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Research Progress of Instrumental Detection Methods for Baijiu Quality Discrimination

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Abstract: *Baijiu is one of the six distilled spirits in the world. It has a long history and unique flavor. Due to open fermentation, the quality of Baijiu is often different with the change of environment, process, operation and other conditions. People have analyzed the quality difference of Baijiu by many instrument detection means. This paper summarizes some of the existing instrument detection means of Baijiu, in order to let people have a deeper understanding of the related aspects of Baijiu quality identification.*

Keywords: *Baijiu; inorganic component testing; quality*

1. Introduction

Baijiu is one of the six distilled spirits in the world, which has a long history and unique flavor. Different environment, process and operation will cause the quality difference of Baijiu. People often analyze and judge the quality of Baijiu through sensory evaluation and instrument detection. Compared with sensory evaluation, instrumental detection can not only carry out accurate quantitative analysis, but also avoid the influence of individual differences, environmental conditions, practical experience and other factors on the test results[1]. With the progress and development of science, there has been a great deal of progress and development in the instrument detection of Baijiu. This paper intends to summarize some of the existing detection methods of Baijiu, in order to get a deeper understanding of the related aspects of Baijiu quality identification.

2. Organization of the Text

2.1 Detection of traditional physical properties of Baijiu

Baijiu is a colloidal dispersion system with particle size ranging from 1nm to 100nm, which has physical properties such as particle size, viscosity, refraction, conductivity, turbidity and viscosity. The commonly used testing equipment for the physical properties of Baijiu such as particle size, viscosity, refraction, conductivity, turbidity and viscosity are respectively nano particle size and Zeta potential analysis detector, Ustner viscosimeter, Kaiabei refraction prism, and conductivity meter, among which the conductivity is often used to explore the changing process of Baijiu aging. The electrical conductivity of original wine samples stored in osmanthus forest, Dai[2] measured the electrical conductivity of the original wine samples in the three storage states of osmanthus forest, thatched hut and open air at different storage times, The results showed that the electrical conductivity of the original wine samples in the three storage states showed a trend of first increasing and then decreasing with time, and the electrical conductivity of the original wine stored in the osmanthus forest decreased the fastest. Luo[3] measured the electrical conductivity of the original wine samples in three kinds of storage containers with different storage time: 3kg unglazed pottery container, 0.5kg glazed pottery container and 2.5kg glazed pottery container. The results showed that the electrical conductivity increased first and then decreased with the increase of storage time, and the electrical conductivity of the wine samples stored in 3kg glazed pottery container was the lowest after one year of storage. Lu[4] compared the electrical conductivity of pottery altar aging, stainless steel barrel aging and stainless steel barrel + ceramic sheet aging, and found that the electrical conductivity of pottery altar aged original wine was significantly higher than that of other aged original wine.

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2.2 Detection of micromorphology of Baijiu

Because of its colloidal properties, the microstructures of Baijiu can be observed by AFM atomic force electron microscopy, cryo-electron microscopy and other nm microelectron microscopy, and the microstructures can show different shapes and sizes of particles or clusters. Zhang[5] observed the microstructure changes of different flavors of liquor by atomic force microscope. It was found that the particles of different wine samples were roughly the same, but the morphology and particle size distribution were different. Luzhou-flavor liquor contains approximately regular spherical particles, Maotai-flavor is evenly distributed in flat shape, Feng-type wine has different sizes of visible particles, some similar to conical, the rest of the shape is different; A few irregular polygons can be seen in the sake. By combining cryo-electron microscopy technique with deep learning technique, Cheng[6] applied convolutional neural network to identify and classify the cryo-electron microscopy image information of liquor samples. At 73000 times magnification, the image is more suitable for microscopic observation of liquor samples. There are some spheroidal substances of relatively large volume and some chain shaped substances of relatively small volume in liquor. Under this magnification, ResNet50 network structure has the best effect on classification of original liquor, adulterated liquor and finished liquor. When ResNet50 network structure is adopted, the sample training accuracy reaches 96 %.

