Int. J. Metrol. Qual. Eng. **15**, 22 (2024)

https://doi.org/10.1051/ijmqe/2024019

International Journal of Metrology and Quality Engineering

Available online at:
www.metrology-journal.org

RESEARCH ARTICLE OPEN ACCESS

Quality approach towards ISO/IEC 17025 accreditation at the center of analysis and characterization of Marrakesh Cadi Ayyad University: metrology stakes

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Received: 21 December 2023 / Accepted: 15 September 2024

Abstract. In the context of the European Tempus project "Quality in Higher Agricultural Education in the Mediterranean (QESAMED)", Analysis and Characterization Center of Cadi Ayyad University has committed to implement a quality approach according to the ISO/IEC 17025 standard. The first objective was to accredit the testing carried out in the microbiology laboratory in response to strong demand from the food industry in the Marrakesh region. The process began with an initial assessment of the center activities to identify the main gaps from ISO/IEC 17025. The range of laboratory and standard testing to be accredited were determined and an appropriate action plan was established. After that, a staff training was programmed to improve their skills in relation to this standard and metrology concepts. Implementation of the metrology function is one of the key steps for the deployment of the continuous improvement process. This function guarantees the traceability of measurements and the reliability of microbiological testing results. Several actions have been carried out, including: (i) identification of critical quantities and associated metrological requirements, (ii) checking of the metrological consistency of equipment through the calculation of the capability coefficient. The management of equipment requires several steps, from receipt of the equipment to its decommissioning or reform: (i) identification of the equipment, (ii) creation of equipment files, (iii) performance of calibration, verification, and maintenance operations. Ultimately, the definition of a strategy ensuring metrological traceability will optimize management costs by taking into account the structural constraints linked to the organization of metrology on a national scale.

Keywords: ISO/IEC 17025 / equipment / metrological requirements / capability / traceability

1 Introduction

Cadi Ayyad University (CAU) was created in 1978 in Marrakesh (Morocco). It currently includes 15 establishments in 4 cities, namely: Marrakesh, Kalaa des Sraghna, Essaouira and Safi, and brings together 1596 scientific staff (professors), 801 administrative staff, and more than 95186 students [1]. As part of the development of its research strategy, the CAU created, among others, the Center of Analysis and Characterization (CAC) attached to "Innovation City" (the CAU technological platform) whose goals are to optimize and pool research equipment, pool resources, and boost university-business partnerships [1].

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The CAC activities started in 2011 within the CAU Faculty of Sciences, and was relocated in 2013 into a dedicated new building covering an area of 1780 m^2 on two floors and housing 13 laboratories, with dedicated measurement and testing equipment. The purpose of the center is to provide testing services in the fields of nanoscience, molecular biology, and agri-food. The CAC performs thousands of testing every year.

The CAC agri-food platform includes equipment used for the physicochemical characterization of foods through the techniques of chromatography, spectrophotometry, polarimetry, etc. The creation of a laboratory specializing in microbiological analyses meets the needs of agri-food companies on a regional, as well as national levels, which, further to the development of hygiene and food safety standards and the increasingly regulatory and consumer requirements, need to carry out quality controls to prove the wholesomeness of their products.

In today's world, quality management is the only route possible for African countries wishing to meet the challenge of globalization [2]. Implementing a quality approach in research laboratories, and especially at the level of a university platform, is currently a major stake to guarantee the results provided and ensure the sustainability of research activities [3,4]. In Africa, there is a real need to develop and maintain skills in metrology and quality management. This point is considered by some authors to be a great challenge [2]. Other authors say that implementing a quality system compatible with ISO/IEC 17025 in a university is entirely feasible and adds significant value to the university [5,6], but it remains a difficult task [7].

