

Proficiency Testing Requirements for the Implementation of ISO/IEC 17025 Quality Management Systems in Food Testing Laboratories

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ABSTRACT

Implementation of quality management system in food services laboratories is very important for customer trust and government approval. Proficiency testing (PT) is one of essential aspects of external quality assurance used to evaluate laboratory performance based on ISO/IEC 17025. However, the number of proficiency testing providers in Indonesia remains limited compared to the demand. This study aimed to assess personal laboratory understanding regarding the concept of PT, laboratory needs and identify several factors influencing a company's decision to perform testing. A quantitative survey using a structured questionnaire was conducted involving 80 food services laboratories located in 23 provinces. The results showed that most respondents had adequate and advanced understanding (61 and 14 % respectively) about PT. Laboratories generally participated in PT programs one to two times per year for each testing parameter, mainly to fulfil accreditation requirements and support quality assurance. The greatest demand for PT programs was observed in microbiological (indicator microorganism and pathogen testing) and proximate chemical testing based on their products. Laboratories reported several constraints, including limited availability of PT schemes, lack of accessible information, and high participation costs. While cost and the credibility of providers were considered the most influential factors affecting participation decisions. This study conclude that the importance of improving the availability, accessibility, and dissemination of PT programs in Indonesia to strengthen laboratory quality management systems.

INTRODUCTION

The increasing complexity of global food supply chains, rapid growth in food trade, and heightened consumer awareness regarding food safety have intensified the demand for reliable food quality assurance systems. According to the latest WHO estimates, unsafe food caused approximately 866 million illnesses and 1.52 million deaths globally in 2021, highlighting the continuing importance of reliable food safety systems and analytical testing laboratories in protecting public health. The managerial aspect of laboratory operations plays a critical role in ensuring the reliability, accountability, and sustainability of testing services. Increasing demands on food safety, public health protection, and regulatory compliance have driven significant growth in the number and scope of food testing laboratories in Indonesia. Laboratories today are not only required to produce accurate analytical data, but also demonstrate competence and accountability through the implementation of an internationally recognized quality management system. In this context, accreditation based on ISO/IEC 17025 is an important requirement in laboratory operations. One of the main components that supports laboratory quality assurance is proficiency testing (PT) regulated in ISO/IEC 17043. However, although the number of accredited laboratories continues to increase, the availability and implementation of proficiency testing (PT) programs at the national level in Indonesia remain relatively limited, particularly for several food testing parameters and testing scopes. This condition poses challenges for laboratories in maintaining compliance with accreditation requirements, evaluating analytical performance, and ensuring continuous quality improvement.

From a management perspective, proficiency tests serve as an important instrument in performance evaluation, benchmarking, and data-driven decision-making. Participation in PT allows laboratories to identify analytical biases, evaluate personnel competencies, verify testing methods, and improve quality control systems (Thompson et al., 2006). This role is becoming increasingly important in microbiological testing due to the high variability and complexity of microbial behavior in the food (Singh et al., 2023). PT also supports organizational credibility, stakeholder trust, and risk management practices, thereby strengthening the competitiveness and sustainability of laboratories (Belli et al., 2012; Ellison & Hardcastle, 2012). PT participation strengthens quality assurance practices, including quality control, staff competency, SOP implementation, and equipment maintenance, thereby improving overall laboratory performance (Rani et al., 2025). In addition to microbiological testing, laboratories also require PT schematics for chemical and physical parameters such as proximate analysis, heavy metals, and mineral testing, reflecting the growing diversity of analytical needs in the food sector.

Despite having a strategic role, laboratory participation in proficiency testing programs is influenced by various managerial and operational constraints. Some laboratories experienced difficulties due to the limited number of PT providers, high participation costs, lack of

dissemination of information about PTs, and incompatibility between the available PT schemes and the scope of laboratory testing. Based on data from the Indonesian National Accreditation Committee, the number of accredited university operators in the food sector is still relatively small compared to the increasing need for laboratories. Previous research has focused more on technical aspects of PT implementation, such as homogeneity and sample stability (Nurjanah et al., 2024), while managerial dimensions—including laboratory understanding, participation behavior, information accessibility, and decision-making factors—have not been widely studied. Therefore, empirical evidence supporting managerial strategies to increase PT participation in Indonesia is still limited.

