Analysis of latent fingerprint constituents: A systematic review of quantitative studies

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Introduction

Fingerprint analysis is an important form of physical evidence in criminal investigations. With these physical properties such as ridge detail being analysed to determine a perpetrator. This has led to fingerprint composition being examined to identify the age, gender and race of an individual through fingerprint constituents characterisation.

Previous literature shows fingerprint composition being investigated through a variety of analytical techniques including chromatographic, spectroscopic and mass spectrometric/hyphenated techniques. The techniques included gas chromatography-mass spectrometry (GC-MS), liquid chromatography-mass spectrometry (LC-MS); capillary electrophoresis-mass spectrometry (CE-MS); thin layer chromatography (TLC); and Fourier-transform infrared (FTIR) spectroscopy.

Aim

To identify the most prominent chemical constituents of latent fingerprints, evaluating the analytical techniques used to determine fingerprint composition and determining the factors that affect fingerprint stability.

❑ Methodology

- ❑ A systematic review of constituents detected through chromatographic, spectroscopic and mass spectrometric/hyphenated techniques was conducted.
- ❑ The review included five databases: Google, Google Scholar, Scopus, Science direct and Web of Science. A total of 13 studies were relevant to the review and included the specified techniques in relation to search terms. Terms applied were: ‘fingerprints’, ‘chemical composition’ and ‘analysis’. The search strategy involved the use of the three terms in each database as follows: ‘fingerprint’ or ‘fingerprint(s)’ or ‘latent fingerprint’ AND ‘chemical composition’ or ‘chemical constituent’ or ‘chemical constituent(s)’ AND ‘analysis’ or ‘determination’ or ‘identification’ (Figure 1).

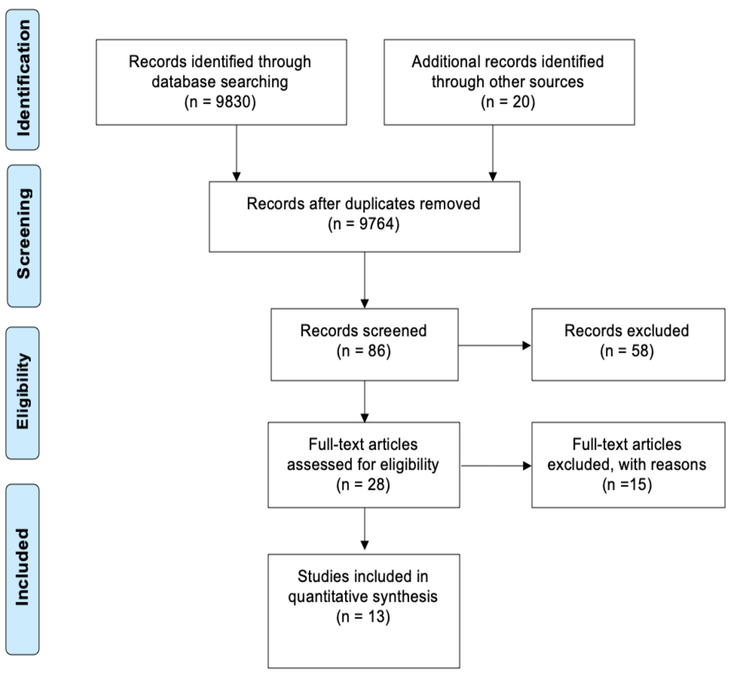

Figure 1. Data extraction criteria including identification, screening, eligibility and inclusion of studies.

- ❑ Inclusion criteria were studies that investigated chemical composition of fingerprints in relation to individual constituents types, donor types and analytical technique investigated. Studies excluded were those that had not stated clearly that ethical and correct procedural protocols; or those that presented an evaluation of a technique without showing any factors that affected the data extraction and results (Table 1).

Table 1. Information extracted through data analysis

Sections	Sub-sections
Title	Aim of study
Study Characteristics	Experimental settings; country settings; participants characteristics; sample type; sample size;
Deposition procedure	Fingers used; Latent fingerprint collected; Grooming procedures; Cleaning procedure
Experimental conditions	Experiment duration; storage conditions
Constituent	Constituents analysed; techniques applied

- ❑ Data analysis and summary statistics included percentages of each of the reported amino acids and lipids in the latent fingerprints; used the SPSS version 22.