Under the impetus of the partnership developed between CAU and the consortium of the European project "Quality in Higher Agricultural Education in the Mediterranean (QESAMED[1])", the CAC has integrated the implementation of this approach into its objectives, with the aim of first accrediting the CAC's microbiology laboratory testing according to the requirements of the standard ISO/IEC 17025 [8]. The latter implies the need to set up a metrology function to ensure the reliability and traceability of testing results. The control of the various measurement and testing equipment becomes mandatory and requires performing several types of operations as calibration, checks, preventive and curative maintenance, etc. Metrology has a preventive role that guarantees high standards for analytical results and gives trust in the conclusions reached [9]. If it is not implemented in certain laboratories it is because that it is a demanding task requiring significant investment [10]. This investment covers the price of buying the necessary equipment, training the staff, and managing the time required for implementing the metrology function. Additionally, it includes ensuring its sustainability through periodic controls [11].

The purpose of this paper is to describe the approach followed to set up the metrology function at the CAC, and more particularly in the microbiological testing laboratory, which will serve as an example for the other laboratories of the platform. A focus is given on the main difficulties encountered and on the solutions that could help overcome them.

2 Methods

The quality approach at the CAC was initiated after the selection of the center as a pilot process in the QESAMED project. The latter aims to strengthen the capacities of research and higher education establishments in Morocco, Algeria, Tunisia, and Lebanon by improving their agronomic training courses. The project's vision essentially includes two components, namely: taking into account the quality approach and metrology and optimizing the networking of economic actors, higher education establishments, and agronomic and forestry research institutes from the Mediterranean region. Within the frame of the QESAMED project the CAC benefits from several assessments (initial, intermediate, and final), as well as specific support in implementing the quality approach, including trainee tutoring and training.

The methodology adopted to implement this approach includes an initial assessment carried out as part of the QESAMED project, identification of the range of laboratory activities and testing standards to be accredited, consideration of the metrological requirements of these standards, and staff training in ISO/IEC 17025 and metrology. This methodology is detailed below.

2.1 Initial assessment

This first step made it possible to:
- Carry out a diagnosis of the existing situation which focused on the internal organization, activities, documentation, and improvement dynamics of the center;
- Establish an action plan integrating several actions linked to the various processes, such as establishing the quality commitment and policy, drafting the quality manual, establishing procedures, staff training, etc.

2.2 Identification of the range of laboratory activities to be accredited

A survey was carried out with the Menara Cluster, a group of companies in the agri-food and cosmetics sectors in the Marrakesh region, in order to determine their main needs in terms of physicochemical, microbiological, and organoleptic testing services. A detailed analysis of the survey results showed that 56% of the testing requested was in the field of microbiology. The CAC microbiology laboratory was thus chosen to initiate the quality approach.

2.3 Identification standard testing to be accredited

A more detailed study of needs revealed a number of common testing requested by the majority of future customers. The complete list of the microbiological methods and the target organisms is as follows:
- Total flora: ISO 4833-1 [12] and ISO 4833-2 [13];
- Coliforms: ISO 4832 [14];

[1] Tempus project n°544564-TEMPUS-1-2013-1-FR-TEMPUSJPHES.

– *Escherichia coli*: ISO 16649-2[15];
– *Staphylococcus aureus*: ISO 6888-1[16] and ISO 6888-3 [17];
– Salmonella: ISO 6579 [18];
– Yeasts and moulds: ISO 21527-1 [19] and ISO 21527-2 [20].

2.4 Equipment: Metrological requirements and management

The quality of measurement results depends on the 5M (material, machine, manpower, method, and mother nature). In this part, we will focus on the "machine" component, which corresponds to the laboratory equipment.

The reliability of the results obtained in a laboratory can only be achieved if measurement and testing equipment are under control. Setting up a metrological function is one way of ensuring this control. According to ISO 10012 [21], the metrological function is a "function with administrative and technical responsibility for defining and implementing the measurement management system". The metrological function makes it possible to: (i) ensure that measurement and testing equipment meets the requirements corresponding to its intended use, namely by performing operations of calibration, verification, adjustment, repair, etc. (ii) carry out continuous monitoring of measurement processes.

