled combustion of kerosene oil.
	Mangosteen charcoal Charred rind of *Garcinia mangostana*, sun-dried for 3 days. Description Index 6: outer rind dark purple to black, latex-free, easily separable from pulp.
	Cashew gum (adhesive) Gum exudate from the stem bark of *Anacardium occidentale* (cashew tree).
	Virgin Coconut Oil (manufactured) Commercially sourced from Multifilla (M) Sdn. Bhd., Selangor, Malaysia.
	Black pepper (Sarawak[14] origin) Sarawak origin, dry-fried (no oil) for 30 minutes, then ground into powder.
	Table salt (NaCl) Commercially available sodium chloride.
	Distilled water Laboratory-grade distilled water for consistency.

14 Sarawak, a Malaysian state on the island of Borneo, stretches along the island's northwest coast and borders the South China Sea. It is known for its rugged interior rainforest, much of which is protected as national parkland.

3.3.3 Ink Preparation Procedure:

In the T1R1 ink-making process, all dried ingredients were first combined with distilled water in their designated proportions. Virgin coconut oil was added, and the mixture was blended using a portable mixer until homogeneous.

The blended ink mixture was then heated on a hot plate at 100°C for 30 minutes, with continuous stirring using a magnetic stir bar to ensure even distribution of the components. Once cooled to room temperature, the mixture was pounded using a mortar and pestle to refine its texture, then filtered through a silk cloth to obtain a fine, smooth suspension.

The final ink was stored in an airtight container to maintain its quality and prevent microbial contamination.

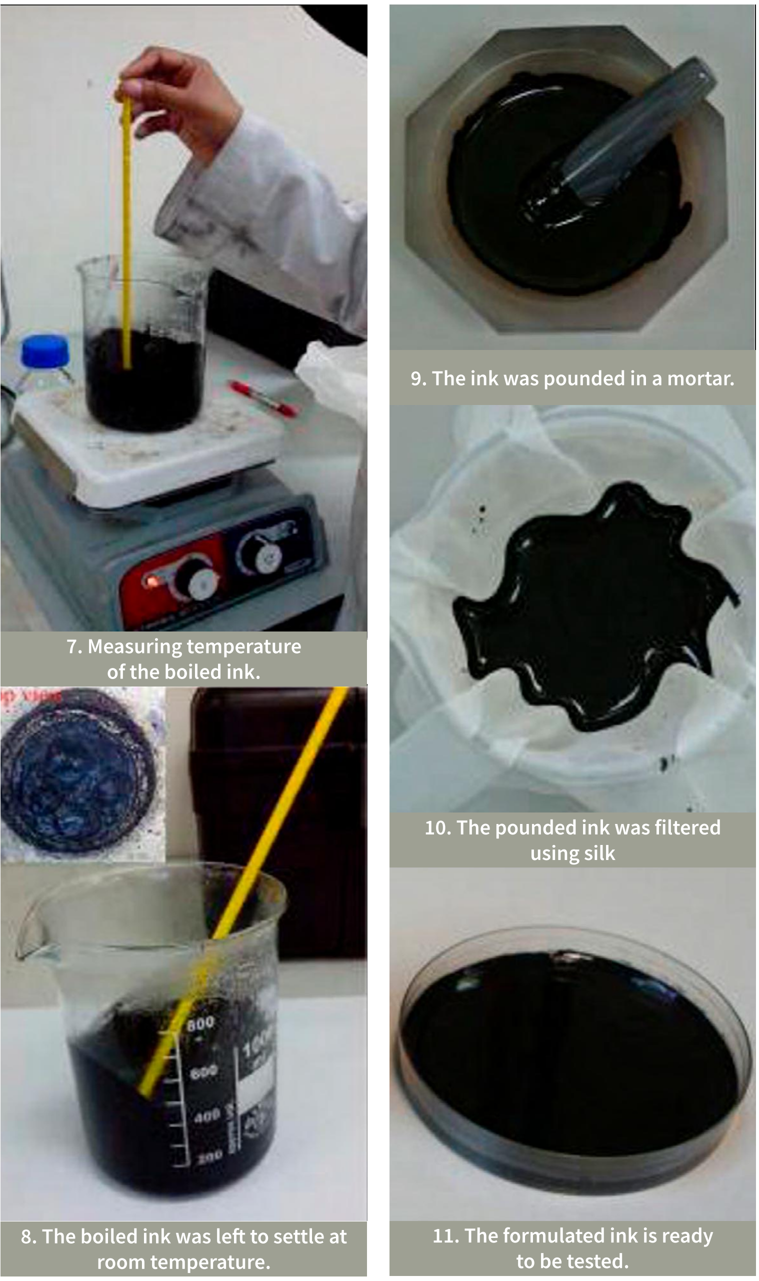
Figure 6 illustrates the quantification process of ingredients during the formulation of traditional Malay black ink, ensuring precision and consistency across all batches.

Fig. 6: *The researcher quantifying the ingredients according to their proportions.* Image source: Author's personal collection.

In the ink preparation process, all dried ingredients were first weighed according to their designated proportions and mixed with 100 ml of distilled water. Virgin coconut oil was then added, and the mixture was blended using a portable mixer until a homogeneous solution was achieved.

