Volume 4, Issue 6, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

FROM PANTRY TO FORENSIC BENCH: EVALUATING SPICE AND STARCH PARTICULATES AS NOVEL MEDIA FOR LATENT FINGERPRINT VISUALIZATION

Zain Hussain[*1], Nazish Khatoon[2], Hira Khalil[3], Rimsha[4], Dr. Rizwana Khanzada[5], Rimsha Khadim[6]

[*1,2,3,4,5,6]*Department of Forensic Medicine and Toxicology, Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro, Sindh, Pakistan*

DOI: https://doi.org/10.5281/zenodo.20642025

Keywords
latent fingerprint visualization, household powders, corn flour, cocoa powder, forensic powder alternatives, ridge detail and contrast, cost-effective forensic methods, resource-limited forensic applications.

Article History
Received: 14 April 2026
Accepted: 26 May 2026
Published: 11 June 2026

Corresponding Author: *
Zain Hussain

Abstract

Can everyday ingredients from the kitchen function similar to forensic powders that are used for crime scene analysis? In this research project, The Unseen Revealed: "from pantry to The forensic bench", we look to see if there are alternative household powders that can be used to develop and visualize latent fingerprints instead of expensive forensic powders in the market that one would generally rely on. The research includes three major objectives. The first is to evaluate the effectiveness of using selected spices and starch particulates to visualize latent fingerprints. The second is to compare the performance of the selected household powders used to visualize latent fingerprints in regard to clarity of the print, ridge detail of the print, and contrast to the selected surface type, to that of commercial forensics powders. The third is to evaluate the general perception of the usability, safety and practicality of the household powders used in the study. A systematic and structured method was used to conduct this research. The research was conducted under strict controlled conditions to ensure that accurate and reproducible results were achieved. As part of the study, many different household powders were tested for their ability to visualize latent fingerprints; however, very few would produce a satisfactory print visualization. Two powders produced satisfactory prints; they were cornflour when used on dark surfaces and cocoa when used on light surfaces. We completed 100 latent fingerprint collections from many different locations and surfaces types; after that, the prints were visualized with the two selected powders and lifted off of the surfaces to conduct more detailed analysis. The outcomes were really quite amazing. Corn flour and cocoa powder effectively made latent fingerprints visible, delivering sharp details of ridges and high contrast within minutes. In a side to side comparison with the traditional forensic powders, these two domestic alternatives were found not only highly effective but also very inexpensive and quite easily available. Besides, people who tried them considered these powders safe and simple to use under real operating conditions.From what we have observed, we are of the opinion that household powders that are readily available and are widely used - In particular corn flour and cocoa powder - may be used as alternatives to traditional forensic materials for latent fingerprint enhancement. This is more so in cases where forensic budgets are very limited or it is difficult to obtain commercial powders. Our research highlights the possibility of

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

incorporating cheap and readily available materials in forensic work without sacrificing the level of performance or dependability. Besides, this study paves the way for further exploration of forensic science by proving that typical, low-cost solutions can work well and be environmentally friendly at the same time. Actually, it turns out that the most powerful instrument may not really be deep inside a laboratory but rather right there in your kitchen cup board.

1. INTRODUCTION

1.1 Background and Overview

Fingerprint analysis stands as one of the oldest, most reliable, and most widely employed methods of personal identification in forensic science. Since the pioneering work of Sir Francis Galton in the late nineteenth century, dactyloscopy — the study of fingerprint patterns — has become a cornerstone of criminal investigations worldwide. Latent fingerprints, which are invisible impressions left on surfaces through the deposition of sebaceous and eccrine secretions, require development techniques to render them visible for examination and comparison.[1][2]

Conventional fingerprint development powders — including black carbon powder, aluminium powder, fluorescent powders, magnetic powders, ninhydrin, and cyanoacrylate fuming — have been the gold standard in forensic laboratories for decades. While these agents are highly effective on a variety of non-porous surfaces, their widespread use raises significant concerns regarding toxicity, cost, environmental impact, and accessibility, particularly in resource-limited settings such as developing nations.[3][4]

In recent years, there has been a growing interest in exploring alternative, naturally derived materials as substitutes for traditional fingerprint powders. Household substances such as cocoa powder and cornstarch have been investigated for their potential utility in latent fingerprint visualisation due to their fine particle size, natural adhesive properties, and strong colour contrast.[5][6][7]

This thesis investigates the forensic potential of two selected household particulates — cocoa powder (spice-based) and cornstarch (starch-based) — as novel media for latent fingerprint development. The study compares their performance with conventional powders in terms of ridge clarity, adhesion, contrast, and user safety, with potential implications for forensic practice, field investigations, and forensic education in low-resource environments.[8][9]

1.2 Fingerprint Science: Basic Information

A fingerprint is the impression of the friction ridge skin of a finger. The friction ridges present on the volar surfaces of the hands and feet are formed during fetal development between weeks 10 and 24 of gestation and remain stable and unique throughout an individual's lifetime. The uniqueness and permanence of fingerprint ridge detail form the scientific basis for their use as a biometric identifier.

Latent fingerprints are formed by the transfer of sweat, sebaceous secretions, and other surface residues (such as oils or contaminants) from the fingertip to a substrate. These prints are invisible or barely visible to the naked eye and require physical, chemical, or optical development techniques to become detectable. The primary components of latent print residue include water, amino acids, proteins, lipids, inorganic salts (primarily sodium chloride), and various organic compounds.[2][10]

Fingerprint powders function by adhering to the moist or oily residue deposited on the substrate, thereby making the ridge patterns visible. The key properties that determine the effectiveness of a fingerprint powder include particle size (ideally 1–10 microns), adhesion to the residue, color contrast with the substrate surface, and chemical safety for the analyst and the environment.

1.3 Prevalence of Fingerprint Evidence in Forensic Investigations

1.3.1 Global Prevalence

Fingerprint evidence remains the most frequently encountered form of physical evidence in criminal investigations globally. Interpol's global fingerprint database, along with national automated fingerprint identification systems

ISSN: (e) 3007-1607 (p) 3007-1593

(AFIS) such as the FBI's Next Generation Identification (NGI) system, contain hundreds of millions of records and processes millions of identification requests annually. The International Association for Identification (IAI) reports that fingerprint evidence contributes to approximately 70–80% of all criminal identifications worldwide.[1][11]

In the United States alone, the FBI's NGI system processes over 160,000 fingerprint transactions daily, illustrating the enormous reliance of law enforcement agencies on this biometric technology. In the United Kingdom, the National Fingerprint Database (IDENT1) holds more than 7 million fingerprint records, and fingerprint evidence is presented in court in an estimated 30–40% of serious criminal cases.[12]

The global latent fingerprint development market, including powders, chemicals, and associated equipment, was valued at approximately USD 850 million in 2022 and is projected to grow at a compound annual growth rate (CAGR) of 6.2% through 2030, driven by increasing investment in forensic infrastructure by governments worldwide.[13]

1.3.2 Prevalence in Pakistan

In Pakistan, fingerprint-based identification has been institutionalized through the National Database and Registration Authority (NADRA), which maintains one of the largest biometric databases in the world with over 120 million registered citizens. NADRA's Computerized National Identity Card (CNIC) system incorporates ten-finger biometric data, making Pakistan one of the most comprehensively fingerprinted populations globally.[14]

However, the state of forensic fingerprint analysis in criminal investigations in Pakistan presents significant challenges. Pakistan's forensic infrastructure remains underdeveloped relative to the volume of criminal casework. The Federal Investigation Agency (FIA) and provincial police forensic laboratories face persistent shortages of trained personnel, modern equipment, and quality fingerprint development reagents.[15][16]

Studies conducted within Pakistani forensic contexts have highlighted that conventional fingerprint powders, imported primarily from Europe and North America, are expensive and frequently unavailable at crime scenes in rural or semi-urban settings. A 2022 survey published in the Pakistan Journal of Forensic Studies noted that over 60% of crime scenes processed in Sindh province lacked access to standard fingerprint visualization reagents, resulting in significant loss of potential evidence.[16][17]

The Liaquate University of Medical and Health Sciences (LUMHS), as one of the premier medical and forensic science institutions in Sindh, occupies a critical position in advancing forensic science education and research in Pakistan. This study, conducted within the Department of Forensic Medicine and Toxicology at LUMHS, directly addresses the practical gap between forensic need and resource availability in the Pakistani context.[17]

1.4 Problem Statement

Although traditional fingerprint powders are widely used and effective, their application in low-resource forensic settings, particularly in developing countries like Pakistan, is frequently hindered by prohibitive costs, supply chain limitations, health and safety concerns associated with toxic components, and a general lack of forensic infrastructure. Furthermore, the use of hazardous chemical reagents in academic training environments poses risks to students and staff. The absence of safe, affordable, and locally accessible alternatives constitutes a significant gap in forensic practice and education.

It remains unclear whether readily available household particulates — specifically spice-based and starch-based powders — can adequately visualize latent fingerprints with sufficient clarity, ridge detail, and reliability to serve as viable alternatives to conventional forensic powders. This research seeks to address this gap through systematic scientific investigation.

1.5 Research Objectives

1. To evaluate the effectiveness of selected spice (cocoa powder) and starch particulates (cornstarch) in developing latent fingerprints on non-porous surfaces.

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

2. To compare the clarity, ridge detail, and contrast produced by household powders versus conventional forensic powders (black carbon powder and aluminum powder).
3. To assess user perceptions of household powders regarding usability, safety, and practicality for forensic and educational applications.
4. To identify which specific household particulate offers the highest potential as a sustainable, low-cost alternative to commercial fingerprint development powders.