2.3 Determination of inorganic components in Baijiu

There are a lot of trace or trace metal elements in Baijiu, which come from every link of Baijiu production[7]. Positively charged metal ions in Baijiu can combine with negatively charged acid ions, so that the vapor pressure of each trace component decreases and the boiling point increases to different degrees, thus changing the taste of Baijiu[8]. Ni^{2+}, Ti^{4+}, Cu^{2+} and other metal ions have catalytic effects on oxidation and condensation of alcohols and aldehydes. The inorganic components in Baijiu were detected by atomic absorption spectrometry (AAS), inductively coupled plasma atomic emission spectrometry (ICP-AES) and inductively coupled plasma mass spectrometry (ICP-MS). The linear range of ICP-AES and ICP-MS was wider than that of AAS. Moreover, it has the ability to detect multiple elements at the same time, which has a wider application prospect[9].

2.4 Detection of organic components in Baijiu

The 2% trace components in Baijiu determine the aroma[10], taste and style of Baijiu. Usually, the analysis methods of these trace components mainly include chromatographic analysis and spectral analysis.

2.4.1 Chromatographic detection

The chromatographic analysis methods commonly used in Baijiu detection mainly include gas chromatography (GC), liquid chromatography (HPLC) and ion chromatography (IC), among which gas chromatography is widely used in Baijiu flavor analysis because of its fast analysis speed, high separation efficiency and high analysis sensitivity. ion chromatography (IC) is a chromatography method that uses the ionic properties of the tested substance to separate and detect. This method is fast, convenient, sensitive and selective, and can be used to analyze a variety of ionic compounds in the sample. Currently, it is widely used in the determination of organic acids in Baijiu. Luo[11] used ion chromatography to simultaneously determine nine organic acids in special flavor Baijiu: formic acid, acetic acid, propionic acid, butyric acid, lactic acid, isobutyric acid, valeric acid, isovaleric acid and caproic acid; Alcohol, 6-methyl-5-hepten-2-one, 1,1-diethoxy-2-methylpropane, 2-furfuryl alcohol, ethyl 2-furoate and dimethyl trisulfide are important aroma compounds in Fuhexiang Baijiu. High performance liquid chromatography (HPLC) is a chromatographic method that uses liquid as mobile phase, uses high pressure fluid system and uses different polarity to separate. This method has certain advantages for the analysis of compounds with high boiling point, macromolecules, strong polarity and poor thermal stability, and is widely used in the analysis of organic acids, sugar components, amino acids, vitamins, proteins and other non-volatile components in Baijiu. Zhang[12] established a method for simultaneous determination of lactic acid, acetic acid, butyric acid and caproic acid in Baijiu by high performance liquid chromatography (HPLC). The linear relationship of the four organic acids was good in the range of 8 ~ 430 mg/L (R2>0.999), and the relative standard deviation (RSDS) of precision test results was <1.6%. The recoveries ranged from 97.24% to 104.40%. Gas chromatography (GC) uses gas as the mobile phase. It uses different adsorption and desorption capabilities of compounds fixed at different poles and boiling points to separate each component. It has the advantages of fast analysis, high separation efficiency, high sensitivity and wide application range. It is often used in combination with olfactory instrument, mass spectrometry, time of flight mass spectrometry, etc., and widely used in flavor analysis and aroma substance analysis of Baijiu. Qin[13] used headspace solid phase microextraction, full two-dimensional gas chromatography and time of flight mass spectrometry (Headspace solid phase microextraction-comprehensive two-dimensional gas) chromatography-time-of-flight mass spectrometry, HS-SPME-GC×GC-TOF-MS) was used to identify the volatile aroma compounds of spring aroma Baijiu, and 566 aroma compounds were identified.

