Advancements and Foresight of Accelerated Nuclear DNA Equipment for Rapid DNA Analysis

ABSTRACT

The accelerated nuclear DNA equipment 6c Rapid Deoxyribonucleic Acid Analysis System represents a significant technological advancement in forensic science, offering expedited DNA profiling directly at crime scenes or other locations of interest. The system generates human Deoxyribonucleic Acid identifications that are compatible with Deoxyribonucleic Acid DNA databases worldwide in less than 2 hours. This automated system minimizes the analytical complexity and user manipulations required for field-forward biometric and forensic applications. This review aims to internally emphasize the current advancements, advantages, and limitations of the accelerated nuclear DNA equipment 6c system, particularly its application to forensic casework.

This review aims to internally emphasize the current advancement, advantages, and limitations of accelerated nuclear DNA equipment 6c rapid DNA analysis system for forensic casework with future perspectives.

This rapid turnaround time facilitates real-time decision-making in forensic investigations, enabling law enforcement agencies to quickly identify or exclude suspects, link cases, and take immediate action. The system's portability and user-friendly interface make it accessible to non-experts, thus broadening its usability across various scenarios. However, despite its advancements, the accelerated nuclear DNA equipment 6c system has limitations. Challenges such as potential contamination risks, limited ability to process complex mixtures, and reliance on high-quality DNA samples can impact the accuracy and reliability of the results. Furthermore, the system's current cost and the need for specific consumables may limit widespread adoption, particularly in resource-constrained environments, and for the future, accelerated nuclear DNA equipment 6c should need advancements in sample processing, to increase sensitivity, software system optimization, electropherogram, and cost reduction

could further enhance the accelerated nuclear DNA equipment 6c utility in forensic casework.

Keywords: forensic DNA, electropherogram. ANDE 6C (Accelerated Nuclear DNA Equipment)

1. INTRODUCTION

1.1. Background

Over the past few decades, the use of Deoxyribonucleic Acid (DNA) analysis in criminal investigations and prosecutions has increased dramatically and continues to do so. This asks for 'rapid' solutions, especially during the investigation phase, where forensic evidence increasingly influences the direction, and thereby, the effectiveness of the investigation [1]. Forensic DNA typing was first used in investigations in 1986. Since then, there have been significant improvements to the speed and sensitivity of testing, making it the gold standard in forensic testing. Rapid DNA technology now allows testing to be completed in under 2 hours. [2]. Technological advancement and increased demand for faster and more efficient DNA analysis motivated the development of Rapid DNA technologies [3, 4].

Rapid DNA technology is a hands-free process that develops a DNA profile from a cheek swab sample in just two hours. This technology helps the FBI link commercial instruments to the Combined DNA Index System (CODIS) infrastructure to search for unsolved crimes and process arrestees quickly [5]. Rapid DNA instruments perform the complete forensic DNA workflow using disposable consumables for short tandem repeats (STR) analysis. They are compact and can be deployed at various locations, including laboratories, police booking areas, disaster sites, and border crossing stations. The latest models are optimized for use outside the laboratory in decentralized environments and can be operated by nonscientists [6].

In 2018, three rapid DNA instruments were analyzed as part of a technology maturity assessment, including the accelerated nuclear DNA equipment (ANDE) 6C System developed by ANDE (Longmont), which was acquired by ThermoFisher Scientific.[7].

The ANDE 6c system is a Rapid DNA Identification system consisting of a fully automated instrument, single-use microfluidic chips, and fully integrated Expert System analysis software. Two types of chips were utilized: I-Chips for Unidentified Human Remains (UHR) samples and A-Chips for Family Reference Sample (FRS) buccal swabs. Both chips perform automated purification, and PCR amplification of 27 Short Tandem Repeat (STR) markers [7]. The ANDE 6C instrument can analyze 27 loci (FlexPlex27 Amplification kit, ANDE Corporation, Longmont, USA) by expanding sets of core STR (Short Tandem Repeat) loci. The use of the analytical microchip has numerous advantages over conventional technology, including execution speed, portability of the instrument, decrease of potential contamination, and simplicity of the analysis execution [8].

