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 ($h^\circ$) 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 Lev. 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 phophoribide, 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
(Kunshan Ultrasound Equipment Co., China) was used to extract flavonoids from samples.

2.2 Analysis of color
For all measurements, 1.5 g of each sample was placed in a quartz cell with a 1 mm path length and scanned across the wavelength range of spectra of 380–780 nm. The CIELAB coordinates of lightness ($L^*$), redness ($a^*$) and yellowness ($b^*$) were determined following the recommendations of the CIE for the CIE illuminant D65 and 10° standard observer conditions. $L^*$ represents the difference between light ($L = 100$) and dark ($L = 0$), $a^*$ represents the difference between red ($+a$) and green ($-a$), while $b^*$ represents the difference between yellow ($+b$) and blue ($-b$). All spectra measurements were completed on the same day.

In addition, the chroma ($C^*$) and hue angle ($h^\circ$) values were calculated. Chroma ($C^*$) is considered the quantitative parameter of the vividness or purity of a color and is calculated as $C^* = (a^*^2 + b^*^2)^{1/2}$. Hue angle ($h^\circ$) is the attribute according to which colors are traditionally described and is calculated as $h^\circ = \tan^{-1}(b^*/a^*)$, where $0^\circ$ corresponds to red, $90^\circ$ to yellow, $180^\circ$ to green, and $270^\circ$ to blue.

2.3 Determination of total flavonoid content
Extracts of flavonoids were prepared by incubating 1 g of each moxa floss sample in 70 mL of aqueous ethanol (50%) for 1 h. The extract was then sonicated for 30 min, filtered into a 100 mL volumetric flask using filter paper of pore size 15 to 20 μm and diluted with 50% aqueous ethanol to a final volume of 100 mL. Total flavonoid content (TFC) was determined following a colorimetric protocol with minor modifications. At time zero, 0.50 mL of sample was transferred to 10 mL volumetric flask and 0.30 mL of 5% NaNO$_2$ was added. At 6 min, 0.30 mL of 10% Al(NO$_3$)$_3$ was added to the mixture, and at 12 min, 4 mL of 4% NaOH was added. At this point, the solution was diluted to 10 mL using 50% aqueous ethanol and allowed to stand for 15 min. The absorbance of the solution was measured at 510 nm with a spectrophotometer (Hitachi U-3010), using the same mixture, without the sample as a blank. Rutin was used as the standard for a calibration curve. The flavonoid content was calculated using the following linear equation based on the calibration curve: $A = 10.022C - 0.016$, $r^2 = 0.999$, where $A$ is the absorbance and $C$ is the flavonoid content in mL.

2.4 Statistical analysis
All analyses were done in triplicate and the values were presented as mean and standard deviation. One-way analysis of variance (ANOVA) was used for data that have a normal distribution or the Kruskal-Wallis test for data with non-normal distribution. Principal component analysis (PCA) and a bivariate correlation analysis of the results were performed using the statistical software SPSS 17.0 (SPSS Inc., Chicago, IL, USA). Differences of $P < 0.05$ was considered statistically significant.

3 Results

3.1 Analysis of chromatic coordinates and TFC
The $L^*$, $a^*$, $b^*$ and $C^*$ coordinates were positively dependent on the moxa floss production ratio, while $h^\circ$ was negatively dependent on the moxa floss production ratio (Table 1). The $a^*$ and $b^*$ coordinates were all positive, indicating that the moxa floss samples had typical yellow and red coloration. The sample with the highest ratio 30:1 had the highest $L^*$, $b^*$ and $C^*$ values, signifying highest saturation. The hue angle ($h^\circ$) values were all above 70°, which means that the samples were perceived as a combination of yellowish-red in the color perception of the human eyes. Significant differences were observed in each of the chromatic coordinates and TFC ($P < 0.05$) when samples with different moxa floss production ratios were compared with samples from the same storage year (Table 1). There were also significant differences ($P < 0.05$) in the $a^*$ coordinate and TFC when samples with the same moxa floss production ratio were compared across storage years (Table 2).

The TFC results showed a significant variation among the moxa floss samples, with values ranging from 2.13 mg/g to 13.56 mg/g (Table 1). The mean TFC values for the 0-, 3- (excluding the sample of ratio 30:1) and 10-storage year samples were (5.50 ± 1.78), (5.99 ± 1.33) and (10.66 ± 2.35) mg/g, respectively. The mean TFC values among the samples of ratios 3:1, 5:1, 10:1, 15:1 and 30:1 were (9.68 ± 2.99), (7.66 ± 2.99), (6.81 ± 2.95), (5.38 ± 2.17) and (2.13 ± 0.18) mg/g, respectively. It was observed that an increase in moxa floss production ratio was accompanied by a decrease in TFC. Interestingly, there was an increase in TFC as storage time lengthened.