The resulting mixture was transferred to a hot plate and heated at 100°C for 30 minutes, with continuous stirring facilitated by a magnetic stir bar to ensure uniform dispersion of the components. Once the solution cooled to room temperature, it was transferred to a mortar and pounded to refine its texture. The ink was then filtered using a silk cloth, producing a fine suspension suitable for application. The final product was stored in an airtight container to preserve its quality, prevent contamination, and prepare it for testing and further applications.

Figure 7 illustrates the step-by-step preparation of the ink, highlighting key stages to ensure the uniform distribution of ingredients and optimal consistency.



7. Measuring temperature of the boiled ink.

8. The boiled ink was left to settle at room temperature.

9. The ink was pounded in a mortar.

10. The pounded ink was filtered using silk

11. The formulated ink is ready to be tested.

Fig. 7: *Flowchart illustrating the sequential steps in the preparation of traditional Malay black ink, from ingredient mixing to final storage.*

3.4. Ink application

To further validate the formulation, the ink was subjected to extensive performance testing. Application trials were conducted on European handmade paper[15] (Magnani Platinum), sourced online from TALAS (Conservation, Archival & Bookbinding Supplies). The ink was applied using a traditional Malay writing instrument made from fern stem (batang resam) or batang kabung (Arenga pinnata). These pens require dipping into ink and operate similarly in function and mechanism to the Western quill and the Chinese brush.

As noted by Wan Ali (1988), *pena kabung* and *pena resam* were commonly used by Malays as writing tools. Although numerous traditional Malay ink recipes exist, this study focused on a single formulation, designated as T1R1 (Test 1 for Recipe 1).

Figure 8 illustrates the results of the ink test, where the word “Test” was written using the T1R1 formulation. Under magnification, the ink demonstrated a deep black colouration with slight brownish staining around the edges, likely caused by excess virgin coconut oil.

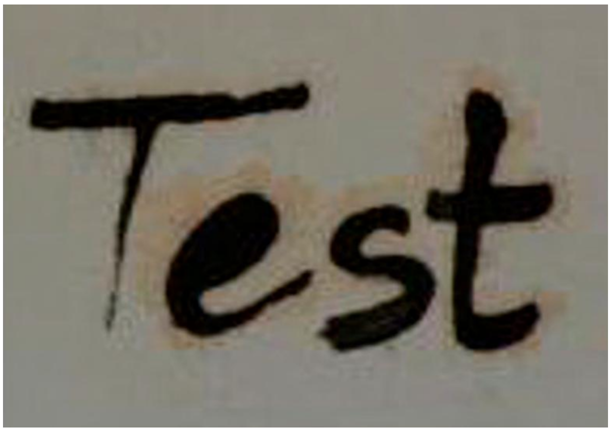


Fig. 8: *T1R1 ink formulation tested on European handmade paper (Magnani Platinum).*

3.5. Ink Performance and Required Modifications

Initial observations of the freshly prepared ink revealed limited flowability, particular-

15 Magnani Pescia *is a mould-made printmaking paper from Italy, produced from 100% cotton. It is chlorine-free and pH-neutral, with internal sizing and minimal surface sizing, making it ideal for delicate printing and writing applications. Malay manuscripts were typically written on imported European papers, identifiable through watermarks. See: Russell (1986), pp. 49–53; Russell (1993), pp. 474–502. On* delaung *paper used in Java, see: Ricklefs (1974), pp. 120–122; Ricklefs (1981), pp. 60–61; Kumar (1976), pp. 87–90.*

ly during application with traditional writing tools. Notably, after a two-month stabilisation period, the ink exhibited significant improvement in flow characteristics, suggesting that resting time played an important role in enhancing the formulation's usability.

These findings informed a series of iterative modifications, targeting the enhancement of:

- Pigment intensity for deeper blackness,
- Binding strength to improve adhesion and consistency, and
- Drying time to increase practicality during artistic use.

Adjustments were made to the proportions of carbon sources, cashew gum, and additives. The refinements led to notable improvements in visual and handling properties, particularly in terms of ink smoothness, colour depth, and response on different paper substrates.

The optimised ink formulation preserved the material authenticity of traditional recipes while improving its **suitability for artistic and calligraphic applications**, thereby reinforcing its value as a historically informed, sustainable medium.

3.6. Ink Optimisation

The initial test results indicated that several modifications were necessary to improve both the physical and visual properties of the traditional Malay ink. These refinements were based on direct observation during application and post-application assessments.

3.6.1 Recommended Modifications

The key recommendations are as follows:

1. Enhance Black Colour Intensity: The colour output was insufficiently dark. To address this, the proportions of lamp black (soot) and mangosteen charcoal were increased.
2. Improve Emulsification and Stabilisation: A slow emulsification process and extended stabilisation time suggested an inadequate concentration of binding agent. An increase in cashew gum was proposed to enhance viscosity and colloidal stability.
3. Reduce Drying Time: The ink exhibited a relatively slow drying rate. Additional black pepper was found to effectively accelerate drying.
4. Eliminate Brownish Staining: A brown halo observed around the ink strokes (8) indicated an excess of virgin coconut oil, which was subsequently reduced.
5. Neutralise Odour: Salt was originally included to remove unpleasant odours. As other ingredient quantities increased, the amount of salt was proportionally adjusted to maintain olfactory neutrality.

