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Sensory evaluation, physicochemical properties and aroma-active profiles in a diverse collection of Chinese bayberry (*Myrica rubra*) cultivars

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ABSTRACT

The present study aimed to differentiate the flavor (taste and odor) profiles of 11 Chinese bayberry cultivars (*Myrica rubra*). The physicochemical analysis for taste indicated the bayberry cultivars were quite different in soluble sugars, organic acids, color, total phenolics and anthocyanin contents. Sucrose was the main soluble sugar in bayberry fruit. Principal component analysis (PCA) of physicochemical properties indicated bayberries could be divided into 5 groups, and the *Bi qi* cultivar contained the highest brix/acid ratio demonstrating the sweetest taste. PCA of aroma-active profile for odor (analyzed by SPME–GC–MS–O) indicated bayberries could be divided into 3 groups: α-pinene ("pine" odor) for group 1 (four cultivars), β-caryophyllene and isocaryophyllene ("woody" odor) for group 2 (six cultivars), and ethyl acetate ("over-ripe" odor) for group 3 (one cultivar). Our research on the physicochemical and active-aroma of 11 bayberry cultivars will help to select suitable cultivars to increase consumer satisfaction.

1. Introduction

Chinese bayberry fruit is widely cultivated in the south of China. Ripe berries can be purple, red, pink, or white, depending on the specific cultivar, and have a sweet-sour taste and pleasant aroma (Cheng, Chen, Chen, et al., 2015). Bayberry fruits are consumed in a variety of forms, including jam, juice, and wine, or canned in syrup. These products are highly esteemed by consumers due to their unique flavor and pleasant taste (Cheng, Chen, Li, et al., 2015). This appeal is aided by their high levels of various nutritional components, including soluble sugars, organic acids, minerals, vitamins, and phenolics. Also, the high antioxidant potential of bayberry resulting in a beneficial effect for human health is an additional factor that influences the customers' choice (Huang, Sun, Lou, Li, & Ye, 2014).

The characterization of the physicochemical properties and the volatile composition will determine the overall fruit quality including taste and odor, which will have an influence on the perception of different cultivars (Gokbulut & Karabulut, 2012). The fruit flavor consists of taste, mainly contributed by non-volatile compounds, and odor mostly resulting from aroma-active volatile compounds.

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Flavor involves the combination of gustatory and olfactory stimuli and while it is natural to think that taste will play a key role in multisensory flavor perception, it is largely the sense of smell (olfaction) which contributes to the consumer experience of flavor (Spence, 2015). However, while there have been several publications that have focused on the non-volatile taste identification and biological activities of Chinese bayberry (Huang et al., 2014; Zhang et al., 2015; Zhou et al., 2009), there have been little studies on the aroma-active compounds present in selected cultivars (Cheng, Chen, Chen, et al., 2015; Xu et al., 2014), especially even less with bayberry germplasm. Thus, it is important to identify the contribution that is made by the physicochemical and volatile compounds to the similarities and differences of bayberry cultivars.

Gas chromatography mass spectrometry-olfactometry (GC–MS–O) is a common approach for separating aroma-active compounds from the bulk of odorless volatiles in produce (Pino, 2014; Selli, Kelebek, Ayseli, & Tokbas, 2014). Kang et al. (Kang, Li, Xu, Jiang, & Tao, 2012) revealed that the most important aroma-active compounds in Chinese bayberry fruits were menthol, caryophyllene, 4-terpineol, linalool oxide, linalool, and acetic acid. Xu et al. (Xu et al., 2014) applied the headspace solid-phase micro-extraction (HS-SPME) coupled with GC–MS to analyze the flavor variations during bayberry fruit juice processing and storage. They concluded that ethyl acetate could be classified as the "top-note" of the bayberry fruit, and that the main contributors to the fermentation-like flavors would be high levels of alcohols and low levels of esters. However, in their research, the active aroma of the bayberry is still unclear. Recently, we identified the aroma compounds in Chinese bayberry using GC–MS with olfactometry (Cheng, Chen, Chen, et al., 2015), which was helpful to identify the key aroma of the bayberry. However, a systemically research of aroma profile and physiochemical in the main Chinese bayberry cultivars for differentiation is also needed for future products developments.

