QUALIFYING FOODS BY NEAR INFRARED REFLECTANCE SPECTROSCOPY

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Summary

The physical methods used for determining quality parameters are summarized and the NIR technique has been dealt with enlightening the results attained with this method for the quick, accurate, non-destructive quality determination and composition analysis of row meats, fruits, vegetables, sunflower seed, pastas (pastries), cocoa powder, wine etc.

The application of promptly measurable selective physical parameters has been used for a long time for determining the constituents of certain products, however, with an increasing need for accuracy their use has decreased. The measuring alteration method applies several non-selective physical parameters of the samples, independent of one another, to transform the measured values for determining their composition. This method has been successfully used for determining the composition of drinks, brines and dairy products, usually measuring physical parameters in an equal number of constituents, thus sensors and measuring instruments of the same number had to be used. In several cases, due to the texture of foodstuffs, the measurement of physical parameters proved to be extremely difficult. In the past years, however, limiting the physical parameters to optical properties paradoxically facilitated the widening of the applicability of this method. This was a result of the findings according to which we measure the transmission or reflection properties, respectively, at different wavelengths characteristic of a constituent to determine composition. Optical properties can be measured independent of the consistency of the sample, accurately and non-destructively, and many independent parameters can be measured with one and the same detector (sensor).

The basis of the above idea is that a beam reflected or transmitted contains the needed information about the irradiated material. The information is hidden in the spectrum of the reflected or transmitted beam which must be—of course—related to the spectrum of the incident beam. In the case of food products or other opaque materials, however, the incident beam will be reflected or transmitted diffusely. Therefore, as illustrated in Fig. 1 we relate the flux reflected by the sample reaching the detector to the flux which would be reflected into the same beam-geometry by an ideal (loss-less), perfectly diffuse

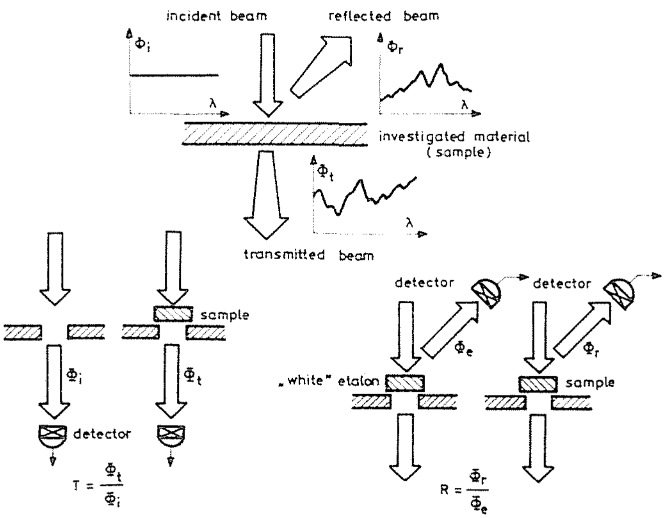

Fig. 1

(Lambertian) material; the spectrum will be given by this ratio (R) in the function of the wavelength. In case of transmission the ratio of the fluxes reaching the detector with and without the sample (T) will be given in the function of the wavelength.

A large number of food components have absorption peaks in the near infrared spectral region of 1000–2500 nm; therefore, this region is particularly useful for determining the composition of food products. In Figure 2 the spectra of some significant components such as protein, fat, starch and water are shown.

The transmission or reflection spectra of the majority of food products are complex, due to the overlapping of absorption bands and blurredness of absorption peaks. Thus, in order to determine the percentage of components, complicated mathematical methods had to be employed alongside with the sophisticated transformations of the original spectra.

Lately a world-wide boom in the application of the NIR technique can be experienced together with the widening of its application field. Recognising the importance of this technique Hungary has also joined in this activity both in research and development, as well as in production and application. Certain results have been achieved, some of them will be illustrated here.

In cooperation with the experts from the National Meat Research Inst. good results have been achieved using non-destructive, rapid methods, namely measuring optical properties for determining protein, fat and water content of *raw meats* such as beef, pork and bacon. With measurements in the near infrared wavelength region it proved possible to determine protein content with a standard error (*SE*) of 0.5 mass %, the fat content with an *SE* of 0.9 mass %, the water content with an *SE* of 0.8 mass %. Results are being applied using INFRAPID 61 type instrument through the help of the experts in meat factories and Labor MIM, the producer [1, 2].

