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Volatile profile of breba and fig fruits (peel and pulp) from different *Ficus carica* L. varieties

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ABSTRACT

Background: It is currently estimated that around 50 % of fig production in Spain is not marketed and it is wasted, increasing the quantity of food loss. It is necessary to highlight that this is the first study comparing peels and pulps of breba and figs fruits to help improve the knowledge of volatile profile in four different Spanish varieties. The aim of this study was to investigate the volatile composition by HS-SPME of breba and figs (peel and pulp) of different varieties selected for their commercial relevance in Spain.

Results: In this study, 35 compounds have been detected in the different parts of breba and figs fruits. It can be said that the data presented here showed that variety affected the volatile profile in both edible (pulp) and non-edible (peel) *Ficus carica* L. fruit parts in both brebas and fig fruits, being Colar de Albatera which presented higher content in key volatile compounds. On the other hand, differences have also been observed between pulp and peel fruit part in each fruit: peel was richer in key volatile compounds than pulp, especially in Colar de Albatera variety.

Conclusion: Apart from the high content of phenolic compounds and nutritive properties of the edible and non-edible part of brebas and figs, specially Colar variety, it can be concluded that this material can also increase the olfactory sensory attributes.

1. Introduction

The fig tree (*Ficus carica* L.) is the most important *Ficus* species plant in the Moraceae family and is native to the Sub-Himalayan region and central India, although its cultivation is currently widespread in the Mediterranean area and the Near East due to its mild winters and hot and dry summers (Teruel-Andreu et al., 2023a). Therefore, the main figs/brebas -producing countries in the world are Turkey with 320,000 t in 2021, followed by Egypt, Morocco, Algeria, Iran, and Spain. In Europe, Spain is the major producer of figs/brebas (60,190 t), followed by Italy (12,760 t) (FAOSTAT, 2021).

However, the *Ficus carica* crop in Spain has been mainly grown in marginal areas traditionally cultivated under restrictive conditions (Lipan et al., 2020), but those under irrigation provide high-quality fruit for the fresh market and exports. Fig culture is oriented towards producing both breba and fig crops, using parthenocarpic and biferous cultivars (Melgarejo et al., 2007). Biferous varieties produce two crops – brebas and figs. The first crop Breba (dormant figs that develop from the previous year's growth and begin their development in the following spring) and the second crops Figs (develops on the stems of the current season). These varieties are characterized by the first crop being grown from the flowers of the previous year, this fruit is known as breba and it ripens at the beginning of the summer, whereas the second crop produces the figs, that emerge on the stems of the current season, and the fruit is harvested between mid-July and September, hence the main differences between breba and figs are due to the climatic conditions in which each develops (Palassarou et al., 2017) (Melgarejo et al., 2007; Núñez-Gómez et al., 2021; Palassarou et al., 2017).

Consumers are not only looking for the appearance of fruit (size, color, texture, etc.), but are also looking for internal quality (flavor, volatile compounds, functional compounds, etc.) (Sánchez-Bravo et al., 2022). Aroma present in fresh and processed fruit is affected by a

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complex group of chemical substances, such as aldehydes, alcohols, ketones, esters, lactones, and terpenes, which play an important role in the sensory quality (Villalobos et al., 2018). The volatile compound profile present in fresh fig can be used to identify each variety because it is considered to be unique and has a great influence on flavor and quality of the aroma and therefore on consumer acceptance (Pereira et al., 2020). Besides genotype other components that can influent aroma are geographical origin due to diversity in climatological conditions, maturity degree, agronomic techniques, and post-harvest treatment (Palassarou et al., 2017).

Volatile compounds belong to several chemical families, mainly aldehydes, terpenes, esters, alcohols, acids, and ketones contributing to the aroma of fresh figs (Pereira et al., 2020; Russo et al., 2017). In addition, other studies suggests that terpenes are the main volatile compound that influences the aroma of figs (Gozlekci et al., 2011). Similarly, Sertkaya et al. (2021) reported that the terpenes followed by esters and alcohols, were the most dominant aroma compounds in fig samples. Other compounds associated with fig aroma include 2-furancarboxaldehyde, 5-hydroxymethyl-2-furancarboxylic acid, benzaldehyde, furfural and phenol, 2,6-bis(1,1-dimethylethyl)−4-methyl phenol (Villalobos et al., 2018).

Currently, to determine the direct relationships between the odor or taste of a sample and the responsible volatile compounds, it is possible to compare sensory analysis, using GCMS– to detect volatiles and find associations or using GC olfactometry ports -MS to detect and identify the responsible compounds (Sánchez-Bravo et al., 2022). For the determination of volatile compounds with gas chromatography analysis with a mass detector (GC–MS) the most widely used extraction and pre-concentration of volatile compounds technique is solid-phase microextraction of headspace (HS-SPME) that does not produce alterations in the volatile compounds due to temperature or solvent effect (Oliveira et al., 2010).