Based on these issues, this study addressed the following research questions:

1. How well do food testing laboratories in Indonesia understand proficiency testing?
2. What are the laboratories' needs regarding proficiency testing parameters and implementation?
3. What factors influence laboratory participation decisions in proficiency testing programs?
4. What constraints are faced by laboratories in participating in proficiency testing programs?

In response to these questions, this study used a quantitative approach through the development and validation of a questionnaire, followed by a survey involving 80 food services laboratories. The instrument captures laboratory profiles, level of understanding of proficiency testing, testing parameters needs for PT implementation, and factors influencing participation decisions, including information sources, administrative aspects, cost considerations, and performance of PT providers. This study aimed to assess respondents' level of understanding of microbiological and physico-chemical proficiency testing, analyse laboratory needs for PT as part of quality assurance strategies, and identify key factors influencing participation decisions, including constraints and potential solutions. The findings are expected to establish new service providers in addition to the existing ones, data-based insights that support managerial decision-making, and enhance the effectiveness of ISO/IEC 17043 implementation in participation in proficiency testing programs.

RESEARCH METHODS

Materials and Equipment. The primary research instrument used in this study was a structured questionnaire consisting of open-ended, semi-closed, and closed-ended questions. The questionnaire was administered online using Google Forms. Data processing and statistical analyses were conducted using Microsoft Excel and IBM SPSS software.

Respondents and Sampling Technique. The target population comprised 461 food testing laboratories across Indonesia. Food testing laboratories were selected because they represent one of the most quality-sensitive sectors, where analytical accuracy directly affects food safety, public health, regulatory compliance, and consumer trust. In addition, these laboratories routinely participate in proficiency testing programs to maintain accreditation and demonstrate

technical competence under ISO/IEC 17025 requirements. Respondents were selected using purposive sampling based on the following criteria: 1) laboratories conducting food testing in accordance with national food regulatory standards; and 2) laboratories that had previously participated in interlaboratory comparison or proficiency testing programs. The minimum sample size was determined using the Slovin formula with a significance level of 10%, resulting in a minimum requirement of 80 laboratories.

Research Procedure. This study was conducted in several stages. The first stage involved questionnaire development based on previous studies related to proficiency testing, laboratory quality management, and participation factors in quality assurance programs (Thompson et al., 2006). The second stage involved validity and reliability testing of the questionnaire using responses from 30 respondents. After the instrument was confirmed to be valid and reliable, the final questionnaire was distributed online via email to selected laboratories across Indonesia. The third stage involved data tabulation, descriptive analysis, and interpretation of laboratory understanding, needs, participation behaviour, information accessibility, and factors influencing participation in proficiency testing programs.

Questionnaire Design and Measurement Scale. The questionnaire was structured into four sections. The first section collected general information regarding laboratory profiles. The second section assessed the level of laboratory understanding of proficiency testing. The third section explored laboratory needs and perceived urgency regarding the implementation of proficiency testing in Indonesia. The fourth section examined information sources related to proficiency testing and factors influencing participation decisions, including administrative processes, cost considerations, provider characteristics (location and frequency of PT implementation), promotional activities, and communication channels. Measurement of understanding and participation factors was conducted using descriptive categorical and importance scales. The level of laboratory understanding of proficiency testing is categorized as Advanced, Adequate, Limited and Low based on the score of trueness respectively (>80; 70–80; 50–60 and ≤ 50).

Validity and Reliability Testing. Validity testing was conducted using Pearson correlation analysis to assess the relationship between each questionnaire item and the total score, ensuring that the instrument accurately measured the intended variables (Taherdoost, 2016). Questionnaire items were considered valid when the calculated correlation coefficient exceeded the critical r-table value at a significance level of 0.05. Reliability testing was performed using Cronbach's alpha coefficient to evaluate the internal consistency of the instrument. A Cronbach's alpha value greater than 0.60 indicated acceptable reliability of the questionnaire (Black & Babin, 2019).