2.4.2 Spectroscopic detection

The commonly used spectral analysis methods in Baijiu detection include ultraviolet spectrum, infrared spectrum, Raman spectrum, fluorescence spectrum, etc[14]. The UV-VIS spectrum has the advantages of low cost, simple operation and fast speed. It is usually used to analyze some trace components in baijiu. Zhao[15] used UV spectrum to quantitatively analyze the furfural in 10 kinds of baijiu at 273nm. Raman spectroscopy is a spectral analysis technology based on Raman scattering to analyze molecular vibration or rotation information. It has the characteristics of high efficiency, simple operation, no need for pretreatment, no sample loss, etc. It is usually used in Baijiu quality detection, year detection, alcohol prediction and pesticide residue detection. Yan[16] established the unary linear regression model of bottled Baijiu alcohol accuracy by using Raman spectrum, in which the model at the spectrum 888 cm-1 Raman characteristic shift after the extended multiplicative scattering correction is the best. The ratio correction method is used to correct the Baijiu models of different brands and different packages and the non-destructive prediction of alcohol accuracy. Fluorescence spectrum is a detection method that analyzes the obtained spectral data by measuring the secondary light emission of substances. It has the advantages of high sensitivity and strong selectivity, and is usually used for vintage wine identification and authenticity identification. Jin [17] determined the three-dimensional fluorescence spectrum of fragrant fragrant Xiangquan, Drunkler and Neishen wine with Aqualog fluorescence spectrometer. It was found that their fluorescence peaks were 3, 2 and 1 in the range of 200-300 nm, and two fluorescence peaks appeared in the excitation wavelength above 300 nm. Near-infrared spectrum information comes from the frequency-doubling absorption and frequency-co-absorption of internal vibration of molecules, and mainly reflects the relevant information of hydrogen-containing groups such as C-H, NH, O-H and S-H in organic molecules. Compared with traditional analysis methods, near infrared spectroscopy analysis technology has the obvious advantages of fast, non-destructive, simple, accurate and efficient. It can predict the alcohol content and total acid and ester in wine samples by near infrared spectroscopy, and can also be used to identify the authenticity of Baijiu. Zhou[18] collected the near infrared transmission spectrum of Baijiu samples by using near infrared spectrometer. The two dimensional correlation spectra of each Baijiu sample were constructed, and it was found that the effective information of Baijiu sample with aging was contained in the range of 1 400 ~ 1 800 nm. After extracting the autocorrelation spectra of each sample and combining Mahalanobis distance method, the Baijiu age discrimination model was established. The accuracy of discrimination was 93.3%, and the accuracy of prediction set discrimination was 92.0%.

2.5 Detection of Baijiu by electrochemical sensor

Chemical sensors are instruments that are sensitive to chemical substances and convert their concentrations into electrical signals for detection. Compared with human sense organs, chemical sensors roughly correspond to human smell and taste organs. A device that realizes the function of a chemical sensor system, if used in gas analysis, is called an electronic nose; When used in liquid analysis it is called an electronic tongue. Electronic nose, also known as odor scanner, is composed of gas sensor, signal processing system, pattern recognition system and other functional components. It simulates the formation process of human olfaction when working: gas sensor array responds to odor to generate signals, which are first preprocessed, then pattern recognition and discrimination are carried out, and finally the qualitative or quantitative output of the detection results of the components contained in the gas. Liu[19] used electronic nose to analyze the differences of seven different Luzhou-flavor baijiu brands. The results showed that the electronic nose sensors S2, S6, S7 and S9 had better response signals to different Luzhou-flavor baijiu brands. After principal component analysis (PCA) screening, they could be used as characteristic indicators to measure the difference of Luzhou-flavor baijiu. Sun[20] used the electronic tongue technology and multivariate statistics method to evaluate and analyze the taste quality of Guangdong Real estate soy-based Baijiu. The results show that the electronic tongue can distinguish the different brands of soya bean Baijiu from the same origin. By means of electronic nose, electronic tongue and colorimeter, Li[21] measured and analyzed the aroma, taste and color of twelve Chinese Baijiu flavors, and compared the characteristics and differences of different flavor flavors. The results showed that compared with the aroma indexes, there were more differences among the taste indexes of different baijiu, among which the astringency, umami, saltiness and bitterness were the biggest

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differences.

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