Kertas Asli/Original Articles

Quality Assessment Of Alternative Patent Fingerprint Method Using Alcohol Gel And Thermal Paper

Chialeexian Chelladurai, Hamzah Noor Hazfalinda, Gabriel Gina Francesca, Khairunnisa Zaidan, Khairul Osman

ABSTRACT

Fingerprints are unique structures made up of a combination of friction ridges. Due to the individual characteristics of fingerprints, it is used commonly used for identification. Traditionally, patent fingerprints are obtained using an ink pad. Unfortunately, the print takes time to dry on paper and sometimes the fingerprint will leave streaks on a finger and nearby surfaces. Alcohol gel and thermal paper could address this problem as the alcohol component in gel is a weak acid that can reacts with the leuco dyes present on thermal paper. Hence forth, this study intends to find an alternative method of obtaining patent fingerprints using various combinations of alcohol gels and thermal papers. Six donors were requested to deposit their fingerprints on different types of thermal paper using different brands of alcohol gel hand sanitisers. Quality scores based on CAST's grading scheme were used to determine the fingerprint quality using various combinations of thermal paper and hand sanitisers. The result showed that patent fingerprints developed using hand sanitiser and thermal paper were of lower quality than the standard (ink pad). Combination of alcohol-based hand sanitiser, which consists of 70% alcohol concentration and ATM receipt paper was found to be able to produce the best quality fingerprint among the studied combinations. Despite this result, it still indicates that fingerprints using an ink pad is still the best method to record a fingerprint.

Keywords: patent fingerprints, hand sanitisers, thermal paper

ABSTRAK

Cap jari ialah struktur unik yang terdiri daripada gabungan-gabungan rabung geseran. Oleh kerana ciri-ciri cap jari individu amat unik, ia kerap digunakan untuk pengenalan diri. Secara tradisinya, cap jari paten diperoleh menggunakan pad dakwat. Malangnya, cetakan cap jari mengambil masa untuk mengering di atas kertas dan kadangkala cap jari akan meninggalkan coretan pada jari dan permukaan berdekatan. Gel alkohol dan kertas haba boleh menangani masalah ini kerana komponen alkohol dalam gel adalah asid lemah. Asid ini mudah bertindak balas dengan pewarna leuco yang terdapat pada kertas haba bagi menghasilkan warna. Justeru itu, kajian ini berhasrat untuk mencari kaedah alternatif untuk mendapatkan cap jari paten menggunakan pelbagai kombinasi gel alkohol dan kertas haba. Enam penderma telah diminta untuk meletakkan cap jari mereka pada pelbagai jenis kertas haba menggunakan pelbagai jenama pembersih tangan gel alkohol. Skor kualiti berdasarkan skema penggredan CAST digunakan untuk menentukan kualiti cap jari menggunakan pelbagai kombinasi kertas haba dan pembersih tangan. Hasil kajian menunjukkan cap jari paten yang dibangunkan menggunakan gel sanitiser tangan dan kertas haba adalah berkualiti rendah daripada piawai (pad dakwat). Gabungan pembersih tangan berasaskan alkohol, yang terdiri daripada 70% kepekatan alkohol dan kertas resit ATM didapati mampu menghasilkan cap jari berkualiti terbaik antara gabungan yang dikaji. Walaupun begitu, kajian jelas membuktikan bahawa cap jari menggunakan pad dakwat masih merupakan kaedah terbaik untuk merekod cap jari.

Kata kunci: cap jari paten, sanitiser tangan, kertas sensitif haba

INTRODUCTION

A fingerprint is an impression left by a subject on a surface. The fingerprint is unique in structure, consisting of a combination of friction ridges on the finger's epidermis (Monson et al. 2019). Friction ridges such as whorls, loops, arches, and bifurcations are pattern of ridges that make up a fingerprint, and each person will possess a different pattern ridged fingerprint. A fingerprint is even more unique when its composition is further considered.

Due to banking and security industries requiring identification of individual before any form of data is released, approved, or rejected; various fingerprint technology have been developed (Das & Debbarma 2011; Sharma & Mathuria 2018). In general, three types are commonly used: the contactless method, the use of the capacitive sensor and the traditional ink pad method.

