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Objectives and Scope

The discipline of forensic science has nurtured many publications oriented toward research and case reports, as well as broad-based formal treatises. Rapid advances in forensic science have created a need for a review journal to bridge the gap between research-oriented journals and reference volumes.

The goal of *Forensic Science Review* is to fill this void and provide a base for authors to extrapolate state-of-the-art information and to synthesize and translate it into readable review articles. The addition of this journal extends the spectrum of forensic science publications.

Articles bring into focus various narrowly defined topics whose literature has been widely scattered. Articles are presented to stimulate further research on one hand and worthwhile technological applications on the other. The publisher's aim is to provide forensic scientists with a forum enabling them to accomplish this goal.

Technological applications based on basic research are emphasized. Articles address techniques now widely used in forensic science as well as innovations holding promise for the future.

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The journal, original founded by President Shih-Si Yen, President of the Central Police University (Taoyuan, Taiwan), is currently published by Forensic Science Review with executive editorial offices located in Vancouver (Washington, US) and the Department of Criminal Justice, University of Alabama at Birmingham (Alabama, US).

Both professional review/commentary and review articles published in **Forensic Science Review** are mostly invited contributions. Review articles are peer-reviewed. The invitation process normally originates from the recommendations of the Editorial Board. Unsolicited articles from the general readership are also welcomed but should be preceded by a query letter to the Editor-in-Chief for presentation to the Editorial Board. Query letters and editorial correspondence should be addressed to: Editor-in-Chief, **Forensic Science Review**, Department of Criminal Justice, University of Alabama at Birmingham, Birmingham, AL 35294, US or preferably through E-mail to rayliu@uab.edu. Honoraria are presented to authors and reviewers upon distribution of the issue in which the article appears. All published articles represent the opinions of the authors and do not represent the official policy of the publisher or the institution with which the author is affiliated, unless clearly specified.

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[a]The views expressed are those of the authors and do not necessarily reflect the view, the position, or the policy of *Forensic Science Review* or members of its editorial board.

Exclusionary Criteria for the Authentication of Fake Scotch Whiskies in Taiwan

Hsiao-Wen Huang, Wei-Tun Chang*

Department of Forensic Science
Central Police University
Taoyuan City
Taiwan

+886 3-328-2321 Ext 5232; una030@mail.cpu.edu.tw

Scotch whisky, one of the world's most popular distilled alcoholic beverages, is a premium product rich in history and tradition, produced following the strict regulations of Scottish statutory instruments and manufactured only in Scotland [1]. Distilleries often use their brand identity and history as selling points in their marketing campaigns, emphasizing the craftsmanship and heritage of their products. Additionally, Scotch whisky is often marketed as a luxury item, with many distilleries offering high-end, limited-edition whiskies.

The Markets of Scotch Whisky in the World

The Scotch Whisky Association (SWA) plays a vital role in promoting Scotch whisky around the world. According to the SWA export report, the value of Scotch whisky exported to Taiwan in 2021 increased by 24% compared to 2020 [2]. Among the top ten export destinations of Scotch whisky in 2021, the value of Scotch whisky exported to Taiwan is as high as 226 million GBP, ranking third in the world after the United States and France, as shown in **Table 1.** However, in terms of total volume, the Taiwanese market has yet to enter the top ten. This indicates that people in Taiwan prefer high-priced Scotch whisky more. Based on the imported report from the National Treasury Administration, Ministry of Finance in Taiwan, Scotch whisky accounted for about 92% of the total imported whisky in 2021 [3], as shown in **Table 2.** Moreover, unlike the consumption habits of blended Scotch whisky in other countries, single malt Scotch whisky is especially popular with Taiwanese. According to a consumer survey report in Taiwan, the sales market of single malt Scotch whisky is almost similar to that of blended Scotch whisky [4]. With these products' commercial value, there have been reports on the investigation and seizure of illegal single malt Scotch whisky and illegal blended Scotch whisky in Taiwan [5].

Modus Operandi of Fake Scotch Whisky in Taiwan

Adulterated Scotch Whisky and Counterfeit Scotch Whisky

In terms of modus operandi, fake whisky in Taiwan can be divided into adulterated Scotch whisky and counterfeit Scotch whisky. *Adulterated Scotch whisky* typically uses a bottle of a well-known and market-accepted brand of Scotch whisky and then refills it with a liquor mixed with a small amount of genuine Scotch whisky and a large amount of edible rectified spirit. *Counterfeit Scotch whisky*, by contrast, is misleading illegal Scotch whisky made by counterfeiters using vague Scotch whisky names, when in fact there is no such distillery in Scotland. In order to reduce manufacturing costs, counterfeit Scotch whisky seized in Taiwan contains

Table 1. Top 10 markets of Scotch whisky from the 2021 Scotch Whisky Association export report [2]

By value				By volume			
Country	Value (GBP)[a]	vs 2019	vs 2020	Country	Volume[a,b]	vs 2019	vs 2020
US	789.8 m	26% ▼	8% ▲	France	176 m	1% ▲	0% --
France	386.6 m	11% ▼	3% ▲	India	136 m	4% ▲	44% ▲
Taiwan	226.1 m	10% ▲	24% ▲	US	126 m	1% ▼	13% ▲
Singapore	211.5 m	29% ▼	14% ▼	Brazil	82 m	91% ▲	81% ▲
China	197.8 m	123% ▲	85% ▲	Japan	56 m	7% ▼	26% ▲
Latvia	155.5 m	9% ▲	12% ▼	Spain	48 m	15% ▼	31% ▲
Germany	147.8 m	20% ▼	6% ▲	Mexico	48 m	7% ▼	13% ▲
India	146.2 m	12% ▼	43% ▲	Germany	46 m	8% ▼	7% ▲
Japan	132.9 m	10% ▼	16% ▲	Poland	45 m	37% ▲	19% ▲
Spain	118.1 m	34% ▼	8% ▲	Russia	42 m	61% ▲	41% ▲

[a] m = million.
[b] 70-cL bottle equivalent.

Table 2. Whisky import statistics in Taiwan (2021) [3]

Source	Volume[a]	Ratio (%)
Scotch whisky	206,055.83	92.51
Japanese whisky	8,542.37	3.84
American whisky	3,907.22	1.75
French whisky	2,014.20	0.90
Irish whisky	1,107.96	0.50
Canadian whisky	260.94	0.12

[a] Unit: In hectoliter (hL).

a large amount of edible rectified spirit mixed with some artificial food flavoring and/or a small amount of genuine Scotch whisky, so the counterfeit Scotch whisky often loses important characteristics of genuine Scotch whisky. In some cases, these counterfeit Scotch whiskies might also contain unusual ingredients in the liquor.

According to case reports provided by Taiwanese authorities [5], illegal whisky is often sold in nightclubs, bars, KTVs, and other places where it is difficult for consumers to distinguish the authenticity of Scotch whisky. Criminals sometimes salvage empty bottles of high-priced Scotch whisky from these locations, refill them with adulterated Scotch whisky, and resell them. Therefore, consumers and related departments urgently need to develop a more valuable and efficient discrimination method for authentication purposes.

The Role of Edible Rectified Spirit to Fake Scotch Whisky

Edible rectified spirit, known as neutral alcohol, is made from various materials, including grain, molasses, potatoes, and other agricultural products [6]. The manufacturing process involves rectification of the spirit several times to remove impurities and increase the alcohol content to over 95% ABV. The resulting product is, therefore, a clear, colorless liquor. Most importantly, there are quite low amounts of methanol (MeOH) and other components in edible rectified spirit aside from water and ethanol. In fact, edible rectified spirits are pure spirits that are considered safe to drink and used as ingredients in various food and beverage products. For example, these spirits are often used as flavoring agents or solvents for food-grade flavorings and extracts. They are also used to produce many spirits, such as gins, liqueurs, and bitters. However, according to court judgments and seized cases in recent years, the primary counterfeiting method of adulterated and counterfeit scotch whisky found in Taiwan mainly uses edible rectified spirit for dilution or modulation.

In Taiwan, the production of legal spirits must comply with the provisions of the "Tobacco and Alcohol Administration Law" [7]. In addition, according to the "Enforcement Rules of the Tobacco and Alcohol Administration Act" [8], products using edible rectified spirit should be listed on the permit list, so it is illegal to use edible rectified spirit to dilute or blend whisky in Taiwan.

Authentication of Scotch Whiskies

In earlier studies, qualitative analysis by gas chromatography-flame ionization detector (GC-FID), gas chromatography-mass spectrometry (GC-MS), and liquid chromatography-mass spectrometry (LC-MS) was usually used to identify the authenticity of Scotch whisky [9–14]. In addition, many studies also used spectroscopy analysis combined with statistical evaluation, such as principal component analysis (PCA) or partial least squares (PLS) regression, to establish fast and reliable identification of authentic Scotch whisky. These spectroscopy analyses include Fourier-transform infrared spectroscopy (FTIR), near-infrared spectroscopy (NIR), mid-infrared spectroscopy (MIR), ultraviolet-visible (UV-vis) analysis, and Raman spectroscopy [15–18]. These analytical methods mainly aim to distinguish the individual differences in whisky samples based on the brand, age, or spectral characteristics of Scotch whisky. In addition to qualitative research, some used mass spectrometry to analyze whisky components to determine the authenticity quantitatively. However, these literature studies rarely discuss establishing quantitative criteria of Scotch whisky authenticity.