The ANDE 6c was operated by first responders in tents placed proximal to the mock disaster sites manuscript submitted [7, 9]. The system was originally developed by NetBio and integrates the steps of DNA extraction, STR amplification, separation by electrophoresis, and detection and performs them all within 90 min [10].

The ANDE 6C Rapid DNA Act of 2017 allows for rapid DNA implementation in police stations, contingent on NDIS approval. The System generates DNA profiles for automatic searching of the FBI's DNA database via the Rapid DNA Index System (RDI). Recently, fully automated rapid DNA systems have been developed, and the accreditation outcomes of the ANDE 6C Rapid DNA Identification System for reference sample typing are presented here [8]. NDIS approval has been provided by the FBI Laboratory for accredited forensic DNA laboratories to use the ANDE 6C System [11]. The data supports the initiation of a developmental validation study of the system and subsequent submission to NDIS. The ANDE 6C instrument, Expert System, and A-Chip generate STR profiles meeting SWGDAM Validation Guidelines for reproducibility and sensitivity, accuracy, concordance, precision, resolution, peak height ratio, species specificity, mixtures, inhibitors, stability, and contamination.[12].

The ANDE 6C Rapid DNA Analysis system successfully analyzed 97% of biological samples regardless of conditions and demonstrated robustness in determining correct DNA profiles from reference samples.[13]. Buccal samples produced 83-98% complete DNA profiles when allelic ladders were typed accurately[14].

This review aims to internally emphasize the current advancements, advantages, and limitations of the accelerated nuclear DNA equipment 6c system, particularly its application to forensic casework.

2. OVERVIEW OF ANDE 6C RAPID DNA ANALYSIS SYSTEM

The ANDE 6C Rapid DNA Analysis System includes the ANDE instrument, ANDE chips, and ANDE swabs. The ANDE chip is a fully integrated lab-on-a-chip that performs all steps required for STR analysis in less than 90 minutes.[13]. Three modules comprise the forensic workflow within the chip: Modules 1, 2, and 3 deal with DNA purification, STR amplification, and electrophoretic separation and detection, respectively [8].

The ANDE 6c System includes integrated software for instrument control, data collection, and Expert System interpretation of STR profiles. After sample insertion and door closure, processing starts automatically. The Expert System software analyzes and interprets the data, providing rapid feedback on STR profile usability. Output files are encrypted and can be reviewed by a qualified DNA analyst using FAIRS software.[4].

Table 1: components of ANDE 6c rapid DNA analysis system

Component	**Name**	**Version number**
Rapid DNA instrument	**ANDE 6C**	**A0120001003**
Typing kit	**Flex plex27**	**Flexplex27**
Cartridge	**ANDE A chip**	**A0210001057**
System software	**ANDE system software (FAIRS)**	**2.0.6**
System expert software	**Expert software**	**2.0.5**

3. WORKING PROCEDURE OVERVIEW OF ANDE 6C

The ANDE 6C Rapid DNA Analysis System is designed for fast and automated DNA profiling. Here's an overview of its working procedure:

3.1 Sample Collection

The process begins with the collection of a biological sample, such as a buccal swab, blood, or other tissue types.

3.2 Sample Preparation

The collected sample is loaded into a specialized cartridge. This cartridge contains all the necessary reagents for DNA extraction, amplification, separation, and detection.

3.3 Insertion into ANDE 6C System

The prepared cartridge is inserted into the ANDE 6C instrument. The system is designed to be user-friendly, requiring minimal training to operate.

3.4 Automated Processing

The automated process refers to the series of steps the system performs without human intervention once the sample is loaded into the device and performs the following activities.

