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Goluguri Baby Rani
Pesticide Testing Centre, Pesticide Management Division, National Institute of Plant Health Management, Rajendranagar, Hyderabad, Telangana, India

Yelleti Tejaswi
Pesticide Testing Centre, Pesticide Management Division, National Institute of Plant Health Management, Rajendranagar, Hyderabad, Telangana, India

NR Meena
Pesticide Testing Centre, Pesticide Management Division, National Institute of Plant Health Management, Rajendranagar, Hyderabad, Telangana, India

Tangella Meghana
Pesticide Testing Centre, Pesticide Management Division, National Institute of Plant Health Management, Rajendranagar, Hyderabad, Telangana, India

Nirmali Saikia
Pesticide Testing Centre, Pesticide Management Division, National Institute of Plant Health Management, Rajendranagar, Hyderabad, Telangana, India

Corresponding Author:
Goluguri Baby Rani
Pesticide Testing Centre, Pesticide Management Division, National Institute of Plant Health Management, Rajendranagar, Hyderabad, Telangana, India

Proficiency testing (PT): The tool in quality assurance of testing laboratories

Goluguri Baby Rani, Yelleti Tejaswi, NR Meena, Tangella Meghana and Nirmali Saikia

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Abstract
The proficiency testing (PT) is the ideal approach for the assessment of laboratory efficiency by evaluating their results by using external resources. The foremost objective of PT is to examine the accuracy of the results attained by a laboratory and which allows the laboratory to determine their gross errors and eventually overcome the incorrect procedures. Therefore, proficiency testing is the tool for quality assurance of the laboratories. Apart from this, laboratories are required to participate in a proficiency test scheme to obtain the scores and reduce notable inaccuracies of the laboratory by documenting.

Keywords: Proficiency testing, quality assurance, assessment, accreditation, laboratories

Introduction
The most importance of Pesticide residue analysis of fruits, vegetables and other food items is for safeguarding public health and also for regulatory control and foreign trade. In worldwide, over one thousand active substances against pest control are used [1]. Perhaps other uses of chemicals are less regulated than pesticides. To assess the good agricultural practices (GAP) and to protect the population from hazardous health impacts, Regulatory guidelines have defined maximum residue levels (MRLs) for pesticide residues and their derivative products [1]. The low MRLs of Pesticide residues aims to develop more sensitive and powerful analytical methods [3-6]. The presence of various pesticide residues are at trace level, which are measured critically with accuracy [7, 8]. As per ISO/IEC 17025, the pesticide testing laboratories should include all the technical and management requirements for maintaining the quality system [9]. It is a vital prerequisite for the laboratories to participate on a regular basis in PT programs [10].
Proficiency testing is an Inter Laboratory Comparison (ILC) aimed at evaluating the performance of each laboratory for particular tests or parameters. In a Proficiency testing scheme one or more samples are sent to various participating laboratories. Participating laboratory analyses the test items and outcomes obtained are reported to the Proficiency testing (PT) coordinator [11]. The outcomes reported by the Participating laboratory are then assessed through statistical analysis as well as individual Participating laboratory acquires a performance evaluation. According to ISO/IEC 17025, to attain accreditation by a laboratory, a regular assessment of Proficiency testing is crucial.
The obtained data through statistical evaluation from centrally distributed materials by participating laboratories helps in checking their competence, plays an essential role in PT scheme [12-16]. A performance index or score is provided to individual laboratory with a numerical indicator of its competence [17, 18] along with the information about the performance of the whole group, which enables to compare and evaluate its proficiency [19]. The goal PT is to enhance acceptable performance but participation in the proficiency test scheme is to strengthen interest in quality assurance and provide basic correctional measures in laboratories that do not meet the required levels of acceptability data [2, 17, 18].

Discussion
It is advisable to conduct a routine independent evaluation of a laboratory's technical performance, as this serves as a crucial method for ensuring the accuracy of analytical

measurements and is integral to a comprehensive quality strategy [21, 22]. The independent proficiency testing (PT) schemes are the common approach for assessment [23, 24]. A thorough quality assurance (QA) framework in analytical and quality control laboratories should encompass the following components alongside proficiency testing scheme: the validation of analytical methods [25, 26]; the utilization of certified reference materials (CRMs) [27]; and the employment of routine internal quality control (IQC) [28, 29]. In principle, method validation and IQC alone are important to ensure accuracy. In practice, they are often less than perfect. Proficiency testing is ensuring that these two within-laboratory procedures are working adequately. During the process of validation of method developed, unforeseen factors might disrupt the measurement process, and in numerous industries, Certified Reference Materials are often unavailable. In those kind of scenarios, establishing traceability becomes challenging, and unidentified sources of inaccuracy might exist during the quantification. Laboratories lacking external references can function for extended durations with significant biases or random variations. PT serves as a tool for identifying and addressing these issues. Its primary advantage lies in offering participants an independent and external evaluation of the validity of their results [20].

PT scheme is a structured approach for the objective assessment of QC or analytical laboratory results through external methods. It involves the periodic comparison of QC or analytical laboratory's results with other laboratories. This process will be facilitated by the PT Provider, who routinely distributes homogeneous samples [30, 31] to the QC or analytical laboratories for analysis and data reporting [32].

