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• Research Article

Influence of storage duration and processing on chromatic attributes and flavonoid content of moxa floss

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ABSTRACT

OBJECTIVE: Moxibustion is an important traditional Chinese medicine therapy using heat from ignited moxa floss for disease treatment. The purpose of the present study is to establish a reproducible method to assess the color of moxa floss, discriminate the samples based on chromatic coordinates and explore the relationship between chromatic coordinates and total flavonoid content (TFC).

METHODS: Moxa floss samples of different storage years and production ratios were obtained from a moxa production factory in Henan Province, China. Chromatic coordinates (L^*, a^* and b^*) were analyzed with an ultraviolet-visible spectrophotometer and the chroma (C^*) and hue angle ($h°$) values were calculated. TFC was determined by a colorimetric method. Data were analyzed with correlation, principal component analysis (PCA).

RESULTS: Significant differences in the chromatic values and TFC were observed among samples of different storage years and production ratios. Samples of higher production ratio displayed higher chromatic characteristics and lower TFC. Samples of longer storage years contained higher TFC. Preliminary separation of moxa floss production ratio was obtained by means of color feature maps developed using L^*-a^* or L^*-b^* as coordinates. PCA allowed the separation of the samples from their storage years and production ratios based on their chromatic characteristics and TFC.

CONCLUSION: The use of a colorimetric technique and CIELAB coordinates coupled with chemometrics can be practical and objective for discriminating moxa floss of different storage years and production ratios. The development of color feature maps could be used as a model for classifying the color grading of moxa floss.

Keywords: moxa floss; moxibustion; color; total flavonoid content; quality control

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1 Introduction

Moxibustion is an integral traditional Chinese medicine therapy that uses heat from ignited moxa floss as its main combustion material for disease treatment[1]. Moxa floss is usually processed from mugwort leaves of the species *Artemisia argyi* Levl. et Vant., *Artemisia princeps* Willd. and *Artemisia vulgaris* L[2]. The production of moxa floss first begins with storage of the mugwort leaves to allow drying. During storage, a number of physicochemical and physiological changes occur, which are termed aging. The aged and dried mugwort leaves are then subjected to several rounds of pulverization and sifting. During each round of sifting, the ratio of mesophyll decreased and that of tomentose hairs found on the underside of leaves increased. It has been reported that discoloration and browning of plant material occur during postharvest storage, possibly due to a change in phenolic composition and a loss of bioactives, or due to chlorophyll degradation, leading to pheophorbide, which causes a color change from bright green to olive brown[3]. The destruction of cell integrity during pulverization and exposure to oxygen also initiates oxidation of polyphenols, particularly flavonoids[4]. However, it is not known to what extent changes in color and flavonoid composition of moxa floss take place during storage and pulverization.

Moxa floss possesses a characteristic green or yellow color and its color grading is traditionally judged visually by expert panelists. However, it is very difficult to distinguish among minor color differences between grades of moxa floss products. Currently, instrumental techniques, including spectrophotometers and colorimeters, eliminate the variability and subjectivity of human perception by retrieving color coordinates from different color spaces by statistical methods. Among the different spectrophotometric systems, measurements based on the tristimulus CIE (Commission Internationale de l'Eclairage) space are defined by chromatic coordinates called lightness (L^*), redness (a^*) and yellowness (b^*) and are known as the CIELAB color space; this system is commonly used because it uniformly covers the full visible spectrum of the human eye[5]. According to the CIE 1976 publication[6], lightness (L^*) describes whether the color is closer to black or white, hue ($h°$) is the perceived color of an object (*e.g.*, yellow, red, blue or green), and chroma (C^*) describes the saturation, vividness or purity of a color, of which high values correspond to rich and full colors, while low values correspond to dull and grayish colors[7].

Flavonoids are a group of phenolic compounds, which consists of two aromatic rings linked by three carbons that are usually in an oxygenated heterocycle ring[8]. In addition to encompassing a wide range of biological and physiological activities, flavonoids have been shown to make important contributions to the organoleptic nature of plant material[9,10]. The relationship between flavonoids and plant pigmentation is one of the oldest areas of study in plant science[11]. Many studies have also used the CIELAB coordinates for the quantitative analysis of color and have indicated its correlation with flavonoid composition during postharvest treatment and storage of a broad range of products, including herbal material such as *Ginkgo biloba*[12] and ribwort plantain (*Plantago lanceolata* L.) leaves[13], and food products such as rice[14], wine[15,16] and tea[17,18].

Previous chemical studies have reported that mugwort leaves are rich in flavonoids, and flavonoid compounds such as quercetin derivatives, luteolin and kaempferol have been isolated and identified[19–21]. The flavonoid eupatilin was also recently selected as a standard marker compound to control the quality of *Artemisia* preparation used in botanical drugs in Korea[22]. However, the influence of storage duration and processing on the color and flavonoid content of moxa floss has not been studied. The objective of the present study was to: 1) establish a simple and reproducible method to assess the color of moxa floss, 2) explore the relationship between the chromatic coordinates, total flavonoid content and chemometrics of moxa floss and 3) develop a model to discriminate moxa floss samples according to their storage year or production ratio based on CIE $L^*a^*b^*$ chromatic coordinates.

2 Materials and methods

2.1 Materials and instruments

Moxa floss samples prepared from *Artemisia argyi* collected on Tongbai Mountain in Henan Province, China were obtained from a moxa floss production factory in Nanyang, Henan Province, China. The samples included different storage years and production ratios. Storage year refers to the number of years that the dried mugwort leaves were stored before processing into moxa floss, while production ratio refers to the ratio of the weight of the starting material to the weight of the finished product. Twelve moxa floss samples included production ratios of 3:1, 5:1, 10:1 and 15:1 from each of 3 storage years (0, 3 and 10). A thirteen sample had a production ratio of 30:1 from 3-storage-year mugwort, a combination traditionally considered to be of the best quality. Rutin was purchased from the Chinese Institute for the Control of Pharmaceutical and Biological Products (Beijing, China). Ethanol, sodium nitrite, aluminum nitrate and sodium hydroxide were of analytical grade and purchased from Beijing Reagent Company (Beijing, China). Deionized water was purified by a Milli-Q academic water purification system (Millipore, Bedford, MA, USA).

An ultraviolet-Vis spectrophotometer (Hitachi U-3010; Shimadzu Scientific Instruments, Japan) was used for color and total flavonoid analysis. A KQ-500DE ultrasonic bath