Previous studies have reported the presence of volatile compounds in *F. carica* L. as mentioned above, but no-published data related to the volatile profile comparison research between pulp and peel in breba and/or fig fruits from *F. carica* L. was found. Therefore, the aim of this work was to determine the volatile profile of breba (pulp and peel) and fig (pulp and peel) of four varieties of *F. carica* L., one of them grown in two different localities. This information can will be used to select of the most suitable varieties, and can contribute valuable insights to the field of functional foods and potentially contribute to the development of new, health-promoting fig/ fig peel-based products.. It is important to highlight that this is the first work comparing breba and figs and their different parts (pulp and peel) of *F. carica* L. Spanish varieties.

2. Materials and methods

2.1. Plant material and sample processing

The fruit of 4 varieties of *F. carica* were used for this study. The *F. carica* variety "San Antonio" (SA), *F. carica* variety "Colar" (CA, CUMH), *F. carica* variety "Cuello Dama Negro" (CDN) and *F. carica* variety "Superfig" (SF) varieties were harvested at the experimental field station of Universidad Miguel Hernández de Elche (UMH) (Alicante, Spain; 02° 03′ 50′' W, 38° 03′ 50′' N, and 25 masl), while the "Colar" variety was harvested both at the experimental field station of University (CUMH) and at the local producers in the Albatera area (CA) (Alicante, Spain; 0° 55′ 49′' W, 38° 13′ 17′' N). The study was conducted in the year 2021 and fruits were harvested in two different periods. (i) June: for the breba crop, which is the first crop of figs in the season, (ii) August: For the main fig crop. The average number of fruits collected per tree was five. Mature fruits were randomly collected from four trees of each variety for both brebas and figs. All the harvested materials were immediately frozen at a temperature of −20 °C and stored until they were ready for analysis. Previous study (Teruel-Andreu et al., 2023b) about the nutritional and functional characterization of the same material has recently published.

2.2. Extraction procedure of volatile aroma compounds

Different extraction system was used to each sample peel and pulp. In the case of the first, two grams of peel (obtained using a peeler on frozen fruit) was added to a hermetic vial with polypropylene cap and PTFE (polytetrafluoroethylene)/silicone septa, together with 1 g NaCl. As to pulp samples, eight grams of pulp was added to vial with 2 mL of water and 1 g of NaCl.

The extraction of the volatile compounds of samples of peel and pulp was carried out by headspace solid-phase microextraction (HS_SPME) method. A fiber of 50/30 mm DVB/CAR/PDMS (Divinylbenzene/Carboxen/Polydimethylsiloxane) of 1 cm of length was used to absorb the compounds along the extraction. Samples were exposed for 60 min at 40 °C, with constant agitation (500 rpm) by using a Shimadzu AOC-6000 Plus autosampler (Shimadzu Corporation, Kyoto, Japan).

2.3. Chromatographic analyses

Volatile compounds were determined as previously described by Oliveira et al. (2010) using a chromatograph Shimadzu GC2030 (Shimadzu Scientific Instruments, Inc., Columbia, MD, USA) for isolation and identification of the volatile compounds. The gas chromatograph was equipped with an SLB-5 MS column of 30 m x 0.25 mm x 0.25 μm (length, diameter, and film thickness, respectively) (Teknokroma, Barcelona, Spain). For the identification of compounds, the chromatograph was coupled with a Shimadzu TQ8040 NX mass spectrometer detector. The parameters of the mass spectrometer were: (i) mass range 40–350 *m/z*, (ii) scan speed 3333 amu/s, (iii) event time of 0.100 s, and (iv) electronic impact of 70 eV Helium was used as gas carrier at a column flow of 1 mL min^{-1} in a splitless mode, purge flow of 6 mL min^{-1}, and a total column flow of 17.0 mL min^{-1}. The temperature of the interface was 280 °C, the ion source was 230 °C, and the injector was 220 °C. The desorption time of the sample in the injection port was 3 min. The oven program was the following: (i) initial temperature of 40 °C, and holded 1 min, and (ii), ramp of 2 °C min^{-1} up to 220 °C, and holded for 30 min.

The volatile compounds were identified using 3 methods: (i) retention indexes (RI) that were calculated with a commercial alkane standard mixture (C8–24) (Sigma-Aldrich, Steinheim, Germany), (ii) GC–MS retention time of the chemical pure compounds, and (iii) comparison of the compound mass spectrum with those of databases (NIST, 2023). In addition, the relative intensity of each volatile compound has been calculated as the ratio between the area of the specific molecule and the sum of the areas of all identified peaks (peak area normalization method) in the chromatogram. Compounds with spectral similarity >90 % and with a deviation of less than 10 units of linear retention similarity were considered as correctly identified.

