ORIGINAL ARTICLE

Recycling Potential of Natural Waste Products in the Development of Fingerprint Powders for Forensic Application

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ABSTRACT

Introduction: The most common method to emerge latent fingermarks on non-porous surfaces is powdering by applying commercial fingerprint powders. However, the chemical composition of the powder is often toxic and poses health hazards to humans. This study was endeavoured to explore the effectiveness and potential use of natural resources for the enhancement of latent fingermarks. **Methods:** Eggshells and clamshells were prepared in fine powder form, and latent fingermarks were developed using each powder. Five non-porous substrates were selected for fingermarks deposition; glass, aluminium can, plastic book cover, painted wood, and compact disc. **Results:** Both natural powders have successfully developed high-quality finger marks with high clarity of ridge characteristics in comparison to commercial fingerprint powder (positive control) and untreated fingermark (negative control) on most of the tested surfaces tested. The sebaceous fingermarks have shown the best quality fingermarks when developed with both powders. In the ageing study, it was found that most non-porous substrates bearing latent fingermarks exposed to the destructive conditions can be successfully visualised in the early period of exposure. **Conclusion:** Eggshell and clamshell powders are as effective as commercial white powder but preferrable to be applied because of the low cost, abundant and non-hazardous.

Keywords: Fingerprint, Eggshell, Clamshell, Powder

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INTRODUCTION

In forensic investigations, the relationship between the criminal, the victim, and the crime scene can be firmly established through the detection of latent fingermarks (1). Over the centuries, there were many reagents and methods have been sought for the development of latent fingermarks, such as powder dusting, superglue fuming, multi-metal deposition and fluorescent dyes (2). Powder dusting method is the conventional technique. This method is the most widely practiced for the enhancement of latent fingermarks because it is only need adequate preparation for operators and requires simple toolset. When the fingermark powder is applied over a region, the powder affixes to the constituents left in a fingermark.

Regular powders for fingerprint development include a resinous polymer such as starch, kaolin, and silica gel for adhesion, as well as a colourant made up of inorganic or organic compounds for better visualization (3). The commercial fingerprint powder contains inorganic salt of heavy metals such as mercury, cadmium, titanium, lead, and manganese, which cause health hazards to the users. Therefore, instead of commercial methods used to develop latent fingermarks, there are also alternative ways that researchers have previously investigated to achieve a non-toxic and successful approach to latent fingermark development. Turmeric powder, for example, has been tested to develop latent fingermarks on different surfaces (4). Turmeric or *Curcuma longa* is a rhizomatous herbaceous perennial plant of the ginger family Zingiberaceae. The functional use of curcumin, a component in turmeric, gives colour as a food additive. The powdering method was implemented using a few grams of commercially available turmeric powder. The powder has demonstrated to be efficient for fingermark visualisation, especially on contrasting backgrounds.

Seerat *et al.* (5) had conducted comparative studies of various natural resources for the development of latent fingerprints on non-porous surfaces by using red chilli, turmeric, marigold, black charcoal powders, and mustard oil soot. They concluded these natural powders produced well and clear results for the development of latent fingermarks on non-porous substrates for example, plastic and glass. The powders are also less expensive, simple, readily available, and could be simply used successfully on various non-porous surfaces. For instance, due to the small size of the carbon-rich mustard oil soot, it only adheres to the fingerprint, not on all over the surface, and thus, less amount of it can be applied and produces the best result. Hence, less amount of soot is sufficient for developing the latent print.

Another study reported that Durian seed powder has successfully developed natural latent fingermark with a better visualization (6). The seed of Durian is plentiful in starch and produces white powder which adheres to the deposited fingerprint residues. The good interaction may be due to the structure of hydrogen bonds between the fatty acids/glycerides of sebum and the carbonyl and hydroxyl group of the components in the seed powder. This natural powder is also not poisonous, unharmful, and readily obtainable as compared to the currently available chemical powders, that offers potential health hazards.

Sari *et al.* (7) had sought an alternative cheap and natural fingerprint powder from gambir plants. The studies discovered that gambir powder is efficient for latent fingermarks visualisation on dry, non-porous surfaces. Gambir is the dried aqueous extract from the leaves and twigs of *Uncaria gambir* Roxburgh plants, used as a traditional medicinal material, which is native to India, Sri Lanka, Indonesia, and Malaysia. Further study revealed that the coarse gambir powder was preferable for latent fingermarks on glass slides and transparent plastics, meanwhile finer particle was significantly better for plastic cups, compact discs, and aluminium foils. In another similar study, marine biomasses were reported to be effective for the enhancement of latent fingermarks (8).

