RECENT ADVANCES IN FOOD ANALYSIS

Ramyashree, S. R.,[1*] Snehal Giri[2*], Rekha, B[3*] and Swetha S. L.[4*]

[1 and 4] Research scholar, Department of Food Science and Nutrition

University of Agricultural Sciences, GKVK, Bengaluru-560065, Karnataka, India

[2]Assistant Professor, Food Science and Nutrition, College of Sericulture, Chinthamani- 563125

[3]Assistant Professor of Horticulture, COA, Hassan -573225, Karnataka, India.

Introduction

Hippocrates' proverb says "Let food be thy medicine and medicine be thy food" indicates the significance of food for human health. Scientists can now prove the impact of food on human health rather than just speculating about it because to recent advancements in analytical techniques. Food science has also advanced significantly in recent years, creating new food products, finding methods for producing them, and enhancing packaging materials, food shelf-life, and sensory properties. Food physical chemistry, which studies both physical and chemical interactions in foods, food microbiology, and food chemistry—all of which are concerned with evaluating the molecular composition of food and its involvement in chemical reactions—all benefited greatly from the new analytical techniques.

Food analysis is the field that deals with the design, utilize, and study of analytical techniques for describing the characteristics of foods and their components. Analysis provides knowledge about the various attributes of food, such as composition, structure, physicochemical properties, and sensory qualities.

Food Analysis - Need and importance

- Currently, there are several problems in food analysis that need to be resolved.
- As a result of industrial expansion, novel farming techniques, environmental contamination, and climate change, the range of harmful residues in food is continuously expanding.
- How to identify untargeted chemicals will be a crucial challenge
- One of the crucial elements in the development of any new analytical approach is sample preparation. As a result, one of the most active fields in analytical chemistry is the study of novel sample preparation techniques.

- The goal of improvements in sample preparation is to reduce the amount of laboratory solvent used and the amount of hazardous waste produced, to save staff labor and time, to lower the cost per sample, and to increase the effectiveness of analyte isolation.
- By adopting the QuEChERS (rapid, easy, cheap, effective, robust, and safe) methodology for assessing pesticide residues in food matrices, the development of porous monolith micro extraction techniques for the testing of veterinary residues in food matrices.
- By the introduction of solid-phase micro extraction (SPME) procedures for the quality evaluation of food products, and the use of immune affinity column clean-up techniques in food analysis.
- The use of liquid phase micro extraction in food analysis and the application of ultrasound-assisted extraction to the identification of pollutants in food and soil samples.
- Supercritical fluid extraction (SFE) and subcritical water extraction (SWE, also known as accelerated solvent extraction), two of the most promising techniques in food science, are currently being explored as novel green sample preparation methods.

Conventional technologies

In the past, analytical methods have been categorized based on how they operate

- They may be spectroscopic, such as by the use of mass spectrometry, nuclear magnetic resonance, infrared, or atomic spectroscopy.
- Biological (polymerase chain reaction (PCR); immunological techniques; biosensors), electrochemical (including biosensors)
- For separation, techniques like supercritical fluid chromatography (SFC), capillary electrophoresis, and high-performance liquid chromatography (HPLC) are used.
- For sample preparation (such as combining separation and spectroscopic techniques), purge and trap (PAT), microwave-assisted extraction (MAE), automatic thermal desorption (ATD), solid phase extraction (SPE), supercritical fluid extraction (SFE) and so forth.

SOLID PHASE EXTRACTION

DEFINATION OF SOLID PHASE EXTRACTION (SPE):

"A solid phase extraction consists of bringing a liquid or gaseous test sample in contact with a solid phase, whereby the analyte is selectively adsorbed on the surface of the solid phase"

