# FOOD RESEARCH AND DEVELOPMENT

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**Keywords:** non-destructive quality assessment, near-infrared spectroscopy, predictive microbiology, growth dynamic model, simulation, food development issue

## Contents





## Summary

In food systems consisting of production, distribution and consumption, it is essential for producers, processors and consumers to assess and control food quality. Near-infrared (NIR) spectroscopy is one of the new techniques for assessing food quality. If a NIR calibration model (relationship between near-infrared spectra and item quality) is developed, it could be used for rapid non-destructive quality assessment.

A microbial growth model can be used for predicting the growth of pathogens in salad vegetables under real temperature conditions during distribution. This model can be used for reducing and controlling the microbial risks of fresh fruit and vegetables. To improve the quality of human life, food research and development are always being conducted for human health, and safe, nutritious and high quality foods.

## 1. Introduction

The amount of food production in the world has been increasing every year. Food systems consisting of production, distribution and consumption have become huge and complicated since the middle of 20th Century. In the food systems, it is essential for producers, processors and consumers to assess and control food quality. In this chapter, non-destructive quality assessment and predictive microbiology are introduced and issues of food development in the 21st Century are discussed., and recent issues of food development are discussed.

## 2. Non-destructive Quality Assessment of Foods

### 2.1. Non-destructive Quality Assessment

Quality assessment of foods is essential for food research and development. Chemical and physical analyses are conducted by using various chemicals and instruments to assess food quality, and the analyses are usually time-consuming and costly. When a sample has been used for chemical or physical analysis, it usually can not be used for other analyses.

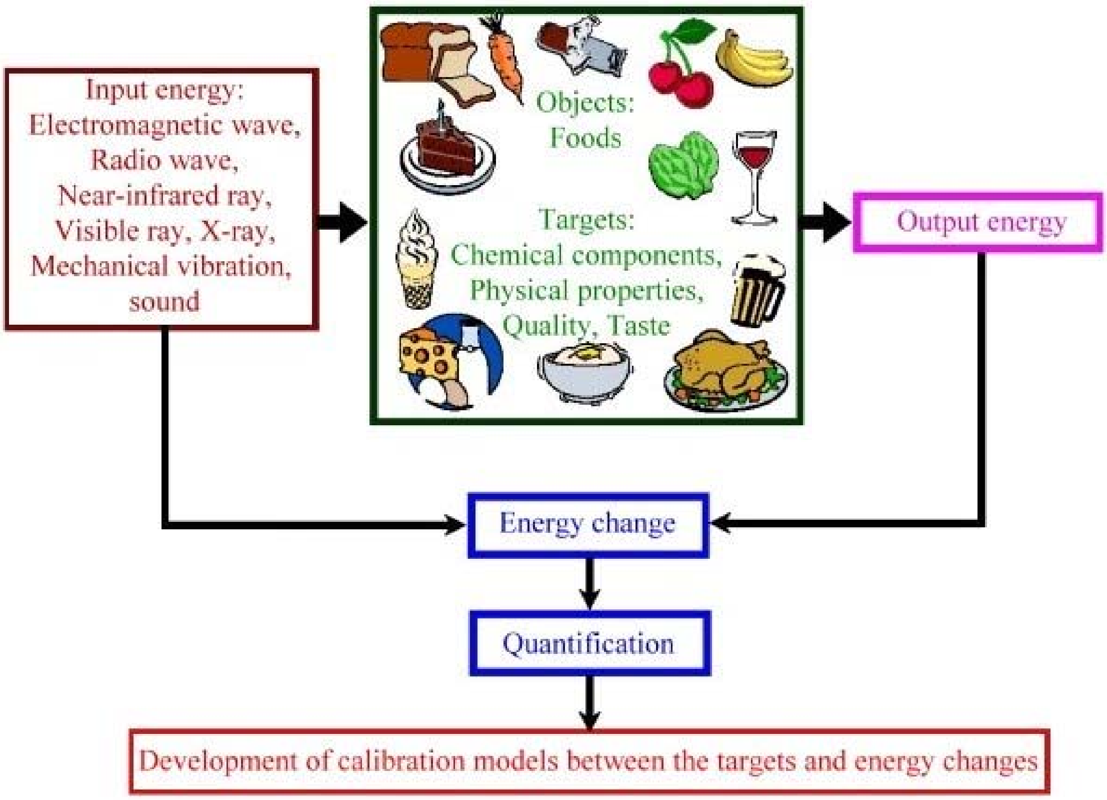


Figure 1: Schematic diagram of the principle of non-destructive quality assessment of foods.

Non-destructive quality assessment is a new technique in the field of food research and development. A schematic diagram of the principle of non-destructive quality assessment of foods is shown in Figure 1. Various energies such as electromagnetic wave, radio wave, near-infrared ray, visible ray, X-ray, mechanical vibration and sound are used for non-destructive quality assessment. If an object (food) is irradiated with energy, the energy is reflected or transmitted from the object. The output energy (reflectance or transmittance energy) changes as compared to the input energy. Development of calibration models between the energy changes and the targets (chemical components and physical properties) of foods would enable the chemical components and physical properties of foods to be assessed non-destructively in a very short time (within seconds).