The previous study also reported the use of rice husk as a nanocarbon powder (NP) that presented sustainable, efficient, and eco-friendly alternatives towards visualising latent fingermarks deposited on various non-porous and semi-porous surfaces (9). The accumulation of rice husk waste, which is the aftermath of rice milling that produced in billions of tones annually, would be significantly minimised. Findings revealed that the rice husk NP offers good clarity of fingermark ridges and proven to outweigh commercial black powder due to the simple synthesis method and its low toxicity content of the powder.

Thakur *et al.* (10) investigated the application of Fuller's earth as an alternative powder for developing latent fingermark. Fuller's earth was grounded into a fine powder, and the powder was sprinkled over the latent fingermarks without using any brushes as the tip of the brush might interfere with the ridge patterns of the fingermarks. The overspill powder was cleared by tapping. The method produced clear images of developed fingermarks on the majority of tested substrates.

The present study aimed to develop new fingerprint powders which are naturally originated. The natural waste materials available in abundance are eggshell and seashell waste. Eggshell waste has been discovered recently because it is inexpensively, abundant, non-toxic, has inherent pore structure, and typically applied as fine powders in industrial waste treatment in the adsorption process. This study only emphasised on the structural part of the eggshell waste, which is the eggshell. The main component of the eggshell is calcium carbonate ($CaCO_3$). The eggshell constituent contains other components such as magnesium carbonate ($MgCO_3$), calcium phosphate ($Ca_3(PO_4)_2$), and organic matter. The eggshell possibly treated for a resource of calcium in the synthesis of hydroxyapatite (11) or being utilised in the area of agriculture in the sort of fertilisers, industrial products, paints, cosmetics, medicine, building and engineering materials, and pharmaceuticals as nutrition. Clamshells are distinctive, very structure materials and can be obtained along the seashore. The main compound present in clamshell is calcium carbonate ($CaCO_3$) that made of two layers; the outer layer is composed of huge and fragile prismatic calcite grains while the inner layer known as nacre, which commonly known as mother-of-pearl. The latter is the lustrous compound that is mostly made of aragonite (a mineral form of $CaCO_3$). This mineral becomes a substantial part due to its extraordinary mechanical properties and biocompatibility.

The thermoluminescent properties of the eggshell and clamshell make them suitable candidates to be investigated in this research for enhancing the quality of the developed fingermark. The components, formation, durability, and coating thickness of these powders may affect adherence. The fineness of the eggshell and clamshell powders enables them to adhere specifically according to the furrow impression of the greasy latent fingermark deposit without producing any smudge. The adhesion between the particles and the fingermark residue was influenced by the size of the powder particles (12). In another study, Choi *et al.* (13) found that the effectiveness of the powder binds to the ridges relies on the form of particles. The nanoparticles adhere easily to the ridges than rough particles.

The present study, therefore, explored the potential use of two types of natural waste products, namely eggshells and clamshells, as sustainable alternatives for latent fingermarks enhancement on non-porous substrates. These natural products are abundant, cheap, simple to be used, easily available and non-hazardous.

MATERIALS AND METHODS

Materials
The materials utilised in this study were eggshells and clamshells. The selected non-porous substrates were glass, aluminium can, plastic book cover, painted wood, and compact disc. Other materials such as commercial HI-FI volcano latent print white powder (SIRCHIE, USA), brown paint (Jotun brand), fingerprint brush, disposable gloves, face masks, tissue paper, sieve, and cotton wool. The chemical used was acetone (Sigma Aldrich, UK). The apparatus utilised in this study were blower, table, weighing balance, spatula, weighing boat, scissors, hand saw, knife, containers, beakers, and cutter. The instruments employed were Hot Air Oven Sterilizer (Memmert, Germany) and personal Blender (Philips).

General approach
The initial experiment was performed to identify the efficacy of natural powder to develop groomed eccrine fingermark, sebaceous fingermark and natural latent fingermark on different types of non-porous surfaces (glass, aluminium can, plastic book cover, painted wood, and compact disc). The study was then extended to the development of the latent fingermarks utilising natural powder after exposed to different environmental conditions through the aging studies. The developed fingermarks were photographed using smartphone Samsung Note 9 under normal light. The quality of the developed marks was assessed according to the fingermarks visibility scoring system, as shown in Table I (14).

Powder preparation
Eggshells and clamshells were collected and washed with tap water, and then boiled at 100°C for 15 minutes to remove potential bacteria. The eggshells and clamshells then arranged in a tray and dried in the Hot Air Oven Sterilizer at 90°C for 10 to 15 minutes. The dried eggshells and clamshells were crushed and blended using 600 W Philips personal blender into fine powders and sieved. The procedure was repeated for at least five times to achieve the required amount of fine powder. Finally, each powder was kept in containers and labelled.

