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Characterization of taste-active compounds of various cherry wines and their correlation with sensory attributes

Yunwei Niu [a,b], Xiaoming Zhang [a,*], Zuobing Xiao [b], Shiqing Song [b], Chengsheng Jia [a], Haiyan Yu [b], Lingling Fang [b], Chunhua Xu [b]

[a] State Key Laboratory of Food Science and Technology, School of Food Science and Technology, Jiangnan University, Wuxi 214112, Jiangsu, PR China
[b] School of Perfume and Aroma Technology, Shanghai Institute of Technology, Shanghai 200235, PR China

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ABSTRACT

Five cherry wines exhibiting marked differences in taste and mouthfeel were selected for the study. The taste and mouthfeel of cherry wines were described by four sensory terms as sour, sweet, bitter and astringent. Eight organic acids, seventeen amino acids, three sugars and tannic acid were determined by high performance liquid chromatography (HPLC). Five phenolic acids were determined by ultra performance liquid chromatography coupled with mass spectrometry (UPLC–MS). The relationship between these taste-active compounds, wine samples and sensory attributes was modeled by partial least squares regression (PLSR). The regression analysis indicated tartaric acid, methionine, proline, sucrose, glucose, fructose, asparagines, serine, glycine, threonine, phenylalanine, leucine, gallic acid, chlorogenic acid, vanillic acid, arginine and tannic acid made a great contribution to the characteristic taste or mouthfeel of cherry wines.

1. Introduction

Taste and mouthfeel are the major determinants of consumer preference and acceptance for wines. The perception of taste and mouthfeel are produced by two sets of chemoreceptors in the mouth. Specialized receptors neurons, grouped in cavities within taste buds, generate taste perceptions, especially sour, sweet, salt and bitter. Free nerve endings scattered throughout the oral cavity generate the mouthfeel perception such as astringency [1]. Astringency is not a taste, but a tactile sensation [2] and is the feeling of dryness or roughness that results from increased friction between the tongue and the surfaces inside the mouth [3]. It is widely acknowledged that high quality wines have a balanced level of taste and mouthfeel.

Most traditional studies on sensory analysis of wines have focused on the contribution of aroma [4–7], by direct nasal or retronasal perception, to flavor profiling. Gradually, some researchers began to realize the importance of taste and mouthfeel attributes in the overall wine quality and some works aiming at characterizing wine taste-active compounds have been developed. Through HPLC, Kelebek et al. [8] identified organic acids, sugars and phenolic compositions in orange wine made from a Turkish cv. Kozan; Barrado et al. [9] characterized primary amino acids in Spanish red and white wines; Jiří Gruz et al. [10] analyzed phenolic acids in white wines by ultra performance liquid chromatography coupled with tandem mass spectrometry; Cosme et al. [11] characterized the tannin profiles of red wines using reversed-phase HPLC analysis. The combination profile of these taste-active compounds forms the characteristic of wine and distinguishes one from others. However, no studies have been done so far on taste-active compounds of cherry wines.

In the latest years, different statistical and chemometric tools have been employed to explore the relationships between sensory profiles and flavor compounds of wines. For example, PCA in conjunction with discriminant analysis was applied to anthocyanins, flavonoids determined in Spanish red wines, and aided distinction of origin [12]. Nonetheless, PCA does not take account into the initial grouping of the variables [13]. Therefore, multiway techniques have been developed in order to cope with these difficulties. Generalized procrustes analysis was used to correlate sensory attributes to gas chromatography-olfactometry data for French Chardonnay Wines [14]. Besides, partial least squares regression (PLSR) analysis has been used to correlate sensory properties to volatile compositions in Spanish Albariño wines [15]. Few studies have been done to gather taste-active compounds information such as organic acids, amino acids, phenolic acids, sugars and tannic acid at the same time and correlated to sensory data. There is still a lack of systematic

* Corresponding author at: Lihu Road 1800, Wuxi 214122, Jiangsu, PR China. Tel.: +86 510 85919106; fax: +86 510 85884496.
E-mail address: xmzhang@jiangnan.edu.cn (X. Zhang).