3.6.2 Modified Ink Formulations

Table 4 presents six experimental formulations (Ex1R1 to Ex2bR1), all derived from the original traditional recipe (T1R1), with systematic variations.

- Ex1R1, Ex2R1, and Ex3R1 differ in cashew gum content.
- Ex2R1, Ex2aR1, and Ex2bR1 vary in their black pepper and salt content.

Table 4
Modified Traditional Black Ink Formulations

Component	T1R1 (original recipe)	Ex1R1	Ex2R1	Ex3R1	Ex2aR1	Ex2bR1
Lamp black/soot	2 g	4 g	4 g	4 g	4 g	4 g
Mangosteen charcoal	2 g	4 g	4 g	4 g	4 g	4 g
Cashew gum	1 g	4 g	2 g	8 g	2 g	2 g
Black pepper	0.5 g	1 g	1 g	1 g	2 g	3 g
Virgin coconut oil	0.5 ml	0.1 ml	0.1 ml	0.1 ml	0.1 ml	0.1 ml
Salt	0.1 g	0.2 g	0.2 g	0.2 g	0.3 g	0.5 g
Distilled water	100 ml	100 ml	100 ml	100 ml	100 ml	100 ml

Stability Assessment and Accelerated Ageing Tests

To evaluate long-term stability, pH levels were monitored for each formulation over a one-year period. Significant pH fluctuations can affect surface tension, viscosity, and colloidal stability, potentially compromising ink performance.[16] In addition to pH monitoring, two accelerated ageing methods were employed:

- Moist-heat treatment
- Lightfastness testing

Ink samples were applied to European handmade paper (Magnani Platinum) in standard dimensions (75 mm × 140 mm). Each formulation was tested in duplicate—one sample and one control—to ensure consistent evaluation.

To benchmark performance, the following commercial carbon inks were tested under the same conditions:

- Mangsi Gentur (Indonesia)
- Sea Lion (Chinese writing fluid)
- Winsor & Newton (Indian Ink Liquid)

3.7. Performance-Based Refinements

Based on testing and the findings of earlier investigations,[17] the initial T1R1 formulation required several refinements:

- **Increased black colour intensity:** Achieved through higher soot and charcoal content.
- **Enhanced binding properties:** Additional cashew gum improved emulsion stability and adhesion.
- **Improved drying time:** Elevated black pepper content facilitated faster drying.
- **Reduced staining:** Lowered coconut oil content minimised lateral ink migration.
- **Balanced odour:** Adjusted salt content helped maintain olfactory neutrality in the final product.

3.8. Reference Formulation

Table 5 revisits the original formulation (T1R1), reconstructed based on historical descriptions and converted into metric measurements for standardisation and reproducibility.

Table 5
Estimated Metric Measurements for the Original Traditional Malay Black Ink Formulation Based on Historical Descriptions (T1R1).

Component	Original Recipe (T1R1)
Lamp black/soot	2 g
Mangosteen charcoal	2 g
Cashew gum	1 g
Black pepper	0.5 g
Virgin coconut oil	0.5 ml
Salt	0.1 g
Distilled water	100 ml

16 Lichtenberger (2004)
17 Rajabi (2016), pp. 119–120

4. Evaluation of the optimised ink formulation

4.1 pH Test

The optimised formulation of traditional Malay black ink demonstrated excellent colloidal stability, with minimal sedimentation and only slight variations in pH observed over a one-year period. These characteristics indicate a stable composition suitable for long-term storage and practical artistic application. The combination of soot and mangosteen charcoal yielded a deep, consistent black tone, while cashew gum effectively functioned as a natural binder, ensuring uniform distribution across the paper fibres.

As is typical with pigment-based inks, the presence of solid particles introduces challenges such as flocculation and sedimentation. Beetsma,[18] in *"How to Prevent Sedimentation and Settling During Storage,"* notes that flocculation refers to the clustering of fine particles, which often precedes sedimentation, the gravitational settling of particles. Sedimentation is influenced by particle size, density, and the viscosity of the surrounding medium—larger particles in a less viscous medium tend to settle more quickly.

In this study, sedimentation was evaluated visually by placing 0.5 ml of each ink formulation into sealed glass tubes, with observations recorded at intervals from 24 hours to 30 days. This approach followed the methodology described by Mitchell[19], who noted that ink typically remains visually stable for up to three weeks before early signs of particle separation appear.

Another key metric for assessing ink stability was pH variation over time, as fluctuations in pH can affect the surface tension, viscosity, and colloidal behaviour of the ink. All formulations were stored in enclosed glass tubes and monitored for pH changes over a 12-month period. Minor water loss due to evaporation was anticipated, potentially influencing pH slightly; however, all readings remained within acceptable ranges, indicating good chemical stability.

Table 6 presents the pH values of each formulation. Most samples showed minimal variation throughout the observation period. Notably, Ex2bR1 exhibited a more distinct shift in pH after one month, suggesting that this formulation may require a longer stabilisation period before optimal use.

Table 5

Estimated Metric Measurements for the Original Traditional Malay Black Ink Formulation Based on Historical Descriptions (T1R1).