Table I: Criteria for grading quality of latent fingerprint

GRADE	CRITERIA
1	No fingermark developed
2	Poor fingermark development: very few ridges visible, poor contrast
3	Medium fingermark development: either contrast or ridge detail was not good
4	Good fingermark development: either contrast or ridge detail was visible
5	Excellent fingermark development: contrast as well as ridge details are very clear

Samples preparation

Surfaces
The materials of non-porous surface utilised in this study were glass, aluminium can, plastic book cover, painted wood and compact disc. All the materials were cut into small pieces, divided into four quadrants and labelled as "I", "II", "III" and "IV", respectively. The aluminium can was cut around its circumference using a knife, and the bottom and upper parts were removed. By using large scissors, the middle part was cut into small pieces, sufficient for the deposition of fingermarks. The compact disc and glass sheet were cut into small pieces by using a cutter and plastic book cover was cut using a pair of scissors. The wood was cut into 2 inches long pieces by using a hand saw and painted with dark brown paint. All surfaces were cleaned prior to the deposition of latent fingermarks using cotton wool soaked with acetone and left to dry at room temperature.

Fingermarks deposition
Three types of fingermarks were used in this study; eccrine, sebaceous and natural fingermarks. Samples of fingermarks were deposited on substrates following the protocol of Sears *et al.* (15). The human ethical clearance was approved by the Human Research Ethics Committee, Universiti Sains Malaysia (USM/JEPeM/20120615).

a) Groomed eccrine fingermarks- The donor has washed hands with soap and water, then rinsed using acetone. Hands were allowed to dry before wearing unpowdered latex gloves for 45 minutes while doing normal activities. This to ensure only eccrine secretions were excreted on the fingers surfaces. The gloves were taken out and fingers were rubbed against each other and deposited immediately on the center of the non-porous surface, which had been then divided into four quadrants to ascertain that the fingerprint sample area, contact time and pressure were as uniform as possible.

b) Groomed sebaceous fingermarks- The donor has washed hands with soap and water, then rinsed using acetone and allowed to be dried. The subject was then asked to wipe right thumb finger on the sebaceous areas of the face including the bridge of nose across the forehead. Fingers were rubbed against each other and deposited in the same manner as groomed eccrine fingermarks.

c) Natural fingermarks- The donor has washed her hands with soap and water, then rinsed meticulously with acetone and allowed to be dried completely. She was informed not to rub on her face or nose or wearing gloves. The donor was asked to conduct her normal daily routine within 30 minutes just before the deposition was carried out. The deposition was made immediately as similar to previous.

Latent fingermarks collection and development

After deposition of fingermarks, all samples were left at room temperature for about half an hour prior to powdering method. Different areas of the latent fingermark of the right thumb deposited on each quadrant were developed by using different powders with the exception of the quadrant IV in which no development was performed. The details of the quadrants were as follows:

a) Quadrant I: Eggshell powder
b) Quadrant II: Clamshell powder
c) Quadrant III: SIRCHIE white powder (Positive control)
d) Quadrant IV: No development was performed (Negative control)

The Quadrant III and IV were used as controls in this study for comparison purposes. The latent fingermarks on quadrants I, II and III were developed via brushing method by using a fingerprint powder brush.

Development of latent fingermark from different secretion types on various types of substrates

There were three types of fingermarks utilised in this study: eccrine fingermark, sebaceous fingermark, and natural fingermark. Fingermarks were deposited on non-porous substrates such as glass, aluminium can, plastic book cover, painted wood, and compact disc. The images of developed fingermark were then viewed and photographed under normal light.

Ageing studies

This research was performed to analyse the efficacy of natural powders; eggshell and clamshell powders for natural latent fingermark development recovered from different destructive conditions. The natural fingermarks from a single donor and all the substrates were used throughout the experiments. The procedure of latent fingermark deposition was repeated similarly to the method described in fingermarks deposition, and the development method of each deposited fingermark was also repeated as detailed in latent fingermark collection and development section.

All developed fingermarks were photographed under normal light for the quality assessment. This study was carried out in triplicates.

a) Latent fingermarks recovered after exposure to sunlight

The study was performed to identify the most effective powder for developing latent fingermark on non-porous surfaces after recovery from exposure to sunlight at different time intervals (exposure time to sunlight). After fingermarks deposition, these samples were placed horizontally in outdoor locations with direct exposure to sunlight. All samples were placed on the flat surface of the table, which was slightly higher than the ground surface to minimise variations among the samples which has the potential to interfere with the progress of degradation. The latent fingermarks were then developed within one week with four time intervals; day 1, 3, 5 and 7.

b) Latent fingermarks recovered after submersion in stagnant water

This study was performed to examine the optimal powder that can recover the natural latent fingermarks on different non-porous substrates submersed in stagnant tap water. After fingermarks deposition, the non-porous materials bearing the deposited natural latent fingermarks were submerged in a bucket filled with tap water and exposed in stagnant condition for different time intervals of 1, 3, 5 and 7 days. The samples were then left at room temperature to be air dried before fingermarks development.