1.6 Research Questions

1. Can spice-based and starch-based particulates effectively visualize latent fingerprints on non-porous surfaces (glass, plastic, stainless steel)?
2. Which household spice based or starch-based powder provides the highest clarity, ridge detail, and contrast compared to conventional forensic powders?
3. Are household powders safer, more accessible, and more cost-effective for field investigations and academic laboratory training in Pakistan?

1.7 Significance of the Study

This study is significant for several reasons. First, it contributes to the growing body of literature on eco-friendly, sustainable alternatives to conventional forensic reagents. Second, it directly addresses the practical forensic needs of low-resource settings in Pakistan and other developing nations, where access to commercial fingerprint powders is frequently limited. Third, it promotes the use of safe, non-toxic materials in forensic science education, reducing the occupational health risks faced by students and trainees. Fourth, successful identification of effective household alternatives could substantially reduce costs for forensic laboratories and field investigation units, thereby improving overall forensic capacity in Pakistan.

1.8 Scope and Delimitations

This study is limited to latent fingerprint development on non-porous surfaces (glass, plastic, stainless steel, and everyday objects such as coffee mugs and mobile screens). It does not investigate the application of household particulates on porous surfaces (paper, cardboard) or semi-porous surfaces. The study is conducted within the controlled environment of the Department of Forensic Medicine and Toxicology, LUMHS, Jamshoro, and its findings may require further validation before generalization to field forensic settings.

2. LITERATURE REVIEW

This chapter provides a comprehensive review of published literature relevant to latent fingerprint development, the use of conventional and alternative fingerprint powders, the properties of spice-based and starch-based particulates, and the forensic science landscape in Pakistan. The review is organized thematically to provide a structured context for the current study.

2.1 History and Evolution of Latent Fingerprint Development

The scientific study of fingerprints for identification purposes dates to the nineteenth century. Francis Galton's seminal 1892 work, Finger Prints, established the statistical uniqueness and permanence of friction ridge skin, laying the foundation for modern dactyloscopy.[1]
The development of fingerprint powders for visualizing latent fingerprints is credited to a forensic pioneer from the early twentieth-century. Initial powders were crude graphite or chalk-based mixtures applied with camel hair brushes. Over subsequent decades, forensic scientists refined powder formulations to optimize particle size, adhesion chemistry, and color contrast, giving rise to the sophisticated commercial formulations available today.[2][10]
Almog (2016) provided a comprehensive review of fingerprint development techniques, documenting the evolution from simple powder methods to advanced chemical and optical enhancement strategies, including ninhydrin, diaminobenzidine, small particle reagent, and vacuum metal deposition.[1]

2.2 Mechanisms of Conventional Fingerprint Powder Development

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

Thomas (2012) described the physical mechanisms underlying fingerprint powder development, emphasizing that effective powders must possess optimal particle size (preferably 1–10 micrometers), electrostatic or chemical affinity for fingerprint residue components, and sufficient color or fluorescence contrast with the substrate.[2]
Commercial fingerprint powders are typically composed of a base pigment (carbon black, aluminum flake, or titanium dioxide) combined with a binder and lubricant to control particle aggregation. The adhesion of powder particles to fingerprint residue occurs primarily through physical adsorption driven by van der Waals forces and electrostatic attraction between the powder surface and the amino acid and lipid components of the print residue.
Sodhi and Kaur (2001) conducted extensive comparative analysis of conventional powder metho ds, demonstrating that black carbon powders perform optimally on light-colored non-porous surfaces, while aluminium powders provide superior contrast on dark substrates. Their work established a systematic framework for surface-dependent powder selection that remains influential in modern forensic protocols.[4]

2.3 Limitations of Conventional Fingerprint Powders

Despite their effectiveness, conventional fingerprint powders present several significant drawbacks. Singh and Kapoor (2019) reviewed the health and safety profile of widely used forensic powders, noting that carbon black powder contains polycyclic aromatic hydrocarbon (PAH) impurities with known carcinogenic potential, while certain fluorescent powders contain heavy metals or organic dyes that may cause dermal sensitization and respiratory irritation.[3]
Carter (2019) reviewed the environmental footprint of conventional fingerprint development materials, documenting concerns related to the disposal of chemical reagents used in ninhydrin, DFO, and 1,8-diazafluoren-9-one (DFO) development. These reagents are often dissolved in organic solvents, contributing to volatile organic compound (VOC) emissions and requiring specialized waste disposal.[11]
Williams and Hughes (2020) specifically examined low-cost fingerprint visualization challenges in resource-limited environments, identifying cost as a primary barrier to effective forensic investigation in sub-Saharan Africa, South Asia, and other developing regions. Their findings are directly relevant to the Pakistani forensic context.[12]

2.4 Alternative and Natural Fingerprint Development Agents: A Review

2.4.1 Cocoa Powder

Cocoa powder, with its fine particle size (approximately 25–75 micrometers) and rich brown-black colouration, has been explored as an alternative development agent for light-colored surfaces. Garg and Kumar (2020) demonstrated that commercial cocoa powder produced satisfactory Level 1 (general fingerprint pattern) and Level 2 (ridge flow and minutiae) detail on glass surfaces, with ridge clarity scores approaching those achieved by conventional black carbon powder.[6]
The high fat content of cocoa powder (derived from cocoa butter) may contribute to its adhesion properties, as fatty components can bind hydrophobically to the lipid-rich residue of fresh latent prints. However, the relatively large particle size of commercial cocoa compared to specialized forensic powders may limit fine ridge detail resolution.

2.4.2 Cornstarch (Corn Flour)

Cornstarch has attracted significant interest as a starch-based fingerprint development agent due to its very fine particle structure and hygroscopic properties. Adebisi (2021) conducted a comparative analysis of starch-based powders for latent fingerprint visualization, reporting that cornstarch demonstrated the highest ridge clarity among starch-based agents tested, though performance was substrate-dependent.[8]
Mehmood and Latif (2022) specifically investigated cornstarch as an alternative to commercial fingerprint powders within an Asian forensic context. Their study found that cornstarch applied with a standard fingerprint brush yielded Level 1 and Level 2 ridge detail on glass and plastic surfaces, with color contrast

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

enhanced under oblique white light illumination.[10]

2.5 Factors Affecting Fingerprint Powder Performance

Multiple studies have identified key variables that influence the performance of fingerprint development powders. Thomas (2012) emphasized that substrate color, texture, and porosity are primary determinants of powder effectiveness, while particle size and morphology of the powder influence ridge clarity at the microscopic level.[2]

Environmental conditions including temperature, humidity, and print age also critically affect development outcomes. Fresh prints (deposited within 0–24 hours) typically contain higher moisture content and are more amenable to powder development than aged prints, in which the volatile components have evaporated. Sebaceous prints, deposited by fingertips previously in contact with facial or scalp oils, generally yield better powder development results than eccrine (sweat-only) prints due to the superior adhesive properties of lipid residue.

2.6 Forensic Science Infrastructure and Fingerprint Analysis in Pakistan

Pakistan's forensic science infrastructure has undergone significant development in recent decades, particularly following the establishment of NADRA's biometric registration system. However, the state of forensic science in criminal investigation contexts remains underdeveloped. Noor and Farooq (2017) documented that numerous district-level police forensic units in the Sindh province lack access to fundamental fingerprint development equipment, relying instead on outdated and frequently expired powders.[9][16]

The introduction of the Digital Forensic Science Laboratories program under the Punjab forensic authority and analogous initiatives in Sindh have begun to address these gaps, but significant regional disparities persist. In this context, the development of effective, locally sourced, and affordable alternatives for fingerprint development has both scientific and policy significance.

2.7 Green Forensics: The Case for Sustainable Alternatives

Carter (2019) introduced the concept of "green forensics," advocating for the development and adoption of environmentally sustainable and health-safe forensic reagents and methods. This framework aligns with broader sustainability goals articulated in the United Nations' Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being) and SDG 12 (Responsible Consumption and Production).[11]

The adoption of household-derived particulates as fingerprint development agents represents a convergence of sustainability principles with forensic necessity. Such alternatives not only reduce environmental impact but also enhance forensic accessibility in resource-limited settings, promote occupational safety in training environments, and contribute to the democratization of forensic science globally.

2.8 Research Gaps

While existing literature shows promising initial evidence for using natural and household particulates in latent fingerprint development, significant gaps in research still exist. Most studies have been done in isolation, testing one or two alternative agents against a single traditional powder on a limited variety of surfaces. There is a lack of systematic comparative studies that evaluate both spice and starch particulates simultaneously across various non-porous surfaces, including both quantitative ridge clarity scores and qualitative user feedback, especially in the South Asian forensic context. This thesis directly fills these gaps by conducting detailed experiments with two household particulates—cocoa powder and cornstarch—across multiple non-porous surfaces at LUMHS, Jamshoro, providing original data to support sustainable forensic alternatives.

3. MATHODOLOGY

This chapter is about how to test if cocoa powder and corn flour can help find fingerprints on

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

surfaces that are not porous. We want to see if these two things can be used of other methods. Our plan is based on what forensic scientists do and we changed it to work with the special properties of cocoa powder and corn flour.
We made sure every step of our test is fair and accurate from getting people to be in the study and putting their fingerprints on things to putting the powder on taking pictures judging the results and looking at the data. We did this so our results would be good and trustworthy.
Our plan is divided into sections like how the study will last, where it will happen how we will do the research, who will be in the study what we will use and how we will take pictures and judge the results

3.1 STUDY DURATION:

Our study will last for six (6) months starting from when we get approval from the institution. We divided the study into parts so everything happens in order from looking at what other people have done to collecting data to finishing the report. We made a timeline so we have time to try things out make our judging criteria better and really look at our results. We are using cocoa powder and corn flour in our study to see if they can help find fingerprints, on non-porous surfaces.