ISO/IEC 17025 [5] has a number of requirements for equipment. The laboratory is obliged to check that the equipment complies with specific requirements (e.g., testing standards) before being put into service or put back into service. It is also necessary to check the need for intermediate equipment checks. Moreover, to ensure the validity of the results, a functional check of the equipment can be carried out, among other things. The equipment used to carry out measurements and testing must be capable of achieving the measurement accuracy and/or uncertainty necessary to deliver a valid result. Therefore, critical equipment must be calibrated according to a calibration program with identification of the calibration status or validity period. These requirements specifically underline the fact that any deviation in equipment affecting the quality of results must be monitored. A small deviation is not necessarily insignificant when it comes to estimating uncertainties [22]. Another requirement of ISO/IEC 17025 [5] highlights the importance of equipment identification, so the laboratory must adopt a unique identification system for its measurement and testing equipment. In practice, one of the most important records to be kept when managing equipment (which may have an influence on laboratory activities) is the life sheet, which may contain a description of all operations (calibration, maintenance, etc.) carried out on the equipment from commissioning to decommissioning because of a malfunction.

At the CAC level, the deployment of the metrology function was initiated by a study of the various testing standards to be accredited. The metrological quantities to be controlled and the associated critical equipment were listed. Critical measurement and testing equipment, with a direct impact on the testing results to be carried out in the laboratory, were identified. This includes the following equipment: incubator, autoclave, water bath, refrigerator, pH meter, balance, and pipette. For each critical equipment, testing standards provide a number of metrological requirements to be met, for example:
– Incubator: a programmable value (e.g., 30 °C) plus or minus a tolerance (e.g., ± 1);
– pH meter: a resolution (e.g., ± 0.01 pH unit at 25 °C), and a tolerance (e.g., ± 0.1);
– Balance: type of balance (analytical balance), resolution (e.g., 1%: to weigh 10 g, the balance should be capable of being read to 0.1 g), and tolerance (± 2 mg);
– Water bath: a programmable value (e.g., 47 °C) plus or minus a tolerance (e.g., ± 2 °C);
– Pipette: a capacity with a graduation (e.g., 1 ml graduated at 0.1), and the class (e.g., class A) which, for pipettes, represents the tolerance.

Further to these examples, we can see that among the metrological requirements highlighted by testing standards are resolution and tolerance related to quantity (it is tolerance related to the accuracy). This tolerance will subsequently be used to: (i) confirm the metrological consistency of existing laboratory equipment by calculating a capability coefficient; or (ii) determine the maximum permissible error (MPE) of equipment to be purchased.

The metrological requirements of testing standards in relation to the target values to be measured or programmed will make it possible to determine the range of a nominal indication interval of each equipment. This methodology was followed to determine the metrological requirements in relation to all the critical equipment identified. Once the metrological requirements have been determined, the next step is to manage the measurement and testing equipment by establishing a procedure allowing this to be done, including methods for identifying equipment and carrying out calibration and verification operations.

2.5 Staff training

In the field of scientific research, implementing a metrology function is of paramount importance since it provides information about the equipment and therefore facilitates the identification of needs, taking into account the capability of the measurement process. Metrology management increases the confidence placed in results, which can be quantified by measurement uncertainty. For this reason, raising staff awareness of metrology is an essential step in highlighting its benefits and the steps involved in its implementation. This is perfectly in line with the objectives of the QESAMED project, which aims to develop tailored training courses in response to the identified needs for metrology and quality.

It is interesting to note the difficulties associated with training, quality, and metrology on a national scale, namely the lack of academic training and highly specialized teachers in these fields in Morocco. For example, metrology training could take place at universities. This training must have a fundamental aspect, both theoretical and practical. Being an experimental science, metrology needs to offer practical work to train students properly [23].

