Recieved: 21/10/2020 Revised: 24/11/2020 Accepted article published: 30/11/2020 Published online: 30/11/2020

Volatile compounds of cvs Magliocco Canino and Dimrit grape seed oils

Onur Sevindik[1,2], Gamze Guclu[3], Giuseppe Bombai[4], Adamo Domenico Rombolá[4], Hasim Kelebek[1], Serkan Selli[3]*

[1] Department of Food Engineering, Faculty of Engineering, Adana Alparslan Turkes Science and Technology University, 01250, Adana, Turkey
[2] Cukurova University Central Research Laboratory, Adana, Turkey
[3] Faculty of Agriculture, Department of Food Engineering, University of Cukurova, Adana 01330, Turkey.
[4] Department of Agricultural and Food Sciences (DISTAL), University of Bologna, Viale Fanin 44, 40127 Bologna, Italy.

Correspondence;
Prof.Dr. Serkan Selli
E-mail adress: sselli@cu.edu.tr
ORCID No: 0000-0003-0450-2668

Abstract

Yields and aroma profiles of "Magliocco Canino" and "Dimrit" grape (*Vitis vinifera* L.) seed oils (GSO) obtained by a soxhlet extraction were studied in the basis of a comparative evaluation. The oil yield was much higher in Italian Magliocco canino GSO (15.8%) when compared to Turkish Dimrit variety (7.5%). A dynamic headspace purge-and-trap (DHS-P&T) and GC-MS techniques used for the identification and quantification of volatile compounds of GSOs. The number of identified aroma compounds and their concentrations were considerably high in Magliocco canino GSO. A total of 34 volatile compound were detected in Magliocco canino GSO while Dimrit GSO possessed 31 volatiles. The aroma groups identified in GSOs were alcohols, esters, acids, terpenes, ketones, aldehydes, lactones and volatile phenols. In both GSO samples, alcohols were the dominant aroma group possessing the 72.5% and 63.8% of total aroma concentrations in Magliocco canino and Dimrit varieties, respectively. In both GSO samples, 2-hexanol and 3-hexanol were the most abundant aroma compounds. Magliocco canino GSO possessed 10565μg/kg and 8400μg/kg while Dimrit GSO contained 16616μg/kg and 13840μg/kg of 3-hexanol and 2-hexanol concentration, respectively. Among aroma profiles of both samples, the most dominant difference was the higher number of identified volatile phenols in Dimrit variety.

Keywords: *Grape seed oil, Magliocco Canino, Dimrit, GC-MS, purge and trap, aroma*

1. INTRODUCTION

Grapes (*Vitis vinifera* L.) is a crop of high economic importance worldwide with a global production of around 80 millions tons (FAOSTAT, 2018). Since about 80% of the total amount is used in winemaking, tons of grape pomace are obtained at the end of the harvest season. The seeds constitute a considerable amount (around 38-52% on a dray matter basis) of the grape pomace and the possibility of producing oil from these seeds is gaining a great interest (Kamel et al., 1985; Bombai et al. 2017). Grape seed oil (GSO) extracted from the seeds of grape berries is drawing attention of the food, cosmetic and nutraceutic industries with its healthy, delightful and nutritional nature. The utilization of this remarkable oil also contributes to the economy of the wine and fruit juice industry by the valorization of the grape seed wastes that contain up to 20% oil yield (Matthäus, 2008). GSO possess high amount of polyphenols (such as; flavonoids, proanthocyanidins, stilbenes etc.), unsaturated fatty acids (particularly linoleic and linolenic acids), phytosterols, vitamin E (tocopherols and tocotrienols) and some specific volatile compounds (Fuleki & Ricardo-da-Silva, 1997). Monomeric phenolics (epicatechin, catechin, and their derivatives) and procyanidins are principal secondary metabolites existed in GSO. Antiviral and antimutagenic properties of these compounds enable the usage of GSO for nutroceutic and medicinal purposes (Davidov-Pardo & McClements, 2015). This spectacular bioactive content and their health promoting potential of GSO provide it an economic importance (Sevindik & Selli, 2016).

Besides, similar to almonds, peanuts and sunflower oil, the GSO is also rich in polyunsaturated fatty acids (PUFAs) which provide it anticarcinogenic, antihypertensive, antiobesity and antiodiabetic properties (Koba & Yanagita, 2014). Linoleic acid (18:2 n-6) is the most abundant PUFA in GSO and its known to be an aroma precursor of C_6 volatiles such as hexanol and hexanal wich provide mainly green and grassy notes to overall aroma (Lachman, 2015; Guclu et al., 2016; Bombai et al., 2017).