DNA Extraction (the system lyses the cells in the sample to release DNA), and PCR Amplification to amplify specific regions of the DNA. The ANDE 6C uses Short Tandem Repeat (STR) markers, which are highly variable regions of the DNA used for identification), Separation, and Detection (the amplified DNA fragments are separated based on size using capillary electrophoresis. The system then detects and records the STR profiles), Data Analysis (the ANDE 6C system analyzes the detected STR profiles to create a DNA profile. NA profile is completed in approximately 90 minutes. The results are displayed on the system's interface and can be printed or exported as needed [15].

The ANDE 6C instrument is comprised of a set of subsystems, including a pneumatic subsystem for driving fluids throughout the chip, a thermal subsystem for performing multiplexed amplification, a high voltage subsystem for electrophoresis, a 6-color optical subsystem for exciting and detecting fluorescently labeled STR fragments during electrophoresis, and a ruggedization subsystem to allow transport and field forward operation without recalibration or optical realignment. The instrument-integrated touchscreen features a graphical user interface with workflow-driven instructions. After the A Chip containing swab samples has been inserted into the instrument and the door closed, sample processing starts automatically [12].

A-Chip is a single-use consumable that includes all reagents, materials, and waste containment required for fully automated STR analysis. It features DNA purification reagents, FlexPlex STR PCR reagents, buffers, and separation polymer pre-loaded on the chip for consistent and precise results. The closed system design minimizes the potential for cross-contamination, and FlexPlex contains 23 autosomal STR loci.[12, 16].

The ANDE 6c Swabs include built-in radio frequency identification (RFID) tags and bar codes to provide traceability and minimize the opportunity for sample switches. By incorporating RFID technology, the ANDE 6C system enhances the accuracy, efficiency, and security of the DNA analysis process, ensuring reliable and traceable results. The ANDE 6c Swab is designed to fully seal and lock into the ANDE Chip to minimize any potential for cross-contamination. The swabs come with a built-in desiccant allowing the samples like Guns and all types of firearm evidence, Buccal swabs, Bloodstains, Cups, cans, bottles, Cigarette butts, gum, drinking straws, Steering wheels, cell phones, handled items, Hair, Bones, Semen, Muscle and tissue to be preserved for longer periods of transport [17].

ANDE 6c Forensic Automated Identification and Retrieval System (FAIRS) is a Windows-based application for the secure management of DNA IDs generated by the ANDE Rapid DNA [18]. FAIRS is the trademark software used by ANDE that creates a database of DNA profiles that passes the instrument's internal quality controls with System Software version 2.0.6. FAIRS matches profiles, provides a report that displays the matching outcome, and displays which loci matched or mismatched between profile pairs. FAIRS™ requires particular criteria for the data to be deemed suitable for analysis[19]. FAIRS integrates database generation and management, search and match, and kinship determination functionalities.[4]

Version 2.0.5 of the ANDE 6c Expert System Software is available. The Expert System uses a set of rules to interpret the profiles. These criteria include the following: allele assignment, locus evaluation, peak evaluation, ILS evaluation, allelic ladder evaluation, and sample evaluation. Subsequent rules process the peaks, alleles, and loci that pass each rule further; those that fail are not processed further. Alleles, loci, and failed peaks will either have no label or a red caution box next to them. Following the application of all rules, the sample is categorized as passed (green checkmark visible), failing (red X), and needing additional evaluation (yellow checkmark)[12].

The purpose of the ANDE 6C Expert System is to recognize and highlight profiles that indicate mixes from two or more contributors. If at least two loci with three alleles or at least one locus with four or more alleles are present, the profile is marked as a combination for analyst assessment [4].

4. PREVIOUS STUDIES BY ANDE RAPID 6C INSTRUMENT

Numerous tests have been conducted on the ANDE 6c Rapid DNA system to evaluate the correctness of the expert system, the reagent chip system, and the instrument's overall concordance, repeatability, and reproducibility in comparison to traditional DNA techniques. According to research by Ragazzo et al., only two of the 2800 markers that were typed were not consistent with the right profile, and 97 percent of the 208 samples were properly evaluated. Peak height ratios were acceptable for heterozygous markers [15].