3.2 Correlations among chromatic coordinates and TFC of moxa floss samples
Table 3 shows the correlation analysis among storage year and production ratio, chromatic coordinates and TFC. Storage year of moxa floss and TFC displayed a positive relationship ($r = 0.633; P < 0.01$), while production ratio and TFC displayed a negative relationship ($r = -0.669; P < 0.01$). The $L^*$ coordinate displayed a negative relationship with TFC ($r = -0.699; P < 0.01$), indicating that an increase in the sample’s brightness reflected a decrease in flavonoid content.

Strong correlations were observed among the moxa floss production ratio and chromatic coordinates, especially with the $L^*$ coordinate ($P < 0.01$), followed by the $b^*$, $C^*$ and $a^*$ coordinates ($P < 0.01$).

High statistical correlation ($r > 0.80$) was observed among the color coordinates $L^* - b^*$, $L^* - C^*$, $a^* - b^*$, $a^*$.
### Table 1 Chromatic coordinates and TFC among the moxa floss samples

<table>
<thead>
<tr>
<th>Storage year</th>
<th>Production ratio</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>Chroma (C*)</th>
<th>Hue angle (h°)</th>
<th>TFC (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3:1</td>
<td>43.69±0.62</td>
<td>3.73±0.32</td>
<td>16.78±0.30</td>
<td>17.19±0.25</td>
<td>77.46±1.21</td>
<td>8.00±0.09</td>
</tr>
<tr>
<td></td>
<td>5:1</td>
<td>48.17±1.09</td>
<td>3.96±0.06</td>
<td>17.80±0.26</td>
<td>18.24±0.27</td>
<td>77.44±0.13</td>
<td>5.48±0.10</td>
</tr>
<tr>
<td></td>
<td>10:1</td>
<td>53.32±0.43</td>
<td>5.36±0.04</td>
<td>21.07±0.32</td>
<td>21.74±0.32</td>
<td>75.72±0.11</td>
<td>4.55±0.24</td>
</tr>
<tr>
<td></td>
<td>15:1</td>
<td>52.44±0.57</td>
<td>5.99±0.10</td>
<td>22.35±0.70</td>
<td>75.13±0.23</td>
<td>3.96±0.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30:1</td>
<td>48.17±1.09</td>
<td>3.96±0.06</td>
<td>17.80±0.26</td>
<td>18.24±0.27</td>
<td>77.44±0.13</td>
<td>5.48±0.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.016</td>
<td>0.024</td>
<td>0.016</td>
<td>0.024</td>
<td>0.015</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3:1</td>
<td>44.73±1.40</td>
<td>4.26±0.15</td>
<td>17.56±0.44</td>
<td>18.08±0.46</td>
<td>76.37±0.28</td>
<td>7.48±0.43</td>
</tr>
<tr>
<td></td>
<td>5:1</td>
<td>47.82±0.48</td>
<td>4.20±0.09</td>
<td>17.97±0.32</td>
<td>18.46±0.32</td>
<td>76.85±0.14</td>
<td>6.43±0.05</td>
</tr>
<tr>
<td></td>
<td>10:1</td>
<td>52.52±0.41</td>
<td>4.79±0.09</td>
<td>21.70±0.33</td>
<td>22.22±0.34</td>
<td>75.74±0.07</td>
<td>5.73±0.50</td>
</tr>
<tr>
<td></td>
<td>15:1</td>
<td>55.56±1.64</td>
<td>4.48±0.04</td>
<td>21.11±0.38</td>
<td>21.58±0.38</td>
<td>78.02±0.11</td>
<td>4.30±0.05</td>
</tr>
<tr>
<td></td>
<td>30:1</td>
<td>59.15±0.12</td>
<td>6.00±0.08</td>
<td>23.63±0.10</td>
<td>24.38±0.12</td>
<td>75.74±0.13</td>
<td>2.13±0.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.009</td>
<td>0.012</td>
<td>0.011</td>
<td>0.009</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3:1</td>
<td>45.96±0.55</td>
<td>4.83±0.14</td>
<td>19.30±0.46</td>
<td>19.90±0.48</td>
<td>75.96±0.07</td>
<td>13.56±0.27</td>
</tr>
<tr>
<td></td>
<td>5:1</td>
<td>46.54±1.08</td>
<td>4.79±0.03</td>
<td>19.58±0.49</td>
<td>20.16±0.49</td>
<td>76.24±0.26</td>
<td>11.08±0.39</td>
</tr>
<tr>
<td></td>
<td>10:1</td>
<td>50.28±0.43</td>
<td>5.72±0.13</td>
<td>21.49±0.13</td>
<td>22.23±0.16</td>
<td>75.10±0.24</td>
<td>10.14±0.15</td>
</tr>
<tr>
<td></td>
<td>15:1</td>
<td>53.14±0.28</td>
<td>6.43±0.07</td>
<td>21.11±0.38</td>
<td>21.58±0.38</td>
<td>78.02±0.11</td>
<td>4.30±0.05</td>
</tr>
<tr>
<td></td>
<td>30:1</td>
<td>59.15±0.12</td>
<td>6.00±0.08</td>
<td>23.63±0.10</td>
<td>24.38±0.12</td>
<td>75.74±0.13</td>
<td>2.13±0.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.009</td>
<td>0.012</td>
<td>0.011</td>
<td>0.009</td>
<td>0.009</td>
<td></td>
</tr>
</tbody>
</table>