Exclusionary Criteria for the Authentication of Scotch Whiskies Seized in Taiwan

Based on the above description of modus operandi, most of the fake Scotch whiskies seized in Taiwan are diluted or formulated with edible rectified spirits. Therefore, when this modus operandi is used, edible rectified spirits will affect some liquor components in whiskies. In this report, we shall focus on exploring the discrimination values for changes in the characteristics of MeOH concentration, characteristic fermentation components, and δ^{13}C-ethanol.

The concept of exclusionary criteria for authentication of Scotch whiskies is shown in **Figure 1**. According to the sample requirements for statistical analysis, a sufficient amount of authentic Scotch whisky was collected for quantitative analysis. Then, the statistical model fitting method was used to evaluate the observation data. The exclusive quantitative criteria from confidence interval (CI) value were consequently established based on the model fitting results of authentic Scotch whisky. Due to the characteristics of edible rectified spirit, establishing these exclusive quantitative criteria will help discriminate against fake Scotch whisky.

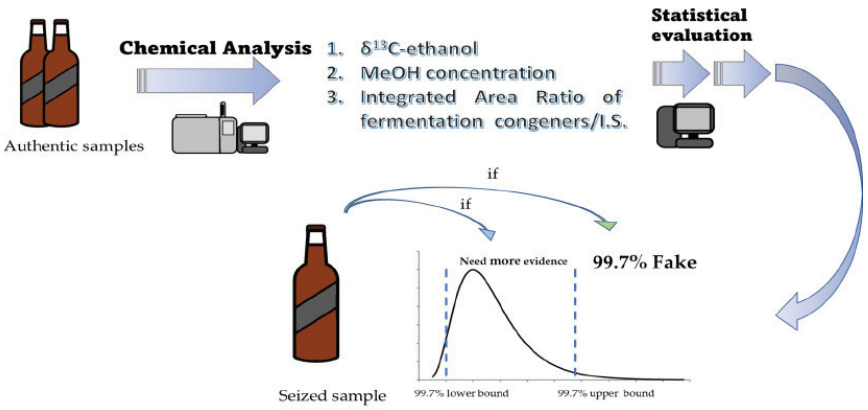

Figure 1. The concept of exclusionary criteria for authentication of Scotch whiskies.

Quantitative Criteria Deriving from Characteristic Components

Methanol (MeOH) Concentration. MeOH is a protic solvent used in various applications such as cleaning, fuel sources, and synthetic fiber industries. According to the metabolic reaction of the human body, MeOH can be metabolized to produce toxic chemicals, such as formaldehyde, formic acid, and formate by alcohol dehydrogenase (ADH) and acetaldehyde dehydrogenase (ALDH) [19,20]. Therefore, many countries and regions have strict regulations on the upper limit of the concentration of MeOH in wine and spirits.

It's worth noting that, during natural fermentation, a small amount of MeOH can be produced through the pectin hydrolysis reaction by pectin methylesterase [21]. Pectin is a natural component of raw materials of spirits, such as grapes [22] and barley [23,24]. For Scotch whisky, the primary raw material is barley, which also contains pectin between the endosperm walls of the barley. The small amount of MeOH produced by pectin methylesterase during fermentation cannot be entirely removed by distillation during Scotch whisky production. Therefore, trace amounts of MeOH in Scotch whisky can be determined by an appropriate analysis.

A series of evaluation processes were employed to establish quantitative discrimination criteria of MeOH concentration for the authentication of Scotch whisky, including a quantitative analysis with GC-MS and data distribution fitting procedures with the obtained data. As a result, it was found that the 99.7% CI of the MeOH concentration of the single malt Scotch whisky was between 13.4 and 44.2 ppm, and the 99.7% CI of the blended Scotch whisky was between 7.87 and 74.9 ppm [25]. In this way, seven bottles of fake Scotch whisky seized in Taiwan were also parallelly analyzed to verify the exclusion discrimination for Scotch whisky. These seized whiskies included three sorts of fake whiskies, S1, adulterated single malt Scotch whisky; S2–S4, adulterated blended Scotch whiskies; and S5–S7, counterfeit Scotch whiskies. As shown in **Figure 2a**, the observed MeOH concentration for S1 was below the lower limit of the 99.7% confidence interval of authentic single malt Scotch whisky; in addition, the observed MeOH concentrations for S2 and S4–S7 were below the lower limit of the 99.7%

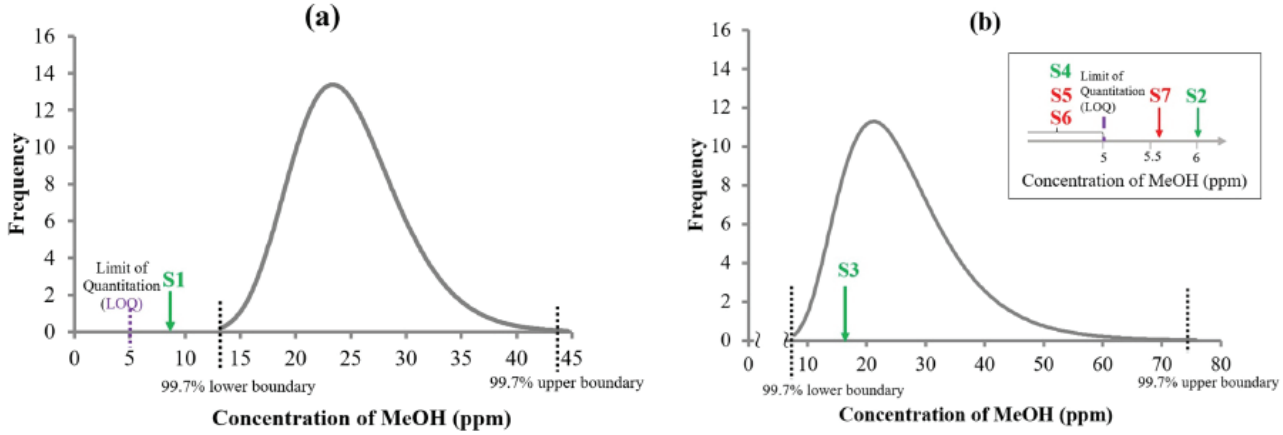

Figure 2. Mapping results of fake whiskies in the confidence interval boundaries of MeOH concentration of (a) authentic single malt Scotch whiskies; (b) authentic blended Scotch whiskies [25].

confidence interval of authentic blended Scotch whisky, as shown in **Figure 2b**. In seized whisky samples S4, S5, and S6, the MeOH concentration of these three samples were all below the limit of quantitation (LOQ). Therefore, the results confirmed that these samples were highly likely to be fake Scotch whiskies. On the other hand, only one of the adulterated blended Scotch whiskies, S3, could not be exclusionary discriminated by this method because its MeOH concentration fell within the 99.7% confidence interval for authentic blended Scotch whisky. In this situation, more supplementary data should be considered to confirm its authenticity.

Integrated Area Ratio of Fermentation Congeners/ Internal Standard (IS). According to regulations, there are six processes in the manufacturing process of Scotch whisky, namely malting, drying, maceration, fermentation, distillation, and aging [26]. As a result of fermenting whisky wort on the lees, it produces ethanol (EtOH) as the main product, a variety of essential congeners such as aldehydes, higher alcohols, organic acids, and then esters as flavor compounds. Furthermore, the enzymes in the wort can continue to react with the carbohydrate molecules/oligosaccharides, thereby increasing the yield of congeners. In contrast, the adulterated or counterfeit Scotch whisky is prepared and diluted with edible rectified spirit, so the content of congener components in the liquor may obviously differ from the authentic Scotch whisky produced through the correct and complete Scotch whisky manufacturing process. Therefore, studying the integrated area ratio of fermentation congeners/IS in authentic Scotch whisky by GC-MS combined with the principal components analysis (PCA) protocol can establish exclusionary quantitative criteria for discriminating Scotch whisky.

To evaluate the discriminating power of PCA with the integrated area ratio of fermentation congeners/IS for authentication, CIs are estimated from a large number of experimental data according to empirical rules of statistics. Based on the classification results on the PC axis in **Figure 3a**, the adulterated sample S1 is outside the 99.7% CI range for both PC1 and PC2, implying good discriminative power. Comparatively, the samples appear to be more spread out on the PC2 axis of the PCA chart for the blended Scotch whisky than for the single malt Scotch whisky. As shown in **Figure 3b**, two adulterated blended Scotch whiskies, S2 and S3, were within the sample distribution of the authentic group in PC1 but showed better discrimination between authentic and adulterated Scotch whisky in PC2. On the other hand, the two counterfeit Scotch whiskies (S5 and S6) also showed better discrimination results in PC2. However, sample S7, counterfeit Scotch whisky, cannot show exclusionary discrimination in this mapping result, as shown in **Figure 3b**, which means more discriminative methods are needed for authentication.