The contactless method uses a light source and a special sensor to create a digital copy of a user's fingerprint. Two types of sensors are currently widely used – reflection and transmission. Reflection sensors utilise LED illuminators to reflect the light on the finger's ridges and valleys to produce an image of the fingerprint. One example of reflection sensors is the reflection sensor used by the bank to obtain our fingerprints when we open a bank account or wish to withdraw a large amount of cash. In contrast, the transmission sensors use illuminators called optical coherence tomography (OCT) based sensors (Nioi et al. 2019). This sensor can penetrate through an owner's finger's skin to produce an image of the fingerprint dermis layer (Bose & Kabir 2017). The advantage of using this method is it reduces the likelihood of fingerprint deformation and smearing due to improper finger placement and eliminates the cost of consumables (Kumar & Kumar 2018). The disadvantage of this method is that the upfront costs to purchase these devices can be quite high hence prohibitive for small and medium enterprise. Comparison of the applicant/ suspect fingerprint to a fingerprint database requires subscription or special access.

The second fingerprint collection technique is the use of the capacitive sensor. This type of sensor is gaining popularity as it is commonly used in high-end smartphones. Capacitive sensors function by measuring multiple capacitance values between two conductive surfaces, such as ridges of human fingers and valleys on a protective coating (Qiu 2014). The ridges on a user's fingers will produce changes in charge of the various capacitors. In contrast, the valleys between the finger ridges and the protective coating surface of the sensor will not affect the capacitor charge. These unique characteristics will provide the device with user's digital fingerprint that is reliable and can be quickly authenticated (Cappelli et al. 2008).

Unlike the light scanning sensors mentioned above, the capacitive sensor array does not require the use of light (Jeon et al. 2016). Hence, it can last longer than the latter. However, this technique requires a powerful processor to conduct the comparison. As this technique works on multiple small conductance sensor, minute details of the fingerprint can't be detected well.

In summary, light reflection scanning and capacitive sensors are costly compared to the conventional method, which uses a simple inkpad to obtain a fingerprint. Due to this, the availability of these unique equipment at any criminalistics lab is rare and far apart. However, their uses are still important but limited to a few specific functions.

Traditional fingerprinting is the most widely used fingerprint recording method. It utilises a technique known as contact-based transfer. This method requires the ink impressions of the finger, such as rolled fingerprint or latent fingerprint impression, to be transferred onto a clear surface to obtain a fingerprint impression (De Alcaraz-Fossoul et al. 2013; De Alcaraz-Fossoul et al. 2018). Rolling fingerprint impressions is the most common way to get a fingerprint imprint. Rolled fingerprint imprint is created by using ink applied on an individual's fingertip and transferring the fingerprint to a clean piece of paper. The ink fingerprints will be deposited from the left lateral to the right lateral nail with even pressure on the form. When done right, this action obtains the maximum number of finger ridges (Jagadiswary & Saraswady 2016). Unfortunately, a disadvantage associated with this method is that it takes time to dry the fingerprint on the paper. Moreover, using an ink pad to obtain the fingerprint will leave streaks on a finger and nearby surfaces (Lin & Kumar 2018). Therefore, an alternative method would be beneficial to eliminate the issues. Possible approaches include using alcohol-gel-like chemicals like hand sanitisers and thermal papers.

Thermal papers are thermosensitive papers extensively used in ATM and retail receipts, parking tickets, transit tickets, and movie tickets. Thermal papers are coated with leuco dyes and co-reactants, with bisphenol A as a colour developer (Bhasin et al. 2016). Leuco dyes are compounds that form a colour with acidic or electron-accepting compounds. When subjected to heat, the thermal paper will create black colour because of the unsubstituted leuco dyes, thus leaving black residues or prints on the thermal paper (Jasuja & Singh 2009). Bisphenol A, also known as BPA, will react with leuco dyes to form visible colours or prints on thermal paper (Björnsdotter et al. 2017).