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study on the relationship between cherry wine samples, sensory attributes and taste-active compounds.

The main objective of this work was to (a) evaluate sensory attributes of cherry wines; (b) study taste-active compounds including organic acids, amino acids, phenolic acids, tannic acid and sugars; (c) distinguish which taste-active compounds have essential effect on sensory attributes of cherry wine through PLSR analysis. Further apprehension of this knowledge will be very meaningful to perfect characteristic taste or mouthfeel of cherry wine by modifying fermentation parameters or making up for taste-active compounds after alcoholic fermentation.

2. Materials and methods

2.1. Materials

Five cherry wines were obtained as follows, W1 (Yantai Hualong wine co., Ltd. pH 3.37, total acidity 5.52, ethyl alcohol 12%); W2 (Shan Dong Linqu sanxin food co., Ltd. pH 3.49, total acidity 5.67, ethyl alcohol 8%); W3 (Shan Dong Zunhuang cherry wine co., Ltd. pH 3.73, total acidity 7.59, ethyl alcohol 12%); W4 (Laizhou Yinghong wine co., Ltd. pH 3.37, total acidity 5.52, ethyl alcohol 12%); W5 (Si Chuan Hanyuan fruit wine company. pH 3.68, total acidity 7.90, ethyl alcohol 11%). The cherry wines were stored in fridge at −2 °C. Storage time was one week. Five bottles of different cherry wines were used for analysis.

Methanol and formic acid of chromatography grade were purchased from Sinopharm Chemical Reagent Co. Ltd. Gallic acid (≥99%), p-hydroxybenzoic acid (≥99%), chlorogenic acid (≥95%), vanillic acid (≥97.0%), caffeic acid (≥99.0%), asparagines (99%), glutamic acid (≥99.5%), serine (≥99.5%), histidine (≥99%), glycine (≥99%), threonine (≥99.5%), arginine (≥99.0%), alanine (≥99.5%), tyrosine (≥99%), cysteine (≥99%), valine (≥99.5%), methionine (≥99.5%), phenylalanine (≥99%), isoleucine (99%), leucine (≥99.5%), lysine (≥98%), praline (≥99.5%),oxalic acid (99.999%), tartaric acid (≥99.9995%), malic acid (≥99.5%), lactic acid (≥98%), acetic acid (≥99.7%), citric acid (≥99.5%), succinic acid (≥99.5%), tannic acid (≥99.5%),sucrose (≥99.5%), glucose (≥99.5%), fructose (≥99%)were chromatography grade and obtained from Sigma–Aldrich Chemical Co. (St. Louis, MO). Pure water was obtained from a Milli-Q purification system (Millipore, Bedford, MA). Other reagents were all purchased from Shanghai Chemical Plant (Shanghai, China).

2.2. Sensory evaluation

Quantitative descriptive sensory analysis was applied for evaluation of the wine samples, using a ten-point interval scale (0 = none, 9 = extremely strong). The sensory evaluation was done by a well-trained panel made of 4 females and 4 males, 23–30 years old. The panel has previously been trained according to ISO 4121, ASTM-MNL 13 and DIN 10964 [16]. Sensory sessions took place in a sensory laboratory, which complied with international standards for test room [17]. Three specific training sessions were carried out. In the first session, panelists generated descriptive terms for the cherry wines; in the second session, different reference standards were presented and discussed by panelists. From these discussions, the four sensory terms (sour, sweet, bitter and astringent) as shown in Fig. 1 were selected for further descriptive analysis. In the third sessions, the cherry wines were evaluated in duplicate using the ten-point interval scale mentioned above. Then, the reference materials of taste and mouthfeel were as follows: sour (4 g L^{-1} tartaric acid), sweet (30 g L^{-1} sucrose), bitter (0.15 g L^{-1} quinine sulphate), astringent (1.0 g L^{-1} aluminium sulphate). Sensory evaluation was performed in coded, tulip glass containing 20 mL of cherry wines. Samples were presented in a random order.