***δ*^{13}C-Ethanol.** According to the relationship between the photosynthesis process of plants and the ratio of stable isotopes, δ^{13}C-ethanol, i.e., $^{13}C/^{12}C$, can be theoretically used to distinguish whether the raw materials for liquor are from C3 plants or C4 plants [28–30]. But practically, the δ^{13}C values of C3 and C4 plants mentioned in the past literature include a large number of different plant species, so the data range is too wide to use for the discrimination purpose of Scotch whisky, whose raw material, barley, belongs to C3 plants. As mentioned in the previous section about modus operandi, some seized Scotch whiskies are adulterated by adding edible rectified spirits to authentic Scotch whisky. In that case, the practical forensic application of δ^{13}C-ethanol may be limited due to the vague range of raw materials.

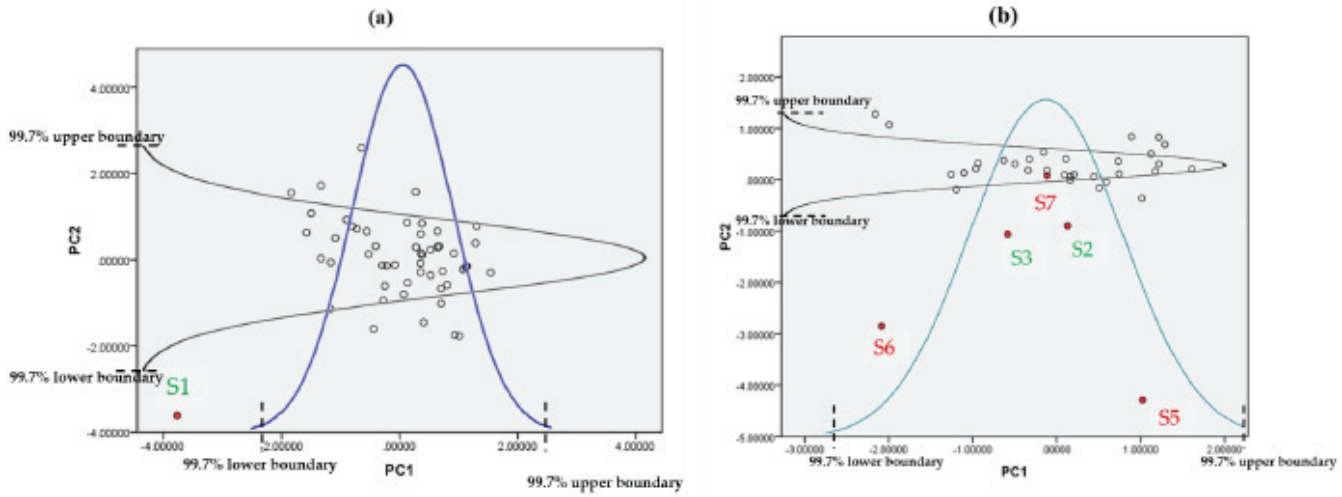

Figure 3. Mapping results of fake whiskies in the PCA charts with (a) authentic single malt Scotch whiskies; (b) authentic blended Scotch whiskies [27].

In our previous study [31], the $\delta^{13}C$ distribution range of ethanol in Scotch whisky was more clearly defined based on a large number of authentic samples, including single malt Scotch whisky and blended Scotch whisky. As a result, the CI of $\delta^{13}C$-ethanol was established as the exclusionary criteria, as shown in **Figure 4a** for authentic single malt Scotch whisky and **Figure 4b** for authentic blended Scotch whisky, respectively. The results showed that the 99.7% CI for $\delta^{13}C$-ethanol ranged from –23.21‰ to –30.07‰ for single malt Scotch whisky and –11.19‰ to –28.93‰ for blended Scotch whisky. Moreover, as shown in **Figure 4a**, based on the known modus operandi of adulterated Scotch whisky, the simulation experiment of adding edible rectified spirits to authentic Scotch whisky expresses the exclusionary result for 30% dilution ratio by C4-edible rectified spirits, which implies some of the clues in the seized Scotch whisky case. Further, it validates that the establishment of $\delta^{13}C$-ethanol CI is valuable for evaluating authentication of suspected Scotch whisky.

As for the case of counterfeit whisky, the $\delta^{13}C$-ethanol of S6 was above the upper limit of the 95.5% confidence interval, while that of S7 was below the lower limit of the 95.5% confidence interval, as shown in **Figure 5**. It is proved that these two samples were considered counterfeit Scotch whiskies under this discrimination criterion with a confidence of 95.5%. In contrast, the discrimination result of S5 suggests that it cannot be ruled out by the exclusionary method established by the $\delta^{13}C$-ethanol value. The authenticity of the S5 sample has been exclusively verified by the MeOH concentration and the PCA method combined

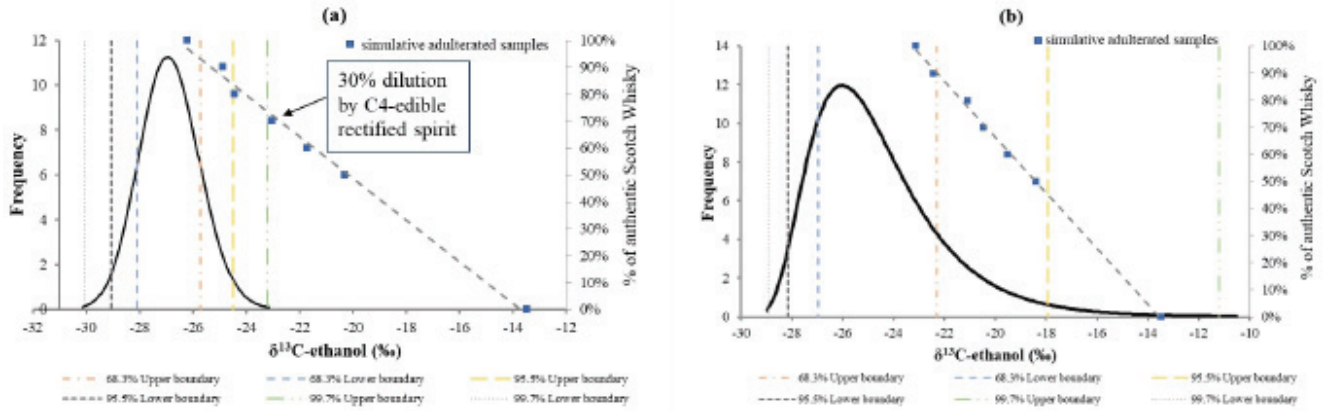

Figure 4. The relation between $\delta^{13}C$-ethanol and the dilution percentage of (a) authentic single malt Scotch whisky; (b) authentic blended Scotch whisky [31].

with the integrated area ratio of fermentation congeners/IS in the previous sections. This example indicates that it is necessary to adopt exclusive quantitative criteria deriving from various characteristic components synthetically.

Concluding Remarks

As for the existing authentication of Scotch whisky, establishing quantitative exclusionary criteria will provide a definite discrimination for practically seized cases. This non-technical report describes the effective discriminating power of quantitative rapid screening methods to exclude fake Scotch whisky, including adulterated and counterfeit samples, from multiple analytical targets, such as MeOH concentration, the integrated area ratio of fermentation congeners/IS, and $\delta^{13}C$-ethanol. When evaluating authentication of samples by complementing using quantitative criteria, it can effectively rule out fake Scotch whiskies.

Furthermore, all exclusionary criteria discussed in this report focus on authenticating suspected Scotch whiskies which are classified by the modus operandi of adding edible rectified spirits. For those illicit Scotch whiskies that have not been diluted or modulated with edible rectified spirits, other discriminating methods, such as pH value measurements or qualitative analysis by GC-MS, LC-MS, or spectroscopy, should be considered.

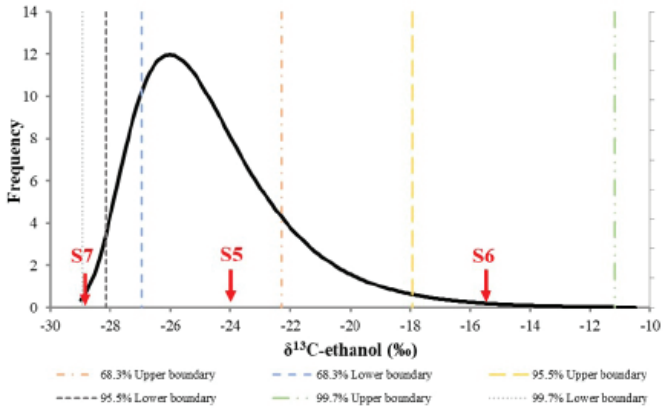

Figure 5. Mapping results of counterfeit Scotch whiskies in the confidence interval boundaries of $\delta^{13}C$-ethanol of authentic blended Scotch whiskies.