### 2.2. Near-infrared Spectroscopy

The wavelength range of near-infrared (NIR) rays is between 700 nm and 2500 nm, which is longer than the longest wavelength of visible rays (red). The constituents of food such as moisture, starch, protein and fat are related to the optical properties of food. Some functional groups, such as the hydroxyl group (OH), carboxyl group (COOH) and carbonyl group (CO), absorb the energy of selective NIR wavelengths. The amount of energy absorbance of certain wavelengths is proportional to the levels of each constituent content.

Near-infrared spectroscopy (NIRS) has advantages of being fast and of determining non-destructively multiple constituents in one measurement. However, a calibration model must first be developed to use NIRS. Development of a calibration model means establishing the relationship between the NIR spectra by measuring log (1/Reflectance) or log (1/Transmittance) and the constituent contents by using reference or standard methods, which are usually conventional chemical or physical methods. There is an excellent book with detailed description of near-infrared technology by Williams and Norris (2001).

### 2.3. Performance of Near-infrared Spectroscopy for Determination of Constituent Contents of Milk and Rice

Original spectra of milk are shown in Figure 2 (Kawamura et al., 2003a). These spectra were collected every ten seconds during milking of a cow. The deep dip in the spectra in the wavelength range of 970 to 990 nm in the figure indicates absorption by water molecules. The two dips in the spectra around 740 nm and 840 nm indicate overtone absorptions by C-H strings and C-C strings, respectively.

The correlation between reference fat content of unhomogenized milk and NIR-predicted fat content of the milk is shown in Figure 3 (Kawamura et al., 2003a). In terms of the precision and accuracy for predicting milk fat, the value of the coefficient of determination ($r^2$) was 0.95, the value of the standard error of prediction (SEP) was sufficiently small (0.42%) compared with the range of reference fat content, and the value of bias was almost zero (0.01%). Calibration models developed for predicting three major milk constituents (fat, protein and lactose), somatic cell count in milk and milk urea nitrogen can be used for real-time assessment of milk quality during milking with sufficient precision and accuracy.

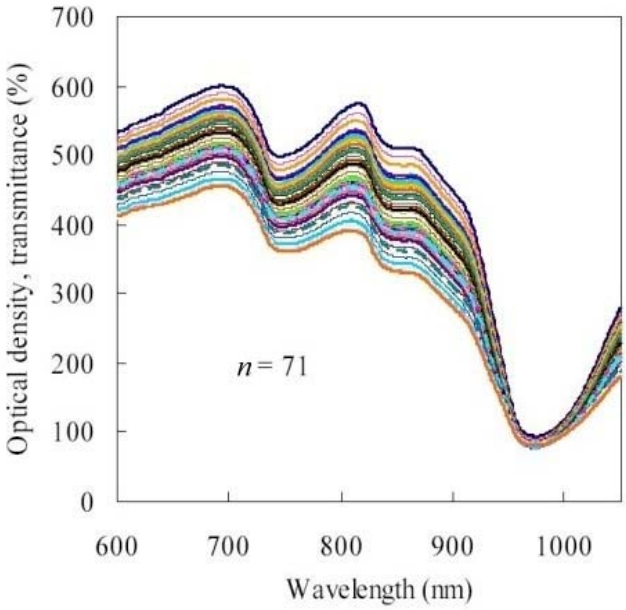


Figure 2: Original spectra of milk from a cow during milking. (Kawamura et al., 2003a)

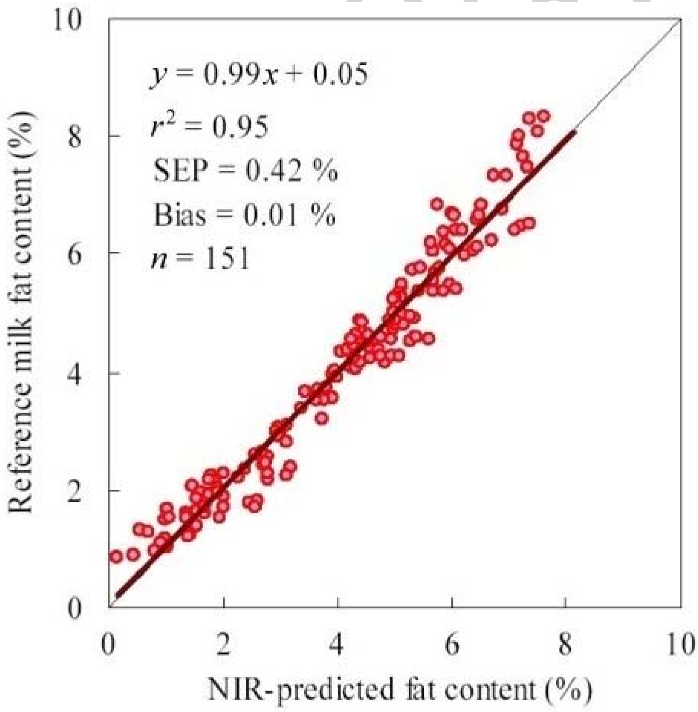


Figure 3: Correlation between reference fat content of unhomogenized milk and NIR-predicted fat content. (Kawamura et al., 2003a)