Organoleptic characteristics of these kind of oil, that have high cosmetic potential, strongly influence consumer preferences. Particularly, some specific volatile compounds are responsible for the unique and dainty aroma of GSO (Bail et al., 2008). Bail et al. (2008) investigated the effect of oil extraction technique and refining on volatiles of GSO obtained from nine different varieties. According to solid phase micro extraction (SPME) results, a total of 36 volatiles are identified mainly composed of alcohols, short chain acids, esters, aldehydes and ketones. Researchers also declared that the varietal differences cause alterations of aroma profile of GSO. Similarly, Karaman et al. (2015) determined some major volatiles in GSO and results showed that the limonene was found to be the most abundant volatile compound followed by myrcene, β-pinene and ethyl octanoate. In another study, Yalcin et al. (2016) examined the GSO obtained by Cabernet, Gamay, Kalecik Karası, Öküzgözü and Senso varieties in order to exhibit the varietal effect on aroma profiles. As a result of the study, a total of 27 volatile compound were identified in GSO mainly consisted of esters, aldehydes and alcohols. Among these compounds, isoamyl acetate, ethyl octanoate, ethyl heptanoate and phenyl ethyl alcohol were the most dominants detected in GSO. In addition, Kiralan et al. (2018) reported that the aldehydes and ketones (particularly, hexanal, *(E)*-2-heptenal, 2-octenal, 3-octanone, 2-octanone and 5-hepten-2-one) are important and sensitive volatiles of GSO and their concentrations partially change during storage owing to oxidation.

Although there is a number of researches about aroma compounds of GSO, to our knowledge, there is no any efficient aroma extraction technique (such as purge & trap extraction) applied to ascertain the volatile profile of GSO yet. Therefore, the present study was designed to investigate oil yields and aroma profiles of a less-known red local Italian variety (Magliocco canino) and a Turkish red variety (Dimrit) by means of purge & trap aroma extraction method.

2. MATERIALS AND METHODS

2.1. Chemicals

Water used in this study was purified by a Millipore-Q system (Millipore Corp., Saint-Quentin, France). The standard volatile compounds were purchased from Sigma-Aldrich (Steinheim, Germany). Dichloromethane, sodium sulfate and 4-nonanol were obtained from Merck (Darmstad, Germany). Dichloromethane was freshly distilled prior to use.

2.2. Samples

The “Magliocco canino” and “Dimrit” cultivar samples of Vitis vinifera were supplied from private vineyards during the harvest season of 2019. The vineyards were located in the Calabria region of Italy (Cantina Masicei) and Nevşehir province Turkey, respectively. Seeds were manually separated from berries, immediately put into oven for 24 h at 60°C and preserved in a dark place prior to analysis.

2.3. Grape seed oil extraction

The crude oil content of grape seeds was analysed according to AOAC method. Dried seeds were grinded and the extraction of GSO was performed by a semi-continuous solvent assisted oil extractor (Soxtherm, Gerhardt, Germany) for 6 h at 70°C. Obtained oil-solvent mixture was evaporated by vacuum evaporator (Buchi, Rotavapor, Switzerland) to remove solvent residues. The lipid extracts were collected in a flask. The extracted lipid was weighed to determine the oil content and stored under nitrogen at 4°C for further analyses (de Souza et al., 2020).

2.4. Extraction of Volatile Compounds

A purge and trap system was used to perform the extraction of aroma compounds as described in Kesen et al. (2020). Aroma compounds of Magliocco canino and Dimrit GSO were extracted by using a purge and trap technique which composed of a flow meter which regulates the carrier gas (nitrogen) flow and a gas splitter which divides the flow into multiple channels in order to purge three replicates at the same time. The most suitable adsorbent material (Lichrolut EN, Merck, 200 mg) were used to prepare trapping tubes as previously described by (Sevindik et al., 2019).

For the purge & trap extraction, 5 mL of GSO sample were previously placed into a 20 mL vial and subjected to a pre-incubation for 10 minutes at an optimized purging temperature (60°C). The extraction process was carried out for 90 min with a regulated nitrogen flow (50 mL/min) which passes through the sample. Once the extraction time is completed, the volatile compounds trapped in the cartridge were eluted by using dichloromethane (12 mL). Obtained aqueous phase was directly subjected to anhydrous sodium sulfate to remove any remaining water from the extract. Pooled aromatic extracts were concentrated up to 5mL at first by using a Kuderna Danish concentrator (Sigma Aldrich, St. Louis, USA) equipped with a Snyder column at 40°C. Subsequently, extracts were concentrated under a gentle flow of nitrogen gas to the final concentration that was about 200 µL. Obtained concentrated extracts were stored at -20°C prior to analysis. Whole extraction procedure were done in triplicate.