2.4. Statistical analyses

Descriptive statistical analysis was done to check the normality and homogeneity of the variance. Once completed, a one-way analysis of variance (ANOVA) was performed to determine whether there were statistical differences ($p < 0.05$) between cultivars, and two-way analysis of variance was performed to determine whether there were statistical differences ($p < 0.05$) between brebas and figs. Tukey's multiple range test were performed for the analysis of the results. The XLSTAT Premium (2016.02.27444 version, Addinsoft: New York, NY, USA) was used to perform statistically significant differences, with a significant level $p < 0.05$.

Table 1
Aromatic compounds found in *F. carica fruits* pulp using headspace solid phase microextraction (HS-SPME).

Code	Volatile Compounds	Pulp	Peel	Chemical Family	[¥]RT (min)	Kovats index (KI)[¶] Exp	Lit	Descriptors
V1	Hexanal	Yes	Yes	Aldehyde	6.263	803	803	Fresh, cut grass [a]
V2	2-Hexenal	Yes	Yes	Aldehyde	8.396	849	850	Almond, apple, green, sweet, vegetable [a]
V3	Heptanal	Yes	No	Aldehyde	10.769	900	900	Oily, fruity, woody, fatty, nutty [a]
V4	2,4-Hexadienal	No	Yes	Aldehyde	11.238	908	909	Floral, citrus, green [a]
V5	Methyl hexanoate	No	Yes	Ester	12.010	921	919	Cheese, fatty, sour [a]
V6	Benzaldehyde	Yes	Yes	Aldehyde	14.061	954	955	Almond, anise, balsam, cherry, floral [a]
V7	1-Octen-3-ol	Yes	Yes	Alcohol	15.488	977	977	Cheese, creamy, earthy, herbaceous [a]
V8	2,3-Octanedione	Yes	No	Ketone	15.790	982	983	Herbal, earthy, fatty [b]
V9	2,2,4,6,6-Pentamethylheptane	Yes	No	Alkane	16.067	987	985	—
V10	2,4-Heptadienal	Yes	Yes	Aldehyde	16.474	993	993	Cinnamon, hazelnut, fatty [a]
V11	Octanal	Yes	Yes	Aldehyde	16.948	1001	1001	Honey, fruity, fatty, citrus [a]
V12	2-Octenal	Yes	Yes	Aldehyde	20.647	1054	1056	Spicy, herbaceous, green [a]
V13	3,5-Octadien-2-one	Yes	No	Ketone	21.436	1065	1068	Fruity, fatty, mushroom [a]
V14	2-Nonanone	Yes	No	Ketone	23.050	1088	1091	Herbaceous, floral, fruity, [a]
V15	Linalool	Yes	Yes	Terpenoid	23.640	1097	1097	Lemon, floral, citrus [a]
V16	Nonanal	Yes	Yes	Aldehyde	23.966	1102	1102	Apple, coconut, grape, lemon, vegetable [a]
V17	Phenylethyl alcohol	No	Yes	Alcohol	24.186	1105	1109	Honey, rose [a]
V18	Methyl octanoate	No	Yes	Ester	25.331	1121	1120	Cheese, oily [a]
V19	2,6-Nonadienal	No	Yes	Aldehyde	27.226	1147	1148	Vegetable, green [a]
V20	Benzenepropanal	No	Yes	Aldehyde	27.675	1153	1160	Floral, Green, Fresh, Powerful [b]
V21	Pinocarveol	No	Yes	Terpenoid	27.809	1155	1147	Herbal,woody, pine, balsam [b]
V22	2-Nonenal	Yes	No	Aldehyde	27.822	1155	1159	Waxy, fatty [a]
V23	Decanal	Yes	Yes	Aldehyde	31.133	1201	1201	Floral, citrus, sweet [a]
V24	2,4-Nonadienal	Yes	No	Aldehyde	31.664	1209	1208	Melon, fatty, floral, vegetable [a]
V25	2-Phenethyl acetate	No	Yes	Ester	34.308	1246	1250	Sweet honey, floral, balsamic [b]
V26	2-Decenal	Yes	Yes	Aldehyde	34.941	1255	1255	Oily, orange, floral, citrus, green, meaty [a]
V27	3-Phenyl 2-propenal	Yes	No	Aldehyde	35.324	1261	1260	Balsam, hyacinth, floral, sweet [a]
V28	Undecanal	No	Yes	Aldehyde	38.045	1299	1301	Orange, fatty, rose, waxy [a]
V29	Copaene	Yes	Yes	Terpene	42.368	1364	1366	—
V30	Caryophyllene	Yes	Yes	Terpene	45.073	1405	1405	Spicy, woody [a]
V31	Aromandendrene	No	Yes	Terpene	47.535	1443	1447	—
V32	*β*-Ionone	No	Yes	Ketone	48.824	1463	1470	Woody [a]
V33	1-Dodecanol	Yes	No	Alcohol	48.904	1464	1466	Coconut, honey, fatty, earthy, soapy, waxy [a]
V34	1-Tetradecanol	No	Yes	Alcohol	60.831	1669	1670	Fatty waxy, dairy creamy, fishy, fruity [b]
V35	Methyl hexadecanoate	No	Yes	Ester	73.788	1921	1921	Floral, waxy [a]