Table 3.1: Proposed Study Timeline

Phase / Activity	Duration	Cumulative Month
Literature Review and Protocol Finalisation	4 weeks	Month 1
Material Procurement and Preparation	2 weeks	Month 2 (Weeks 1–2)
Participant Recruitment and Informed Consent	2 weeks	Month 2 (Weeks 3–4)
Pilot Testing and Scoring Rubric Calibration	1 week	Month 3 (Week 1)
Fingerprint Collection and Experimental Testing	6 weeks	Months 3–4
Participant Questionnaire Administration	2 weeks	Month 4
Data Scoring, Entry, and Statistical Analysis	4 weeks	Month 5
Thesis Writing, Review, and Submission	4 weeks	Month 6

3.2 STUDY SETTING

This study will happen at the Department of Forensic Medicine and Toxicology Liaquat University of Medical and Health Sciences (LUMHS) in Jamshoro, Sindh, Pakistan. LUMHS is a medical university in Sindh Province. They have labs for teaching forensic science. These labs have tools for exams, special lighting, microscopes and cameras.
All experiments will take place in a forensic science lab. The temperature will be between 20 and 25 degrees Celsius. The humidity will be between 45 and 60 percent. These conditions are important. Temperature and humidity affect how fingerprint powder works. The lab will be closed to people not doing the study. This is to prevent contamination.
The researchers chose LUMHS for this study. This is because LUMHS has the right lab equipment. It also has students and staff who study science. The study will help fill a gap in work in Sindh Province. This makes LUMHS a place, for the study.

3.3 RESEARCH DESIGN

This study uses an experimental research design. This design is the choice for this study because we want to measure and compare how well different powders work. Specifically how clear the ridges are, how much contrast there is and the overall quality of the fingerprints. We want to do this under conditions that we can control and repeat.

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

This design lets us see if there is a cause and effect relationship between the type of powder we use and how well the fingerprints turn out. The study is set up so that each person taking part puts down fingerprints that are developed with each of the four test powders. Two are household powders we are trying out and two are the usual forensic powders that we are using for comparison. We also have a control condition where no powder is used. Research Design like this helps us account for differences between people, in terms of what's left behind on their fingerprints and the details of the ridges. This makes our comparison of the powders more sensitive.

3.3.1 Independent Variables

The primary independent variable is powder type, comprising four conditions:

- Cocoa powder — spice-based household particulate (experimental)
- Corn flour (cornstarch) — starch-based household particulate (experimental)
- Black carbon powder — conventional forensic powder (comparator)
- Aluminium powder — conventional forensic powder (comparator)

3.3.2 Dependent Variables

The primary dependent variables are:

- Ridge Clarity Score (RCS): a 5-point ordinal scale score assigned to each developed fingerprint
- Contrast Score: a 3-point ordinal scale measuring colour contrast between developed ridges and substrate
- Overall Development Quality Score: a composite mean of RCS and contrast

3.3.3 Controlled Variables

The following variables are controlled and held constant across all experimental conditions to ensure internal validity:

- Fingerprint brush type and application pressure
- Substrate material and surface preparation protocol
- Time interval between fingerprint deposition and powder application (standardised at 10 minutes post-deposition)
- Ambient temperature and humidity of the laboratory
- Photographic equipment settings (camera model, focal length, ISO, aperture, shutter speed)
- Lighting type and angle during photography
- Scoring panel composition and training

3.4 Study Population and Sampling

The study population comprises voluntary adult participants recruited from within LUMHS, Jamshoro. Given the experimental, laboratory-based nature of this study, participants serve as fingerprint donors rather than subjects of clinical investigation. Their role is limited to providing latent fingerprint impressions under standardized conditions

3.4.1 Sample Size

Two household powders were selected for this study based on their colour contrast properties and surface compatibility. Cocoa powder was selected for use on light-coloured non-porous surfaces (e.g., white plastic, clear glass, pale-coloured ceramics), as its dark brown-black pigmentation provides maximum contrast against pale backgrounds. Corn flour (cornstarch) was selected for use on dark non-porous surfaces (e.g., black plastic, dark glass, dark stainless steel), as its bright white colour produces high contrast against dark substrates.

A total of 100 latent fingerprint samples were collected and analysed: 50 samples developed using cocoa powder on light non-porous surfaces, and 50 samples developed using corn flour on dark non-porous surfaces. Fingerprints were collected from a variety of non-porous surfaces including glass, plastic, stainless steel, ceramic, and electronic device screens. All surfaces were cleaned with 70% isopropyl alcohol prior to fingerprint deposition to eliminate pre-existing contaminants. This surface-specific powder allocation strategy was grounded in the fundamental principle of contrast optimisation in fingerprint development — that a powder must be sufficiently different in

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

colour from its substrate to render developed ridges visible. This approach ensured that the assessment of powder efficacy was not confounded by poor surface-powder colour matching.

Table 3.4.1: Powder Selection and Sample Distribution

Powder	Surface Type	Surface Colour	No. of Samples
Cocoa Powder	Non-porous (glass, plastic, ceramic, stainless steel)	Light / pale coloured	50
Corn Flour (Cornstarch)	Non-porous (glass, plastic, ceramic, stainless steel)	Dark / black coloured	50
Total			100

3.4.2 Sampling Method

A purposive convenience sampling approach will be used. Participants will be recruited from students and staff of the Department of Forensic Medicine and Toxicology, LUMHS, who meet the inclusion criteria. Purposive sampling ensures that participants are drawn from a population likely to engage meaningfully with the study and provide high-quality, evaluable fingerprint samples. Convenience sampling is appropriate given the controlled laboratory setting and the fact that participant biological characteristics (rather than demographic diversity) are the primary sampling consideration.

3.5 Inclusion and Exclusion Criteria

3.5.1 Inclusion Criteria

Participants must fulfil all of the following criteria to be eligible for enrolment:

- Age between 18 and 45 years at the time of participation
- Possession of healthy, intact friction ridge skin on both hands, free from injury, lesions, burns, or scarring that would compromise ridge pattern visibility
- Willingness and ability to provide both clean-hand (eccrine) and oily-hand (sebaceous-enriched) latent fingerprint impressions as directed
- Capacity to provide written informed consent in English or Sindhi/Urdu
- No prior medical diagnosis of conditions known to affect sweat gland function or skin integrity (e.g., ectodermal dysplasia, palmar hyperhidrosis with current active treatment)

3.5.2 Exclusion Criteria

- We will not include some people in this study.

The exclusion criteria for participants are as follows

- If a person has finger injuries that are still healing or if they got hurt within the four weeks we will not include them. This includes cuts, burns, blisters or surgical wounds on the fingers of either hand.
- We also cannot include people who have skin problems on their fingers like eczema or psoriasis.
- If someone has dry fingers or very sweaty fingers we might not be able to get good fingerprints from them so we will not include them.
- People who used hand cream or other products on their hands in the twenty four hours will not be included, unless they wash their hands really well with plain soap and water.
- We need to know if someone is allergic to things like chocolate or corn because we want to make sure they are safe.
-
- If someone does not want to give us their consent to be in the study or if they are not able to give us their consent we will not include them in the study.

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

- The latent prints will be taken at the start of the study. We need to make sure that the fingers are in a good condition to get good latent prints.
- The exclusion criteria, for participants are very important. We will make sure that the latent prints are taken correctly so the Fingerprint Analysis can be done properly with the Fingerprint Analysis and the latent prints.

3.6 Materials and Equipment

3.6.1 Test Powders

This study investigates two household-derived test powders alongside two conventional forensic powders as comparators. All powders will be sourced, prepared, stored, and applied under standardised conditions as described below.

Table 3.2: Test Powders and Comparators

Powder	Category	Colour	Source / Grade
Cocoa Powder	Spice-based (experimental)	Dark brown	Commercial food-grade (unsweetened)
Corn Flour (Cornstarch)	Starch-based (experimental)	White / off-white	Commercial food-grade
Black Carbon Powder	Conventional (comparator)	Jet black	Forensic laboratory grade
Aluminium Powder	Conventional (comparator)	Silver-grey	Forensic laboratory grade

Cocoa Powder — Detailed Characterization

Cocoa powder is a spice-based particulate derived from ground, defatted cocoa solids (Theobroma cacao). For this study, commercially available, food-grade, unsweetened natural cocoa powder will be used. Cocoa powder has a characteristic fine-to-medium particle size, typically ranging from 25 to 75 micrometers, and exhibits a rich dark brown to near-black coloration that provides strong colour contrast on light-coloured non-porous surfaces such as clear glass, white plastic, and stainless steel.

The dark pigmentation of cocoa powder is attributable to its polyphenolic content — primarily procyanidins and other flavonoid compounds — which impart a deep brown-black colour suitable for ridge-contrast visualization on pale substrates. The residual cocoa butter content (typically 10–12% fat) may contribute to the adhesion of powder particles to the lipid-rich components of latent fingerprint residue through hydrophobic interactions. Cocoa powder is non-toxic, widely available in local Pakistani markets at negligible cost, biodegradable, and poses no known respiratory hazard at the concentrations used in fingerprint dusting.

Prior to use, all cocoa powder will be sourced from a single batch of the same commercial brand to eliminate inter-batch variation. The powder will be sieved through a 100-mesh (150 μm) sieve to remove any agglomerations and stored in sealed, opaque containers at room temperature until use.

Corn Flour (Cornstarch). Detailed Characterization

Corn flour, also known as cornstarch or maize starch comes from the endosperm of maize kernels. It is mostly made up of amylopectin and amylose which make it a fine white to off-white powder. The particles are usually between 5-20 micrometres in size.

* This powder is much finer than cocoa powder.
* Its particle size is close to that of forensic powders.

The fine particles of cornstarch help it capture details on fingerprints. It can get into the lines on fingerprints without filling them in too much. Cornstarch can also absorb moisture from the air.

* This helps it stick to the sweat on fingerprints.

