# Development and Evaluation of Latent Fingerprint Using Medicinal Leaf Powders on Non-Porous Surfaces

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***Abstract*—Latent print development is a foundational technique in forensic science that continues to be widely used for suspect identification. It allows for identification because of the unique ridge patterns with ridge characteristics left behind at the crime scene. The study aims to development and evaluation of latent fingerprints using different medicinal leaf powders on non-porous surfaces which is non-toxic, eco-friendly and low-cost powders. This study was conducted in Mangaluru. In the study, the powders were prepared from the dried leaves of Eucalyptus, Hibiscus, Tulsi (Ocimum sanctum), Henna and Neem. The leaves were dried in sunlight for 5 days and grinded. Then it was sieved by using a 75-mesh size. These powders were used on non- porous contrast surfaces including Plastic, Smartphone screen, Glass, Stainless steel and Metal surface for the development and visualization of fingerprint. All medicinal powders performed efficiently on plastic, smartphone screen, glass and stainless steel ensuring more than 85- 90% visibility. The duration of visibility of developed latent fingerprints was observed at different time intervals. This study showed that a forensic investigator is able to identify and develop the latent fingerprints using medicinal leaf powders.**

***Index Terms*—Latent fingerprints, Ridge characteristics, Medicinal leaf powders**

## I. INTRODUCTION

Fingerprints are unique, permanent patterns of raised ridges and valleys on the skin of fingertips and palms that serve as an invaluable, reliable tool for personal identification, forming before birth and remaining unchanged throughout life. Known technically as dactyloscopy, the study of these distinct patterns is a cornerstone of forensic science and law enforcement, enabling investigators to confirm identities, solve crimes and manage biometric security systems. Beyond their forensic and investigative utility, these ridge structures serve functional purposes in daily life by enhancing tactile sensitivity and improving grip friction.

A fingerprint is a unique pattern of ridges and furrows on the tip of a finger or thumb. Fingerprint recovery is a cornerstone of forensic science, as these unique ridge patterns are the most common evidence found at crime scenes. Because fingers naturally carry moisture or oils, they leave distinct marks on various surfaces like metal or glass that remain unchanged throughout a person's life. This permanence and individuality make fingerprinting an exceptionally reliable tool for investigators. By analyzing these prints, forensic experts can quickly and accurately identify individuals, providing a vital link between suspects and specific criminal activities.

Between the 10th and 16th weeks of pregnancy, a baby starts developing the fingerprints they will carry for the rest of their lives. This happens through a fascinating mix of nature and nurture. While a person's DNA provides the basic blueprint like the general shape of the loops or whorls, the tiny details are actually shaped by the baby's environment inside the womb. As the foetus moves around, its fingers and palms press against the uterine wall and swim through amniotic fluid. This physical pressure creates unique ridges and valleys in the skin, similar to how shifting weather and soil create patterns on the earth. Because these movements are never exactly the same, even

identical twins end up with different fingerprints. These tiny details called minutiae, include spots where ridges split or end, making the final pattern completely one-of-a-kind. Once this process is finished in the womb, the design is set for life. Even as a person grows older or suffers minor scrapes, these ridges remain a permanent and reliable way to identify them.

Fingerprint identification traces its origins to ancient Babylonian, Chinese and Persian civilizations, where ridge patterns on clay tablets served as precursors to modern security seals. By the 14th century, Persia saw fingerprints emerge as a form of official signature, though it wasn't until the 17th century that European scholars began documenting their unique individuality without yet possessing a system to organize them. Progress accelerated in the 18th century as Dr. Nehemiah Grew in England and Sir William James Herschel in India explored their utility with Herschel famously applying them to contracts to combat identity fraud. The late 19th century marked a turning point with the work of Dr. Henry Faulds, who proposed their use in criminal identification and Sir Francis Galton, who published the first comprehensive study on the subject in 1892. These efforts culminated in the early 20th century when Sir Edward Henry developed the Henry Classification System, a breakthrough that allowed law enforcement to systematically organize and search records. This official recognition set the stage for the latter half of the 20th century, which saw the transition from manual files to the Automated Fingerprint Identification Systems (AFIS) used today.

There are 5 Basic principles of fingerprint:

Uniqueness: The inherent uniqueness of fingerprints ensures that no two individuals possess identical ridge patterns, a fact reinforced by both theoretical models and the extensive analysis of millions of records. For instance, the FBI’s massive database of nearly 50 million entries has never yielded a duplicate set of prints from different people. This absolute distinctiveness serves as the foundation for the legal validity of fingerprint evidence, supporting the principle that every print is singular. Ultimately, this uniqueness is not derived from the general shape or pattern of the finger, but rather from the specific arrangement, quantity, and individual characteristics of the ridge details known as minutiae.

Permanence: Fingerprint patterns remain unchanging and constant throughout a person's entire life. These designs, created by friction ridges on the thumb and palm sides of the fingers, offer a unique grip and prevent slipping. They develop during the birthing process with the friction skin consisting of grooves that act as valleys and ridges that serve as hills. Every ridge on the skin is associated with a pore connected to sweat glands, which discharge chemicals and perspiration onto the surface of the skin. Latent prints, which cannot be seen by the naked eye are created from this perspiration. Friction ridges start to appear in the third or fourth month of pregnancy and remain from that point forward. Nevertheless, a serious skin injury can harm the dermal papillae, which may change or completely remove a fingerprint.