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Upcoming Events

The 2nd European Congress on Legal & Regulations in *Cannabis*
(*https://lr-cannabis.com/*)
July 6–7, 2023; Sheraton Brussels Airport Hotel
Brussels, Belgium

2023 AACC Annual Scientific Meeting + Clinical Lab Expo
(*https://meeting.aacc.org/about*)
July 23–27, 2023; Anaheim Convention Center
Anaheim, CA, US

American Society of Questioned Document Examiners 81st Annual Conference
(*https://asqde.org/2023.html*)
Aug. 7–9, 2023; John Jay College of Criminal Justice
New York City, NY, US

IACP Impaired Driving & Traffic Safety Conference
(*https://www.theiacp.org/IDTSconference*)
Aug. 9–11, 2023; Anaheim Convention Center
Anaheim, CA, US

International Association for Identification — 107th Educational Conference
(*https://theiai.org/conference.php*)
Aug. 20–26, 2023; Gaylord National Resort and Convention Center
National Harbor, MD, US

Midwestern Association of Forensic Scientists — 2023 Annual Meeting
(*https://mafs.net/page-18457*)
Aug. 26–Sept. 1, 2023; Fort Pontchartrain Detroit
Detroit, MI, US

TIAFT 60th Annual Meeting of the International Association of Forensic Toxicologists
(*https://www.tiaft2023.org/*)
Aug. 27–31, 2023; Auditorium Conciliazione
Rome, Italy

57th Congress of the European Societies of Toxicology
(*https://www.eurotox2023.com/*)
Sept. 10–13, 2023; GR Congress Centre
Ljubljana, Slovenia

ISHI 34: International Symposium on Human Identification
(*https://www.ishinews.com//*)
Sept. 18–21, 2023; Hyatt Regency & Colorado Convention Center
Denver, CO, US

22nd European Document Experts Working Group Business Meeting
(*https://enfsi.eu/agenda-list/*)
Sept. 19–20, 2023; University of Applied Sciences
Stuttgart, Germany

21st International Congress of Therapeutical Drug Monitoring and Clinical Toxicology
(*https://www.iatdmct2023.org*)
Sept. 24–27, 2023; Oslo Congress Centre
Oslo, Norway

2023 International Conference on Forensic Nursing Science and Practice
(*https://www.forensicnurses.org/page/2022AnnualConference*)
Sept. 27–30, 2023; Sheraton Phoenix Downtown
Phoenix, AZ, US

Northwest Association of Forensic Scientists — 2023 Annual Conference
(*http://nwafs.org/wordpress/fall-meeting/*)
Sept. 25–27, 2023; Embassy Suites by Hilton Salt Lake West Valley City
Salt Lake City, UT, US

Southwestern Association of Forensic Scientists — 45th Annual Conference (*http://swafs.us/*)
Oct. 1–4, 2023; Houston CityPlace Marriott at Springwoods Village
Spring, TX, US

ENFSI DNA Expert Working Group, EDNAP and European CODIS Users Working Group Meeting
(*https://enfsi.eu/agenda-list/*)
Oct. 3–6, 2023; Oslo University Hospital
Oslo, Norway

29th ENFSI EWG Firearms/GSR Meeting
(*https://enfsi.eu/agenda-list/*)
Oct. 4–6, 2023; Pacheco Center
Brussels, Belgium

Northeastern Association of Forensic Scientists — Annual Conference
(*https://www.neafs.org/additional-annual-meetings*)
Oct. 6–10, 2023; Mystic Marriott
Groton, CT, US

AACC Middle East 2023
(*https://www.aaccme.com/aaccmiddleeast23/Public/Enter.aspx*)
Oct. 6–7, 2023; GrandHyatt Dubai
Dubai, UAE

SCIX 2023 — Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies
(*https://www.showsbee.com/fairs/19465-FACSS-SciX-2023.html*)
Oct. 8–13, 2023; Nugget Casino Resort
Reno, NV, US

International Association of Bloodstain Pattern Analysts — 2023 Annual Conference
(*https://www.iabpa.org/2023_annual_conference.php*)
Oct. 9–13, 2023; Sheraton Inner Harbor Hotel
Baltimore, MD, US

13th European Workplace Drug Testing Society Symposium
(*http://www.ewdts.org/join-us-in-istanbul-2023.html*)
Oct. 12–13, 2023; Radisson Bleu Hotel
Istanbul Sisli, Turkey

National Association of Medical Examiners
(*https://name.memberclicks.net/annual-meetings*)
Oct. 13–17, 2023; Signia by Hilton
San Jose, CA, US

International Association of Chiefs of Police 2023
(*https://www.theiacpconference.org/*)
Oct. 14–17, 2023; San Diego Convention Center
San Diego, TX, US

Robert F. Borkenstein Course on "The Effect of Drugs on Human Performance and Behavior"
(*https://bcahs.indiana.edu/drugcourse/index.html*)
Oct. 16–20, 2023; Fluno Center, UW-Madison (Hybrid)
Madison, WI, US

Society of Forensic Toxicologists — Annual Meeting
(*https://soft-tox.org/meeting***)**
Oct. 29–Nov. 3, 2023; Gaylord Rockies
Denver, CO, US

X International Conference on Novel Psychoactive Substances
(*https://www.novelpsychoactivesubstances.org/venue/*)
Nov. 6–8, 2023; Fairmont Bab Al Bahr (Hybrid)
Abu Dhabi, UAE

Joint American-Israeli Medical Toxicology Conference
(*https://www.acmt.net/israel/#*)
Nov. 7–9, 2023; Carmel Medical Center
Haifa, Israel

IFDAT 2023 — International Forum for Drug & Alcohol Testing
(*https://ifdat.com/*)
Nov. 12–14, 2023; Tampa Convention Centre
Tampa, FL, US

23rd Triennial Meeting of the International Association of Forensic Sciences
(*https://iafs2023.com.au/*)
Nov. 20–24, 2023; International Convention Centre
Sydney, Australia

26th Symposium of the Australian and New Zealand Forensic Science Society
(*https://anzfss.org.au/*)
Nov. 20–24, 2023; International Convention Centre
Sydney, Australia

American Academy of Forensic Sciences — 76th Annual Meeting (*https://www.aafs.org/*)
Feb. 19–24, 2024; Colorado Convention Center
Denver, CO, US

PITTCON Conference and Expo
(*https://pittcon.org/exposition/*)
Feb. 24–28, 2024; San Diego Convention Center
San Diego, CA, US

2024 ACMT Annual Scientific Meeting
(*https://www.acmt.net/israel/#*)
April 12–14, 2024; Omni Shoreham Hotel
Washington, DC, US

California Association of Criminalists Seminar
(*https://www.cacnews.org/events/seminar/seminars.shtml*)
April 15–19, 2024; Los Angeles Police Department
Los Angeles, CA, US

International Association of Chemical Testing — 2024 Annual Conference
(*http://iactonline.org/*)
April 21–26, 2024
La Jolla, CA, US

Southern Association of Forensic Scientists — 2024 Annual Meeting
(*https://safs1966.org/annual-meeting/*)
April 23–26, 2024; The Chattanoogan Hotel, a Hilton Hotel
Chattanooga, TN, US

American Society of Forensic Laboratory Directors — 51st Annual Symposium
(*https://www.ascld.org/ascld-annual-symposium/*)
April 28–May 2, 2024; Sheraton Birmingham Hotel
Birmingham, AL, US

The Association of Firearm and Tool Mark Examiners — 55th Annual Training Seminar
(*https://afte.org/meetings/annual-seminars*)
May 26–31, 2024; Hilton Downtown Anchorage
Anchorage, AK, US

72nd ASMS Conference on Mass Spectrometry and Allied Topics
(*https://asms.org/conferences/annual-conference*)
June 2–6, 2024; Anaheim Convention Center
Anaheim, CA, US

Forensics Europe Expo
(*https://forensicseuropeexpo.com*)
June 19–20, 2024; ExCeL Exhibition Centre
London, UK

TIAFT 61st Annual Meeting of the International Association of Forensic Toxicologists
(*https://www.tiaft.org/tiaft-annual-meeting.html*)
Sept. 2–6, 2024
St. Gallen, Switzerland

Strengthening Medicolegel Death Investigation in the US: Where Are We Now?

Daniel S. Atherton

Division of Forensic Pathology
University of Alabama School of Medicine
Birmingham, Alabama
United States of America

+1 205-930-3603 datherton@uabmc.edu

Forensic science is a critical component of the justice system. Verdicts in criminal and civil trials often hinge upon the results of forensic investigations and expert witness testimony. While some form of forensic science traces back thousands of years, practical modern forensic science is largely an invention of the 19th and 20th centuries; the past two hundred years have yielded significant advances in forensic techniques involving fingerprint analysis, identification of toxicological substances, anthropometry, deoxyribonucleic acid (DNA) analysis, and other forensic disciplines. The results of forensic analyses are commonly used in courts of law. However, in recent decades, research has demonstrated that forensic techniques and expert witness testimony can be error-prone, and efforts have been made to identify weaknesses and opportunities for improvement in the forensic sciences.

In 2006, the United States (US) Congress authorized the National Academy of Sciences (NAS) to create an independent Forensic Science Committee to assess the state of forensic science in the US and make recommendations on ways to strengthen forensic science practices. The NAS recruited a large and diverse group of professionals including scientists, researchers, medical examiners, law enforcement officials, death investigators, and attorneys to identify areas for improvement and propose specific recommendations intended to address what they considered the most important issues; they were collectively called the Committee on Identifying the Needs of the Forensic Sciences Community (hereby abbreviated CINFSC). The committee's findings were published in 2009 in a report entitled *Strengthening Forensic Science in the United States: A Path Forward* [1]. Thirteen detailed recommendations were proposed; this review addresses a few recommendations specifically related to medicolegal death investigation. Recommendation 1 addressed the development of an independent federal entity that would champion best practices in the forensic sciences, and Recommendation 11 specifically addressed the medicolegal death investigation system in the US. **Table 1** paraphrases Recommendations 1 and 11. This review considers how forensic science related to these specific recommendations has evolved since the publication of the initial report in 2009.