When implementing a quality management system (QMS) in a research laboratory, and more specifically the metrology, a number of challenges can arise. As pointed out by Molinéro-Demilly et al. [24], one of the challenges encountered is the multidisciplinary nature of the scientific community and the need to get people to work effectively together with different backgrounds and habits, but also with different levels of knowledge and skills related to metrology. It is therefore necessary to create both a common interest and a synergy around metrology and quality within the laboratory. To meet this challenge, it was decided to build a QMS common to all CAC activities. To coordinate the implementation of this system, a quality manager has been recruited.

At CAC level, in order to develop the skills of permanent and non-permanent staff in quality management and metrology, an annual training plan has been established. Three training courses have been organized:
- Training in ISO/IEC 17025 [8] standard;
- Laboratory metrology training according to ISO/IEC 17025 [8] requirements;
- Training in self-evaluation / internal audit according to ISO 19011 [25].

Also, as part of the QESAMED project, two Master's-level internship projects/research projects have been defined, one of which concerns the implementation of the metrology function at the CAC.

On an African scale, one of the ways in which metrology can be developed is through the organization of regional and international events in Africa, and provision of more and more training courses. This can be ensured by the African Metrology Committee (CAFMET) [26] (partner of the QESAMED project), aiming at raising awareness among African organizations (public or private) on the importance of metrology for a country's development by promoting and disseminating a culture of metrology in testing and calibration. This objective can also be achieved by contributing to the sharing of knowledge between technical experts in African countries, and by promoting communication between companies, administrations, higher education institutes, and laboratories dedicated to metrology research and development. CAFMET can also support the implementation of metrological processes, and offer tutorials given by experienced international experts [23].

3 Results

3.1 Equipment metrological requirements

After analysis of the testing standards, the critical quantities are: temperature (°C), mass (g), volume (ml), and pH (pH unit). For each critical measuring and testing equipment, the metrological requirements to be met were determined by choosing the most restrictive metrological requirement of all the testing standards analyzed in the context of this study and which will be used by the laboratory. The results of the analysis are summarized in Table 1.

The next step was to make an inventory of the existing equipment at the laboratory concerned, with the aim of checking the range of a nominal indication interval and confirming the metrological consistency of the equipment. For any equipment required to carry out the testing, and that is non-conforming or non-existent, the technical specifications need to be determined so that it can be purchased.

3.1.1 Identification of the range of a nominal indication interval

By definition, the range of a nominal indication interval is the "absolute value of the difference between the extreme quantity values of a nominal indication interval" [29]. These two extreme values can be the minimum and maximum values that an equipment can measure (e.g., balance, thermometers, etc.) or the extreme values that can be programmed when using an equipment (e.g., autoclave, incubator, etc.). In other words, it is the set of measurand values for which the error of a measuring instrument is assumed to be less than the MPE.

At the CAC level, this step consisted of identifying the range of a nominal indication interval of each equipment required to perform the measurements and testing based on the requirements of the testing standards analyzed. For a balance, for example, the maximum extreme value is referred to as the "maximum capacity".

3.1.2 Confirmation of the metrological consistency of existing equipment in the microbiology laboratory

Confirmation of the metrological consistency of existing measurement equipment in the microbiology laboratory in relation to the defined metrological requirements was carried out by calculating the capability (C) of each equipment. Capability is measured as the ratio between the required performance and the actual performance of an equipment [30]. It was calculated using equation (1), with a confidence level of the expanded uncertainty of 95% [31].

$$C = \frac{Tolerance}{2 \times \text{expanded uncertainty}}. \quad (1)$$

In this step, we will consider that the only component of uncertainty in the measurement process is the error due to the instrument. Since the equipment has not yet been calibrated (i.e. there is no measurement bias), we'll use the MPE (extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications or regulations for a given measurement, measuring instrument, or measuring system [29]) of the equipment. To evaluate measurement uncertainty, the type B approach using the rectangular distribution is used. The equation (1) for calculating capability then becomes equation (2).

$$C = \frac{Tolerance}{2 \times \frac{MPE}{\sqrt{3}}} \text{ or } C = \frac{\pm Tolerance}{\frac{2 \times (\pm MPE)}{\sqrt{3}}}. \quad (2)$$

In our case, the minimum capability value to accept is 3. The results of the check of the metrological consistency of measurement and testing equipment are presented in Table 2.

