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BASIC AREAS - Article

Quality of olive oils from southeastern Brazil

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ABSTRACT: This study aimed to characterize the volatile composition and sensory characteristics of virgin olive oils (VOOs) from eight olive cultivars grown in the southeast region of Brazil. The volatiles were extracted by Solid Phase Micro Extraction (SPME) and analyzed by Gas Chromatography coupled to Mass Spectrometry (GC-MS). The dominant sensory attributes were determined by Temporal Dominance of Sensations (TDS). C5 and C6 alcohols and C6 aldehydes were the most abundant volatiles in the investigated VOOs. E-2-hexenal was among the majority of volatiles in all investigated olive oils, mainly in VOOs from cultivars Arbequina, Arbosana and Grappolo 541, in which it had the most of their chromatographic area (about 60-80%). VOOs from cultivars Maria da Fé, Mission, Arbosana and Arbequina were characterized by the dominance of pungency sensation, as well as Frantoio regarding to bitter. Grappolo yielded an olive oil with predominance of bitter, and a blended VOO (Grappolo 541 and Arbequina) had predominance of green leaf. VOO from Ascolano cultivar had dominance of fruity and pungency. Overall, pungent was the main dominant sensation in most of the investigated VOOs, which can be related to C5 and C6 volatiles.

Key words: chemical composition, sensory profile, solid phase micro extraction, edible oils.

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INTRODUCTION

Virgin olive oil (VOO) is a kind of oil highly valued by its delicious taste and aroma and it is an important component in Mediterranean diet. The largest VOO production is mainly concentrated in Mediterranean countries, like Spain, Italy and Greece. Nowadays, some countries far from Mediterranean, such as New Zealand, Australia and South American countries, have increased their VOO production (Tura et al. 2004). Brazil also increased its olives cultivation and, consequently, began to commercialize olive oils (Ballus et al. 2015).

The olive oil quality is based on several chemical parameters, such as free fatty acid content, peroxide value, spectrometric absorptivities in UV and sensory attributes. Volatile composition is responsible for the majority of sensory characteristics of olive oils and it plays an important role on the overall quality, influencing decisively the product acceptability. The lipoxygenase pathway is an enzymatic oxidative process giving rise to the volatiles of high quality VOOs. However, volatile compounds from enzymatic processes are also related to sensory defects of olive oils, but autoxidation and fermentative processes are the main contributors to oil spoilage. These compounds include mainly aldehydes, ketones, esters and alcohols; and C5 and C6 volatiles have considerable contribution to the peculiar and pleasant VOO aroma (Procida et al. 2016; Fernandes-Silva et al. 2013). The mentioned volatiles are mainly derived by enzymatic pathways, which become active upon cell disruption and are involved in the formation of the typical sensory notes of olive oils (Krichene et al. 2010).

External factors, such as climate, soil, harvesting and extraction conditions influence the VOO volatile composition and the sensory characteristics (Fernandes-Silva et al. 2013), but several investigations on monovarietal VOO revealed that its specific characteristics are dependent on the cultivar (Bubola et al. 2012; Krichene et al. 2010). It is accepted that the enzymatic levels and activities involved in the pathways in the volatiles biogenesis of olive cultivars are genetically determined (Krichene et al. 2010).

Geographical origin also plays important role on VOO volatile profile, which can act as fingerprint to discriminate different VOO from different regions. A notable feature is the distinction from European VOO, in which E-2-hexenal is the dominant compound in the volatile profile, to Australian VOO, in which E-2-hexenal is reported as the major compound in less than 50% VOO, in addition to a minor contribution of C5 compounds to the volatile profiles (Prenzler et al. 2002). Regarding Brazilian VOOs, although it was noted some differences in phenolic compounds when compared with VOOs from other countries (Ballus et al. 2015); there is a lack of knowledge about their volatile profile and sensory characteristics, although many previous papers (Tura et al. 2004; Krichene et al. 2010; Bubola et al. 2012; Tanouti et al. 2012; Borges et al. 2017) have described both profiles of VOO cultivars coming from other countries.

Thus, this study aimed to survey the volatile composition, chemical and sensory characteristics of VOO from eight olive cultivars grown in the southeast region of Brazil, providing information for comparisons with VOOs from other regions and help in future studies on a controlled designation of origin or geographical indication.

