TWO DIMENSIONAL PHOTOLUMINESCENCE IMAGING OF FOOD FOR NON-DESTRUCTIVE QUALITY CONTROL

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Abstract: Non-destructive evaluation technique of the foods including starches has been developed based on photoluminescence from starches in the foods. The visible PL with broad peak at wavelength of λ=462 nm are observed from various foods including starches, such as polished rice, flour and corn starch, under illumination of ultra-violet (UV) light at λ=365 nm. Peak intensity is found to vary with the source and the breed of the specimens. PL images from starches also reveal the uniformity of the food products. Two-dimensional images of PL, which revealed the uniformity of foods under UV irradiation, are potentially useful for the evaluation and the quality control of the foods and starchy products.

Keywords: photoluminescence imaging, non-destructive evaluation, food.

1. INTRODUCTION

Non-destructive and quick evaluation technique is required for quality control of foods. In order to develop a non-destructive evaluation technique of the foods including starches, the authors have studied photoluminescence from rice and other starches under illumination of ultra violet (UV) light [1-4]. Visible photoluminescence (PL) from polished rice, flour, peanuts, barley and other starches are evaluated for the future applications in a proof and a quality control of the foods. Two-dimensional evaluation equipment using UV illumination, CCD camera and digital image processing technique is considered to be a powerful tool for non-destructive and quick tool for quality control of foods.

In this paper, two-dimensional imaging of photoluminescence is described for the quick and non-destructive evaluation of foods. Quality control application of two dimensional photoluminescence imaging is proposed for blended rice products.

2. EXPERIMENTAL

Photoluminescence spectrum from rice and other foods including starches are evaluated with UV light irradiation at λ=365 nm. Emission and excitation peaks are compared for each specimen.

Two dimensional evaluations of foods are carried out using the equipment shown in Fig. 1. PL images are evaluated after image processing. PL imaging is carried out for various specimens. Rice, barley, peanuts and blended rice are used for the evaluations. Line scanning of 2-D PL image is also curried out for the evaluation of uniformity.

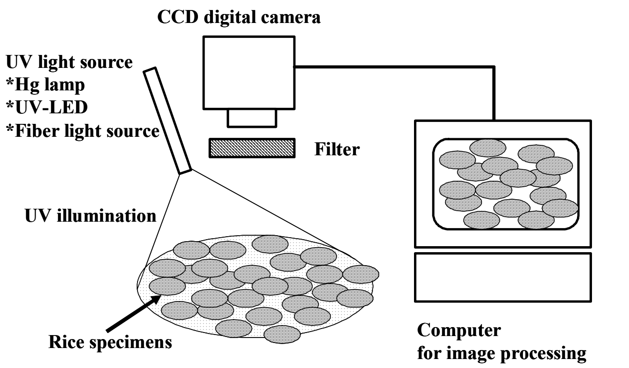

Fig. 1. Two-dimensional evaluation equipment of the photoluminescence (PL) images from foods. Specimens are excited by UV-LED (λ=365 nm) or Hg lamp (λ=365 nm, 40W). PL images are observed CCD camera system. PL images were processed for evaluating the uniformity of the specimens.

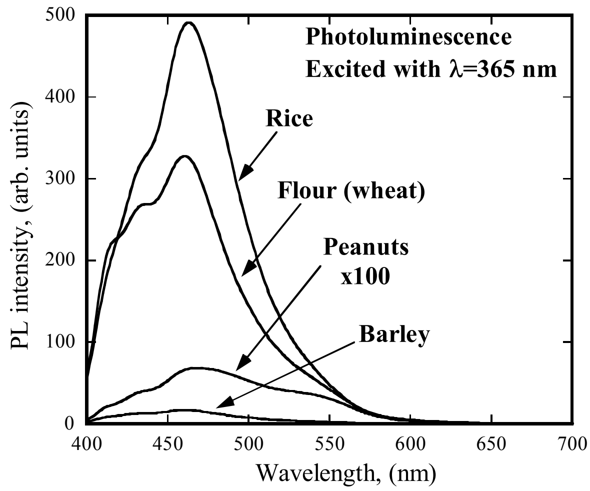

Fig. 2. Photoluminescence (PL) spectra from rice, flour, peanuts and barley. Photoluminescence (PL) is excited with 365 nm UV light irradiation. Peak intensity of PL varies with the source and the breed of the specimens.