Table 1. Results of the metrological analysis of testing standards to be accredited[a].

Metrological quantity	Critical equipment	Min and max values to be measured or programmed	Resolution	Tolerance
Temperature	Incubator	25–55 °C	–	±1.0 °C
	Autoclave	Programmed at 121 °C for 15 min	–	±3.0 °C
	Refrigerator	3–5 °C	–	3 ± 2 °C 5 ± 3 °C
	Water bath	37–100 °C	–	±1.0 °C
Mass	Balance[b]		Unless otherwise stated, the resolution of the balance should achieve a tolerance of 1% but shall be sufficient to achieve a maximum tolerance of 5% of the mass.	± 2 mg
pH	pH meter [d]	–	Capable of being read to the nearest 0.01 pH unit at 25 °C	± 0.1 pH unit
Volume	Graduated pipettes 0.1 ml 2 ml 10 ml	Different capacities:	Graduated 0.01 ml Graduated 0.1 Graduated 0.5	* For the 1 ml pipette, a standard specifies "class A". * Another requirement: Maximum permissible tolerance should be within 2% for dispensing decimal dilution volumes and inocula (to improve precision and to reduce the uncertainty of the final test result, a maximum permissible tolerance of ± 2% is preferable) or 5% for other applications.

[a] Table 1 has been established by analyzing the nine testing standards cited in Section 2.3. In the "normative references" section of each of these standards, a certain number of standards are cited as essential for the application of the standard under study. Given the large number of these standards, we decided, in this paper, to present, in addition to the results of the analysis of the nine testing standards, the results of the analysis of the two that are common to all nine standards studied, namely ISO 7218 [27] and ISO 6887-1 [28].
[b] The minimum and maximum values to be weighed will depend on the analysis of other standards.

3.1.3 Determining the technical specifications of the equipment to be purchased

The absence or non-compliance of certain equipment has highlighted the need for its purchase. The range of a nominal indication interval, resolution, and MPE are among the most important technical specifications to determine when purchasing measurement or testing equipment. The choice of the MPE is often complex and open to discussion, as it represents a real stake for the cost and reliability of measurement. In the same way as the previous two steps, the range of a nominal indication interval was determined, and the MPE was estimated using the equation (1) with 3 as a capability value. The results of these calculations are shown in Table 3.

3.2 Management of measurement and testing equipment

Once all the equipment has been inventoried, it needs to be rigorously managed. To this end, a procedure for managing measurement and testing equipment was established. It defines the rules for identifying and monitoring equipment from receipt to decommissioning or reform, including:

– Equipment identification by assigning to each equipment a unique identification number composed of an abbreviation referring to the type of equipment and a number assigned according to the order in which equipment of the same type is received over time;
– Creation of the equipment file, which includes for each equipment: (i) its life sheet, listing the operations carried out, (ii) its technical data sheet, describing its technical

Table 2. Check of metrological consistency of equipment.

Equipment	Maximum permissible error of equipment	Metrological requirement to respect (tolerance)	C[a]	Decision
Incubator	±1.25 °C	±1.0 °C	0.7	Non-conforming
Autoclave	±0.2 °C	±3 °C	13	Conforming
Water bath	±0.05 °C	±1 °C	17.3	Conforming
pH-meter	±0.003 pH unit	±0.1 pH unit	28.9	Conforming
Balance[b]	±2 mg	±2 mg	0.9	Non-Conforming

[a] Capability.
[b] The maximum permissible error of the balance is not provided in the user manual. To calculate it, the Table 6 and the data in paragraph 3.5.2 of NF EN 45501 [32] standard were used.

Table 3. Maximum permissible error estimated for equipment to be purchased.