Data Analysis. Descriptive statistical analysis was performed using Microsoft Excel to generate tables, charts, frequencies, and percentage distributions. Meanwhile, IBM SPSS was used to conduct validity and reliability testing, including Pearson correlation analysis and Cronbach's

alpha assessment. The results were interpreted descriptively to explain laboratory profiles, levels of understanding, laboratory needs, information accessibility, participation behaviour, and factors influencing proficiency testing participation decisions (Creswell, 2014).

RESULTS & DISCUSSION

This study examined several managerial aspects related to proficiency testing participation among food testing laboratories in Indonesia, including laboratory profiles, level of understanding, participation motives, information accessibility, and factors influencing participation decisions. The analysis was conducted descriptively to identify patterns and managerial implications associated with laboratory quality assurance practices.

Validity and Reliability Testing. The questionnaire consisted of 15 questions designed to measure laboratory understanding of proficiency testing and factors influencing participation decisions. Prior to further analysis, all items were subjected to validity testing using Pearson correlation analysis. The results (Table 1) showed that all items had correlation coefficients (r-count) greater than the critical value (r-table = 0.361, $\alpha = 0.05$), indicating that each item was statistically valid and capable of measuring the intended constructs (Taherdoost, 2016). The r-count values ranged from 0.362 to 0.825, demonstrating acceptable to strong correlations between individual items and the total score.

Table 1. Validity Test Result

Test Variable	r-table ($\alpha = 0.05$)	r-count (Pearson Correlation)	Description
Understanding: Definition of proficiency testing	0.361	0.555	valid
Understanding: Difference between interlaboratory comparison and proficiency testing	0.361	0.671	valid
Understanding: Proficiency testing regulations	0.361	0.374	valid
Understanding: Frequency of participation in proficiency testing	0.361	0.362	valid
Understanding: Proficiency testing scheme	0.361	0.584	valid
Understanding: Proficiency testing provider	0.361	0.479	valid
Understanding: Terminology in testing	0.361	0.469	valid
Understanding: Follow-up actions after proficiency testing	0.361	0.523	valid
Administrative factors	0.361	0.419	valid
Cost factors	0.361	0.533	valid
Proficiency testing provider factors	0.361	0.456	valid
Frequency of proficiency testing implementation factors	0.361	0.592	valid
Location of proficiency testing provider factors	0.361	0.646	valid
Promotion factors	0.361	0.755	valid
Advertising factors	0.361	0.825	valid

Source: Research Data (Processed), 2025

Laboratory Understanding and Reasons for Participation in Proficiency Testing. The results (Figure 2) showed that most laboratories demonstrate a good level of understanding. Out of 80 laboratories, 49 laboratories (61%) were categorized as Adequate, while 11 laboratories (14%) were classified as Advanced (score > 80). In contrast, 17 laboratories (21%) were categorized as Limited, and 3 laboratories (4%) were classified as Low. The findings suggest that laboratory understanding may influence managerial readiness in implementing external quality assurance programs. Laboratories with limited understanding may encounter difficulties in interpreting PT results, identifying corrective actions, and integrating PT outcomes into continuous improvement processes. Given that proficiency testing is a key component of external quality assurance, improving laboratory understanding is essential to ensure effective implementation of quality management systems (Belli *et al.*, 2009; Thompson *et al.*, 2006)