Table 1. Paraphrases of Recommendations 1 and 11 from the 2009 NRC Report: *Strengthening Forensic Science in the United States: A Path Forward* [1]

1	Establish and Appropriate Funds for an Independent Federal Entity to Establish and Enforce Best Practices for Forensic Science
11a	Funding for States and Jurisdictions to Establish Medical Examiner Systems
11b	Funding for Research, Education, and Training in Forensic Pathology
11c	Collaborative Establishment of an FPath and Death Investigation Scientific Working Group to Promote Best Practices
11d	All ME Offices Should Be Accredited Pursuant to Endorsed Standards
11e	All Federal Funding Should Be Restricted to Accredited Offices or Offices Nearing Accreditation (not discussed in this review)
11f	All Medicolegal Autopsies Should Be Performed by a Board-Certified Forensic Pathologist (not discussed in this review)

Recommendation: Establish and Appropriate Funds for an Independent Federal Entity to Establish and Enforce Best Practices for Forensic Science

In February 2013, the National Institute of Standards and Technology (NIST) and the US Department of Justice (DOJ) established a National Commission on Forensic Science (NCFS) with related task forces termed the Organization of Scientific Area Committees (OSAC) [2]. The NCFS was a two-year renewable committee that initially met in 2014. It was initially co-chaired by Deputy Attorney General James M. Cole and NIST Acting Director and Acting Under Secretary of Commerce for Standards and Technology Willie May. Selected members included scientists, academicians, attorneys, law enforcement, and other relevant professionals. Several meetings took place in 2014. Initial meetings focused on providing background and context to the committee from various field experts. Briefings included reports from experts on laboratory accreditation, proficiency testing, and human/cognitive bias factors, among other issues.

At these initial meetings, with guidance from forensic professional organizations including the American Academy of Forensic Sciences (AAFS), the National

Association of Medical Examiners (NAME), the Society of Forensic Toxicologists (SOFT), and the Association of Firearm and Tool Mark Examiners (AFTE) among others, the OSAC structure was developed. Members of several professional societies were invited to apply for positions within OSAC, and in October 2014, members were appointed to 23 OSAC subcommittees. In 2017, the NCFS's charter expired; however, the OSAC persisted under a Forensic Science Standards Board (FSSB) and seven Scientific Area Committees (SACs), and is comprised of 22 subcommittees as of 2023. **Table 2** lists the 22 OSAC subcommittees.

Among OSAC's accomplishments has been the development of over 100 forensic science standards. These standards vary from recommendations, classifications, and guides to assist forensic scientists in forensic practices. In 2022, the OSAC reported that over 100 standards had been developed, and over 90 had been implemented somewhere [3]. The OSAC has also moved from simply developing standards to offering insight on implementation and also analyzing how standards are being used in legal settings.

Table 2. Forensic Discipline Committees and Subcommittees of OSAC (The Organization of Scientific Area Committees for Forensic Science) (*https://www.nist.gov/organization-scientific-area-committees-forensic-science/osac-organizational-structure*)

OSAC Committee	OSAC Subcommittee
Biology	Human Forensic Biology Wildlife Forensic Biology
Chemistry: Seized Drug & Toxicology	Seized Drugs Forensic Toxicology
Chemistry: Trace Evidence	Trace Materials Ignitable Liquids, Explosives, & Gunshot Residue
Physics/Pattern Interpretation	Bloodstain Pattern Analysis Forensic Document Examination Firearms and Toolmarks Friction Ridge Footwear & Tire
Scene Examination	Dogs & Sensors Fire & Explosion Investigation Crime Scene Investigation & Reconstruction
Medicine	Forensic Odontology Forensic Nursing Medical Death Investigation Forensic Anthropology
Digital/Multimedia	Video/Imaging Technology & Analysis Speaker Recognition Facial Identification Digital Evidence

Recommendation: Funding for States and Jurisdictions to Establish Medical Examiner Systems

The vast majority of medicolegal death investigation systems in the US are comprised of Medical Examiner (ME) and coroner systems, or various combinations of the two; these systems operate at various state and local levels from state to state [4]. The ME death investigation system is the better death investigation system, but the coroner system is deeply intertwined in the US death investigation system. In short, coroners are generally elected officials that oversee or initiate the process of investigation into various forms of death, and these individuals work in conjunction but often peripheral to ME systems in various facets of death investigation. There is abundant literature on the history and distinction of coroner and ME death investigation systems, but that is outside the scope of this review [5].

Criticisms and shortcomings of coroner systems include underqualification of coroners, lack of specification and consistency regarding how deaths are investigated and reported, and even conflicts of interest that may affect a death investigation [6]. The CINFSC recommended supporting death investigation systems with the eventual goal of eliminating coroner systems altogether. They specifically indicated that funds were needed to build regional ME offices and support their infrastructure.

Historically, conversions from coroner to ME systems slowed beginning sometime in the 1990s, owing to several possible explanations [7]. No databases exist that track such specific data, and such conversions are best analyzed at the state level. In a comparison of death investigation systems reported in a 2007 publication by Randy Hanzlick, MD with 2023 information reported on the Centers for Disease Control Death Investigation Systems website, one of the few conversions appears to be a transition of North Dakota from a "coroner in each county" system to one in which there is also a state ME in place (**Table 3**) [4,7]. Overall, these data do not suggest a significant conversion from coroner to ME systems in the past several years/decades and, moreover, may reflect differences in categorical nomenclature and not necessarily robust structural changes.

Recommendation: Funding for Research, Education, and Training in Forensic Pathology

It is estimated that there are approximately 500 practicing forensic pathologists (FPs) in the United States; roughly twice that many are needed to adequately handle the burden of death investigation in the United States [8]. In 2012, the National Research Council's Scientific Working Group for Medicolegal Death Investigation (SWGMDI) published a report outlining several factors affecting recruitment and retainment of physicians in forensic pathology (FPath), including medical students' lack of exposure to FPath, low

Table 3. Differences in ME/coroner classifications of various states between 2007 and 2023

States	2007 (per Hanzlick publication [7])	2023 (per CDC website [4])
IA, TN, NJ	State ME with various types of non-coroner, regional or local assistance	County/district-based ME offices
MS, AL, GA	MS: State ME; coroner in each county AL, GA: State ME assisting coroner of most counties; autonomous county ME in some counties	County-based mixture of ME and coroner offices
AR, KY, MT	State ME, coroner in each county	County/district-based coroner offices

salaries relative to other medical specialties, and burnout [9].

A review of forensic pathology program directors from 2011 documented 37 ACGME-accredited FPath fellowship training programs in the United States with approximately 80 FPath positions available each year; Dr. Hanzlick reported that about 30-40 FPath fellows were being trained each year [10]. In 2017, the NIJ initiated a Strengthening the Medical Examiner-Coroner System Program with two overarching goals, 1) to increase the supply of forensic pathology practitioners and 2) to strengthen the quality and consistency of ME/coroner services [11]. From 2017 to 2022, the program made 84 awards totaling $12.4 million. Much of the funding involved establishment of training programs and assistance in achieving accreditation by various recognized accrediting bodies, but funding specifically to support FPath training programs has also been generously awarded. Data specifically related to federal funding being restricted to accredited offices is unknown.

As recently as 2022, funding was given to FPath training programs in Western Michigan, Connecticut, West Tennessee, King County (Seattle), Milwaukee County, Los Angeles, and Broward County [12]. Information obtained from the Accreditation Council for Graduate Medical Education (ACGME) for 2022–2023 indicates that there are currently 48 accredited FPath training programs and 60 current FPath trainees [13]. This represents a 30% increase in accredited FPath training programs and about a 70% increase in FPath trainees from 2011 to 2022.

Recommendation: Collaborative Establishment of an FPath and Death Investigation Scientific Working Group to Promote Best Practices

The Forensic Science Research and Development Technology Working Group (TWG) is a committee of forensic professionals that was formed under the NIJ as early as 2013 [14]. The TWG isn't so much concerned with implementation of solutions, but rather identifying key areas for improvement in various forensic disciplines to help inform the NIJ of priorities for strengthening forensic science.

The TWG satisfies the first phase of the NIJ's established research and development process, "identifying needs through stakeholder engagement" [15]. In 2021, the committee was comprised of 50 forensic science professionals. The TWG specifically focuses on forensic disciples including forensic biology/DNA science, evidentiary science, toxicology, forensic anthropology and pathology, and seized drugs. They produced their findings in an extensive list of operational requirements with suggestions on what specifically is needed to strengthen that scientific area. Activities cited to strengthen various areas include scientific research, training, technology development, database collections, and/or policy and protocol development.