2.5. GC-FID and GC-MS conditions

The GC system used in this work is composed of an Agilent 6890 chromatograph equipped with a flame ionization detector (FID) and Agilent 5973-Network-mass selective detector (MSD) (Wilmington, DE, USA). The column used in the separation of volatiles was DB-Wax (30 m length × 0.25 mm i.d. × 0.5 µm thickness, J&W Scientific, Folsom, CA, USA). A 3 µL of concentrated GSO aromatic extract was injected in pulsed splitless mode (40 psi; 0.5 min) while the injector and FID detectors were set at 270°C and 280°C, respectively. The flow of carrier gas (helium) of GC system was set up to a 1.5 mL/min while the oven temperature ramp of the DB-Wax column and MSD rised from 50°C to 250°C at 4 °C/min with 10 min holding time. The MS parameters were set as: 70 eV ionization energy, m/z of 30–300 amu mass range, 2.0 scan/sec, 250°C interface temperature, and source temperature 180°C. The aroma compounds of GSO extracts were identified by a comparison of their mass spectra with those of a commercial spectra database (Wiley 9, NIST 11), their retention index and the instrument's own internal library. Besides the identification, the quantification of each aroma compound was done with the use of 4-nonanol (41.5 µg/L) and hexyl decanoate (41 µg/L) as internal standards. All quantifications were performed by constructing a standard curve. The abscissa was referred to the ratio of the peak area of each compound to the internal standards that are obtained by FID. To avoid the fluctuation of the data collected by the instrument and matrix effect, the standard curve was calibrated and evaluation index (R^2) of fitting regression effects was performed. In addition, limits of quantitation (LOQ) and limits of detection (LOD) values were calculated and a recovery rate of system was evaluated to verify the standard curve. The mean values were calculated by the triplicate analysis. Linear retention indices of each compound was computed using n-alkane (C_8–C_{32}) series (Sonmezdag et al., 2017; Pino & Barzola Miranda, 2020).

2.6. Statistical analysis

Statistical analysis to provide standard deviations of volatile concentrations was performed in the software package SPSS, version 22.0 (Chicago, Illinois, USA).

3. RESULTS AND DISCUSSION

3.1. Oil content of Magliocco canino and Dimrit varieties

According to revealed results, it was observed that the oil content is changed significantly across grape varieties. The oil yield of Magliocco canino and Dimrit grape seeds were calculated as 15.8% and 7.5%, respectively. These results ties well with previous studies wherein the oil yileds of several grape seeds were investigated (Baydar & Akkurt, 2001; Sabir et al., 2012; Lachman et al., 2015). Baydar & Akkurt (2001) examined the seeds of 12 wine and 6 table grape varieties by means of oil content and found that the wine grapes possess higher amount of GSO (ranging from 13.1% for Kalecik karası to 19.6% for Okuzgozu v/w) than table grapes (ranging from 11.6% for Çavuş to 18.1% for Amasya beyazı v/w). Additionally, Sabir et al. (2012) determined the seed oil content of 21 different grape varieties and researchers were found oil yield of grape seeds in a range between 7.3 g/100g seed (Perle de csaba) and 22.3 g/100g seed (Italia). On the other hand, Lachman et al. (2015) declared the oil extraction yields of grape seeds obtained by Soxhlet apparatus by using hexane solvent. According to results, among 23 grape varieties, Chardonnay possessed the highest oil content (17.3 g/100gseed) while Zenit variety had the lowest oil content (3.9 g/100gseed).

These findings support the fact that the oil yield of grape seeds not only alter due to the maturation phase of a grape berry, but also depends highly on the variety, canopy management and climatic conditions.

3.2. Volatile Profiles of GSOs

The GC-MS results were shown in Table 1. As can be seen, a total of 34 aroma compounds were detected in Magliocco canino GSO including 15 volatile alcohols, 5 esters, 3 aldehydes, 4 acids, 2 terpenes, 3 ketons, 1 lactone and 1 phenol. However, Dimrit GSO possessed a total of 31 volatiles including 9 alcohols, 6 volatile phenols, 3 esters, 3 volatile acids, 5 aldehydes, 1 ketone, 1 lactone, 1 terpene, 1 furan and 1 pyranone.