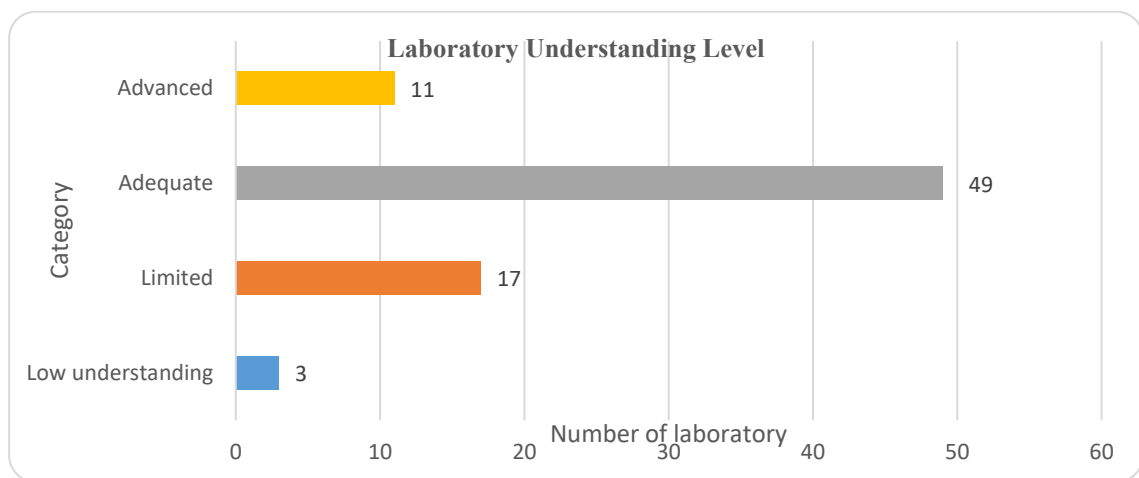


Figure 2. Laboratory understanding of proficiency testing in general

Source: Research Data (Processed), 2025

The reasons for laboratory participation in proficiency testing are illustrated in Figure 3. The primary reason identified was compliance with accreditation purposes, followed by efforts to enhance customer trust and other operational considerations.

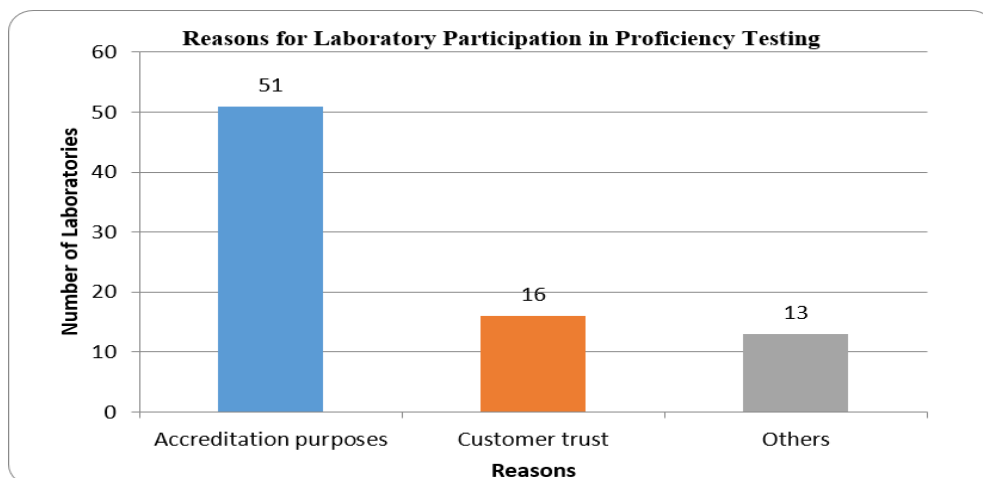


Figure 3. Reasons of Laboratory Participation in Proficiency Testing

Source: Research Data (Processed), 2025

Beyond accreditation requirements, laboratories reported several managerial and technical motivations for participating in proficiency testing. These include ensuring the reliability of test results, benchmarking performance against other laboratories, evaluating personnel competence, testing methods and equipment, and identifying potential problems that require corrective actions. Participation in PT also supports performance evaluation and long-term planning for laboratory improvement.

These findings indicated that participation in proficiency testing is driven not only by regulatory compliance, but also by organizational motivations related to reputation, customer trust, and operational performance improvement. These results are consistent with previous studies indicating that proficiency testing provides assurance of analytical performance, identifies operational weaknesses, and supports continuous quality improvement (Mustafa et al., 2025; Sri & Krismastuti, 2016). From a management perspective, participation in PT can be viewed as a strategic tool to enhance organizational performance, strengthen stakeholder trust, and support evidence-based decision-making in laboratory operations.

Factors Influencing Laboratory Participation in Proficiency Testing. The factors influencing laboratory participation in proficiency testing are presented in Table 2. The analysis indicates that several managerial and operational factors play significant roles in shaping participation decisions, including administrative processes, cost, characteristics of proficiency testing providers (such as location and frequency), as well as promotion and advertising.

