Laboratory Training in Biotechnology Applied To Diagnostic Activity in Food Safety

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The main goal of this presentation is to provide a comprehensive resume of modern biotechnology methods that can be applied to diagnostics in the entire scope of the food industry.

Introduction:

While covering conventional (typically lab-based) methods of analysis, this presentation focuses on leading-edge technologies that are being (or about to be) introduced. We are going to review its relevance to areas such as:

i. food quality assurance
ii. safety, and
iii. traceability

In the process, this review is going to cover issues such as:

i. improved quality control
ii. monitoring pesticide and herbicide residues in food
iii. determining the nutritional content of food, and
iv. distinguishing between GM and "conventional" foodstuffs

Thus, we shall proceed to review those sixteen outstanding **techniques/considerations** that have become widely used for the biotechnological analysis of foods and are currently included in modern laboratory training in biotechnology as applied to diagnostic activities in Food Safety:

1 Assuring Safety and Quality along the Food Chain

Throughout such a training, primary consideration is given to issues about safety and quality along the food chain. Increased globalization, industrialization, and sophistication of food production and trade have considerably increased the need for:

i. improved process control
ii. process management, and
iii. communication inside enterprises, but especially ***between enterprises along the vertical food production chain***.

2 Methodologies for Improved Quality Control Assessment of Food Products

A technique such as Fourier Transform Infrared (FT-IR) spectroscopy combined with Principal Component Analysis (PCA) can be used as a rapid tool for the analysis of polysaccharide food additives and to trace food adulterations. PCA and Partial Least Squares (PLS1) regression are chemometric methodologies that allow significant improvements in data analysis when compared with univariate analysis.

For example, it is noteworthy that screening and distinction of coffee brews can be done based on the Combined Headspace (HS)–Solid Phase micro-extraction (SPME)–Gas Chromatography (GC)–PCA (HS-SPME-GC-PCA) methodology.

Meanwhile, a new methodological approach based on cyclic voltammetry for assessment of quality control for cork stoppers, which has been recently proposed for the rapid screening of cork-wine model interactions can be employed to determine if the cork stoppers are able to contaminate a wine.

3 Application of Microwaves for On-line Quality Assessment

Wide experience has now been accumulated in the field of microwave applications. Sensor systems based upon microwaves can be taught as a viable nondestructive method of on-line control.

4. Ultrasounds for Quality Assurance

Meanwhile, ultrasounds of foods are also being applied for quality assurance, including evaluations of texture, viscosity, density, and particle size.

5. NMR for Food Quality and Traceability

Applications of Nuclear Magnetic Resonance (NMR) in food science are being taught and utilized as a versatile and powerful technique closely focused on “food quality and traceability”. In particular, examples of applications of NMR in the fields of food quality (nutritional, sensory, freshness) and traceability (geographical origin, botanical origin, animal species, process technology applied to foods) have been undertaken.

6. Electronic Nose for Quality and Safety Control

Rapid early detection of mold activity in food throughout the food chain is required as part of a quality assurance program and to enable critical control points to be effectively monitored. The rapid development of electronic nose (e.nose) technology has resulted in examination of the potential of using this qualitative approach to decide the status of raw materials and processed food, including bakery products. The recent developments of electronic nose and also of **electronic tongue technology** with applications for different foods are important tools that are highly rated in today’s diagnostic activities.

7. Rapid Microbiological Methods in Food Diagnostics

Meanwhile, "Rapid microbiological methods" has now become a dynamic area in applied microbiology dealing with the study of improved methods in the isolation, early detection, characterization, and enumeration of microorganisms and their products in clinical, food, industrial, and environmental samples. In the past 15 years this field has emerged into an important subdivision of the general field of applied microbiology and is gaining momentum internationally as an area of research and application to monitor the numbers, kinds, and metabolites of microorganisms related to food spoilage, food preservation, food fermentation, food safety, and food-borne pathogens.

8. Molecular Technologies for Detecting and Characterizing Pathogens

Molecular diagnostic techniques are based on the detection of a fragment of genetic material (nucleic acids, i.e., DNA or RNA) that is unique to the target organism, and as such they are highly specific. One of the most practical and useful applications of molecular tools is their specificity as they target genetic regions unique to the organism, and depending on the gene target, they can also yield valuable information about virulence properties of the organism. They are also invaluable in detecting and identifying infectious agents.