Additionally, they experimented with shifting the instrument to three different run conditions, but this had no discernible impact on the nine profiles that were generated[8]. Using 150 samples of saliva and blood on various substrates and concentrations, a comparison study between the ANDE 6C and Rapid Human Identification Technology (HIT) instruments found that the ANDE instrument was similar to the Rapid HIT instrument, in that it can produce complete DNA profiles from as little as 5-10 ng of DNA, and that sample preparation variations from those advised by the manufacturer would negatively impact the success of the sample profile generated [3].

With the help of eight laboratories, early developmental validation of the first edition of the ANDE equipment known as the DNA scan was carried out. 2300 total swabs from 1400 distinct persons were tested. The study's findings showed that, with an accurate allele call rate of 99.998 percent, the system functioned in a precise, repeatable, accurate, and dependable manner[15]. This study proved the concept of the ANDE 6C Rapid DNA instrument and its reliability in producing full profiles that covered the core 13 CODIS loci.

Carney et al. conducted a large-scale developmental validation of the ANDE instrument in five laboratories using a total of 2045 swabs from 1387 distinct persons, utilizing 13 different equipment. The study discovered laboratory profile concordance, concordance for every other 1338 distinct donor sample examined, and a 92% success rate, where samples that had a complete profile for all 20 CODIS core loci on the first run were considered successful[20].

The Carney validation confirms the successful function of the ANDE 6c instrument and the A-Chip on standardized samples.

A set of controlled samples was employed in research by Hinton and co-authors on the field deployment of the ANDE 6C Rapid Instrument to verify the device's functionality for evidence swabs. Samples were identical to those found from improvised explosive devices, whether they were detonated or not. Seven viable single-source profiles, two partials, and two samples lacking profiles were obtained from the 12 samples included in the controlled study. One sample was operated on a chip that went through a power loss; no data could be recovered for this sample. During the testing of forty-four uncontrolled samples on the I-Chip, 25 did not yield a profile, nine yielded partial profiles, three were mixes, and seven yielded single source profiles. [15, 21]. The instrument could reliably detect mixture samples and flag them as such for further review[21]. This attests to the expert system's functionality and its ability to recognize and fail combination samples when they are present.

The ANDE 6C instrument's field readiness and application in DVI samples and simulated mass disaster situations have been the subject of several investigations. The Australian Facility for Taphonomic Experimental Research and Watherson et al. (2022) conducted a study that evaluated the performance of the ANDE 6C and Rapid HIT equipment on DVI samples taken from cadavers positioned in a mass simulation of a disaster [15].

In two exercises conducted in 2019 and 2020, two sets of fragmented remains were found in an exploded truck near a simulated building collapse, and six cadavers were left beneath debris. The samples taken from the cadavers were diverse and included bone marrow, a second distal phalanx, a tooth, a femur wedge, fingernail, and toenail cuttings, whole little toe cuttings, tissue biopsies, and facial hair. Of these collected samples that were run on the ANDE 6C instrument, seven produced no result, one tissue biopsy produced a full profile, and a sample of hair produced a high partial profile [14]. The challenge of dealing with DVI samples and the reality of creating profiles from them are illustrated by this use of the I-Chip on faux DVI samples.

Manzella et identifications of Hurricane Dorian victims in 2019 also revealed challenges with using the ANDE 6C device to process DVI samples subjected to natural disaster circumstances. Before testing, samples were gathered and kept for a year. Ten or more loci were necessary to meet the ANDE instrument's criteria for a passing run. One rib provided 15 of the 27 loci, no muscle sample matched this requirement, and 13 teeth produced passing profiles, four of which were full profiles [22]. For DVI samples exposed to the weather, this rate of recovery is normal. DVI samples can have very little DNA, and the lack of complete profiles produced on the ANDE 6C is probably due to the sample decomposing more quickly. The ANDE 6C had trouble creating profiles from contaminated bone samples, according to a study that compared Rapid DNA techniques to traditional DNA methods for creating DNA profiles from compromised materials. The device was shown to have less sensitivity than the 13 traditional DNA methods, according to the study. To see if changing the amount of bone sample input or the length of time the sample was incubated beforehand could improve profile quality, several technique adjustments were made, but they had little impact. The number of alleles called by the expert system did not significantly increase with overnight incubation, and amounts of bone material less than 200 mg were not useful for creating DNA profiles [23].