MATERIALS AND METHODS

Samples

Olive oils from eight cultivars grown in the microregion of Serra da Mantiqueira, located in the southeast region of Brazil, were evaluated: Frantoio, Arbequina, Mission, Arbosana, Maria da Fé, Grappolo 541, Ascolano 315, and a blend (Grappolo 541 and Arbequina). For the oil extraction, all olives were processed within approximately 12 h after harvest. Three bottles (250 mL) of olive oil from each cultivar were collected for sensory and physicochemical analysis. All the oils were extracted in a cold centrifuge system from olives with a maturation index of 3.5 (Oliveira and Silva 2014). All samples were maintained under refrigeration (4 °C) and protected from light until the analysis.

Physicochemical characterization

The free fatty acid content as oleic acid, the peroxide value and the specific extinctions in ultraviolet were determined according to International Olive Council methods Nº 34 (IOC 2015), 35 (IOC 2016) and 19 (IOC 2010), respectively. All parameters were determined in triplicate.

Fatty acid profile

The fatty acids were determined (in duplicate) as corresponding methyl esters, which were prepared →

according to the International Olive Council method Nº 24 (IOC 2001). The fatty acid methyl esters were analyzed in a gas chromatograph Shimadzu GC- (2010 Plus) equipped with an SPTM-2560 capillary column (100 mm x 0.25 mm x 0.2 μmol) and a flame ionization detector (FID). The chromatographic conditions were: slit ratio of 1:100; initial column temperature of 140 °C for 5 min, heat from 140 °C to 240 °C at 4 °C·min^{-1}, maintenance of 240 °C for 30 min; helium as the carrier gas at 1 mL·min^{-1}; and detector and injector temperature of 260 °C. The identification was performed by comparing the retention periods of standard fatty acid methyl esters (FAME-37, Supelco) by co-chromatography.

Volatile profile

Olive oil volatiles were determined (in duplicate) by gas chromatography/mass spectrometry, with prior Solid Phase Micro-Extraction (SPME) with headspace. The headspace was performed with 5 g of sample at 45 °C for 5 min. The compounds in the vapor phase were extracted using a solid phase microextraction fiber with DVB/CAR/PDMS (divinylbenzene, carboxen, and polydimethylsiloxane). After 30 min of extraction (Silva et al. 2012), the fiber was injected into a gas chromatograph coupled with mass spectrometer (GC-MS Shimadzu QP2010 Ultra) equipped with an autosampler (CombiPAL AOC - 5000) and an Equity-5 column (5% phenyl - 95% dimethylpolysiloxane, 30 m × 0.25 mm × 0.25 mm). The injection was made in the splitless mode using helium as the carrier gas at a rate of 1.0 mL·min^{-1}. The injector temperature was 250 °C. The oven temperature was programmed up 35 °C (2 min) to 250 °C at a rate of 5 °C·min^{-1}, and maintained at 250 °C for 1 min. The mass spectrometer was operated in electron impact (70 eV) and at a mass scan range of 40-600 Da. The temperatures of the ion source and GC-MS interface were 200 °C and 240 °C, respectively.

Compounds were identified by comparing their mass spectra with GC/MS spectral libraries (Wiley 8 and FFNSC 1.2). A comparison of relative retention index (obtained using a series of n-alkanes under the same operational conditions) with references (El-Sayed 2009) was also used for compound identification. The abundance of the compounds was expressed as the chromatographic peak area.

Temporal Dominance of Sensations (TDS)

Twelve VOO consumers (7 females and 5 males, aged from 20 to 30 years old), familiar with sensory analysis and with a good general health were selected based on ISO 8586:2012 to perform the TDS tests.

TDS sensations (green leaf, pungent, bitter, rancid, oil, fruity and olive) were determined based on sensory studies conducted with olive oils and by the repertory grid method (Jaeger et al. 2005). The selected panelists were trained to recognize the sensations established to describe the product and to use the Sensomaker software to data collection. The panel passed through one session to introduce them to the TDS module of Sensomaker. They were instructed that the dominant sensation is the one perceived with the greatest clarity and predominance, i.e., the most striking perception at a given time (Pineau et al. 2009). The definitive TDS test was performed according to Pineau et al. (2009) over 40 s, totalizing 36 evaluations (12 panelists in triplicate). The samples were served following a balanced block design according to Wakeling and Macfie (1995).

Statistical analysis

Quality indices, fatty acid content, volatile profile (absolute areas) and sensory data (maximum dominance rate) were explored by principal components analysis (PCA). An $m \times n$ matrix, where m was the number of samples and n was the number of variables, was used to perform the PCA. The data were autoscaled and the PCA routines were performed using the Chemoface software.

TDS sensory data was explored by the TDS curves taking into account the dominance rates of the significant sensations (Pineau et al. 2009). Computations were carried out in Sensomaker software.

