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Effects of typical food additives on the absorption spectrum properties of black tea

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ABSTRACT

This thesis regards black tea as the analysis target. Basing on the analysis of plenty of black tea added with different food additives, the visual spectral analysis technology is used to scan the absorption spectrum of the tea, and the MATLAB software is applied to optimize the data, then ultimately we can get the absorption spectrum curves of several groups of tea added with different food additives. Through the analysis and comparison of the absorption spectrum curves of the tea before and after added with food additives, we can observe the effects of different additives on the tea intuitively. This study provides a new way for analyzing the effects of food additives on black tea and the composition of tea beverages with the usage of visual spectral analysis technology.

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1. Introduction

The spectral testing and analysis techniques have many advantages, for example, the testing process is not only simple and quick, but also brings no pollution; in addition, the testing range can be continually expanded. Therefore, it has been widely used in many fields, especially in the fields of biology and medicine, and has brought us many important results in recent years, such as the study of serum's fluorescence spectrum [1], the study of cholesterol's content basing on serum's UV–Visible absorption spectrum [2], the effects of serum's concentration on serum's fluorescence spectrum [3], using spectroscopy to detect protein's molecular structure [4], applying near-infrared Raman spectroscopy to diagnose cancer [5].

Tea, known as the "national drink", is an ancient Chinese beverage. Modern medical technology has shown that, tea has not only the usual pharmacological effects, but also high nutritional values; therefore, tea has become more respected and drinking tea has become people's daily habits nowadays. The relation between the trace elements in tea and human's health has achieved increasing attention in recent years. The fields of ecology, chemistry, agriculture and environmental conservation have carried out extensive and in-depth research on the trace elements in tea and have yielded fruitful results. The usage of spectroscopy analysis techniques on the determination of tea has become a focus in recent years, such as the determination and analysis of polyphenol in tea, the determination of the substances that mainly contributes to flavors in tea, the extraction of pigments [6–8]. In the study of tea spectrum at home and abroad, the UV–Visible absorption spectrum is generally used to qualitatively distinguish the difference of components between different kinds of tea [9]; of course, in addition to the absorption spectrum of tea, we can also apply fluorescence spectroscopy to quantitatively determine the element content in tea [10], thus to provide scientific information and basis for the further study of the health effects of tea [11]. The spectral analysis of some samples can be carried out directly without any chemical treatment; computer technology can be used to automatically analyze and process data before printing the analysis results out, and has advantages like the good selectivity,

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Nomenclature

I_0	input light energy	ε	the absorption coefficient
I_t	output light energy	T	the transmission ratio
A	the transmission absorbance		

ability to determine elements and compounds that have similar chemical properties and less sample damage. with the usage of spectroscopy analysis technology on the study of tea, we can also use the quality index in scientific measurements to evaluate tea's quality [12–14].

This article intends to apply spectroscopy analysis technology to the study on the characteristics of black tea added with different food additives. In experiments, we mainly collected the absorption spectrum at the wavelength from 200 nm to 700 nm; then we detected the changes of the absorption intensity and the values of absorption peaks at this wave band; at last, we analyzed the experimental results according to existing theory. Through the changes of the spectrum characteristics, we can get the results of the effects of different food additives on tea.

2. Basic principle

Absorption spectroscopy is based on the determination of the transmittance of the solution in the transparent pool with the optical path length of d. Generally substance's UV–Visible absorption involves the excitation of valence electrons, so we can establish correlation between the wavelength of the absorption peak and the existing bond types in substances, thus to achieve the goal of determining the compounds in substances. Basically there are three kinds of molecular energy transition: electron level, vibration level and transition level. The corresponding absorption bands of different energy levels are respectively located in ultraviolet area, visible area, near-infrared area, far-infrared area and microwave area. Therefore, when we use the UV–Visible light to irradiate substances, the molecular electron transition will happen, and thus there will be light absorption in the UV–Visible area. Different types of electron transitions need different energies to realize the transition, and thus the wavelength range of absorption is also different.

The absorption of light by substances can be described by plotting the absorption curve. The relation between the absorption intensity of light and the content of the absorptive components in substances can be described by the law of Lambert–Beer. When a substance is irradiated by a monochromatic light of wavelength λ, energy $I_0(\lambda)$, the energy of output light $I_t(\lambda)$ at the other end t is much lower than the energy of the input light. If it is assumed that there is a thin layer of thickness d_x, and the input light is of intensity $I(\lambda)$, then the intensity of the output light will be reduced to $I(\lambda) - d_{I(\lambda)}$. It can be considered that the decrease of light intensity $d_{I(\lambda)}$ is proportional to the concentration of the absorption components in the thin layer as well as the intensity $I(\lambda)$ of the incident light that enters the thin layer. Assumed that the proportionality constant is k, the concentration of absorption components is c, then we get the formula:

$$A(\lambda) = \lg[I_0(\lambda)/I_t(\lambda)] = \lg[1/T(\lambda)] = \varepsilon cd \quad (1)$$

In this formula: ε is called absorptivity; $T(\lambda)$ is called transmission ratio; $A(\lambda)$ is called absorbance. If c is fixed, this formula is called the Lambert law; if d is fixed, it is known as the Bill law. ε reflects substance's absorptive capacity of light, and also reflects the sensitivity of quantitative measurement [15]. The greater value of ε reflects the substance's stronger absorption of light under certain conditions and higher measurement sensitivity; thus it is the main characteristic of UV–Visible spectrum [16–18].

3. Experimental samples and methods

We choose the typical black tea produced in Anhui province as the experimental sample. In experiments we use boiling water to brew quantitative tea (0.5 g), thus to obtain the required tea. Then we add typical food additives (cream, sugar, vinegar) in the tea, and extract the samples with cuvettes. At room temperature, using multifunctional grating spectrometer to detect the absorption spectra of tea in the before and after adding food additives. The multifunctional grating spectrometer consists of grating monochromator, receiving element, scanning system, electronic amplifier, A/D acquisition card and computer. This instrument mainly does absorption spectrum experiment. But another way of saying it is, we call transmitted spectrum experiment. transmitted spectrum is the spectrum detected after incident ray through the sample which under test. Compared with the incident light, the transmitted light lack of some spectrum which is absorbed or reflected by sample. So in one sense, transmission spectra and absorption spectra are equivalent, both of them can reflect the certain properties of the sample.

The instrument schematic as shown below Fig. 1, wavelength scanning range from 200 nm to 700 nm, the sampling interval is 0.2 nm, quickly and automatically scan, draw the spectral curve. (Note: Because the changes of curve mainly concentrated in 400–600 nm, so we chose 420–640 nm to analysis and omit the others in the follow figures).

As Fig. 1(a) shows the schematic of the instrument [19]. Fig. 1(b) shows the shape of the multifunction grating spectrometer.

In order to avoid the influence of external light, we did the experiments in the dark room. When experimental apparatus started running, close all the light.

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