

## METHOD AND PROBLEM OF OPTICAL INVESTIGATION OF FOOD COLORS

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### ABSTRACT

The Lambert-Beer law relating to the absorption of optical emission allows the quantitative and qualitative examination of food products, semi-finished products and raw materials whose production can be followed optically. This paper examines the possibilities of food engineering quality analyses with this physical method, the results of the locally developed computerized spectrum analysis, and the restrictions of the applicability of this method, with special emphasis on confectionery colouring substances.

### 1. INTRODUCTION

An ever increasing tasks related to the qualification of food products are arising as food engineering develops. Attention has already been paid to determination of the energy content of nutrients. Examinations are now being made of those elements which are present in only small amounts, only but which are of importance because their presence in living organisms is essential, since they are biologically active.

Apart from the lengthy and labour-intensive chemical procedures, there is a need for the development of physical methods which ensure the relatively rapid and simple determination of the qualification parameters of food products and satisfy the prescribed microbiological and preservative requirements. These aspects have drawn attention to colouring substances and spices, which have been studied at our Faculty for several decades. We have developed a personal computer-supported absorption spectrum analysis method, which we have primarily employed to determine the surface colour and the colouring substance content of granulated products (e.g. ground paprika) [1-3], to qualify the degree of ripeness of raw paprika [4] and to examine the physical and microbiological characteristics of the products [5;6]. We have paid particular attention to identifying the relation between the quantitative development of colouring substances added to food products and the surface colours [7].

In the past few years, the examination of colouring substances has received increasing attention, since there is a generally accepted trend that the colouring of basic food products is not purposeful. However, the colouring effect also affects the flavour of the products, and consumer conservatism demands the presence of the familiar colours. Efforts to decrease the use of artificial colouring substances to a minimum are global. Under particular circumstances, absorption spectroscopy can serve as the basis of the development of a system which allows the quantitative determination and qualitative detection of colouring substances. The present paper introduces the method of spectrophotometric examination of confectionery colouring substances, and discusses the limitations of the developed method.

## 2. MATERIALS AND METHODS

Spectrum analysis is based on the Lambert-Beer law relating to the absorption of optical emission, which states that the intensity of a monochromatic and parallel beam of light decreases exponentially with the distance ( $d$ ) covered in the medium. The common logarithm of the quotient of the amount of light entering the medium and the reduced amount emitted is called the extinction ( $E$ ) or optical density. When the light absorption is due to only one homogeneous constituent with molar concentration ( $c$ ), the extinction will be

$$E(\lambda) = \varepsilon(\lambda) c d,$$

where  $\varepsilon(\lambda)$  is the molar extinction coefficient. The wavelength function of the above formula is called the absorption spectrum.

Various authors have proved [8;9] that, under given conditions, the extinction of an  $m$ -component solution mixture measured at certain wavelengths can be expressed by summing the extinctions of the constituents measured at the same wavelength:

$$E(\lambda_i) = \sum_{k=1}^m \varepsilon_k(\lambda_i) c_k d.$$

According to this relationship, it is possible to quantify the constituents of an  $m$ -component solution mixture of known molar extinction coefficient but unknown concentration  $c$ . To achieve this, a linear system of equations is needed, consisting of  $m$  equations and produced with  $m$  measurements at different wavelengths, provided that the equations are linearly independent. The spectra of the solutions are extended as far as possible in order to diminish the effects of relative measurement errors occurring at certain wavelengths ( $i > m$ ).

