Hindawi
Journal of Food Quality
Volume 2022, Article ID 3307160, 12 pages
https://doi.org/10.1155/2022/3307160

Research Article

Relationships between Shanghai Five Different Home-Brewed Wines Sensory Properties and Their Volatile Composition Assessed by GC-MS

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Received 3 March 2022; Revised 27 April 2022; Accepted 17 May 2022; Published 2 June 2022

Academic Editor: Yuxia Fan

In order to determine the key aroma components of home-brewed wines made from different local grapes in Shanghai. In the work, the identification and quantification of 63 aroma compounds of five home-brewed wines characterized by gas chromatography-mass spectrometry (GC-MS) combined with Headspace Solid-Phase Microextraction (HS-SPME). To study the possible correlation between the sensory attributions and 22 aroma compounds in Odor Activity Value (OAV) > 1 for five home-brewed wines, the Partial Least Squares Regression (PLSR) was a multivariate data analysis performed. Furthermore, to investigate the percentage of contribution of a particular aroma compound to its overall flavor, the relative odor contribution (ROC) and odor activity value of volatiles in home-brewed wines were conducted and performed. According to the comprehensive results, Summer Black Seedless grape (SBSG) and Black Beet grape (BBG) were the most appropriate varieties to be brewed wines for people in Shanghai or around it.

1. Introduction

Wine is the only alkaline alcoholic beverage rich in resveratrol, tannin, organic acids, sugars, amino acids, and other nutrients, with high nutritional health value, which is the loved by people in China and other countries. But the ordinary consumers feel that wine of more than one hundred yuan is too luxurious to offer, and suspect wine of more than ten yuan is likely sham product not to buy. Therefore, many home-brewed wines are very popular in China, and home-brewed wines in North America and Western Europe are not only very popular, but also very mature and successful industries [1]. The brewing process of home-brewed wine generally adopts crushing brewing method, including terilization equipment, crushing grapes, alcoholic fermentation, lactic acid fermentation, and aging, respectively. These grape varieties and continuous processes have a positive impact on the formation of wine aroma. There are subtle differences between many home-made wines made by different families.

The aroma characteristics of wine are an important index determining its quality and value [2].The aroma composition of grape wine is the key elements of wine aroma characteristics, including esters, aldehydes, alcohols, lactones, phenols, ketones, acids, and terpenes. The volatile substances of grape wines are extremely [3] complex, so far, more than a thousand flavor compositions of grape wines have been detected. They are classified as primary, secondary, and tertiary aroma originated from grapes, wine fermentation, and the aging process. Aroma compounds including alcohols, esters, aldehydes, ketones, acids, and terpenes are frequently reported as the main contributors of pleasant wine aroma [4].Detection and analysis of aroma characteristics of grape wines are very meaningful. Many volatiles characterization and detection in wines are usually performed by gas chromatography-mass spectrometry (GC-

MS) due to its highly effective and rapid [5–7]. Daniela Barbera et al. [8] used HS-SPME-GC-MS to detect and assay the 15 different Sicilian Muscat wines in different years effect on producing the aroma compounds especially four fundamental terpene alcohols (linalool, geraniol, nerol, and citronellol) as described by Lukić and Horvat [9]. To differentiate monovarietal wines made from native and introduced varieties in Istria (Croatia), samples of Malvazij a istarska, Chardonnay, and Muscat yellow from two harvest years (2013 and 2014) were subjected to HS-SPME-GC/MS of volatile aroma compounds. Barata et al. [10] analyzed and identified the key aroma compounds of the monovarietal wines produced with the Portuguese red grape variety Trincadeira and in blends of Cabernet Sauvignon and sour rotten Trincadeira grapes, which are most likely associated with this disease (sour rot), have been studied by sensory analysis, gas chromatography-olfactometry (GC-O), and gas chromatography-mass spectrometry (GC-MS). Principal component analysis (PCA) and hierarchical cluster analysis (HCA) were selected to find the correlation of two or more quality indexes of wine and classify the parallel quality indexes to a class, which simplify quality index of wines. PCA and partial least squares regression (PLSR) were assayed to appraise the correlation between the aroma compounds' sensory properties in Spanish Albarino wines and chemical characteristics [11]. PCA, HCA, and PLSR were common and important chemical quantitative analysis, which have been applied to foods [12–14], Liu et al., 2010), nonfoods [3, 15], and other fields [16, 17]. Yu et al [18]evaluate the key aroma compounds in Chinese rice wine sensory attributes produced by different processing techniques, to analyze the aroma components using GC–MS, and finally to determine the key aroma compounds by GC–O and OAV measurement. The correlations between the key aroma compounds and the sensory attributes were calculated by PLSR.

Aroma is an important sensory characteristics of wine, which is complicated and not single. Although instrumental analysis such as GC-O [19, 20] plays a significant role in complex aroma of wine, the olfactory sensation is still needed to identify whether the wine can bring pleasure feeling and spiritual satisfaction to people. Hence, sensory analysis cannot all be replaced by any other advanced instruments. There were a phenomenon that the high-concentration volatile substance cannot be perceived by a trained sensory judge, but other low concentrations of sniffed aroma can be; why aroma compounds that are themselves above threshold (AT) are more easier to be smelled than sub-threshold (ST) substances [21]. Between the intricate matrix effects and oral human physiological effects, variables make a complex matter of wine aroma perception. Hence, Simonetta Capone et al. [22] quoted a parametel that was known as "odour activity value" (OAV), defined it as concentration/OTH ratio, which is commonly used to assess the contribution of each volatile compound detected by GC-MS to wine aroma. OTH is a logogram of the volatile compound odor threshold, which is defined as the lowest concentration that can be recognized by smelling [23]. Many researchers [24, 25] have estimated the OTHS of volatile compounds in synthetic wine. The aroma perception in a sample cannot be related to OTHS but can be a positive correlation to OAV, and only volatile compounds with OAV≥1 be perceived by trained sensory panels, and not all the volatiles present in wine [3, 26] using OAV to assess the contribution of individual chemical components in wine sample to wine aroma is useful and meaningful.

Studied on wines in the market [27–29] have been reported. For example, Sagratini et al. [30] studied and compared the volatile composition of Montepulciano monovarietal red wines from the Marches and Abruzzo regions of Italy by HS-SPME–GC–MS analysis, and a total of 50 aromatic compounds were having a characteristic flavor of jujube wine, such as 1 acid, 7 alcohol, 8 alkanes, 25 esters, 4 ketones, 3 phenols, and 2 others compounds, notably esters, and the volatile compounds of the highest values in the analysis of wines were consisting largely of ethyl esters which have C3–C8 straight chain fatty acid residues by Zhang reported [31]. Five premium red wines' aroma characterization have been studied by odor descriptive analysis, quantization of their volatile compounds been dealt with GC-MS, and odor interaction in wine volatiles showed aroma enhancers or aroma suppression by GC-O [32]. PCA assayed 17 volatile components with OAVs greater than 1 between Godello white wines, and PLSR analyzed the correlation between Godello white wines' sensory properties and their aromatic fingerprinting obtained by GC-MS [33]. And it turned out that the issue of wine in the market of aroma characterization depended on its aroma components, detected and quantized by GC-MS, and OAV of volatiles been estimated to analyze its contribution to wine aroma perception. Niu et al. [34]used a combination of GC–O, GC–MS, and OAVs to analyze the characteristic flavor components in Chinese liquors. Wang et al. [35] used physical and chemical analysis (HS-SPME-GC-MS, NMR), sensory evaluation, and multivariate analysis (PLSR) to study the relationship between aroma-phenolic reactions and perceived intensity of aroma attributes.

