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Studies on the Expression of Color Tone in Rose Petals X.

Transmittance Curve of the Red Petal Extract, Measured with Translucent Cuvette.

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Abstract

On the reflectance measurements of red petals, part of incident light should be absorbed into some inner constituents of petals, and the remaining part passed away through the petals. The only part of incident light is detected by the spectrophotometer as the reflected light.

In the present study, the transmittance measurements on pigment solutions were taken with the translucent cuvette to give an optical state similar to the translucent property of the petal.

The translucent cuvettes were prepared by inserting the semitransparent pieces of plastic sheets along the inner walls of ordinary cuvettes.

When the cuvettes having the transmittance of 40 to 60% were used, the transmittance curves of red petal extracts became more approximate to the reflectance ones of red petals.

From the results of colorimetric calculation it is suggested that the translucent property brings some modification of the color tone in the petals having higher content of pigment.

Introduction

The previous studies on the development of petal color in red roses were made by comparing the reflectance curves of red petals with the transmittance ones of pigment solutions[1),2)]. As the transmittances in these experiments were measured with transparent cuvettes (ordinary cuvettes), all of the incident lights were captured by the light detector of spectrophotometer after being characterized by the spectra of pigment solution.

On the contrary, in measuring the reflectance of petal, only a certain part of incident light must be captured by the light detector after being characterized by the spectrum of cell sap containing the pigment. Other parts must be absorbed partly into the various constituents of the petals, e. g. cell wall, cytoplasm and others, and passed away partly through the petals.

For the more detailed comparison between the shapes of reflectance curves and transmittance ones, it seems desirable that a translucent state is brought about in the light path of transmittance measurement. In the present investigation, an attempt was made to produce this optical state by the application of translucent cuvette.

Materials and Methods

The plant materials used were red and white cultivars of rose, which will be refered below.

The petals of a red cultivar, Happiness, were cut into small pieces, and immersed in the mixture of equal volumes of 0.1 N phosphoric acid and 0.1 N malic acid over night. This acid mixture was recommended, in the previous paper[2)], as an extractant to prepare the red petal extracts. The extracts were filtered, and then the pH values were adjusted to 3 with N sodium hydroxide. Cyanin contents in the extracts were determined by the method described previously[3)].

The spectral transmittances of extracts were determined with a Baush and

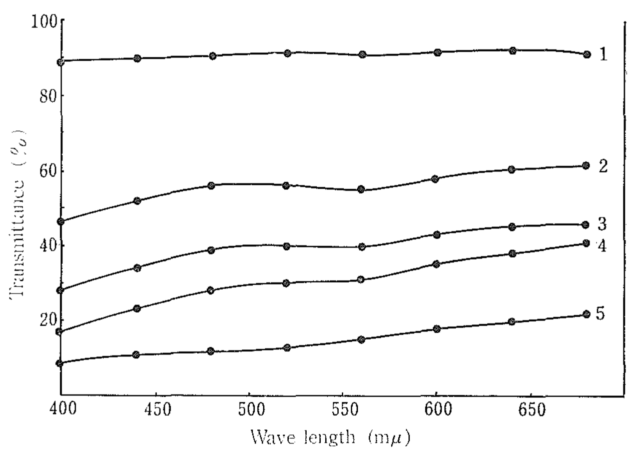

Fig. 1 Transmittance curves of translucent cuvettes.
Pieces of plastic sheets used are
curve 1 : 0.1 mm in thickness with 1 sheet
〃 2 : 0.2 mm 〃 with 3 sheets
〃 3 : 0.2 mm 〃 with 4 〃
〃 4 : 0.2 mm 〃 with 4 〃
〃 5 : 0.1 mm 〃 with 6 〃

Lomb "Spectronic 20" spectrophotometer, using 1 inch cuvette. Translucent cuvettes were made by inserting semitransparent pieces of splastic sheets along the inner wall of ordinary cuvette. Transmittance measurements with the translucent cuvette mentioned in the present paper, are meant by that incident light is measured with the ordinary cuvette and transmitted light with the translucent one.

The reflectance measurements were taken with integrating sphere attached to the spectrophotometer, using the following white cultivars: Virgo, Caledonia and White Swan.

