World Metrology Day: 20 May 2023

Measurements supporting the global food system

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This theme was chosen because of the increasing challenges of climate change, and the global distribution of food in a world whose population reached 8 billion at the end of 2022 [1].

World Metrology Day is an annual celebration of the signature of the Metre Convention on 20 May 1875 by representatives of seventeen nations. The Convention set the framework for global collaboration in the science of measurement and in its industrial, commercial and societal applications. The original aim of the Metre Convention - the world-wide uniformity of measurement - remains as important today as it was in 1875.
The World Metrology Day project is realized jointly by the BIPM and the OIML.

INTRODUCTION

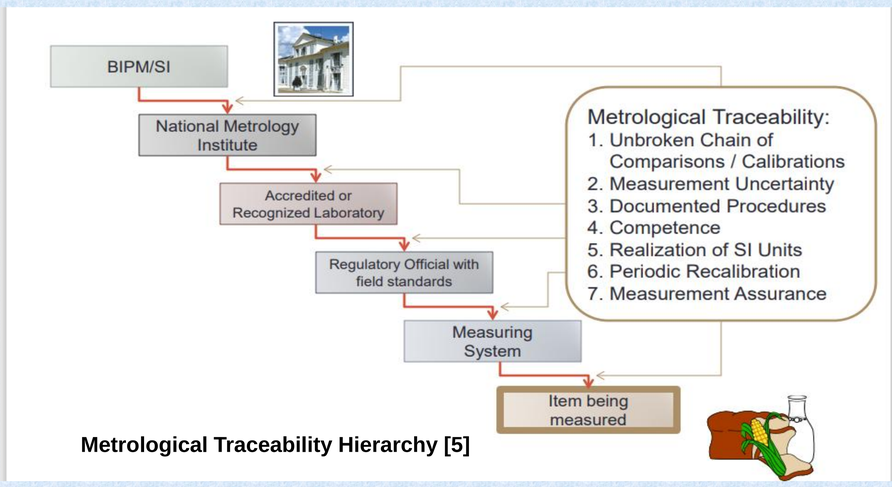
More than ever, the world requires accurate measurement to guarantee further advancements in science and society. Through the use of reliable infrastructure, good measurement supports social advancement and economic prosperity. Providing reliable definitions of measuring units and the realization of main standards for these, from which traceability chains can flow, metrology stands at the top of this quality infrastructure. It also improves these realizations to continue to minimize uncertainties for the end user. Metrology encompasses more than just meters, kilograms, and atomic clocks; it aspires to be more relevant to daily life by, for instance, using the “farm to fork model” and reaching consumers by establishing food origin. Metrology has always accompanied the expansion of brand-new technologies, and it continues to do so in the modern day. Science and technology are better understood when measurements are improved. Better metrology enhances measurement knowledge. Advances in science and technology allow for improvements in metrology. The positive feedback loop that propels human advancement is this one "Good measurement" is what is meant by measurement. That is a measurement that demonstrates the characteristics of stability, comparability (and coherence, if traceable to the SI), with demonstrable, appropriate accuracy and a statement of uncertainty in the measurement values produced, under the supervision of a local quality system and within the larger purview of a national quality infrastructure that promotes widespread confidence in the measurement.

Metrology Concepts on Food

We all have serious concerns about food. One of the biggest issues facing governments throughout the world is continuing to provide access to healthy, cheap food. Farmers and food producers that sell their goods to customers on a global, national, and local scale through distributors and merchants share this objective. This commerce represented 20% of total world trade in 2021 and had a value of 22 trillion USD.
Producers must be able to demonstrate that they adhere to food standards in order to conduct business worldwide and gain access to markets for high-value goods. Governments also need to guarantee fair trade and safety, particularly in local food markets. Reliable assessments of the amount and quality of raw and processed food items provide evidence for all of this.
For example[1]:

- The quantity of food bought and sold is measured according to its mass or volume. These measurements range from the large volumes of grain and wheat traded internationally down to rapid online weighing measurements to ensure pre-packaged goods are labeled correctly;
- The effective storage and packaging of food depends on the accurate control of the temperature and humidity of its storage environment;
- The quality and authenticity of the food is determined by measuring its chemical composition. This requires measurements to ensure that it contains the stated levels of vitamins through to measurements of its isotopic composition to validate the origin of high-value foods such as honey; and
- The safety of food is ensured by careful measurement to detect the presence of chemical contamination such as pesticide residues and heavy metals or biological contamination such as mycotoxins.

It is now recognized that the depletion of natural resources and the impact of climate change pose major challenges to the global food system such that the goal of a world with zero hunger and universal access to clean water was included amongst the Sustainable Development Goals set by the United Nations.