RESULTS AND DISCUSSION

Classification of the olive oil samples

After extraction, the olive oils were characterized by physicochemical parameters in order to classify the quality of the samples. The values of acidity, peroxide index and specific extinctions in ultraviolet, as well as the fatty acid content, are shown in Table 1. The acidity varied from 0.20 to 0.55%, which according to Codex Standard for Olive Oils →

Table 1. Physicochemical parameters and fatty acid composition (%) of olive oils from Frantoio, Arbequina, Mission, Arbosana, Maria da Fé, Grappolo, Ascolano, and a blended (Grappolo and Arbequina) cultivars.

	Frantoio	Arbequina	Mission	Arbosana	Maria da Fé	Grappolo	Ascolano	Blend
Acidity (%)	0.20±0.02	0.28±0.01	0.29±0.01	0.21±0.01	0.34±0.01	0.34±0.01	0.30±0.01	0.55±0.02
Peroxide value (mEq.kg^{-1})	5.13±0.76	7.93±0.50	16.53±0.81	6.33±0.31	11.67±0.99	6.27±0.31	5.00±0.20	6.47±0.36
K232	1.54±0.00	1.78±0.02	1.37±0.00	1.69±0.01	1.42±0.01	1.43±0.01	1.42±0.00	1.30±0.00
K270	0.14±0.00	0.13±0.00	0.15±0.00	0.17±0.00	0.22±0.00	0.19±0.00	0.14±0.00	0.17±0.0
ΔK	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01
C 16:0	13.73±0.11	16.16±0.85	13.89±0.43	15.9±0.87	13.35±0.73	8.78±0.56	12.8±0.81	12.7±0.75
C 17:0	0.04±0.00	0.04±0.00	0.06±0.00	0.07±0.01	0.04±0.00	0.02±0.00	0.07±0.01	0.06±0.00
C 18:0	1.39±0.03	1.46±0.02	1.56±0.06	1.38±0.03	1.97±0.54	1.47±0.07	1.83±0.21	1.9±0.32
C 20:0	0.24±0.00	0.28±0.01	0.28±0.03	0.33±0.08	0.33±0.04	0.26±0.01	0.36±0.03	0.39±0.03
C 22:0	0.07±0.00	0.07±0.00	0.08±0.01	0.10±0.00	0.12±0.02	0.08±0.00	0.11±0.02	0.13±0.02
C 24:0	0.03±0.00	0.02±0.00	0.02±0.00	0.04±0.00	0.04±0.01	0.03±0.00	0.05±0.00	0.06±0.00
C 16:1	1.78±0.01	2.12±0.03	1.27±0.09	2.28±0.10	0.78±0.06	0.26±0.03	1.24±0.08	1.22±0.05
C 17:1	0.10±0.00	0.16±0.01	0.15±0.00	0.21±0.03	0.06±0.01	0.05±0.00	0.21±0.07	0.18±0.03
C18:1n9c	74.59±0.98	65.72±1.02	74.73±0.87	67.8±1.23	75.82±0.99	82.78±1.01	75.75±0.79	75.67±0.91
C20:1n9	0.22±0.01	0.18±0.00	0.24±0.01	0.24±0.03	0.24±0.01	0.35±0.03	0.35±0.02	0.33±0.03
C18:2n6c	5.91±0.21	12.48±0.03	5.83±0.03	10.4±0.81	5.78±0.62	4.48±0.23	4.73±0.32	5.61±0.54
C18:3n3	0.62±0.02	0.52±0.00	0.75±0.02	0.65±0.05	0.97±0.03	0.73±0.05	0.49±0.05	0.66±0.21

and Olive Pomace Oils (CODEX STAN 33-1981) classify the samples as extra virgin olive oils (acidity ≤ 0.8%). The maximum peroxide value observed of 16.53 mEq·kg^{-1} was less than the limit of 20 mEq·kg^{-1} for virgin olive oils (CODEX STAN 33-1981). All values for K232, K270 and ΔK were less than the limits for extra virgin olive oils (CODEX STAN 33-1981). The fatty acid compositions were also in accordance of Codex Standard for virgin olive oils, mainly the high percentage of oleic acid, varying from 65.72 to 82.78%, followed by palmitic acid (8.78-16.16%) and linoleic acid (4.48-12.48%). Other fatty acids were found at a concentration of less than 2%, and *trans* isomers were not detected, which corroborates the fatty acid profile of Brazilian olive oils (Bruscatto et al. 2017; Borges et al. 2017). According to studies of olive oils, different cultivation and environmental conditions may have a substantial effect on the fatty acid composition of oils, mainly on monounsaturated and polyunsaturated contents (Borges et al. 2017). Among the environmental factors, temperature plays an essential role in the fatty acid composition, in which low temperatures increase the polyunsaturated/monounsaturated ratio. Corroborating this relationship, in the present study the highest content of oleic and lowest content of linoleic acids were verified when compared with some olive oils from Southern Brazil (Bruscatto et al. 2017). However, a relevant role of olive cultivar over the fatty acid composition also was verified.