Table 2. The Importance Level of Factors Affecting Participation Consideration in Proficiency Testing

Factors	Very important (%)	Important (%)	Less important (%)	Not important (%)
Administrative	38.75	58.75	1.25	1.25
Cost	73.75	25.00	1.25	0.00
Credibility of provider	68.75	27.50	3.75	0.00
Frequency of proficiency testing implementation	37.50	58.75	3.75	0.00
Location of proficiency testing provider	28.75	50.00	18.75	2.50
Promotion	31.25	55.00	12.50	1.25
Advertising	25.00	53.75	20.00	1.25

Source: Research Data (Processed), 2025

The factors influencing laboratory participation in proficiency testing are presented in Table 2. The analysis revealed that several managerial and operational factors play important roles in shaping participation decisions, including administrative processes, cost considerations, characteristics of proficiency testing providers (such as credibility, location, and implementation frequency), as well as promotional and advertising activities.

Among these factors, cost and credibility of proficiency testing providers were identified as the most influential considerations. A total of 73.75% of respondents rated cost as “very important,” followed by 68.75% who considered provider credibility as “very important.” These findings indicate that financial considerations and provider reliability are the primary determinants influencing laboratory participation decisions. From a management perspective, laboratories tend to evaluate proficiency testing participation not only based on technical requirements but also on resource efficiency, organizational trust, and service reliability. This finding is consistent with previous studies showing that price and organizational reputation significantly influence decision-making behaviour because they shape perceptions of quality, credibility, and service reliability (Sagala, 2019).

Administrative processes and the frequency of proficiency testing implementation were predominantly categorized as “important,” each receiving 58.75% of responses in this category. These findings suggest that operational convenience and scheduling flexibility remain important considerations in laboratory management systems. Laboratories generally require PT programs that align with their operational schedules, workload distribution, and accreditation timelines. Therefore, simplified administrative procedures and predictable implementation schedules may improve participation effectiveness and organizational readiness.

Other factors, such as location of the proficiency testing provider, promotion, and advertising, showed more varied responses. Half of the respondents (50.00%) considered provider location as “important,” while 18.75% perceived it as “less important,” indicating different levels of dependence on geographical accessibility. Laboratories located outside major industrial regions may face greater logistical challenges and limited access to PT providers. Similarly, promotion and advertising were generally perceived as “important” (55.00% and 53.75%, respectively), although these factors received relatively higher responses in the “less important” category compared to operational and financial considerations. This suggests that communication and promotional activities function mainly as supporting factors rather than primary determinants of participation.

Overall, these findings demonstrate that participation in proficiency testing is influenced by a combination of strategic and operational management considerations. Cost efficiency and provider credibility represent strategic priorities, while administrative simplicity and implementation flexibility reflect operational needs. These results reinforce the importance of improving accessibility, affordability, provider credibility, and communication effectiveness to strengthen laboratory participation and support the implementation of quality management systems (Pillai & Fox, 2025; Thompson et al., 2006).

Sources of Information on Proficiency Testing. The sources of information used by laboratories to obtain information about proficiency testing are presented in Figure 4. The results indicated that email is the most effective communication channel, accounting for 44% of responses (65 laboratories). This is followed by WhatsApp (38%; 56 laboratories), Instagram (15%; 22 laboratories), and other communication channels (3%; 5 laboratories).

