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DEVELOPMENT OF QUALITY EVALUATION SYSTEM FOR PEANUT WITH POD USING OPTICAL METHODS

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ABSTRACT

Optical methods were developed to examine their feasibility for quality evaluation of peanut with pod. Surface color and internal quality of peanut were measured without contact.

The surface color of peanut was measured by light reflectance at a region of visible wavelengths. Its characteristic was high correlated with a visual grading of peanut. A trial machine for the color grading of peanut was developed using an optical sensor and it was considered to compare with the visual grading.

The spectral reflectance at a region of near infrared wavelengths from 1,200 to 2,500nm was measured, and the chemical components of peanut were related to spectral reflectance at special wavelengths. The protein, fat and moisture contents of peanut were estimated by the near infrared method.

An infrared imaging method was developed to evaluate the internal quality of peanut with pod. As thermal characteristic of peanut with pod was deeply related to internal quality, the quality of peanut can be evaluated by temperature changes on the surface of peanut.

Measurement of surface color, near infrared reflectance and thermal imaging were shown to be very effective in grading of peanut with pod.

Key Word: Peanut, Quality, Color sorting, NIR, Infrared imaging

INTRODUCTION

Quality evaluation of agricultural products has always been one of the most elusive problems associated with the harvesting,handling,processing and marketing of the agricultural products. The quality of peanut has been evaluated by their appearance characteristics, such as surface color, shape, bruise, defect and

damage. The visual inspection has been used in the grading process of peanuts, but psychological factors surrounding the involvement of human beings in this process lead to the introduction of errors and reduced efficiency. There have been many attempts at developing nondestructive grading techniques for agricultural products which offer improvements over the visual inspection method "Mayers et al.(1990),Prussia et al.(1983)".

In the case of peanuts, as it consists of seeds and pod, it is difficult to evaluate its internal quality by the visual inspection. The outer appearance of peanut is not always consistent with its internal quality. Therefore, it is impossible to improve the precision of grading process using visual inspection. Moreover, a nondestructive method for internal quality evaluation of peanut has not yet been developed.

Optical techniques were attempted to be applied for the grading process of many agricultural products. Light reflectance characteristic at the visible region was applied for evaluation of surface color and defects "Chuma et al.(1981), Morita et al.(1990)". Near infrared characteristic was applied for estimation of internal quality (protein, fat and moisture etc.) "McClure(1968),Iwamoto(1985)". Infrared imaging can provide a thermal characteristic of agricultural products "Danno(1980)".

The purpose of this study is to obtain some basic data for the three kinds of optical characteristics and to establish the mechanical grading system of peanut with pod. Preliminary results on quality evaluation of peanut are discussed in this paper.

MATERIALS AND METHODS

1.Materials

Peanuts(Nakateyutaka) harvested at Koyama-cho, Kagoshima, Japan were used in this experiment. These peanuts were kindly offered by the Koyama Agricultural Co-operative Association, and were visually sorted to three grades 'A,B,C' in the packinghouse. The 'A' grade peanuts are used as dried or boiled peanuts. The 'B' grade peanuts are used in making butter or tofu. The 'C' grade peanuts are used for producing oil.

2.Measuring of surface color

The quality of peanut was usually evaluated by its surface color. The surface color of peanut was measured using a differential colorimeter(Minolta CR-200). Surface color was represented as UCS values using the Hunter(L,a,b) scale. In this experiment, a relationship between surface color(L,a,b) and the grade 'A,B,C' of

peanuts sorted out using visual inspection was also investigated.

3.Development of color sorting machine

An experimental equipment for easy practical application was designed to obtain some basic data for surface color evaluation of peanut with pod by optical sensor. The basic feature of the experimental apparatus is illustrated in Fig.1 and the optical system was arranged on the principle of measurement based on the rice grader manufactured by Satake Engineering Co., Ltd. The apparatus consists of vibrator, conveyer, sensor and separator. The important feature of this machine is sensor-sensitivity and it is adjusted by the voltage and power level of the sensor circuitry.

4.Measuring of near infrared characteristic

The near infrared (NIR) spectra of the samples were determined using a Infra-analyzer 500S (Satake Engineering Co., Ltd.). Three types of sample, ground seed, whole seed and peanut with pod were used in this experiment and spectral reflectance in the wavelength region of 1,200 to 2,400nm was measured.

