

Scotch Whiskies and Forensic Examinations of Manufacturing-Derived Features for Their Authentication

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ABSTRACT: With the global whisky market reaching \$65.6 billion in 2024 and projected to reach \$89.48 billion by the end of 2029, the incentives for fraud in relation to (and adulteration of) this alcoholic beverage are self-evident. Law enforcement agencies worldwide have taken actions against crimes of this nature, with forensic scientists playing crucial roles (mainly through expert testimonies on sample authenticities) during legal proceedings.

Important issues associated with Scotch whisky authentication include: (a) understanding the typical manufacturing process; (b) acquisition of reference samples; and (c) effective utilization of instrumentations to characterize features derived from the manufacturing process and strategic approaches for the interpretation of analytical findings. Following a brief review of the definition/classification, manufacturing, and adulteration/counterfeiting of Scotch whiskies, this review focuses on the characterization of manufacturing-derived features and interpretation of analytical findings as grouped into: (a) quantitative analysis of single compounds; (b) qualitative analysis and intensity ratio of multiple compounds; (c) chemometric analysis of selected multi-compounds; and (d) quantitative analysis of selected elements. Finally, a flowchart for conducting the authentication process, from various significantly different perspectives, is proposed.

KEYWORDS: Authentication, feature, meaningful difference, Scotch whisky.

INTRODUCTION

When dealing with suspected counterfeit or adulterated Scotch whisky samples, forensic scientists are required to take a series of steps to identify any meaningful differences between the suspected and reference samples for authentication. A fuller understanding of the Scotch whisky production process is helpful to the characterization of forensic features and the formulation of analytical strategies. These strategies include selecting features for qualitative and quantitative analysis and determining if the resulting findings — derived from the questioned sample and the reference material — can be meaningfully interpreted for authentication purposes. Reconstructing the *modus operandi* of potential counterfeit processes may also help forensic examiners elucidate any associated forensic characteristics. Such information will assist the forensic expert in the courtroom cross-examination process.

With this in mind, this paper first reviews some fundamental knowledge related to Scotch whiskies, including (a) the definition and classification of Scotch whisky; (b) manufacturing standards as specified by UK law in the Scotch Whisky Regulations 2009 and the five related categories [87]; and (c) the manufacturing process of Scotch whisky, including malting, fermentation, distillation, maturation, coloring, and other stages, as different brewing processes will produce Scotch whiskies with unique/specific forensic features that would differ from counterfeit materials.

A brief discussion on methods of producing counterfeit Scotch whisky will also provide (a) an understanding of the differences between typical and non-typical practices; and (b) the causes of specific forensic features generated by different production processes, thereby aiding the forensic analyst to better understand and differentiate between genuine and counterfeit Scotch whiskies.

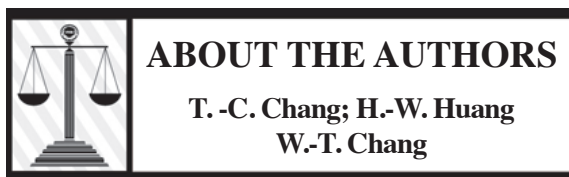
The focus of this review will be the characterization of manufacturing-derived distinguishing features and the interpretation of associated analytical markers, i.e., (a) quantitative analysis of single compounds; (b) qualitative analysis and intensity ratio of multiple compounds; (c) chemometric analysis of selected multi-compounds; and (d) quantitative analysis of selected elements.

Finally, the authors have derived a flowchart to guide the authentication process, suggesting the order in which various methods could be used. A forensic laboratory can select methods according to their equipment incorporated into testing procedures, as well as the specific requirements of judicial authorities, to identify meaningful differences and achieve the goal of distinguishing authenticity.

I. DEFINITION AND CLASSIFICATION OF SCOTCH WHISKY

With the escalating complexity of our food supply chain and the increasing demand for food commodities, the potential risks of food fraud and safety issues are on the rise. Estimates indicate that the global whisky market

92. Wiśniewska P, Śliwińska M, Dymerski T, Wardencki W, Namieśnik J: Comparison of an electronic nose based on ultrafast gas chromatography, comprehensive two-dimensional gas chromatography, and sensory evaluation for an analysis of type of whisky; *J Chem* 2017:2710104; 2017.
93. Zhang CY, Lin NB, Chai XS, Barnes DG: A rapid method for simultaneously determining ethanol and methanol content in wines by full evaporation headspace gas chromatography; *Food Chem* 183:169; 2015.



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Hsiao-Wen Huang received her B.S. and M.S. degrees from the National Tsing Hua University (Hsinchu, Taiwan), and a Ph.D. degree in forensic science from the Central Police University (Taoyuan, Taiwan). Dr. Huang's expertise is mainly in inorganic chemical synthesis, chemical and instrumental analysis, authentic and counterfeit whisky authentication, and relative statistical model fitting applications.

Wei-Tun Chang received his B.S. and M.S. degrees from the Central Police University (Taoyuan, Taiwan), and a Ph.D. degree in chemistry from the Chung Yuan Christian University (Taoyuan, Taiwan). Dr. Chang has been teaching in the Department of Forensic Science at Central Police University (Taoyuan, Taiwan) ever since and reached the rank of full professor in 2001. His expertise lies in the fields of forensic chemistry, trace paint identification, fire investigation and residue analysis, quantitative analysis of drugs, forensic photography, and authentication of alcoholic beverages.

In addition to his academic research, Prof. Chang also serves as a certificated auditor conducting on-site assessments of testing laboratories. He plays a crucial role in advancing forensic science in Taiwan through his involvement with the Taiwan Academy of Forensic Sciences (TAFS) and the Henry C. Lee Forensic Science Foundation. In September 2018, he established the TAFS Library, collecting books in English, German, Japanese, and Chinese languages. The library is open to the forensic science community offering book-box visiting activity with a free-of-charge policy. Prof. Chang is also the founder of the CSI Forensic Science Experience Camp — an educational summer program, for high school students and teachers, associated with TAFS and established on the campus of the Central Police University in 2015.