RESEARCH PAPER

Development of Latent Fingerprints Using Air-Dried Plant Extract Powders: An Eco-Conscious Approach

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Abstract
Chemical reagents develop latent fingerprints which serve as essential forensic evidence. The research investigates plant-based extracts from neem guava banana peepal papaya and curry leaves as natural fingerprint development solutions. Guava and neem were most effective on porous surfaces while papaya and betel extracts worked best on non-porous surfaces. The curry leaf extract displayed strong fluorescence under. These findings suggest plant-based reagents offer a safe, eco-friendly, and cost-effective alternative for forensic fingerprint visualization.

Keywords: latent fingerprints, natural reagents, plant ex- tracts, porous vs non-porous surfaces, fluorescence, forensic chemistry, sustainability
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Introduction

Latent fingerprints, the invisible residue left behind by friction ridges on fingers, are the cornerstone of forensic identification. Printing the marks onto evidence surfaces is conventionally visualized using chemical or physical reagents specific to the surface: porous (e.g., paper) or nonporous (e.g., glass, plastic). General-purpose reagents such as ninhydrin, DFO, and fingerprint powders are typically toxic or hazardous to the environment [1], [2]. This has provided the impetus for seeking alternative natural, nontoxic, and biodegradable methods of fingerprint development.
One of the numerous alternatives is plant material, which offers a cheaper, safer, and environmentally friendly option for forensic application [3]. Several earlier research studies have demonstrated the effectiveness of a variety of plant- based dyes and powders, such as turmeric, henna, and genipin, in the formation of latent fingerprints, with different degrees of effectiveness depending on the substrate and application method used [4], [5].

This study explores extracted compounds of five com- mon plant species — Neem, Guava, banana leaves, peepal leaves, and papaya — and examines their effectiveness in the development of latent fingerprints on both porous and nonporous surfaces. The study also evaluates the fluorescence properties of curry leaf extract when exposed to ultraviolet light, acting as a natural alternative to commercially used fluorescent fingerprint reagents.

The main objectives of the present study are the following:

1) To assess the effectiveness of certain botanical extracts in the development of latent fingerprints on different surfaces.
2) To compare the contrast and clarity of fingerprints developed with those developed using standard reagents.
3) To assess the viability of curry leaf extract as a fluores- cent fingerprint reagent.

The hypothesis is that Neem and Guava extracts, rich in polyphenols and tannins, will be more effective on porous surfaces due to chemical interactions with amino acids, while Papaya and Betel extracts will perform better on non-porous surfaces due to adhesion to lipid-based residues.

2. Materials and Methods

2.1 Collection and Preparation of Plant Samples

Fresh mature leaves of five plant species known for their bioactive potential were collected: Musa spp. (Banana), Psid- ium guajava (Guava), Carica papaya (Papaya), Azadirachta indica (Neem), and Ficus religiosa (Peepal) [9]. The researchers performed a thorough washing of the collected leaves by using distilled water to eliminate all surface contaminants before they proceeded to air-dry the leaves in a shaded area at room temperature which maintained a temperature of approximately 25°C for a duration of 5 to 7 days [5]. The researchers used a sterile laboratory-grade
grinder to grind the leaves into fine powder after they reached complete dryness. The powders obtained were sieved through a fine mesh to ensure uniform particle size and then stored in labeled,

2.2 Surface Preparation for Fingerprint Development

The study used non-porous surfaces which included glass slides plastic sheets and stainless steel plates to test leaf-based powders for their ability to visualize latent fingerprints. [8]. The researchers first cleaned the surfaces before using ethanol to sterilize them because any contaminants on the surfaces would interfere with fingerprint adhesion tests. [4].

2.3 Fingerprint Deposition

Latent fingerprints were naturally deposited by volunteers aged between 18 and 25 years without pressing or enhance- ment, relying solely on natural skin secretions [11]. Volunteers first washed and dried their hands, followed by a 10-minute wait to allow accumulation of natural secretions before cau- tiously depositing fingerprints on prepared test surfaces. Three types of fingerprints were specifically evaluated:

1) Recent prints (developed immediately after deposition)
2) Antique prints (left undisturbed for durations of 24 and 72 hours)
3) Sebaceous prints (deposited after volunteers imprinted their fingers on their forehead)

All fingerprint sample were carefully labelled for proper documentation and tracking throughout experiment.