5.Measuring of infrared imaging

(1)Infrared imaging device

A Fujitsu Infra-Eye 102A, a medical thermograph, was used in this experiment. A mercury-cadmium-telluride(Hg Cd Te) detector was employed for infrared measurement. Fig.2 shows a block diagram of the experimental arrangement. Infrared radiation emitted from the samples were collected by an infrared vidicon camera which in turn transmitted the signal to the Infra-eye 102A. Thermal images were produced on a color T.V. monitor.

(2)Measuring of thermal characterisitc

Surface temperature of peanut in a thermal image taken by the infrared camera was generated similarly to a color television picture. Before measuring the thermal image, a base temperature and the measuring temperature interval were adjusted in order to provide a uniform image.

(3)Measuring conditions

In order to find a suitable condition for infrared radiation measurement, several preliminary studies have been carried out relating to heating tests in a microwave oven. The thirty seconds heating period was adopted for our experiment. Infrared radiation measurements of peanut were made at room temperature, approximately 25° C, immediately after bringing them out from the microwave oven. Since there were temperature gradients between the surface temperature of samples and room temperature, the surface temperature of samples changed with time.

RESULTS AND DISCUSSION

1.Surface color vs. visual inspection

The relationship between surface color as indicated by the Hunter values and the grade of peanut sorted by visual inspection was investigated. Measurement of surface color was carried out for twenty samples which were classified into three different grades by visual inspection. Table 1 shows the relationship between the L,a,b values and the visual grading 'A,B,C' using the average value and standard deviation. The 'L' and 'b' values showed some correlations with the peanut grades, but 'a' values were not related to the visual grades of peanut. Considering only 'L' and 'b' values, it seems that the grade 'A' was selected for its lightness and for the transition from yellow to brown of the surface color. It seems that the grade 'B'and 'C' were classified by surface defects or injuries.

Consequently, the grading of peanuts was classified by surface color and defects or injuries of the pod, and it was be noted that the grading of peanut by visual inspection was not concerned with internal quality.

2.Machine sorting vs. visual sorting

In order to investigate the grading accuracy of the color sorting machine, relationships between machine sorting and visual sorting was shown in Table 2. Peanut with pod was sorted out with three grades, and the results were presented by amount of peanut weight in each grade. The peanut weight in each grade was different between machine sorting and visual sorting. As the visual sorting is not always best separation, the grading accuracy of the machine sorting can not discuss. But it could be easy to adjust the sensor sensitivity in the color sorting machine. It is felt that successful sorting can be accomplished if more basic date for judgment of the best criteria for separation was collected under various conditions, and the appropriate sensitivity level was chosen by observing the output from the color sorting machine.

3.NIR Spectral characteristics

NIR spectral curves of peanuts were measured at various conditions such as ground seed, whole seed and peanut with pod. Fig.3 shows typical second derivative spectral curves of ground seed in the wavelength region of 1,200 to 2,400nm. The effects of moisture, protein and fat were readily observed and the spectra showed prominent absorption bands at 1,460nm (protein content), 1,725nm, 2,310nm (fat content) and 1930nm (moisture content). Three curves for different grade of

peanut indicated remarkable differences at these absorption bands. The internal quality of peanut could be estimated by measurements of absorbance at these wavelengths. However, in case of peanut with pod, these differences of absorbance were very small during three grades of peanut. In order to evaluate the internal quality of peanut with pod, it is considered to be necessary to improve the optical measuring device.

4.Temperature changes on the surface

The thermal image of the peanut was collected just after heated in a microwave oven for thirty seconds. Fig.4 shows temperature changes on the surface for whole peanut, peanut seeds and peanut pod, respectively. Surface temperatures decreased gradually and approached room temperature. The surface temperature changes for whole peanut and peanut seeds were different among the grades of peanut. The surface temperature of the high grade peanut was consistently higher than that of low grade peanut. The surface temperature for peanut pod approached room temperature within ninety seconds after heating. After ninety seconds, all grades of peanut showed the same temperature distribution. It is concluded that the grading of peanuts could be estimated by the surface temperature changes observed in its thermal image.