However, there is a little information about the correlation of sensory properties and volatile compositions identified by GC-MS regarding various home-brewed wines. In addition, no report about the sensory attributes of odor descriptors for home-brewed wines been described by the trained sensory judges and to identify key aroma compounds of home-brewed wines. The objectives of this study were the following: (*a*) to identify and quantify volatile compounds of the five home-brewed wines by HS-SPME combined with GC-MS. (b) To elucidate the correlation between sensory attributions and the aroma compounds in the five home-brewed wines by PLSR. (c) To analyze and compare the percentage of contribution of a particular compound in each wine to its overall aroma through its OAV combined ROC. A better comprehension of this knowledge will be significantly helpful for people in Shanghai or around it to find a good grape variable for brewing wine.

2. Materials and Methods

2.1. Wine Samples and Materials. The winemaking process of five home-brewed wines all adopted the home-brewed vinification method. The five grapes all were purchased from

Table 1: General analysis of the must and wine parameter.

General analysis of the must					
Parameter	DIG	SBSG	FCG	MG	BBG
Grape juice yield (%)	72.0	63.6	72.8	71.6	74.4
Total carbohydrate content (%)	12.0	11.2	12.2	11.6	10.8
General analysis of the wine parameter					
Parameter	DIW	SBSW	FCW	MW	BBW
pH	3.78	4.09	3.65	3.93	4.25
Alcoholic strength (%v/v)	13.40	12.50	13.60	12.90	12.20
Total acid	5.03	4.91	4.39	4.61	5.44

an identical vineyard in Shanghai, which were Muscat (MG), Black Beet (BBG), Summer Black Seedless (SBSG), Fuji cream (FCG), and Drunk the incense (DIG), respectively. The five home-brewed wines were, respectively, Muscat wine (MW), Black Beet wine (BBW), Summer Black Seedless wine (SBSW), Fuji cream wine (FCW), and Drunk the incense wine (DIW), ran as follows: an amount of 5 kg of each grape was crushed and pressed to obtain must with its skin and seed, and all were set in individual glass vessels. Alcoholic fermentation was conducted at temperature of 26~30°C for 7 days. During alcoholic fermentation, to mix must, skin, and seed with a long sterilized stick in case of *Saccharomyces cerevisiae* can not have enough fermentation, and to be monitored by measuring the temperature and density in each container on a daily basis. White granulated sugar, served as carbon source of *S.cerevisiae* in grapes' skin, was successively added 0.2 kg, 0.2 kg, and 0.1 kg in the first day, the third day, and the fifth day of alcoholic fermentation, respectively. After 7 days, each wine was clarified (natural clarification), filtered with 5 layers of gauze, and bottled to the new individual glass vessel with bibcock through siphonage.

The five musts (DIG, SBSG, FCG, MG, and BBG) been obtained to analyze grape juice yield, defined as must/grape radio and its total carbohydrate content detected by polarimeter, showed in Table 1.

After 2 months of bottling, the five wines (DIW, SBSW, FCW, MW, and BBW) were obtained and subsequently analyzed for its pH by the five easy plus laboratory pH meter from Mettler-Toledo, its alcoholic strength and its total acid refers to "Analytical methods of wine and fruit wine" of the Chinese national standard (GB/T 15038–2006), which is showed in Table 1.

N-alkane standards (C7–C30) and 2-Octanol that be served as internal standard were purchased from Sigma-Aldrich Chemical Co.

2.2. Sensory Analysis. The sensory analysis of the home-brewed wines was performed in a sensory laboratory set in accordance with ISO 8589 (2007) so as to promote the tasters' task of identifying descriptors. A sensory panel consisted of nine members including six men and three women that had been trained according to ISO 13300-2 (2006). Five home-brewed wines (DIW, SBSW, FCW, MW, and BBW) were analyzed for sensory aroma quality in terms of 11 descriptors (Table 2) according to ISO 11035 (1994) and GB/T 15038-2006.

A constant volume of 30 ml of each home-brewed wine was evaluated in a 215 ml wine-tasting glasses at 12°C according to ISO 3591 (1977). The sensory panel smelled five home-brewed wines presented in random order, noted the specific perceived descriptors and rated the intensity of each sensory attribute on a nine-point scale, where 0 indicated that the descriptor was not perceived, and values 1–9 that its intensity was from the lower to the higher. The average scores of odor descriptors based on the scores given by nine judges were provided as its sensory evaluation results (each repeated three times).

2.3. Extraction of Home-Brewed Wine Volatiles. The home-brewed wine volatiles were separated by adsorption on the extract fiber using 75 ul CAR/PDMS SPME (Shanghai Ann spectrum scientific instrument co., LTD), which performed the Headspace Solid-Phase Microextraction. Before the extraction, each home-brewed wine precisely been got 5 ml, to add directly 1 g Nacl and 5 ul of 2-octanol (262 mgL^{-1} in absolute ethanol) to wine solution, and 2-octanol been viewed as internal standard to facilitate quantitative analysis of wine volatile compounds. The SPME filer been exposed to headspace for 30 min at 60°C, then the SPME fiber was introduced in the injector of the gas chromatography(GC) for desorption for 5 min at 250°C in the splitless mode.

2.4. Gas Chromatography-Mass Spectrometry (GC-MS). The home-brewed wine aroma compounds were separated and identified on a 7890 gas chromatography (GC) coupled to a 5973°C mass spectrometry (MS) (Agilent Technologies, USA). An HP-INNOWAX fused-silica capillary column (60 m × 0.25 mm ID, 0.25 film thickness) served as chromatographic column of wine volatiles separations. Helium, the carrier gas, had a flow rate of 1 ml/min in the constant flow mode. The sample injection was used in the splitless mode, and the injector temperature was set at 250°C. The oven temperature program was as follows: 40°C for 2 min, 5°C/min ramp to 230°C, and holding for 5 min. Temperature of the transfer line, the ion trap was manifold, and the quadrupole mass filter was set at 250°C, 230°C, and 150°C, respectively. The ion energy for electron impact (EI) was always 70 ev. The chromatograms of the five home-brewed wines volatiles were recorded by monitoring the total ion currents in 30–450 mass range, the samples were run in triplicate.

Identification of the home-brewed wines' aroma compounds was obtained through the following ways: comparing of the retention indices (RI) and the fragmentation patterns with those reported in the literature, or mass sepctrums in the Wiley 7 n, I Database (Hewlett-Packard, Palo Alto, CA) and Nist Database. The RI of wines' aroma compounds were calculated using a homologous series of n-alkanes (C7–C30) (concentration of 1000 mg/L in n-hexane) (Sigma-Aldrich, St. Louis, MO) under the same conditions. The RI of expression is as follows [36]:

Table 2: Odor descriptors for wines. The mean scores and definition of different descriptors.

