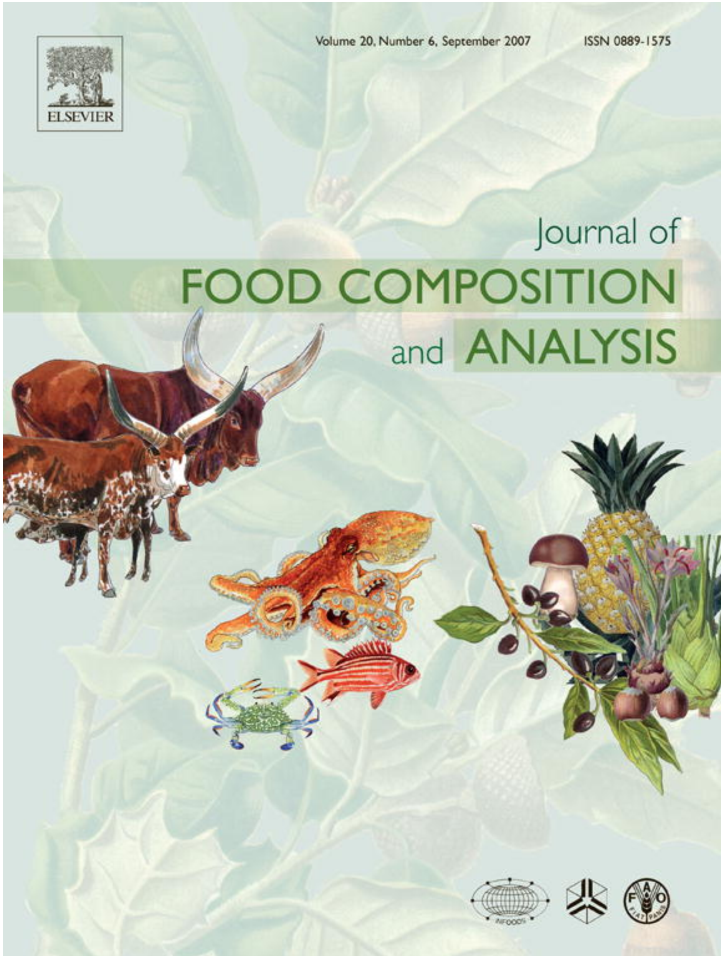
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Commentary

# Metrological concepts for enhancing the reliability of food and nutritional measurements

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**Abstract**

Metrology is a specialized discipline that deals with the science of measurements, irrespective of the field of application and regardless of the size of the measurement uncertainty. Incorporating metrological approaches into the measurement process enhances the reliability of analytical findings. These developments include: high-quality reference standards, validated methods, robust sampling practices, proven calibration approaches, natural matrix reference materials, speciation chemistry, assessment of measurement uncertainty and establishment of traceability links, certified reference materials to facilitate one aspect of traceability, and proficiency testing, among others.


*Keywords:* Metrology; Definitive measurement; Indirect measurement; Uncertainty; Traceability; Conceptual error; Analytical error; Sampling metrology; Food and nutritional metrology

A comprehensive assessment of dietary intake of nutrients and toxicants involves measurements that encompass physiological and metabolic processes. In this context, it is essential to understand (i) the impact of the potential sources of errors arising from the ''bio''dimension of a living system, and (ii) how to minimize such errors to enhance the reliability (i.e. reduce uncertainty) of the analytical findings. The sources include: (i) conceptual errors arising from our limited understanding of the presampling factors such as biological variations, short- and long-term variations reflecting influence of food intake, environmental impact and seasonal variations (e.g. variation of iodine content of milk), among others (Iyengar, 1982); (ii) analytical errors stemming from sampling, sample preparation and matrix effects. Variations arising from biological properties and pathological shifts are identifiable but are not always quantifiable (Iyengar, 1981). Yet, the extent of variability of results due to this must be understood for a meaningful data interpretation (Iyengar, 1989). The sampling part of the metrology reflects its own problems: valid sampling through sample quality, quantity, validity and stability (Heydorn, 1984). Identifying sources of uncertainty followed by establishment of traceability (i.e. internationally accepted credibility links) of measurements in life sciences can be accomplished by adopting metrological concepts used in physical and chemical measurements.