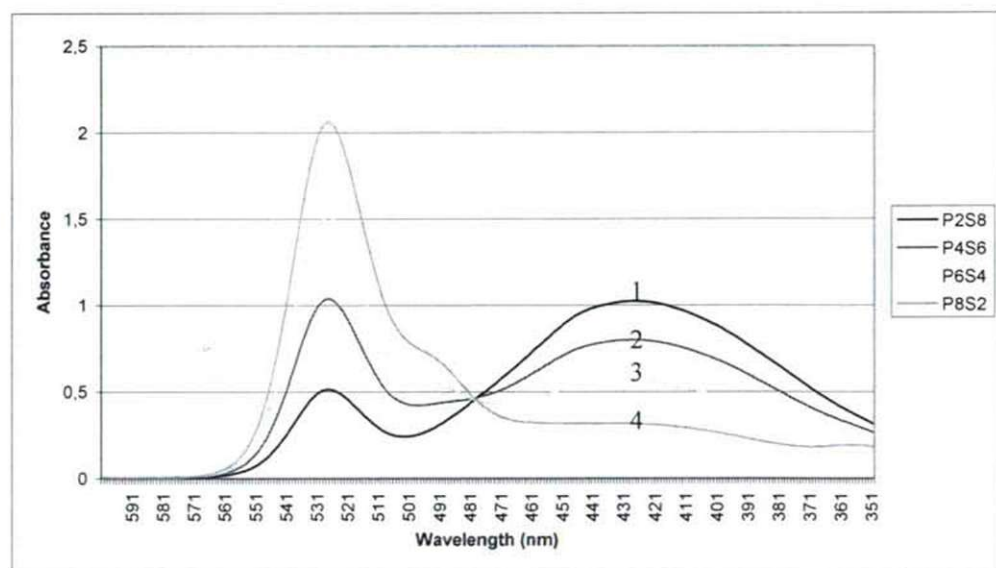
During our examinations, we used distilled water solutions (30 mg/1000 cm<sup>3</sup>) of the granulated colouring substances indigocarmine (blue), quinoline yellow (yellow) and neococcine (red). The absorption spectra of the model solutions were recorded with a UVIKON 930 spectrophotometer at each nm within the wavelength interval 350-650 nm. The spectrophotometer saves the data on disk in text format (ASCII), and these data are processed by the method of least squares (IBM PC AT/STATGRAPHICS). Verification of the conclusions drawn from the measurements and calculated results was based on mathematical statistics. Acidification of solutions was carried out with citric acid, while an alkaline reaction was achieved with the use of 0.1M NaOH solution. Later, we shall deal with the examination of the conditions of application, and also the spectrum-altering factors (pH, concentration of colouring substances, sugar content and duration of storage).

### 3. RESULTS

We first, checked the applicability of the method by the use of model solutions, analysing colouring substances in known mixing proportions. The results are demonstrated in Table I and Figure 1.

**Table I – Computer-supported evaluation of neococcine and quinoline yellow solution mixtures**

	Measured value		Calculated value		Difference in %	
	Neococcine (%)	Quinoline yellow (%)	Neococcine (%)	Quinoline yellow (%)	Neococcine (%)	Quinoline yellow (%)
4	20	80	19.43	80.57	-2.35	0.71
3	40	60	38.56	61.44	-3.60	2.40
2	60	40	58.23	41.77	-2.95	4.42
1	80	20	79.27	20.73	-0.91	3.65



**Figure 1 – Spectra of neococcine and quinoline yellow solution mixtures**

Next, we examined the spectrum-influencing effects of the pH (Fig. 2), the concentration of the colouring substance (Fig. 3), the sugar content, and the duration of storage (Fig. 4).