Descriptor	DIW	SBSW	FCW	MW	BBW	Definition
Odour intensity	6.51[a]	8.53[e]	6.97[b]	7.38[c]	7.87[d]	Overall odor strength
Pineapple	2.25[a]	5.97[c]	2.16[a]	4.41[b]	3.96[b]	Perfumed
Citrus	0	0	0	0	4.62[b]	Lemon
Grape	5.84[ab]	6.25[b]	5.35[a]	7.17[c]	6.86[c]	Ripe grape
Alcohol	5.60[b]	7.46[c]	4.36[a]	5.97[b]	7.05[c]	Napa
Cream	3.53[a]	6.45[d]	5.52[c]	3.06[a]	4.29[b]	Butter fatty
Sweet	3.82[b]	5.83[d]	1.08[a]	4.05[bc]	4.25[c]	Honey aroma
Phenolic	4.61[c]	1.25[a]	5.05[d]	3.26[b]	1.02[a]	Clove curry
Floral	4.32[a]	4.85[b]	4.04[a]	9.05[c]	8.85[c]	Rose, Violet flowers
Herbaceous	0	5.09[c]	0.76[b]	0	6.03[d]	Green wood, freshly mown grass
Berry fruit	5.02[b]	7.14[e]	5.53[c]	4.24[a]	6.46[d]	Tropical fruit
Undesirable flavor	5.27[c]	0	4.36[b]	0	0	Brett

(1)ND: Not detected. (2) * Mean ± SD Value in each row with different letters are significantly different ($p < 0.05$).

$$RI(X) = 100 \times \left(\frac{\log(tx) - \log(tz)}{\log(tz+1) - \log(tz)} \right) + z. \quad (1)$$

2.5. Odor Activity Value (OAV) and Relative Odor Contribution (ROC). To quantify the overall home-brewed wine aroma compounds identified by GC-MS through a comparison with the concentration of the internal standard (2-octanol), the wine aroma compounds' odor activity value were calculated by dividing each specific volatile' mean concentration by its recognition threshold concentration [22].

The values of OAV for aroma compounds which were presented OAV>1 in the five home-brewed wines are analyzed in Table 3. ROC was calculated by dividing the value of OAV for each individual compound by the sum of the OAV of compounds that showed OAV>1(Table 4).

2.6. Statistical Processing. The sensory analysis of five home-brewed wines was carried out with the techniques of SAS V8 (SAS Institute Inc, Cary, NC, USA) with ANOVA. Duncan's multiple range tests were applied to ascertain a significant differences ($p < 0.0001$) between the sensory attributions in the five home-brewed wines.

PLSR is a method for the correlation between sensory attributors and volatile compounds identified by GC-MS through Unscarmbler version 9.7 (CAMO ASA, Olso Norway). Our X-variables included the wines and Y variables were the odor descriptors by seven sensory panels (Figure 1). Figure 2 presented the correlation between the aroma compounds (OAV>1) in-X-variables and 11 odor descriptors in Y- variables.

3. Results and Discussion

3.1. Volatile Compositions of Five Home-Brewed Wines. Identification and quantification for aroma compounds of the five different species wines by GC-MS are showed in Table 2 and their RI calculated through the RI's expression. All the volatile compound concentrations' mean and standard deviation determined in triplication with SPME-GC-MS. Table 2 showed a total of 63 volatile compounds that were identified. Volatiles in five wines basically were compose of seven groups: esters, alcohols, acids, aldehydes, volatile phenol, terpenes, and other. Aroma compounds' odour descriptor and odour threshold were reported in the literature showed in Table 2.

3.2. Esters. Esters comprised of important home-brewed aroma compounds in wine, which are associated with floral and fruity attributes [52]. Generally, wines contained a large number of different alcohols and acids, so esters formed by etherification of alcohols and acids followed by water molecule elimination. Table 2 shows 15 esters in the five wines. SBSW and BBW possessed the highest amount of total esters in comparison to other wines. Ethyl acetate gives pleasant pineapple aroma impact, and was the main contributor to this class of volatile compounds in home-brewed wines. SBSW presented the most content (31.676 mg/L) than MW (24.459 mg/L), FCW (20.463 mg/L), DIW (20.715 mg/L), and BBW (27.542 mg/L). The concentration of ethyl lactate with fruit and lactic aroma was higher in SBSW and MW (>1 mg/L) compared with DIW, FCW, and BBW (<1 mg/L). Ethyl octanoate (2.322 mg/L) and ethyl laurate (0.408 mg/L) were the highest in SBSW, while ethyl laurate was not found in FCW. Ethyl decanoate with pleasant grape fragrance was the lowest in SBSW (0.029 mg/L). Diethyl succinate with enjoyable fruit aroma was the main contributor to volatile compounds in Portugieser red wine and Kekfrankos red wine [53]; however, it was low among the wines (concentration between 0.116 and 0.322 mg/L). 2-Phenylethyl acetate with rose, honey, tobacco aroma, presented higher in FCW (0.633 mg/L), while in SBSW it was no found. Gamma-butyrolactone (1.029 mg/L, sweet), ethyl valerate (0.015 mg/L, yeast fruit), and isoamyl formate (8.486 mg/L, plum black currant ethereal vinous dry earthy fruit green) only appeared in BBW. Ethyl tetradecanoate (1.258 mg/L), and neryl acetate (1.029 mg/L, fruit) also only presented in SBSW.

3.3. Alcohols. As presented in Table 2, alcohols were detected in the five home-brewed wines and the total concentration of the alcohols ranged from 13.888 for FCW to 55.194 mg/L for SBSW. 1-Propanol with ripe fruit alcohol

Table 3: Volatile compounds of five home-brewed wines (mg/L, $n = 3$) identified by GC-MS.