Metrology in physics and chemistry is well advanced, although not in all cases with respect to chemical measurements. The high accuracy measurements in physics for length, mass, time, temperature, electric current, etc., are carried out by definitive methods (measurements based on a specific natural phenomenon). Metrology in chemistry is also advanced as demonstrated by physical chemistry (e.g. molar relationships, volume, pressure, etc.), which follows the principles of metrology in physics. Further, examples are available through classical analytical chemistry (e.g. gravimetry for preparing high-purity standards, related definitive analytical techniques, among others). However, a transition is seen in dealing with chemical measurements in complex chemical matrices (mixed entities, complex compositions), as it adds an additional parameter, namely indirect measurements (e.g. AAS

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determination of Zn in foods, mixed diets). This practice is common in field assays and calls for extra steps to account for traceability to satisfy reliability concerns.

Metrology in biology (i.e. metabolic, physiologic, clinical, food, nutritional and toxicological measurements, etc.) requires that biological parameters should also be considered as part of an analytical evaluation. This is particularly true when measurements such as the bioavailability of nutrients are carried out in human subjects. Typically, the bioavailability measurement involves knowledge of nutrient composition of the food, chemical species of the nutrients, methodologies used (definitive or indirect methods, and if indirect, what measures are adopted to account for traceability and how measurement uncertainties are assessed), and procedures adopted for assessment of sampling metrology issues. In addition, inter-disciplinary (physiological and nutritional) expertize is also required. Other measurements assessed by indirect methods include body composition, dietary energy intake and energy expenditure by traditional methods that lack evidence of a proven traceability link. However, these deficiencies are amenable for metrological improvements using stable isotope techniques based on single- or double-labeled water and utilizing mass spectrometry for ratio measurements. In this context, it should be stressed that systematic studies designed for estimating measurement uncertainties are lacking (Iyengar and Parr, 2005). Bone mineral density as a tool for nutritional assessment (e.g. Ca nutrition and osteoporosis) using dual-energy X-ray absorption method is another example, since multiple parameters have to be met for a valid measurement to be accomplished.

Broader application of metrological concepts for food and nutrition (F&N) measurements is still in its infancy. The silver lining is that many of these measurement processes are amenable for harmonization and facilitate comparability (a vital requirement when results from different laboratories are evaluated). Comparability is broadly understood here as internationally recognized measurement procedures offering some degree of flexibility to address the SI issue because of practical reality faced in F&N laboratories (de Bievre, 2004). Examples are: successful integration of metrological principles into food safety (i.e. food labeling) measurements by internationally accredited laboratories, certification of natural matrix food-based materials for fat, protein, and other dietary measurements (Sharpless et al., 1997), and the IAEA database for reference materials (Arunachalam et al., 2006).

F&N metrology is an emerging discipline and the public health and nutrition investigators should develop awareness for current concepts in measurement practices. It is essential for projecting the reliability of food compositional data, among others. Food safety has become a global issue and it should be recognized that in some parts of the world, movement of foods has assumed the status of borderless-trade. In this context, integration of metrology into F&N measurements strengthens the very base of the institutional measurement infrastructure efforts supported by the Food and Agricultural Organization (FAO, 2004).

In conclusion, the society, as a client and as an end-user, looks at quality assurance (QA) in terms of net economic benefits gained by solving real-life problems that contribute to national development. Thus, economic benefit can serve as a measurable parameter, demonstrating the role of QA in a larger context. Steps undertaken to strengthen laboratory outcomes infuse authority to the F&N measurements as a whole and therefore, enhance the value of ensuing public health decisions. In addition, integration of metrology into F&N measurements strengthens the very base of nutrition education, a nearly forgotten agenda in our academic practices (de Bievre, 2004).

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