Universality: Friction ridges are found everywhere on the palmar surface of the fingers, making their categorization and individualization easier. They are universally present, because every person performs activities with their hands, leaving prints on the objects they handle or at the scenes of crimes. As a result, fingerprints are frequently discovered in a broad range of criminal occurrences.

Classifiable: Fingerprints show various designs such as loops, whorls, arches and composite, which allow them to be categorized. Roughly 5% of people possess arches,1-2% of people having composite, while 30-35% have whorls and 60-65% show loops. These four main patterns are used across all ten fingerprint classification systems to assist in organizing prints.

Recordable: The practical reliability and forensic value of fingerprints through the ease with which they can be captured and documented. This process includes taking controlled, known prints such as rolled ink impressions or high-resolution digital scans, as well as recovering latent prints left unintentionally at crime scenes. Because these patterns can be accurately transferred into permanent records, they provide a stable and objective basis for comparison. This high level of reproducibility ensures that once a print is recorded, it serves as a dependable piece of evidence that can be stored in databases and analyzed across different time periods or jurisdictions.

There are 4 types pf fingerprint classification:

1. Arch: The ridges run from one side of the print to another side forming an arch. There is no recurving of the ridges and has approximately 5% of recorded fingerprint.

It has two types:

- Plain arch: The ridges run from one side to other side with a small rise at the centre like a hill or hump.
- Tented arch: The ridges entering from one side makes an upright thrust at the centre flowing towards the right side of the pattern.

2. Loop: It is formed when one or more ridges entering from the same side recurving and existing from the same side. It has a core and a delta. 60-65% of population have loop pattern.

It has two types:

- Radial loop: The ridges start from radial bone or thumb side of the hand and recurving around the core and exiting to the same side of the hand.
- Ulnar loop: The ridges start from ulnar bone or little finger of the hand and recurving around the core and exiting to the same side of the hand.

3. Whorl: It has at least one ridge forming complete trip may be in the form of spiral or oval having one core and 2 deltas. Almost 30-35% populations have whorl pattern.

4. Composite: They are the combinations of all three patterns- loop, whorl and arch. 1 to 2% of composite patterns are present.

It has four types:

- Central pocket loop: The ridges forming a loop but at the centre one or more ridges within the pattern are forming a whorl or pocket-like structure.
- Lateral pocket loop: The two loops are overlapping or surrounding each other, with one loop forming a pocket by the downward bending of its ridges before they recurve.
- Twin loop: It is also known as Double loop pattern. This pattern consisting of two distinct loops that are typically interlocked, often resembling the letter ‘S’.
- Accidental: It is a combination of any two or more different patterns within a single print. They usually have two or more prints.

Fingerprints are essential in solving crimes because they uniquely identify individuals. When investigators search a crime scene, they typically find three main types: plastic prints, patent prints and latent prints. Experts use several different names for these discoveries, including "chance prints" or "finger marks," but they all serve as vital evidence to help catch the right person.

- Plastic fingerprints are three-dimensional impressions that occur when a finger is pressed into a soft, malleable material. Common substances that capture these prints include wax, soap, wet putty or fresh paint. Because the ridges of the finger create a physical indentation in the surface, these prints are easily visible to the naked eye and can be recorded immediately through photography with specialized lighting.
- Patent fingerprints are also known as visible prints, that are formed when a finger coated in a foreign substance touches a surface. These substances might include blood, ink, dirt or grease, leaving a clear and distinct image of the finger’s ridge patterns behind. Much like plastic prints, these are readily apparent without the need for advanced detection tools and are typically documented by forensic investigators using high-resolution photography.
- Latent fingerprints are the most common yet challenging type of evidence because they are initially invisible. They are created when the natural oils and sweat produced by the skin are transferred onto a surface through touch. To make these hidden marks appear, forensic experts must use various enhancement techniques, such as dusting the area with fine powders or applying chemical reagents that react with the biological residue to reveal the ridge details.

Forensic science relies heavily on fingerprint development to identify suspects and solve crimes. Latent prints are typically processed using either physical or chemical approaches. Physical methods work by adhering to perspiration and oils without altering their structure, preserving the print's original characteristics. In contrast, chemical techniques trigger a reaction with the components of the sweat, inducing a colour change that makes the fingerprint visible.

Physical methods having powder development techniques:

Black Powder consists of graphite and charcoal and is a staple in fingerprint development. By dusting it onto a surface, the powder sticks to the oily residues left behind by skin. This process makes ridges and patterns much easier to see, especially when working with materials like paper or chinaware.

Silver Powder is created from finely ground aluminium dust. This specific variety is best suited for surfaces that have been painted or varnished. Like other powders, it adheres to oily deposits to reveal latent prints that would otherwise remain invisible to the naked eye.

White or Grey Powder, often made from mercury and chalk, works much like its black counterpart but is designed for contrast. It is the go-to choice for darker surfaces where black powder would blend in. Investigators find it most effective when dusting glassware, silverware, and other plated items.

Red Powder is frequently referred to as "Dragon's blood" because it is made from the powdered resin of palm fruit. It contains a specific colouring agent that makes prints pop against light-coloured backgrounds. It is particularly useful for lifting fresh fingerprints from paper surfaces.

Fluorescent Powders are unique because they are designed to be used with UV or alternate light sources. Containing substances like Rhodamine-B or Anthracene, these powders glow under specific wavelengths of light. This makes them the ideal choice for detecting prints on busy, multi-coloured surfaces such as magazine covers and calendars.