Compound	RIcal[a]	ID[b]	Riref	DIW[h]	SBSW[h]	FCW[h]	MW[h]	BBW[h]	Odour descriptor	Odour threshold(mg/L)
Esters										
Ethyl acetate	873	R	907[c]	16.902[f] ± 0.24[gb]	25.052 ± 0.13[d]	17.033 ± 0.02[b]	20.990 ± 0.01[c]	14.793 ± 0.18[a]	pineapple[i]	12.27[p]
Ethyl Lactate	1350	R	1358[c]	0.928 ± 0.02[a]	1.404 ± 0.01[c]	0.931 ± 0.02[a]	1.242 ± 0.01[b]	0.906 ± 0.02[a]	fruit[i]	154[q]
Ethyl octanoate	1434	R	1436[c]	1.181 ± 1.02[b]	2.322 ± 1.23[d]	0.966 ± 0.28[a]	1.581 ± 1.01[c]	0.954 ± 0.28[a]	Pineapple,pear[k]	0.6[i]
Ethyl decanoate	1630	R	1636[c]	0.181 ± 0.13[b]	0.029 ± 0.15[a]	0.044 ± 0.02[a]	0.181 ± 0.08[b]	0.440 ± 0.15[c]	Grape[i]	0.023[r]
Diethyl succinate	1693	R	1689[c]	0.121 ± 0.02[a]	0.116 ± 0.98[a]	0.153 ± 0.09[b]	0.121 ± 0.87[a]	0.322 ± 0.28[c]	Wine , fruit[i]	200[s]
γ-butyrolactone	1643	R	1647[c]	nd	Nd	nd	nd	1.029 ± 0.15[a]	Caramel, sweet[i]	1[r]
2-Phenylethyl acetate	1832	R	1829[c]	0.262 ± 0.19[a]	Nd	0.633 ± 0.48[c]	0.262 ± 0.12[a]	0.393 ± 0.17[b]	Rose, honey, tobacco[i]	0.25[t]
Ethyl laurate	1845	R	1842[c]	0.060 ± 0.04[a]	0.408 ± 0.04[c]	nd	0.041 ± 0.01[a]	0.073 ± 0.01[b]	Leaf[l]	0.4[r]
Diethyl phthalate	2295	M		0.040 ± 0.01[bc]	0.029 ± 0.04[a]	0.044 ± 0.01[c]	0.042 ± 0.01[bc]	0.029 ± 0.02[a]	Odorless[j]	
Diisobutyl phthalate	2348	M		0.040 ± 0.01[b]	0.029 ± 0.02[a]	0.153 ± 0.08[c]	0.041 ± 0.01[b]	0.029 ± 0.02[a]		
Ethyl Tetradecanoate	2031	R	2042[c]	nd	1.258 ± 0.09[a]	nd	nd	nd	Ether[i]	0.18[r]
Neryl acetate	1718	R	1742[c]	nd	1.029 ± 0.16[a]	nd	nd	nd	Fruit[i]	0.88–905.4[u]
Ethyl hexadecanoate	2262	R	2250[c]	nd	Nd	0.506 ± 0.12[c]	0.020 ± 0.01[a]	0.073 ± 0.03[b]	Wax[i]	>2[r]
Ethyl valerate	1152	R	1133[c]	nd	Nd	nd	nd	0.015 ± 0.09[a]	Yeast, fruit[i]	0.0015-0.005[r]
Isoamyl formate	1195	M		nd	nd	nd	nd	8.486 ± 0.18[a]	Plum black currant ethereal vinous dry earthy fruit green[j]	
Total esters				20.715 ± 1.68[a]	31.676 ± 2.85[e]	20.463 ± 3.97[a]	24.459 ± 2.14[b]	27.542 ± 1.58[bc]		
Alcohols										
1-Propanol	1052	R	1037[c]	4.676 ± 0.01[b]	9.869 ± 0.04[d]	1.201 ± 0.01[a]	4.676 ± 0.06[b]	4.745 ± 0.01[c]	Alcohol, pungent[i]	0.9[v]
2-Butyl alcohol	1036	R	1024[c]	19.509 ± 0.79[b]	25.239 ± 0.98[c]	0	19.509 ± 0.58 [b]	16.346 ± 0.74[a]	Wine[i]	
1-Butanol	1134	R	1158[d]	0.181 ± 0.07[b]	0.378 ± 0.09[d]	0.131 ± 0.09[a]	0.181 ± 0.07[b]	0.306 ± 0.08[c]	Medicine,	
Fruit[i]	4.33[r]									
3-Methyl-1-butanol	1198	R	1205[c]	9.029 ± 0.87[c]	14.177 ± 0.98[d]	7.183 ± 0.47[a]	9.029 ± 0.67[c]	8.544 ± 0.72[b]	Whiskey, malt, burnt[i]	1[r]
2,3-Butanediol	1530	R	1583[c]	2.499 ± 0.02[c]	2.678 ± 0.04[d]	2.336 ± 0.03[b]	2.499 ± 0.04[c]	1.121 ± 0.01[a]	fruit, onion[i]	>100[r]
1,2-Propylene glycol	1565	M		0.081 ± ±0.02[d]	0.058 ± 0.01[c]	0.022 ± 0.02[a]	0.081 ± 0.02[d]	0.029 ± 0.01[b]	Odorless very slight alcoholic[j]	340[r]
Phenylethyl alcohol	1921	R	1925[c]	1.814 ± 0.12[b]	1.633 ± 0.14[a]	1.814 ± 0.02[b]	3.603 ± 0.08[d]	2.154 ± 0.30[c]	Honey, spice, rose, lilac[i]	0.06[r]
Glycerol	2112	M		0.202 ± 0.12[c]	0.175 ± 0.11[a]	nd	0.202 ± 0.24[ab]	nd	Odorless[j]	>20000[r]
1-Hexanol	1353	R	1360[c]	nd	0.175 ± 1.12[c]	0.153 ± 0.12[b]	nd	0.087 ± 0.03[a]	Grass	
Resin,										
flower[i]	8[w]									
Fenchyl alcohol	1591	M		nd	0.116 ± 0.06[a]	nd	nd	nd	Camphor borneol pine woody dry sweet lemon[j]	
Nerolidol	1846	M		nd	nd	nd	nd	2.558 ± 0.02[a]	Floral green waxy citrus woody[j]	2.25~10[r]
Nerol	1779	R	1770[c]	nd	0.696 ± 0.18[a]	nd	nd	nd	Flower	
Grass[l]; sweet[i]	0.04[x]									
Leaf alcohol	1368	R	1392[e]	nd	nd	nd	nd	1.029 ± 0.42[a]	Grass[i]	0.91[r]
Alpha terpneol	1679	M		nd	nd	nd	nd	0.044 ± 0.08[a]	Pine terpene lilac citrus woody floral[j]	5[r]
Cedrol	2005	R	2100[c]	0.040 ± 0.02[b]	nd	nd	0.043 ± 0.02[b]	0.029 ± 0.08[a]	Cedarwood woody dry sweet soft[j]	
2-Propanol	1550	M		nd	nd	1.048 ± 01.02[a]	nd	nd	Alcohol musty woody[j]	40~78[r]
Total alcohols				38.030 ± 1.84[b]	55.194 ± 03.81[c]	13.888 ± 01.78[a]	39.823 ± 1.78[bc]	36.992 ± 2.50[b]		
Aldehydes										
Acetaldehyde	717	R	724[c]	1.653 ± 0.08[b]	2.154 ± 00.06[c]	3.231 ± 00.12[d]	0.786 ± 0.01[a]	1.063 ± 0.07[a]	Pungent ethereal aldehydic fruity[j]	0.01[r]
Furfural	1463	R	1455[c]	0.081 ± 0.04[c]	0.058 ± 00.01[b]	nd	0.081 ± 0.04[c]	0.029 ± 0.01[a]	Sweet woody almond fragrant baked bread[j]	0.77[r]
Benzaldehyde	1501	R	1495[c]	0.061 ± 0.01[a]	0.146 ± 00.12[b]	0.131 ± 00.25[b]	0.065 ± 0.01[a]	0.058 ± 0.02[a]	Almond, burnt sugar[i]	2[y]
Anisaldehyde dimethyl acetal	1728	M		nd	nd	0.246 ± 00.01[b]	0.081 ± 0.01[a]	0.277 ± 0.02[b]	Mild floral hawthorn, jasmine, lilac, elder flower[j]	
Ttal aldehydes				1.794 ± 0.13[b]	2.358 ± 00.19[c]	3.602 ± 00.38[d]	1.008 ± 0.07[a]	1.427 ± 0.12[ab]		
Ketones										
3-Hydroxy-2-butanone	1275	R	1287[c]	2.036 ± 0.96[c]	0.728 ± 00.02[b]	3.397 ± 00.28[d]	2.036 ± 0.20[c]	0.087 ± 0.01[a]	Butter, cream[i]	0.8[r]
1-Hdroxy-2-acetone	1288	M		0.042 ± 0.01[a]	nd	nd	0.047 ± 0.01[a]	nd	Pungent sweet caramellic ethereal[j]	0[r]
1-Phenyl-2-acetone	1713	M		nd	0.403 ± 00.01[a]	nd	nd	nd	Almond[j]	
β-Ionone	1471	M		nd	nd	nd	nd	0.069 ± 0.02[a]	Floral woody sweet fruity berry tropical beeswax[j]	0.00009[w]
2-Octanone	1283	R	1285[c]	nd	nd	nd	nd	0.029 ± 0.01[a]	Earthy weedy natural woody herbal[j]	0.05[r]
Iso E super		M		nd	0.323 ± 00.01[b]	nd	nd	0.082 ± 0.02[a]	Woody dry ambergris cedar old wood ketonic phenolic[j]	
Geranyl acetone	1838	R	1840[c]	0.041 ± 0.01[b]	nd	nd	0.218 ± 0.06[a]	nd	Magnolia, green[i]	0.186[r]
Total ketones				5.707 ± 1.24[b]	6.17 ± 00.42[b]	10.607 ± 01.04[d]	4.322 ± 0.41[ab]	3.128 ± 0.3[a]		
Acids										