The quality 14 profiles obtained from these samples differ from those produced by Manzella et al. (2021) and Date Chong et al. (2023), suggesting that the DVI samples used in this investigation were probably of a significantly higher caliber than the real or fake DVI samples that were previously examined. Samples subjected to harsh environmental conditions characteristic of a catastrophic natural disaster or protracted remains recovery attempts, like those that followed 9/11, were tested by Manzella et al. and Date Chong et al [15].

In a further study, Turingan et al. (2020a) examined DVI samples of bone and tissue swabs taken from bodies that were either kept in morgue refrigeration for 14 days at a time or allowed to decay outdoors. Samples were then taken after one month, three months, and one year. For processing, tissue samples were put straight into ANDE 6C chips. The same procedure was applied to older bone samples, with the exception that 100–500 mg of material was employed and incubated at 56°C for the entire night in ANDE bone solution. 15 µL of extract was then spotted onto ANDE 6C swabs [7].

In general, samples recovered in the first 2-3 days produced full profiles; however, the study also showed that there was increased variability in profile generation from tissue samples and that those from the exposed decomposing individuals showed a decrease in profile quality as decomposition occurred. Eighty-three out of the eighty-seven bone samples that were evaluated at different times for up to a year produced complete DNA profiles, three samples failed because of chip malfunctions and one sample produced no profile at all [15]. The results from the development of the I-Chip prototype are further expanded upon in this validation of the I-Chip, which validates the findings of that study.

The 15 studies by Gin et al. showed an actual application of the instrument on a range of DVI samples exposed to hazardous environmental conditions. The ANDE 6C was used to identify the victims of the 2018 California wildfires. Using the ANDE 6C device, 69 DVI samples were examined. Of them, 62 produced DNA profiles, which were then compared to profiles from 255 family reference samples to identify 58 victims [24]. Remember this: Dried blood and blood clot samples made up the majority of the full DNA profiles created. Fifteen profiles were produced from tissue samples of various origins, and ten profiles from bone samples. In this case, twenty or nineteen CODIS loci were found in 95.2% of the analyzed samples.[15]. This, considering the environmental circumstances the remains were subjected to during the flames, is a noteworthy success rate.

5. ADVANTAGE OF ANDE 6C IN FORENSIC CASES

FBI Director James Comey proposed implementing ANDE 6C rapid DNA technology at booking stations across the US in December 2015. This technology could also be utilized for humanitarian purposes such as reuniting families separated during mass migrations, preventing human trafficking, and assisting authorities in identifying mass casualty victims during natural disasters or conflict situations. The system has been in use since 2015 and has helped police solve numerous cases, including burglaries, sexual assaults, and other violent crimes.[25, 26].

The ANDE 6C fast method is commonly used to create a strong forensic DNA profile with up to 27 loci, which provides a universally compatible identification. This method reduces the risk of terrorism and has a proven track record of success. Privacy protection is ensured as race, ethnicity, and genetic medical information are not included in DNA IDs. This method requires minimal personal information to verify identity, making it efficient for government services. It can be used in various scenarios such as criminal investigations, military operations, disaster victim identification, and situations where rapid DNA analysis is essential.[18].

6. LIMITATION OF ANDE 6C

Despite the numerous advantages of rapid DNA analysis, the sector still faces several challenges. While the range of sample types supported by current technology is expanding, not all sample types are compatible, and some still require pre-processing. The yield rate, which is the percentage of evaluated samples that produce a usable output, is not yet 100%. Although the technique is generally less expensive than other conventional DNA solutions, some market segments, especially police departments with limited resources, still find it too costly. While ANDE 6c fast DNA is praised by legislators and law enforcement for its ability to assist with the backlog of rape kits, its effectiveness in this regard may be limited by the degree of degradation of the kits, potentially due to age. However, by providing testing facilities and booking stations with a quick platform for more standard enrollment applications, it might free up other resources to deal with the more challenging forensic cases and backlogs of rape kits [19].