9. DNA-Based Detection of GM Ingredients

Applications of DNA-based methods to the analysis of foods are also important. In the last decade the need for methods to **detect** and to **quantify** DNA from Genetically Modified Organisms (GMOs) has been a major driver for the development and optimization of PCR-based techniques. Therefore, this field of application is used to outline principles, challenges, and current developments of DNA analysis in foods. In addition, DNA-based approaches in the areas of **food authentication**, **detection of food-borne pathogenic microorganisms**, and **screening for food allergens** are valuable tools currently in use.

10. Protein-Based Detection of GM Ingredients

The advantages and limitations of **protein detection for GMOs** are important techniques to be considered. Specific attention is also focused on the use of these methods in the traceability of GMOs along the production chain.

11. Immunodiagnostic Technology and Its Applications

In comparison to other analytical methods such as HPLC, electrophoresis, gas chromatography, or mass spectrometry, **immunoassays** can provide highly sensitive and specific analyses that are rapid, economical, and relatively simple to perform, and is more so flexible since there are a wide variety of immunoassays formats. As such, a critical appraisal of their applications in food analysis is necessary to be included in modern training programs.

12. Rapid Liquid Chromatographic Techniques for Detection of Key (Bio) Chemical

Markers

High Performance Liquid Chromatography (HPLC) constitutes a technique that has become widely use for the analysis of foods. It is being used for a large number of applications, which include the analysis of nutrients, chemical and biochemical contaminants, markers for processing control, detection of adulterations, and control of raw materials and products. HPLC has been traditionally used for almost all these tasks, but the actual challenge is to improve the throughput to better compete with other techniques that have been appearing lately. The fundamentals of this technique and a summarized description of these applications are included in many training options. As **sample preparation is the most tedious and time-consuming step in food analysis**, a focus on those methodologies with less sample manipulation before HPLC analysis are critically important.

13. Sampling Procedures with Special Focus on Automatization

Modern sample preparation techniques are normally done with regard to subsequent analytical methods. In the majority of cases, sampling procedures cannot be considered separately but have to be considered as a combination of analyte extraction and measurement. The most important extraction methods are usually based on aroma and flavor analytics, since related compounds cover a wide range of different chemical classes and properties. Further focus can be directed to specific extraction and analytical methods for the **main food ingredients: lipids, proteins, and carbohydrates**. These methods are often characterized by conventional extraction procedures followed by specific analytical techniques.

14. Data Processing (Chemometrics)

This encompasses various techniques for data display, classification, modeling, and calibration. Here it is necessary to appreciate the great superiority of multivariate analysis over the commonly used univariate approach. So although “Chemometrics” is easy and powerful indeed, we need to always think in a multivariate way.

15. Data Handling

Data handling includes all activities dealing with data, from their collection (How should experiments be set up? How many samples/measurements are required?) to their transformation into useful information (Which method should be used?) so as to answer a specific question.

16. The Market for Diagnostic Devices in the Food Industry

Finally it is worthy to note that trainees need to have a sound knowledge of the market for diagnostic devices in the food industry. **The industry is in general driven by consumer demands and by governmental legislation**. Over the last decade an immense change with consumers has taken place. Food has changed from an energy and nutrient source to a product that influences the well-being of individuals.

Consumers realize that food may have a significant impact on their lives, and consequently they demand **higher quality** and **fresher products**. Moreover, it is now known that a large part of the population is **allergic to some foods**. In rare cases allergens may have severe - even life-threatening consequences.

Consumers therefore need to know **what is in the food they buy**, and regulators try to provide this information because consumers assume that governments ascertain that food is always safe. This puts severe pressures on the industry that now needs to **comply with accurate labeling** and **stringent tracking** and **tracing systems** to be able to respond instantly to any (***real***, ***potential***, or ***perceived***) incident.

On top of these requirements, the industry is faced with the complexity of today's supply chains. ***Ingredients are sourced from all over the world (globalization), spreading food-related hazards as fast as the ingredients and products move. Consequently, surveillance must be stepped up to be able to keep hazards with microorganisms, toxins, allergens (labeling), and chemical contamination under control***.