[¥] RT = retention time,.
[¶] KI (Exp.) = experimental Kovats index, (Lit.) = literature Kovats index,.
[a] SAFC (SAFC, 2012),.
[b] TGSC (TGSC, 2023).

3. Results and discussion

3.1. Volatile composition in pulp and peel of breba and figs

The volatile compounds were determined using HS-SPME standard method combined with GC for the isolation, identified and their relative abundance determined. Thirty-five volatile compounds were identified in the pulp and peel of the Ficus carica L. (Table 1).

The volatile compounds identified in the pulp (Table 2) of fruits studied were classified as aldehydes ($n = 13$), alcohols (2), alkanes (1), terpenes (4), terpenoids (1) and ketones (3). While the volatile compounds identify in the peel (Table 4) were classified as aldehydes (13), esters (4), alcohols (3), terpenes (2), terpenoids (2) and ketones (1). This trend was in agreement with those reported by others authors (Lachtar et al., 2022; Yao et al., 2021; Zidi et al., 2021).

For the pulp samples in the breba of the different varieties, hexanal was the one that obtained the highest percentage in the CA variety with 57.86 %, while for the CUMH and SF varieties it was benzaldehyde with a percentage of 43.45 and 34.38 % respectively. Previous works indicated that hexanal and benzaldehyde were the main compounds detected in figs (Gibernau et al., 1997; Lachtar et al., 2022; Pereira et al., 2020).

For alcohols only, significant differences have been found in the 1-octen-3-ol compound, also in this case the CA variety had the highest percentage (1.99 %). In a study dried fig cultivar of the major fig-producing geographical regions in Greece were analysed (Palassarou et al., 2017) and detected this compound in some varieties such as "Tsapelosika" and "Vassiliko" in values 1.33 % and 0.36 %, respectively.

Regarding the alkanes, the 2,2,4,6,6-pentamethyl heptane compound was found with a percentage range of 2.91–24.19 % between all the varieties. As in the terpene group, two compounds were detected copaene and caryophyllene but no significant differences were found between the varieties for any of the compounds.

The only one identified terpenoid was Linalool in this study. This compound also was found in figs of others varieties as "Azegzaw", although it was not the only one terpenoid found but it was the most abundant (Zidi et al., 2021). In ketone group, the CA variety obtained the highest percentage for the three compounds 2,3-octanedione (1.42 %), 2,3-octanedione (5.20 %) and 2-nonanone (1.69 %). 2-nonanone. Moreover, increase of some of these compounds such as 2-nonanone were detected in oven-dried "Dottato" figs (Palassarou et al., 2017; Russo et al., 2017).

For fig pulp, the compound that had the highest percentage was hexanal which belongs to the aldehyde group and CA (64.69 %) variety was the variety that obtained the highest percentage. Benzaldehyde is also a relevant compound in fig pulp other authors (Zidi et al., 2021) argue that hexanal and benzaldehyde were the most abundant aldehydes in "Taamriwthe" and "Azegzaw" figs. Benzaldehyde, showed a range of percentages between the different varieties studied (3.68–43.20 %), other authors agree with this and confirm results of 7.13 % (average value of several fig varieties) (Pereira et al., 2020). In the alcohol group, significant differences were found for the compounds 1-octen-3-ol and 1-dodecanol, CUMH (2.34 %) and SA (1.88 %) were showed the highest percentage respectively, this compound was also detected in low

Table 2
Volatile compound (% of volatile profile) of breba and fig pulp as affected by cultivar.