Equipment	Metrological requirement to respect (tolerance)	Estimated maximum equipment MPE*
Incubator	±1.0 °C	±0.3 °C
Refrigerator	±2.0 °C	±0.6 °C
Balance	±2.0 mg	±0.6 mg

* Maximum permissible error.

Table 4. Methods and frequency of calibration for certain equipment.

Equipment	Calibration method	Frequency
Balance	Internal calibration weight	3 months
Laboratory glassware	Calibration performed by an external service provider	12 months
Incubator	Calibration performed by an external service provider	12 months
Autoclave	Calibration performed by an external service provider	12 months

characteristics, (iii) its operating instructions, (iv) its calibration and verification procedures, (v) its internal checks carried out, (vi) its external intervention reports, (vii) its calibration and/or verification certificates, where applicable.

Metrological monitoring of critical equipment is essential to ensure the quality of testing results [33]. ISO/IEC 17025 [8] requires metrological traceability of measurements. To meet the requirements of the standard and ensure the trueness (closeness of agreement between the average of an infinite number of replicate measured quantity values and a reference quantity value [29]) of results, appropriate metrological methods must be chosen to allow linking the result to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty. To identify an efficient strategy (subcontracting the calibration operation to an accredited laboratory or carrying it out in-house), several factors were taken into consideration: the cost of the external metrological service, the competence of the CAC staff, the availability of measurement standards, etc. The frequency initially defined for carrying out metrological operations depends on the criticality of the measurement result, the age of the equipment, the utilization rate, the metrological history, the requirements or recommendations (standards, technical guides, etc.), and finally, the cost [34]. Table 4 summarizes the decisions made for critical equipment.

The frequencies presented in Table 4 may vary over time based on the results of a regular intermediate checks and control charts capable of detecting measurement drifts. These tools can be used to track recalibration equipment needs. Depending on the results obtained, the equipment may not necessarily be recalibrated at fixed time intervals [35].

4 Discussion

Testing services for external customers are provided to generate an additional budget, and there may be a clear awareness of the need for systematic quality assurance and quality control actions. However, the provision of services is not a high priority in most universities. Staff performance is generally assessed on the basis of published papers and teaching activities, with little or no emphasis on testing services [6]. As a result, the implementation of a quality system often takes a back seat, leading to its postponement. Researchers have stated that a number of characteristics specific to each institution contribute to demotivating, hindering or even preventing the deployment of a quality

management system in universities [36]. In the case of the CAC, we have identified a number of challenges related to the nature of the tests to be carried out and others related to the financial management system.

The difficulty of an accreditation process in microbiology is linked, on the one hand, to its technical specificity, combining manual and automated techniques, and, on the other hand, to the lack of information on organizational, technical, and methodological implementation in specialized scientific literature [37]. Among the other obstacles encountered during the realization of this project, some are directly linked to the structural constraints of universities in Morocco. A limited number of permanent staff are permanently assigned to the CAC. One of the transitional solutions put in place is the fact of calling on trainees to carry out testing steps requiring low technical skills, in particular the preparation of culture media and autoclaving operations. Of course, this does not preclude the drafting of a specific procedure describing a solid training, qualification, and authorization process. In the medium term, the recruitment of additional specialized technicians appears to be an absolute necessity. Also, the CAC's financial management is dependent on the strict rules imposed on universities, causing significant delays in the processing of requests for the acquisition of measurement and testing equipment and consumable materials. This has a direct impact on the optimal layout of the microbiology laboratory, in line with accreditation requirements. Attaching the CAC to the City of Innovation, which aims to adopt a status that will allow more flexible financial management, should provide the management flexibility needed to overcome these obstacles.

To facilitate the implementation of a quality management system in accordance with ISO/IEC 17025, the process approach can be used as proposed by some researchers. This approach has a number of advantages: it focuses on the customer; it promotes an overview of all activities and their relationships; it helps to determine responsibilities; it allows processes to be optimized and unnecessary activities to be eliminated; and it generates the elements needed for the evaluation and continuous improvement of the quality management system [38]. To increase the chances of success of such an approach, particular attention must be paid to staff involvement [39,40], and more specifically, trained and qualified laboratory technicians. Without these, the laboratory cannot function effectively [41]. Also, when seeking to accredit a number of tests influenced by random and systematic errors, using different measuring and test equipment, and carried out by staff with different experience and skill levels, risk management and the identification of the impact of changes can be very effective in preventing non-conformities [42].

