# Spectroscopy in Food Industry

Spectroscopy is used in physical and analytical chemistry to detect, determine or quantify the molecular or structural composition of a sample. It is the study of the interaction between matter and electromagnetic radiation as a function of the wavelength or frequency of the radiation. This case study is about Near Infrared Spectroscopy (IR) and its applications in food industry. The IR forms that part of the electromagnetic spectrum in the wavelength range 780 nm to 2500 nm.

The IR spectroscopy is used routinely for the compositional, functional and sensory analysis of food ingredients, process intermediates and final products. Milk analyzers based on mid IR spectroscopy have been available since the 1960s but it was not until much later that IR began to be used in the dairy industry. Although the mid IR is satisfactory for the proximate analysis of liquid milk, dairy chemists are faced with one of the widest ranges of sample types in the food industry. IR has a key role in the analysis and process control of dairy products. It offers flexibility in the analysis of protein, moisture, fat and lactose contents in a wide range of dairy products including liquid milk, dried whole milk, skim milk and whey powders, cream, traditional and processed cheese. Many of these products are emulsions whose sampling for classical chemical analysis is difficult. For example, blending such samples changes their physical characteristics. IR offers the possibility of on-line analysis which avoids the need for batch sampling and minimizes sampling error by averaging of virtually instantaneous, continuous measurements. Milk powders are analyzed on-line using a powder analyzer which enables the moisture content to be controlled. For most other on-line applications, fiber-optic probes are used. These have the advantages of minimal maintenance owing to the absence of moving parts, robustness to high temperatures and pressures and the survival of clean-in-place protocols involving the use of caustic chemicals. Two examples of on-line IR fiber-optic measurement in dairy processing are moisture control of cream cheese and processed cheese. Cream cheese is manufactured in a series of set tanks from which product is transferred into a separator. IR monitoring of the product from the separator enables compensation for the variation in characteristics from different set tanks. IR measurements of processed cheese have been used for process diagnostics in which a greater understanding of the effect of temperature on the final moisture content has been gained. The extent of development of IR applications in the dairy industry is such that it is possible to purchase an instrument, which is factory-calibrated for proximate analysis of cheddar cheese. However, these calibrations are only valid for cheddar made to the traditional recipe and sampled directly from the vat; non-traditional and matured cheddars require different calibrations.

IR spectroscopy is widely used in the meat industry for proximate analysis. A special interactance fiber-optic probe has been designed to spear carcasses and determine their fat content. This enables the carcasses to be sorted prior to butchering. Dedicated instruments are available to determine the protein, fat and moisture contents of ground meat and meat products and factory-set calibrations are available for cooked meat, cooked ham, liver sausage, and pepperoni. Meat samples are minced then blended in a food processor before being packed into an open sample cell. The amount of sample needs to be controlled either by mass or by depth. Fresh fruit and vegetables are graded by shape, size and color. Objective, nondestructive methods of sorting enable growers and packers to market a consistent product over an extended season. In addition, high-quality produce can be segregated for high-return markets while lower-quality produce can be identified for processing or other uses. The nondestructive sorting of fruit for ripeness by optical spectroscopy was originally carried out in the visible region. However, the availability of fiber-optic interactance probes led to a resurgence of research interest in this application via the determination of sugar content. The reason for developing a direct measure of sugar content of fruit is that appearance is not a reliable guide to sweetness. Japanese researchers have demonstrated the successful application of IR to the on-line determination of sugar content in intact peaches and mandarins and developed an automated fruit-sorting machine based on this principle. Australian scientists have extended this concept to tropical fruits such as melons, mangoes and pineapples.

When barley is germinated under controlled conditions, it undergoes a series of complex biochemical reactions, which result in its conversion to malt. The malt is then mashed with water to produce a liquid called wort, which is then fermented to produce beer. Since malting takes about twelve days, barley breeders need a rapid means of predicting the malting quality of barley grain. Calibrations have been developed for nitrogen, lysine, b-glucan and malt hot water extract. As with wheat functional quality, IR analysis of barley is used to predict the quality of material that is derived by processing of the grain and there is doubt whether tests on ungerminated grain fully account for the interaction of enzymes and substrates during germination. Attempts have been made to improve the accuracy of prediction by analysis of key quality characteristics of the malt or the wort. In the brewing industry, IR is widely used to monitor the original gravity and alcohol content of beer using online flow-through cells. Standard errors of the calibration for alcohol of 0.1–0.2% have been reported.2/ using either transmittance or transflectance cells. The Liquidate probe has been used to achieve a process guarantee on any beer to better than 0.04% alcohol. IR is used to monitor fruit quality and determine the alcohol content of wine and dedicated filter instruments for wine analysis are commercially available.

The major advantage of IR is that usually no sample preparation is necessary, hence the analysis is very simple and very fast (between 15 and 90 s) and can be carried out on-line. One of the strengths of IR technology is that it allows several constituents to be measured concurrently.