The International Organization for Standardization (ISO) has released a guidelines pertaining to PT [33], along with a guide concerning quantitative methods applicable within proficiency testing [34]. Additionally, the International Laboratory Accreditation Corporation (ILAC) issued a document outlining the qualitative requirements for proficiency testing schemes [35], and numerous proficiency testing programs have now received accreditation.

Proficiency Testing plays a crucial role in ensuring quality assurance of laboratory. Along the growing requirements for unconventional verification of efficiency from customers and regulatory authorities [36, 37], proficiency testing is pertinent to all participating laboratories that assess safety and food quality across the globe. Equally important for the technical performance of the laboratory, regular proficiency testing provides independent evaluations of the quality of analytical results, enabling laboratories to monitor and improve their performance over time [38].

Proficiency Testing refers to the assessment of participant laboratories performance based on predetermined standards through inter-laboratory comparisons (a). PT serves as a means to showcase efficiency and verify a participant's measurement process by comparing results with those from a reference lab and other participant's [38]. The significance of Proficiency Testing is multifaceted. Firstly, it allows the participant laboratory to exhibit its efficiency in a specific measurement discipline, which can be utilized to verify various components such as measurement methods, traceability of standards, technical training of personnel, and evaluations of measurement uncertainty.

Accordingly as per ISO 17043 [33], Proficiency Testing scheme is a structured procedure overseen by a organization that involves a standard or reference laboratory. The outcomes are presented in a report form that distinctly indicates the "En and z" score. z scores will be calculated for the participants based on the assigned value and standard deviation, after eliminating any gross errors. The scoring system is specifically designed to fulfil these requirements. Consequently, the foundation of PT lies in the distribution of materials that are commonly encountered, along with the participant's application of standard methods, ensuring that the results are as representative of typical working practices as possible. Ideally, the proficiency test materials should be analysed as part of a routine analysis [39, 42].

Additionally, ISO/IEC 17043 describes an inter-laboratory comparison as a procedure conducted by mutual agreement among two or more laboratories, with the results documented in a formal report. In contrast, a proficiency test is a type of inter-laboratory comparison that is organized and overseen by an independent third party. Moreover, a proficiency test involves the participation of a reference laboratory, utilizing its results to assess the performance of the participants. On the other hand, an inter-laboratory comparison does not necessitate the involvement of a reference laboratory or a coordinating entity. Consequently, the laboratories involved are merely comparing their performance with that of other similar participating members, which, while alike, are distinct.

Proficiency tests conducted through inter-laboratory comparison serve as a valuable means to evaluate and oversee the quality performance of analytical laboratories [43, 22]. They are primarily intended to assist participating laboratories in identifying and addressing lacunae in their procedures [44]. For accreditation under ISO 17025:2017, taking part in proficiency tests constitutes a component of the laboratory's external quality assessment and is a prerequisite for the participating laboratories [45]. As per ISO 17043:2023, Inter-laboratory Comparison (ILC) refers to the organizational performance and assessment of measurements or tests on identical or comparable items by two or more laboratories or inspection bodies, conducted under established conditions.

PT program serves as a highly beneficial aid for assessing a laboratory's performance; nevertheless, it must be complemented by additional methods to evaluate the overall quality of the testing process within the laboratory. Proficiency testing primarily reflects the analytical performance. Regarding PT as an indicator of accuracy, several studies demonstrated a positive correlation between the accuracy of testing biological specimens and the results achieved in PT programs.

Advantages and Constraints of participation in a PT program

Participating in a Proficiency tests program offers the following Advantages: Overall performance and assessment of the laboratory individually. An accurate estimation of the laboratory's bias concerning a specific analyte when compared to a whole group. An opportunity to assess the long-term stability of the method in relation to the whole group. If the acceptance criteria are not satisfied, the subsequent investigation to identify the underlying cause will frequently lead to a quality enhancement that impacts the testing of actual samples. The significance of adhering to the Proficiency Testing acceptance criteria will direct the participant's attention towards quality assurance matters,

including daily Quality Control measurements, comparison of Quality Control data, training of staff, SOP's, and equipment maintenance, ultimately resulting in an overall improvement in the quality of the testing process.

The Constraints associated with participation in a PT program

The interval between proficiency testing occurrences typically ranges from 01 to 06 months, resulting in a relatively weak oversight of the laboratory's short-term testing quality.

The number of PT samples is often low, limiting the possibilities of the evaluation of repeatability. Furthermore, the "matrix" of the PT samples usually differs from that of actual routine samples, thereby hindering comparisons between various methods. This situation also suggests that true values for the PT samples are rarely established using a reference method, as the true value may have limited applicability due to the "matrix" effects. Additionally, the cost of participation and the resources required for testing Proficiency Test items can serve as a limiting factor for participation in Proficiency Test programs.

Conclusions

- PT plays a crucial role in the accreditation process of ISO/IEC 17025. Although it is not explicitly mandated by the international standard, it is strongly advocated and required by various international committees and accreditation organizations.
- The significance of proficiency testing is growing, as it is acknowledged as an essential quality assurance mechanism for laboratories involved in analytical measurements.
- Additionally, the results of laboratories participating in PT programs are more widely utilized, particularly by accredited bodies, as a benchmark for evaluating the proficiency and standards of laboratories.

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