c) Latent fingermarks recovered from the burial environment

The experiments were conducted to imitate the situations in forensic investigation wherein all the substrates having the fingermarks were embedded in the peaty soil. The selected location was an open flat ground surface area. At the sampling area, approximately 1 m x 2 m in size was allotted for this study. All of the unwanted foreign materials on the designated area were removed. The soil was dug to a depth of approximately from the surface, and the 5 mm mesh sieve was used to filter the soil from any foreign materials. An effort has been made to standardise the soil sample to reduce variations. The filtered soil was filled into the hole and flattened. All the substrates were located and arranged on the filtered soil. At the side of the substrate, a 20 cm stick has been put and marked with a location and depth indicator. The second layer of filtered soil was then filled into the hole to cover all the substrates. All the substrates were embedded at the same depth; 10 cm from the soil surface. Samples were excavated on days 1, 3, 5 and 7, respectively. The surface of the recovered substrates had been clear away from the soils and other contaminants by using an air blower. The recovered substrates were moved to the laboratory for latent fingermarks development.

RESULTS

Development of different types of fingermark secretions on various non-porous surfaces

The latent fingermarks found in almost all of the substrates could be enhanced using eggshell and clamshell powders are shown in Figure 1. The developed sebaceous fingermarks demonstrated the best quality fingermarks when developed with both powders. The clamshells powder showed the best results with the majority of substrates demonstrated very good visibility (score 5) except for the painted wood surface (score 4). On the other hand, eggshells powder yielded very good quality with high clarity of fingermarks when developed on the glass and compact disc with score 5 and the remaining substrates exhibited score 4. Meanwhile, natural fingermarks also exhibited good quality images as compared to eccrine fingermarks. Glass and compact

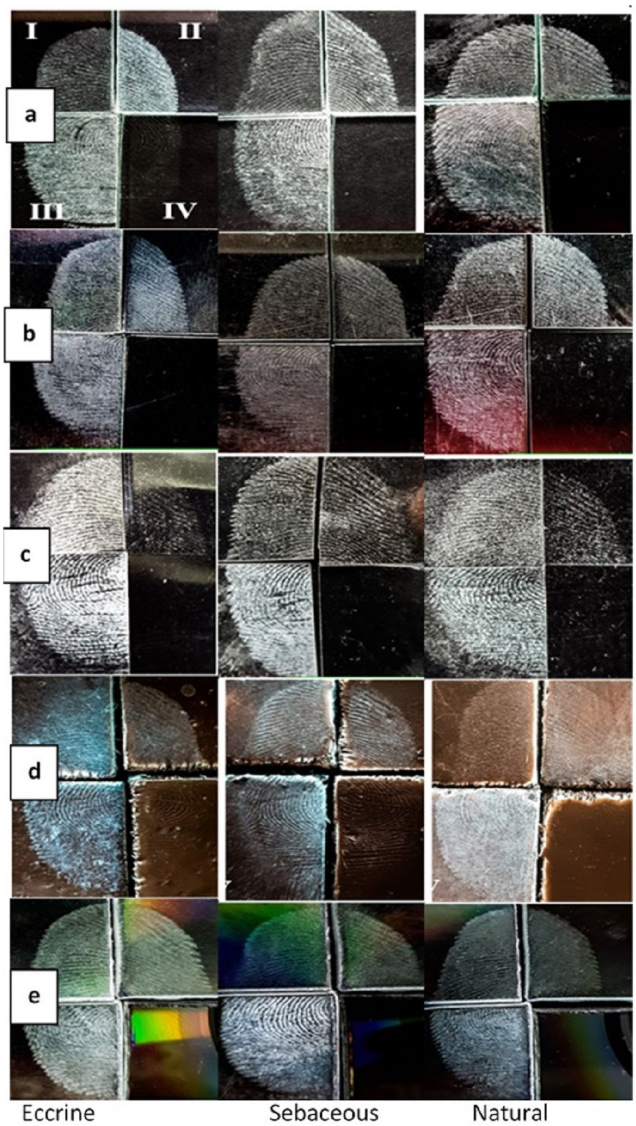

Figure 1: Developed eccrine, sebaceous and natural fingermarks on (a) glass, (b) aluminium can, (c) plastic book cover, (d) painted wood and (e) compact disc

disc produced the highest visibility scores but showed good visibility on the plastic book cover with score 4 when developed with eggshell powder. On the contrary, developed eccrine fingermarks yielded good visibility on plastic book cover and glass surface with score 4 and produced bad visibility (score 3) on the compact disc surface. In this present study, natural and eccrine fingermarks on the aluminium can and painted wood were not clearly visible and poor quality when developed with eggshells powder. The development of eccrine and natural fingermarks utilising clamshell powder produced quite similar results on compact disc and aluminium can which showed good clarity. In contrast, clamshell powder yielded poor visibility on glass, plastic book cover, and painted wood surfaces with scores 3, 2, and 1, respectively on both natural and eccrine fingermarks. In general, both powders are relatively effective as commercial fingerprint powder to develop different types of latent fingermarks on various substrates.

