FT-NIR AND ITS APPLICATION IN FISHERIES SECTOR

Tejpal, C. S., Lekshmi R.G. Kumar., Renuka, V & Anas, K.K

Biochemistry & Nutrition Division

ICAR-Central Institute of Fisheries Technology, Kochi-29

Introduction

Although in 1800, Herschel discovered light in the near-infrared region (NIR), the acceptance of the NIR region of the electromagnetic spectrum as a valuable tool can be credited to two investigators. First, Karl Norris in the 1960s who worked on instruments that could record NIR spectra and applied multivariate treatment of the spectra to determine major plant components (Norris, 1996). Second, Phil Williams in the 1970s, who recognized the potential of the technology to segregate wheat grain according to protein content (Williams, 1995). Since then, the development of equipment featuring improved electronic and optical components, as well as the advent of computers capable of effectively processing the information contained in NIR spectra, has facilitated the expansion of this technique in an increasing number of fields. In recent past, the use of near-infrared spectroscopy (NIRS) for the assessment of mineral composition and trace elements in plant and animal tissues, has opened new horizons to NIR spectroscopists dealing with the application of this technique to the agricultural, medical, food safety and environmental fields (Font et al., 2007). Infrared energy is the electromagnetic energy of molecular vibration. The energy band is defined for convenience as the near infrared (0.78 to 2.50 microns); the infrared (or mid-infrared) 2.50 to 40.0 microns; and the far infrared (40.0 to 1000 microns). In the recent past, the FT-Near-infrared (NIR) spectroscopy has gained much importance as a non-destructive analytical technique and it has become the tool of choice in several fields of application (Bec et al., 2021). Similar to the IR and Raman techniques, NIR spectroscopy extracts information from the sample through molecular vibrational. Spectral region for NIR is 12 500–4000 cm^{-1} or 800–2500 nm, and it measures the absorption of light from the sample in the NIR region at different wavelengths. The recorded NIR spectrum consists of overtones and combination vibrations of molecules that contain CH, NH or OH groups. This makes NIR spectroscopy the first choice for the analysis of organic materials in the chemical and pharmaceutical industry, as well as in the food, feed and agricultural industries. Near-infrared spectroscopy is primarily a more of quantitative technique (Whetsel, 1968).

Advantages of FT-NIR

- The low absorptivities of absorption bands are compatible with moderately concentrated samples and longer path lengths than those used in the mid-infrared region.
- It is a non-destructive technique because sample preparation is avoided.
- As the sample preparation step has been avoided in NIRS analysis being very simple to perform so that there are few operator-induced sources of error.
- Measurement and result delivery is fast.
- It is an environmentally friendly analytical technique, as no chemicals are used during the process.
- Many components of the material being analyzed can be determined simultaneously from a unique spectrum, and not only chemical but also physical parameters can be determined on the sample.
- The accuracy of an NIR analysis is comparable to that of the chemistry reference method, and its precision is usually high because the avoidance of sample treatment.

Disadvantages of FT-NIR

- The complexity of the NIR spectrum requires chemometric techniques to extract the relevant information to the component being measured.
- In constructing the calibration models the whole physical and chemical variability predicted to be present in the population must be added to the calibration set of samples. This implies continuous addition of new samples to the original set to encompass all variations.
- No specific methodology for transferring calibrations between instruments has gained widespread acceptance in recent years.

Relevance of IR and NIR in Agriculture

Infrared radiation is absorbed, transmitted, and emitted by compounds, depending on the vibrations of the chemical bonding between component atoms or molecules. The vibrations' frequencies determine the parts of the infrared spectrum that they absorb, transmit, or reflect. Thus, each molecule or compound has its unique fingerprint or spectral signature. Based on the spectral signature, it is possible to know the size, shape of atoms and molecules, and the bonds holding them together. The information on the structure of the compounds helps to identify the makeup of compounds or plants. Depending on the interaction with light, it is also possible to determine the amount of these compounds. Therefore, infrared light is valuable in studying the different compounds and their concentrations.

Applications of NIRS in fish and fishery products

In the recent years, NIR spectroscopy has given wide array of applications many fields. But this chapter we are restricting to applications in fishery sector. NIR is generally used in fish quality control, fish authenticity and fish safety aspects. Fish quality control refers specially to the determination of the proximate composition of the fish samples and the evaluation of the freshness of the products (Liu. et al., 2013). The proximate composition determines the organoleptic quality of a specific fish product. At the same time, the determination of the freshness of samples is another indicator of the quality of the product. Nowadays, NIRS is becoming an alternative as a quality control method, due to its advantages over traditional analysis (Karlsdottir et al., 2014). The globalization and expansion of the fish and aquaculture sector, in addition to the increasing public concern about food quality, have caused a growing interest in several issues related to fish authenticity. According to the European Regulation (EU) n. 1379/2013 (European Regulation (EU) n. 1379/2013), fishery and aquaculture products must be labelled with the commercial designation, proper scientific name of the species, production method (e.g. caught, farmed), fishing gear (e.g. hook, trap, trawl), catch or production area and storage method (unfrozen or frozen-thawed). Both the geographical origin and the production method, among others, can strongly affect the characteristics of the two types of products, whose discriminating properties are usually difficult to determine. Several analytical techniques have been traditionally used to assess fish authenticity. However, even though they are well established, there is still a necessity for faster, easier and more affordable methods. The substitution of valuable species with cheaper ones is most commonly happing food fraud in fish and fishery products. However, the differences in the economic value, the exploitation of endangered species, the replacement with poisonous fish and their difficult identification, make the substitution of fish species an extended problem, especially severe after processing, at the retailers and supermarkets (Blanco-Fernandez et al., 2021). The mentioned frauds particularly affect fish fillets and ready-to-eat products, such as fish products, which cannot be recognized through the traditional morphological analysis. The use of NIRS with the objective of discriminating between species has been explored during the recent years (Ghidini et al., 2019).

NIR Applications

NIR is a technology seemingly tailor-made for agriculture, not only for research but also for growers, packers, and distributors. Today's devices are sophisticated and give rapid measurements that are easy to understand and use in real-time. They are precise enough for use in research and complement existing equipment, taking the guesswork out of farm management, while becoming ever-more user friendly. NIR scanners are more widespread and developed for spot measurements, with imaging applications gradually gaining popularity. Smaller and portable tools are more affordable than ever and will continue to be an essential step in bringing quantifiable scientific value to the food supply chain, saving stakeholders time, money, and resources.

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