	Breba pulp (%)						Fig pulp (%)						Breba*Fig pulp (%)		
Volatile compound	ANOVA	SA	CA	CUMH	CDN	SF	ANOVA	SA	CA	CUMH	CDN	SF	ANOVA	Breba	Fig
Aldehyde															
Hexanal	***	26.14 b	57.86 a	4.61 c	10.22 bc	4.34 c	***	2.70 c	64.69 a	31.46 b	3.96 c	2.86 c	NS	20.63 a	21.13 a
2-Hexenal	NS	6.23 a	6.41 a	3.69 a	7.35 a	4.47 a	NS	5.01 a	2.06 a	1.90 a	3.38 a	3.63 a	**	5.63 a	3.20 b
Heptanal	NS	0.79 a	2.09 a	0.21 a	5.71 a	7.77 a	NS	0.40 a	0.53 a	0.48 a	0.20 a	0.54 a	*	3.31 a	0.43 b
Benzaldehyde	**	19.43 bc	3.17 d	43.45 a	9.05 cd	34.38 ab	**	20.76 ab	3.68 b	33.82 a	43.20 a	23.81 ab	NS	21.90 a	25.05 a
2,4-Heptadienal	**	2.01 a	1.68 ab	0.42 bc	0.20 c	0.13 c	NS	0.09 a	0.87 a	0.25 a	0.27 a	1.01 a	NS	0.89 a	0.50 a
Octanal	*	2.64 ab	1.46 b	2.88 ab	3.87 a	2.89 ab	NS	2.73 a	1.55 a	2.10 a	1.84 a	4.15 a	NS	2.75 a	2.47 a
2-Octenal	**	3.19 b	5.12 a	1.18 c	1.56 bc	0.67 c	NS	0.78 a	2.75 a	4.31 a	0.91 a	0.44 a	NS	2.34 a	1.84 a
Nonanal	**	8.64 b	3.57 c	10.54 b	17.71 a	8.72 b	NS	11.45 a	5.22 a	4.20 a	8.26 a	26.11 a	NS	9.84 a	11.05 a
2-Nonenal	*	0.92 ab	0.62 b	1.84 a	0.92 ab	1.17 ab	*	1.11 a	0.49 b	1.01 ab	0.83 ab	1.09 a	NS	1.10 a	0.91 a
Decanal	NS	2.90 a	0.77 a	2.28 a	2.35 a	1.76 a	NS	3.13 a	0.75 a	1.33 a	1.87 a	1.96 a	NS	2.01 a	1.81 a
2,4-Nonadienal	**	1.36 a	1.55 a	0.69 b	0.66 b	0.45 b	NS	0.82 a	1.12 a	1.39 a	0.31 a	0.47 a	NS	0.95 a	0.82 a
2-Decenal	NS	0.64 a	0.57 a	0.59 a	0.78 a	0.37 a	NS	0.53 a	0.43 a	0.66 a	0.40 a	0.51 a	NS	0.59 a	0.51 a
3-Phenyl 2-propenal	*	1.17 bc	0.49 c	1.62 abc	2.91 a	2.28 ab	NS	2.04 a	1.04 a	0.54 a	1.45 a	1.28 a	NS	1.69 a	1.27 a
Alcohol															
1-Octen-3-ol	*	1.59 a	2.00 a	0.65 a	1.04 a	0.39 a	*	0.65 b	1.11 ab	2.34 a	0.54 b	0.63 b	NS	1.13 a	1.05 a
1-Dodecanol	NS	0.90 a	0.48 a	1.46 a	1.39 a	0.93 a	*	1.88 a	0.51 b	0.57 b	0.85 b	0.94 ab	NS	1.03 a	0.95 a
Alkane															
2,2,4,6,6-Pentamethylheptane	***	5.12 bc	2.92 c	9.16 b	24.20 a	7.10 bc	NS	12.51 a	8.27 a	2.06 a	23.07 a	20.63 a	NS	9.70 a	13.31 a
Terpene															
Copaene	NS	0.18 a	0.39 a	1.85 a	3.07 a	2.19 a	NS	2.12 a	0.99 a	0.35 a	1.03 a	1.51 a	NS	1.54 a	1.20 a
Caryophyllene	NS	0.12 a	0.22 a	2.10 a	3.49 a	2.15 a	NS	2.14 a	0.86 a	0.18 a	2.10 a	2.27 a	NS	1.62 a	1.51 a
Terpenoid															
Linalool	***	12.24 b	0.33 c	9.77 b	1.89 c	17.21 a	**	27.98 a	0.39 b	7.19 b	4.04 b	5.47 b	NS	8.29 a	9.01 a
Ketone															
2,3-Octanedione	**	1.35 ab	1.42 a	0.83 bc	0.70 c	0.44 c	*	0.79 ab	0.88 ab	2.10 a	0.51 b	0.52 b	NS	0.95 a	0.96 a
3,5-Octadien-2-one	***	1.82 b	5.20 a	0.11 c	0.35 c	0.11 c	NS	0.17 a	1.51 a	1.68 a	0.26 a	0.10 a	NS	1.52 a	0.75 a
2-Nonanone	*	0.59 ab	1.69 a	0.09 b	0.60 ab	0.10 b	**	0.23 b	0.31 b	0.10 b	0.73 a	0.08 b	NS	0.61 a	0.29 a

NS: not significant at $p > 0.05$, ** and ***: significant at $p < 0.01$ and 0.001, respectively. Values followed by different letters, within the same column, were significantly different ($p < 0.05$). SA – San Antonio; CA – Colar Albatera; CUMH – Colar UMH; CDN – Cuello Dama negro; SF – Superfig.