With the help of the experts from the Research Institute for Fruit Growing and Ornamental Plants we have achieved to determine relationship between optical properties and ripeness together with compositional data in *stone fruits:* cherry, sour-cherry and apricot. Our examinations were extended on different species and their varieties; different years of production; different producing areas. The standard error for determining ripeness of cherry is 4%, of sour-cherry is 3%, of apricot is 3% using the $\log(1/R)$ spectrum values measured at two different wavelengths. The economic analyses as regards the practical application of results are underway both in production and processing [3, 4].

Good results have been achieved in determining relationship between composition parameters and optical properties of *vegetables* mainly peppers, tomato and carrot. Identifying chlorophyll, oils, carotenoids, fibers was rather successful together with the help of experts from the Research Institute for Canning Industry. The standard error for determining moisture in green peppers was 1 mass %, while in paprika powder was 0.5 mass % using NIR technique [5].

The experts from Research Institute for the Vegetable Oil and Detergent Industry contributed to determining relationship between *sunflower seed* oil, protein, moisture and fiber content, as well as their respective optical properties. The standard error for determining oil content was 0.64 mass %, for protein content 0.65 mass %, for fiber content 0.95 mass % using reflection

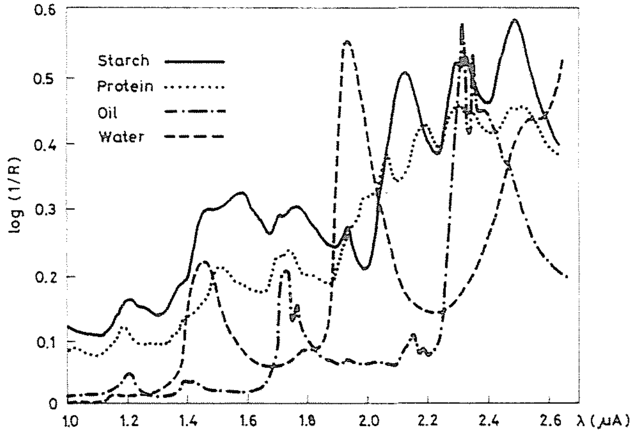

Fig. 2

spectrum values measured in the near infrared wavelength range. The method is being introduced in vegetable oil industry. Preliminary tests are also being performed as regards relationship between vegetable oil saturation and optical properties [6].

For digestion *bran* is a significant source of dietary fiber. In collaboration with dietary experts of the Medical University we elaborated a quick, non-destructive NIR-method for determining dietary fiber content, as well as its components. The standard error for dietary fiber content was 0.3 mass %, for water-soluble components 0.6 mass %, and for water-non-soluble components 1 mass %. [7]

We elaborated a NIR technique for determining the egg content, protein and fat content of *pastry products* together with the experts from the Research Institute of Flour Milling and Backing Industries. Our results were: standard error for determining protein content was 0.24 mass %, fat 0.11 mass % and egg content 0.09 egg/kg pastry [8, 9].

The experts of the Centre of Food Control and Analysis of the Ministry of Agriculture and Food contributed to our work in generating a form of equation with which relationship could be established between *cocoa-powder* carbohydrate, fat, protein content and relevant optical properties. The standard error for fat content was 0.13 mass %, for carbohydrate content 0.22 mass %, for protein content 0.18 mass % using the NIR technique [10].

Analyzing *wine* using the NIR technique was performed together with experts from the University for Horticulture and National Wine Control Institute. Promising results have been achieved in determining alcohol, extract, sugar, and acid content [11, 12].

The above mentioned results could be achieved with the Neotec 6450 type research composition analyzer (RCA). The RCA works within the wavelength-range of 250 nm to 2500 nm. This range is shared between two monochromators each working in two regions with certain overlap. The instrument can take and store a spectrum containing 700 or 1400 transmission or reflection data of six digits every 400 ms. The equipment works with unusually high energy, thus its beam is able to penetrate through intact fruits and vegetables to produce spectra up to a $\log(1/R)$ value of 8.

Our research work aimed at determining one or more characteristic wavelengths for different food products and also to create the most suitable forms of regression equations for the constituents in question and also determining the coefficients and constants of these equations. In possession of these, there is a possibility for constructing cheap, simple single-purpose instruments for a rapid and non-destructive determination of composition. Such an instrument can already be used by a simple trained worker and can save a lot of time.

The revolutionary development of the means of NIR-technique, i.e. light sources, dispersive elements, sensors and their respective computer elements has resulted in achieving accuracy as good as with wet-chemistry methods in the case of components in the studied products; moreover NIR technique has provided us with such depths of knowledge and details which has so far never even been thought of.

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