Table 3: Continued.

Compound	RIcal[a]	ID[b]	Riref	DIW[h]	SBSW[h]	FCW[h]	MW[h]	BBW[h]	Odour descriptor	Odour threshold(mg/L)
Acetic acid	1458	R	1450^{c}	1.915 ± 0.95^{b}	1.135 ± 00.68^{b}	17.183 ± 01.20^{c}	1.915 ± 0.82^{b}	0.466 ± 0.04^{a}	Sour[i]	25.59-26[r]
Hexanoic acid	1863	R	1864^{c}	0.046 ± 0.01^{b}	0.029 ± 00.02^{a}	nd	0.049 ± 0.01^{b}	0.073 ± 0.02^{c}	Green[m]	0.42[w]
Octanoic acid	2079	R	2083^{c}	0.161 ± 0.01^{b}	0.175 ± 00.04^{c}	0.109 ± 00.03^{a}	0.161 ± 0.01^{b}	0.116 ± 0.01^{a}	Candy,caramelized,perfumy,fruity,peachy,strawberry[n]	0.5[w]
Decanoic Acid	2368	R	2361^{c}	0.081 ± 0.03^{b}	nd	nd	0.081 ± 0.03^{b}	0.058 ± 0.02^{a}	Rancid,	
fat[i]	1[w]									
Dodecanoic acid	2516	R	2517^{c}	nd	0.146 ± 00.04^{a}	nd	nd	nd	Metal[i]	
Heptanoic acid	1836	M		nd	nd	nd	0.047 ± 0.01^{a}	nd	Rancid sour cheesy sweat[j]	0.64-0.91[r]
Propionic acid	1520	R	1523^{c}	nd	nd	0.066 ± 00.02^{a}	nd	nd	Pngent, rancid, soy[i]	8.1[y]
Total acids				2.203 ± 1.00^{b}	1.485 ± 00.78^{a}	17.358 ± 01.25^{c}	2.253 ± 0.88^{b}	0.713 ± 0.09^{a}		
Phenols										
4-Ethylpheno	2194	R	2195^{c}	1.498 ± 00.14^{c}	nd	0.808 ± 00.14^{b}	0.065 ± 0.02^{a}	nd	Phenol, spice[i]	0.44[z]
4-Ethylguaiacol	2018	R	2031^{c}	0.784 ± 00.04^{c}	nd	0.635 ± 00.12^{b}	0.043 ± 00.01^{a}	nd	Spice, clove[i]	0.033[w]
4-Vinylphenol	2425	R	2427^{c}	0.028 ± 00.01^{a}	0.084 ± 00.02^{a}	0.168 ± 00.04^{b}	0.126 ± 00.02^{b}	nd	Almond shell[i]	0.18[aa]
4-Vinylguaiacol	2202	R	2198^{c}	1.204 ± 00.12^{b}	nd	1.380 ± 00.09^{b}	0.184 ± 00.04^{b}	0.038 ± 0.01^{a}	Clove[o] ; clove, curry[i]	0.04[bb]
2,4-Di-tert-pentylphenol	2106	M		0.826 ± 00.28^{b}	0.932 ± 00.12^{c}	0.742 ± 00.18^{b}	0.826 ± 00.22^{b}	0.422 ± 0.09^{a}		
Total phenols				4.340 ± 00.59^{c}	1.016 ± 00.14^{b}	3.733 ± 00.57^{c}	1.244 ± 00.31^{b}	0.460 ± 0.10^{a}		
Terpenes										
Cedrene		M		nd	nd	nd	nd	0.044 ± 0.02^{a}	Cedarwood woody[j]	
2,6-Dimethyl-2,6-Octadiene	1541	M		nd	0.116 ± 00.12^{a}	nd	nd	nd		
α-curcumene	1552	M		nd	nd	nd	nd	0.058 ± 0.01^{a}		
1-Dodecene	1758	M		nd	nd	nd	nd	0.087 ± 0.03^{a}		
Citronellol	1759	R	1762^{c}	0.042 ± 00.01^{b}	0.204 ± 00.12^{c}	0.047 ± 00.03^{b}	0.043 ± 00.01^{b}	0.029 ± 0.01^{a}	Rose[i]	
β-Guaiene	1827	R	1831^{c}	nd	nd	nd	nd	0.058 ± 0.01^{a}	Wood, spice[i]	
Total terpenes				0.042 ± 00.01^{a}	0.320 ± 00.24^{c}	0.047 ± 00.03^{a}	0.043 ± 00.01^{a}	0.276 ± 0.08^{b}		
Other										
Piperidine	1944	M		nd	nd	nd	nd	0.015 ± 0.08^{a}	Heavy sweet floral animal[j]	D: 70.6[r]
Tetadecane	1380	R	1400^{c}	nd	nd	nd	nd	0.044 ± 0.06^{a}	Alkane[i]	1[r]
2-Methyltetrahydrothiophene	1788	M		0.064 ± 0.02^{b}	nd	nd	0.060 ± 0.02^{b}	0.015 ± 0.01^{a}		
Total others				0.064 ± 0.02^{a}	0	0	0.060 ± 0.02^{a}	0.074 ± 0.15^{b}		