Chemometric tools, such as principal component analysis (PCA), are often used to obtain insights into variations in the varietal volatile profiles and physiochemical compounds responsible for the sensory differences among berry cultivars. Beaulieu et al. (Beaulieu et al., 2015) studied the aroma volatile profiles in different pomegranate cultivars, and found that there were variations in the dominant compounds in the different cultivars, thus allowing differentiation between the pomegranate cultivars; additionally, these workers found that aldehyde and terpene concentrations could be used to characterize cultivars when combined with PCA. In our previous studies, we have studied on the characterization of aroma-active volatiles in three Chinese bayberry cultivars using GC–MS–olfactometry and an electronic nose combined with principal component analysis and revealed their contributions to the odor differences among the bayberry cultivar groups (Cheng, Chen, Chen, et al., 2015). The above data showed that PCA could be used to identify the aroma compounds responsible for the flavor differences between berry cultivars, as well as accurately explain the results based on the berry variety. However, a further systematic research of the main cultivars in China as well as the physiochemical profile by PCA is still needed.

Thus, the present study aimed to determine the similarities and differences of the 11 bayberry cultivars in the sensory evaluation, aroma-active profile and physicochemical properties. Few studies include comprehensive sensory-directed flavor analysis on the bayberry cultivars. This study is the first report of the effect that different cultivars has on the variation in bayberry juice qualities. Additionally, the present research aimed to establish the physiochemical and volatile profiles of different cultivars of bayberry fruit providing useful data for the bayberry industry.

2. Materials and methods

2.1. Fruit materials

Fruits from 11 bayberry cultivars, including *Li zhi* (LZ), *Bai yangmei* (BYM), *Ding ao* (DA), *Zao se* (ZS), *Chi se* (CS), *Bi qi* (BQ), *Shui mei* (SM), *Dong kui* (DK), *Wan dao* (WD), *Tan mei* (TM), and *Fen hongzhong* (FHZ) were collected from bayberry growers in Zhejiang Province, China, during May and July, 2014. The samples (5 kg for each bayberry cultivar) were immediately transported to the laboratory after collection. For each cultivar, a random sample of 30 fresh fruits (about 190–630 g) of uniform size was used for aroma analysis within several hours after collection. The remainders were frozen in liquid nitrogen and stored at −80 °C until required for analysis.

2.2. Chemicals

Folin-Ciocalteu reagent was purchased from Shanghai Chemical Reagent Company (China). A mixture of n-alkanes (C_8–C_{20}) was used for the retention index (RI) analyses. The RI calculation was carried out according to the manufacturer's instructions (Sigma Chemical Co., St. Louis, MO, USA). Cyclohexanone, used as the internal standard, was purchased from J&K Chemical Ltd (Shanghai, China). Sodium chloride and all other reagents were either of analytical grade or the highest commercially available purity.

2.3. Sensory evaluation of bayberry juice

For the sensory evaluation, a panel of 12 assessors, aged 22–35 years (six females and six males) was trained in descriptive evaluation of fruit juices. All panelists worked in Wahaha Co., Ltd., (Hangzhou, China) and had expertise in food sensory evaluation. The evaluation of bayberry juice samples was carried out at room temperature, and the sample order for each panelist was randomized. Approximately 15 mL of juice was served into odor-free, disposable, covered, transparent 50 mL plastic cups to each panelist along with the appropriate questionnaire, one at a time, with a ~3 min wait between samples. The bayberry juices were assessed using descriptive sensory analysis. A complete list of flavor terms and their definitions is shown in Fig. 1. The intensities of the various sensory attributes were evaluated using unstructured 10 cm-long lines ranging from "no perception or extremely weak" to "strong perception," and sensory data were recorded as distances from the origin in cm, with intermediate steps of 0.5 cm. The sensory attributes data are presented as the mean of the scores provided by the 12 panel members.

2.4. Physicochemical properties

2.4.1. pH, titratable acidity (TA) and total soluble solids (TSS)

The pH, titratable acidity (TA) and total soluble solids (TSS) determinations were done as previously reported (Kelebek, Selli, Gubbuk, & Gunes, 2015). pH and TA were quantified using a Mettler automatic titrator (Shanghai, China). TA was expressed as an equivalent of citric acid. TSS was measured using an Abbe digital refractometer (Shanghai, China) and expressed in Brix.

2.4.2. Sugars (glucose, fructose, sucrose)

Sugar extractions (glucose, fructose, sucrose) were performed by high-performance anion-exchange chromatography with pulsed amperometric detection as previously described (Zhang, Khan, Nuenz, Chess, & Szabo, 2012).