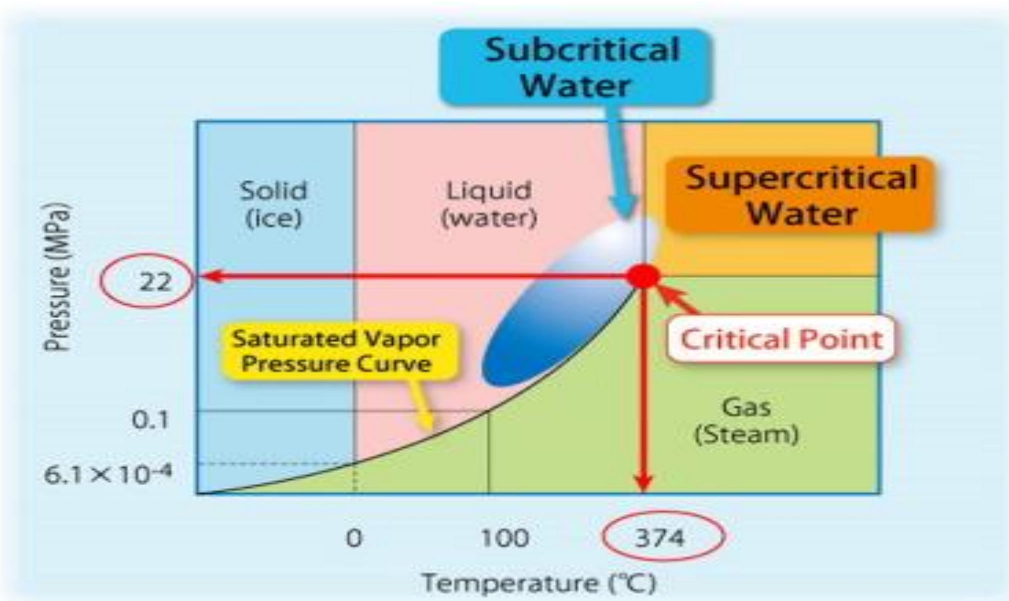
Principle of Solid Phase Extraction

- Compounds can be divided into two states: solid and liquid
- Must be more averse to the solid phase than the sample matrix.
- By eluting compounds with a higher affinity for the analytes, such as those produced by a pH change, compounds remained on the solid phase can be eliminated.

SUBCRITICAL-WATER EXTRACTION (SWE)

An environmentally acceptable technique for extracting antioxidants using only water is subcritical water extraction.

In daily life, the principles of extraction are advantageously applied, for instance, in the production of juices, coffee, and other consumables. To reduce the use of organic solvents and enhance plant material constituents' extraction techniques. At high pressure and temperatures between 100 and 374°C, SWE is a new and effective technology.



Extraction process

Six consecutive steps can be proposed for the SWE process:

(1) Swift liquid entry

(2) Solutes that have been desorbing from matrix active sites

(3) Solvent diffusion through organic compounds

(4) Solute diffusion in porous materials with static fluid

(5) Solute diffusion via a layer of still fluid outside particles and

(6) Elution of solutes via fluid mass flow

Potential of imaging mass spectrometry in characterization of food crops

- Mass Spectrometry Imaging (MSI) is a technique used to visualize the spatial distribution of biomolecules such as peptides, proteins, lipids or other organic compounds by their molecular masses.
- By collecting mass spectra spot by spot, the sample is scanned and the MS data is used to map the distribution of selected compounds across the sample.
- Pictures showing the spatially localized distribution of a compound are produced as a result, pixel by pixel.
- The two ionization techniques that are most frequently used in MSI are DESI imaging and MALDI imaging.
- Understanding the impact of biotic and abiotic stress on crops can be greatly aided by MSI.
- Plant response to environmental conditions may not necessarily result in an excess or deficiency of a particular metabolite, but more frequently results in a change in the metabolite's spatial distribution.
- Following mycotoxin exposure, MSI was recently used to clarify the geographical distribution of secondary metabolites in plants.
- AP-SMALDI, or atmospheric-pressure scanning microprobe matrix-assisted laser desorption/ionization For example, MSI is adaptable enough to encompass a variety of plant metabolites, enabling simultaneous localization information on the potential activation and the spatial, histological distribution of specific metabolic pathways.

- Modern metabolomics in combination with MSI may provide a thorough understanding of the interaction between plants and mycotoxins in this area, revealing potential differences and connections between various metabolites.