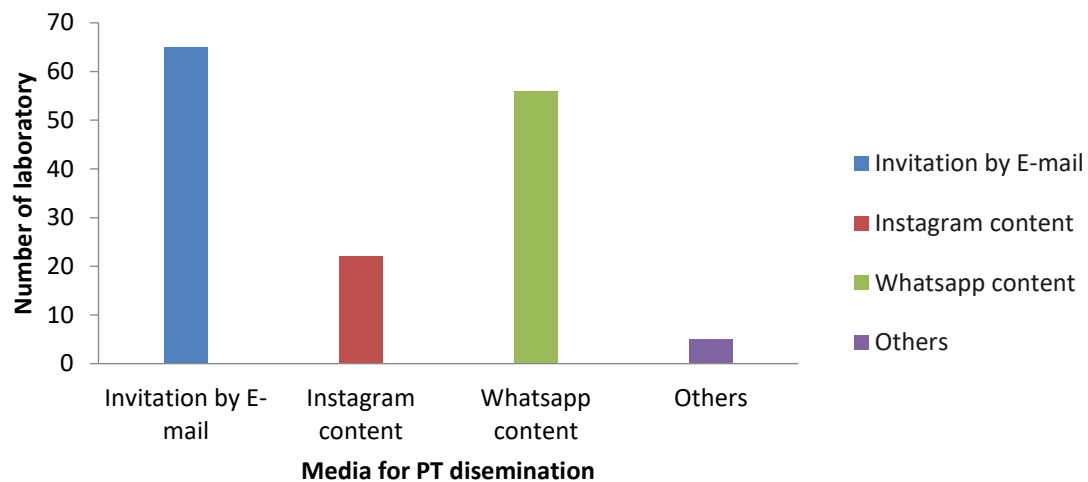


Figure 4. Sources of proficiency testing information among respondent laboratories

Source: Research Data (Processed), 2025

The sources of information used by laboratories to obtain information related to proficiency testing are presented in Figure 4. The results showed that email was the most preferred communication channel, accounting for 44% of responses (65 laboratories). This was followed by WhatsApp (38%; 56 laboratories), Instagram (15%; 22 laboratories), and other communication channels (3%; 5 laboratories).

These findings indicated that formal and direct communication channels remain the primary means for disseminating proficiency testing information. Email was perceived as the most effective medium because it enables official, structured, and targeted communication between proficiency testing providers and laboratories. In organizational settings, email communication also supports documentation, traceability, and administrative accountability, which are important elements in laboratory quality management systems. Previous studies have similarly emphasized that email serves as an effective institutional communication tool due to its reliability and ability to deliver structured information efficiently (Kong et al., 2021).

The significant use of WhatsApp reflects the increasing role of instant messaging platforms in facilitating rapid information exchange and operational coordination. Compared with email, WhatsApp provides faster communication and easier interaction between laboratories and PT providers. Meanwhile, social media platforms such as Instagram mainly function as complementary channels to increase awareness and outreach, although they are considered less effective for formal organizational communication.

From a management perspective, these results suggest the importance of adopting an integrated multi-channel communication strategy in disseminating information regarding proficiency testing programs. While email should remain the primary medium for formal communication and documentation, integrating instant messaging platforms and social media may enhance

accessibility, responsiveness, and engagement among laboratories. Such communication strategies may ultimately improve participation rates and strengthen laboratory involvement in proficiency testing activities.

Laboratory Needs for Proficiency Testing Parameters. The results presented in Table 3 indicated that laboratory needs for proficiency testing (PT) are highly diverse and extend beyond microbiological parameters to include chemical and physical analyses. The identified needs vary significantly depending on the type of product and scope of testing, such as microbiological parameters (e.g., *Enterobacteriaceae*, *Salmonella* sp., *Escherichia coli*), chemical parameters (e.g., heavy metals, 3-MCPD, aflatoxin), and physical or proximate analyses (e.g., moisture, ash, fat, and protein content). This diversity reflects the complexity of laboratory testing services and the need for PT schemes that accommodate a wide range of analytical scopes.

Table 3. Food Products and Testing Parameters Required for Proficiency Testing

Product	Testing parameters
Fish meal	Proximate analysis (moisture, ash, protein, fat, and crude fibre content)
Wheat flour	Enterobacteriaceae, molds, yeasts
Milk powder	Enterobacteriaceae, Total Plate Count (TPC)
Powdered beverages	Total Plate Count (TPC), total coliforms
Palm cooking oil	3-MCPD
Edible bird's nest	Total Plate Count (TPC / ALT), <i>Escherichia coli</i> , molds and yeasts <i>Salmonella</i> (must be absent / negative) <i>Staphylococcus aureus</i> (commonly included for food safety criteria), moisture content, ash content, protein content, fat content
Cassava chips	Moisture content, ash content, free fatty acids (FFA), and heavy metals, namely lead (Pb), copper (Cu), zinc (Zn), mercury (Hg), and arsenic (As). Total Plate Count (TPC), total coliforms, and molds.
Instant noodle	Heavy metal contamination (Pb, Hg, As)
Ground pepper	Moisture content, ash content, essential oil (volatile oil) content, crude fiber, and contamination levels of heavy metals such as lead (Pb), copper (Cu), and arsenic (As). Total Plate Count (TPC), <i>Escherichia coli</i> , molds, and aflatoxin
Chocolate product	Moisture content, fat content, Enterobacteriaceae, molds and yeasts, total coliforms
Milk candy	Total Plate Count (TPC), <i>Salmonella</i> sp., Enterobacteriaceae
Refined powdered sugar	Moisture content, ash content; Total Plate Count (TPC), total coliforms, molds and yeasts, <i>Staphylococcus aureus</i> , <i>Bacillus cereus</i>
Processed fruits	Total sugar, molds and yeasts
Dairy based-ice cream	Density, protein, fat, total sugar; Total Plate Count (TPC), Enterobacteriaceae, <i>Listeria monocytogenes</i>
Powdered sweetener	Total Plate Count (TPC)
Desiccated coconut	Moisture content, fat content; Total Plate Count (TPC), total coliforms, <i>Escherichia coli</i> , <i>Salmonella</i> sp.