3. Results

The performance of the plant extracts derived from Plant based extract was highly inconsistent across the diverse surface types and application modes. Table I provides a general summary of the results on the development of fingerprints on porous and non-porous surfaces. Each rating reflects the over- all evaluation of ridge details, contrast values, and background disturbance, as described in the methodology.

3.1. Porous surface observations

Neem and guava extracts performed best on paper, with clear and identifiable ridge details exhibiting excellent con- trast. Neem produced a light purple-brown coloration resem- bling ninhydrin development, while guava produced a brown coloration in the ridge regions [1].

The extracts from banana and peepal trees produced partial ridge features which showed minimal color changes. The assessment resulted in moderate evaluation because the ridge development showed incomplete progress and produced lesser contrast [2]. The ability of papaya extract to function on porous surfaces was restricted because of its high water content and low pigment presence [3]. The performance of curry leaf extract under visible light was below optimal because of excessive background discoloration. The material showed clear fluorescent ridge patterns under 365 nm UV light which indicates its potential use as a natural fluorescent reagent [4].

Table 1. Effectiveness of Plant Extracts on Different Surface Types

Plant Extract	Porous surface (Paper)	Non-Porous surface (Glass)
Neem (Azadirachta indica)	Clear	Poor
Guava (Psidium guajava)	Clear	Poor
Banana (Musa acuminata)	Moderate	None
Peepal (Ficus reli-giosa)	Moderate	None
Papaya (Carica pa- paya)	Poor	Clear
Curry (Murraya koenigii)	Poor (Visible)/ Clear (UV)	Poor (Visible)/ Clear (UV)

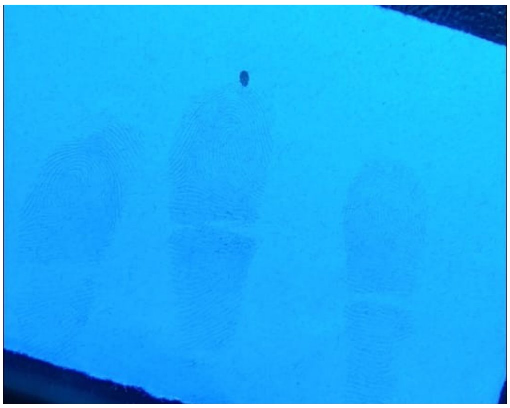


Figure 1. Better clarity of ridges of fingerprint developed by guava leaves powder under Shortwave UV light.

3.2 Non-Porous Surface Observations

The study showed that Papaya extract demonstrated strong ability to stick on fingerprint residue which it left behind on glass surfaces, creating a white crystalline material that maintained fingerprint details through the drying process. [5]. Curry leaf extract demonstrated its ability to support UV testing when it was applied to glass surfaces. The extract produced greenish fluorescence which revealed the ridge patterns on the surface. [6]. The glass surface showed poor adhesion to neem extract, guava extract, banana extract, and peepal extract which resulted in two outcomes: the first outcome failed to show any ridge details and the second outcome produced smudged and uneven impressions [7].

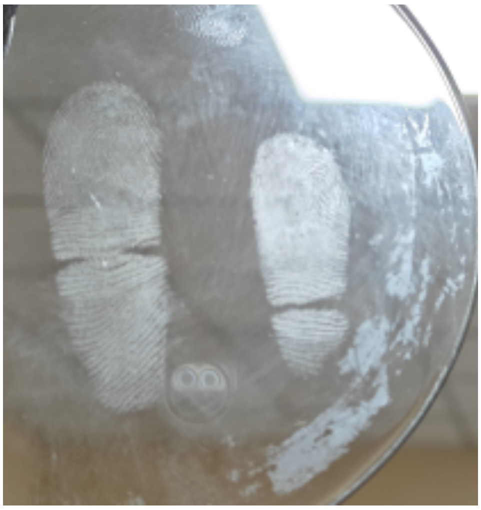
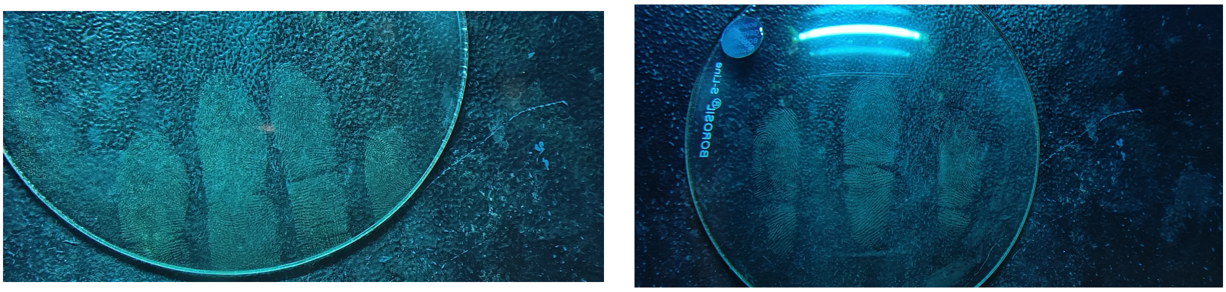