Hand sanitisers are gel or liquids that help to kill bacteria or microbes on the hands. Hand sanitisers can be divided into two main groups: non-alcohol-based and alcohol-based. The non-alcohol-based hand sanitisers mainly comprise chlorhexidine, chloroxylenol, iodine and

quaternary ammonium compounds. In contrast, alcohol-based hand sanitisers primarily consist of 60 – 95% alcohol group (ethanol, isopropanol or n-propanol), water, excipients and humectants (Yalçin et al. 2016).

In this study, the various hand sanitiser used were alcohol-based. These sanitisers were selected because alcohol is a weak acid that reacts with the leuco dyes on thermal paper. The reaction causes the opening structure of lactone (Raditoiu et al. 2016).Thus, extending the conjugated double bond system, which in turn forms a coloured cation (Wang & Yan 2020). Furthermore, protic solvents and alcohol such as ethanol and propylene glycol will act as dermal penetration enhancers to enhance BPA absorption from thermal paper (Hormann et al. 2014). As BPA penetrates and absorbs through the epidermis of the finger, the finger's ridges may give prints on thermal paper as BPA will react with leuco dyes on the thermal paper to provide a colour precipitate.

Hence, this research was aimed to study the development and quality of alternative method of obtaining patent fingerprints using various combinations of alcohol gels and thermal papers.

MATERIALS AND METHODS

SAMPLE PREPARATION

Different alcohol-based hand sanitisers and thermal paper were purchased from local online markets. These included six different brands of alcohol hand sanitisers – labelled as A, B, C, D, E, and F. Furthermore, five different types of thermal paper were also obtained – thermal cashier receipt paper, ATM receipt, thermal fax paper, thermal A4 paper and BPA free thermal paper. These thermal papers were chosen as they are commonly used, cheap, and easy to obtain. All the materials were kept at room temperature and away from direct sunlight.

Subjects that provided the fingerprint were undergraduate students from UKM Bangi Malaysia. The sample of this study was done by convenience sampling. The source of the fingerprint consisted of six undergraduate students (Von Paris & Jackson 2012). Each subject was required to provide six fingerprints from the same phalange – index finger. The subjects were required to clean their hands using a dry clean tissue paper between prints. Time take between prints are 1 to 2 minutes. Hence, the total number of fingerprints collected was 36 from the fingerprint ink pad method. Furthermore, an additional 36 fingerprints were also collected for each brand of hand sanitiser and each type of thermal paper, thus making a total of 180 fingerprints for thermal paper and 216 fingerprints for hand sanitisers. 1080 fingerprints were also collected for the validation study. Inclusion factors for this study where the test subject must be between 18 to 60 years old, healthy with no medical illness such as a fracture that affected the movement of hands, the phalanges (fingers) must not have any significant scars, and the fingerprints were not worn out.

EXPERIMENTAL PROTOCOLS

To determine differences between the quality of fingerprints produced by various combinations of hand sanitisers and thermal paper, the six donors of fingerprints were required to wash, dry their hands, and touch the selected hand sanitisers before depositing their fingerprints on thermal paper. Research protocols are shown in Figure 1. Similar steps were repeated using different types and brands of alcohol-based hand sanitisers and thermal paper types. A standard fingerprint ink pad method was used as a positive control. Donors were also requested to deposit their fingerprints using the fingerprint pad on different types of thermal paper.

Hand sanitiser and ink pad were applied to donors' finger.

↓

Fingerprints were deposited on thermal paper with light pressure for 1 to 2 seconds.

↓

The quality of the fingerprint was determined using CAST's grading scheme.
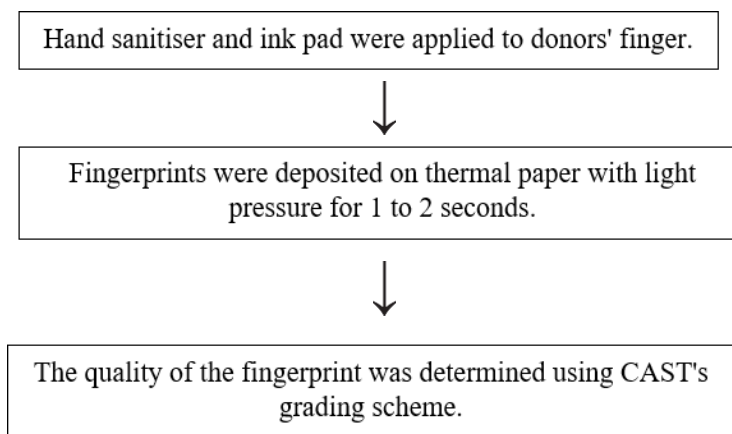
Figure 1. Protocols for deposition of fingerprints on thermal paper