7. COMPARISON OF ANDE 6C WITH THE TRADITIONAL METHOD

Rapid DNA systems are smaller, faster, and less complicated than traditional DNA testing methods. However, traditional DNA testing methods are still more affordable, sensitive, and able to handle a wider range of sample types [27].

7.1 Sample Collection

Samples need to be collected for both conventional and fast DNA approaches. One rapid DNA instrument performs better with specialized swabs made for that system, while some rapid systems use regular swabs. [22, 28]. To prevent sample switching during a run, these specific swabs have RFID-tagged lids that seal inside the biochip. Although using these RFID swabs is advantageous for users of quick DNA instruments, it also raises costs and limits the flexibility of submitting samples to either a standard or rapid DNA process as needed [29].

7.2 Extraction

The lysis buffer is used with mechanical procedures like heating and agitation for a variable amount of time, depending on the sample. Low-content DNA samples may need up to 24 hours of incubation, while high-content DNA samples require less time. This can result in cellular components other than DNA passing through the system after the lysis step. Traditional extraction methods may yield more DNA compared to lysis on ANDE 6c rapid DNA instrument due to differences in the lysis and purification processes [27, 30].

7.3 Quantification

Traditional DNA testing involves a quantification step to estimate the DNA amount before PCR amplification. However, ANDE 6C rapid DNA instruments skip this step, saving time but potentially impacting result accuracy. These instruments use two different sample cartridges to optimize DNA recovery[27].

7.4 PCR Amplification

Traditional DNA and ANDE 6C rapid DNA methods use similar or the same PCR amplification chemistry, depending on the platform, with a common set of standardized loci [31]. The amplification kits used today target the 20 CODIS core loci established by the FBI and additional loci. Profiles from rapid or traditional DNA processing can be compared. The amplification chemistries have received FBI NDIS approval in the USA, allowing reference samples generated using these chemistries to be uploaded into the national level of the CODIS database, following all FBI standards and procedures.[32, 33].

7.5 Electrophoresis

The method used to separate and identify DNA in both quick and conventional DNA procedures is called electrophoretic separation. Even though the ANDE 6C system's electrophoretic separation procedures differ from those of other DNA devices. Single-use electrophoretic separation channels are injected and molded onto the cassette to be used with the ANDE 6C system. In each run, a fresh capillary is utilized. Since there is no means to confirm the capillaries' quality before use, the operator will have to rely on the manufacturer's quality control procedures [27].

7.6 Data Interpretation

ANDE 6C Rapid DNA systems accomplish data interpretation by predetermined rules, similar to those utilized in conventional DNA analysis techniques, by utilizing expert system software and the FAIRS software system. Expert system software automates data analysis, allowing non-scientists to operate the fast DNA system. It uses interpretation criteria and quality flags to identify profiles needing review. If a sample meets interpretation parameters, manual review is not necessary [35].

Low-level samples or samples with a combination of DNA donors show larger differences between the data interpretation algorithms. Low-level samples or samples with a combination of DNA donors show larger differences between the data interpretation algorithms [36]. For these types of samples, the ANDE 6C Expert System is used to recognize and highlight profiles that indicate mixes from two or more contributors [27].

8. ADVANCEMENT OF ANDE 6C SYSTEM

The initial system released by ANDE was called DNA Scan, later renamed ANDE 4C (4-color). It was used to analyze reference samples, samples from controlled environments, and samples from uncontrolled contexts.[10]. In 2016, the ANDE 4C System received the first and only NDIS Approval for a Rapid DNA System [16]. ANDE 6C instrument was designed to permit the detection of six fluorescent dyes. Accordingly, the goals of this internal study of the ANDE 6C system and FlexPlex assay were twofold [12].