Values in each row with different letters are significantly different ($p < 0.05$). Data are represented as the mean ± SD. nd: not found. (a). Linear retention index of unknown aroma compound on a HP-INNOWAX fused-silica capillary column ($60 \times 0.25 \times$ mm $\times 0.25\ \mu$m) with a homologous series of n-alkanes(C7–C30). (b) Identification method is indicated as follows: M, mass spectrum and RI agree with of aroma compound conducted under similar GC-MS condition.; R, identification of retention index with literature data. (c) The referenced RI from the flavor net database (https://www.flavornet. org, accessed June 2007), (on C20 M stationary phase); in the literature. (d) The referenced RI from EI-Sayed. (e) The referenced RI from Kondjoyan and Berdague. (f) The means of aroma compounds of triplicates were calculated through an internal standard method (2-octanol). (g) Standard deviation of triplicates. (h) DIW, SBSW, FCW, MW, and BBW were abbreviation of Drunk the incense wine, Summer Black Seedless wine, Fuji cream wine, Muscat wine, and Black Beet wine, respectively. (i) Odour descriptor from https://www.flavornet.org/flavornet.html. (j) Odor descriptor from https://www.thegoodscentscompany.com/index.html. (k) Odor descriptor from [37]. (l) Odor descriptor from [38]; odor thresholds were determined in 14% ethanolic solution. (m) Odor descriptor from [39].. (n) Odor descriptor from [40]. (o) Odor descriptor from [41]. (p) Odor threshold from [42]. (q) Odor threshold from [43]. (i) Odor threshold from [38], odor thresholds were determined in 14% ethanolic solution. (r) Odor threshold from (shu). (s) Odor threshold from [43], thresholds were calculated in a 12% water/ethanol mixture. (t) Odor threshold from [44]. (u) Odor threshold from [45]. (v) Odor threshold from [46]. (w) Odor threshold from [47]. (x) Odor threshold from [48]. (y) Odour threshold from [43], thresholds were calculated in wine. (z) Odor threshold from [49]. (aa) Odor threshold from [50]. (bb) Odor threshold from [51].

aroma had been reported in the literature [22], and was the highest in SBSW (9.869 mg/L), and the lowest in FCW (1.201 mg/L). The highest 2-butyl alcohol content was found in SBSW (25.239 mg/L, grape wine aroma), and about same amounts were found in DIW and MW, and was not found in FCW. 3-Methyl-1-butanol with banana fragrance [22]was a solvent [54] and had the highest content and was found in SWSB. Similar contents were found in the rest of wines. The concentration of phenylethyl alcohol with rose aroma was higher in MW and BBW compared with DIW, SBSW, and FCW. It has been found that fenchyl aocohol (0.116 mg/L) and nerol (0.696 mg/L) were present only in SBSW, nerolidol, leaf alcohol, and alpha terpneol only in BBW, and 2-propanol with pungent [55]aroma wasonly in FCW. These alcohols mainly were produced during the yeast metabolism which played an important role in the flavor for wines. In general, the alcohols were the largest group of the volatile compounds, accounting for more than half of the volatile constituents of the wines except FCW.

3.4. Aldehydes and Ketones. Four aldehydes were detected: acetaldehyde, furfural, benzaldehyde, and anisaldehyde dimethyl acetal. These compounds played an influence on the wines' flavor. The concentrations of the seven ketones identified in five home-brewed wines were shown in Table 2. 3-Hydroxy-2-butanone was responsible for butter and cream notes, which were markedly the most abundant higher ketones in all the five home-brewed wines. Further, it was found that 1-phenyl-2-acetone only was present in SBSW, β-ionone and 2-octanone only in BBW.

3.5. Acids. Seven different volatile acids were identified in five wines. Hexanoic acid, octanoic acid, and decanoic acid among others belong to the group of fatty acids, and were produced by the fermentation of ethanol and lactic acid [56]. Acids were responsible for fruity such as octanoic acid; cheese, and fatty such as decanoic acid; green such as hexanoic acid; and rancid, sour such as acetic acids. The suitable acid concentration of wines could contribute to a balanced aroma in wine [41], was welcome, and could inhibit the alcoholic fermentation [57].

3.6. Phenol and Terpenes. The structural properties and concentration of aroma and phenolic compounds are significant factors influencing the behavior of wine aroma release [58]. Five volatile phenols were identified in wines (Table 2). The highest phenol content was found first in the DIW, and second in FCW. 4-Vinylguaiacol with clove, spicy aroma was present in FCW (the highest 1.38 mg/L), which resulted from the decarboxylation of the nonflavonoid compound ferulic acid during fermentation [59]. However, 4-Vinylguaiacol could not have been detected in SBSW. 4-Ethylpheno and 4-ethylguaiacol, a certain concentration, were responsible for smoke, creosote, plastic, burnt plastic, cow dung flavor, and barnyard [60], and the former concentration was the highest first in DIW (1.498 mg/L), second in FCW (0.808 mg/L), the latter concentration also was the highest in DIW (0.784 mg/L), second in FCW (0.635 mg/L), while both were not found in SBSW and BBW.

Other and important classes of aroma compounds were terpenes. Monoterpenes give wine distinctive floral aromas that represent the vinification character of wine grapes, adding complexity to the wine aroma [61].As Table 2 show that six terpenes were found in the five wines: cedrene, 2,6-dimethyl-2, 6-octadiene, α-curcumene, 1-dodecene, citronellol, and β-guaiene. These volatiles all played a role in wines' aroma. Cedrene, α-curcumene, 1-dodecene, and β-guaiene only were found in BBW, and 2,6-dimethyl-2,6-octadiene only was present in SBSW.

3.6.1. Main Sensory Analysis. The results of the sensory evaluation of five home-brewed wines were shown in Table 3. There were statistically significant differences for all the 11 odor descriptors ($p < 0.0001$) used to describe the aroma feature of five home-brewed wines. ANOVA analysis indicated that SBSW show the highest intensities of most of the odor descriptors, including odour intensity (8.53), pineapple (5.97), alcohol (7.46), cream (6.45), sweet (5.83), and berry fruit (7.14) comparing to the rest of wines. BBW with the highest of herbaceous (6.03) and only citrus (4.62) was shown in Table 3. Further, MW had the highest score in floral (rose 9.05) descriptor, which agreed well with the grape' flavor type.

The results for 11 odor descriptors used in the sensory analysis (Table 3) were analyzed in a partial least square regression (PLS). Figure 1 showed the relationships between sensory aroma descriptors and five home-brewed wines. A total of 50% of the explained variance shows small ellipses and 100% of the explained variance show in big ellipses. PLSR modeling between the matrices of five wines and 11 of odor descriptors provided a two-factor model explaining 50% of the variance in X (five wines) and 83% of that in Y (sensory attributes). DIW and FCW were similar with the phenolic and undersirable flavor (brett in Table 3), which are all located in the below left of PC1 that were positively correlated to phenolic and undersirable flavor. SBSW with rich flavors of cream, berry fruit, odor intensity, herbaceous, alcohols, sweet, and pineapple was shown in Figure 1 combined in Table 3. The only aroma of citrus was found in BBW, and it also had high sweet, pineapple, alcohols, odor intensity, herbaceous, grape, and floral aroma.