The quality of fingerprints formed was determined visually by referring to Table 1. Table 1 is a modified fingerprint assessment scale based on CAST's grading scheme (Wang and Yan 2020). The quality score of the fingerprints was then analysed using Fisher's Exact Test on IBM SPSS Statistics Version 21. The level of significance was set at $p<0.05$.

Table 1. Modified quantitative fingerprint assessment scale based on modified CAST's grading scheme

Grades	Qualitative Equivalent
0	No visible prints or marks
1	Poor quality, weak development of prints with very few ridges detail
2	Reasonable quality, limited development of prints, about 1/3 of ridge details are present but limited characteristics, probably cannot be used for identification purposes
3	Good quality, strong development where between 1/3 and 2/3 ridge-details and some characteristics are visible, probable identifiable fingerprint
4	Excellent quality, strong development with clear prints, full ridge details, and identification assured.

A validation study was also conducted by pairing all five types of thermal paper with all six brands of hand sanitisers. The fingerprint quality score was determined for each combination of thermal paper and hand sanitiser, then tabulated in a table to compare each combination of thermal paper and hand sanitiser.

STATISTICAL ANALYSIS

Results were analysed descriptively.

RESULTS AND DISCUSSION

The main objective of the present study was to determine the types of thermal paper and hand sanitiser suitable for developing a clear and observable fingerprint. Based on the result (Table 2), ATM receipt papers had the highest average fingerprint quality score among all the types of thermal paper, which indicated that ATM receipt was the best thermal paper that could produce good patent fingerprints. The other types of thermal papers subsequently followed this. Regular receipt, thermal A4 paper, thermal fax paper and BPA-free thermal paper had shown an equal average fingerprint quality score of 0. The lowest fingerprint quality score. This showed that except for ATM receipt paper, other types of thermal paper could not produce good patent fingerprint quality.

By determining ATM receipt was the best thermal paper that can produce a fingerprint, different brands of hand sanitisers were then used to determine the best combination. As above, the quality scores were compared between different hand sanitisers. Based on Table 2, brands D and F had the highest average fingerprint quality score, indicating that brands D and F were the best hand sanitisers producing good patent fingerprints on ATM receipt paper.

Table 2. Total patent fingerprint quality score for each of the thermal paper and hand sanitiser

	Average fingerprint quality score
Thermal Paper	
Receipt Paper	0
Thermal A4 Paper	0
Thermal Fax Paper	0
ATM Receipt	1
BPA Free Thermal Paper	0
Hand Sanitiser (brand)	
A	0
B	0
C	0
D	1

E	0
F	1

To validate the above results, each combination of thermal paper and hand sanitiser was compared and is shown in Table 3. ATM receipt also demonstrated the highest fingerprint quality score combined with all types of hand sanitiser. Fax and BPA-free thermal paper had the lowest fingerprint quality score - 0. The low score may be due to the thermal paper's topcoat layer, which consists of antioxidants. This was confirmed by past research that reported the topcoat layer of thermal paper functions as a protective layer from substrate adherence and chemical inertness (Kumar & Kumar 2018; Sirohi et al. 2021). Thus, we suspect that this protective layer may have made the thermal paper more inert to the chemical changes on the thermal paper, resulting in the overall patent fingerprint's low quality.

Table 3 also indicated that brands D and F were the best hand sanitisers to produce good patent fingerprints on different types of thermal paper, as brand F had the highest fingerprint quality score in Table 3. This supported Table 2, showing that brands D and F were the best hand sanitisers to produce good patent fingerprints. It is suspected that the opening-ring structure on the leuco dye had reacted with the acidic compound (alcohol) in the sanitiser (Jasuja & Singh 2009). By reviewing the label product on the hand sanitisers, brands D and F were composed of 70 and above per cent alcohol, whereas brands A, B, C and E were made up of alcohol with a concentration below the threshold mentioned earlier. This indicated that a high alcohol concentration might influence the fingerprint quality of the thermal paper.