Colorimetric calculations for the transmittance curves were performed according to the way previously described[4]. I. S. C. C. -N. B. S. color names were according to HIOKI's figures[5].

Results

As shown in Fig. 1, the transmittance curves of translucent cuvettes were

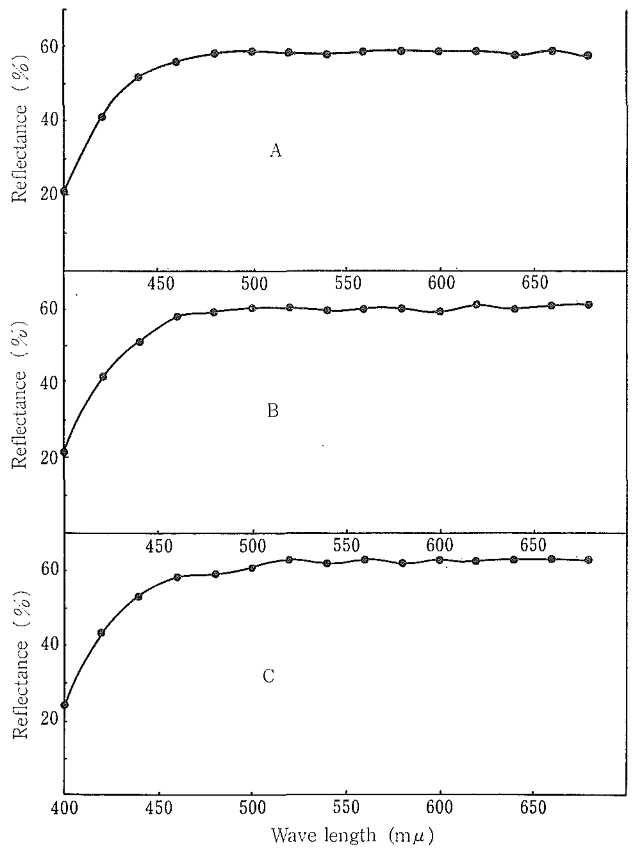

Fig. 2 Reflectance curves of white rose petals.
A : Caledonia, B : Virgo, C : White Swan.