3.2.1. Alcohols

As can be exhibited from the Table 1, alcohols were the dominant volatiles in the Magliocco canino and Dimrit GSOs as they accounted for the largest proportion (72.5 and 63.8%, respectively) of the total volatile compounds. Despite this, the total content of alcohols in Dimrit GSO (41562 μg/kg) was considerably higher than total amount of alcohols quantified in Magliocco canino GSO (25138 μg/kg). Among alcohols, 2-hexanol and 3-hexanol were the two principal compounds that are well-known products of lipoxygenase pathway. This mechanism occurs in the presence of oxygen in the medium that disrupt the cell structure of specific polyunsaturated fatty acids (especially, linoleic and α-linolenic) followed by the formation of hexanal and its derivatives. Afterwards, as a result of the alcohol dehydrogenase enzyme activity, C_6-alcohols form and accumulate in the grape berries during their maturation phases (Oliveira et al., 2006). 1-Hexanol was another C6-alcohol identified in GSO samples which quantified apparently higher in Dimrit variety (9219 μg/kg) than Magliocco canino (893 μg/kg). These specific compounds are known to be precursors of esters that provides red berry aroma (Dennis et al., 2012). Phenyl ethyl alcohol demonstrated another discrepancy between varieties regarding their concentration. Magliocco canino GSO possessed much higher amount of phenyl ethyl alcohol (2333 μg/kg) than Dimrit GSO (377 μg/kg). This volatile alcohol has already been detected in Tempranillo grapes and its wines in earlier studies (López-Tamames et al., 1997). Many previous studies reported phenyl ethyl alcohol as having rose odor in Pinot noir, Kalecik karasi and Fondillon wines (Selli et al., 2004; Rutan et al., 2014; Issa-Issa et al., 2020). 3-Penten-2-ol, 1-methyl cyclopentanol, 2-methyl-2-buten-1-ol, 2,3 butanediol and 1-octanol were the compounds only detected in Magliocco canino GSO aromatic extracts while they were absent in Dimrit GSO.

Besides, 2-butoxy ethanol, 1-octen-3-ol, 2-phenyl-2-propanol, benzyl alcohol and 2-phenoxy ethanol were other volatile alcohols identified in GSO samples.

3.2.2. Esters

In the aroma profile of GSO samples, esters accounted for the second largest proportion of the total volatiles (15,4% and 13,6% for Magliocco canino and Dimrit GSOs, respectively). Among esters, isoamyl acetate, which is known to be its pleasant banana odour,

Table 1. Volatile profiles of Magliocco canino and Dimrit grape seed oils (μg/kg)