Product	Testing parameters
Fishery product	Heavy metal contamination; <i>Vibrio cholerae</i> , <i>Listeria monocytogenes</i>
Fish and shrimp	Heavy metals (Cu and Cd), dimetridazole, 1-aminohydantoin
Cereals and cereal based product	Total Plate Count (TPC), <i>Escherichia coli</i> , <i>Staphylococcus aureus</i> , <i>Bacillus cereus</i> , <i>Salmonella</i> sp., molds and yeasts
Meat, milk, egg	Amino acids and fatty acids
Spice powder	Curcumin content, gingerol content, sugar content

Source: Research Data (Processed), 2025

From a management perspective, these findings highlight a critical mismatch between laboratory needs and the availability of proficiency testing providers. One of the main challenges faced by laboratories is the limited availability of domestic PT schemes, particularly for specific products and testing parameters. This issue arises because the demand for PT participation across various testing scopes is not proportional to the number of accredited proficiency testing providers (PTPs) in Indonesia. According to data from the Komite Akreditasi Nasional, as of 2022, only 31 PTPs in Indonesia were accredited under ISO/IEC 17043, with only six institutions covering the food testing sector and offering limited scopes.

In addition to limited availability, laboratories also face challenges in accessing information regarding suitable PT programs. Since PT schemes are conducted periodically rather than continuously, timely and accurate information becomes a crucial factor influencing participation decisions. Laboratories require sufficient time to prepare for participation, including administrative arrangements, resource allocation, and technical readiness. Therefore, the lack of accessible and well-structured information can hinder effective participation in PT programs.

Another significant constraint is the cost associated with participation in proficiency testing. High participation fees are perceived as a burden, particularly for laboratories with broad testing scopes that require participation in multiple PT schemes. This finding aligns with previous studies emphasizing that financial constraints and limited access to PT programs remain significant barriers to laboratory participation, particularly in developing and resource-limited countries (Carter, 2017).

Overall, these findings indicated that improving the availability, accessibility, and affordability of proficiency testing programs is essential to support laboratory quality management systems. From a managerial standpoint, strengthening coordination between laboratories and PT providers, expanding the scope of PT schemes, and enhancing information dissemination systems are critical strategies to address existing gaps and improve participation in proficiency testing.

CONCLUSION & SUGGESTION

This study highlights the managerial importance of proficiency testing (PT) in supporting laboratory quality management systems under ISO/IEC 17025 and ISO/IEC 17043. Referring to the research objectives, the study found that most laboratories demonstrated adequate understanding of PT, where 61% of respondents were categorized as having “adequate” understanding and 14% as “advanced”. PT is recognized not only as a technical requirement but also as part of quality assurance and organizational performance improvement. The study also identified that laboratory needs for PT programs are highly diverse, covering microbiological, chemical, and physical testing parameters. In addition, participation decisions were mainly influenced by cost (73.75% categorized as “very important”) and the credibility of PT providers (68.75%). Communication channels also played an important role, with email (44%) and WhatsApp (38%) being the primary sources of PT information. Overall, the findings indicated the need to improve the availability, accessibility, affordability, and communication effectiveness of PT programs in Indonesia. Strengthening these aspects is important to support broader laboratory participation, improve laboratory quality management practices, and encourage the development of PT providers with more diverse testing scopes aligned with laboratory needs.

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