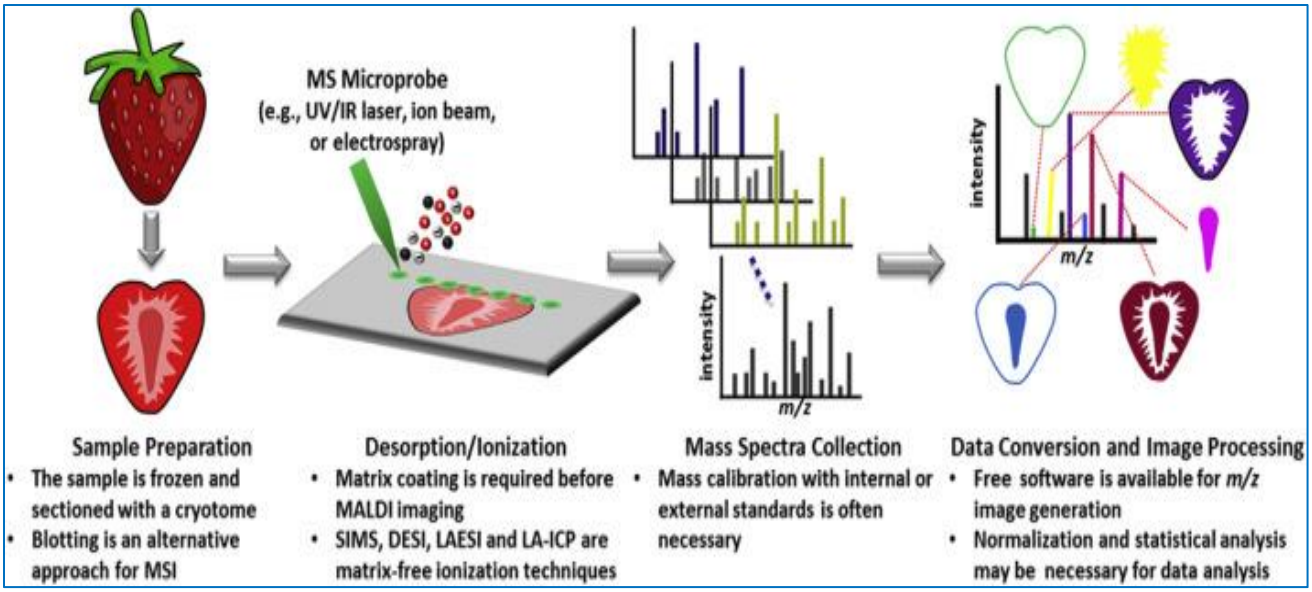


Figure demonstrates cryo section and mounting of frozen sample on a suitable support. The microprobe is sequentially restored across the sample surface after the proper pretreatment (as determined by the limitations of the ionization process and the sample at hand), producing a pixelated array of position-specific mass spectra. Individual ion abundances are plotted using MSI software programs as a function of their location, creating a false color map that reflects the chemical distribution across the sample.

Three dimensional chromatography with quadruple parallel mass spectrometry, lc3ms4, for infant/adult formula analysis

- Spatial comprehensive three-dimensional chromatography (3D-LC) separates components within a three-dimensional separation space, which can result in previously unheard-of resolving power in terms of peak capacity and peak-production rate.
- As commercially accessible instruments multiply, two-dimensional liquid chromatography (2D-LC) is becoming less novel and more commonplace.
- Even with 2D-LC's outstanding capabilities, there are situations when a proper separation cannot be achieved.
- An innovative method was created that combined quadruple parallel (x4) mass spectrometry with dual parallel comprehensive 2D-LC to create three dimensions of chromatography.

- To enable the second 2D separation, two contact-closure (CC) regulated UHPLC switching valves were connected to a timed CC circuit.

Nutrient Analysis Software

This technique allows the user to estimate the nutritional content of food. Standardized recipes are ones that are adapted and retrieved for use by a food service operation. Using the same quantity and quality of ingredients in standardized recipes yield the same results in the nutrition analysis. This analysis is limited by the selection of ingredients available in the food database. This approach does not consider the effects of cooking and processing on the food which can dramatically alter the content. Hence, this software plays vital role in nutrients calculation and advisable for food preparation and analysis widely.

Laser Scanning Confocal Microscopy (LSCM)

In addition to the chemical and physical analysis of food samples, this technique is employed in food analysis and research.