Magna brush development is a specialized forensic technique used to visualize latent fingerprints on non-porous surfaces like glass, plastic and metal. This method utilizes a magnetized applicator, or "Magna Brush," to pick up magnetic powder that is typically iron-based, which then forms its own "bristle" structure. As the investigator lightly passes this magnetic brush over a surface, the fine powder particles adhere to the oily residues and moisture left by finger ridges. Because the powder itself acts as the brush, this method is significantly less abrasive than traditional fiber brushes, greatly reducing the risk of smudging or destroying delicate ridge patterns. The result is a high-contrast image of the fingerprint that is clear enough to be photographed or lifted for evidence.

Chemical Method includes:

Iodine development is a chemical technique used to reveal latent fingerprints on porous items such as cardboard or paper. The process involves iodine vapours reacting with the oils and fatty acids in the print residue, creating a temporary yellow or brown stain. Because these prints are unstable and fade quickly, documentation through photography is necessary immediately after they appear.

Silver nitrate development offers a more permanent solution for porous surfaces by targeting chloride ions in the fingerprint. When a silver nitrate solution is applied, it creates silver chloride, which darkens upon exposure to light. This method is particularly useful for identifying older fingerprints that might not respond to other chemical treatments.

Ninhydrin development is a widely used method that reacts with the amino acids found in human perspiration. This chemical reaction produces a distinct purple or red colour, which can be further intensified through the application of heat. Known for its high sensitivity, ninhydrin is often used for the long-term preservation of evidence on porous materials.

Ridge characteristics:

The study of ridge characteristics, technically known as minutiae, forms the cornerstone of modern dactyloscopy because these patterns are unique to every individual and remain virtually unchanged from birth until death. Beyond the general flow of loops, whorls, arches and composite, forensic experts meticulously analyze micro-details such as ridge endings, where a friction ridge terminates abruptly, and bifurcations, where a single ridge splits into two separate paths. These features, along with dots, enclosures and short ridges, create a complex biological map that allows investigators to establish identity with an incredibly high degree of mathematical certainty. Even identical twins, who share the same DNA, possess different ridge characteristics, making fingerprints a more specific biometric marker than genetic sequencing in many forensic contexts. Because these patterns are permanent and distinctive, they serve as a nearly infallible tool for linking specific individuals to physical evidence found at a crime scene.

## II. REVIEW OF LITERATURE

A literature review is a critical, systematic analysis of existing scholarly research such as books and journal articles on a specific topic. It goes beyond a simple summary by synthesizing multiple sources to identify major themes, current trends and key debates within a field.

The study done by R Dwivedi et al. (2026) on titled "Green Synthesis of Eco-Friendly Fingerprint Powders from Brewed Green and Black Tea Leaves" developed sustainable, non-toxic fingerprint powders from brewed black and green tea waste to assess their efficiency on various surfaces. The experimental study utilized Camellia sinensis leaves, demonstrating that these eco-friendly materials effectively visualize latent prints, offering a cost-effective and safer alternative to conventional methods while recommending further research into natural waste for forensics.

The study by N Zafar et al. (2026) on titled "Enhancing Fingerprint Development Using Aloe Vera Powder from Waste Plant Material" evaluates the efficacy of eco-friendly, cost-effective aloe vera powder derived from waste plant material for developing latent fingerprints on diverse surfaces. Using an experimental design on multiple sample sets, the study found the powder produces high-quality ridge detail with minimal background staining, recommending it as a viable, non-toxic alternative for forensic dactyloscopy.

The study conducted by Jaffna Nisha K et al. (2025) on titled "Development of Latent Fingerprints on Indoor Plant Leaves Using Powder Methods" is an experimental study investigates the feasibility of using powder dusting techniques to recover latent fingerprints from 10 common indoor plant species in Northern Kerala. Employing black, white and fluorescent powders, the research assessed print quality on leaves over seven days intervals, finding that fluorescent powder yielded the best results, particularly on smooth-surfaced leaves like the Heartleaf Philodendron, while overall print quality significantly declined after one week. The authors suggest that forensic investigators should routinely examine indoor plants at crime scenes and recommend future research extend time intervals and explore various other techniques.

The study by J Verma et al. (2025) on titled "A Comparative Study of Latent Fingerprint Development via Physical Methods on Money Plant (Epipremnum aureum) Leaves" conducted a cross-sectional experimental study in Delhi using 30 participants to evaluate the effectiveness of physical dusting methods, specifically black and fluorescent orange powders on waxy Epipremnum aureum (money plant) leaves. The study utilizing a stereomicroscope and SPSS for analysis, found that black powder significantly outperforms fluorescent orange powder in yielding superior ridge detail, suggesting its use in forensic investigations for botanical evidence.

The study conducted by Elipe, A., et al. (2025) on titled "Sustainable Nanotechnology in Forensics: Advances in Latent Fingerprint Development Using Plant-based Materials" investigated the efficacy of eco-friendly, green-synthesized nanoparticles derived from agricultural waste (rice husk, neem, potato, lemon, and orange peels) as sustainable alternatives to conventional forensic reagents for latent fingerprint (LFP) visualization. Using an experimental design, the study involved applying nanoparticle powders to latent fingerprints collected from participants on non-porous surfaces to analyse ridge detail and compare performance against commercial standards. Findings showed that rice husk nanoparticles were the most effective, achieving approximately 90% visibility and high-quality ridge detail, while neem also demonstrated high effectiveness. The study concludes that these cost-effective, non-toxic materials are viable alternatives and recommends expanding research to other agricultural waste sources for routine forensic application.