The correlation between reference moisture content and predicted moisture content and the correlation between reference protein content and predicted protein content of rice are shown in Figures 4 and 5, respectively (Kawamura et al., 2002). The values of $r^2$, SEP and bias in measurement of rice moisture content were 0.98, 0.13% and -0.02%, and those in measurement of rice protein content were 0.90, 0.17% and 0.01%, respectively. The calibration models can be used to determine moisture content and protein content. An automatic rice-quality inspection system was designed using an NIR instrument and a visible light segregator (Kawamura et al., 2003b). Based on the information of rice quality items (protein content, moisture content and sound whole kernel ratio), rice can be classified into several qualitative grades. NIRS can be used for classifying rice samples into qualitative groups such as poor taste, better taste and the best taste (Kawamura et al., 1997).

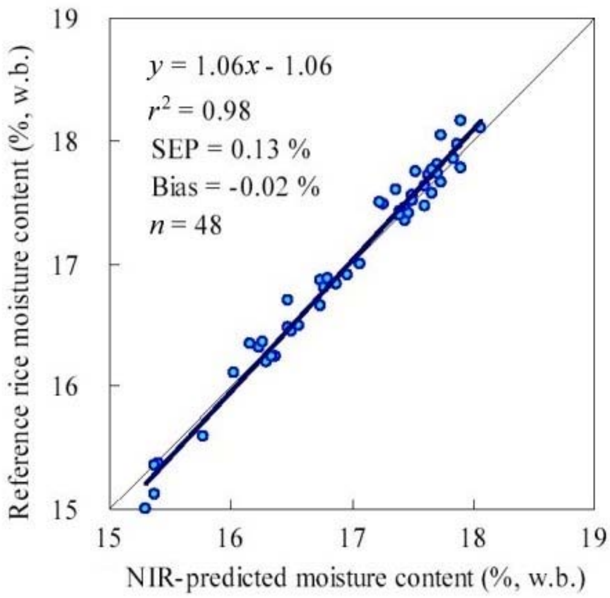


Figure 4: Correlation between reference moisture content of brown rice and NIR-predicted moisture content. (Kawamura et al., 2002)

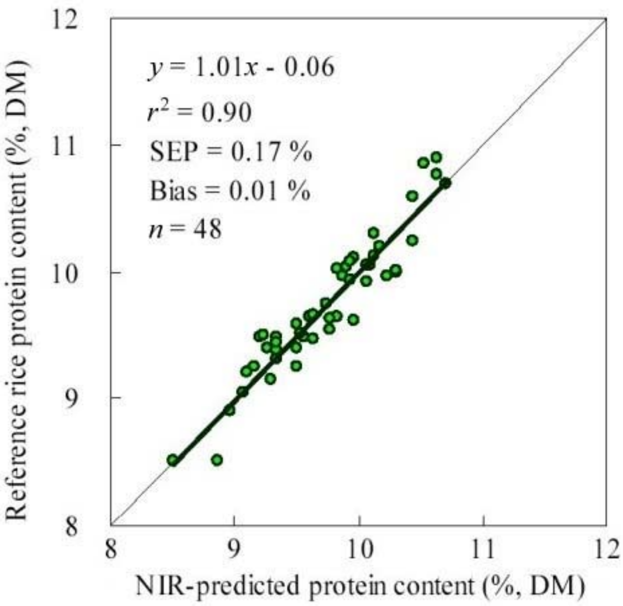


Figure 5: Correlation between reference protein content of brown rice and NIR-predicted protein content. (Kawamura et al., 2002)

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### Biographical Sketches

**Shuso Kawamura** is Associate Professor of Bioproduction Engineering in the Graduate School of Agricultural Science at Hokkaido University, Japan. He has been a faculty member of Hokkaido

University since 1983. His doctoral dissertation is “Rice Milling and the Quality and Taste of Milled Rice.” His major fields are agricultural process engineering and food process engineering. His recent research includes the following:
*Postharvest handling optimization techniques for preserving and improving the quality of grain such as rice, wheat and soybean.*
*Rice storage at temperature below ice point (i.e., super-low-temperature storage of rice).*
*Rice storage on a farm-scale facility under super-low-temperature condition using natural cold fresh air in winter.*
*Cleaning rough rice and brown rice for improving rice quality.*
*Quality characteristics and storage properties of new value-added rice (Rinse-free rice: Musenmai)*
*Near infrared spectroscopy for un-homogenized milk quality evaluation during milking.*

**Shigenobu Koseki** is a researcher at the National Food Research Institute, Japan. His doctoral dissertation is “Advancement of Vegetables Decontamination Technology using Electrolyzed Water.” His major fields are food science and engineering, and food protection.
His recent research includes the following:
*Development of a new food processing process using high pressure techniques.*
*Analyses of disinfection properties of food under a high pressure condition.*
*Development of predictive decontamination models under a high pressure condition.*