- Unlike the Laser Scanning (LS) technique, the LSCM concentrates irradiation on particular areas of the sample.
- Small areas are illuminated one at a time, boosting contrast and bringing down out-of-focus blur.
- Using image analysis software, the sample's pictures can be examined separately or grouped to create a 3D image.
- The capacity to view optically tiny portions of the food sample gives insight into the product's three-dimensional (3D) structure.
- Compound-specific fluorescent probes are used in LSCM to image the presence, condition, and spatial arrangement of constituents like protein and fat.
- This method makes it possible to closely and in-depth examination of physical condition and movement and distribution of the various dietary components.

Immuno assays

Three factors explain why immunoassays are frequently employed in food analysis to identify and measure proteins in a particular diet.

- First, immuno tests are performed to find low-cost components that are substituted with high-quality goods. Examples of this include adding cheaper meats, such as sheep, goat, and rabbit, or soy proteins, to beef and pork; adding cow's milk to products made from goat's milk; and swapping out more expensive nuts, such as hazelnuts, for less expensive ones.

- The detection and quantification of proteins implicated in food intolerance and allergic reactions is the second use of immuno tests.
- The ability to identify tissue-specific antigens in food that may be linked to transmittable encephalopathies is the third justification for utilizing this technology.

Mass Spectrometry

According to the different mass to charge ratios, ionized atoms and molecules are separated using this technique. The identification of structural elements is made possible by mass spectrometry because atoms and molecules have various patterns of fragmentation. Gas chromatography-mass spectrometry (GC-MS) is used in mass spectrometry to food analysis.

The GC-MS technique is used

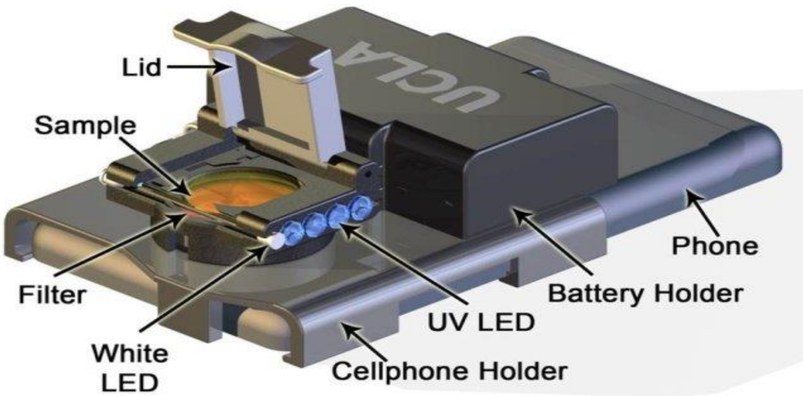
- To analyze substances including sterols, alcohol, fatty acids, and low mass carbohydrates both qualitatively and quantitatively.
- Detecting dietary contaminants such pesticides, pollutants, poisons, and pharmaceuticals is another function of this system. It is regarded as a key technique for identifying fatty acid contents. The measurement of polyphenols in fruits and vegetables is done using GC-MS.

Food smartphone

Food safety was previously seen as a government and industry responsibility. However, as people learn more about food safety and the risks involved, we are seeing an increase in user-friendly food safety tests, such lateral flow immuno assays (LFIAs), which will enable economical and sensitive on-the-go food testing — this is where food smartphones come in.

Smartphones, in our opinion, have the power to revolutionize the food industry.

- Because sophisticated analytical tools, such mass spectrometry (MS), will only be used on suspicious samples that have already been initially screened by end-users using a smartphone-based method, the Food Smartphone strategy can help save laboratory expenses.
- All that is required are a smartphone, a lightweight 3D-printed auxiliary item, and a portable test that can identify a target compound or a certain class of compounds.



BIOSENSORS

A biosensor is a measurement tool made up of a biological component acting as a target recognition entity and a transducer that transforms a biological recognition activity into a quantifiable signal.

Essentially, a biosensor setup consists of three components:

1. Biological receptor for sample analyte bimolecular recognition.

2. A transducer that converts an event of recognition into the proper signal

3. A method of signal analysis and processing detection.

FOODOMICS

The "high-throughput" technologies used to apply the comprehensive omics approach are the key drivers of new analytical approaches. A technique is referred to as high-throughput if it allows for the rapid collection of a huge (or even infinite) number of measurements. The suffixes "ome" and "omics" are derived from the word "genome," which was coined by Hans Winkler 1920, although the use of ome is older, signifying a homogeneous set of items as a whole.