Table 3
Volatile compound (% of volatile profile) of breba and fig peel as affected by cultivar.

	Breba peel (%)						Fig peel (%)						Breba*Fig peel (%)		
Code	ANOVA	SA	CA	CUMH	CDN	SF	ANOVA	SA	CA	CUMH	CDN	SF	ANOVA	Breba	Fig
Aldehyde															
Hexanal	***	7.60 b	52.72 a	5.23 b	4.62 b	8.89 b	***	2.09 c	28.08 a	9.57 b	4.56 c	2.91 c	NS	15.81 a	9.44 a
2-Hexenal	NS	36.78 a	11.86 a	51.36 a	54.86 a	45.68 a	***	37.16 a	14.36 bc	6.24 c	37.55 a	25.24 ab	**	40.11 a	24.11 b
2,4-Hexadienal	NS	0.27 a	0.44 a	0.13 a	0.48 a	0.04 a	**	0.30 ab	0.33 a	0.15 ab	0.13 ab	0.09 b	NS	0.27 a	0.20 a
Benzaldehyde	NS	40.59 a	9.72 a	37.74 a	32.72 a	33.29 a	***	47.12 ab	28.74 b	62.48 a	48.91 a	65.63 a	***	30.81 b	50.58 a
2,4-Heptadienal	***	3.27 ab	3.74 a	0.51 c	0.28 c	1.59 bc	***	0.36 b	1.33 a	1.82 a	0.46 b	0.53 b	NS	1.88 a	0.90 a
Octanal	**	0.66 ab	1.44 a	0.50 b	0.34 b	0.80 ab	***	0.59 b	1.39 a	1.15 a	0.35 b	0.29 b	NS	0.75 a	0.75 a
2-Octenal	***	0.90 b	5.42 a	0.39 b	0.48 b	0.82 b	***	0.56 b	2.89 a	1.87 a	0.32 b	0.24 b	NS	1.60 a	1.17 a
Nonanal	***	1.89 b	4.05 a	1.14 b	1.60 b	2.18 b	***	1.38 b	9.39 a	2.71 b	1.72 b	1.20 b	NS	2.17 a	3.28 a
2,6-Nonadienal	***	0.36 d	2.06 a	0.55 cd	1.02 bc	1.30 b	NS	1.03 a	1.08 a	0.60 a	1.10 a	0.39 a	NS	1.06 a	0.84 a
Benzenepropanal	***	0.16 a	0.01 b	0.01 b	0.05 b	0.03 b	***	0.15 b	0.70 a	0.11 b	0.18 b	0.11 b	**	0.05 b	0.25 a
Decanal	***	1.40 ab	1.98 a	0.37 c	0.63 c	0.84 bc	***	0.48 b	2.47 a	0.57 b	0.44 b	0.27 b	NS	1.04 a	0.85 a
2-Decenal	NS	0.10 a	0.24 a	0.12 a	0.02 a	0.03 a	NS	0.38 a	0.29 a	0.10 a	0.08 a	0.06 a	NS	0.10 a	0.18 a
Undecanal	***	0.13 ab	0.21 a	0.02 b	0.03 b	0.06 b	***	0.16 b	0.28 a	0.31 a	0.05 c	0.09 c	**	0.09 b	0.18 a
Ester														0.00	0.00
Methyl hexanoate	**	0.19 ab	0.37 a	0.06 b	0.08 b	0.10 b	***	0.03 b	0.47 a	0.42 a	0.02 b	0.02 b	NS	0.16 a	0.19 a
Methyl octanoate	***	0.17 a	0.18 a	0.07 b	0.02 c	0.01 c	***	0.09 b	0.29 a	0.32 a	0.06 b	0.05 b	NS	0.09 a	0.16 a
2-Phenethyl acetate	NS	0.01 a	0.02 a	0.14 a	0.21 a	0.57 a	NS	0.11 a	0.08 a	0.29 a	0.06 a	0.05 a	NS	0.19 a	0.12 a
Methyl hexadecanoate	***	0.10 b	0.42 a	0.01 c	0.01 c	0.01 c	***	0.01 b	0.10 a	0.13 a	0.01 b	0.01 b	NS	0.11 a	0.05 a
Alcohol														0.00	0.00
1-Octen-3-ol	***	0.61 b	2.46 a	0.36 b	0.35 b	0.84 b	***	0.67 c	3.38 a	2.07 b	0.52 c	0.33 c	NS	0.92 a	1.39 a
Phenylethyl Alcohol	**	0.24 b	0.19 b	0.52 ab	0.64 ab	1.03 a	**	0.63 a	0.41 ab	0.47 ab	0.25 b	0.11 b	NS	0.53 a	0.37 a
1-Tetradecanol	**	0.01 a	0.00 ab	0.00 b	0.00 b	0.00 ab	***	0.10 ab	0.11 a	0.04 bc	0.03 c	0.03 c	***	0.00 b	0.06 a
Terpene														0.00	0.00
Copaene	***	0.14 b	0.52 a	0.08 b	0.17 b	0.29 b	***	0.36 b	0.47 b	0.26 b	0.84 a	0.24 b	NS	0.24 a	0.43 a
Aromandendrene	NS	0.02 a	0.02 a	0.01 a	0.02 a	0.01 a	***	0.06 c	0.36 a	0.04 c	0.12 b	0.03 c	**	0.02 b	0.12 a
Terpenoid														0.00	0.00
Linalool	***	3.79 a	0.65 c	0.52 c	1.00 bc	1.26 b	***	5.46 ab	1.79 b	7.63 a	1.49 b	1.91 b	**	1.44 b	3.65 a
Pinocarveol	**	0.18 ab	0.48 a	0.09 b	0.20 ab	0.14 ab	***	0.31 bc	0.67 a	0.22 bc	0.42 ab	0.06 c	NS	0.22 a	0.34 a
Ketone														0.00	0.00
β-Ionone	***	0.45 ab	0.82 a	0.07 b	0.17 b	0.22 b	***	0.43 ab	0.58 a	0.45 ab	0.32 bc	0.13 c	NS	0.34 a	0.38 a