The study done by Rai, A. R., Sharma et al. (2024) on titled "Exploring the Forensic Potential of Ashwagandha (Withania somnifera) Powder: A Novel Approach for Enhancing Latent Fingerprint Development" investigated the forensic potential of Withania somnifera (Ashwagandha) powder as an eco-friendly, non-toxic alternative for developing latent fingerprints, utilizing an experimental design to test powder dusting on various surfaces in Jaipur. The study successfully developed clear ridge characteristics on substrates like aluminium foil and plywood with 80–100% clarity scores, though it proved ineffective on leather. The findings suggest adopting this herbal approach for safer forensic investigations and conducting future research on environmental factors.

The study conducted by A Srivastava et al. (2024) on titled "A green approach to fingerprint enhancement: The potential of Alternanthera dentata leaf powder" investigated Alternanthera dentata (AD) leaf powder as a sustainable, eco-friendly and cost-effective forensic alternative for latent fingerprint enhancement on various surfaces like glass, metal and paper. Utilizing an experimental design, the study which fell under the domain of forensic science, involved applying 5 grams of processed AD leaf powder to samples and utilizing ATR-FT-IR spectroscopy for analysis. Findings indicated that the powder is rich in natural anthocyanins, effectively visualized clear ridge details and changed colour upon interaction with sweat. The authors concluded that this non-toxic material serves as a viable, green alternative for forensic investigations. The study by Parkale et al. (2024) on titled "A Review of Latent Fingerprint Developed Powder from using Natural Materials" examines natural materials as eco-friendly alternatives to conventional forensic fingerprint powders, covering the field of latent fingerprint development on various surfaces. Using a review-based design, the authors analyzed 64 materials, including plant, food and mineral-based powders through a systematic literature review. Findings indicate that materials like turmeric, white cement and gram flour are effective for ridge visualization, prompting suggestions to further explore luminescent carbon dots and sustainable green forensic tools.

The study conducted by Nugroho et al. (2023) on titled "Fluorophores-rich natural powder from selected medicinal plants for detection latent fingerprints and cyanide" investigated the use of fluorophore-rich powders from four medicinal plants (Zingiber montanum, Solanum indicum L., Rhinacanthus nasutus and Euphorbia tirucalli) as sustainable, non-toxic alternatives for detecting latent fingerprints (LFPs) and cyanide in forensic science. Using an experimental design, the study analyzed plant powders through characterization techniques such as FIB-SEM, FTIR and fluorescence spectrophotometry with sample fingerprints provided by a volunteer. Findings indicated that these plant-based powders successfully developed high-quality, long-lasting LFP images on non-porous surfaces and identified trace cyanide via a "turn-on-off" fluorescent mechanism, leading to suggestions that they are effective for forensic applications on complex, multicoloured surfaces.

The study conducted by TK Hariprasath (2021) on titled "Ocimum sanctum Powder as a Dusting Material in Latent Fingerprints - An Observational Study in Forensic Science" investigated the effectiveness of Ocimum sanctum (Tulsi) powder as a non-toxic, cost-effective dusting material for visualizing latent fingerprints on electronic surfaces, utilizing an observational design on a sample of 10 surfaces. Data collected via traditional dusting and photography showed the powder successfully develops prints on smooth surfaces, though it is limited on rough, multi-coloured surfaces due to its colour and flow, suggesting a need for further research to enhance forensic application.

All the above studies reveal that natural and chemical powders can develop fingerprints, focusing on the immediate results. There is a lack of detailed observation on how the powders maintain ridge characteristics over a long period. But this study fills the gap by observing the persistence of specific patterns and identifying which non- porous surfaces keep these prints visible the longest. Furthermore, the uniqueness of this study lies in its focus on powders made from medicinal leaves where most of the studies hasn't focused on.

## III. METHODOLOGY

It is a systematic framework that begins with a clear aim and need to justify the study's importance. It uses specific objectives and research questions to guide the study's design, which determines the sample size and population. The process involves selecting tools and techniques for data collection, such as surveys or interviews to gather information for data analysis. Finally, the findings undergo interpretation to explain their meaning and provide answers to the original research problem.

### 3.1 Need for the Study

The present study focuses on use of non-toxic, eco-friendly and low-cost powders for the development of latent fingerprint found on the non-porous surfaces in the crime scene. This study uses easily available medicinal leaf powders such as Eucalyptus, Hibiscus, Neem, Tulsi and Henna, that promotes green forensics providing a safe, biodegradable alternative that ensures identification of fingerprint patterns and ridge characteristics on non-porous surfaces. If the findings

of the study help to identify the fingerprint patterns and ridge characteristics clearly and lasts for longer, these powders can be replaced with the currently used chemical powders.

3.2 Aim of the Study

To study the development and evaluation of latent fingerprints using different medicinal leaf powders on non-porous surfaces.

3.3 Objectives

- To determine the specific medicinal leaf powder that provides the highest level of ridge detail in developing latent fingerprint.
- To identify the most suitable non-porous surface for maximizing the visibility of latent fingerprints.
- To assess the fingerprint patterns and ridge characteristics and its persistence over time.