5.Thermal image vs. internal quality

In general, the internal quality of peanut could not be evaluated by external visual inspection. The relationship between thermal images obtained with the Infra-Eye 102A and the internal quality of peanut was investigated. Fig.5(Up) shows the thermal image of peanut with pod. It is quite obvious that the difference in surface temperatures in the thermal image corresponded to the internal quality of peanut. Fig.5(Down) shows that only one seed was present in the pod. This situation could not be detected by the visual inspection, but it could be easily detected by the thermal image method. It is concluded that surface temperature in the thermal image correlated to the internal quality of peanut.

CONCLUSIONS

In order to evaluate surface color and internalquality of peanut with pod by nondestructive method, optical characteristics were measured in regions of visible, near infrared and infrared wavelengths. The color grading machine was developed using optical sensor in visible regions, and successful sorting was considered to be accomplished by judgment of the best criteria for separation. The internal

quality (protein, fat, moisture contents) of peanut could be estimated by measurements of absorbance at special near infrared wavelengths. Infrared imaging method was developed to evaluate the internal quality of peanut with pod. As thermal characteristic of peanut with pod was deeply related to internal quality, the quality of peanut can be evaluated by temperature changes on the surface of peanut pod.

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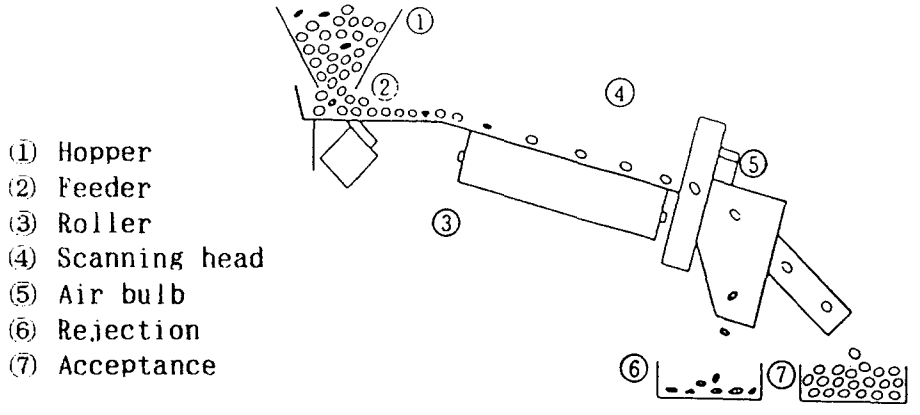
Table 1. Relationship between surface color, L, a, b and the visual grading of peanuts

Visual grading	Hunter		
	L	a	b
A (Ave.)	70.01	3.83	24.91
(S.D.)	1.97	0.44	1.66
B	54.63	3.93	18.85
	3.55	0.75	1.59
C	47.88	3.80	16.30
	8.24	1.04	2.88

Table 2. Comparison of visual color sorting with mechanical color sorting of peanuts

Grade	Visual	Mechanical
A	551.6g	726.2g
B	559.0g	337.8g
C	347.5g	349.1g



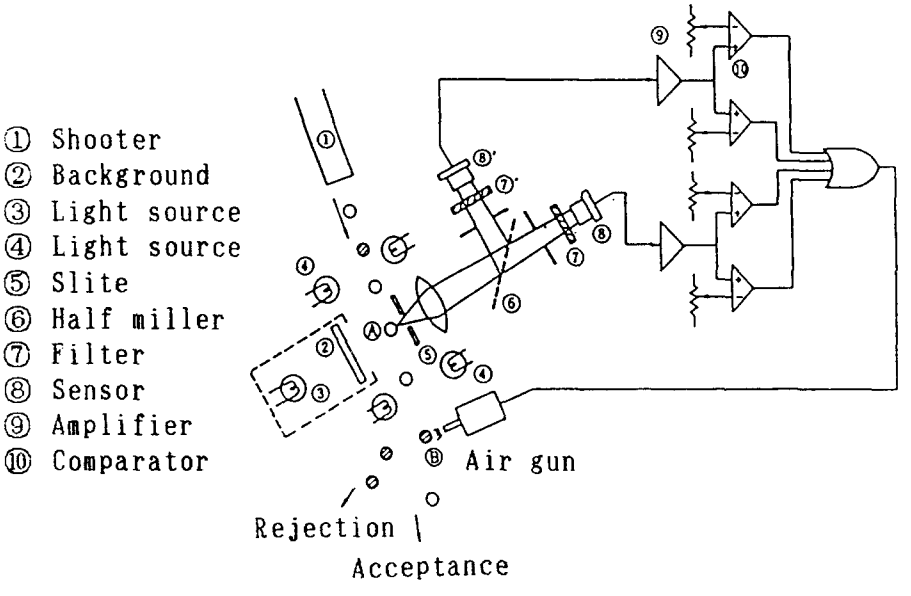


Fig.1 Schematic diagram of color sorting machine.