Finally, there are two possibilities for obtaining accreditation. The competence of testing laboratories can be recognized either by the national organization, the Moroccan Accreditation Service (SEMAC), which is not yet recognized by the International Laboratory Accreditation Cooperation (ILAC), or by an internationally recognized organization such as the French Accreditation Committee (COFRAC), the Tunisian Accreditation Council (TUNAC) or the West African Accreditation System (WAAS).

The definition of the CAC's recognition strategy must take into account the needs of future customers, most of whom wish to export part of their production to Europe. The costs inherent in any request for accreditation, in particular the calling on recognized metrology laboratories to ensure metrological traceability, and the assignment of quality and technical experts from outside the national community for assessments, are thus naturally impacted.

Finally, the implementation of such an approach could, as stated in a study, improve the ability to attract new resources [43].

5 Conclusion

Implementing a quality management system that meets the requirements of ISO/IEC 17025 involves several steps, and requires control of the metrological process in particular. This system allows the laboratory not only to guarantee the reliability and quality of the testing services it provides, but also to identify potential sources of malfunction and improvement. As a result, the impact of this work on the quality organization, internal audits and external evaluation can be significant. Concerning the quality organization, several requirements of the ISO/IEC 17025 standard have been taken into consideration and implemented in relation to the measurement and testing processes. This led to an improvement and formalization of these processes while ensuring effective management based on identification, calibration, verification, and maintenance, thus reducing the risks associated with these processes. Moreover, the definition of a metrological traceability strategy makes it possible to optimize management costs by taking into account national structural constraints. Staff training has led to improved skills, particularly in metrology concepts and standard requirements, which enhances understanding of audit criteria, making audits more effective. Additionally, the documentation and procedures put in place to meet the requirements of the ISO/IEC 17025 standard facilitate the preparation and performance of these audits, during which deviations can be identified, promoting a culture of continuous improvement. The emphasis placed on metrology and traceability of measurements guarantees reliable and reproducible results, essential for the credibility of the microbiological tests carried out. This not only improves the confidence of customers, but also that of the organizations providing recognition during the accreditation process. The latter is necessary for confirming the laboratory's compliance with the standard's requirements, thus strengthening its credibility.

Ultimately, once the various challenges have been overcome, the approach taken will enable the CAC (i) to be equipped with laboratories whose competence to produce technically valid data and results, (ii) to participate in interlaboratory comparisons if they are available and (iii) to undergo an accreditation audit byan independent organization. This will, on the one hand, strengthen CAU's links with the economic sector, particularly the regional food industry, and, on the other hand, reinforce the credibility, on the international scene, of the scientific

research activities carried out by teams from the university establishments. Furthermore, international recognition can attract new opportunities for collaboration and funding.

Funding

This research was supported by the European Tempus project n°544564-TEMPUS-1-2013-1-FR-TEMPUS-JPHES.

Conflicts of interest

The authors have no competing interests to declare that are relevant to the content of this paper.

Data availability statement

This article has no associated data.

Author contribution statement

Writing original draft: all authors, Writing-review and editing: Meriem Outaki, Marie-France Thevenon.

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Cite this article as: Meriem Outaki, Sara Benhaida, Majdouline Belaqziz, Abdelkader Outzourhit, Gilles Calchera, Marie-France Thévenon, Luc Martin, Abdérafi Charki, Hamid Ajana, Quality approach towards ISO/IEC 17025 accreditation at the center of analysis and characterization of Marrakesh Cadi Ayyad University: metrology stakes, Int. J. Metrol. Qual. Eng. **15**, 22 (2024)