3.4 Research Questions

1. How well do the medicinal leaf powders enhance visibility of latent fingerprints on non-porous surfaces?
2. Which non-porous surface provides maximum visibility of latent fingerprint?
3. How long do the developed fingerprints retain on non-porous surfaces?

3.5 Research Design

Research design is strategic blueprint that outlines the methods for collecting and analysing data to solve a specific problem. It ensures the study remains logical and unbiased, acting as a master plan to answer research questions effectively.

A laboratory based experimental method with qualitative approach was used for this study, where latent fingerprints were developed directly using medicinal leaf powders namely Eucalyptus, Neem, Henna, Hibiscus and Tulsi.

3.6 Universe, sample and sampling techniques

This present study was conducted in Mangaluru with a total of 25 latent fingerprint samples collected on five non-porous surfaces from the participants randomly. This includes 5 latent fingerprint samples for each medicinal leaf powder (Tulsi, Henna, Hibiscus, Neem and Eucalyptus) fingerprints left on different non-porous contrast surfaces like Plastic, Smartphone screen, Glass, Stainless Steel and Metal surface. This study was based on non-probability purposive sampling.

3.7 Tools for data collection

Different types of Medicinal leaf powders are used to develop latent fingerprints on non- porous surfaces such as Plastic, Smartphone screen, Glass, Stainless steel and Metal surface.

The leaves were dried in sunlight for 5 days and grinded. Then it was sieved by using a 75-mesh sieve.

## IV. MATERIALS AND METHODS

- Selection of powders: Medicinal Leaf powders- Eucalyptus, Hibiscus, Neem, Henna and Tulsi were used for the study.
- Surface selection: Different types of non- porous surfaces such as Plastic, Smartphone screen, Glass, Stainless steel and Metal surface.

Procedure for Developing Latent fingerprint

- Different types of Medicinal leaf powders were used to develop latent fingerprints on non- porous surfaces such as Plastic, Smartphone screen, Glass, Stainless steel and Metal surface.
- A participant was asked for consent and asked to press their finger onto a clean, non-porous surfaces to create a latent print.
- A small amount of the selected medicinal leaf powder was lightly dusted over the area using a camel brush on surfaces.
- The excess powders are gently brushed off using ostrich brush to reveal the developed prints, which was then photographed
- The developed prints were kept for a period of time to assess the long-term stability and clarity of powder's ridge characteristics.

4.1 Inclusion criteria

- Individuals randomly selected from the available population.
- Individuals whose fingerprints can be consistently recorded under established protocols.
- Individuals with clean and intact hands (free from visible dirt, cuts or contaminants).

4.2 Exclusion criteria

- Individuals with cuts, burns or injuries on fingertips that may distort fingerprint patterns.

- Individuals with dermatological conditions affecting the skin of the hands (e.g., peeling, infections).
- Individuals with excessively sweaty or oily hands that may interfere with proper fingerprint development.

## V. DATA PRESENTATION AND ANALYSIS

In the present study, the collected data was analysed in Microsoft Excel and presented in the tables.

### 5.1 Report design

Report design is the process of deciding how research findings will be presented so that readers can easily understand and interpret the information.

The research report will include the following chapters:
Chapter I: Introduction: It contains background, history about the topic
Chapter II: Review of literature: It includes the note on previous studies conducted on the same topic
Chapter III: Methodology: It contains need and aim of the study, objectives, research statements, research design, sample selection, tools of data collection, inclusion and exclusion criteria, method of data collection.
Chapter IV: Data analysis: It presents the processed data, categorized using tables, charts and graphs, along with interpretation of the results in relation to the objectives.
Chapter V: Major findings, Suggestions and Conclusion: It summarizes core findings, proposes strategies for policy or practice and provides a concludes the study.

### 5.2 Limitations

- The study is based on limited number of samples (i.e. 100 fingerprints), which may not represent entire population.
- Limited duration effect depth of analysis or repeated observation.
- Some fingerprints may smudge, partial or unclear due to improper deposition or collection affecting analysis accuracy.
- Fingerprints samples collected on limited or small surfaces may result in reduced availability of ridge characteristics for analysis.
- Interpretation of ridge characteristics may vary between examiners.
- Lack of advanced tools like AFIS, may reduce precision.

### 5.3 Data analysis and discussion

Data Analysis and Interpretation is the process of systematically organizing raw data to identify patterns and then assigning meaning to those patterns to draw valid conclusions.
In this study, the observations were analyzed to evaluate the effectiveness of different types of medicinal leaf powders in developing latent fingerprints on various surfaces.
Different types of Medicinal leaf powders from dry leaves such as Eucalyptus, Hibiscus, Henna, Tulsi and Neem were used to develop latent fingerprints on non-porous surfaces such as Plastic, Smartphone screen, Glass, Stainless steel and Metal surface.

## VI. DEVELOPMENT OF LATENT FINGERPRINT USING DIFFERENT TYPES OF MEDICINAL LEAF POWDERS ON VARIOUS NON- POROUS SURFACES

The study used the medicinal leaf powders to develop these prints, as the fine particles bond to the oily residues left behind. This adhesion highlights the unique ridge patterns and its ridge characteristics, making invisible prints clearly visible.