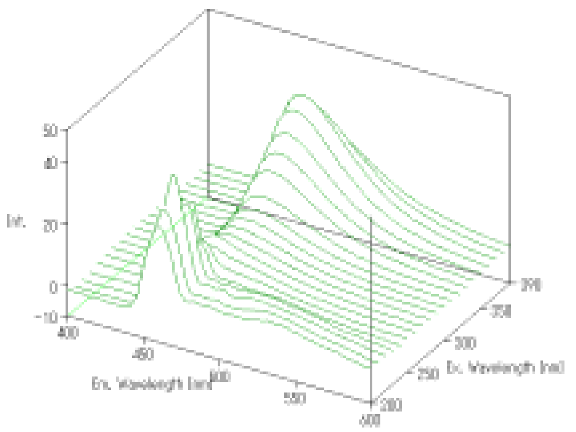

Fig. 3. Photoluminescence (PL) spectra from rice with various excitation wavelengths. Photoluminescence (PL) spectrum varies with wavelength of excitation light.

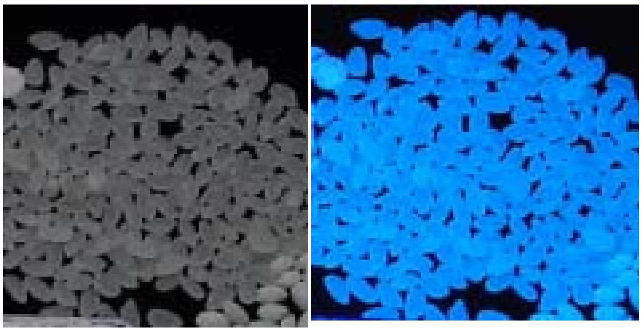

Fig. 4. Visible light photograph (left) and PL image (right) from polished rice.

Fig. 5. Visible light photograph (left) and PL image (right) from polished barley.

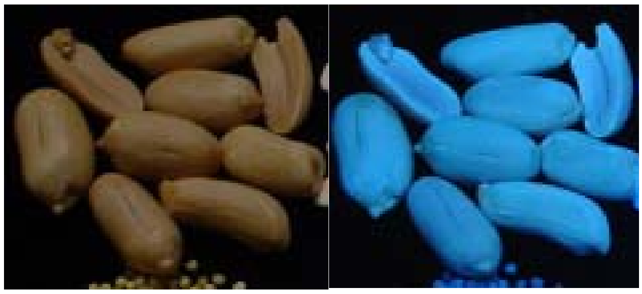

Fig. 6. Visible light photograph (left) and PL image (right) from peanuts.

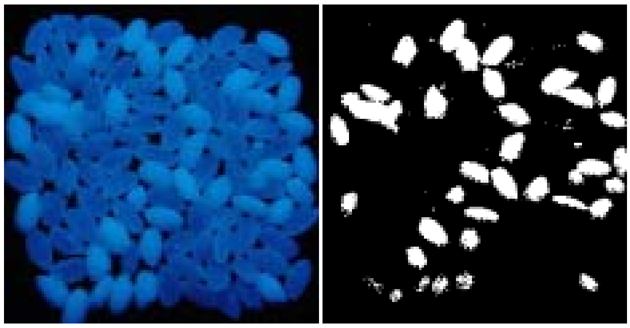

Fig. 7. PL images from blended polished rice. Specimens are excited with UV light at λ=365 nm. PL image before (left) and after (right) image processing are shown in the figure. Two kind of rice can be identified clearly after image processing (contrast enhancement).

2. RESULTS AND DISCUSSION

The visible PL with broad peak at wavelength of λ=460 nm are observed clearly from polished rice, flour, peanuts and barley under illumination of ultra-violet (UV) light as shown in Fig. 2. Visible PL can also be seen in the boiled rice. In various foods including starches, PL peaking at λ=462 nm is excited effectively with UV light at λ=365 nm. Although, peak wavelength dose not vary, peak intensity vary with the source and the breed of the specimens.

Figure 3 shows photoluminescence (PL) spectra with various excitation beams at wavelength from 220 to 390 nm. PL peaks at 460 nm and 550 nm are seen in the excitation with shorter wavelength from 220 nm to 250 nm. Broad PL peak at 460 nm is seen in the excitation from 300 to 390 nm.

Photoluminescence peaks observed in Fig. 2 and 3 are thought to be mainly due to starch in the foods. Other components in the foods also emit luminescence under UV light illumination. For example, small amount of amino-acids, lipid and some minerals

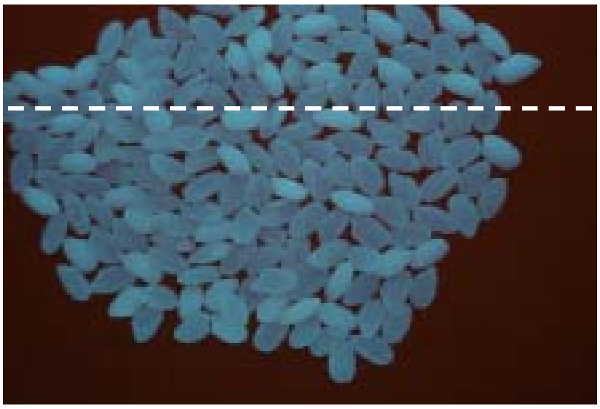

Fig. 8. PL images from blended polished rice with 3 different species. Specimens are excited with UV light at λ=365 nm. Distribution of brightness is measured along the broken line shown in the figure.