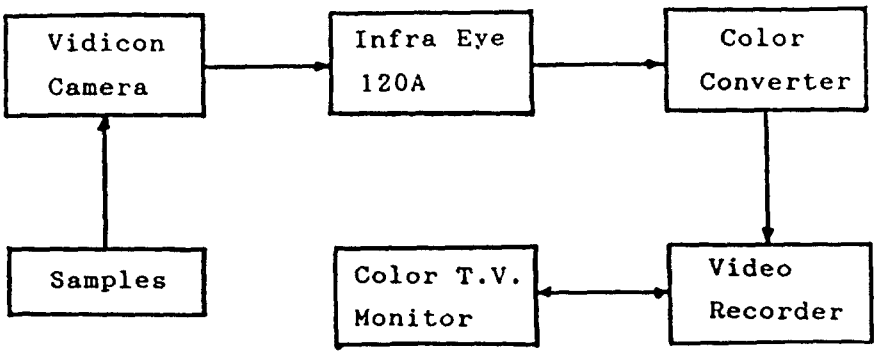


Fig.2 Block diagram of experimental arrangement.

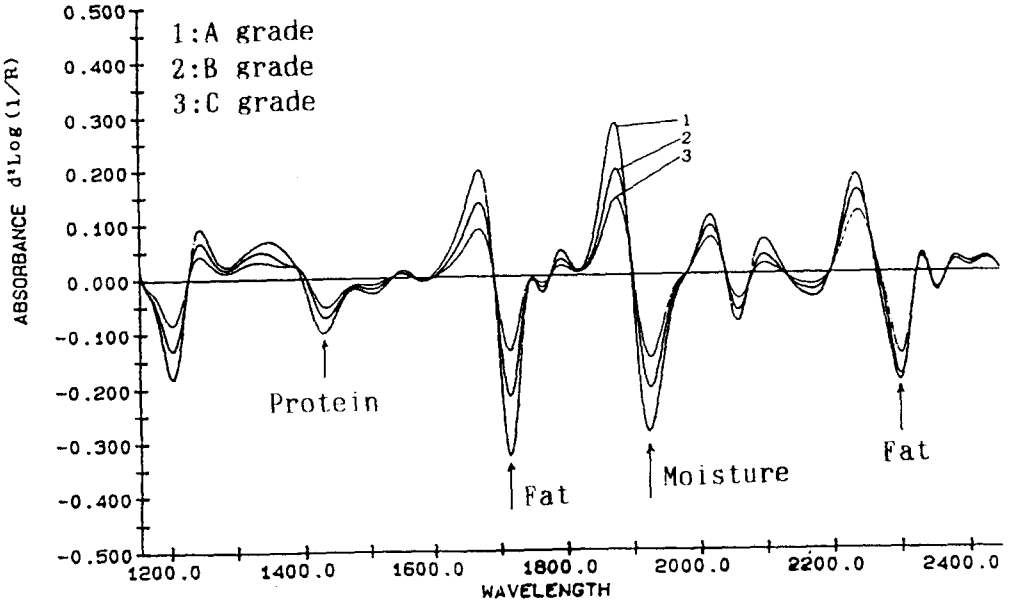


Fig.3 The second derivative spectra of ground peanut seeds for different grades.