Metrological Traceability Hierarchy [5]

Establishing metrological traceability of measurement results is a prerequisite to obtaining metrological comparability of measurement results. Metrological concepts need to be added to chemical and biological measures in food analysis generally. The definition and implementation of globally recognized units of measurement as well as the (metrological) traceability measured by evaluating uncertainty in relation to national and international Reference Measurements Standards (RMs). Additionally, metrology offers the resources needed to make measurement findings consistent and comparable. The accuracy of measurements is becoming an increasingly important factor in technical and socioeconomic growth, promoting commerce, demonstrating the quality of goods and services, and enhancing the body of knowledge used to make decisions in the forensic, environmental, and health fields. RMs are crucial in implementing metrological principles in food analysis.
For the legitimacy and comparability of measurement findings, the idea of ensuring traceability of the chemical measurement results to the SI units is fundamental [2] To ensure food quality and safety, chemical tests are frequently carried out in the food and medicine industries [3]. Certified reference materials (CRMs) are used as a tool to connect the measurement results to the SI units. Reference material with accompanying documentation from an authorized organization that provides one or more specified property values together with related uncertainties and traceability is referred to as certified reference material. CRMs are often created in batches, with measurements made on samples that are representative of the total to determine the property values within the stipulated uncertainty limits [3]. Metrological considerations need to be added to chemical and biological measures in food analysis generally. RMs are crucial in implementing metrological principles in food analysis.

Ensuring Food Integrity by Metrology

Foods with high "integrity," which is a phrase that encompasses sound, nutritive, healthful, flavorful, safe, authentic, traceable, as well as ethically, safely, environmentally friendly, and sustainably produced foods, are in great demand from consumers. Food chain integrity, in particular, is a multidisciplinary issue that affects every link in the food chain, from producers to consumers, and is based on the safety of chemicals and microorganisms in food, the veracity of food origin, and nutritional value. Two methods are currently thought to be the most effective for ensuring product integrity: the first is to maintain an unbreakable chain of traceability, like the blockchain concept (storage and networking of information in a virtual open space as a decentralized shared ledger), and the second is to rigorously test the products in question using contemporary analytical methods [4]. In analytical Food Chemistry, the problem of food authenticity is becoming more and more significant in addition to food safety. Consumers are becoming more aware of food fraud, especially in food categories including meat, olive oil, spices, milk products, fish, honey, coffee, tea, and juices, which are targeted by producers of tainted goods . Consumer confidence in the food sector declines as a result of incorrect labeling, misbranding, or misrepresentation of food and food components, food packaging, or false or misleading remarks made about a product.

Metrology has always supported the demands of the modern world, and it continues to do so as brand-new technologies proliferate today. Food quality and authenticity are at the center of consumer requirements, and in this way, food safety and traceability play a crucial role in assuring food quality and safeguarding consumer interests.
The agri-food industry has challenges in delivering sustainable and nutritious diets [4].
As part of so-called "precision agriculture," which combines images from sensors and actuators with those from satellites and drones, metrology is also a tool used to identify, for example, the most effective interventions in relation to the actual cultivation needs and the biochemical and physical characteristics of the soil. In reality, the necessity to increase community and territorial resilience, reduce the use of natural resources and chemical and phytosanitary fertilizers, and maximize agricultural productivity has compelled the development of novel crop management strategies in recent years. Thus, metrology may enable the coordination of activities related to the reduction of emissions and the development of information technologies for precision agriculture, such as networks of sensors, geolocation systems, and agrometeorological models, thanks to the experience in the field of meteorological forecasts and the knowledge of historical and current agronomic data [6]. It is challenging to imagine any scientific, technical, engineering, or medical activity that does not rely on measurement traceability, comparison, and uncertainty since measurement space is so vast in science and technology.

[1] “World Metrology Day - 20 May 2023.” https://www.worldmetrologyday.org/ (accessed Feb. 04, 2023).
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[3] A. B. Shehata, A. R. Alaskar, M. A. Alrasheed, A. S. Alosaimi, F. A. Alkharraa, and A. M. Alzahrani, “Certification of sodium benzoate solution reference material by hplc-uv, lc-ms/ms and uv-vis-nir spectrophotometry for food and drug analysis,” *J. Chem. Metrol.*, vol. 14, no. 2, pp. 88–105, 2020, doi: 10.25135/jcm.48.20.08.1780.
[4] *Ensuring Food Integrity by Metrology*.
[5]National Institute of Standards and Technology, no date)
[6] A. Durazzo, E. B. Souto, G. Lombardi-Boccia, A. Santini, and M. Lucarini, “Metrology, agriculture and food: Literature quantitative analysis,” *Agric.*, vol. 11, no. 9, 2021, doi: 10.3390/agriculture11090889.