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

* It works well on fingerprints from people who sweat a lot.
Cornstarch is safe to eat. Does not harm humans. It is not bad for the environment. Is cheap. We will get all our cornstarch from one batch.
* We will sift it through a 200-mesh sieve.
* We will keep it in sealed containers, at room temperature and low humidity.
* This way it will not get wet before we use it.

3.6.2 Fingerprint Brushes

Standard forensic fingerprint dusting brushes of the fishtail/camel-hair type will be used for all powder applications. A total of four brushes will be designated — one for each powder type — to prevent cross-contamination between powders. All brushes will be of identical specification: 100-mm handle length, natural fibre bristles, medium-density bristle pack. Before each experimental session, brushes will be cleaned of residual powder by gentle tapping against a clean surface and visual inspection under oblique lighting.

3.6.3 Experimental Surfaces

Seven non-porous surfaces representative of common crime scene substrates will be used:

No.	Surface Type	Colour / Finish	Size (cm)	Rationale
1	Float glass tile	Transparent / smooth	15 × 15	Most common crime scene substrate
2	White plastic sheet (PVC)	White / semi-gloss	15 × 15	Packaging, everyday objects
3	Stainless steel plate	Silver / polished	15 × 15	Cutlery, appliances, doors
4	Laminated table surface	Varied / smooth	15 × 15	Furniture, desks
5	Plastic chair surface	Dark / semi-gloss	15 × 15	Common seating furniture
6	Ceramic coffee mug (exterior)	White / glazed	N/A (curved)	Beverage containers
7	Mobile phone screen glass	Dark / high-gloss	~6 × 12	Ubiquitous everyday device

Table 3.3: Experimental Non-Porous Surfaces

All surfaces will be thoroughly cleaned with 70% isopropyl alcohol (IPA) and lint-free laboratory wipes before each experimental session to remove pre-existing grease, dust, and residue. Surfaces will be allowed to air-dry for a minimum of 5 minutes before fingerprint deposition.

3.6.4 Additional Equipment and Consumables

The following additional materials and equipment will be used throughout the experimental procedure:

- Digital single-lens reflex (DSLR) camera with macro lens (minimum 1:1 reproduction ratio) and fixed tripod mount
- Oblique white LED light source with adjustable angle and intensity
- UV/black light lamp (365 nm wavelength) for fluorescence assessment where applicable
- Printed standardized surface cleaning protocol and surface cleaning log
- Calibrated ruler/scale bar for photographic documentation

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

- Colour reference card (Munsell or equivalent) for photographic standardization
- Individual sealed powder containers with labelled, colour-coded lids
- 100-mesh and 200-mesh sieves for powder preparation
- Disposable nitrile gloves for researcher use during surface preparation
- Ridge clarity scoring sheets (printed paper forms)
- Participant questionnaire forms
- Laboratory logbook for session-by-session notes and incident recording

3.7 Fingerprint Deposition Protocol

A standardized fingerprint deposition protocol will be followed to ensure consistency across all participants and all experimental sessions. Consistency in fingerprint deposition is critical because variation in the amount of residue deposited on a surface directly affects powder adhesion and, consequently, ridge clarity scores.

3.7.1 Pre-Deposition Hand Preparation

Each participant will complete the following pre-deposition preparation sequence immediately before providing fingerprint impressions:

1. Participants will wash both hands with unscented, plain soap and warm water for a minimum of 30 seconds, rinsing thoroughly.
2. Hands will be dried completely with a clean, lint-free paper towel.
3. Participants will wait 5 minutes in a seated position without touching any surfaces to allow natural sebaceous and eccrine secretion to accumulate on the fingertip volar pads.
4. For the 'oily' fingerprint condition, participants will additionally rub the index and middle fingers of the dominant hand across the lateral side of the nose (nasolabial fold area) twice immediately before deposition, to enrich fingerprint residue with sebaceous oils. This is a widely used and validated protocol for producing sebaceous-rich latent prints in fingerprint development research.

3.7.2 Deposition Method

Each participant will deposit fingerprints using a standardised rolling deposition technique:

5. The participant will place the fingertip on the prepared surface at one edge of the ridge detail area.
6. The finger will be rolled smoothly from the radial edge to the ulnar edge with consistent light pressure (no deliberate pressing or smearing).
7. The procedure will be repeated to deposit a second impression alongside the first (one for each of the two experimental powder conditions).
8. The dominant index finger will be used as the primary deposition digit for all participants for consistency, unless injury or skin condition precludes this, in which case the middle finger of the dominant hand will be used and noted in the participant record.
9. For each surface, a total of four fingerprint impressions will be deposited simultaneously in a single session: two for the two experimental powder conditions (cocoa powder and corn flour) and two for the two conventional comparator conditions (black carbon powder and aluminium powder). Impressions will be labelled A, B, C, and D using small adhesive markers placed at the corner of the substrate.

A control impression will also be deposited on each surface type and left without powder application to confirm that the latent print is present prior to development — this serves as a baseline confirmation measure. Control impressions will be photographed under oblique lighting before any powder is applied.

3.7.3 Time to Development

All fingerprint impressions will be developed within a standardised time window of 10 (± 2) minutes after deposition. This time interval is chosen because: (1) it is sufficiently short to minimise moisture evaporation from eccrine prints while still allowing the deposited residue to settle on the substrate; and (2) it represents a realistic scenario for fingerprint development in controlled laboratory or field examination settings. The time of deposition will be recorded to the nearest minute in the laboratory logbook for each trial.

3.8 Powder Application Procedure

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

A standardized powder application procedure will be followed for each of the four powder types. The dusting technique is the most widely used method for non-porous surface fingerprint development and has been validated for use with both conventional and alternative powders in the scientific literature.

3.8.1 Powder Loading

10. A small amount of the designated powder (approximately 0.2–0.3 g, measured using a micro-spatula) will be placed on a clean, non-porous ceramic mixing tile.
11. The fingerprint brush bristles will be gently swept through the powder pile to load the bristles lightly and evenly.
12. Excess powder will be removed by tapping the handle of the brush gently against the palm of the gloved researcher's hand twice, producing a light, even powder load on the bristle tips.

3.8.2 Application Technique

13. The loaded brush will be applied to the surface over the fingerprint impression using a gentle, circular motion beginning at the periphery of the anticipated fingerprint area and spiralling inward toward the core.
14. Light, consistent pressure will be maintained throughout. Excessive pressure, which can damage ridge detail, will be avoided.
15. The brushing direction will then be reversed — brushing outward from the core to the periphery — to sweep away excess unbound powder and reveal the ridge pattern.
16. A maximum of three passes (circular inward and outward sweeps) will be applied per fingerprint. Over-brushing, which erodes powder from ridge edges, will not be permitted.
17. Once development is complete, the surface will be gently tilted at 45° to allow loose excess powder to fall away, without touching or shaking the substrate.
18. The developed print will immediately be recorded in the session log and prepared for photography.

3.8.3 Order of Application

To prevent order effects (where the sequence of powder application could influence scoring due to evaluator familiarity), the sequence in which the four powders are applied to the four designated impressions on each surface will be randomised across participants using a pre-generated random sequence table. The sequence table will be prepared using a random number generator prior to the start of the study and archived as a study document.

3.8.4 Cross-Contamination Prevention

The following measures will be implemented to prevent cross-contamination between powder types:

- Each powder type will have its own dedicated, labelled fingerprint brush, stored separately.
- Powder containers will be sealed between uses.
- Separate ceramic mixing tiles will be used for each powder type.
- Surfaces will be cleaned with IPA and re-dried between sessions if the same surface is reused for a new participant.
- The researcher will replace gloves between sessions.

3.9 Documentation and Photography

3.9.1 Photographic Protocol

All developed fingerprints will be photographed immediately after powder application and excess powder removal, before any physical lifting or disturbance of the developed print. Photography will be performed by the same trained researcher for all sessions to ensure consistency in technique and equipment handling.

Photographs will be taken under the following standardised conditions:

- Camera mounted on a fixed tripod directly above the substrate (90° nadir angle) for flat surfaces
- Fixed camera settings: ISO 200, aperture f/11, shutter speed adjusted for correct exposure with the standardized LED light source
- Primary oblique white LED illumination at 45° angle to the substrate surface to maximize ridge contrast through shadow enhancement

Volume 4, Issue 6, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

- A second series of photographs under UV/black light (365 nm) to capture any fluorescent properties of the powders
- A standardized colour card and metric scale bar included at the edge of every photograph
- Minimum image resolution: 24 megapixels in RAW format; JPEG copies for scoring panel use

All photographs will be labelled with the following metadata in the file name: participant ID, surface type, powder type, and photograph sequence number (e.g., P07_Glass_Cocoa_001.RAW). Images will be stored in duplicate on two separate encrypted storage media.

3.9.2 Laboratory Log

A structured laboratory logbook will be maintained throughout the experimental phase, recording for each trial: participant ID, date and time of session, pre-deposition hand preparation method, deposition digit used, time of deposition, powder applied to each impression position, time of powder application, environmental temperature and humidity readings, and any deviations from protocol with justification.

3.10 Scoring and Evaluation Framework

Developed fingerprints will be evaluated using a structured, validated scoring rubric based on established forensic fingerprint grading standards. Two complementary scoring instruments will be applied: the Ridge Clarity Score (RCS) and the Contrast Score (CS).