Volatile profile

According to Boskou et al. (2006), olive oils contain approximately 280 volatile compounds. However, despite the large number of compounds, only about 70 are intimately responsible for the aroma because many of them are not present in sufficient quantity to be detected. According to Belitz et al. (2009), only the volatile products capable of interacting with the receptor proteins of the human olfactory bulb are responsible for the aroma.

Thirty-eight volatile compounds were identified in the evaluated VOOs, including aldehydes (12), alcohols (12), ketones (4), ester (1), hydrocarbons (4), carboxylic acids (4) and terpene (1). Table 2 shows the areas of volatile compounds identified in the VOO samples from different cultivars and the respective percentage of chromatographic area of each chemical class. The majority of the volatile compounds identified in this study has also been identified in Italian, Spanish and Greek olive oils (Ranalli et al. 2001; Vichi et al. 2007).

Table 2. Absolute areas of the volatile compounds in VOO from Frantoio, Arbequina, Mission, Arbosana, Maria da Fé, Grappolo, Ascolano, and a blended (Grappolo and Arbequina) cultivars.

Compound	Retention time	Retention index	Absolute area							
			Frantoio	Arbequina	Mission	Arbosana	Maria da Fé	Grappolo	Ascolano	Blend
2-methyl-butanal	3.72	658	nd	nd	45162	nd	nd	nd	nd	268957
Pentanal	4.28	694	2071151	nd	370502	nd	141576.5	277422	nd	2332268
2-pentenal	5.70	752	1566229	nd	nd	nd	nd	nd	nd	913484
3-hexenal	6.92	799	3127814	nd	nd	nd	nd	1524004	nd	3722213
Hexanal	7.00	800	13645930	431525	430823	544223	nd	648647	522503	17998897
E-2-hexenal	8.63	847	103102109	9130435	5025666	17880277	2874811	13383946	1845360	137751769
2-heptenal	10.65	957	nd	nd	nd	nd	nd	nd	nd	1123542
Octanal	14.65	1003	nd	nd	nd	nd	nd	nd	nd	1251661
2-octenal	16.83	1059	nd	nd	nd	nd	nd	nd	nd	810029
2-decenal	24.40	1263	3373629	nd	97324	nd	nd	nd	nd	4947932
2.4 decadienal	26.35	1319	nd	nd	nd	nd	nd	nd	nd	2127598
2-undecenal	27.88	1365	4791214	nd	nd	nd	nd	nd	nd	4629414
Aldehydes	-	-	131678076	9561960	5969477	18424500	3016387.5	15834019	2367863	177877764
Ethanol	2.09	-	3618500	nd	nd	nd	nd	nd	nd	10168979
methyl-butanol	3.57	648	nd	nd	1464401	413853	nd	nd	nd	254678
1-penten-3-ol	4.02	677	8654797	137308	128373	348273	109794	256968	141337	4440694
3-methyl-butanol	5.24	733	nd	nd	149754	nd	nd	nd	nd	845065
2-methyl-butanol	5.33	736	nd	nd	127484	nd	nd	nd	nd	nd
Pentanol	6.10	766	nd	nd	83944	nd	nd	nd	368775	nd
2-penten-1-ol	6.16	768	9267894	nd	152369	nd	nd	243534	143834	7480965
3-hexen-1-ol	8.96	855	92468892	nd	nd	nd	454782	1184448	3842027	22977032
2-hexenol	9.33	865	6984021	nd	3236764	978095	2753867	1038752	808289	17703396
Hexanol	9.49	870	1607974	1020986	720069	390587	407362	203650	1235973	12230459
2-ethylhexanol	15.68	1030	11021592	nd	nd	496097	664106	nd	892168	16587120
Octanol	17.35	1072	nd	nd	nd	nd	nd	nd	nd	1160644
Alcohols	-	-	133623670	1158294	6063158	2626905	4389911	2927352	7432403	93849033
1-penten-3-one	4.05	678	2314247	nd	nd	nd	nd	256968	nd	4440694
2-pentanone	4.08	681	nd	nd	nd	nd	nd	nd	123509	nd
3-pentanone	4.24	692	2995015	467840	nd	149894	141576	105089	372744	1527005
2-Furanone, 5-ethyl	12.98	961	nd	nd	nd	nd	nd	902713	nd	4919796
Ketones	-	-	5309262	467840	nd	149894	141576.5	1264770	496253	10887496
3-Hexen-1-ol acetate	14.72	1005	nd	nd	nd	nd	nd	nd	nd	1251661
Esters			nd	nd	nd	nd	nd	nd	nd	1251661
Octane	6.94	798	4522106	nd	141881	337582	360277	nd	476818	6192532
Undecane	18.42	1100	nd	nd	nd	nd	nd	nd	99540	1062035
Dodecane	22.16	1200	3203643	nd	nd	nd	nd	nd	268351	4039987
Tridecane	25.70	1300	nd	nd	nd	nd	nd	nd	0	2591157
Hydrocarbons	-	-	7725749	nd	141881	337582	360277	0	844709	13885711
Formic acid	2.58	-	8956418	nd	nd	nd	nd	nd	nd	7482525
Acetic acid	3.02	631	12041583	nd	662329	746697	2721275	803608	nd	43233502
Butanoic acid	6.58	784	nd	nd	408723	nd	nd	nd	nd	nd
Nonanoic acid	24.71	1275	nd	nd	nd	nd	nd	nd	nd	4021341
Carboxylic acids	-	-	28723751	nd	1212933	1084279	3081552	803608	844709	68623079
B-ocimene	16.34	1047	3551816	447551	432129	nd	nd	nd	nd	2990551
Terpenes	-	-	3551816	447551	432129	nd	nd	nd	nd	2990551