Results

Constituents of latent fingerprints

- ❑ A total of 66 lipids and 22 amino acids were detected using five techniques. The most detected lipids were cholesterol, pentadecanoic acid, squalene (and its degradation products) and triconsanoic acid. Along with the amino acids were alanine, glycine, leucine and lysine.
- ❑ The main analytical techniques used was GC-MS that detected all the aforementioned lipids and amino acids respectively. This was followed by FTIR that could detect squalene and its degradation products. GC-MS was more sensitive where it identified fingerprint constituents at concentrations down to 10 pg/ml (Renterghem et al. 2020).
- ❑ Stability squalene was a significant factor identified in fingerprint composition. LC-MS identified that squalene (SQ); squalene monohydroperoxide (SQ-[OOH]) and SQ epoxide in freshly deposited fingerprints but increased after 1 day and continued to increase up to 5 days of print deposition. After this period, the detection began to decrease and by day 7 can not be detected (Mountfort et al. 2007) (Figure 2).

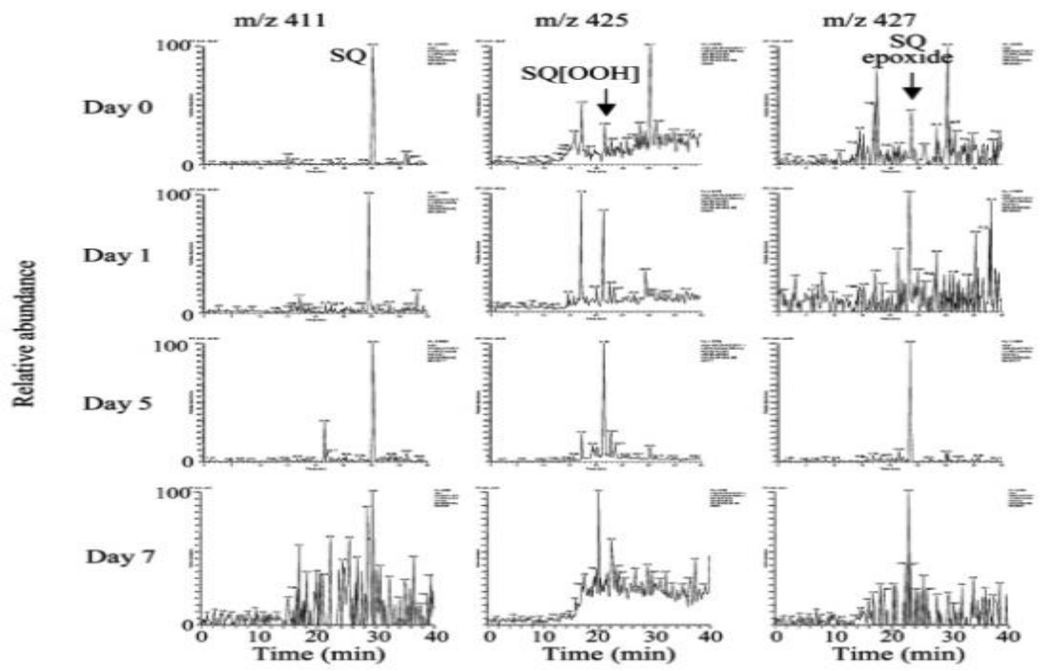

Figure 2. Squalene, SQ [OOH] and SQ epoxide degradation levels over seven days and detectable markers.

Fingerprint collection method

- ❑ Collection procedures features were: finger specification; the grooming procedure and the fingerprint collection procedure. The grooming procedure included rubbing along the forehead, hair, nose, cheeks and chin with the forehead being the most utilised source.
- ❑ The most used fingers were the ring finger; middle finger; index and the thumbs.
- ❑ The fingerprints were deposited onto substrates of which the main types were fibreglass filter paper and microfiber filter paper that had high porosity. Moreover, mylar strip, glass and ZnSe ATR crystal were used for their strength, non-porosity and solvents’ resistance.

Experimental conditions

- ❑ The maximal reported temperatures for storage of fingerprint substrates prior to analysis were 100˚ C for potassium bromide discs, and 25˚ C for the other kinds of substrates, when accompanied with the dark setting. The latter temperature was the optimal for slowing down the degradation of fingerprint constituents.
- ❑ Nonetheless, substrates were mainly analysed in light and at room temperature conditions.

Conclusion

Latent fingerprint constituents detected included lipids and amino acids due to there abundance and of which the main biomarker present was squalene alongside its degradation products. The main detection technique efficient for identification of fingerprint composition was GC-MS that has shown to be sensitive down to ng levels. However, none of the studies explored the degradation of fingerprint secretions or the concentrations of the amino acid or lipid components in fingerprints and this should be considered in future work.

References

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