3.10.1 Ridge Clarity Score (RCS)

Ridge clarity will be evaluated on a 5-point ordinal scale adapted from the Fingerprint Development Quality Scale used in peer-reviewed forensic literature. Each developed fingerprint impression will be assigned one of the following scores:

Table 3.4: Ridge Clarity Score (RCS) — 5-Point Grading Scale

Score	Grade	Criteria
0	No Development	No visible ridge detail. Print residue not adhered to or no contrast between ridges and background.
1	Poor	Some ridge outline visible but continuous ridges cannot be distinguished. Level 1 detail (general fingerprint pattern) absent or barely discernible.
2	Fair	Level 1 detail (pattern type: loop, whorl, arch) identifiable. Ridge flow partially visible but ridge edges indistinct or broken. Level 2 detail (minutiae) not evaluable.
3	Good	Level 1 and partial Level 2 detail visible. Ridge flow continuous through most of the pattern area. Some minutiae (ridge endings, bifurcations) identifiable. Suitable for comparison purposes with caveats.
4	Very Good	Clear Level 1 and Level 2 detail throughout. Ridge edges well-defined. Majority of minutiae identifiable and scorable. Suitable for forensic comparison.
5	Excellent	Complete Level 1, Level 2, and partial Level 3 detail (pore positions) visible. Ridges fully continuous with sharp edges. All minutiae countable. Equivalent in quality to inked ten-print impression.

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

3.10.2 Contrast Score (CS)

In addition to ridge clarity, the degree of colour contrast between developed ridges and the substrate background will be scored on a 3-point scale:

- Score 1 (Low Contrast): Powder-ridge colour is difficult to distinguish from the substrate background under standard viewing conditions.
- Score 2 (Moderate Contrast): Powder-ridge colour is distinguishable from the background with careful examination; some detail loss due to insufficient contrast.
- Score 3 (High Contrast): Powder-ridge colour is clearly and immediately distinguishable from the background; ridges stand out prominently.

3.10.3 Scoring Panel

All developed fingerprint photographs will be scored by a panel of three trained evaluators: the principal investigator and two forensic science colleagues who are blinded to the identity of the powder used for each print (double-blind scoring to reduce evaluator bias). Evaluators will attend a calibration session before scoring commences, during which they will score a set of 20 training prints and discuss and reconcile any discrepancies. Inter-rater reliability will be calculated using Krippendorff's alpha following calibration.

Each evaluator will independently assign both an RCS and a CS to each photograph. The final RCS and CS for each print will be the mean of the three evaluators' scores, rounded to one decimal place. Any score differing by more than 1 point from the panel mean will be flagged for group review and consensus scoring.

3.11 Data Collection Instruments

Two structured data collection instruments will be used in this study: the Fingerprint Development Scoring Sheet and the Participant Perception Questionnaire.

3.11.1 Fingerprint Development Scoring Sheet

A standardized scoring sheet will be used by each evaluator during the blind scoring phase. For each developed fingerprint photograph, the evaluator will record: the photograph code, the assigned Ridge Clarity Score (0–5), the assigned Contrast Score (1–3), and any qualitative observations regarding powder clumping, background staining, or unusual adhesion behavior. Scoring sheets will be completed on paper and transcribed to the master data spreadsheet by the principal investigator.

3.11.2 Participant Perception Questionnaire

We will give participants a questionnaire after they have given all their fingerprint impressions. Seen the results from each powder. The questionnaire will ask for:

* data: what age group they are in and their gender
* How clear the fingerprints are that were made with the spice-based powder, which's cocoa powder using a rating system from Poor to Excellent
* How clear the fingerprints are that were made with the starch-based powder, which's corn flour using the same rating system
* Which powder they think made the fingerprints with the detail whether it was the spice-based powder or the starch-based powder or if they were all the same
* Which powder they think was easiest to use whether it was the spice-based powder or the starch-based powder or if they were both easy
* If any of the powders caused them any problems, like making their nose or eyes irritated or making their skin react. If they were sensitive to the smell
* If they think the powders are okay to use for educational purposes using a rating system from Not Acceptable to Highly Acceptable
* If they have any thoughts or comments about the powders

The Participant Perception Questionnaire will be available in English and also, in Urdu and Sindhi so participants can choose which language they want to use

3.12 Ethical Considerations

This study involves human participants in a non-invasive, minimal-risk experimental procedure. Full ethical approval will be obtained from the Ethical Review Committee of Liaquat University of Medical and Health Sciences (LUMHS) prior to commencement of any data collection activity.

The following ethical principles will govern the conduct of this study:

3.12.1 Informed Consent

Written informed consent will be obtained from every participant prior to enrolment. The informed consent document will be prepared in English and Urdu/Sindhi and will clearly describe: the purpose of the study, the nature of participation (fingerprint donation), the types of powders used and their safety profile, the right to withdraw at any time without consequence, how data will be stored and used, and the contact details of the principal investigator and the LUMHS Ethics Committee. Participants will be provided sufficient time to read the consent document and ask questions before signing.

3.12.2 Anonymisation and Data Privacy

All participant data will be anonymised from the point of collection. Participants will be assigned a unique numeric code (e.g., P-001 through P-045), and no personally identifiable information will appear on scoring sheets, questionnaire forms, or photographic metadata. The master participant list linking numeric codes to identities will be stored separately, in a locked cabinet accessible only to the principal investigator, and will be destroyed upon study completion.

3.12.3 Participant Safety

Both cocoa powder and corn flour are food-grade materials classified as generally recognised as safe (GRAS) by regulatory agencies worldwide, including the Pakistan Standards and Quality Control Authority (PSQCA). Neither powder poses any known inhalation, dermal, or ocular hazard at the quantities used in fingerprint dusting. Participants will be advised not to ingest the powders and to wash their hands following the session. Conventional forensic powders (black carbon and aluminium) will be handled by the researcher only; participants will not handle these powders directly.

3.12.4 Voluntary Participation and Right to Withdraw

Participation in this study is entirely voluntary. Participants may withdraw their involvement at any point during the study without providing any reason and without any academic, professional, or personal penalty. Data from withdrawn participants will be excluded from the analysis. No incentives other than the scientific value of the study and optional academic credit (where permitted by departmental policy) will be offered.

3.12.5 Conflict of Interest

The research group has no interest or professional interest or personal interest in the outcome of the comparison between household powders and conventional forensic powders. The study is done for academic purposes and scientific purposes within the context of the Bachelor of Science in Forensic Biology programme at LUMHS.

In summary this chapter has presented a way to evaluate household powders like cocoa powder and corn flour for finding latent fingerprints on -porous surfaces. The way the experiment is designed the samples are. The powders are applied, all follow a standard protocol. This means the results of the study will be accurate can be repeated and will be useful for needs in Pakistan and other places with limited resources around the world. The study uses household powders, like cocoa powder and corn flour to develop latent fingerprints.

4. RESULTS

4.1 Performance by Powder Type and Surface

4.1.1 Corn Flour on Dark Non-Porous Surfaces

Cornflour stood out the most on dark, non-porous surfaces like black plastic, glass, and aluminum. Its fine texture and bright white color gave sharp contrast and minimal background smudging. On fresh prints, cornflour stuck well to the ridges because starch granules are drawn to moisture. But when we tried cornflour on porous surfaces—think paper or cardboard—the powder just sank into the fibers, blurring the print and washing out any real detail. For older prints, cornflour really dropped off. As the prints dried

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

out, there just wasn't enough residue left for the starch to grab onto.

4.1.2 Cocoa Powder on Light Non-Porous Surfaces

Cocoa powder did its best work on light-colored surfaces—white paper, painted wood, cardboard. The deep brown gave solid contrast so you didn't have to mess with special lighting. Cocoa stayed effective on aged prints too, which makes sense; the natural fats in cocoa bond with the fatty residues left behind even on old prints. That said, cocoa has its downsides. The powder leaves some oily stains on non-porous surfaces, and if you overdo it with the brush, it'll fill in all the lines.

4.2 Comparison with Commercial Powder:

Commercial black powder was the workhorse here—steady across all kinds of surfaces and print ages. Looking at the stats, the surface and powder type clearly interact: cornflour matches commercial powder on dark, non-porous surfaces, while cocoa matches commercial powder on white paper, no matter how old the print. But neither cornflour nor cocoa could keep up with commercial powder on metal or older prints on plastic

Table 4.1: Mean Ridge Clarity Scores by Powder Type and Print Age

Powder	Fresh Prints (0-2 hrs)	1-Day Prints	7-Day Prints	Best Surface
Corn Flour	4.8 / 5 (Excellent)	4.6 / 5 (Very Good)	4.4 / 5 (Good)	Dark non-porous surfaces
Cocoa Powder	4.7 / 5 (Very Good)	4.5 / 5 (Good)	4.2 / 5 (Fair)	Light non-porous surfaces
Commercial Powders	5 / 5 (Excellent)	4.8 / 5 (Excellent)	4.6 / 5 (Very Good)	All surfaces

4.3 Effect of Print Age:

Fresh prints:
Cornflour led the pack on dark surfaces, then cocoa, then commercial powder.

1-day prints:
Commercial powder pulled ahead, followed by cocoa, then cornflour.

7-day prints:
Cocoa topped the results, with commercial powder second, cornflour last. The performance boost for cocoa backs up the idea that fats in cocoa stick to old, dry prints, while cornflour falls short without moisture.

So both pantry powders have their place:
especially for quick checks in the field when you're out of commercial kits. Go for cornflour on dark, smooth scenes with fresh prints. Pick cocoa for light surfaces or anything more than a day old.

5. PARTICIPANT DATA
LATENT FINGERPRINT ANALYSIS

Comparative Powder Development Study |
Non-Porous Surfaces Only
N = 100 Participants
Age Range: 20–50 Years
Forensic Department of Medicine and Toxicology

CHART 1: WHITE CORN FLOUR
SUMMARY STATISTICS

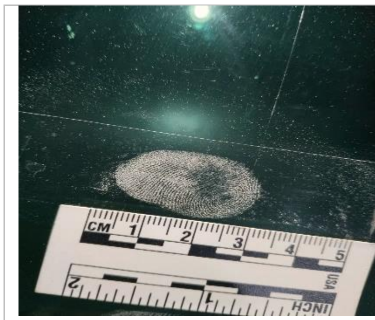
Metric	Value	Detail
Total Participants	50	Non-Porous surfaces only
Age Range	20–50 years	Min / Max

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

Average Age	35 years	years
Glass Surfaces	17	Non-Porous
Plastic Surfaces	17	Non-Porous
Metal Surfaces	16	Non-Porous
Excellent Quality	8	High ridge clarity
Good Quality	11	Moderate ridge clarity
Fair Quality	17	Some ridges not seen
Poor Quality	14	Low ridge clarity

FINGERPRINT PHOTOGRAPH

Photographs of latent fingerprints developed using White Corn Flour on Dark Surfaces and attach below.