No	RT	LRI	Compounds	Magliocco Canino	Dimrit	Sig.	Identification
			Alcohols				
1	10,7	1170	3-Penten-2-ol	335,3 ± 0,8	Nd	*	LRI, MS, Std.
2	12,2	1211	3-Hexanol	8400,8 ± 635,3	13840,4 ±1849,2	Ns	LRI, MS, Tent.
3	13,3	1218	2-Hexanol	10565,5 ± 626,8	16616,2 ± 2920,4	*	LRI, MS, Std.
4	13,4	1314	1-Methyl cyclopentanol	987,6 ± 220,8	Nd	*	LRI, MS, Std.
5	17,1	1322	2-Methyl-2-buten-1-ol	107,2 ± 32,7	Nd	*	LRI, MS, Std.
6	18,1	1342	3-Methyl-cyclopentanol	583,0 ± 16,7	Nd	*	LRI, MS, Tent.
7	19,0	1359	1-Hexanol	893,8 ± 79,6	9219,1 ± 2177,4	*	LRI, MS, Std.
8	20,2	1389	2-Butoxy ethanol	37,1 ± 1,8	177,2 ± 83,5	*	LRI, MS, Std.
9	23,3	1430	1-Octen-3-ol	65,0 ± 7,9	229,1 ± 1,7	*	LRI, MS, Std.
10	27,2	1543	2,3-Butanediol	106,9 ± 21,4	Nd	*	LRI, MS, Std.
11	27,5	1561	1-Octanol	255,7 ± 2,8	Nd	*	LRI, MS, Std.
12	33,9	1776	2-Phenyl-2-propanol	267,5 ± 12,7	298,7 ± 76,4	*	LRI, MS, Std.
13	38,2	1885	Benzyl alcohol	151,9 ± 5,2	355,4 ± 48,4	Ns	LRI, MS, Std.
14	39,5	1923	Phenyl ethyl alcohol	2333,4 ± 30,3	377,1 ± 23,9	*	LRI, MS, Std.
15	45,6	2126	2-Phenoxy ethanol	47,6 ± 0,8	449,3 ± 284,1	*	LRI, MS, Std.
			Total	25138,3	41562,5		
			Esters				
16	9,3	1126	Isoamyl acetate	3539,3 ± 300,3	3817,7 ± 260,3	*	LRI, MS, Std.
17	23,7	1441	Ethyl octanoate	869,2 ± 97,1	2544,5 ± 175,4	*	LRI, MS, Std.
18	31,4	1606	Ethyl decanoate	146,1 ± 10,6	Nd	*	LRI, MS, Std.
19	36,5	1822	Phenyl ethyl acetate	235,3 ± 17,6	Nd	*	LRI, MS, Std.
20	39,3	1851	Ethyl dodecanoate	588,0 ± 61,8	2673,7 ± 217,6	*	LRI, MS, Std.
			Total	5377,9	9035,9		
			Aldehydes				
21	7,6	1080	Hexanal	1182,7 ± 178,4	1832,1 ± 364,7	*	LRI, MS, Std.
22	17,5	1292	*(E)*-2-Heptenal	Nd	249,3 ± 49,6	*	LRI, MS, Std.
23	21,4	1400	Nonanal	472,2 ± 33,9	2107,5 ± 364,4	*	LRI, MS, Std.
24	25,2	1497	*(E,E)*-2,4 Heptadienal	91,9 ± 29,1	Nd	*	LRI, MS, Std.
25	26,8	1542	*(E)*-2-Nonenal	Nd	430,7 ± 26,6	*	LRI, MS, Std.
26	29,4	1646	Benzene acetaldehyde	Nd	301,5 ± 75,1	*	LRI, MS, Std.
			Total	1746,4	4921,1		
			Ketones				
27	25,7	1386	2-Nonanone	621,1 ± 70,4	Nd	*	LRI, MS, Std.
28	29,7	1600	Acetophenone	183 ± 9,7	845 ± 55,7	*	LRI, MS, Std.
29	30,2	1809	2-Dodecanone	78,1 ± 7,1	Nd	*	LRI, MS, Std.
			Total	882,2	845,0		
			Terpenes				
30	12,9	1182	Isocumene	Nd	261,9 ± 11,5	*	LRI, MS, Std.
31	34,6	1539	β-Cubebene	134 ± 25,6	Nd	*	LRI, MS, Std.
32	34,7	1676	Germacrene	168,2 ± 8,7	Nd	*	LRI, MS, Std.
			Total	302,1	261,9		
			Volatile phenols				
33	42,0	1987	Phenol	28,7 ± 2,3	833,5 ± 91,3	*	LRI, MS, Std.
34	43,8	2105	3,5-Xylenol	Nd	2602,4 ± 374,5		
35	44,0	2127	2,4-Dimethyl phenol	Nd	517,7 ± 46,7		
36	45,1	2189	Carvacrol	Nd	741,8 ± 84,9		
37	46,2	2225	3,4-Dimethyl phenol	Nd	449,3 ± 74,2		
38	49,9	2330	2,4-Ditert-butyl phenol	Nd	3262,4 ± 169,25		
			Total	28,7	8407,1		
			Volatile acids				
39	37,4	1854	Hexanoic acid	125,5 ± 10,8	495,4 ± 20,6		
40	41,1	1914	2-Ethyl hexanoic acid	Nd	802,9 ± 87,8		
41	44,0	2070	Octanoic acid	46,2 ± 3,7	377,2 ± 74,5		
42	46,6	2174	Nonanoic acid	34,9 ± 4,6	Nd		
43	46,8	2593	4-Ethoxy benzoic acid	209 ± 92,1	Nd		
			Total	415,6	1675,4		
			Other volatiles				
44	14,3	1231	2-pentyl furan	nd	391,62 ± 99,9		
45	29,3	1617	γ-Butyrolactone	76,05 ± 7,9	355,4 ± 5,9		
46	48,2	2295	Dihydroxy maltol	nd	1486,4 ± 148,1		
			General Total	**33967,8**	**68944,3**		

LRI retention indices on DB-WAX column. Concentration mean values based on three repetitions as μg/kg.
Identification methods of identification; LRI (linear retention index), Std (chemical standard); When only MS or LRI is available for the identification of compounds, it must be considered as an attempt of identification.

was the prominent ester compound having 3539 μg/kg in Magliocco canino and 3817 μg/kg in Dimrit GSO. Ethyl octanoate, generally associated with the fruity, floral and brandy scent, was the second important ester compound identified in GSO samples. Similarly, Bail et al. (2008) reported that the ethyl octanoate was one of an important volatile compound of GSO and its concentration varied among grape varieties. Apart from ethyl octanoate, phenyl ethyl acetate and ethyl decanoate were the compounds that are only found in Magliocco canino GSO aromatic extract while butyl butanoate was the other volatile ester determinated in both samples.