Figure 2. Fingerprint developed on a glass surface using papaya leaves powder.

3.3 Comparative Reagents

Ninhydrin-treated paper samples exhibited deep purple ridge impressions with excellent clarity, outperforming all natural extracts in intensity, though not in safety or sustainability [8]. Black magnetic fingerprint powder yielded high-clarity ridge patterns on glass, serving as a benchmark for evaluating non-porous fingerprint development methods [9].



(a) (b)

Figure 3. (a) Better clarity of ridges of fingerprint developed by neem powder under Shortwave UV light. (b) Better clarity of ridges of fingerprint developed by papaya leaves under Shortwave UV light.

Table 2. Comparison of Fingerprint Development by Different Plant Powders

Plant Powder	Surface Type	Ridge Counting	Adherence	Contrast	Overall Performance
Neem	Glass	Excellent	High	Good	Very Effective
Guava	Paper	Good	High	Excellent	Very Effective
Peepal	Metal	Moderate	Medium	Fair	Moderate
Banana	Metal	Fair	Low	Low	Least effective
Papaya	Glass	Moderate	Medium	Fair	Moderate

4.Discussion

The results of this experiment align with those of several published papers which allude to the possibility of utilising plant-based products for developing fingerprints on porous surfaces in an eco-friendly manner. Adhitya and Suneetha [1, 3] demonstrated that naturally occurring fine powders such as turmeric and plant-based products can be equally effective for lifting fingermark prints compared with traditional methods as it simultaneously minimizes the harmful chemicals to human health and the environment.

In this case study, the best prints were obtained after using neem and guava extract in the case of fingerprints left on paper while papaya extract was found to be more suitable after it had revealed fingerprints at surfaces made of glass. One reason might be the high amounts of tannins and polyphenols contained in the neem and guavail materials that can cause fingerprint residues to bind with amino acids as explained by Harborne [5]. Another explanation is that in the case of the papaya, its enzyme and sugar content gets precipitated and adheres fingerprint marks on the surface very easily. Also, the fluorescence of curry leaf extract under UV light is very similar to those natural fingerprint reagents which were described to be fluorescent in the work of Gaskell et al. [7] and Pattaritha et al. [12]. Though some of the standard reagents like ninhydrin and commercial fingerprint powders still give clearer results [4, 6], these results indicate that some of the botanical extracts have the potential to serve as a sustainable, low-cost, and safer method for fingerprinting, especially in those forensic labs with less financial resources.

5. Conclusions

The research study assessed how extracted plant materials function as suitable substitutes for conventional fingerprint development reagents. The study results proved that certain plant extracts are able to reveal hidden fingerprints which depend on both the surface material and the extract's chemical characteristics.

The performance of neem and guava extracts showed better results on paper surfaces because their applied extract produced complex ridge patterns through visible color changes. Their performance was comparable to ninhydrin but with the added benefits of safety and environmental compatibility. On non-porous surfaces such as glass, papaya extract exhibited very high activity, producing clear crystallographic ridge patterns. Curry leaf extract developed a new property because it showed ultraviolet- induced fluorescence which makes it suitable as a natural substitute for artificial fluorescent dyes Plant-based alternatives provide major benefits over standard reagents because they do not produce toxic effects and they save costs and protect the environment. The results showed a need for specific reagent applications which required two different studies to assess their effectiveness on various forensic materials and testing environments . Future research should focus on optimizing extract con- centration, improving long-term storage conditions, and ex- panding testing across various environmental and substrate conditions. The study explores two different options because researchers will evaluate the effects of mixing extracts and testing them with other natural substances.

This research supports the use of selected plant extracts in forensic science as eco-friendly, cost-effective, and accessible solutions for latent fingerprint development, especially in resource-constrained or field-based settings

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