Ageing studies

Exposure to sunlight

According to the visibility score of developed natural fingermark after exposure to the sunlight on the glass surface, very good clarity of the development fingermarks (score 4 and 5) was obtained using eggshell, clamshell and commercial powders in the first day until fifth day of sunlight exposure (Figure 2). However, the quality of the marks declined dramatically after prolonged exposure for 7 days in which no friction ridges were visible, and the marks were almost completely smudged. On the aluminium can surface, all the developed fingermarks illustrated very good visibility up to 5 days of exposure under direct sunlight when developed with eggshells powder. However, the quality had deteriorated from day 7 with poor visibility of score 3. By using clamshells powder, fingermarks can be developed on such surface up to the third days of exposure with very high clarity, and the quality begins to deteriorate stably after five days onwards. When developed with eggshells and clamshells powder, it has been demonstrated that there were no dramatic changes observed on the recovered fingermarks on plastic book cover surfaces after 1 to 3 days of exposure to sunlight (score 4 and 5). On day 5 of exposure, there was no significant decrease in the quality of the developed marks as a good clarity of

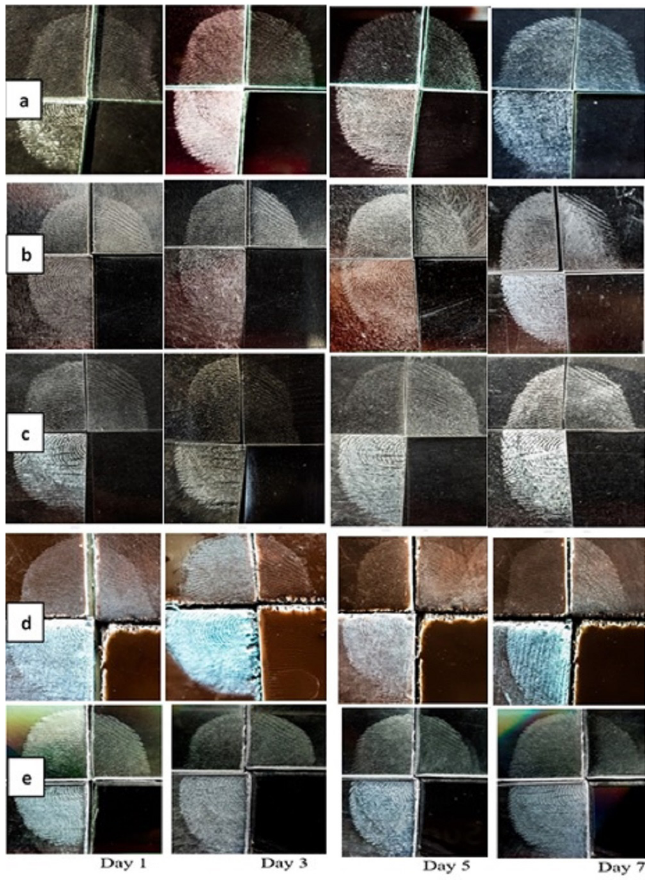

Figure 2: Developed natural fingermarks recovered from sunlight exposure at different time intervals on (a) glass, (b) aluminium can, (c) plastic book cover, (d) painted wood and (e) compact disc

developed marks was still obtained with detailed friction ridges observable across the majority of the mark (score 4). The quality of the fingermarks declined steadily to score 3 after exposed to the direct sunlight for 7 days. On the painted wood surface, a quick degradation was observed from the first day until third day of exposure to sunlight after developed using both natural powders in which ridges can still be seen although the visibility was poor (score 3). The quality had extremely degenerated as ridge forms on fingermarks were faded from day 5 onwards in the sunlight exposure circumstance (score 1). The development process using both natural powders from the first day of exposure to sunlight conditions produced excellent results as the quality of the developed marks on compact disc surface revealed that the majority of traces were useable and very good for identification (score 4 and 5). Clear ridge detail can still be visualised after prolonged exposure to sunlight up to 7 days as the marks exhibited good visibility after development was carried out using eggshells powder. However, the quality deteriorated from day 5 to day 7 with scores 4 and 2, respectively for clamshells powder. Similar observation was also noted for commercial white powder with decreasing trend in the quality of the developed fingermarks.