3.2.3. Aldehydes

Of all aroma compounds detected in GSO samples, aldehydes were another chemical group present in a significant amount immediately after volatile alcohols and esters. Similar to dominant character of other PUFA derived volatiles, hexanal was the principal aldehyde in both GSO samples (1182 μg/kg and 1832 μg/kg, respectively). Nonanal was found to be the second most abundant aldehyde in GSO samples and generally associated with green, grassy and fatty notes in plant-based oils together with hexanal (Guclu et al., 2016). *(E)*-2-Heptenal, *(E)*-2-nonenal, *(E,E)*-2,4 heptadienal and benzene acetaldehyde were other aldehydes identified in the samples.

3.2.4. Volatile Phenols

Another remarkable finding of the present study was the apparent difference between the number and the concentrations of identified volatile phenols among two varieties. A total of six volatile phenol compound were identified and quantified in Dimrit GSO including phenol, 3,5-xylenol, 2,4-dimethyl phenol, carvacrol, 3,4-dimethyl phenol and 2,4-ditert-butyl phenol while only one of them (phenol) presented in Magliocco canino GSO. Volatile phenols were accounted for the 11.8% proportion of overall Dimrit GSO aroma profile while this proportion was only 0.08% in Magliocco canino GSO.

3.2.5. Carboxylic Acids

Five volatile acids were identified and quantified in GSO samples examined in the present study. Among them, the highest concentrations were quantified again in the six carbon volatiles. 2-Ethyl hexanoic acid was the most abundant volatile acid with an average concentration of 802 μg/kg in Dimrit GSO while this compound not identified in Magliocco canino variety. This compound was previously reported in the purge and trap extracts of Pinot Noir grape must while liquid-liquid extracts of the same sample did not contain this compound (Mamede and Pastore, 2006).

3.2.6. Other volatile compounds

In GSO samples, apart from major aroma groups, terpenes, ketones, furans, pyranones and lactones were other minor aroma groups identified in GSO samples. The concentration of ketones was reported to be declined during berry development and reached the minimum level at harvest period (Zhang et al., 2014). Among ketones, although, the compound acetophenone was the only ketone identified in both samples, 2-nonanone and 3-octanone were found only in Magliocco anino variety. Interestingly, terpenes were not one of a major contributor to the overall GSO scent despite the fact that they play a crucial role in wine grape aroma profile (Dziadas and Jeleń, 2010). Moreover, these marker compounds, particularly free monoterpenes accumulated in the grape berries during maturation, classify the wine aroma profile as muscat/floral, non-muscat or neutral (Luo et al., 2019). In the present study, isocumene, β-cubebene and germacrene were the terpene compounds detected in GSO samples. Additionally, γ-butyrolactone was the only lactone compound detected in Magliocco canino and Dimrit GSO aromatic extracts. This compound has already been cited in several previous studies as one of a major aroma compound of ripe grapes as in Pedro Ximénez grape variety of Spain (Franco et al., 2004). Unlike the Magliocco canino variety, Dimrit GSO possessed a furan (2-penthyl furan) and a pyranone (maltol) which generally provide fruity and caramel-like notes, respectively (Mayr et al., 2015). The presence of these compounds may be associated with the applied high temperature during the oil extraction procedure (Wang et al., 2017).

4. CONCLUSIONS

Key differences between Magliocco canino and Dimrit GSO aroma profiles have been detected in the present work. According to results, alcohols were the dominant aroma group of both GSOs followed by esters and aldehydes. Difference between oil yields and some aroma compounds demonstrated the fact that oil yield and aroma profiles of GSO may vary significantly through different varietal characters although the extraction procedure carried out under the same conditions. A notable difference between varieties emerged by the higher concentrations of volatile phenols presented in Dimrit variety. Another important outcome of the study was the negative effect of the the high temperature applied during the extraction of GSO on the aroma profile of GSO aromatic extracts. As the aroma plays a crucial role for the consumer perceptions, it is expected that the rising popularity of GSO will draw an attention of aroma investigations to construct a fingerprint of aroma characteristics of different local grape varieties and their GSOs. Moreover, possible transfer of the volatiles presented in seeds into the grape must and wine is still needed to be clearize by future studies.