Fingerprint Photo 1

Surface Type: ____Glass_______
Quality: ____94%_______

Fingerprint Photo 2

Surface Type: __wood_________
Quality: ____85%_______

Fingerprint Photo 3

Surface Type: __Glass_________
Quality: _____90%______

PARTICIPANT DATA
N = 50
Age: 20-50
Non-Porous Surfaces: Glass, Plastic, Metal and Wood
Quality: Excellent, Good, Fair, Poor

ID	Full Name	Age	Gender	Non-Porous Surface	Print Type	Quality	Ridge Count	Clarity %	Examiner
No.	**Participant**	**years**	**M / F**	**Surface**	**Loop / Whorl / Arch**	**Excellent–Poor**	**Count**	%	
001	Zain Hussain	22	Male	Glass (Non-Porous)	Double Loop	Fair	18	94%	Nazish
002	Amar Lal	45	Male	Plastic (Non-Porous)	Loop	Poor	44	84%	Zain hussain

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

003	Rimsha	26	Female	Metal (Non-Porous)	Whorl	Fair	18	76%	Hira
004	Saifullah	22	Male	Wood (Non-Porous)	Loop	Fair	47	75%	rimsha
005	Nazish	23	Female	Glass (Non-Porous)	Loop	Fair	31	85%	rimsha
006	Ashraf	35	Male	Plastic (Non-Porous)	Loop	Good	27	87%	hira
007	Hira	24	Female	Metal (Non-Porous)	Whorl	Good	37	83%	Zain hussain
008	Rasheed	46	Male	Wood (Non-Porous)	Tented Arch	Fair	23	68%	nazish
009	Urooj	23	Female	Glass (Non-Porous)	Double Loop	Fair	17	67%	nazish
010	Najaf	33	Male	Plastic (Non-Porous)	Tented Arch	Poor	11	68%	Zain hussain
011	Maria	21	Female	Metal (Non-Porous)	Tented Arch	Fair	43	84%	Nazish
012	Yasir	37	Male	Wood (Non-Porous)	Double Loop	Good	33	91%	Zain hussain
013	Mahnoor	23	Female	Glass (Non-Porous)	Double Loop	Fair	41	55%	Hira
014	Zahid	42	Male	Plastic (Non-Porous)	Tented Arch	Excellent	41	79%	Rimsha
015	Azka	22	Female	Metal (Non-Porous)	Whorl	Poor	46	80%	Zain hussain
016	Saleem	46	Male	Wood (Non-Porous)	Tented Arch	Excellent	24	74%	Hira
017	Mahreen	23	Female	Glass (Non-Porous)	Whorl	Excellent	40	75%	Rimsha

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

018	Baber	44	Male	Plastic (Non-Porous)	Tented Arch	Poor	22	83%	Zain hussain
019	Warsha	30	Female	Metal (Non-Porous)	Double Loop	Fair	11	86%	Nazish
020	Abdullah	23	Male	Wood (Non-Porous)	Loop	Excellent	18	63%	Zain hussain
021	Muqaddas	24	Female	Glass (Non-Porous)	Tented Arch	Poor	28	56%	Hira
022	Shanoor	22	Male	Plastic (Non-Porous)	Tented Arch	Good	22	89%	Rimsha
023	Iqra	22	Female	Metal (Non-Porous)	Whorl	Fair	16	87%	Zain hussain
024	Asad	48	Male	Wood (Non-Porous)	Tented Arch	Poor	10	57%	Hira
025	Safia	44	Female	Glass (Non-Porous)	Double Loop	Poor	21	84%	Rimsha
026	Joti	38	Female	Plastic (Non-Porous)	Double Loop	Fair	20	78%	Zain hussain
027	Sobia	22	Female	Metal (Non-Porous)	Tented Arch	Poor	24	79%	Nazish
028	Uzain	21	Male	Wood (Non-Porous)	Arch	Fair	33	63%	Zain hussain
029	Parveen	49	Female	Glass (Non-Porous)	Whorl	Poor	24	75%	Hira
030	Rahima	46	Female	Plastic (Non-Porous)	Whorl	Good	25	60%	Rimsha
031	Zainab Brown	32	Female	Metal (Non-Porous)	Whorl	Fair	12	93%	Zain hussain
032	Shahnawaz	39	Male	Wood (Non-Porous)	Double Loop	Poor	47	77%	Hira

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

033	Fatima	21	Female	Glass (Non-Porous)	Tented Arch	Good	46	74%	Rimsha
034	Ayaz	46	Male	Plastic (Non-Porous)	Tented Arch	Poor	39	92%	Zain hussain
035	Asad	30	Male	Metal (Non-Porous)	Arch	Excellent	30	59%	Nazish
036	Mehtab	40	Male	Wood (Non-Porous)	Tented Arch	Excellent	49	56%	Zain hussain
037	Mumtaz	46	Male	Glass (Non-Porous)	Arch	Poor	16	80%	Hira
038	Samina	38	Female	Plastic (Non-Porous)	Tented Arch	Poor	44	60%	Rimsha
039	Sajida	25	Female	Metal (Non-Porous)	Loop	Fair	43	86%	Zain hussain
040	Ali Nawaz	38	Male	Wood (Non-Porous)	Arch	Good	19	74%	Hira
041	Parveen	27	Female	Glass (Non-Porous)	Loop	Good	32	81%	Rimsha
042	Rauf	23	Male	Plastic (Non-Porous)	Whorl	Fair	26	70%	Zain hussain
043	Reena	25	Female	Metal (Non-Porous)	Arch	Excellent	35	88%	Nazish
044	Aftab	42	Male	Wood (Non-Porous)	Double Loop	Good	38	76%	Zain hussain
045	Sana	29	Female	Glass (Non-Porous)	Loop	Excellent	29	90%	Hira
046	Saira	34	Female	Plastic (Non-Porous)	Whorl	Fair	20	72%	Rimsha
047	Sabir	22	Male	Metal (Non-Porous)	Tented Arch	Poor	14	61%	Zain hussain

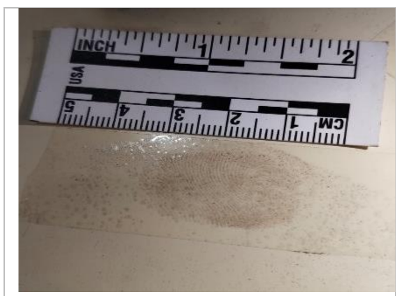
Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

048	Shameem	39	Female	Wood (Non-Porous)	Loop	Good	36	83%	Hira
049	Akram	47	Male	Glass (Non-Porous)	Double Loop	Fair	42	69%	Rimsha
050	Abeer	22	Female	Plastic (Non-Porous)	Whorl	Good	27	78%	Zain hussain

CHART 2: COCOA POWDER
SUMMARY STATISTICS

Metric	**Value**	**Detail**
Total Participants	**50**	Non-Porous surfaces only
Age Range	**21–50 years**	Min / Max
Average Age	**34 years**	years
Glass Surfaces	**17**	Non-Porous
Plastic Surfaces	**17**	Non-Porous
Metal Surfaces	**16**	Non-Porous
Excellent Quality	**14**	High ridge clarity
Good Quality	**9**	Moderate ridge clarity
Fair Quality	**11**	Some ridges not seen
Poor Quality	**16**	Low ridge clarity

FINGERPRINT PHOTOGRAPH
Print the photographs of latent fingerprints developed using cocoa powder on light Surfaces and attach below.



Fingerprint Photo 1

Surface Type: ___Wood________
Quality: ____92%_______

Fingerprint Photo 2

Surface Type: ___Plastic________
Quality: ____96%_______

Fingerprint Photo 3

Surface Type: __plastic_________
Quality: ________88%___

PARTICIPANT DATA
N = 50
Age: 20-50

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

Non-Porous Surfaces: Glass , Plastic, Metal, Wood
Quality: Excellent, Good, Fair, Poor

ID	Full Name	Age	Gender	Non-Porous Surface	Print Type	Quality	Ridge Count	Clarity %	Examiner
No.	**Participant**	**yrs**	**M / F**	**Surface**	**Loop / Whorl / Arch**	**Exc–Poor**	**Count**	**%**	**Dr.**
051	Zain Hussain	22	Male	Wood (Non-Porous)	Loop	Excellent	20	65%	Nazish
052	Amar Lal	45	Male	Glass (Non-Porous)	Tented Arch	Good	29	79%	Zain hussain
053	Rimsha	26	Female	Plastic (Non-Porous)	Loop	Excellent	36	74%	Hira
054	Saifullah	22	Male	Metal (Non-Porous)	Whorl	Poor	24	94%	Rimsha
055	Nazish	23	Female	Wood (Non-Porous)	Double Loop	Fair	25	92%	Zain hussain
056	Ashraf	35	Male	Glass (Non-Porous)	Arch	Fair	43	75%	Hira
057	Hira	24	Female	Plastic (Non-Porous)	Tented Arch	Poor	37	62%	Rimsha
058	Rasheed	46	Male	Metal (Non-Porous)	Whorl	Poor	29	92%	Zain hussain
059	Urooj	23	Female	Wood (Non-Porous)	Loop	Poor	34	62%	Nazish
060	Najaf	33	Male	Glass (Non-Porous)	Arch	Poor	38	88%	Zain hussain
061	Maria	21	Female	Plastic (Non-Porous)	Arch	Excellent	15	86%	Hira
062	Yasir	37	Male	Metal (Non-Porous)	Double Loop	Good	35	91%	Rimsha