are also included in rice, peanuts, flour, barley and other foods. PL spectrum, therefore, includes various peaks these photoactive components. PL spectrum is also found to vary with the kind of plant from which the starch is prepared. In PL spectra from polished rice, flour, peanuts and barley, the peak intensity and/or peak shape of PL varies with the kind of the starches. PL spectrum is suggested to be a powerful tool for the evaluation of foods including starches.

Two dimensional (2-D) image of photoluminescence (PL) from polished rice is shown in Fig. 4. Photograph taken under visible light illumination is also shown in left part of the figure. Bright PL images in blue color are seen under UV irradiation (right pert in the figure). From the results in Fig. 2 and 3, PL peaking at 460 nm is seen in the figure. Brightness of the 2-D PL image is uniform because the specimen is prepared from single kind.

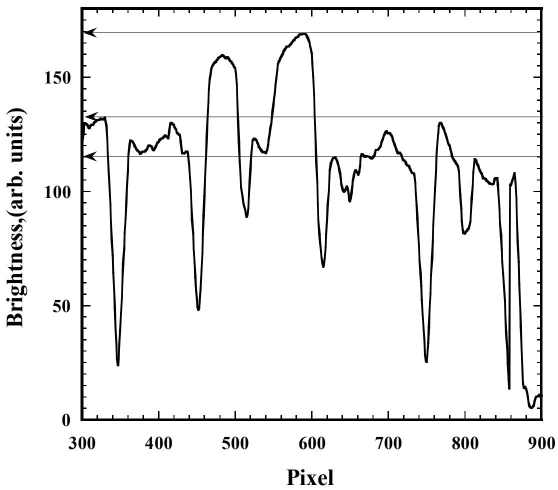

Fig. 9. Distribution of brightness measured along the broken line of the 2-D PL image in Fig. 8.

Two dimensional (2-D) image of photoluminescence from polished barley is also shown in Fig. 5. From PL spectrum in Fig. 2, PL intensity from the barley is weaker than that of rice and flour. Two-D PL image can be successfully observed as shown in the figure. Brightness of the 2-D PL image is also uniform because the specimen is prepared from single kind. Bright PL image in blue color are seen under UV irradiation.

Figure 6 shows 2-D PL image from peanuts. From PL spectrum in Fig. 2, PL intensity from the peanuts is weaker than that of barley, rice and flour. Two-D PL image can be observed as shown in the figure. Brightness of the 2-D PL image is uniform because of the single kind. PL image from peanuts is slightly different from other specimens because relatively strong luminescence peak at 550 nm.

PL intensity from food specimens vary with kind of the starches. Uniformity of PL image is, therefore, influenced greatly with blending with other kind of starches.

Two dimensional (2-D) images of photoluminescence from blended polished rice before and after image processing are also shown in Fig. 6 (left) and (right), respectively. Photograph of polished rice under UV light illumination (left) is shown as compared with the photoluminescence image after image processing (right). Hg lamp is used as an excitation source. Low pass filter (cut off wavelength of 400 nm) is used for observation. Blended rice can be effectively evaluated using PL imaging and image processing technique. Two kind of cereal can be identified due to difference in PL intensity. Blended rice can be effectively evaluated using 2-D PL imaging and image processing technique.

Figure 8 shows 2-D PL image from blended polished rice with 3 different species. Specimens are excited with UV light at λ=365 nm. PL intensity from the specimens, which is observed as the brightness of image, varies with species of rice. From 2-D PL image, uniformity of rice can be detected based on the variation of brightness. Distribution of brightness is also measured along the broken line shown in the figure.

Line scanning of brightness along the broken line in the 2-D PL image of blended rice reveals the uniformity of rice more clearly. Figure 9 shows a variation of brightness measured along the broken line in Fig. 8. In the figure, brightness at the position along the line in 2-D PL image is plotted against the position. Bright part in the figure corresponds to strong PL intensity. In the blended rice, brightness varies depending on the position in the 2-D PL image. Uniformity of cereals and/or starchy products can be evaluated based on the variation of brightness in the 2-D PL images.

4. CONCLUSION

Photoluminescence (PL) spectrum and 2-D PL images is found to be effective for the evaluation of foods including starches. The visible light PL over the wavelength from 400 to 600 nm may be potentially applicable to the optical evaluation of the starches. PL imaging of the cereals and the starchy things is suggested to be a powerful tool for non-destructive and quick evaluation of agricultural harvests and food products.

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