Extensive lists of NIJ-funded awards to help promote these initiatives are also available online. In the area of forensic biology/DNA, for example, under the subtopic "DNA (deoxyribonucleic acid)", there were 596 awards totaling over $331 million from 2013 to 2022 [16]. A search of awards in the subtopic "forensic pathology" yielded a total of 260 awards totaling over $71 million [17].

Recommendation: All ME Offices Should Be Accredited Pursuant to Endorsed Standards

The National Association of Medical Examiners (NAME) is the most recognized accrediting body for ME offices in the United States. Offices that achieve NAME accreditation carry an endorsement from the largest organization of forensic pathologists in the United States that their offices meet minimum performance standards as outlined by the NAME Accreditation Program. NAME accreditation is a peer-reviewed process whereby NAME-endorsed inspectors evaluate a multitude of criteria, including quality of death investigation, morgue operations, toxicology procedures, and record keeping. If offices are found to carry too many deficiencies, they can lose full accreditation; provisional accreditation can also be conferred under certain circumstances. Offices can also receive international accreditation through the ANSI-ASQ National Accreditation Board (ANAB); this

is called ISO (International Organization for Standardization) accreditation. A search for NAME-accredited ME and coroner offices in the United States in 2023 yielded 107 accredited offices [18]. In 2009, there were 15 NAME-accredited offices (D. Dye, personal communication, Feb. 24, 2023). Thus, the number of NAME-accredited offices has increased approximately sevenfold from 2009 to 2023.

In summary, efforts have been made in the past few decades to address some shortcomings in the forensic sciences. Some of the challenges stem from new research that has undermined areas of forensic science that were once thought to be ironclad, and other challenges stem from a system that is still affected by its roots in antiquated death investigation systems. Some progress has been made since the organized effort to characterize areas for improvement in 2009, but there is much more work to be done.

References

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NEW BOOKS AND BOOK REVIEW

New Forensic Science Books

Advanced Crime Scene Photography, 3rd ed
C. D. Duncan
CRC Press: Boca Raton, FL, US; March 2023

Anthropology of Violent Death: Theoretical Foundations for Forensic Humanitarian Action
R. C. Parra, D. H. Ubelaker, Eds
Wiley-Blackwell: Somerset, NJ, US; Feb. 2023

Artificial Intelligence and Blockchain in Digital Forensics
P. Karthikeyan, H. M. Pande, V. Sarveshwaran, Eds
River Publishers: Gistrup, Denmark; Feb. 2023

Battlefield Forensics — Using Criminalistics to Support Combat Operations
R. G. Meyer
CRC Press: Boca Raton, FL, US; Forthcoming

Cannabis and Khat in Drug Discovery — The Discovery Pipeline and the Endocannabinoid System
A. G. Mtewa, T. Mekuriya, P. E. Alete, J. O. Igoli, F. Lampiao, Eds
Elsevier Science: San Diego, CA; Forthcoming

Death Investigation — A Field Guide, 2nd ed
S. A. Wagner
CRC Press: Boca Raton, FL, US; March 2023

Designer Drugs — Chemistry, Analysis, Regulation, Toxicology, Epidemiology, Legislation of New Phycoactive Substances
R. Gerona
Elsevier: San Diego, CA; Forthcoming

Field Guide to Clandestime Laboratory Identification and Investigation, 2nd ed
D. R. Christian, Jr
CRC Press: Boca Raton, FL, US; June 2023

Forensic and Legal Medicine — Clinical and Pathological Aspects
J. Payne-James, R. Byard, Eds
CRC Press: Boca Raton, FL, US; Forthcoming

Forensic Art Therapy — The Art of Investigating, Interviewing, and Testifying
M. S. Cohen-Liebman
CRC Press: Boca Raton, FL, US; March 2023

Forensic DNA Analyses Made Simple: A Guide to the Curious
O. Bagasra, M. Saffar, E. McLean
CRC Press: Boca Raton, FL, US; July 2023

Forensic DNA Applications — An Interdisciplinary Perspective, 2nd ed
D. Primorac, M. Schanfield, Eds
CRC Press: Boca Raton, FL, US; April 2023

Forensic DNA Transfer
J. M. Taupin
CRC Press: Boca Raton, FL, US; Forthcoming

Forensic Victimology — Examining Violent Crime Victims in Investigative and Legal Contexts, 3rd ed
B. Turvey
Academic Press/Elsevier: Waltham, MA, US; July 2023

Introduction to Forensic Anthropology, 6th ed
S. N. Byers, C. A. Juarez
CRC Press: Boca Raton, FL, US; July 2023

Introduction to Toxicology, 4th ed
J. Timbrell, F. A. Barile
CRC Press: Boca Raton, FL, US; Feb. 2023

Law and Evidence — A Primer for Criminal Justice, Criminology, and Legal Studies, 3rd ed
C. P. Nemeth
CRC Press: Boca Raton, FL, US; March 2023

Trends in Counterfeit Drugs
K. M. Elkins, Ed
CRC Press: Boca Raton, FL, US; July 2023

Wildfire Arson Prevention Guide
R. J. Woods
CRC Press: Boca Raton, FL, US; March 2023

Wrongful Convictions and Forensic Science Errors — Case Studies and Root Causes
J. Morgan
CRC Press: Boca Raton, FL, US; March 2023

Modern Forensic Tools and Devices: Trends in Crime Investigation
D. Rawtani, C. M. Hussain, Eds
Wiley-Blackwell: Somerset, NJ, US; July 2023

Solving Problems with Microscopy: Real-Life Examples in Forensic, Life and Chemical Sciences
B. W. Kammrath, J. J. Reffner
Wiley-Blackwell: Somerset, NJ, US; Forthcoming

Book Review

Wastewater Analysis for Substance Abuse Monitoring and Policy Development

Jeremy Prichard, Wayne Hall, Paul Kirbride, Jake O'Brien

CRC Press: Boca Raton, FL, US; 2021

Reviewed by

Chia-Yang Chen
Institute of Environmental and Occupational Health Sciences
College of Public Health
National Taiwan University
Taipei City
Taiwan

+886 2 3366 8101; dbms@ntu.edu.tw

Abused substances have been a long-term issue in public health and social welfare. Knowing the trends, amounts, and locations related to substance abuse is crucial to be able to propose an effective strategy to reduce the use or harm of abused substances. In addition to traditional sources such as surveys, seized drugs, and analysis of biospecimens, wastewater epidemiology is emerging and complementary to other approaches for obtaining critical data on abused substances. Analysis of influents from municipal wastewater treatment plants (WWTPs) has been used to answer questions on environmental pollutants and illicit drugs. It has also been used to monitor and predict new strains of COVID-19 viruses during the pandemic period.

This 164-page book was written by a multi-disciplinary team including those in criminal law, environmental health, and forensic science, and proposes ways to reduce the health and social burdens of abused substances using the tool of wastewater analysis. The detailed descriptions are well organized in six chapters and can be easily read by people without backgrounds in biomedical sciences.

The first chapter comprehensively illustrates the hazard mechanisms of abused substances based on human physiology and metabolism, the resulting social and medical problems, and health burdens. Many local and global references are cited for elucidation.

The second chapter explains what wastewater analysis can do to answer questions related to investigations into abused substances and how to convert the measured concentrations of parent compounds or metabolites in the influent into used doses of abused substances per thousand persons. This content is designed for readers with backgrounds in social sciences. The authors introduce this approach and explain the information needed to achieve a good design. The significance of water sampling, which is often not emphasized enough, is stressed. Moreover, water authorities are critical stakeholders in adopting wastewater analysis. This chapter also discusses the data variations of several potential factors, such as wastewater flowing of WWTPs, the dynamic of residents in a catchment, and the stability of targeted chemical markers (biomarkers); therefore, the authors suggest inter-laboratory validations to ensure data reliability.

In chapter 3, international study data are used to compare the traditional approaches for investigating abused substances with those applying wastewater analysis. By doing wastewater analysis regularly or during a specific event, this tool can provide the approximate amount of abused substances, their use trends, and variations of use. Wastewater analysis is also suitable for monitoring population trends. This chapter is a good and quick reference to learn more about the global abuse of substances.

By emphasizing rural areas, chapter 4 explores the feasibility of wastewater analysis within a country. The infrastructure of sewage treatment is essential to utilizing this approach. The chapter explains the varying patterns and health problems related to abused substances in urban and rural areas. It shares a few countries' experiences with rural wastewater monitoring to obtain the data gap and find the hot spots.

Chapter 5 discusses the potential of using wastewater analysis in unique locations, such as prisons, educational institutes, and workspaces. The chapter discusses the features of abused substances in prisons and the benefits of using wastewater analysis compared to mandatory drug testing. The major limitation is how to sample representative wastewater from building complexes.

Chapter 6 provides perspectives on using wastewater analysis to obtain more information about substance abuse, and how the global expansion in the infrastructure of wastewater treatments makes it easier to use this technology. It would be helpful if the authors could include the development of suspect screening or non-target analysis of new psychoactive substances with high-resolution mass spectrometry in the next edition of this book.

This is a useful book to become familiar with the technology of wastewater analysis for monitoring abused substances, which is complementary to conventional surveys. The content includes plenty of international and updated information on the use of traditional illicit drugs (e.g., heroin, cocaine, amphetamine-type substances, and *cannabis*). Many related information sources are provided, and there are suggestions for study designs to evaluate the effectiveness of a strategy to reduce the use of abused substances. To accommodate readers with social science backgrounds, this book includes certain background information most analytical chemists (or biomedical scientists) may not require.