nd = not detected

VOO prepared by blending Grappolo 541 and Arbequina cultivars had the largest number of volatile compounds, followed by the Frantoio VOO. On the other hand, the oil produced with the Arbequina cultivar had the lowest number of identified compounds. Aldehydes and alcohols were the most abundant compounds in the VOOs. Concerning the total area of aldehydes, Arbosana and Arbequina VOOs were the richest samples, and Maria da Fé was the poorest VOO. Different activities of hydroperoxide lyase are probably responsible by these differences in aldehyde fractions, which catalyze the cleavage of fatty acid hydroperoxides that produce volatile aldehydes (Bubola et al. 2012). Different acylhydrolase activity and consequently good or poor availability of free polyunsaturated fatty acids can also influence the aldehyde content, as found by Sánchez-Ortiz et al. (2007). Among the aldehydes, E-2-hexenal was the most prevalent volatile compound in all the investigated VOO samples (Table 2). This is in accordance with the results noted by other authors for European VOOs, like Greek and Croatian VOOs (Bubola et al. 2012). Furthermore, Prenzler et al. (2002), Krichene et al. (2010) and Kiralan et al. (2012) showed that E-2-hexenal is the dominant compound in some Australian, Tunisian and Turkish VOOs, besides the minor contribution of C5 compounds to the volatile profiles. E-2-hexenal is derived from the enzymatic conversion of fatty acids and can be used as a marker of quality and freshness (Tanouti et al. 2012), and it is inversely related to the degree of oxidation of virgin olive oil (Silva et al. 2012).

Regarding the alcohols, Ascolano 315 had the richest VOO, followed by Frantoio, Maria da Fé and Mission samples. According to Angerosa et al. (1999), the alcohol fraction is related to the alcohol dehydrogenase activity and it is genetically determined for each cultivar, which justifies the differences among the proportions of individual alcohols in the evaluated VOO samples. Among the alcohols, 3-hexen-1-ol and hexanol was detected in abundance in Frantoio and in both Mission and Maria da Fé VOOs.

Overall, hydrocarbons, carboxylic acids, terpenes, ketones and esters presented low area for all VOOs, similar to the observed in other studies with Croatian (Bubola et al. 2012), Italian (Procida et al. 2016) and Turkish (Kiralan et al. 2012) olive oils. A low total area of esters was also noted in Portuguese oils (Fernandes-Silva et al. 2013). According to Tanouti et al. (2014), this may be due to the low activity of the alcohol acyl transferase enzyme involved in C6 esters biogeneration, which acts on an optimal pH range from neutral to basic (Salas 2004), while regular pH values of olive paste during olive oil production are in the acidic range (Bubola et al. 2012). Reiners and Grosch (1998) confirmed the richness of C6 volatile compounds in Italian oils but showed that they are poor esters, as observed in this study.