Sample	pH Measurement			
	Day-0	Month-1	Month-6	Month-12
T1R1 (original recipe)	6.1	9.1	8.8	8.9
Ex1R1	7.8	7.8	8.1	8.1
Ex2R1	7.9	8.2	8.4	8.7
Ex3R1	7.7	7.5	7.2	7.4
Ex2aR1	7.4	7.9	8.3	8.4
Ex2bR1	7.2	8.8	8.2	8.2

4.2. Ink Adhesion and Drying

The writing performance of the various ink formulations was evaluated through direct application using traditional pens. The results of these tests are summarised in Table 7. All formulations were tested in their freshly prepared state.

Among the formulations Ex1R1, Ex2R1, and Ex3R1, only Ex2R1 ink demonstrated smooth flow from the pen, producing a dense black line with good surface adhesion. In con-

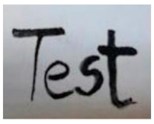
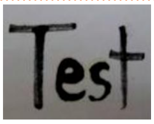
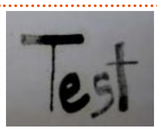
18 Beetsma (2019)
19 Mitchell (1904), p. 251

trast, both Ex1R1 and Ex3R1 resulted in writing that flaked off once dried and turned powdery, suggesting poor binding strength or oversaturation of solid components.

In the next group—Ex2R1, Ex2aR1, and Ex2bR1—the Ex2aR1 formulation was deemed unsuitable. The ink appeared pale black and watery, with uneven contours and poor adhesion. This is consistent with earlier sedimentation test results, which indicated the presence of a thick solvent layer over a thin, dense sediment layer, suggesting that carbon pigments had flocculated and settled, reducing pigment availability in the liquid phase.

Both Ex2R1 and Ex2bR1 inks flowed smoothly during writing. Notably, Ex2bR1 exhibited a glossy and dense black finish, indicating improved pigment dispersion and surface finish.

Table 7
Ink Writing Test Results.

Sample	Writing Test	Remarks/Descriptions
Ex1R1		- Ink did not flow well from pen - Writing flaked out upon drying
Ex2R1		- Ink flowed smoothly - Thin consistency, dense black colour
Ex3R1		- Ink was too thick - Poor flow and powdery after drying
Ex2aR1		- Ink was watery and uneven - Did not flow properly from pen
Ex2bR1		- Ink flowed smoothly - Dense black, thin consistency, glossy finish

4.2.1 Ink Drying Time

The drying time of the ink was also closely linked to its composition, particularly the amount of cashew gum and black pepper:

- Increasing cashew gum content prolonged the drying time:

- Ex2R1 (2 g): 5 minutes
- Ex1R1 (4 g): 10 minutes
- Ex3R1 (8 g): 15 minutes

- Conversely, higher black pepper content accelerated drying:

- Ex2R1 (1 g): 5 minutes
- Ex2aR1 (2 g): 4 minutes
- Ex2bR1 (3 g): 3 minutes

By modifying the original recipe (T1R1), which had a drying time of 30 minutes, the optimised formulations reduced drying time significantly—down to 15 minutes or less, with Ex2bR1 emerging as the most efficient in both flowability and drying performance.

4.3. Accelerated Ageing

Accelerated ageing tests were conducted to assess the robustness and stability of the formulated ink samples under simulated environmental stress. Although carbon inks are generally known for their inherent stability, their interaction with substrates over time required further observation. The performance of the traditional formulations was benchmarked against several commercial black inks, including Indonesian *Mangsi Gentur*, *Chinese Sea Lion* (CS 28), and Indian *Winsor & Newton* (No.030).

All ink samples were applied to European handmade paper (75 mm × 140 mm), with duplicate sets prepared: one control and one exposed to ageing procedures. The same preparation method was used across both ageing tests.

4.3.1 Moist-Heat Treatment

To evaluate thermal and humidity resistance, the ISO 5630-3:1996 standard was followed. Samples were suspended in a moist-heat chamber at 80°C and 65% RH for 12 days, with observations taken at intervals on Days 1, 2, 3, 6, and 12.

Table 8
Grayscale Ratings of Inked Paper Samples After Moist-Heat Ageing Test

Sample	Visual Assessment				
	Day 1	Day 2	Day 3	Day 4	Day 5
T1R1	5	5	5	5	5
Ex1R1	5	5	5	5	5
Ex2R1	5	5	5	5	5
Ex3R1	5	5	5	5	5
Ex2aR1	5	5	5	5	5
Ex2bR1	5	5	5	5	5

All samples retained their original colour intensity with no visible degradation, confirming their high thermal and humidity resistance.

4.3.2 Lightfastness Test

The lightfastness of the formulated inks was assessed using ASTM D3424-11 procedures. A filtered Xenon Arc light source (ASTM G155-13) was employed for 120 hours, simulating natural UV, visible, and infrared light exposure under 40 ± 5% RH at a wavelength of 340 nm (Lucas, 2001).

4.3.3 Colour Measurement

The initial colour values of each ink sample under normal conditions (prior to exposure) were recorded using CIE L*a*b* colour space parameters, which quantify lightness (L*), red-green (a*), and yellow-blue (b*) values. These are presented in Table 9.