Results are expressed as mean±standard deviation. P-values refer to the statistical analysis of moxa floss samples of the same storage year but different production ratios. TFC: total flavonoid content.

### Table 2 P-values of moxa floss samples of the same production ratio but different storage years

<table>
<thead>
<tr>
<th>Storage year</th>
<th>Production ratio</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>Chroma (C*)</th>
<th>Hue angle (h°)</th>
<th>TFC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3:1</td>
<td>0.067</td>
<td>0.003</td>
<td>0.001</td>
<td>0.001</td>
<td>0.097</td>
<td>4.48×10^7</td>
</tr>
<tr>
<td></td>
<td>5:1</td>
<td>0.177</td>
<td>0.027</td>
<td>0.061</td>
<td>0.061</td>
<td>0.026</td>
<td>0.027</td>
</tr>
<tr>
<td></td>
<td>10:1</td>
<td>0.039</td>
<td>0.027</td>
<td>0.079</td>
<td>0.252</td>
<td>0.027</td>
<td>0.027</td>
</tr>
<tr>
<td></td>
<td>15:1</td>
<td>0.027</td>
<td>0.027</td>
<td>0.066</td>
<td>0.061</td>
<td>0.027</td>
<td>0.027</td>
</tr>
</tbody>
</table>

F value: 78.986, 180.366, 58.720, 67.608, 70.332, 245.272

P-value: 2.76×10^-6, 1.10×10^-7, 8.61×10^-6, 5.02×10^-6, 4.32×10^-6, 3.28×10^-8

TFC: total flavonoid content.

### Table 3 Correlation coefficients between TFC and chromatic coordinates among moxa floss samples

<table>
<thead>
<tr>
<th>Storage year</th>
<th>Production ratio</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>Chroma (C*)</th>
<th>Hue angle (h°)</th>
<th>TFC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3:1</td>
<td>-0.041</td>
<td>0.927</td>
<td>1.000</td>
<td>0.357</td>
<td>0.720</td>
<td>0.635</td>
</tr>
<tr>
<td></td>
<td>5:1</td>
<td>0.177</td>
<td>0.866</td>
<td>0.930</td>
<td>0.902</td>
<td>0.882</td>
<td>0.925</td>
</tr>
<tr>
<td></td>
<td>10:1</td>
<td>0.039</td>
<td>0.823</td>
<td>0.925</td>
<td>0.994</td>
<td>0.823</td>
<td>0.925</td>
</tr>
<tr>
<td></td>
<td>15:1</td>
<td>0.027</td>
<td>0.699</td>
<td>0.699</td>
<td>0.699</td>
<td>0.699</td>
<td>0.699</td>
</tr>
</tbody>
</table>

TFC: total flavonoid content.
and \( C^* \) and \( b^*-C^* \). In particular, a very strong correlation was found between the coordinates \( b^*-C^* \).

### 3.3 PCA of chromatic coordinates and TFC of moxa floss samples

In order to evaluate the moxa floss sample discriminating potential of the color chromatic method and TFC, CIE \( L^* \), \( a^* \) and \( b^* \) chromatic coordinates and TFC results were submitted to PCA analysis. Two principal components (PCs) were identified. PC1 explained up to 72.10% of the total variance and PC2 explained another 23.53%. Samples were separated in the first PC by differences observed in the chromatic coordinates of \( L^* \), \( a^* \), \( b^* \) and \( C^* \), while the second PC separated the samples on the basis of TFC, explaining 95.63% of the total variability of experimental data.

The bi-dimensional plot of the samples in the space defined by the two principal components (Figure 1) shows a separation of moxa floss samples from the lower production ratios (3:1 and 5:1) on the left to the higher production ratios (10:1, 15:1 and 30:1) on the right. The PCA model also showed a distinct separation between moxa floss samples of 10 storage years (group D) from samples of 0 storage year (group A) and 3 storage years (groups B and C). The present PCA model thus shows an effective classification of moxa floss into different storage years and production ratios based on chromatic coordinates and TFC.