The ANDE 6C instrument is an improved version of the ANDE 4C. It can perform STR analysis with four or six fluorescent dye labels, a 2-D barcode scanner for sample tracking, and improved ruggedization for mobile and outdoor use. The system can detect two additional dye colors (purple and orange) for a total of six colors.[6, 37].

The software processes the raw data, assigns allele designations, and employs rules to interpret the DNA profiles. The Expert System software was specifically designed and developed for the analysis of ANDE data and is fully integrated with no user intervention required. After the evaluation, the ANDE Expert System generates the following outputs: an allele table listing all passing allele calls for all samples, a file (electropherogram) for rapid output visualization, a file load to the Combined DNA Index System (CODIS) & a file to the permit review with conventional software package [12, 38].

9. FUTURE PERSPECTIVE OF ANDE 6C RAPID

In the future, empirically determining factors such as optimal sample amount, suitable 'rapid' preparation protocols, and optimal interaction with reagents will assist in defining a standard operating procedure for rapid sample collection and preparation to ensure robust and reliable rapid DNA analysis. The preferred platform will depend on several factors, including its intended use and operating environment [14]. The current rapid DNA systems have already made a significant impact on both the forensic and law enforcement communities and are poised to make an even greater impact in the future. However, there is still a need for further development to address the remaining performance gaps and barriers to adoption[2].

ANDE 6C Rapid DNA for crime scene use Enhancements and data needed to consider the use of forensic evidence for State and National DNA Databasing an agreed position statement by ENFSI, SWGDAM, and the Rapid DNA Crime Scene Technology Advancement Task Group was the subject of a July 2020 letter to the editor of Forensic Science International Genetics.[36].

This document outlines five key areas for manufacturers to improve rapid DNA analysis of forensic evidence samples: using integrated human-specific controls, meeting common quantification needs, exporting analyzable raw data, incorporating an automated expert system, and achieving improved peak height ratio balance for low-quantity and mixture samples.[36, 39].

Additional development is required to address the recognition of the need for increased sensitivity with rapid DNA systems to facilitate improved detection of low-level DNA samples. Once the areas above have been developed and validated, rapid DNA systems will in many respects possess performance capabilities that are on par with the current traditional laboratory methods [1, 36, 40].

10. CONCLUSION

The ANDE 6c Rapid DNA System can process the most comprehensive suite of DNA sample types and is largely intended for law enforcement officials with no DNA background to obtain DNA profiles for quick identification purposes of individuals. The system is self-sufficient and enables users to respond to mass casualty and biohazard situations. The device doesn't require any further maintenance and may be swiftly transported and redeployed at Police stations, Crime scenes, Vans, trucks, and cars, Booking stations, Jails/prisons, Coroners' and medical examiners' offices, Hospitals and sexual assault kit collection centers, Mass casualty sites, Borders and ports, Embassies and Essentially anywhere.

The ANDE 6C Rapid DNA System can operate at normal office temperatures, does not require special shipping or refrigeration, and can produce a profile on various samples within two hours, handling 5 samples at a time. Furthermore, one must balance performance and speed while using (modified) fast DNA techniques at crime scenes. Rapid DNA systems are typically less sensitive than traditional laboratory techniques. While speed and portability are useful in situations such as DVI, more work needs to be done to increase the techniques' sensitivity and capacity to use samples other than buccal swabs before they can be applied to crime scenes. The techniques under discussion function effectively when single-source buccal swabs (i.e., reference samples) are used, but the success rate (i.e., producing a complete DNA profile) is too low for more complicated samples.

The following conclusions about currently available commercial systems for ANDE 6C rapid DNA analysis are given by concentrating on several factors and requirements, such as the ANDE 6c system's low sensitivity when compared to traditional DNA analysis in a forensic laboratory and the time-saving elimination of work-up steps like extraction and/or purification. Although the ANDE 6C system is somewhat heavier, it has a better sensitivity range for different samples at the same time.

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