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Review

Present and foreseeable future of metabolomics in forensic analysis

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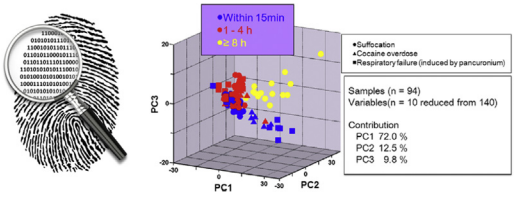
HIGHLIGHTS

- The precariousness of forensic science worldwide has promoted its urgent improvement.
- The features of metabolomics make this omics a useful tool in forensic analysis.
- Examples of usefulness of metabolomics in forensic analysis are critically discussed.
- The pillars to support the future of metabolomics–forensic analysis are established.

GRAPHICAL ABSTRACT



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ABSTRACT

The revulsive publications during the last years on the precariousness of forensic sciences worldwide have promoted the move of major steps towards improvement of this science. One of the steps (*viz.* a higher involvement of metabolomics in the new era of forensic analysis) deserves to be discussed under different angles. Thus, the characteristics of metabolomics that make it a useful tool in forensic analysis, the aspects in which this omics is so far implicit, but not mentioned in forensic analyses, and how typical forensic parameters such as the post-mortem interval or fingerprints take benefits from metabolomics are critically discussed in this review. The way in which the metabolomics–forensic binomial succeeds when either conventional or less frequent samples are used is highlighted here. Finally, the pillars that should support future developments involving metabolomics and forensic analysis, and the research required for a fruitful in-depth involvement of metabolomics in forensic analysis are critically discussed.

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1. Introduction

1.1. Definition of forensic science

Forensic science is the application of science in criminal investigation. In forensics, findings based on scientific knowledge and technologies are used to serve as witnesses to prove guilt or innocence in criminal and civil matters. It is proved that even eyewitness may turn hostile, while scientific evidences properly gathered from a crime scene become solid evidences, which does not change with time. Forensic science is an established branch of criminal investigation that encompasses disciplines such as forensic chemistry, forensic biology and serology, forensic ballistics, forensic physics, forensic photography and forensic DNA fingerprinting. Microbial forensics is a relatively new emerging branch, which connects microbiology with forensic science, where microbial agents, their origin and their potential effects can be presented as medico legal evidences. It is the interplay of classical microbiology, microbial genomics, phylogenetics and bioinformatics, in which metabolomics is each time more involved [1].

1.2. State-of-the-art of forensic science and forces acting for improvement

The publication “Strengthening Forensic Science in the United States: A Path Forward” by the National Academies of Science (NAS) in 2009 [2] constituted an authentic revulsive of the forensic science with a global impact that not only affected to the U.S., as the challenges related to high case loads, lack of resources, insufficient quality control and lack of scientific basis in several areas of forensic expertise as well as in laboratories found echo worldwide. A response to the reported situation is the move of one of the first major steps toward improving forensic science in the U.S., as the study found little research underlying forensic science. The proposal involves that by 2020, all Department of Justice laboratories must be accredited, and the agency's attorneys must have forensic evidence tested in accredited laboratories whenever possible. The changes were recommended by the National Commission of Forensic Science, a major policy body created by the Justice Department and National Institute of Standard and Technology two years ago to help improvement of the practice in forensic science. Digital evidence is exempted from the recommendation [3]. Interestingly, not many other publications can be found in recent scientific literature discussing and proposing challenges, strategies, missions and visions for forensic science. In the aftermath of the NAS report a conference was organized in Arizona in 2009 on the future of forensic science [4] and in 2010 the 20th Australian and New Zealand Forensic Science Society Conference in Sydney adopted a special theme named “forensic science on trial”. The international journal Forensic Science Policy and Management is dedicated to “improving the effectiveness, efficiency, quality, and operations of forensic science laboratories” and a number of interesting articles were published in this journal when key performance indicators based on business principles were introduced to monitor, compare and optimize forensic science laboratories [4–8]. Already in 2006 two articles were published on the views expressed by forensic science users and providers in the UK during a one-day conference entitled “The Future of Forensic and Crime Scene Science” [9,10]. During the conference a third era of change in forensic science was argued in which key drivers for forensic innovation were considered as follows: increased capacity (“more”) and quality (“better”), reduced lead times (“faster”) and costs (“cheaper”) and improved integration in the overall chain (“easier”). Around the time of the conference the Netherlands Forensic Institute was facing several challenges, which have recently been discussed by van Asten [11].