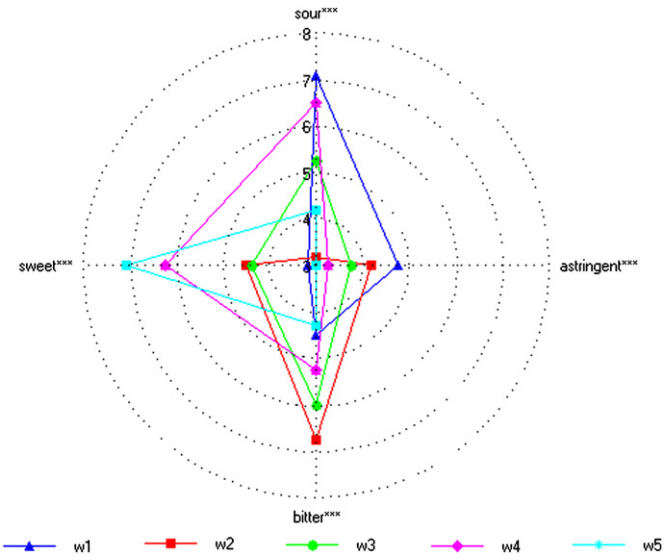

Fig. 1. Graph of the mean sensory score of the five cherry wines studied. Notations *** indicate significance at $p < 0.001$.

Between samples, the panellists were asked to rinse their mouth with distilled water, to eat some plain crackers for 30 s and finally to rinse again with distilled water for another 45 s in order to minimize fatigue and standardize the assessment process.

2.3. Analysis of taste-active compounds

2.3.1. HPLC analysis of organic acids

A HPLC system (Agilent 1100, Agilent Company, Palo Alto, CA, America) equipped with a UV/Vis detector (SPD-20A) monitored at 210 nm was used for the analysis of organic acids. The column was Waters Atlantis C18, (Waters, Britain), 250 mm × 4.5 mm, 5 μm. The column temperature was 30 °C. The mobile phase was a mixture of 0.05 mol L^{-1} H_3PO_4 and methanol (95:5, v/v) at the flow rate of 0.8 mL min^{-1}. Before injection, samples were filtered through 0.45 μm pore size membrane filter. A volume of 10 μL was injected into the instrument for analysis. Percentage recovery values of the standards ranged from 93.2% to 100.5%. The R^2 values of the standards ranged from 0.9998 to 0.9999.

2.3.2. HPLC analysis of amino acids

The amino acids in the sample were analyzed using an Agilent liquid chromatograph 1100 with a UV detector operated at 338 nm. The column was ODS Hypersil (250 mm × 4.6 mm, 5 μm), whilst the mobile phase, consisting of 20 mM sodium acetate and 1:2 (v/v) methanol–acetonitrile, was delivered at a flow rate of 1 mL min^{-1}. The column temperature was 40 °C. Pre-column derivation with o-phthalaldehyde (OPA) was used. Samples were filtered through 0.45 μm pore size membrane filter before injection. A volume of 10 μL was injected into the instrument for analysis. Percentage recovery values of the standards ranged from 92.2% to 101.1%. The R^2 values of the standards ranged from 0.9972 to 0.9999.

2.3.3. UPLC-MS analysis of phenolic acids

Chromatographic analysis for phenolic acids of the cherry wine was performed on a UPLC system Acquity (Waters, Massachusetts, USA) consisting of a binary solvent manager and a sample manager. A bridged ethylene hybrid (BEH) C_{18} analytical column (100 mm × 2.1 mm, 1.7 μm, Waters, MA, USA) was used at 25 °C. The mobile phase consisted of solvent A (water with 5% formic acid, v/v) and solvent B (methanol with 5% formic acid, v/v) and the flow rate was 0.25 mL min^{-1}. The gradient program was as