All formulations initially received a grayscale rating of 5, indicating excellent baseline lightfastness.

Table 9
*CIE L*a*b* Values of Formulated Inks Before Exposure*

Sample	CIE		
	L1*	a1*	b1*
T1R1	17.26	-0.06	0.31
Ex1R1	17.03	-0.16	0.01
Ex2R1	17.59	-0.09	0.15
Ex3R1	18.39	0.13	0.61
Ex2aR1	17.52	0.03	0.55
Ex2bR1	17.74	0.06	0.42

4.3.4 Colour Stability Results (Post-Exposure)

After 12 days of light exposure, total colour difference (ΔE*) was measured to evaluate the extent of visual change shown in Table 12.

Table 10
Total Colour Difference (ΔE) of Ink Samples After 12-Day Lightfastness Test*

Ink Formulation	ΔE* after day-12
Varying cashew gum content	
T1R1 (1 g)	0.45
Ex2R1 (2 g)	0.55
Ex1R1 (4 g)	0.75
Ex3R1 (8g)	0.82
Varying black pepper content	
Ex2R1 (1 g)	0.55
Ex2aR1 (2 g)	0.32
Ex2bR1 (3g)	0.32

The results indicate:

- Higher cashew gum content increased the ink's susceptibility to light-induced degradation, reflected by higher ΔE* values.
- Increased black pepper content improved lightfastness, lowering ΔE* values and enhancing overall stability.

The accelerated ageing tests validated the robustness and environmental resilience of the optimised ink formulations. The Ex2bR1 sample, with balanced pigment, binding, and additive composition, showed superior performance across all categories, making it the most stable and visually consistent formulation under both thermal and UV exposure.

5. Comparison with commercial inks

To further evaluate the stability and durability of the formulated traditional ink, several commercial black inks were tested under moist-heat accelerated ageing and lightfastness conditions. The performance of these inks was assessed both visually (based on the grayscale index) and instrumentally (via total colour difference, ΔE*).

5.1. Moist-Heat Ageing Test (Grayscale Index Evaluation)

The grayscale index provides a visual measure of colour retention and fading. As shown in Table 11, most commercial inks maintained consistent grayscale ratings, indicating good stability. However, Indonesian ink (Gentur) exhibited slightly lower performance across the exposure interval.

Table 11
Stability of Inked Paper Samples Using Various Commercial Black Inks Evaluated Under Moist-Heat Ageing Test Based on Grey Scale Index.

Test specimen	Exposure Interval				
	Day-1	Day-2	Day-3	Day-6	Day-12
Indonesian Ink (Gentur)	4/5	4/5	4/5	4/5	4/5
Liquid Indian Ink	5	5	5	5	5
Japanese Ink	5	5	5	5	5
German ink (Black Noir)	5	5	5	5	5
German Ink (Sepia)	5	5	5	5	5
Chinese Ink	5	5	5	5	5

5.2. Moist-Heat Ageing Test (ΔE* Colour Change)

Table 12 presents the ΔE* values of commercial inks after 12 days of moist-heat exposure. The Indonesian ink recorded the highest ΔE* (1.23), aligning with the visual observation of greater fading. In contrast, Liquid Indian ink exhibited the lowest ΔE* (0.15), indicating excellent colour stability.

Table 12
*Total Colour Difference (ΔE) * for Inked Paper Samples Using Commercial Black Inks After Exposure to Moist-Heat Accelerated Ageing.*

Test specimen	ΔE* after day-12
Indonesian Ink	1.23
Liquid Indian Ink	0.15
Japanese Ink	0.37
German ink (Black Noir)	0.48
German Ink (Sepia)	0.82
Chinese Ink (Sea Lion)	0.40

In comparison, the formulated traditional inks showed ΔE* values below 0.82, with Ex3R1 being the highest and Ex2bR1 the lowest (0.32), demonstrating comparable or superior performance to several commercial inks.

5.3. Lightfastness Test

The lightfastness performance of commercial carbon inks was further assessed after

120 hours of exposure using a Xenon Arc light source. Table 13 presents the ΔE* values alongside visual assessment scores.

Table 13
ΔE Index and Visual Assessment for Commercial Carbon Ink Specimens After Lightfastness Accelerated Ageing.*

Sample	Visual Assessment	ΔE* after 120- hour exposure
Indonesian ink (Gentur)	4/5	1.18
Chinese ink (Dolphin Hwa)	5	0.42
Indian ink (Talens)	4	1.88
Japanese ink (Holbein)	5	0.44
German ink (Aero Colour Professional) (black noir)	5	0.84
German ink (Aero Colour Professional) (Sepia)	3/5	2.56

The Sepia German ink performed the worst in the lightfastness test, recording the highest ΔE* value (2.56) and a visual score of 3/5, indicating visible fading. In contrast, Chinese and Japanese inks performed well with minimal colour shift.

5.4. Visual Comparison

Table 14 shows visual images of three specimens—Indonesian ink, Indian ink, and Sepia—before and after lightfastness exposure. The ink was applied using a brush. These images further corroborate the ΔE* data, particularly the significant fading seen in the Sepia ink sample.

