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OPTICAL EVALUATION TECHNIQUES FOR BOVINE FAT

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Background:

Bovine fat quality affects its grade and the price. Fat with color or bad texture is downgraded. Especially, for Wagyuu beef from the Japanese black breed, the hard fat is not liked by buyers. In addition, fat quality is related to the preservation period of the meat, the texture and human health. Ordinary methods for the evaluation of fat quality, however, are time-consuming, subjective, expensive, damaging or not safe. Fiber optic spectrophotometry can easily detect the yellow coloration of fat from healthy animals due to ß-carotene (Swatland, 1987). However, as stated also by him, the subjective perception of grades of yellowness in bovine adipose tissue may involve something more than just their carotene content. Bovine fat color must be investigated in more detail. Fiber optic methods are rapid and useful techniques for determining the physio-chemical characteristics of porcine fat (Irie & Swatland, 1994: Irie, 1999) and also are worth using on bovine fat.

Objectives:

This research was undertaken to determine if new spectroscopies using four types of fiber-optic probes and the sensor over a wide wavelength range are suitable for evaluating the bovine fat quality. In other words, the objectives in this research are (1) to investigate the factors affecting bovine fat color, and (2) to estimate the physio-chemical characteristics of bovine white fat by optical techniques.

Methods:

Sample. A total number of 60 samples of subcutaneous, leaf and intermuscular adipose tissues was obtained from the Japanese Black breed, Holstein breed and their cross breds at the meat market.

Physio-chemical characteristics. The fatty acid composition of the fat was measured by gas-chromatography (Irie & Sakimoto, 1992). The refractive index was determined using an Abbe refractometer (Type Ⅲ, Atago, Tokyo, Japan) at 50 ℃ using fat extracted in an oven. The melting point was measured by the capillary tube method (AOAC, 1975).

Apparatus. Fiber optic spectroscopy (HRS-6500, Optoelectronics Co., Japan) with four probes (Figure 1) was used. The surface probe transmits and accepts the light via an air space to the surface of the sample like an ordinary colormeter. In the contact probe, the fiber-optic was arranged in a circle, the light from inner circle of fiber optic passes into the sample and the scattered light reflects from the sample to the outer circle of fiber separated by 1.5 mm. The insertion probe was a continuous ring-like window of arranged adjacent out-going and in-going optical fibers around the body of the shaft. For the transmittance probe, the thickness of the sample was adjusted to .5 mm between two slide glasses. Optical data were downloaded to a microcomputer from 400 to 1,100 nm increments with a bandwidth of 1 nm. Measurements were made at 4 ℃. The interactances of the fat with insertion probe exceeded 100, meaning that the sample has a higher reflectance than the white standard plate. Therefore, interactance with the insertion probe was called the internal reflectance ratio in this study. The measuring time was within 1 second. The data were downloaded to a portable personal computer via IEEE and displayed on the monitor.

Statistical analysis. The data were analyzed using a simple regression analysis between the optical and physio-chemical measurements.

Results and Discussion

Color. Figure 2 shows the reflectance spectra of white adipose tissue, colored fat and the extracted fat dissolved with or without carotene. In the adipose tissue, weak absorbance peaks from residual haemoglobin associated with capillaries with haemoorrhages were observed. Two absorbance peaks around 540 to 580 nm were derived from oxyhaemoglobin and the peak around 670 nm was derived from methaemoglobin. Peaks around 410 or 420 nm were formed by oxyhaemoglobin and methaemoglobin. However, the extracted fat was devoid of these peaks because of elucidating the haemoglobin. Peaks at 930 nm and 1,040 nm in the near infrared region are characteristic of fat, irrespective of the sample conditions. The stretching modes of

the carbon-hydrogen overtone bands and 2 × C-H stretching+2 × C-H deformation+$(CH_2)n$ in oil have absorbance peaks at 928 nm and 1,037 nm, respectively (Osborn et al. 1986). The tissue fat had a higher reflectance than extracted fat. This means that the connective tissues and the cell membrane increase reflectance or whiteness. The transmittance differed among the samples reflecting permeability of the depot fat. The supplementation of carotene in the extracted fat produced the typical absorbance peak around 470 nm. Brown-yellowish fat gave stronger visual impression of yellowness than the pink yellowish fat, irrespective of the carotene content. A decrease in brightness, increase in permeability, or brown color formation of methaemoglobin probably enhances the yellowness. In contrast, the vivid redness of oxyhaemoglobin possibly masks the yellowness.