Temporal dominance of sensations (TDS)

In a TDS analysis, each curve represents the dominance of a particular attribute over time. The graph includes the "chance line" and the "significance line". The chance line is the dominance value that an attribute can obtain through chance; and the significance line is the minimum dominance value or minimum dominance proportion of a particular attribute considered significant at 95% confidence level (Pineau et al. 2009). TDS profiles of the Brazilian VOOs produced from different cultivars are shown in Fig. 1.

Maria da Fé and Mission VOOs had similar TDS profiles with pungent as the main significant sensation after approximately 15 s of the intake.

Bitter was perceived as dominant at the beginning of TDS analysis in Grappolo 541 and Frantoio VOOs. In addition, Frantoio VOO had pungent as dominant from approximately 15 s to the end of the test.

Olive flavor was dominant at the beginning of the intake of the blended VOO, but green leaf was the main dominant sensation from approximately 10 to 20 s, when pungent became dominant. Similarly, Arbosana VOO also had green leaf and pungent as dominant sensations, but with a lower dominance rate.

Ascolano VOO had oil as dominant sensation from up to 10 s, which can be due to no perception of a specific flavor at the beginning of the intake; fruity was dominant from approximately 10 to 20 s, when pungent became dominant up to about 30 s. Arbequina VOO had predominance of the pungency sensation.

The rancid flavor, a negative attribute, was not significant in any of the evaluated oils, which attests the good quality of these VOOs, corroborating the physicochemical characterization (Table 1).

Overall, pungent was the main dominant sensation in the majority of the investigated VOOs, corroborating previous study reporting TDS profiles of Italian VOOs (blend of cultivars Frantoio, Leccino and Moraiolo, and cultivar Grignano), from which the dominant sensations →