The formulated traditional Malay ink demonstrated comparable or superior performance to commercial inks in both moist-heat ageing and lightfastness tests. In particular, formulation Ex2bR1 showed excellent resistance to fading, low ΔE* values, and glossy black appearance.

Moreover, the traditional ink outperformed modern inks in terms of environmental sustainability, relying entirely on natural, locally available materials. These results reaffirm its potential as a viable alternative for sustainable artistic practices and for the reproduction of heritage materials in educational, display, or facsimile contexts.

Table 14
Visual Images of Three Specimens Before and After Exposure to Lightfastness Test Using Brush-Applied Ink.

Test Specimen	Before	After
Indonesia Ink		
India Ink		
Sepia		

6. Calligraphy performance

To evaluate the artistic usability of the newly formulated ink, a series of calligraphy trials were conducted in collaboration with professional calligraphers. The ink, developed based on a historical Malay recipe and optimised as described earlier, was tested on two types of paper substrates: European handmade paper and glossy-surfaced art paper.

The ink was distributed to five calligraphers aged between 23 and 35, with five to fifteen years of experience in both formal and informal training. All participants had received basic calligraphy education from accredited institutions. Figure 9 documents the survey session conducted at the Calligraphy and Jawi Division, Yayasan Restu, Shah Alam, Selangor.

Fig. 9: *Calligraphers in action during the survey session. Image from author's personal collection during the survey session conducted in the Calligraphy and Jawi Division in Yayasan Restu, Shah Alam, Selangor.*

6.1. Substrate Performance and User Feedback

Calligraphers evaluated the ink based on seven criteria: colour, smell, flowability, fluidity, drying rate, permanency, and texture. Performance on European handmade paper and art glossy paper was rated separately, with Tables 15 and 16 summarising the results.

On average, the ink received "Fair" ratings, with slightly better performance on glossy art paper.

Table 15
Calligraphers' Ratings on the Ink's Performance on European Handmade Paper.

Category	R1	R2	R3	R4	R5	Average
Colour	2	2	2	2	2	2
Smell	5	3	3	4	3	3.6
Flowability	2	2	2	2	2	2
Fluidity	2	2	2	2	1	1.8
Drying rate	3	2	2	1	2	2
Permanency	1	3	1	1	2	1.6
Texture	1	3	2	2	1	1.8

Rating scale: 5 = Excellent; 4 = Good; 3 = Satisfactory; 2 = Fair; 1 = Poor

Table 16
Calligrapher's ratings on the ink performance on art glossy paper.

Category	R1	R2	R3	R4	R5	Average
Colour	2	3	3	2	2	2.4
Smell	5	2	3	2	3	3
Flowability	1	3	3	2	2	2.2
Fluidity	2	2	2	2	2	2
Drying rate	2	2	2	1	3	2
Permanency	1	3	1	1	2	1.6
Texture	1	3	3	2	2	2.2

6.2. Observations and Visual Documentation

- Figure 10 illustrates poor flow on European handmade paper.
- Figure 11 shows satisfactory flowability on art paper.
- Figure 12 demonstrates weak ink adhesion under rubbing stress using an eraser, reflecting the low permanency rating.

Fig. 10: *The ink flows insufficiently when drawn on European handmade paper. Image from the author's personal collection.*

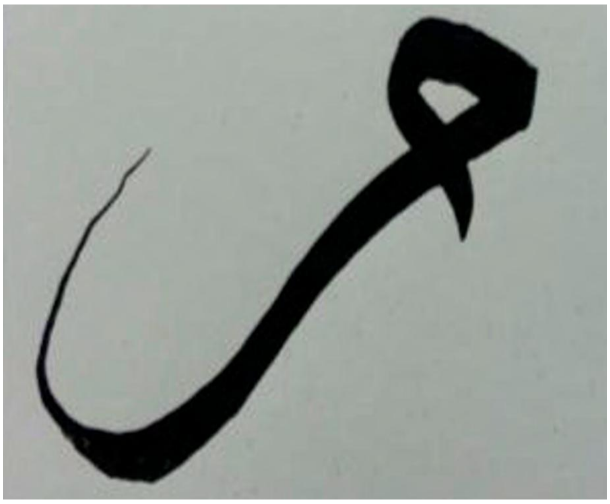


Fig. 11: *The satisfactory flowability of ink on calligraphy art paper. Image from the author's personal collection.*

Fig. 12: *Formulated ink written on Art paper tested for the rubbing effect using an eraser. Image from the author's personal collection.*

6.3. Professional Comparison and Calligrapher Insights

The calligraphers noted that the formulated ink (Ex2bR1) was being unconsciously compared to commercial inks they frequently use, such as Japanese (Holbein), German (Aero Colour Professional), and Indian (Talens). While they acknowledged a performance gap, especially in permanency and flow, they appreciated the historical and ecological value of the project.

The ink's smell received the highest ratings, likely due to its use of natural ingredients such as black pepper and coconut oil. Flowability and drying time were moderate, but permanency remained the main challenge, particularly due to its low resistance to mechanical abrasion during early drying stages.

6. 4. Environmental Sustainability

The traditional Malay black ink developed in this study emphasises environmental sustainability through its use of plant-based, biodegradable materials. Ingredients such as cashew gum, soot, and mangosteen charcoal are derived from renewable natural resources, often sourced locally. This composition supports reduced reliance on synthetic or petroleum-derived additives and reflects the potential for low-impact, culturally rooted material practices.