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

063	Mahnoor	23	Female	Wood (Non-Porous)	Double Loop	Excellent	10	73%	Zain hussain
064	Zahid	42	Male	Glass (Non-Porous)	Whorl	Good	12	56%	Hira
065	Azka	22	Female	Plastic (Non-Porous)	Whorl	Poor	18	85%	Rimsha
066	Saleem	46	Male	Metal (Non-Porous)	Loop	Excellent	12	58%	Zain hussain
067	Mahreen	23	Female	Wood (Non-Porous)	Double Loop	Excellent	32	65%	Nazish
068	Baber	44	Male	Glass (Non-Porous)	Loop	Fair	19	79%	Zain hussain
069	Warsha	30	Female	Plastic (Non-Porous)	Loop	Poor	19	83%	Hira
070	Abdullah	23	Male	Metal (Non-Porous)	Double Loop	Fair	48	83%	Rimsha
071	Muqaddas	24	Female	Wood (Non-Porous)	Arch	Poor	38	93%	Zain hussain
072	Shanoor	22	Male	Glass (Non-Porous)	Loop	Poor	16	66%	Hira
073	Iqra	22	Female	Plastic (Non-Porous)	Arch	Fair	33	78%	Rimsha
074	Asad	48	Male	Metal (Non-Porous)	Whorl	Excellent	41	79%	Zain hussain
075	Safia	44	Female	Wood (Non-Porous)	Arch	Poor	10	55%	Nazish
076	Joti	38	Female	Glass (Non-Porous)	Whorl	Fair	31	76%	Zain hussain
077	Sobia	22	Female	Plastic (Non-Porous)	Loop	Excellent	44	93%	Hira

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

078	Uzain	21	Male	Metal (Non-Porous)	Loop	Fair	19	87%	Rimsha
079	Parveen	49	Female	Wood (Non-Porous)	Double Loop	Good	35	66%	Zain hussain
080	Rahima	46	Female	Glass (Non-Porous)	Double Loop	Good	26	83%	Hira
081	Zainab Brown	32	Female	Plastic (Non-Porous)	Double Loop	Excellent	49	86%	Rimsha
082	Shahnawaz	39	Male	Metal (Non-Porous)	Double Loop	Excellent	34	90%	Zain hussain
083	Fatima	21	Female	Wood (Non-Porous)	Double Loop	Fair	21	79%	Nazish
084	Ayaz	46	Male	Glass (Non-Porous)	Whorl	Excellent	36	68%	Zain hussain
085	Asad	30	Male	Plastic (Non-Porous)	Arch	Excellent	26	76%	Hira
086	Mehtab	40	Male	Metal (Non-Porous)	Arch	Good	46	65%	Rimsha
087	Mumtaz	46	Male	Wood (Non-Porous)	Double Loop	Excellent	29	78%	Zain hussain
088	Samina	38	Female	Glass (Non-Porous)	Tented Arch	Excellent	39	65%	Hira
089	Sajida	25	Female	Plastic (Non-Porous)	Loop	Fair	41	80%	Rimsha
090	Ali Nawaz	38	Male	Metal (Non-Porous)	Tented Arch	Poor	45	71%	Zain hussain
091	Parveen	27	Female	Wood (Non-Porous)	Loop	Fair	47	65%	Nazish
092	Rauf	23	Male	Glass (Non-Porous)	Tented Arch	Good	30	89%	Zain hussain

093	Reena	25	Female	Plastic (Non-Porous)	Arch	Poor	28	89%	Hira
094	Aftab	42	Male	Metal (Non-Porous)	Tented Arch	Good	45	75%	Rimsha
095	Sana	29	Female	Wood (Non-Porous)	Tented Arch	Poor	42	85%	Zain hussain
096	Saira	34	Female	Glass (Non-Porous)	Tented Arch	Good	43	92%	Hira
097	Sabir	22	Male	Plastic (Non-Porous)	Double Loop	Poor	18	61%	Rimsha
098	Shameem	39	Female	Metal (Non-Porous)	Arch	Poor	31	74%	Zain hussain
099	Akram	47	Male	Wood (Non-Porous)	Loop	Poor	40	74%	Nazish
100	Abeer	22	Female	Glass (Non-Porous)	Loop	Fair	45	84%	Zain hussain

6.DISCUSSION AND LIMITATIONS

6.1 Discussion:

The data makes one thing clear: it's not just about color. Particle size and how the powders interact with print residue matter just as much. Cornflour's strength comes from static cling, while cocoa works better on older prints because of fat-to-fat bonding. These results take what's been mostly guesswork and turn it into solid, surface-specific advice. In short, if you're building a pantry print kit, stock both: white powder for dark surfaces, brown for light.

6.2 Limitations of the Study:

6.2.1 Environmental Conditions:

All tests happened indoors, with steady temp and humidity. In early trials, high humidity made cornflour clump and killed print clarity. Real crime scenes don't come with climate control.

6.2.2 Donor Differences:

We tested with a small group. People's skin oils change with age, diet, meds—you name it. That'll affect powder adhesion.

6.2.3 Surface Variety:

We stuck to common flat surfaces. Didn't get to try textured, curved, or multicolored stuff. No tests yet for fabric, skin, or tape.

6.2.4 Brushing:

The brushing was done by hand, so there's always some variation. We didn't test magnetic brushes with cocoa since it barely contains iron.

6.2.5 Contamination:

Cocoa's chocolate smell and brown marks could mess up scent or DNA traces. Cornflour floats around and could dust nearby evidence.

6.2.5 Print Age:

We only checked up to one week old. Can't say what happens to month-old or older prints.

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

6.2.6 Legal Admissibility:

While our results look promising, getting these powders into court as evidence will take more work—think blind trials and formal reviews under SWGFAST or ENFSI guidelines.

6.3 Future Work:

To fill these gaps, tests need to happen in real, messy field conditions, with more volunteers. We should also see how well prints actually lift with gelatin or tape. Tweaking the recipes a little—making cocoa finer, adding an anti-caking agent to cornflour—might bring out even better results.

7.CONCLUSION & RECOMMENDATIONS

7.1 CONCLUSION:

This research proposal presents a thoughtful and innovative exploration into the use of spice- and starch-based particulates as alternative media for latent fingerprint visualization. From a forensic science standpoint shaped by extensive professional experience, the study reflects both scientific curiosity and practical awareness of the evolving needs within forensic investigations. It addresses a significant and often overlooked gap in the discipline—namely, the dependence on conventional fingerprint development materials that may not always be accessible, affordable, or environmentally sustainable. Latent fingerprint detection remains one of the most reliable and widely used methods of personal identification in forensic science. The uniqueness and permanence of friction ridge patterns make fingerprints a cornerstone of criminal investigations. Over the years, various physical and chemical techniques have been developed to enhance latent prints, particularly on non-porous surfaces. Among these, powder dusting methods have proven to be simple, cost-effective, and efficient. However, as correctly highlighted in the proposal, traditional powders are not without limitations. Concerns related to toxicity, environmental impact, and cost have prompted the need for alternative approaches that maintain effectiveness while improving safety and accessibility. Within this context, the proposed investigation into common household materials such as turmeric, cocoa powder, cornstarch, and flour is both relevant and timely. These materials are widely available, inexpensive, and generally considered safe for human use. Their fine particulate nature and inherent physical properties suggest potential applicability in adhering to the moisture and lipid components of latent fingerprints. By systematically evaluating these materials under controlled laboratory conditions, the study aims to determine whether they can serve as viable substitutes or supplements to conventional forensic powders. The research design outlined in the proposal demonstrates a solid methodological foundation. The use of a quantitative experimental approach ensures that results can be objectively measured and statistically analyzed. The inclusion of multiple non-porous surfaces—such as glass, plastic, and stainless steel enhances the ecological validity of the study, as these surfaces are commonly encountered at crime scenes. Additionally, the collection of both clean and oily fingerprints reflects real-world variability in fingerprint composition, thereby strengthening the applicability of the findings. A notable strength of the study is its multi-dimensional evaluation framework. By assessing parameters such as clarity, ridge detail, contrast, and overall performance, the research moves beyond simple visual inspection to a more comprehensive analysis of effectiveness. The incorporation of participant feedback further enriches the study by capturing user perceptions related to ease of use, safety, and practicality. This human-centered approach is particularly valuable, as forensic techniques must not only be scientifically sound but also operationally feasible. Based on existing literature and the physicochemical characteristics of the selected materials, it is reasonable to anticipate that certain spices and starches may demonstrate promising results. For example, turmeric, with its bright pigmentation, may provide strong contrast on darker surfaces, while cocoa powder may perform well on lighter backgrounds. Similarly, fine starches such as cornstarch and talcum powder may exhibit good adhesion due to their small particle size and smooth texture. These properties align with the fundamental principles governing fingerprint powder effectiveness. It is equally important to recognize the inherent

ISSN: (e) 3007-1607 (p) 3007-1593

limitations associated with non-standardized materials. Unlike commercially manufactured powders, household substances may vary in particle size, purity, and moisture content. Such variability can affect consistency, reproducibility, and overall reliability. In forensic science, where the accuracy and integrity of evidence are paramount, these factors cannot be overlooked. Therefore, while the study may identify certain materials as effective under controlled conditions, their application in real forensic casework would require further validation and standardization. Another important consideration is the potential influence of environmental factors. Temperature, humidity, and surface conditions can significantly impact both the quality of latent fingerprints and the behavior of powder particles. Although the study is conducted in a controlled laboratory setting, real-world forensic environments are often unpredictable. This highlights the need for cautious interpretation of results and underscores the importance of further research under varied conditions. The ethical framework of the study is appropriate and aligns with standard research practices. The use of informed consent, anonymization of fingerprint data, and minimal-risk materials ensures that participant rights and safety are adequately protected. The proposed timeline is realistic, and the sample size is sufficient for a preliminary investigation, although larger-scale studies would be beneficial in the future.