3.7. Relationship among Sensory Attribute and Volatile Compounds with OVA>1. According to literature [22, 62, 63], odor activity value (OAV) had been extensively used to estimate aromatic compounds' sensory contribution to the overall aroma in wines and only the specific compound of OAV>1 contribute to the wines' aroma [51]. In order to know those specific components in five home-brewed wines effect on its overall aroma and cite, OAV for volatiles were determined by GC-MS. A total of 22 of volatiles in wines (OAV>1) contained four types of esters, alcohols, aldehydes, and phenols as shown in Table 4. The esters of nine were the main, and most compounds in 22 volatiles, specially, ethyl valerate (OAV = 10) has the highest

Table 4: OAV and ROC contents of volatile compounds in five home-brewed wines.

Cod-es	Compounds	OAV					ROC				
		DIW	SBSW	FCW	MW	BBW	DIW	SBSW	FCW	MW	BBW
C1	Ethyl acetate	1.380	2.040	1.390	1.710	1.210	0.005	0.007	0.003	0.01	0.001
C2	Ethyl octanoate	1.970	3.870	1.610	2.640	1.590	0.007	0.013	0.004	0.015	0.002
C3	Ethyl decanoate	7.870	1.260	1.910	7.870	1.901	0.028	0.004	0.004	0.045	0.002
C4	Gamma-butyrolactone	<1[a]	<1	<1	<1	1.029	0	0	0	0	0.001
C5	2-Phenylethyl acetate	1.048	<1	2.532	1.048	1.572	0.004	0	0.006	0.006	0.002
C6	Ethyl laurate	<1	1.020	<1	<1	<1	0	0.003	0	0	0
C7	Ethyl tetradecanoate	<1	6.990	<1	<1	<1	0	0.023	0	0	0
C8	Neryl acetate	<1	1.170	<1	<1	<1	0	0.004	0	0	0
C9	Ethyl valerate	<1	<1	<1	<1	10.000	0	0	0	0	0.011
C10	1-Propanol	5.196	10.966	1.334	5.196	5.272	0.018	0.036	0.003	0.03	0.006
C11	3-Methyl-1-butanol	9.029	14.177	7.183	9.029	8.544	0.032	0.047	0.017	0.051	0.009
C12	Phenylethyl alcohol	30.230	27.170	30.230	60.050	35.900	0.107	0.09	0.07	0.342	0.038
C13	Nerolidol	<1	<1	<1	<1	1.137	0	0	0	0	0.001
C14	Nerol	<1	17.400	<1	<1	<1	0	0.058	0	0	0
C15	Leaf alcohol	<1	<1	<1	<1	1.131	0	0	0	0	0.001
C16	Acetaldehyde	165.300	215.400	323.100	78.600	106.300	0.587	0.715	0.753	0.447	0.113
C17	3-Hydroxy-2-butanone	2.545	<1	4.250	2.545	<1	0.009	0	0.01	0.014	0
C18	β-Ionone	<1	<1	<1	<1	766.670	0	0	0	0	0.814
C19	Geranyl acetone	<1	<1	<1	1.172	<1	0	0	0	0.007	0
C20	4-Ethylpheno	3.405	<1	1.836	<1	<1	0.012	0	0.004	0	0
C21	4-Ethylguaiacol	23.760	<1	19.240	1.212	<1	0.084	0	0.045	0.007	0
C22	4-Vinylguaiacol	30.100	<1	34.500	4.600	<1	0.107	0	0.08	0.026	0
	Total	281.833	301.463	429.115	175.672	942.265	1	1	1	1	1

a. it showed OAV <1 or no found in five home-brewed wines.

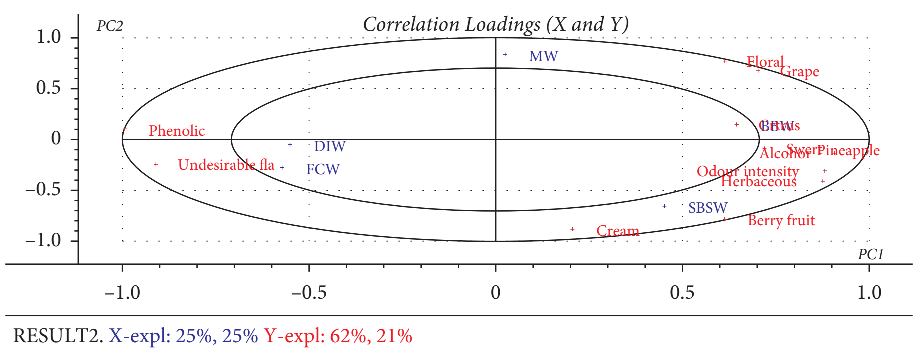

Figure 1: PLS regression map showing the five home-brewed wines correlated with 11 odor descriptors analyzed by seven sensory panels.

in the 9 kinds of esters that only were found in BBW, and not found in the rest of wines. While ethyl acetate (OAV = 2.04) and ethyl octanoate (OAV = 3.87) all were the highest in nine of esters for SBSW compared to DIW, FCW, MW, and BBW. Ethyl laurate, ethyl tetradecanoate, and neryl acetate in nine of the esters were only for SBSW and OVA of ethyl tetra-decanoate that reached to 6.99, which ranked only second to ethyl valerate (OAV = 10) for BBW. Alcohols had 6 of 22 in total volatile (OAV>1), account for a high proportion. 1-Propanol and 3-me-thyl-1-butanol were rich alcohols in wines reported in literature [32]. Showed the highest OAV values for SBSW, and nerol only existed in SBSW and its OAV value was very high (OAV = 17.4). While BBW had also two alcohols compounds: nerolidol (OAV = 1.137), leaf alcohol (OAV = 1.131), which were not determined in the rest of wines. Phenylethyl alcohol with rose aroma was the highest OVA values (OAV = 60.5) presented in MW, which agreed well with the red grape wines' flavor type [64, 65]. β-Ionone was the highest OVA value (OAV = 766.67) of 22 volatiles only occurred in BBW (Table 4).

To study the relationships between odor descriptors and aroma compounds only OAV>1 detected by GC-MS was used, and partial least square regression (PLSR) was performed. A total of 11 of odor descriptors are shown in Table 3 and regarded as X variable, and 22 (C1–C22) of aroma compounds are shown in Table 4 and acted as Y variable as shown in Figure 2. PLSR modeling between the matrices of 22 of volatiles and 11 of odor descriptors provided a two-factor model explaining 76% of the variance in X (sensory attributes) and 93% of that in Y (volatiles of OVA>1). As shown in Figure 2(b), x axis was mainly described by the odor descriptors showing a contrast between cream, sweet, pineapple, herbaceous, alcohols, floral, grape, and citrus aroma on the positive dimension and