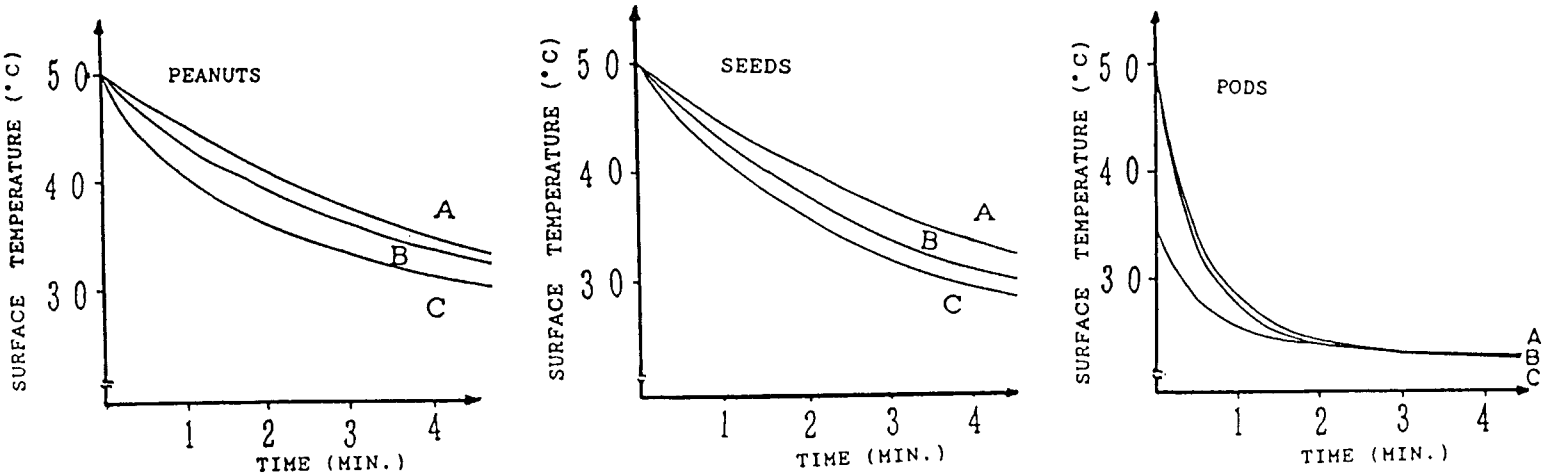
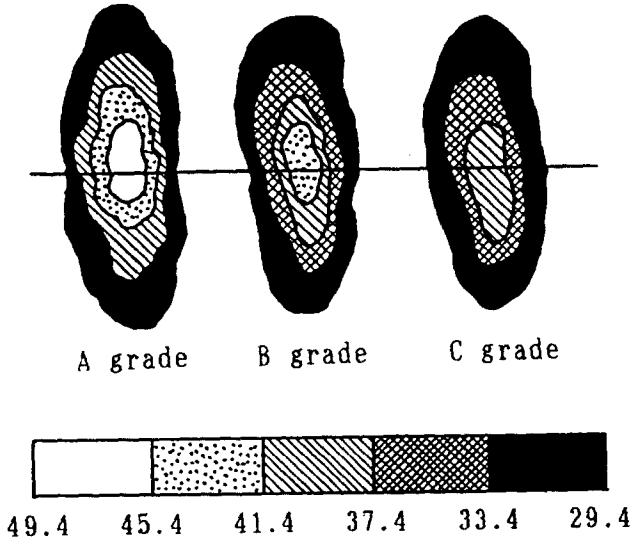
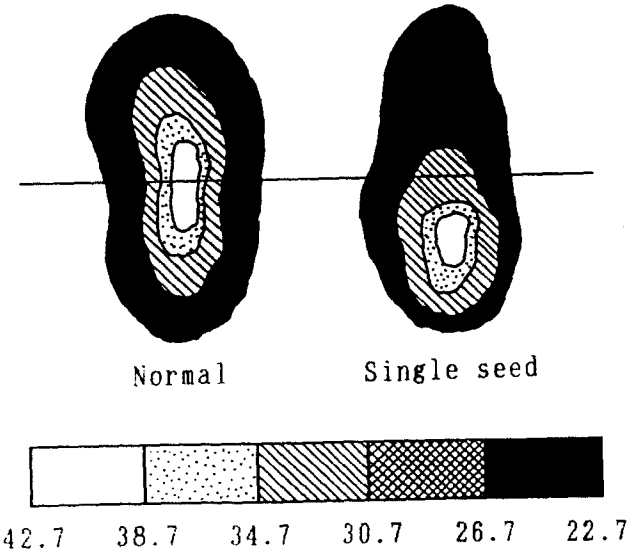


Fig.4 Temperatuer changes on surface for whole peanuts, seeds, pods.



(a)



(b)

Fig.5 Thermal images of peanuts.
(a): Different grades (b): Internal seeds condition