Table No. 4. 1 Developed fingerprint on non-porous surfaces using eucalyptus leaf powder

| Surface | Characteristics of visibility | | | |
|---|---|---|---|---|
| | No visibility | Partially visible | Pattern visible | Pattern along ridge characteristics |
| Plastic | | | | ✓ |
| Smartphone screen | | | | ✓ |
| Glass | | | ✓ | |
| Stainless steel | | | ✓ | |
| Metal surface | | ✓ | | |

The data shown in the table no. 4.1 indicates that latent fingerprints were developed on non-porous surfaces using Eucalyptus leaf powder. For plastic surface and smartphone screen, clear pattern was developed along with ridge characteristics. Following the same process, for glass and stainless-steel surface, the fingerprint pattern was visible. However, for the metal surface, the fingerprint was only partially visible.

Table No. 4.2 Developed fingerprint on non-porous surfaces using hibiscus leaf powder

| Surface | Characteristics of visibility | | | |
|---|---|---|---|---|
| | No visibility | Partially visible | Pattern visible | Pattern along ridge characteristics |
| Plastic | | | ✓ | |
| Smartphone screen | | | ✓ | |
| Glass | | | ✓ | |
| Stainless steel | | | ✓ | |
| Metal surface | ✓ | | | |

The data shown in the table no. 4.2 indicates that latent fingerprints were developed on non-porous surfaces using Hibiscus leaf powder. For plastic, smartphone screen, glass and stainless-steel surfaces, the fingerprint patterns were visible, while for the metal surface, the fingerprint was only partially visible.

Table No. 4.3 Developed fingerprint on non-porous surfaces using henna leaf powder

| Surface | Characteristics of visibility | | | |
|---|---|---|---|---|
| | No visibility | Partially visible | Pattern visible | Pattern along ridge characteristics |
| Plastic | | | ✓ | |
| Smartphone screen | | | ✓ | |
| Glass | | | ✓ | |
| Stainless steel | | | | ✓ |
| Metal surface | | ✓ | | |

The data shown in the table no. 4.3 indicates that latent fingerprints were developed on non-porous surfaces using Henna leaf powder. For the stainless-steel surface, a clear fingerprint pattern was developed along with ridge characteristics. On plastic, smartphone screen and glass surfaces, only the developed fingerprint patterns were visible. However, for the metal surface, the fingerprint was only partially visible.

Table no. 4.4 Developed fingerprint on non-porous surfaces using tulsi leaf powder

| Surface | Characteristics of visibility | | | |
|---|---|---|---|---|
| | No visibility | Partially visible | Pattern visible | Pattern along ridge characteristics |
| Plastic | | | | ✓ |
| Smartphone screen | | | | ✓ |
| Glass | | | | ✓ |
| Stainless steel | | | | ✓ |
| Metal surface | | | ✓ | |

The data shown in the table no. 4.4 indicates that latent fingerprints were developed on non-porous surfaces using Tulsi leaf powder. For plastic, smartphone screen, glass and stainless-steel surfaces, the powder was developed clear fingerprint patterns along with ridge characteristics. However, for the metal surface, only the developed fingerprint pattern was visible.

Table no. 4.5 Developed fingerprint on non-porous surfaces using neem leaf powder

| Surface | Characteristics of visibility | | | |
|---|---|---|---|---|
| | No visibility | Partially visible | Pattern visible | Pattern along ridge characteristics |
| Plastic | | | | ✓ |
| Smartphone screen | | | | ✓ |
| Glass | | | | ✓ |
| Stainless steel | | | | ✓ |
| Metal surface | | | ✓ | |

The data shown in the table no. 4.5 indicates that latent fingerprints were developed on non-porous surfaces

using Neem leaf powder. For plastic, smartphone screen, glass and stainless-steel surfaces, clear fingerprint patterns were developed along with ridge characteristics. However, for the metal surface, only the developed fingerprint pattern was visible.

Table no. 4.6 Developed fingerprint on plastic surface

| Sl. No | Different types of medicinal leaf powders | Duration of visibility of latent fingerprint on plastic surface | | |
|---|---|---|---|---|
| | | Immediate | 24 hours | 48 hours |
| 1 | Eucalyptus leaf powder | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified |
| 2 | Hibiscus leaf powder | Fingerprint pattern identified | Fingerprint pattern identified | Fingerprint pattern identified |
| 3 | Henna leaf powder | Fingerprint pattern identified | Fingerprint pattern identified | Fingerprint pattern identified |
| 4 | Tulsi leaf powder | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified |
| 5 | Neem leaf powder | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified |

The data shown in the table no. 4.6 indicates the results of developed latent fingerprints on plastic surface using different medicinal leaf powders such Eucalyptus leaves, Hibiscus leaves, Henna leaves, Tulsi leaves and Neem leaves at varying time intervals. The researcher observed that in the immediate duration, fingerprint patterns and ridge characteristics were clearly visible and identifiable for Eucalyptus, Tulsi and Neem leaf powders and only fingerprint pattern identifiable for Hibiscus and Henna leaf powders. At 24 hours, fingerprint patterns and ridge characteristics remained stable on the plastic surface and even at 48 hours, the visibility remained unchanged. This indicated that Eucalyptus, Tulsi and Neem are highly effective for developing latent fingerprints on plastic surfaces, maintaining fingerprints patterns and ridge characteristics.