COMMENTARY

Cannabis Is More Like Alcohol Than a Schedule I Drug

James G. Wigmore
Alcohol, Cannabis, and Nicotine
Toronto, Ontario
Canada
https://www.wigmoreonalcohol.com/

James Wigmore worked at the largest forensic laboratory in Canada, the Centre of Forensic Sciences in Toronto, for 29 years between 1976 and 2005. He was fortunate to have Doug Lucas as his director and mentor for many of those years. While working as a medical technologist in the toxicology section, repairing all the Breathalyzers used by the police in Ontario, he was able to obtain his four-year Hons. BSc. part time from the nearby University of Toronto in 1986. This was before the many excellent forensic toxicology programs currently available and training was conducted mainly in-house.

James Wigmore was a faculty member of the Center for Studies of Law in Action ("the Borkenstein course") at Indiana University between 2004 and 2012 and was privileged and honored to have such international alcohol colleagues as Kurt Dubowski, Wayne Jones, Rod Gullberg, Bob Zettl, Patrick Harding, and Barry Logan. This was the same course that Wigmore attended in 1986 which was taught by Bob Borkenstein himself.

He has published an outstanding forensic toxicology series of books on alcohol, cannabis, and nicotine. Kurt Dubowski reviewed his book Wigmore on Alcohol and predicted that "It will certainly be the new Alcohol Bible for decades to come and be of great value to active practitioners and researchers."

James Wigmore has testified in over 700 criminal cases across Canada and in personal injury, wrongful death, and coroner cases, mainly on alcohol but also cannabis and other drugs, for over 35 years. He has published over 70 scientific articles on forensic toxicology, which have been cited by the Supreme Court of Canada and the High Court of South Africa. He received the prestigious Wilfrid Derome Award/Prix du Merite from the Canadian Society of Forensic Science in recognition of his outstanding contributions to the field of forensic science in 2005.

"Marijuana is like Coors beer. If you could buy the damn stuff at a Georgia filling station, you'd decide you wouldn't want it."
Billy Carter (brother of President Jimmy Carter) [1]

"THC is just a 21-carbon alcohol."
James Wigmore: *Wigmore on Cannabis*, 2018 [2]

Although *cannabis* has been legalized in Canada and many US states, it is still classified as a Schedule I drug under the US Controlled Substances Act [3] and joins other drugs on the list such as heroin, LSD, peyote, ecstasy, and methaqualone. But this classification has been questioned scientifically over and over again for many years. As far back as 1967, Dr. James L. Goddard, then head of the FDA, testified when comparing alcohol and *cannabis* that:

"*A well known physician named Jim.*
Has really gone out on a limb.
Believe it or not.
He's decided that pot.
Is better than drinking straight gin."
(Martin and Rashidan, 2014) [4]

In fact, as you will see in this commentary, *cannabis* has more in common with alcohol than a narcotic and the major psychoactive component of *cannabis*, delta-9-tetrahydrocannabinol (THC), shares many characteristics with the main psychoactive component of alcoholic beverages: ethanol.

THC vs. Ethanol

Similarities

- Both THC and ethanol are alcohols or hydrocarbons. Neither drug contains nitrogen in their structure, just carbon, oxygen, and hydrogen. Nitrogen is found in numerous other drugs, including nicotine, narcotics, LSD, and ecstasy, all of which are more addictive and toxic than either THC or ethanol. A wise colleague of mine at the Centre of Forensic Sciences (Toronto,

Canada) told this novice forensic toxicologist many years ago that "If it's got nitrogen, it's a drug."
- Both drugs have depressant action.
- The active ingredients of alcohol (ethanol) and *cannabis* (THC) do not have strong odors, it is mainly the congeners and terpenes respectively that provide the distinct smell of both drugs.
- Both drugs were initially of low potency and were used as food (weak beer from barley and grains, and hemp seeds respectively) and for fiber (rope, canvas, cloth from hemp). In fact, *cannabis* was so important a military crop for the sailing fleets that in many countries farmers were forced to grow low-potency *cannabis* or hemp. And yes, George Washington did grow *cannabis* (hemp) to support the US Navy, but you would not get high smoking it, just a bad headache. Hemp was soon replaced with the cheaper and easier to grow and manufacture cotton.
- Both drugs are less toxic and addictive than nicotine (cigarettes).
- Both drugs went through a period of prohibition, which was broken in part by the so-called medical use of the drugs.
- Both drugs impair the ability to operate a motor vehicle and roadside screening tests have been developed to detect them, although *cannabis* currently appears to cause less impairment of driving ability than alcohol [5].
- Both drugs are metabolized by the liver into inactive metabolites, acetate and carboxy-THC respectively [6].
- Both drugs are relatively easy to make at home, by brewing beer or fermenting wine for alcohol and growing marijuana. In Canada, each household can grow four plants legally.

Differences

- Since THC is a 21-carbon alcohol, its long carbon structure makes it insoluble in water and is only fat soluble, whereas short 2-carbon chain ethanol is totally water soluble and does not dissolve in fat. This means that the pharmacokinetics of THC are more complicated than ethanol and it does not have a pseudo zero order (straight line) elimination rate like ethanol [6].
- As THC is fat soluble, it remains in the body for a much longer period of time than water-soluble ethanol and is eliminated mainly in the feces.
- THC is psychoactive at 1,000,000 times less than the concentration of ethanol (nanograms vs. milligrams respectively) and can be absorbed orally (edibles or a tea), smoking, or vaping. Alcohol can only be absorbed via oral consumption.

* In Canada and many other countries, *cannabis* has health warning labels attached such as those below required by Health Canada for all *cannabis* sold in Canada. There are no such legislated health warnings for alcoholic beverages in most countries.

- **WARNING: Do not drive or operate heavy equipment after using *cannabis*.** *Cannabis* can cause drowsiness and impair your ability to concentration and make quick decisions.
- **WARNING: Frequent and prolonged use of *cannabis* containing THC can contribute to mental health problems over time.** Daily or near-daily use increases the risk of dependence and may bring on or worsen disorders related to anxiety and depression.
- **WARNING: The higher the THC content of a product, the more likely you are to experience adverse effects and greater levels of impairment.** THC can cause anxiety and impair memory and concentration.

Shown in **Table 1** are comparisons of some terms for imbibing alcohol compared to *cannabis*.

How to Break a Prohibition

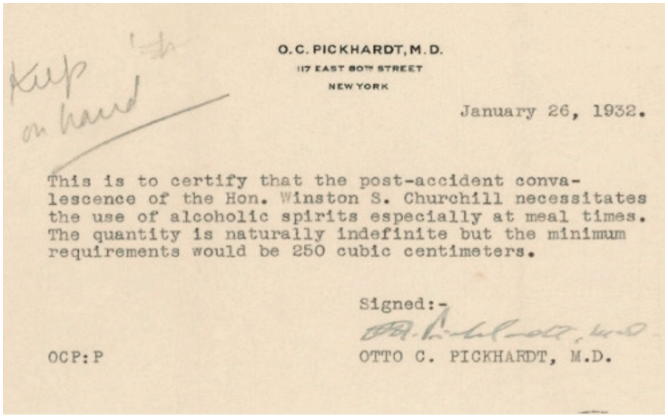
Prohibition of alcohol in the US was due to a constitutional amendment passed in 1919, but in 1933, it became the only constitutional amendment that was ever repealed. Part of the undermining of the prohibition of alcohol was to allow alcohol to be prescribed by doctors for virtually any medical condition (including liver disease!), which they did with alacrity in the thousands and thousands. By 1929, 100,000 permitted doctors were writing 11 million prescriptions for alcohol annually [7]. Even the future Prime Minister of Britain obtained a medical prescription (**Figure 1**).

"Medical" Marijuana

In many countries medical marijuana was seized on by many *cannabis* advocates starting in the 1960s and 1970s as a way of undermining prohibition of this drug (see **Figure 2**). For example, in Oregon, only nine doctors approved more than half of the 56,531 medical marijuana applications and one 80-year-old retired heart surgeon at a clinic in southeast Portland signed off on 4,180 medical marijuana cards in one year alone [8].

Table 1. A comparison of terms for imbibing alcohol compared to *cannabis*

Action	Alcohol	Cannabis
Intoxicated	Tipsy, Drunk	Buzzed, Stoned
Overindulgence	Binge drinking, Bender (pale, dizzy, vomiting)	Greening out, pulling a whitey
Next day sickness	Hangover	Burnout, come down
Imbibing in the morning	Eye opener	Wake and bake



O.C. PICKHARDT, M.D.
117 EAST 80TH STREET
NEW YORK

January 26, 1932.

Kept on hand

This is to certify that the post-accident convalescence of the Hon. Winston S. Churchill necessitates the use of alcoholic spirits especially at meal times. The quantity is naturally indefinite but the minimum requirements would be 250 cubic centimeters.

Signed:-

OCP:P

OTTO C. PICKHARDT, M.D.

Figure 1. Medical alcohol prescription for Winston Churchill during Prohibition.