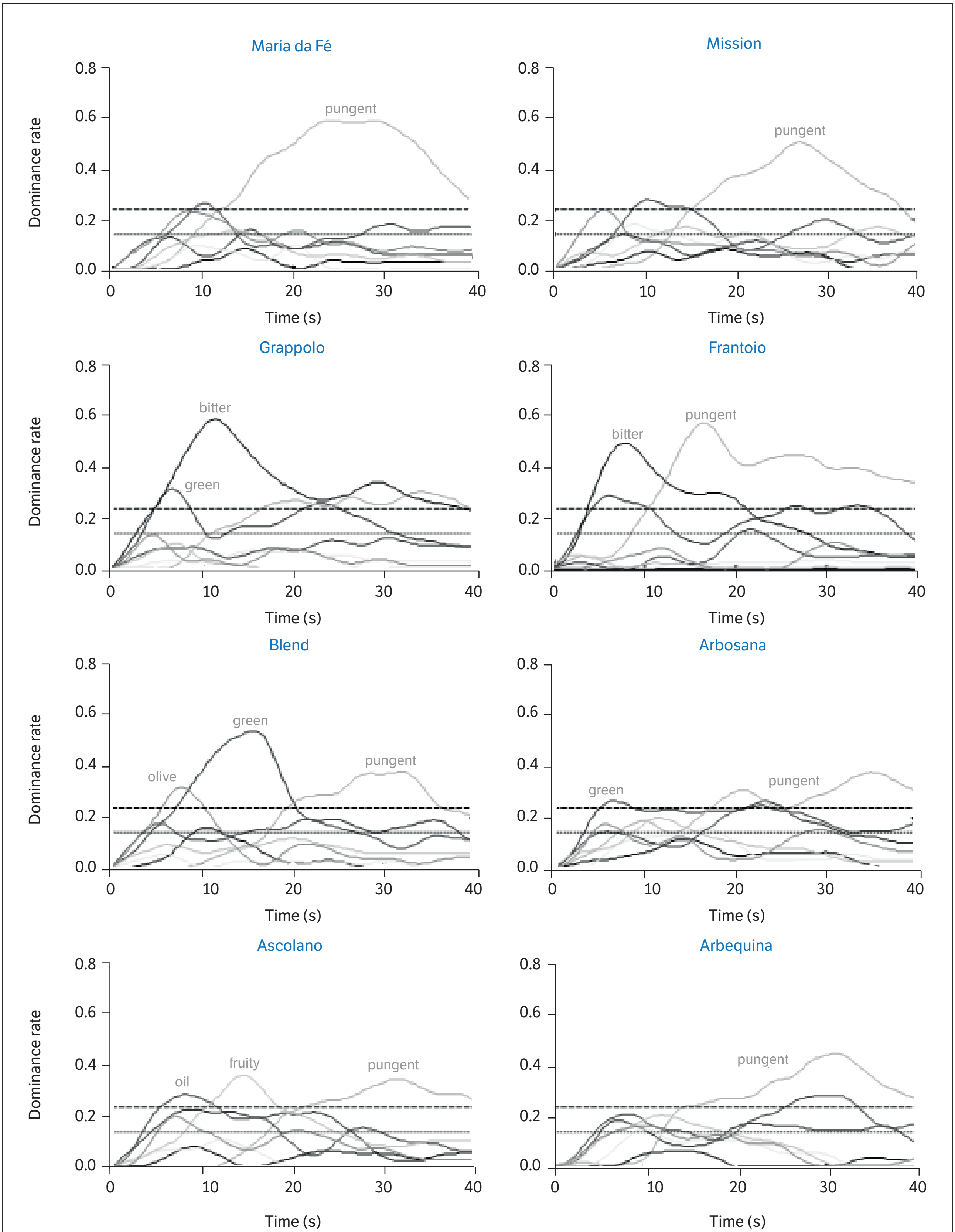

Figure 1. Temporal dominance of sensations profiles of the Brazilian VOOs produced from different cultivars. The inferior dashed line is the chance level and the superior dashed line is the significance level.

were related to C5 and C6 volatile compounds (Angerosa et al. 1999) also identified in the Brazilian VOOs.

Overall comparison of Brazilian VOOs

A PCA including quality indexes, such as fatty acid profile, volatile compounds and sensory data (Fg. 2) was carried out. According to PC1 × PC2 plot, Mission and Maria da Fé VOOs were highlighted due to higher peroxide value, which can be associated with the content of linolenic acid (C18:3), a polyunsaturated acid very susceptible to oxidation. Arbosana and Arbequina VOOs were characterized by the highest percentage of palmitic (C16:0) and palmitoleic (C16:1) acids, as well as linoleic acid (C18:2), which may have influenced the high value for K232 in these samples due to its susceptibility to oxidation. K270 and the contents of oleic (C18:1) and stearic (C18:0) acids had a low contribution (low loadings in PC1 and PC2) to discriminate the samples; nevertheless, Grappolo VOO was highlighted by the highest content of oleic acid (C18:1). The high free acidity influenced the discrimination of the blended VOO. Although these quality parameters, especially those related to oxidation, are influenced by the fatty acids profile, it is essential to consider that they can also be affected by harvest and processing conditions. Discrimination based on sensory characteristics was observed along PC1, which can be associated with some volatiles highlighted in the samples. Hexanal, 2-pentenal, 2-octenal, 2-penten-1-ol, 2-heptenal and 1-penten-3-one can be related to green flavor (Angerosa et al. 2004; Prenzler et al. 2002; Bubola et al. 2012) in the blended VOO; hexanol, 3-pentanone, 3-hexen-1-ol and pentanol to fruity flavor (Angerosa et al. 2004) in Ascolano VOO; and 2-hexenol, 2-hexenol, and acetic acid to pungency (Angerosa et al. 2004) in Mission, Maria da Fé, Arbosana and Arbequina VOOs. Due to the perception threshold,