Submersion in water

The quality of recovered fingermarks on glass surfaces using both natural powders after more than 3 days of submersion in water showed the clamshells powder still yielded a very high clarity of marks (score 5), and the visibility score of 4 after being developed using eggshell powder. After 5th and 7th day of exposure, the quality of developed marks slowly declined as friction ridges were only detectable on the part of fingermarks recovered on 5th day of submersion (score 2 and 3). It was found that eggshell powders had effectively developed fingermarks on aluminium can surface after 1 day submersion in water with the majority of marks were suitable for identification (score 5) as compared clamshell powder (Figure 3). After more than 3 days of exposure, the quality had deteriorated with poor visibility of score 3 for both natural powders and commercial powder. The results of developed marks using eggshell, clamshell and commercial powder after the 5th and 7th days of submersion in the water had shown bad visibility as quality reduced steadily to score 2 and 1.

On the plastic book cover surface, fingermarks developed using both powders yielded very good result on the first day of submersion, and very good clarity of development on the third day of submersion (score 4 and 5). Despite that, the quality of developed fingermarks on plastic material deteriorated from day 5 of submersion onwards. Although eggshell powder yielded good visibility of fingermarks after one day of submersion in water, most of the developed marks on painted wood surfaces showed very poor quality. From days 3 and day 5 of the submersion period, only the form of fingermarks

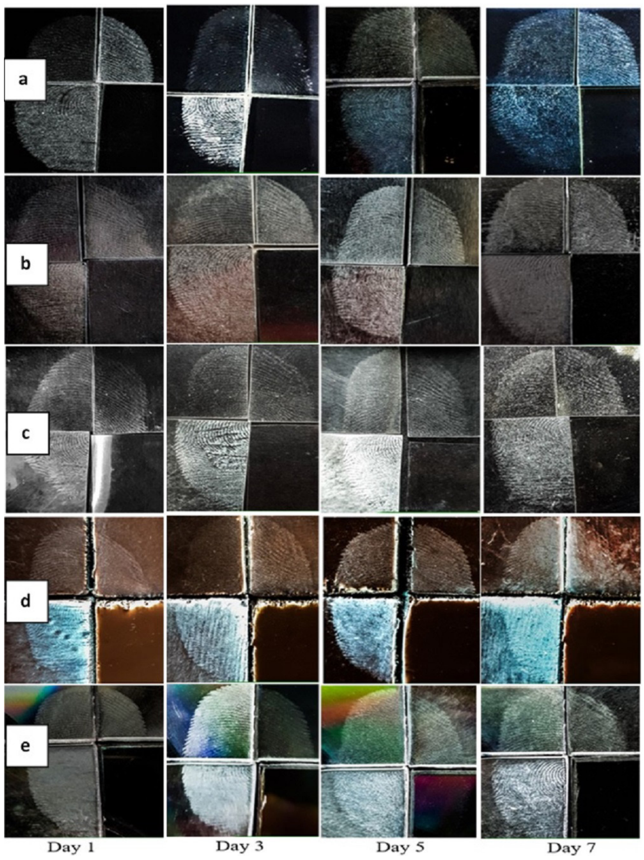

Figure 3: Developed natural fingermarks recovered after submersion in stagnant water at different time intervals on (a) glass, (b) aluminium can, (c) plastic book cover, (d) painted wood and (e) compact disc

with minimal ridge details was noted with a visibility score of 1. On day 7 of submersion, only partial mark with limited characteristics was visible. Eggshell and clamshell powders developed very high clarity of fingermarks on compact disc with score 5 on the first day of recovery. Marks of great visibility (score 4) were still obtained on 3rd days when eggshell was applied whereas clamshell produced the best result after the 3rd day of submersion with score 5. However, there was a quick degradation observed on examined marks on the 5th day after development was carried out using both natural powders, and on day 7 of submersion, the quality of fingermarks was found to be continually decreased as marks almost completely smudged (score 1).

Burial in soil

The quality of developed fingermarks using both natural powders and commercial powder on the glass surface after one day of the burial period was very good with a visibility score of 5. However, a slow degradation was observed after 3 and 5 days of exposure to soil burial with poor and bad visibility (scores 2 and 3). On the other hand, prints on the 7th day of the burial period score 1 as the friction ridges are only detectable on a part of marks because they were almost completely smudged (Figure 4).