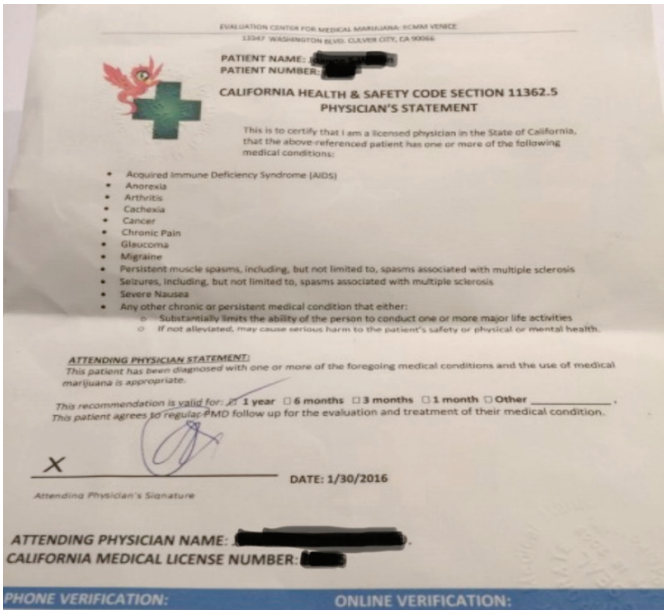
But it was effective. Support for *cannabis* legalization increased from only 12% of adult Americans in 1969 to 67% in 2019. And by October 2022, only 10% of American adults stated that *cannabis* should not be legal at all. As of 2023, 17 US states have legalized *cannabis* for medical use and an additional 22 states have legalized *cannabis* for both recreational and medical use [9].

In July 2001, Canada became one of the first countries to legalize *cannabis* for medical use, but it required a doctor's certificate and testaments from two witnesses that the user had epilepsy or a terminal illness such as cancer. These conditions were loosened over time (some ordered by the courts), until finally on October 17, 2018, the *Cannabis* Act was passed, which made Canada the first G7 country to legalize the recreational use of *cannabis*.

Medical marijuana has been used as a smokescreen in order to legally use *cannabis* recreationally. This can be seen in the numbers of medical marijuana clients in Canada, which increased from about 25,000 in 2015 to 345,000 just after *cannabis* was legalized and now has declined to 232,105 in September 2022, according to Health Canada [10].

Urine Employment Testing

The hypocrisy in the treatment of THC compared to ethanol can be seen in widespread workplace urine testing of the inactive metabolite of *cannabis*, carboxy-THC, which does not indicate impairment, and not even how much was used or when. Workplace testing could also be conducted for long-acting inactive metabolites of ethanol but aren't. Imagine the outcry if an employee had a beer on Friday evening and was fired from a job on Monday due to traces of an ethanol metabolite being detected in the urine. This is still happening with THC on a routine basis and needs to be stopped.



EVALUATION CENTER FOR MEDICAL MARIJUANA: ECMM VENICE
12347 WASHINGTON BLVD. CULVER CITY, CA 90066

PATIENT NAME: [redacted]
PATIENT NUMBER: [redacted]

CALIFORNIA HEALTH & SAFETY CODE SECTION 11362.5
PHYSICIAN'S STATEMENT

This is to certify that I am a licensed physician in the State of California, that the above-referenced patient has one or more of the following medical conditions:

- Acquired Immune Deficiency Syndrome (AIDS)
- Anorexia
- Arthritis
- Cachexia
- Cancer
- Chronic Pain
- Glaucoma
- Migraine
- Persistent muscle spasms, including, but not limited to, spasms associated with multiple sclerosis
- Seizures, including, but not limited to, spasms associated with multiple sclerosis
- Severe Nausea
- Any other chronic or persistent medical condition that either:
  - Substantially limits the ability of the person to conduct one or more major life activities
  - If not alleviated, may cause serious harm to the patient's safety or physical or mental health.

ATTENDING PHYSICIAN STATEMENT:
This patient has been diagnosed with one or more of the foregoing medical conditions and the use of medical marijuana is appropriate.

This recommendation is valid for: ☑ 1 year ☐ 6 months ☐ 3 months ☐ 1 month ☐ Other _____.
This patient agrees to regular PMD follow up for the evaluation and treatment of their medical condition.

X
Attending Physician's Signature

DATE: 1/30/2016

ATTENDING PHYSICIAN NAME: [redacted]
CALIFORNIA MEDICAL LICENSE NUMBER: [redacted]

PHONE VERIFICATION: ONLINE VERIFICATION:

Figure 2. A prescription for medical marijuana from California in 2016, which lists the medical use of cannabis for cancer, glaucoma, arthritis, or any other chronic medical condition.

Urine testing of the inactive, long-lasting metabolite of *cannabis* should be replaced by oral fluid or blood testing for THC, which indicates recent use of *cannabis* and a much greater probability of detecting impairment.

Legalization Five Years Later: The Devil's in the Details

The success of *cannabis* legalization in Canada has been due in part to its strict banning of any *cannabis* advertising outside of the point of purchase in *cannabis* stores. Celebrity or cartoon endorsement of *cannabis* is also not permitted. In addition, *cannabis* products must be sold in plain, child-resistant packaging with health warnings and standardized printing, similar to what is required for cigarettes.

The number of legal *cannabis* stores in Canada has increased from about 260 stores shortly after legalization to 2,600 in 2021 and over 3,000 in 2022 [11]. The major complaint that I have heard in my numerous public presentations about the legalization of *cannabis* in Canada is that there are too many *cannabis* stores, especially in Toronto. This is due in part to the "green rush" and the overselling and commercialization of *cannabis* after legalization.

But I consider that this is in some ways to be a good sign, as it indicates that the *cannabis* being purchased at legal storefronts, which do not sell other drugs, is a much safer and uniform product than the *cannabis* sold in back alleys by an illegal drug dealer. In addition, the legal sellers are required to have mandatory training. The

cannabis stores are paying taxes and providing proper and legal employment. Indeed, 42% of *cannabis* users obtained it from legal sources in 2019, which increased to 63% in 2021 and has increasingly undermined the black market and its greater illegal harms [12].

I have not heard many complaints from the public about the smell of *cannabis*, or an increased visibility of *cannabis* users, or other adverse consequences. When I walk through Toronto's neighbourhoods and downtown, I observe that cigarette and e-cigarette smokers have outnumbered *cannabis* smokers by a wide margin.

There have been problems with legalization, namely a ninefold increase in hospital attendance due to *cannabis* poisoning after consuming edibles in children less than 10 years of age, even though edibles are sold in child-resistant containers in Canada. But fortunately, there have been no reported deaths in children due to *cannabis* poisoning yet [13].

Although *cannabis* use has appeared to increase in Canadians over the age of 25, there appears to have been no substantial increase in youths (ages 15 to 24 years) after legalization. There has been no increase in youth crime since legalization; instead, there has been a substantial decrease in police-reported criminal rates for *cannabis* crimes, from about 220 per 100,000 population in 2010 to 32.8 per 100,000 in 2020 [14].

Since legalization, there has been a substantial reduction in fires, explosions, and burns caused by the illegal extraction of THC from *cannabis* using highly flammable solvents, and in illegal grow ops in houses.

One worrying statistic is that the prevalence of moderately injured drivers at British Columbia trauma centres with a blood THC of at least 2 ng/mL has more than doubled post legalization. However, the greatest increase was among drivers of at least 50 years of age and not youths. This indicates that more work is required to increase the deterrent effect of *cannabis* impaired driving laws and the education of the general public on the harmful effects of *cannabis* use on driver safety [15].

Not Your Granddad/Grandmother's Weed Anymore

Legalization and especially commercialization of *cannabis* have increased the amount of THC in *cannabis* from around 3% in the 1960s and 1970s to over 25% currently. This dramatic increase in THC concentration may cause increased problems related to addiction, psychosis, *cannabis* use disorders, and hyperemesis over the next five years or so and needs to be closely monitored.

High THC concentration *cannabis* products such as edibles, extracts, and vaping may have to be restricted if increased harms occur.

Conclusions

Initially I was against the legalization of *cannabis*, but now having nearly five years of experience in Canada, if the proper laws, regulations, and education are enacted, I have seen that its negative effects can be minimized, especially for youths. Legalization also opens a window into this drug's use, illustrating what potential problems need to be addressed and not be hidden away in back alleys.

As THC is less addictive than nicotine and causes far less death than tobacco products or alcohol, it should be legalized. But legalization must be introduced initially with extensive restrictions, as in Canada, to minimize the harm of *cannabis* use especially to youths, and to allow more time for greater public education about this drug.

An insightful global history of *cannabis* since Neolithic times written by Professor Chasteen stated [16]:

> *"Those who worry about marijuana need not be so fearful, however. Marijuana is unlikely to replace or even rival alcohol as our recreational drug of choice. It is not for everybody. For most people, its euphoriant effect is less than alcohol's. It is most likely to be used by the poor, by the marginal, by the chronically ill, by the artistically and philosophically inclined, by seekers after the meaning of life and by social and religious nonconformists of various stripes. That at least is the picture that emerges from this short global history. Marijuana, it seems is a mind-expanding drug after all."*

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