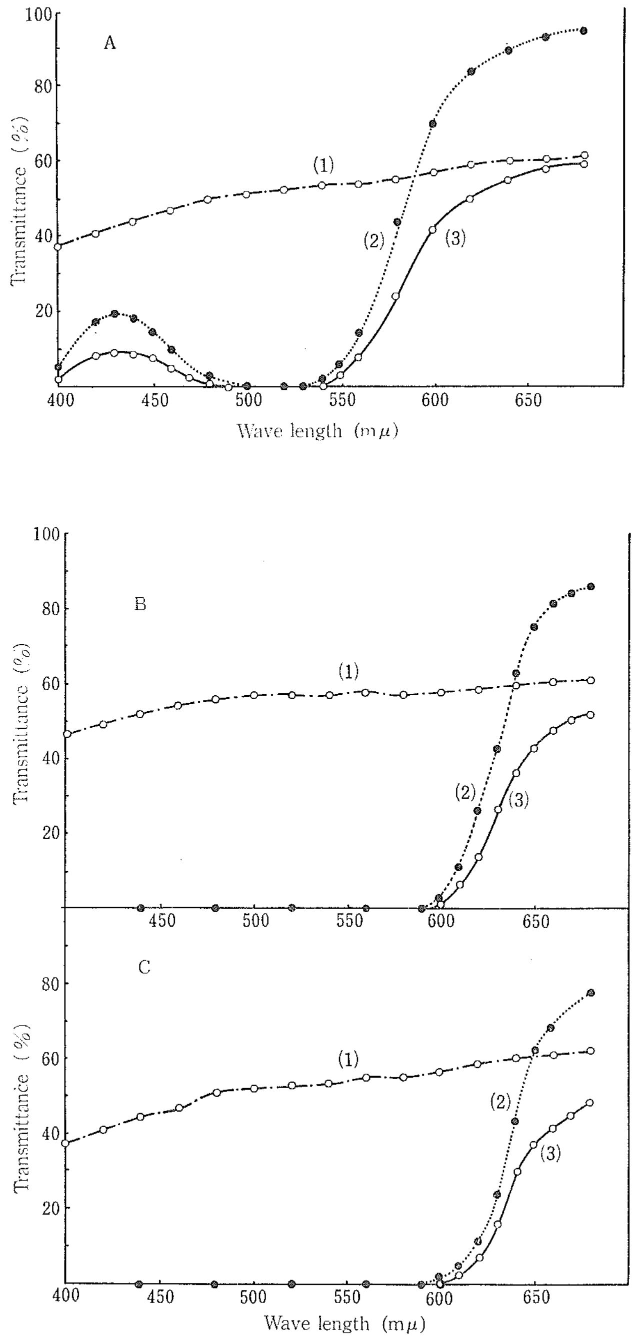

Fig. 3 Transmittance curves of a petal extract with ordinary and translucent cuvettes. Cyanin contents are A : 180 μg/ml, B : 700 μg/ml and C : 970μg/ml.

Table 1 Results of colorimetric calculation on the spectral transmittance curves, measured with ordinary and translucent cuvettes.

Transmittance curve		Chromaticity coordinates x	Chromaticity coordinates y	Lightness Y (%)	I.S.C.C.-N.B.S. Color name
Petal extract 1 Cyanin content: 180μg/ml, pH 3	Ordinary cuvette	0.53	0.31	26.91	vivid Red
	Translucent cuvette	0.54	0.32	15.92	vivid Red
Petal extract 2 Cyanin content: 700μg/ml, pH 3	Ordinary cuvette	0.71	0.29	4.93	deep reddish Brown
	Translucent cuvette	0.71	0.29	2.75	deep reddish Brown
Petal extract 3 Cyanin content: 970μg/ml, pH 3	Ordinary cuvette	0.70	0.29	3.26	deep reddish Brown
	Translucent cuvette	0.72	0.29	1.87	deep Brown

somewhat rectilineal and became slightly higher toward the longer wave length. Their levels in the figures depended upon the thickness and the number of polyvinyl sheets. On the other hand, in the reflectance curves of white petals the flat portions lay between 450 mμ and 700 mμ, and were on the level of nearly 60% in reflectance (Fig. 2).

In the present experiments, 60% level in reflectance curve of white petals was tentatively accepted as a general standard for the degree of translucency in a cuvette. That is, transmittance of translucent cuvettes were adjusted to approximately 50 to 60% by altering the thickness or the number of polyvinyl sheets.

The transmittance curves obtained by the ordinary and the translucent cuvettes were illustrated in Fig. 3 A~C. Curves 2 which were recorded with the ordinary cuvettes were turned to curves 3 by the application of cuvettes having the spectral transmittance of curves 1.

The results of colorimetric calculations from the curves indicated in Fig. 3 are listed in Table 1. Little difference was found between the chromaticity coordinates calculated from the curves obtained by the uses of ordinary and translucent cuvettes. On the contrary, the application of translucent cuvette caused a significant decrease, approximately 60%, in lightness Y. Only in the petal extract containing 970 μg/ml of cyanin, I.S.C.C.-N.B.S. color name with translucent cuvette was not similar to the name with ordinary one.

Discussion

According to SHIBATA's suggestion[6),7)], it may be expected that when the petals or the translucent cuvettes are irradiated, various light paths are distinguishable. The representative light paths in these cases are illustrated schematically in Fig. 4 A and B. The nomenclatures and the symbols of light paths were