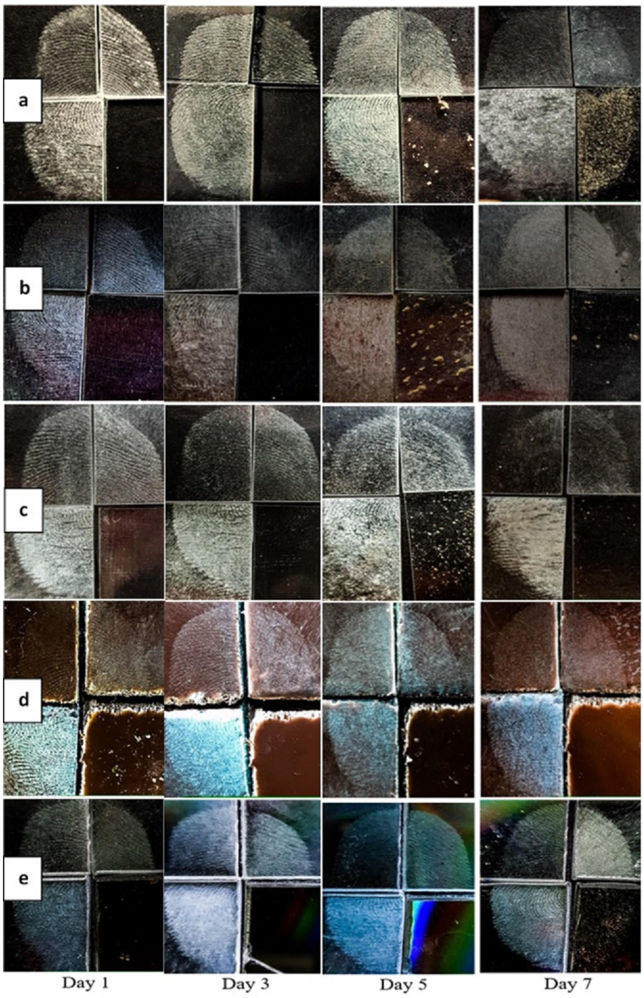

Figure 4: Developed natural fingermarks recovered from soil burial at different time intervals on (a) glass, (b) aluminium can, (c) plastic book cover, (d) painted wood and (e) compact disc

The developed fingermarks on aluminium can surface demonstrated good visibility after 1 day of soil burial when developed using eggshell and clamshell powder. The degradation was slowly imminent after the 3rd and 5th day of burial periods with poor visibility (score 2). There was no fingermark observed on the 7th day of burial for both natural powders (score 1). On the plastic material, the enhanced fingermark presented great and excellent visibility after 1 day of burial when developed using both natural powders (score 4 and 5). However, a quick degradation was discerned on the third day of burial after developed using eggshells powder (score 2). In contrast, fingermarks developed using clamshells powder still yielded a good result with clear ridges and high clarity (score 4). The results of developed marks after five and seven days of exposure to soil burial were quite similar in the eggshell and clamshell powder (score 1 and 2). On days 1 and 3 of burial, painted wood demonstrated bad quality fingermarks with decrement of ridge detail and clarity (score 3) after developed using eggshells powder. The quality had extremely degenerated as ridge details on fingermarks were faded from day 5 onwards. Moreover, there were no friction ridges visible on fingermarks developed using clamshells powder on the first day of burial in which the marks were almost completely smudged (score 2), and the quality declined significantly along with the consecutive time intervals. The fingermarks developed on compact disc resulted in good visibility (score 4 and 5) after day 1 to day 3 of burial after powdering using eggshell and clamshell powder. The resultant developed fingermarks after the 5th day of exposure to soil conditions showed the visibility score of 4 for clamshell powder and score of 3 for eggshell powder. However, the quality had deteriorated dramatically after the 7th day of the burial period for clamshell powder (score 1). The effectiveness of the commercial powder to develop good quality fingermarks had also decreased as the burial periods increased for all tested substrates.

DISCUSSION

Development of different types of fingermark secretions on various non-porous surfaces

The application of natural products for the development of latent fingermarks was demonstrated in this study. From the comparative study, it has been observed that both natural powders distinctively stick to the ridges in comparison with the conventional white powder that normally used by the forensic CSI team. Due to this reason, the fingermarks developed using eggshell and clamshell powders had better clarity in terms of ridge details. It was thought that the components of natural powders were more seemingly attracted to sebaceous glands than from the other secretions due to the fineness of the powder that physically adhered to the lipid, oil, and grease of the fingermark residue. It is evident that the clarity of the fingermarks was varied on each surface. For instance, the majority of surfaces can be developed using natural powders as the ridge details of developed prints on glass and compact disc surfaces can be clearly seen, meanwhile plastic and aluminium yielded satisfactory development results. Among all substrates, painted wood surface yielded poor development results, particularly for eccrine and natural fingermarks. Painted wood was observed to be not suitable for the powdering method due to the ineffectiveness of its surface that has a weak interaction with a finely divided component of natural powders.

Among all powders employed in the study for the development of fingermark, eggshells were the most effective, which produced developed fingermarks with identifiable ridge characteristics on most of the tested substrates. The developed sebaceous fingermarks demonstrated the best quality fingermarks when developed with all powders in which clamshells powder showed the best results with the majority of substrates produced very good visibility (score 5) except for painted wood surface. However, natural fingermark produced better results as compared to eccrine fingermarks, particularly on the glass, compact disc, and plastic book cover.