Table 3. Fingerprint quality score using different types of thermal paper and hand sanitiser with fingerprint pad (positive control)

	Fingerprint Quality Score				
	Receipt	A4	Fax Paper	ATM Receipt	BPA Free
A	0	0	0	1	0
B	0	0	0	1	0
C	0	0	0	1	0
D	1	1	0	1	0
E	0	0	0	1	0

F	1	0	0	2	0
Fingerprint pad (positive control)	4	4	4	4	4

According to Table 3, fingerprint quality produced on thermal paper using a fingerprint pad showed a significantly higher quality score than hand sanitisers. The variability in fingerprint quality score is because the deposition of fingerprints on thermal paper using a fingerprint pad did not involve the chemical reaction on thermal paper as experienced by hand sanitisers. All the fingerprints deposited on thermal paper using a fingerprint pad gave an average score of 4, indicating excellent quality with clear and identifiable ridges prints. Among all the thermal papers, ATM receipt had shown the lowest standard deviation value, which supported the previous result; ATM receipt was the best thermal paper to develop good patent fingerprints. Although using a fingerprint pad to deposit the fingerprints on thermal paper left smudges on the paper surface, this method still gave the highest fingerprint quality score compared to thermal paper and hand sanitiser.

It is also suspected that the amount of hand sanitiser applied by the donors on all thermal papers under study varied between individuals. This made the fingerprint quality score inconsistent. To overcome the variation in the hand sanitiser applied by donors, a small container containing a fixed amount of hand sanitiser should be prepared (Chadwick et al. 2018). This would avoid excess uptake of hand sanitiser fluid onto the fingerprints.

Observation from Table 4 (fingerprint pad method) has shown a variation of SD values between thermal paper. Possibility due to how much pressure was applied by the fingerprint when creating a mark on a paper. To avoid this problem in the future, a semi-flexible pad should be put under the paper to standardise fingerprint pressure. To further minimise the occurrence of bias, repetition of fingerprints' quality examination by two experts should be done.

Table 4. Average, SD, and Mean ± SD of fingerprint quality score using fingerprint pad development method.

	Receipt	A4	Fax Paper	ATM Receipt	BPA Free
Average	4.0	4.0	4.0	4.0	4.0
SD	0.3	0.4	0.4	0.2	0.4
Mean ± SD	4.0±0.3	4.0±0.4	4.0±0.4	4.0±0.2	4.0±0.4

Due to the obtained results, the application of this study seems limited. Despite it, this study hopefully would provide additional knowledge to crime scene investigators when dealing with cases that require a fingerprint. When an establishment with ATM machines requires its patrons to wipe their hands with 70% or above hand sanitisers before entering, patent fingerprints can be found in ATM receipts that are usually thrown away in nearby ATM bins.

Patent fingerprints developed using hand sanitiser with thermal paper have a lower quality fingerprint score than the traditional inkpad method. Among all the combinations of thermal paper and hand sanitiser, ATM receipt with brands D and F was the best combination to develop a good patent fingerprint. Alcohol-based hand sanitisers that consist of 70% and above alcohol tend to generate acceptable quality fingerprints.

CONCLUSION

We have demonstrated that combination of alcohol-based hand sanitisers and thermal paper are able to produce fingerprint marks. Despite this, the quality of the prints is much lower than using the ink pad-paper method (gold standard). Based on the results, we conclude that combination of alcohol-based hand liquids and various

tested paper mentioned above are not good alternatives to the current gold standard for fingerprinting.

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Chialeexian Chelladurai
Hamzah Noor Hazfalinda
Gabriel Gina Francesca
Khairunnisa Zaidan
Khairul Osman
Forensic Science Program Center Diagnostic,
Therapeutic and Investigative Studies (CODTIS)
Faculty of Health
Sciences Universiti Kebangsaan Malaysia, Jalan Raja
Muda Abdul Aziz
50300 Kuala Lumpur, MALAYSIA

Corresponding author:
Khairul Osman
khairos@gmail.com