REFERENCES

Bail, S., Stuebiger, G., Krist, S., Unterweger, H., & Buchbauer, G. (2008). Characterisation of various grape seed oils by volatile compounds, triacylglycerol composition, total phenols and antioxidant capacity. *Food Chemistry*, 108(3), 1122-1132.

Baydar, N. G., & Akkurt, M. (2001). Oil content and oil quality properties of some grape seeds. *Turkish Journal of Agriculture and Forestry*, 25(3), 163-168.

Bombai, G., Pasini, F., Verardo, V., Sevindik, O., Di Foggia, M., Tessarin, P., Bregoli, A. M., Caboni M. F., & Rombolà, A. D. (2017). Monitoring of compositional changes during berry ripening in grape seed extracts of cv. Sangiovese (*Vitis vinifera* L.). *Journal of the Science of Food and Agriculture*, 97(9), 3058-3064.

Davidov-Pardo, G., & McClements, D. J. (2015). Nutraceutical delivery systems: resveratrol encapsulation in grape seed oil nanoemulsions formed by spontaneous emulsification. *Food Chemistry*, 167, 205-212.

de Souza, R. D. C., Machado, B. A. S., Barreto, G. D. A., Leal, I. L., Anjos, J. P. D., & Umsza-Guez, M. A. (2020). Effect of Experimental Parameters on the Extraction of Grape Seed Oil Obtained by Low Pressure and Supercritical Fluid Extraction. *Molecules*, 25(7), 1634.

Dennis, E. G., Keyzers, R. A., Kalua, C. M., Maffei, S. M., Nicholson, E. L., & Boss, P. K. (2012). Grape contribution to wine aroma: Production of hexyl acetate, octyl acetate, and benzyl acetate during yeast fermentation is dependent upon precursors in the must. Journal of Agricultural and *Food Chemistry*, 60(10), 2638-2646.

Dziadas, M., & Jeleń, H. H. (2010). Analysis of terpenes in white wines using SPE–SPME–GC/MS approach. *Analytica Chimica Acta*, 677(1), 43-49.

FAOSTAT, 2018. FAOSTAT (Food and Agriculture Organization of the United Nations Statistics Division) http://www.fao.org/faostat/en/#data/QC. Accessed at 18.10.2020.

Franco, M., Peinado, R. A., Medina, M., & Moreno, J. (2004). Off-vine grape drying effect on volatile compounds and aromatic series in must from Pedro Ximénez grape variety. *Journal of Agricultural and Food Chemistry*, 52(12), 3905-3910.

Fuleki, T., & Ricardo da Silva, J. M. (1997). Catechin and procyanidin composition of seeds from grape cultivars grown in Ontario. *Journal of Agricultural and Food Chemistry*, 45(4), 1156-1160.

Guclu G, Sevindik O, Kelebek H, Selli S. (2016). Determination of Volatiles by Odor Activity Value and Phenolics of cv. Ayvalik Early-Harvest Olive Oil. *Foods*. 5(3): 46.

Issa-Issa, H., Guclu, G., Noguera-Artiaga, L., López-Lluch, D., Poveda, R., Kelebek, H., Selli, S., Carbonell-Barrachina, A.A. (2020). Aroma-active compounds, sensory profile, and phenolic composition of Fondillón. *Food Chemistry*, 316, 126353.

Kamel, B. S., Dawson, H., & Kakuda, Y. (1985). Characteristics and composition of melon and grape seed oils and cakes. *Journal of the American Oil Chemists' Society*, 62(5), 881-883.

Karaman, S., Karasu, S., Tornuk, F., Toker, O. S., Geçgel, U., Sagdic, O., Ozcan, N., & Gül, O. (2015). Recovery potential of cold press byproducts obtained from the edible oil industry: physicochemical, bioactive, and antimicrobial properties. *Journal of Agricultural and Food Chemistry*, 63(8), 2305-2313.

Kesen, S. (2020).GC-MS-Olfactometric characterization of aroma active compounds of turmeric (*Curcuma longa*) extract using aroma extract diluton analysis. *Journal of Raw Materials to Processed Foods*, 1, 13-21.

Kiralan, M., Çalik, G., Kiralan, S., & Ramadan, M. F. (2018). Monitoring stability and volatile oxidation compounds of cold-pressed flax seed, grape seed and black cumin seed oils upon photo-oxidation. *Journal of Food Measurement and Characterization*, 12(1), 616-621.

Koba, K., & Yanagita, T. (2014). Health benefits of conjugated linoleic acid (CLA). *Obesity Research & Clinical Practice*, 8(6), e525-e532.