Table no. 4.7 Developed Fingerprint on Smartphone Screen Surface

| Sl. no | Different types of medicinal leaf powders | Duration of visibility of latent fingerprint on smartphone screen surface | | |
|---|---|---|---|---|
| | | Immediate | 24 hours | 48 hours |
| 1 | Eucalyptus leaf powder | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified |
| 2 | Hibiscus leaf powder | Fingerprint pattern identified | Fingerprint pattern identified | Fingerprint pattern identified |
| 3 | Henna leaf powder | Fingerprint pattern identified | Fingerprint pattern identified | Fingerprint pattern identified |
| 4 | Tulsi leaf powder | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern identified | Fingerprint pattern identified |
| 5 | Neem leaf powder | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified |

The data shown in the table no. 4.7 indicates the results of developed latent fingerprints on smartphone screen surface using different medicinal leaf powders such Eucalyptus leaves, Hibiscus leaves, Henna leaves, Tulsi leaves and Neem leaves at varying time intervals. The researcher observed that in the immediate duration, fingerprint patterns and ridge characteristics were clearly visible and identifiable for Eucalyptus, Tulsi and Neem leaf powders and only fingerprint pattern identifiable for Hibiscus and Henna leaf powders. At 24 hours, fingerprint patterns and

ridge characteristics remained stable on the plastic surface and even at 48 hours, the visibility remained unchanged. This indicated that Eucalyptus, Tulsi and Neem are highly effective for developing latent fingerprints on smartphone screen surfaces, maintaining fingerprints patterns and ridge characteristics.

Table no. 4.8 Developed Fingerprint on Glass Surface

| Sl. no | Different types of medicinal leaf powders | Duration of visibility of latent fingerprint on glass surface | | |
|---|---|---|---|---|
| | | Immediate | 24 hours | 48 hours |
| 1 | Eucalyptus leaf powder | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified |
| 2 | Hibiscus leaf powder | Fingerprint pattern identified | Fingerprint pattern identified | Fingerprint pattern identified |
| 3 | Henna leaf powder | Fingerprint pattern identified | Fingerprint pattern identified | Fingerprint pattern identified |
| 4 | Tulsi leaf powder | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified |
| 5 | Neem leaf powder | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified |

The data shown in the table no. 4.8 indicates the results of developed latent fingerprints on glass surface using different medicinal leaf powders such Eucalyptus leaves, Hibiscus leaves, Henna leaves, Tulsi leaves and Neem leaves at varying time intervals. The researcher observed that in the immediate duration, fingerprint patterns and ridge characteristics were clearly visible and identifiable for Eucalyptus, Tulsi and Neem leaf powders and only fingerprint pattern identifiable for Hibiscus and Henna leaf powders. At 24 hours, fingerprint patterns and ridge characteristics remained stable on the plastic surface and even at 48 hours, the visibility remained unchanged. This indicated that Eucalyptus, Tulsi and Neem are highly effective for developing latent fingerprints on glass surfaces, maintaining fingerprints patterns and ridge characteristics.

Table no. 4.9 Developed fingerprint on stainless steel surface

| Sl. No | Different types of medicinal leaf powders | Duration of visibility of latent fingerprint on stainless steel surface | | |
|---|---|---|---|---|
| | | Immediate | 24 HOURS | 48 HOURS |
| 1 | Eucalyptus leaf powder | Fingerprint pattern identified | Fingerprint pattern identified | Fingerprint pattern identified |
| 2 | Hibiscus leaf powder | Fingerprint pattern identified | Fingerprint pattern identified | Fingerprint pattern identified |
| 3 | Henna leaf powder | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified |
| 4 | Tulsi leaf powder | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified |
| 5 | Neem leaf powder | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified | Fingerprint pattern and ridge characteristics are identified |

The data shown in the table no. 4.9 indicates the results of developed latent fingerprints on smartphone screen surface using different medicinal leaf powders such Eucalyptus leaves, Hibiscus leaves, Henna leaves, Tulsi leaves and Neem leaves at varying time intervals. The researcher observed that in the immediate duration, fingerprint patterns and ridge characteristics were clearly visible and identifiable for Henna, Tulsi and Neem leaf powders and only fingerprint pattern identifiable for Eucalyptus and Hibiscus leaf powders. At 24 hours, fingerprint

patterns and ridge characteristics remained stable on the plastic surface and even at 48 hours, the visibility remained unchanged. This indicated that Henna, Tulsi and Neem are highly effective for developing latent fingerprints on Stainless steel surfaces, maintaining fingerprints patterns and ridge characteristics.

Table no. 4.10 Developed fingerprint on metal surface

| Sl. No | Different types of medicinal leaf powders | Duration of visibility of latent fingerprint on metal surface | | |
|---|---|---|---|---|
| | | Immediate | 24 hours | 48 hours |
| 1 | Eucalyptus leaf powder | Fingerprint pattern identified | Fingerprint is not developed | Fingerprint is not developed |
| 2 | Hibiscus leaf powder | Fingerprint pattern not identified | Fingerprint is not developed | Fingerprint is not developed |
| 3 | Henna leaf powder | Fingerprint pattern identified | Fingerprint is not developed | Fingerprint is not developed |
| 4 | Tulsi leaf powder | Fingerprint pattern identified | Fingerprint is not developed | Fingerprint is not developed |
| 5 | Neem leaf powder | Fingerprint pattern identified | Fingerprint is not developed | Fingerprint is not developed |

The data shown in the table no. 4.10 indicates the results of developed latent fingerprints on metal surface using different medicinal leaf powders such Eucalyptus leaves, Hibiscus leaves, Henna leaves, Tulsi leaves and Neem leaves at varying time intervals. The researcher observed that in the immediate duration, fingerprint patterns were identifiable for Eucalyptus, Henna, Tulsi and Neem leaf powders and only fingerprint pattern not identifiable for Hibiscus leaf powder. At 24 hours, fingerprints were not developed for any medicinal leaf powders and even at 48 hours, fingerprints were also not developed. This indicated that medicinal leaf powders are little effective for developing fresh fingerprints on metal surfaces and they become ineffective after 24 hours.