Geneomics, transcriptomics, proteomics, and metabolomics are the four main types of high-throughput omics measurements that are frequently carried out. A number of omics sub-disciplines, each with their own set of tools, methods, reagents, and software, have also started to emerge, including lipidomics, interactomics, metallomics, and diseasomics.

By using cutting-edge omics technology, the field of foodomics explores the food and nutrition domains with the goal of enhancing consumer well-being, health, and knowledge.

The main aim behind the use of this new term was to highlight the fact that the investigation into both traditional and novel problems in food analysis in the postgenomic era and can find exciting opportunities and new answers through the use of epigenomics, genomics, transcriptomics, proteomics, and metabolomics as emerging technologies.

Transcriptomics enables the development of microbial mitigation techniques for ready-to-eat food products and the demonstration of the regulation of the global gene expression profile by various nutrients in relation to illness prevention.

According to Shukla and George (2011), **proteomics** can significantly contribute to both food safety and the prevention of cancer through dietary bioactives.

In food science as well as nutrition research (Puiggrs et al. 2011), **metabolomics,** the systematic study of the distinct chemical fingerprints that particular cellular processes leave behind, is quickly emerging as a core methodology.

REFERENCES

- R. J. Mcgorrin, "One hundred years of progress in food analysis," Journal of Agricultural and Food Chemistry, vol. 57, no. 18, pp. 8076–8088, 2009.
- A. Cifuentes, "Food analysis and foodomics," Journal of Chromatography A, vol. 1216, no. 43, pp. 7109–7110, 2009
- C. M. Lok and R. Son, "Application of molecularly imprinted polymers in food sample analysis—a perspective," International Food Research Journal, vol. 16, no. 2, pp. 127–140, 2009
- V. F. Samanidou and E. G. Karageorgou, "An overview of the use of monoliths in sample preparation and analysis of milk," Journal of Separation Science, vol. 34, pp. 2013–2025, 2011
- F. Wei and Y. Q. Feng, "Methods of sample preparation for determination of veterinary residues in food matrices by porous monolith micro extraction-based techniques," Analytical Methods, vol. 3, no. 6, pp. 1246–1256, 2011
- A. Wilkowska and M. Biziuk, "Determination of pesticide residues in food matrices using the QuEChERS methodology," Food Chemistry, vol. 125, no. 3, pp. 803–812, 2011.
- H. Z. S¸ enyuva and J. Gilbert, "Immuno affinity column clean-up techniques in food analysis: a review," Journal of Chromatography B, vol. 878, no. 2, pp. 115–132, 2010.
- S. Balasubramanian and S. Panigrahi, "Solid-phase micro extraction (SPME) techniques for quality characterization of food products: a review," Food and Bioprocess Technology, vol. 4, no. 1, pp. 1–26, 2011.
- J. L. Tadeo, C. Sanchez-Brunete, B. Albero, and A. I. Garc ´ ´ıaValcarcel, "Application of ultrasound-assisted extraction to ´ the determination of contaminants in food and soil samples," Journal of Chromatography A, vol. 1217, no. 16, pp. 2415– 2440, 2010.

- M. Asensio-Ramos, J. Hernandez-Borges, A. Rocco, and S. ´ Fanali, "Food analysis: a continuous challenge for miniaturized separation techniques," Journal of Separation Science, vol. 32, no. 21, pp. 3764–3800, 2009.

- M. Asensio-Ramos, J. Hernandez-Borges, A. Rocco, and S. ´ Fanali, "Food analysis: a continuous challenge for miniaturized separation techniques," Journal of Separation Science, vol. 32, no. 21, pp. 3764–3800, 2009.

- M. D. Marazuela and S. Bogialli, "A review of novel strategies of sample preparation for the determination of antibacterial residues in foodstuffs using liquid chromatography-based analytical methods," Analytica Chimica Acta, vol. 645, no. 1- 2, pp. 5–17, 2009.