Ageing studies

Exposure to sunlight
Fingermarks can still be observed, and the general ridge characteristics can be identified even after five days of exposure to direct sunlight exposure on most of the surfaces except for painted wood surfaces. Development of latent fingrmarks with both powders provided very poor result during the experiment on this type of surface and this is might be due to the ineffectiveness of such surface. Depositions that exposed to direct sunlight were better preserved as not much degradation occurred on the developed marks during the exposure period between the first days to the fifth day on the majority of surfaces. The more prolonged aging durations could produce higher deterioration of fingermark elements (16). Although still potentially identifiable, it was noticeable that degradation was observed after the exposure to the sunlight up to seven days. Most of the fingermarks developed using natural powders are of better quality than that of developed using the commercial white fingerprint powder in terms of ridge details and clarity. It was evident that eggshell and clamshell powders were more effective than commercially available white fingerprint powder to develop latent fingermarks that were exposed to direct sunlight.

Submersion in water
On the first day of submersion, the quality of fingermarks that had been developed was good with visible and adequate ridges detail. However, the physical contact of water particles with the marks extremely degraded the quality of the restored fingermarks as the submersion periods increased. According to the obtained results, both natural powders had proven to be as effective as a commercial white powder in developing fingermarks that submerged in the water. Eggshell and clamshell powders produced better quality with clear ridge details and visibility of latent fingermarks on the first day on all substrates except for painted wood. The development results, however, indicated that the marks had gradually degraded after more than 3 days of exposure to stagnant water because of the longer duration of submersion has significantly affected the quality of developed fingermarks. The presence of smudges after the surface was completely dried had consequently deteriorated the quality of developed fingermark. Water has an impact on the durability of latent fingermarks, and their effective enhancement when the latent marks were subjected to the impact of the aquatic condition as a damaged crime scene situation. At the crime scenes, it is less likely that fingermark handling and development to occur right away after deposition, especially in under water crime scene (17). The findings of this study demonstrated that the duration of submersion in the water had a negative effect on fingermarks due to the long interaction between water particles with the traces on the surfaces. The longer period of exposure to water causes of reducing in the amount of fingermarks enhancement that can be used, and more fingermarks remained undeveloped.

Burial in soil
Since this experiment was conducted outdoor, there was a direct influence from environment like weather, water spots and soil sediments which caused interferences toward the marks. The water spots forming in this experiment has affected almost the entire development of fingermarks. The appearance of water spots on the entire of fingermarks was prevalent and had compromised the ridges clarity. Although most soil deposits were removed using an air blower, some soil sediments may be present and sticked to the surface of the substrate due to strong adhesion. In the midst of latent fingermark development, the particles could have damaged and scratched the ridge elements caused by movement during powdering. Eggshell and clamshell powders has formed a clear and adequate ridge detail of latent fingermarks in the first day of the burial on most of the substrates except for painted wood. However, the presence of smudges decreased the quality of developed fingermark. The quality of the fingermarks had mostly degenerated started by the third days of the burial period. The results obtained also indicated that fingermarks were easily affected by the dampness in the soil. Too much dampness had reduced the quality of the fingermarks restored from burial environments. In actual forensic cases, the evidence at the burial location might be exposed to rain before it had been discovered, hence causes a very difficult task for law enforcement officers to detect such fingermarks. During experimenting with an exteriors burial condition, the soil perhaps had a continuous wetness from the surrounding.

In the ageing study, it was found that most of the non-porous substrates bearing latent fingermarks that been subject to the destructive condition can be successfully visualised by utilising the natural product and commercial powder as fingerprint powder at the beginning of the experiment. Both natural powders had proven to be efficient in recovering latent fingermarks on the majority of tested non-porous surfaces except for painted wood surface. The reduction in the quality of developed fingerprints due to the long interval periods after deposition can be considered of the fact that; fingerprint components changed through diversification of chemical, biological and physical processes causing the aged composition. Since the experiment was conducted outdoor, the various contaminants were expected attributable to the surface of substrates, which resulted in the deterioration of the quality of developed marks. The reason for better quality marks obtained using fingerprint powders based natural product as compared to commercial powder is apparently due to the fineness size of particles. The very tiny size of the particles of eggshell and clamshell powders enables them to adhere specifically according to the ridge pattern of the greasy latent fingermark deposits.

CONCLUSION

Eggshell and clamshell powders have more benefits over commercial white powders by reason of simple synthesis, simple to be used, easily available, non-hazardous in nature and also low toxicity. The findings of this study strengthen the point that natural products have potential and contributions in forensic science, specifically in the fingermark study, where the natural powders can be useful resources as cheaper alternatives to commercially available white powder in the market.

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