The formulation also demonstrates how historical recipes relied on practical, locally available substances that are both functional and environmentally conscious. These material choices support ongoing efforts to reconnect artisanal practices with sustainable production, particularly in the context of traditional and contemporary artistic applications.

6.5. Challenges and Limitations

This study identifies several challenges associated with the revival, documentation, and sustainable production of traditional Malay black ink:

- Sourcing of Natural Materials
- The primary ingredients—such as mangosteen rinds, soot, and cashew gum—are subject to seasonal availability, environmental change, and increasing urbanisa tion. This poses difficulties in ensuring a consistent supply of raw materials for future production or experimentation.
- Preservation of Traditional Knowledge
- Traditional ink-making techniques are often transmitted through oral tradition or apprenticeship, with limited written documentation. As the number of knowledgeable practitioners declines, there is an urgent need for systematic recording and dissemination of these techniques to prevent the loss of intangible heritage.
- Sustainability and Scalability
- Broader application of traditional ink requires careful consideration of the environmental impact of resource harvesting. Strategies to ensure responsible sourcing and scalable production must be developed to maintain the viability of traditional ink-making practices in both artisanal and educational contexts.

These challenges highlight the importance of interdisciplinary collaboration, combining historical research, material studies, and ethnographic engagement to support the long-term viability of traditional Malay ink practices.

7. Conclusion

A dense carbon-based black ink has been successfully reconstructed using a traditional Malay recipe originating from the Malay Peninsula. This ink formulation employs soot and mangosteen charcoal as colourants, cashew gum as a natural adhesive, and black pepper, virgin coconut oil, and salt as functional additives, with distilled water as the solvent. The optimal composition consists of 4 g soot, 4 g mangosteen charcoal, 2 g cashew gum, 3 g black pepper, 0.1 ml virgin coconut oil, 0.5 g salt, and 100 ml distilled water.

The ink was subjected to a series of qualitative and quantitative assessments, including sedimentation behaviour, pH stability, drying time, permanency, intensity, flowability, viscosity, penetration depth, and durability under accelerated ageing conditions (moist-heat and lightfastness). A total of six experimental formulations were evaluated, and their performance was benchmarked against well-established commercial inks from Indonesia (Mangsi Gentur), Japan (Holbein), India (Winsor & Newton), China (Sea Lion), and Germany (Aero Colour Professional – Sepia and Black Noir).

Results indicated that the optimised traditional formulation (Ex2bR1) demonstrated durability and stability comparable to commercial inks, particularly in terms of lightfastness and environmental resistance. While some limitations remain—especially in flowability and permanency—the ink showed promising results in its intended applications, especially on glossy art paper.

Professional calligraphers who participated in the trial acknowledged both the strengths and areas for improvement, reinforcing the ink's viability for artistic and educational applications, while also recognis ing its cultural and ecological significance.

This research marks a pioneering effort to revive and scientifically validate traditional Malay black ink, laying the groundwork for further studies in historical ink reconstruction, sustainable art materials, and heritage preservation. The systematic documentation of traditional recipes and reformulation processes serves as a valuable resource for artisans, conservators, and researchers alike.

By integrating traditional knowledge with scientific inquiry, this study contributes not only to the preservation of indigenous craftsmanship but also to the promotion of eco-conscious innovation in material culture. These achievements underscore the enduring value of traditional Malay black ink as a living legacy, worthy of continued exploration and celebration.

8. Further research

Future research should address the limitations identified in this study while expanding the scope of knowledge related to Malay traditional ink practices. The following recommendations outline key areas for continued investigation and development:

8.1. Documentation and Dissemination of Traditional Knowledge

There is an urgent need to systematically document the traditional processes involved in the preparation of Malay inks. This includes the collection of oral histories, practical demonstrations, and ethnographic fieldwork with surviving practitioners. Platforms such as digital archives, scholarly publications, and public workshops could facilitate the preservation and transmission of this artisanal knowledge for future generations.

8.2. Study of Coloured Inks in Malay Manuscripts

While this study focused on black ink, traditional manuscripts also employed coloured inks—such as red, yellow, and green—for textual emphasis and decoration. These inks likely involve distinct ingredients and techniques, with unique symbolic and functional significance. Future research should investigate their materials, methods of preparation, and cultural roles within manuscript traditions to enrich our understanding of Southeast Asian writing systems and visual culture.

8.3. Interdisciplinary Collaborations

Further advancement in this field would benefit from collaborations across disciplines. Chemists can assist in optimis ing ink stability and composition, while materials scientists can explore interactions with various substrates. Historians, ethnographers, and manuscript scholars can contribute contextual insights into usage, symbolism, and regional adaptation. Such collaborations can ensure the research remains culturally grounded and materially precise.

8.4. Application of Modern Analytical Techniques

Advanced instrumental techniques such as Fourier-transform infrared spectroscopy (FTIR), gas chromatography–mass spectrometry (GC-MS), and X-ray fluorescence (XRF) offer valuable insights into the chemical composition and degradation mechanisms of historical inks. These methods can support more accurate reconstructions and help track historical shifts in ink preparation practices over time.