NS: not significant at $p > 0.05$, ** and ***: significant at $p < 0.01$ and 0.001, respectively. Values followed by different letters, within the same column, were significantly different ($p < 0.05$). SA – San Antonio; CA – Colar Albatera; CUMH – Colar UMH; CDN – Cuello Dama negro; SF – Superfig.

concentration (1.09 mg kg^{-1}) in other study with dried figs "Dottato" cv. (Russo et al., 2017). For alkane group only one compound (2,2,4,6, 6-pentamethylheptane) was detected and no significant differences were found between varieties. Copaene and caryophyllene were the two compounds found belonging to the group terpene and no significant differences were found for these compounds. On the other hand, Oliveira et al. (2010) found this compound only in pulp, while in this study it has been detected in peel and pulp (the amount found in pulp is 5.75 times higher than in peel). The linalool compound is a terpenoid for which significant differences have been found between the varieties studied. For the SA (27.98 %) variety, this compound was detected in a higher percentage than for the rest of the varieties. In the ketone group, no differences were found for compound 3,5-octadien-2-one, but for compounds 2,3-octanedione and 2-nonanone significant differences were found, being the CUMH (2.10 %) and CDN (0.73 %) varieties obtaining the highest percentage, respectively, for each compound. Finally, considering breba and fig as factors, we only found significant differences between breba and fig for compounds 2-hexenal and heptanal. Breba had the highest percentages in these compounds.

The aldehyde group represents the highest percentage of the total compounds found in the breba peel (Table 3). The main compound of this group was 2-hexenal, followed by benzaldehyde and hexanal. No significant differences were found for 2-hexenal and benzaldehyde among the varieties. Hexanal, was found in a ranged 4.62–52.72 % between varieties for CDN and CA, respectively. The percentage of hexanal detected in this study was similar to that reported by Pereira et al. (2020). Its percentage detected in fresh figs was 1.76 %. Besides, Villalobos et al. (2018) mentioned that 2-hexenal and hexanal are key compounds to the volatile aroma profile in figs. The CA variety also obtained the highest percentages for the main compounds of each one of each of the families, ester (methyl hexadecanoate 0.42 %), alcohol (1-octen-3-ol 2.46 %), terpene (copaene 0.52 %) and ketone (β-ionone 0.82 %). On the other hand, the SA variety showed a linalool percentage 5.82, 7.34, 3.78 and 3.01 times higher than the varieties CA, CUMH, CDN y SF respectively. The mean of all the varieties in peel breba for linalool 1.44 %. Previous work reported that the percentage for linalool