Lachman, J., Hejtmánková, A., Táborský, J., Kotíková, Z., Pivec, V., Střalková, R., Vollmannová, A., Bojňanská, T. & Dědina, M. (2015). Evaluation of oil content and fatty acid composition in the seed of grapevine varieties. *LWT-Food Science and Technology*, 63(1), 620-625.

López-Tamames, E., Carro-Mariño, N., Gunata, Y. Z., Sapis, C., Baumes, R., & Bayonove, C. (1997). Potential aroma in several varieties of Spanish grapes. *Journal of Agricultural and Food Chemistry*, 45(5), 1729-1735.

Luo, J., Brotchie, J., Pang, M., Marriott, P. J., Howell, K., & Zhang, P. (2019). Free terpene evolution during the berry maturation of five *Vitis vinifera* L. cultivars. *Food Chemistry*, 299, 125101.

Mamede, M. E., & Pastore, G. M. (2006). Study of methods for the extraction of volatile compounds from fermented grape must. *Food Chemistry*, 96(4), 586-590.

Matthäus, B. (2008). Virgin grape seed oil: is it really a nutritional highlight. *European Journal of Lipid Science and Technology*, 110, 645–650.

Mayr, C. M., Capone, D. L., Pardon, K. H., Black, C. A., Pomeroy, D., & Francis, I. L. (2015). Quantitative analysis by GC-MS/MS of 18 aroma compounds related to oxidative off-flavor in wines. *Journal of Agricultural and Food Chemistry*, 63(13), 3394-3401.

Oliveira, J. M., Faria, M., Sá, F., Barros, F., & Araújo, I. M. (2006). C6-alcohols as varietal markers for assessment of wine origin. *Analytica Chimica Acta*, 563(1-2), 300-309.

Pino, J. A., & Barzola-Miranda, E. S. (2020) Characterization of odor-active compounds in pechiche (*Vitex cymosa* Berteo ex Speng) fruit. *Journal of Raw Materials to Processed Foods*, 1(2), 33-39.

Rutan, T., Herbst-Johnstone, M., Pineau, B., & Kilmartin, P. A. (2014). Characterization of the aroma of central Otago pinot noir wines using sensory reconstitution studies. *American Journal of Enology and Viticulture*, 65(4), 424–434.

Sabir, A., Unver, A., & Kara, Z. (2012). The fatty acid and tocopherol constituents of the seed oil extracted from 21 grape varieties (Vitis spp.). *Journal of the Science of Food and Agriculture*, 92(9), 1982-1987.

Selli, S., Cabaroglu, T., Canbas, A., Erten, H., Nurgel, C., Lepoutre, J.P., & Gunata, Z. (2004). Volatile composition of red wine from cv. Kalecik Karası grown in central Anatolia, *Food Chemistry*, 85, 207 213.

Sevindik, O., & Selli, S. (2016). Üzüm Çekirdeklerinin Temel Biyoaktif Bileşenleri. *Çukurova Tarım ve Gıda Bilimleri Dergisi*, 31(2), 9-16.

Sevindik, O., Amanpour, A., Tsouli Sarhir, S., Kelebek, H., & Selli, S. (2019). Characterization of Key Odorants in Moroccan Argan Oil by Aroma Extract Dilution Analysis. *European Journal of Lipid Science and Technology*, 121(5), 1800437.

Sonmezdag, A. S., Kelebek, H., & Selli, S. (2016). Characterization of aroma-active and phenolic profiles of wild thyme (*Thymus serpyllum*) by GC-MS-Olfactometry and LC-ESI-MS/MS. *Journal of Food Science and Technology*, 53(4), 1957-1965.

Sonmezdag, A. S., Kelebek, H., & Selli, S. (2017). Identification of aroma compounds of Lamiaceae species in Turkey using the purge and trap technique. *Foods*, 6(2), 10.

Wang, D., Duan, C. Q., Shi, Y., Zhu, B. Q., Javed, H. U., & Wang, J. (2017). Free and glycosidically bound volatile compounds in sun-dried raisins made from different fragrance intensities grape varieties using a validated HS-SPME with GC–MS method. *Food chemistry*, 228, 125-135.

Yalcin, H., Kavuncuoglu, H., Ekici, L., & Sagdic, O. (2017). Determination of fatty acid composition, volatile components, physico-chemical and bioactive properties of grape (Vitis vinifera) seed and seed oil. *Journal of Food Processing and Preservation*, 41(2), e12854.

Zhang, H., Fan, P., Liu, C., Wu, B., Li, S., & Liang, Z. (2014). Sunlight exclusion from Muscat grape alters volatile profiles during berry development. *Food Chemistry*, 164, 242-250.