8.5. Comparative Studies Across Southeast Asia

A comparative study of traditional ink practices in neighboring regions—including Indonesia, Thailand, Vietnam, and the Philippines—would help identify shared techniques, regional variations, and transcultural influences. This research would contribute to a more nuanced understanding of ink traditions within the broader Islamic and Southeast Asian manuscript heritage.

8.6. Abrasion Resistance Testing

Due to limitations in resources and testing infrastructure, abrasion resistance was not evaluated in the current study. This test is crucial for assessing ink adhesion and durability under mechanical stress, especially during handling or display. Future work should incorporate standard abrasion testing methods to better understand the physical resilience of traditional ink formulations and their suitability for practical applications in heritage preservation.

9. Final Outlook

By integrating traditional craftsmanship with scientific research, future studies can foster deeper engagement with the material history of writing in the Malay world. Such efforts will not only preserve traditional knowledge but also inspire creative and scholarly revitalisations of historical ink-making practices. The continued exploration of these materials ensures that Malay traditional ink remains a living cultural resource, adaptable to both historical inquiry and contemporary artistic expression.

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Source and Supplies

Source	Supplier
Virgin Coconut Oil (manufactured	Purchased from Multifilla (M) Sdn. Bhd (Art & Craft material supply warehouse) No 1, Jalan 2/2 Taman Industri Selesa Jaya, 43300 Balakong, Selangor Malaysia.
European handmade paper	TALAS (Conservation, Archival and Bookbinding supplies) Morgan Ave.Brooklyn, NY11211212-219-0770 https://www.talasonline.com
Chinese ink (Dolphin Hwa)	Weststar The Art Shop Melawati 9171, Jalan Negara, Taman Melawati, 53100 Kuala Lumpur, MALAYSIA
Indian ink (Talens)	Weststar Weststar The Art Shop Melawati 9171, Jalan Negara, Taman Melawati, 53100 Kuala Lumpur, MALAYSIA
Japanese ink (Holbein)	Weststar Weststar The Art Shop Melawati 9171, Jalan Negara, Taman Melawati, 53100 Kuala Lumpur, MALAYSIA
German ink (Aero Colour Professional) (black noir)	Weststar Weststar The Art Shop Melawati 9171, Jalan Negara, Taman Melawati, 53100 Kuala Lumpur, MALAYSIA
German ink (Aero Colour Professional) (Sepia)	Weststar Weststar The Art Shop Melawati 9171, Jalan Negara, Taman Melawati, 53100 Kuala Lumpur, MALAYSIA Weststar Weststar The Art Shop Melawati 9171, Jalan Negara, Taman Melawati, 53100 Kuala Lumpur, MALAYSIA
Chinese ink (Dolphin Hwa)	Weststar Weststar The Art Shop Melawati 9171, Jalan Negara, Taman Melawati, 53100 Kuala Lumpur, MALAYSIA

About the author

Dr. Rajabi Abdul Razak has been serving as an Assistant Professor in the Department of Applied Arts and Design, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia (IIUM), since 2015. Prior to her academic career, she worked as an Assistant Conservator at the Islamic Arts Museum and as a Curator at the Department of Museums Malaysia from 2003 to 2005. She holds a bachelor's and master's degree from Universiti Teknologi MARA (UiTM), Shah Alam, and pursued her Ph.D. at IIUM in 2011. She is also a former Deputy Director of the IIUM Gallery. Her academic journey includes an internship at the Preservation Advisory Centre, British Library, and participation in a Communication and Teaching Skills in Conservation and Science course in Rome, Italy. Her research interests focus on Material Technology in Malay Manuscripts and Heritage Conservation. Dr. Rajabi has published extensively on these subjects, contributing valuable insights into the preservation and understanding of cultural heritage materials, particularly in the context of Southeast Asian manuscripts and textiles. Her work has been featured in various academic journals, conference proceedings, and she has collaborated on several heritage conservation projects both locally and internationally.

Prof. Dr. Mandana Barkeshli is a professor at the Institute of Creative Arts and Design at UCSI University in Malaysia, specialising in conservation science, particularly in the material technology of manuscripts and miniature paintings. She serves as an Honorary Principal Fellow at the University of Melbourne, where she collaborates on projects at the Grimwade Centre for Cultural Materials Conservation.

With a rich academic background, she has held senior positions at the Art Universities of Tehran and Isfahan and the International Islamic University Malaysia and was the inaugural Head Curator at the Islamic Arts Museum Malaysia. She was also the founder and chairman of the Islamic Manuscript Association in Cambridge and a member of the Board of Directors.

Her distinguished research has earned her numerous fellowships, including the Petra Kappert Fellowship at the University of Hamburg and a fellowship from the Barakat Trust in the UK.

Prof. Barkeshli's primary research focus is the material technology of Persian medieval manuscripts, with an emphasis on papers, dyes, pigments, and sizings derived from historical recipes. She has published extensively in reputable international journals and recently launched a website to share her database on Persian manuscript materials: persianmanuscriptmaterials.org.

Additionally, she has conducted professional workshops at esteemed institutions, including the Bodleian Library at Oxford, the École du Louvre, the Qatar Museum of Islamic Art, and the Qatar National Library.