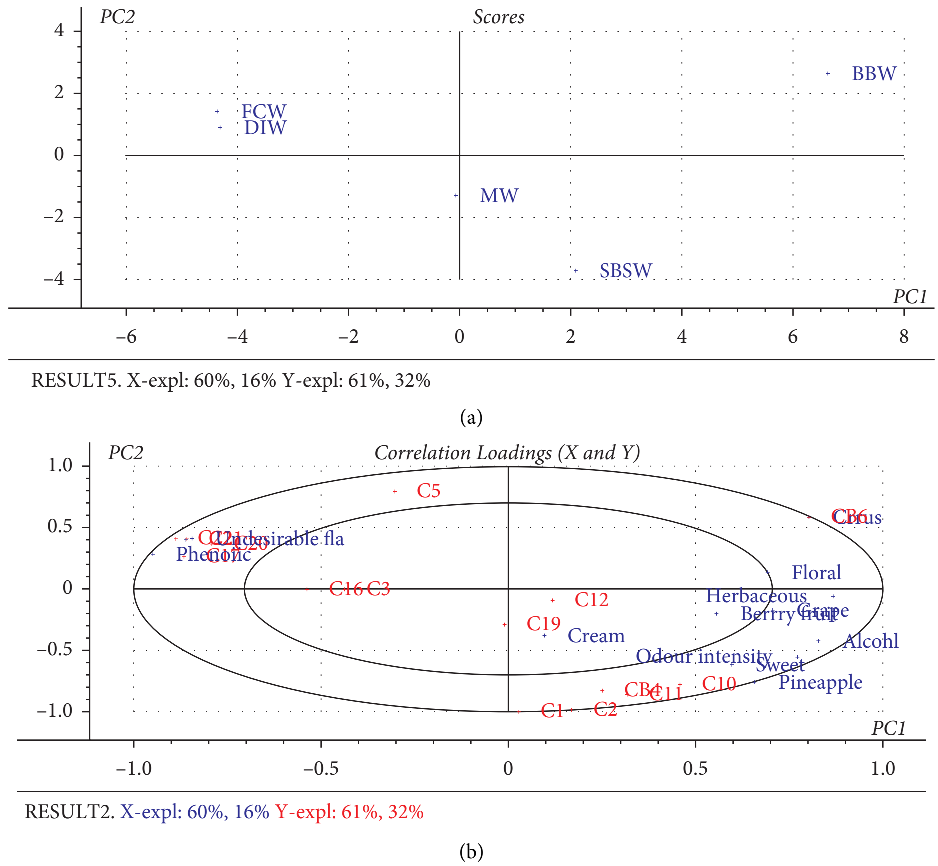

Figure 2: scores plot for five home-brewed wines (a). Correlation between loadings plots of X-variables for 22 volatiles compounds (OAV>1 Table 4) and Y-variables for the 11 odor descriptors (Table 3) (b).

phenolic and undersirable flavor aroma on the negative dimension. Obviously, the phenolic is located in the upper left of PC1 of Figure 2(b) and was mainly explained by positive contributions of not only 4-vinylguaiacol (C22) but also 4-ethylguaiacol (C21). Undesirable flavor near phenolic was significantly and positively correlated to 4-ethylpheno together with 4-ethylguaiacol, in a certain concentration, which both could be responsible for off-odor such as brett flavor, plastic burning taste [66, 67]. In the upper rightmost of PC1 of Figure 2(b), citrus and floral aroma correlated with β-ionone(C18), together with nerolidol (C13), which was in agreement with the results of GC-MS data and presented only in BBW (Figure 2(a)). Alcohol flavor accounted for a proportion in overall aroma of wines, which presented a negative correlation to 2-phenylethyl acetate. In the positive PC1 and negative PC2 in Figure 2(a) included only SBSW, which was strongly characterized by pineapple, sweet, herbaceous, and berry fruit and with the following volatiles compounds: ethyl acetate, ethyl octanoate, 1-propanol, 3-methyl-1-butanol, and nerol. Hence, PLSR can present an obvious and successful relationship of positive and negative correlations between odor descriptors and aroma compounds only OAV>1 detected by GC-MS.

To further judge the contribution of each individual compound in each wine to its overall aroma, the relative odor contribution (ROC) was performed. Only 12 of 22 volatiles (OAV>1) was found in DIW, and the ROC of its 4-vinylguaiacol and phenylethyl alcohol were similarly highest, 4-ethylguaiacol with could off-odor was presented the second high percentage of its total ROC (Table 4). Hence, DIW might be not favorite by sensory panels. Although only 11 volatiles (OAV>1) was presented in SBSW, acetaldehyde with fruity aroma presented the highest of contribution to SBSW and its ROC reached 0.715, and phenylethyl alcohol (ROC = 0.09) was characterized for agreeable flavors, which accounted for the great proportion in its total ROC. The particular nerol (ROC = 0.058) in SBSW also gave a great contribution to SBSW aroma. Acetaldehyde (ROC = 0.753) occupied the highest percentage of FIW's ROC, but 4-ethylguaiacol in FIW also accounted for the third high percentage of total ROC for FIW. Phenylethyl alcohol (ROC = 0.342) and acetaldehyde (ROC = 0.447) were similar percentage of contribution to MW, ethyl decanoate and 3-methyl-1-butanol also took a great proportion in the total flavor for MW. BBW had 14 volatiles compounds with near unity or higher OAVs, which was the maximum type of compounds compared to the four rest of wines. β-Ionone (ROC = 0.814) was the obvious and particular volatile, which presented the most high proportion of contribution and only was found in BBW. Ethyl valerate only in BBW also provided an extent contribution to it. Therefore, ROC was successfully able to analyze the percentage of contribution of a particular aroma compound to overall flavor of wines.

4. Conclusions

The aroma volatile compounds of the five home-brewed wines were obtained by GC-MS combined with HS-SPME. Volatiles in five wines basically were composed of seven groups: esters, alcohols, acids, aldehydes, volatile phenol, terpenes, and other. ANOVA analysis indicated that SBSW showed the highest intensities of most of the odor descriptors, PLSR was successfully able to detect positive and negative correlations between odor descriptors and the OAV compounds that showed OAV with higher. It was successful to further judge contribution of each individual compound in each wine to its overall aroma through OVA combined with ROC. ROC results revealed that the following volatiles: ethyl acetate, ethyl octanoate, ethyl decanoate, ethyl laurate, ethyl tetradecanoate, neryl acetate, 1-propanol, 3-methyl-1-butanol, phenylethyl alcohol, nerol, and acetaldehyde, which showed the common contribution to favorite flavors for SBSW. ROC and OAV results showed that ethyl valerate, nerolidol, and β-ionone were particular components in BBW, especially, β-ionone gave its unique due to it is the most percentage of contribution in total ROC of BBW. What is more, grape juice yield of BBG was 77.4 as shown in Table 1, which was the highest maximum compared to the rest of grapes of variety. To conclude, BBG and SBSG are very appropriate to act as varieties of wines brewing for people in Shanghai and around it.

Data Availability

Some or all data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The research was supported by Key Projects of Technology Innovation of Shanghai Education Committee (12ZZ187), and The Experimental Facilities in School of Perfume and Aroma Technology, Shanghai Institute of Technology, Preparation of Natural Flavor by Multi-component solvent transfer extraction combined with rotating vertebral column technique, funded by Key Laboratory of Cigarette Flavoring Technology in Tobacco Industry, TX2018001.

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