## VII. DISCUSSION

The researcher used all five fingers of right hand for leaving the latent fingerprints and observed the fingerprints before and after leaving the prints. By checking the prints both before and after leaving latent fingerprints on different non-porous surfaces like plastic, smartphone screen, glass, stainless steel and metal surfaces, observed the time intervals and surface type affecting the fingerprint pattern and its ridge characteristics of the latent prints left behind.

To make the prints visible, five different medicinal leaf powders- Eucalyptus, Hibiscus, Henna, Tulsi and Neem leaf powders were applied on non-porous surfaces. While every medicinal leaf powders worked well to reveal the prints, the Tulsi and Neem powders was the most effective, producing the clearest fingerprint patterns along with ridge characteristics across all tested surfaces.

The results showed that the Stainless-steel surface was the best non-porous surface. On non-porous surfaces, all five medicinal leaf powders worked successfully. It revealed clear fingerprint patterns and ridge characteristics, proving these powders and surfaces are the most reliable for testing.

### 7.1 Major Findings

- Latent fingerprints were developed on different non-porous surfaces using different medicinal leaf powders, maintaining clear fingerprint patterns and ridge characteristics for up to 48 hours.
- Tulsi and Neem leaf powders were the most effective, producing the clearest fingerprint patterns and ridge characteristics across all tested non-porous surfaces.
- A Stainless-steel surface was found to be one of the best non-porous surfaces among all the developed fingerprints using different medicinal leaf powders.

### 7.2 Suggestions

- Future researchers can try using other medicinal leaf powders.
- Further studies can be made to develop latent fingerprints on other non-porous surfaces, as well as porous surfaces.
- Further attempts can be conducted by combining any adhesives to improve adhesion.
- Future research should test the temperature variations affect the quality of fingerprints developed with medicinal leaf powders.

## VIII. CONCLUSION

The present study focused on non-toxic and commonly available medicinal leaf powders such as Eucalyptus, Hibiscus, Henna, Tulsi and Neem leaf powders that could reveal latent fingerprints on five non-porous surfaces such as Plastic, Smartphone screen, Glass, Stainless steel and Metal surface choosing them because they are often seen and touched at crime scenes. After applying the powder at different time intervals, the fingerprints were photographed for clear documentation. The results showed that Tulsi and Neem leaf powders work well on smooth surfaces and a Stainless-steel surface was found to be the best non-porous surface among all other surfaces.

## REFERENCES


[1]. Dwivedi, R., H. Kothari, G. Saxena, V. Thakre, and B. Jangir, "Green synthesis of eco-friendly fingerprint powders from brewed green and black tea leaves," International Journal of Research and Review, vol. 97, 2026.

[2]. Zafar, N., A. R. Rai, V. Sharma, D. Jain, A. Sharma, V. Tripathi, A. Gautam, T. Sharma, V. Mishra, K. K. Awasthi, and M. S. Sankhla, "Enhancing fingerprint development using Aloe vera powder from waste plant material," Journal of Forensic Science and Medicine, vol. 12, pp. 15–19, 2026.

[3]. Jaffna Nisha, K., et al., "Development of latent fingerprints on indoor plant leaves using powder methods," 2025.

[4]. Verma, J., and N. K. Mamta, "A comparative study of latent fingerprint development via physical methods on money plant (Epipremnum aureum) leaves," 2025.

[5]. Elipe, A., V. Garg, D. Upadhyay, and P. Singh, "Sustainable nanotechnology in forensics: Advances in latent fingerprint development using plant-based materials," Journal of Environmental Nanotechnology, vol. 14, pp. 454–465, 2025.

[6]. Rai, A. R., V. Sharma, D. Jain, A. Kaur, M. Agrawal, K. Vikas, V. Nagar, P. Kumari, et al., "Exploring the forensic potential of Ashwagandha (Withania somnifera) powder: A novel approach for enhancing latent fingerprint development," 2024.

[7]. Srivastava, A., P. Verma, D. Mukherjee, B. Moza, A. Saha, P. Ujjainia, P. Dhondiyal, and P. Jain, "A green approach to fingerprint enhancement: The potential of Alternanthera dentata leaf powder," IP International Journal of Forensic Medicine and Toxicological Sciences, vol. 9, pp. 18–27, 2024.

[8]. Parkale, K. J., and M. S. Bagul, "A review of latent fingerprint development powder from using natural materials," 2024.

[9]. Nugroho, D., S. Chanthai, W. C. Oh, and R. Benchawattananon, "Fluorophores-rich natural powder from selected medicinal plants for detection latent fingerprints and cyanide," 2023.

[10]. Hariprasath, T. K., "Ocimum sanctum powder as a dusting material in latent fingerprints: An observational study in forensic science," 2021.




Ostrich brush



Eucalyptus leaf powder



Hibiscus leaf powder



Henna leaf powder



Tulsi leaf powder



Neem leaf powder




Plastic surface



Glass surface



Stainless steel



Metal surface



Smartphone screen