Physio-chemical Characteristics. When the four types of probes were applied to bovine fats of different quality, the shapes of the spectra differed among the samples and for the type of probes (Figure 3). For bovine leaf fat, the internal reflectance ratio using the insertion probe at many wavelengths (about 600 to 1,100 nm) was positively correlated with the melting point, but negatively with the refractive index. The results in this study were in agreement with the results for pig (Irie, 1999). The Japanese bovine fat score is negatively correlated with the surface reflectance for the leaf and subcutaneous fats. The transmittance positively correlated with the refractive index. The interactance using the contact probe did not have a significant correlation with any physio-chemical characteristics. Although it was not significant, simple correlation coefficients for fatty acid composition were the highest for the insertion type among the probes.

Conclusions

The main factors affecting bovine fat color are carotene, the amounts and chemical states of the residual haemoglobins, the permeability of the depot fat, connective tissues and the cell membrane. The fiber-optic method can possibility determine the causes of the color changes and estimate the physio-chemical characteristics of bovine fat.

Pertinent Literature

AOAC. 1975. Official Methods of Analysis (12th Ed.). Association of Official Analytical Chemists, Arlington, VA.

Irie, M. 1999. J. Anim. Sci. 77 (In press).

Irie, M. & M. Sakimoto. 1992. J. Anim. Sci. 70: 470-477.

Irie, M. & H. J. Swatland. 1992. AJAS. 5: 753-756.

Osborn, B. G. & T. Fearn. 1986. Near infrared spectroscopy in food analysis. Longman Scientific & Technical, New York.

Swatland, H. J. 1987. Can. Inst. Food Sci. Technol.J. 20: 383-385.

Figures

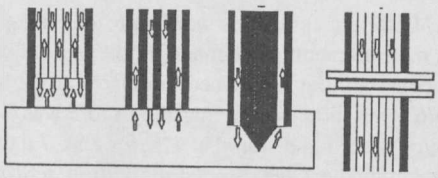

Figure 1. Four types of fiber-optic probe (surface, contact, insertion and transmittance). Arrows denote light path.

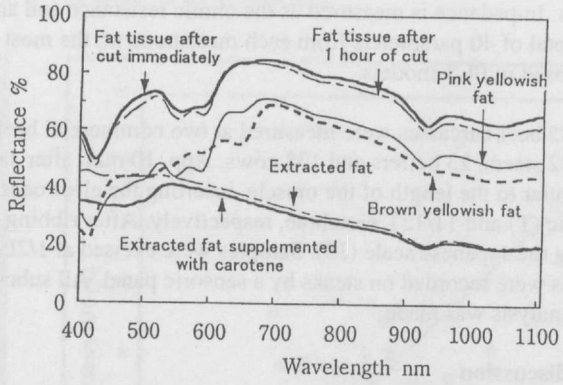

Figure 2. Surface reflectance spectra of bovine tissue and extracted fats.

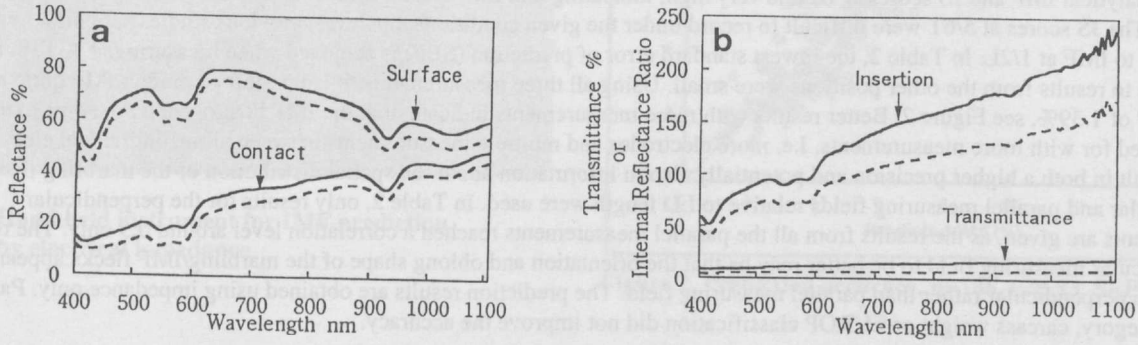

Figure 3. Mean spectra of bovine fat using various probes. Dotted line shows the mean minus one standard deviation.