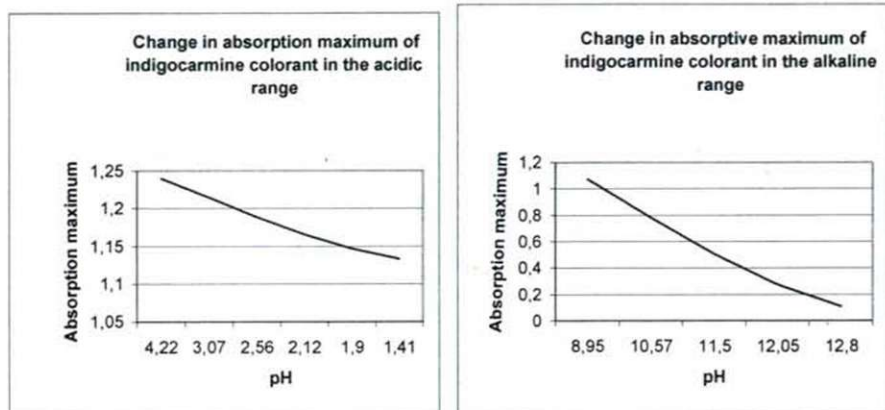


Figure 2 – Absorbance vs. pH

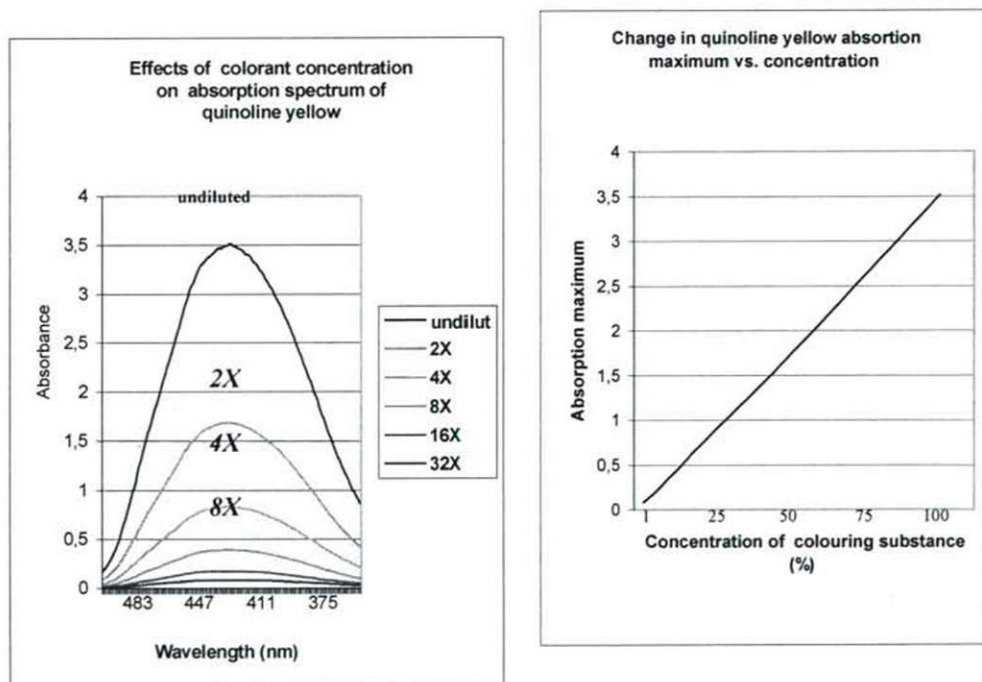


Figure 3 – Effects of concentration of colorant on absorption spectrum

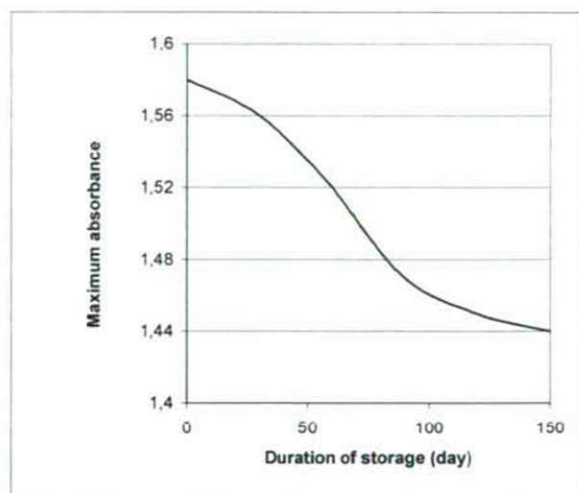


Figure 4 – Effects of storage time on maximum absorbance of indigocarmine solution

#### 4. DISCUSSION AND CONCLUSIONS

Our absorption spectrum analysis method is suitable for the examination and qualitative classification of the colouring substance contents of raw materials, semi-finished and finished products whose production can be followed optically. The application of the method may be restricted by the fact that it can be used to examine only those substances which undergo no qualitative or quantitative changes during solution preparation. The present work examined of factors that can exert considerable effects on the operating conditions. Our findings were as follows [10]:

- The computer-supported procedure is applicable to model solutions. The percentage differences between the measured and calculated values were within a margin of error of 5%.
- As concerns the effects of the pH on the spectrum (Fig. 2), the absorption maxima decreased in both acidic and alkaline media. This may be due to the instability of the colouring substances, because the colour changes of the solutions were clearly visible to the naked eye. However, it must also be noted that these extremely high pH values do not occur in food engineering.
- By varying the concentrations of the colouring substances, we examined the validity of the Lambert-Beer law, which is applicable only to dilute solutions, with monochromatic radiation and one energy state. As anticipated, the maximum absorbance varied linearly (Fig. 3).
- Variation of the amount of sugar affected the shape of the spectrum only slightly. No significant change occurred in the absorption maxima, i.e. the sugar content was not a determining factor at the examined concentrations up to of 0.5%.

- The solutions of the colouring substances stored in the dark underwent changes in time, as shown in Fig. 4, whereas the granulated substances remained practically unchanged.

We plan to continue our research with the analysis of new spectrum-altering effects, and study of the relation between the quantity of colouring substance applied and the visually observed colour effect.

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