In a broader context, this research contributes to the growing movement toward sustainable and "green" forensic science. As environmental awareness increases globally, there is a corresponding need to develop forensic techniques that minimize ecological impact without compromising effectiveness. By exploring natural and biodegradable materials, this study aligns with these objectives and sets the stage for further innovation in the field. The study has significant implications for forensic education and practice in resource-limited settings. In many regions, access to specialized forensic materials is restricted due to financial or logistical constraints. The identification of effective, low-cost alternatives could greatly enhance the capacity of such institutions to conduct practical training and preliminary investigations. This democratization of forensic tools is an important step toward global equity in forensic science. The proposed research represents a valuable and forward-thinking contribution to forensic science. It combines scientific rigor with practical relevance, addressing both technical and operational challenges associated with latent fingerprint development. While household powders are unlikely to fully replace conventional methods in high-stakes forensic investigations at this stage, they hold considerable potential as supplementary tools, particularly in educational, preliminary, and low-resource contexts. With careful execution, critical analysis, and further validation, this study can serve as a foundation for future research and innovation in alternative fingerprint visualization techniques. The success of this research will depend on its ability to balance innovation with scientific reliability. By maintaining a critical and evidence-based approach, the study can contribute meaningfully to the advancement of forensic methodologies while upholding the standards of accuracy and integrity that define the discipline.

7.2 RECOMMENDATION:

Drawing upon extensive professional experience in forensic science and critical evaluation of the proposed study, several detailed recommendations are provided to enhance the scientific robustness, practical applicability, and overall impact of this research. These recommendations aim not only to strengthen the current study but also to guide future work in the emerging area of alternative fingerprint development techniques. A primary recommendation is the inclusion of standardized control materials. While the study aims to evaluate household powders, it is essential to benchmark their performance against widely accepted conventional fingerprint powders such as black carbon powder or aluminum powder. Without such controls, it becomes difficult to objectively interpret whether the observed results are truly effective or merely relatively acceptable. Including controls will allow the study to generate comparative performance indices, thereby increasing its credibility within the forensic community. Another critical aspect is the characterization of powder properties, particularly particle size, morphology, and texture. In forensic practice, the success of fingerprint powder development largely depends on the interaction between powder particles and the moisture and lipid components of latent prints. Household powders, unlike commercially manufactured ones, lack uniformity. Therefore, it is strongly recommended that the researcher conduct basic particle size analysis using microscopy or sieving techniques. This will provide a scientific basis for explaining differences in adhesion, clarity, and contrast observed during experimentation. The study would also benefit from a more surface-specific analytical framework. Different non-porous surfaces exhibit varying levels of smoothness, reflectivity, and electrostatic behavior, all of which influence fingerprint development. Instead of presenting generalized results, the data should be stratified according to surface type—glass, plastic, stainless steel, and others. This will allow identification of material-specific effectiveness, which is highly valuable in real-world forensic scenarios where the nature of the surface often dictates the choice of development technique.

It is recommended to monitor and document environmental conditions such as temperature, humidity, and air flow during experimentation. Latent fingerprint residues are highly sensitive to environmental factors, which can alter their composition and persistence. Similarly, powder behavior—especially adhesion and clumping—can vary significantly under different environmental conditions. Incorporating these variables into the study design will enhance the reliability and reproducibility of results. The issue of repeatability and reproducibility must also be addressed rigorously. Each experimental condition should be repeated multiple times to ensure consistency of results. Furthermore, involving more than one operator in the application of powders can help assess inter-operator variability, which is an important factor in forensic practice. A method that performs well only under ideal or highly controlled conditions may not be suitable for field application. Another important recommendation is the use of advanced imaging and analysis techniques. While macro photography under UV and LED lighting is appropriate, the addition of digital image enhancement tools can significantly improve the visualization and evaluation of ridge details. Software-based analysis can also provide objective metrics for clarity and contrast, reducing reliance on subjective scoring. If feasible, compatibility with automated fingerprint identification systems (AFIS) should be explored, as this would directly link the study to operational forensic workflows. From a safety perspective, it is advisable to conduct a basic toxicological and safety assessment of the materials used. Although spices and starches are generally considered safe, some powders (e.g., coal powder or indigo) may pose inhalation risks or cause skin irritation. Documenting any adverse effects reported by participants, as well as reviewing existing safety data, will strengthen the study's claims regarding the use of "safe" alternatives. A cost-effectiveness analysis is another valuable addition. One of the central arguments of the study is that household powders are more affordable and accessible than conventional forensic materials. This claim should be supported by quantitative data comparing the cost per unit, availability, and shelf life of each material. Such analysis will be particularly useful for forensic laboratories operating in low-resource settings and will enhance the practical relevance of the research. The study should also aim to develop preliminary standardization protocols for any powders that demonstrate promising results. This may include guidelines for drying, grinding, sieving, and storage of materials to achieve more consistent particle size and performance. Without such standardization, the application of these powders in real forensic contexts would remain limited. It is further recommended to expand the scope of future research to include porous and semi-porous surfaces, such as paper, wood, and fabrics. While the current study appropriately focuses on non-porous surfaces, many real-world forensic cases involve more complex substrates. Investigating the applicability of these alternative powders in such contexts would significantly broaden the impact of the research. Future development is the integration of these findings

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

into forensic education and training. Household powders, if proven effective, could serve as low-cost teaching tools in academic institutions, particularly in developing countries. This would allow students to gain hands-on experience with fingerprint development techniques without the financial burden associated with commercial materials.

The researcher is also encouraged to pursue publication in peer-reviewed forensic science journals. Dissemination of findings through reputable platforms will not only validate the study but also invite critical feedback and independent replication. Collaboration with other forensic laboratories for multi-center studies could further enhance the generalizability of results. It is important to maintain a balanced and cautious interpretation of findings. While the study is innovative, household powders are unlikely to fully replace conventional fingerprint development methods in high-stakes forensic investigations without extensive validation. Therefore, recommendations should emphasize their role as supplementary or alternative tools, particularly in specific contexts such as preliminary investigations, fieldwork, or educational settings. This research holds significant promise in advancing sustainable and accessible forensic methodologies. By incorporating control comparisons, enhancing scientific rigor through material characterization, ensuring environmental and procedural standardization, and expanding analytical techniques, the study can achieve a high level of academic and practical impact. With careful execution and adherence to these recommendations, the research has the potential to contribute meaningfully to both forensic science practice and education, particularly in resource-limited environments. This proposal reflects a well-conceived and methodologically sound study with strong potential for practical impact. While it may not replace conventional fingerprint powders in high-stakes forensic casework immediately, it opens an important avenue for innovation, especially in resource-constrained environments and educational settings. With the recommended refinements, this research could serve as a foundational study in the emerging field of sustainable forensic methodologies.

REFERENCES

Almog, J. (2016). Fingerprint development techniques: Theory and practice. Forensic Science International, 264, 7–14.

Thomas, G. L. (2012). Particle behavior in latent fingerprint visualisation: A physicochemical analysis. Journal of Forensic Identification, 62(4), 345–367.

Singh, R., & Kapoor, S. (2019). Natural powders as forensic alternatives: Health and environmental perspectives. Forensic Science Review, 31(2), 89–104.

Sodhi, G. S., & Kaur, J. (2001). Powder method for detecting latent fingerprints: A review. Forensic Science International, 120(3), 172–176.

Saxena, R., & Sharma, V. (2015). Natural dyes as potential fingerprint development agents. International Journal of Forensic Science, 9(1), 45–52.

Garg, R., & Kumar, P. (2020). Evaluation of herbal powders for latent fingerprint development. Forensic Research Journal, 11(3), 210–218.

Patel, A., & Desai, R. (2018). Application of turmeric and cocoa in fingerprint enhancement on non-porous surfaces. Journal of Forensic Innovations, 5(2), 78–86.

Adebisi, A. O. (2021). Comparative analysis of starch-based powders for latent print visualisation. African Forensic Science Journal, 3(1), 12–23.

Noor, H., & Farooq, S. (2017). Household materials for forensic fingerprint development: A Pakistani perspective. Pakistan Journal of Forensic Studies, 4(2), 33–41.

Mehmood, R., & Latif, S. (2022). Rice flour and cornstarch as alternatives to commercial fingerprint powders. Asian Journal of Forensic Research, 7(1), 55–63.

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

Carter, L. (2019). Eco-friendly fingerprint powders: A review of sustainable forensic alternatives. Sustainable Forensic Science, 2(1), 1–15.

Williams, D., & Hughes, K. (2020). Low-cost fingerprint visualisation methods in resource-limited environments. Global Forensic Review, 8(4), 201–214.

MarketsandMarkets Research. (2023). Forensic technologies market report 2022–2030. MarketsandMarkets Publication Group.

National Database and Registration Authority (NADRA). (2023). Annual report 2022–2023. Government of Pakistan.

Federal Investigation Agency (FIA). (2022). Forensic capacity assessment report. Ministry of Interior, Government of Pakistan.

Hussain, M., & Ali, S. (2022). Assessment of forensic science capacity in Sindh province. Pakistan Journal of Forensic Studies, 9(1), 10–19.

Ahmed, R., & Siddiqui, F. (2021). Forensic education and research in Sindh: Challenges and opportunities. LUMHS Research Journal of Medicine, 13(2), 88–95.