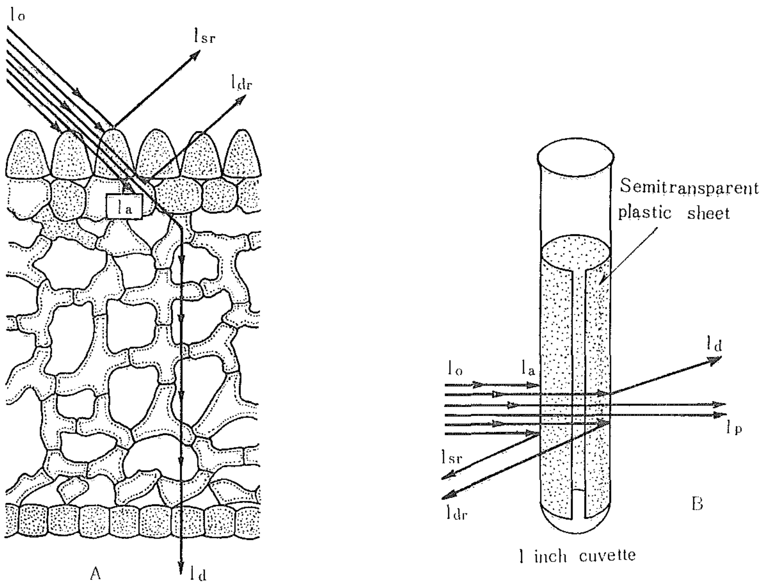

Fig. 4 Schematic figures showing representative light paths in the petal (A) and in the translucent cuvette (B).
I_o : incident light I_{sr} : directly reflected light I_{dr} : diffusely reflected light I_a : absorbed light I_d : diffuse transmitted light I_p : parallel transmitted light.
In (A) spotted portions denote red color.

refered to SHIBATA's. It was pointed out in the previous paper[8] that the light reflected by the red petal is composed of the following two parts: the directly reflected light and the diffused reflected light. On the other hand, transmittance measured with the translucent cuvette must be based on the next two parts: the parallel transmitted light and a part of diffused transmitted light.

There are differences in the names of light captured by the light detector between reflectance and transmittance measurements, but two spectroscopic measurements are common in the next point: a certain part of incident light can be attenuated by the translucent materials, i. e. petal or polyvinyl sheet, and the remainder can be detected by the photometer, after being characterized with spectra of cell sap or pigment solution. The problem as to the significance of directly reflected light in the red petal was discussed in the previous paper[8]. Accordingly, it can be said that by the application of translucent cuvette the translucent property of the petals may be demonstrable to some degree upon the transmittance curves.

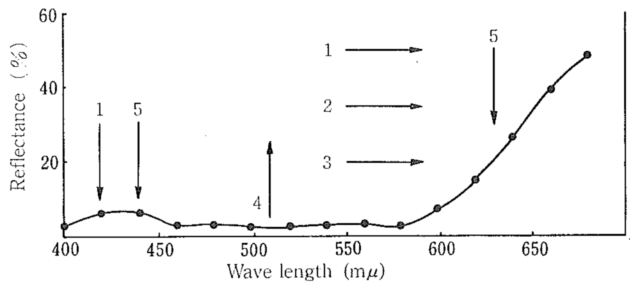

Fig. 5 Schematic figure pointing various effects on the reflectance curve of a red rose petal.
1 : Effect of anthocyanin content.[4]
2 : Effect of surface structure.[9),10]
3 : Effect of copigmentation-like factor.[11]
4 : Effect of surface reflect.[8]
5 : Effect of translucent property.

The present author failed in this experiment to devise a cuvette having the transmittance curve closely similar in shape to the reflectance curve of a white petal. Furthermore, when a red petal deprived of the red pigment is considered a question remains as to whether this imaginary ground of pigmentless red petal can be replaced by the white petal. Hence, curve 3 in Fig. 3 A~C respectively is only an approximate indication of the translucent property in the petals. However, it seems evident that the translucent property has an effect to change the S-shape of transmittance curve toward lower transmittance. Thus, one can give the transmittance curve of pigment solution more similar in shape to the reflectance curve of red petals.

Fig. 5 illustrates summarily the effects of principal factors on the development of petal color in red roses. Effects 1 to 4 were pointed out in the previous papers [4),8),9),10),11)], and effect 5 was revealed in the present work.

From the results shown in Table 1, it can be pointed out that the translucent property brings about some modification, e. g. a change of color in the "tone" level, in the cell sap having the higher concentration of pigment. It is natural to propose that the translucent property of petals depends prominently upon the inner structure of petal. Therefore, it can be said that the result presented here is a possible example of a color modification of pigment caused by the inner structure of the petal.

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