### 3.4 Development of color feature maps based on CIELAB color space

Color feature maps were developed based on the \( L^*-a^* \) and \( L^*-b^* \) chromatic coordinates (Figures 2 and 3). Similar results were obtained in both \( L^*-a^* \) and \( L^*-b^* \) color feature maps. The results illustrated that both maps allowed the separation of moxa floss into low (3:1 and 5:1), middle (10:1 and 15:1) and high (30:1) production ratio regardless of storage duration. This implies that the color of moxa floss is more closely related to its production ratio rather than storage duration and that the use of \( L^*-a^* \) and \( L^*-b^* \) chromatic values is adequate to express color differences and to discriminate moxa floss of different production ratios.

Flavonoids are qualitatively and quantitatively one of the largest groups of natural products found ubiquitously in plant parts\(^{[27]}\). The potential actions of flavonoids as immune modulators, radical-scavengers, enzyme and hormone action inhibitors may make important contributions to health and disease.
to therapeutic and prophylactic applications; these compounds are of particular interest due to their biological activities. Research on the therapeutic mechanisms of moxibustion has suggested that apart from local somato-thermal stimulation, and infrared radiation effects, the pharmacological properties of moxa floss itself may also contribute to its treatment efficacy. The chemical composition of essential oils from mugwort leaves has been widely studied. However, in contrast, the chemical composition of the water-soluble fraction of plant, which contains many flavonoids having a wide range of biological and physiological activities, is less investigated in the literature.

It was found in our study that moxa floss of higher production ratios displayed higher chromatic characteristics and lower flavonoid content. The increase in yellow color and decrease in flavonoid content of the higher moxa floss samples might be due to destruction of the chlorophyll pigments and flavonoids present in the mugwort leaves during the pulverization process. Storage of plant material has been associated with browning, however, the results from our research suggested that color of moxa floss is more closely related to its processing rather than its storage duration.

Interestingly, moxa floss of longer storage years was found to have higher flavonoid content. This was in agreement with postharvest studies of certain plant crops, which also reported an increase in flavonoid concentration and antioxidant capacity as a result of postharvest flavonoid synthesis during storage. Some research has reported that flavonoids are ultraviolet-B absorbing compounds whose concentrations increase in plant cells exposed to ultraviolet-B radiation. The increase in flavonoid content in moxa floss might be due to the synthesis and accumulation of flavonoids in the leaves during storage. Another possible explanation could be that the breakdown of cell walls during pulverization leads to oxidation reactions in phenolic compounds, thus yielding higher flavonoid levels.

The burning of moxa floss during moxibustion can be regarded as a type of agricultural biomass combustion. Studies of biomass combustion characteristics have reported that biomass contains much less carbon and has lower heating value as compared to solid fossil fuels and that the heating value can be positively correlated with carbon concentration. Given that the total flavonoid content decreased as production ratio of moxa floss increased, we hypothesized that moxa floss processed into higher production ratios might burn at a lower temperature and thus might be safer in terms of combustion characteristics. On the other hand, we found that the total flavonoid content increased with longer storage duration in our study. Moxi-\textit{bustion has been reported to be used in many diseases including cardiovasculard, gastrointestinal and senescence-related symptoms. Flavonoids have been reported to have biological activities that include antibacterial, antiviral and antioxidant effects. The thermodynamic characteristics and thermal decomposition products of flavonoids in moxibustion and their correlation with the safety and effectiveness of moxibustion clinical usage thus warrant further investigation.}

5 Conclusion

To the authors’ knowledge, this is the first study that attempts to quantify the color of moxa floss and evaluate the influence of storage duration and processing on the chromatic attributes and flavonoid content of moxa floss. Based on the results of this study, the color of moxa floss was more closely associated with its production ratio than storage duration. A negative relationship existed between TFC and chromatic characteristics of moxa floss, and TFC was found to increase upon longer storage. Considering the many variables that affect the color and chemical composition of moxa floss, PCA demonstrated the segregation of moxa floss into groups based on different storage years and production ratios. The results suggest that the use of CIELAB parameters can be a practical tool for rapid and non-destructive analysis of moxa floss chromatic characteristics. Further, the development of $L^*\cdot a^*$ and $L^*\cdot b^*$ color feature maps can be an objective approach to the color grading of moxa floss. The methods described in this paper could be implemented on a larger number of moxa floss samples to build a CIELAB color database for future quality control and evaluation studies. Such a database would have key significance to the development of objective standards and quality benchmarks related to moxa floss production, thus preventing counterfeit products and providing the safety and quality assurance of moxibustion in clinical usage.

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7 Conflict of interests

The authors have no conflicts of interest to declare.

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