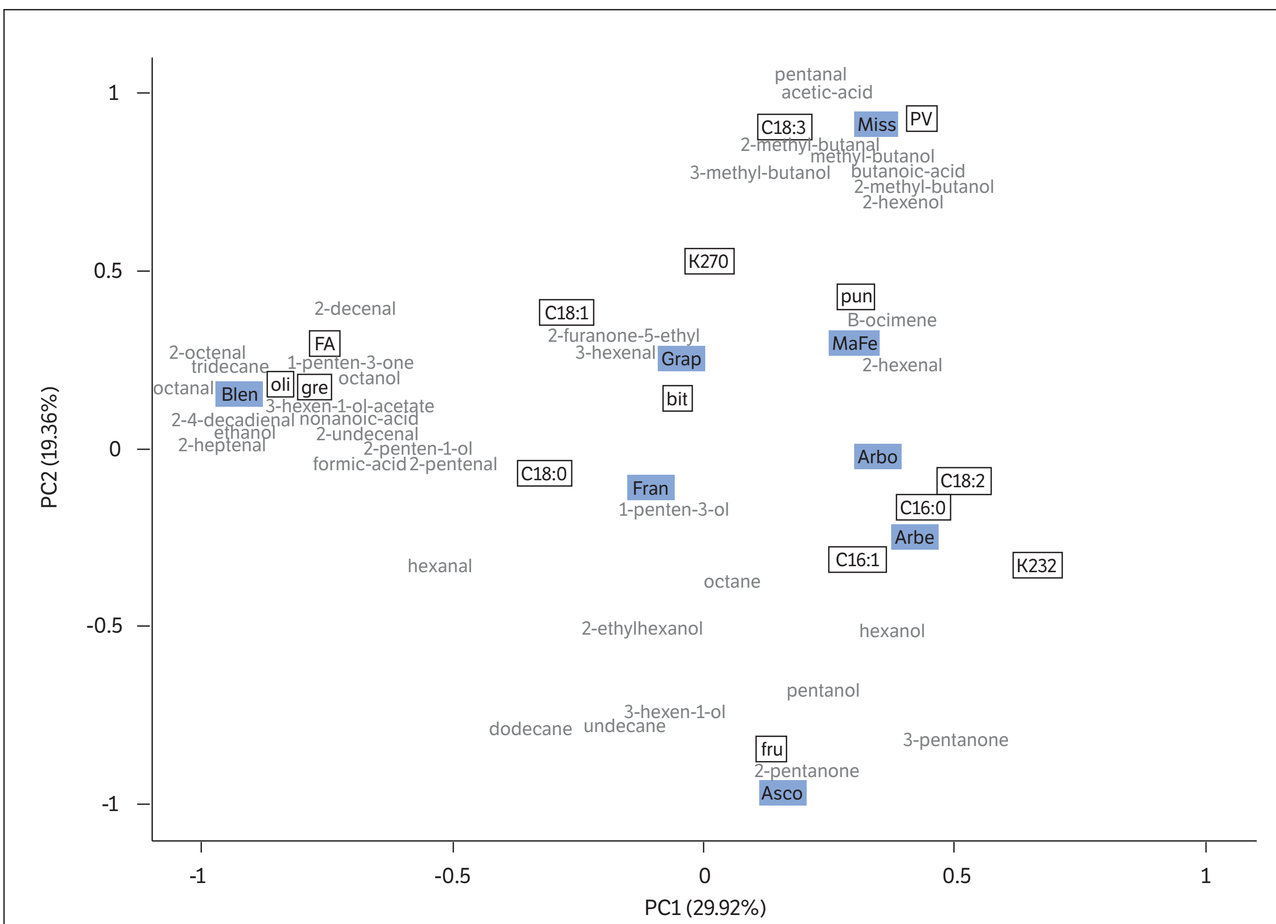

Figure 2. Principal component analysis of the quality indexes, fatty acids, volatile compounds and dominant sensations from Brazilian VOOs produced from different cultivars. Miss: Mission, Grap: Grappolo, MaFe: Maria da Fé, Fran: Frantoio, Arbo: Arbosana, Arbe: Arbquina, Asco: Ascolano, Blen: Blend. PV: peroxide value, FA: free acidity. oli: olive, gre: green leaf, bit: bitter, fru: fruity, pun: pungent.

other volatiles can have contributed to the dominant sensations, even not highlighting in the samples due to low content. The dominance of bitter characterized Grappolo and Frantoio VOOs, but none volatile associated with bitter could be related to this sensation, according to PCA. However, Angerosa et al. (2004) reported that nonvolatile compounds, such as phenolic compounds, stimulate the tasting receptors and also the free endings of the trigeminal nerve eliciting the former with the bitterness perception.

According to Angerosa (2002), the main volatile compounds responsible for the aroma notes of olive oil are compounds with six and five carbons, which are formed from C18 unsaturated fatty acids (oleic, linoleic and linolenic acids) by a chain of enzymatic reactions via lipoxygenase (LOX) (Angerosa 2002). Furthermore, it is well established that C6 aliphatic compounds are the most abundant compounds that impact extra virgin olive oil's flavor (Angerosa 2002). These compounds are known as "green volatiles" and are considered important constituents of oil because of their flavor and green leaf aroma contributions. According to Luna et al. (2006), differences in the concentrations of these compounds are mainly related to the olive variety.

CONCLUSION

Volatile composition and temporal dominance of sensations varied in olive oils from cultivars grown at southeastern region Brazil. C5 and C6 alcohols and C6 aldehydes were the most abundant volatiles in VOOs from olive cultivars grown at Southeastern region of Brazil. E-2-hexenal was among the majority of the volatiles in all investigated olive oils, mainly in VOOs from cultivars Arbequina, Arbosana Grappolo 541, in which it had the most of their chromatographic area (about 60-80%). Overall, pungent was the main dominant sensation in most investigated VOOs, which can be related to C5 and C6 volatiles. Some volatile and sensory characteristics were similar to olive oils from other regions, such as Italy.

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