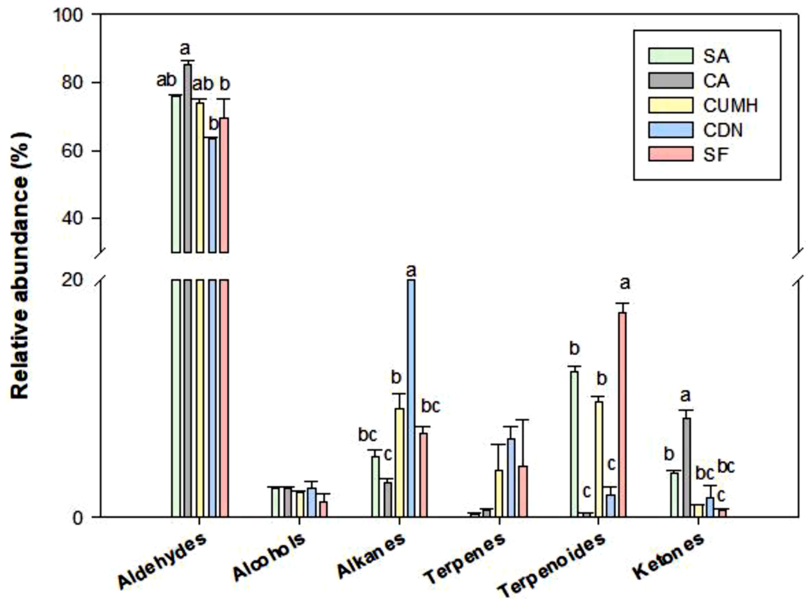

Fig. 1. Group of volatile compounds of breba pulp. SA – San Antonio; CA – Colar Albatera; CUMH – Colar UMH; CDN – Cuello Dama negro; SF – Superfig.

in fresh figs collected in national germplasm bank of the fig tree (Badajoz, Spain). Its percentage detected was 0.89 % (Pereira et al., 2020).

The aldehyde group was the one that obtained the highest representation with respect to all the compounds detected in the peel of figs. The main compound of this group was benzaldehyde, which showed the highest percentage for the SF variety (65.63 %), followed by the 2-hexenal compound with the highest percentages for the SA (37.55 %) and CDN (37.16 %) varieties, on the other hand for the compound hexanal it was the CA variety that obtained the highest percentage (28.08 %). In the group of alcohols, the two compounds with the highest percentage of the total were 1-octen-3-ol and phenylethyl alcohol, the varieties CA (3.38 %) and SA (0.63 %) respectively showed the highest percentage. For the ester group, the CA variety showed the highest percentage in compounds methyl hexanoate, while the CUMH variety showed the highest percentage for compounds methyl octanoate, 2-phenethyl acetate, and methyl hexadecanoate. Therefore, a trend is observed in the "colar" variety due to the volatile compounds of the ester group with respect to the other varieties studied. Three compounds belonging to the alcohol group were detected. The main compound of the alcohols was 1-octen-3-ol, for this compound the CA variety obtained a percentage 5.02, 1.63, 6.53 and 10.33 times higher than the SA, CUMH, CDN and SF varieties, respectively. For the terpene group, significant differences were found in the two compounds. Coapene showed a percentage range of 0.24–0.84 for SF and CDN respectively and aromandendrene showed a range of percentages of 0.03–0.36 for SF and CA, respectively. For the terpenoid group, the linalool compound was the main one, the CA variety was the one that showed the highest percentage 1.40, 4.26, 5.14 and 4 times higher than the SA, CUMH, CDN and SF variety. The last group is ketone, only β-ionone compound was detected and also the CA variety showed the highest percentage (0.58 %).

Using breba and fig as factors, only significant differences were found in the compounds 2-hexenal, benzaldehyde, benzenepropanal, undecanal, 1-tetradecanol, aromandendrene and linalool. Except for compound 2-hexenal, which showed a higher percentage in breba than in Fig. 1.66 times higher, for the rest of the compounds figs that obtained a higher percentage.

For breba, 12 volatile compounds were detected both in peel and pulp of the analyzed fruits. 2-Hexenal and 2,4-heptadienal compounds were detected in the highest percentages in the peel than in the pulp in all the varieties studied. However, octanal and 2-decenal it was the opposite. These compounds were detected in a higher percentage in pulp than in the breba peel. The CA variety showed higher percentages in peel than pulp for compounds benzaldehyde, decanal and linalool with percentages 3.06, 2.58 and 1.96 times higher respectively. For figs 2-hexenal and benzaldehyde compounds were detected in the highest percentages in the peel than in the pulp in all the varieties studied, however for octanal, 2-decenal and copaene it was the opposite, these compounds were detected in a higher percentage in pulp than in the breba peel. CA variety showed higher percentages in peel than pulp for the decanal, 1-octen-3-ol and linalool compounds with percentages 3.31, 3.05 and 4.60 times higher, respectively. Previous works (Gozlekci et al., 2011)indicated that the content of aldehydes were 4–9 times higher in pulps rather than in peel of figs varieties of Turkey ("Bursa Siyahi", "Karabakunya", "Sari Lop" and "Sultan Selim"). On the contrary, in this study the% of aldehydes detected in the peel was 1.30 times higher than for the pulp in breba and 1.29 higher in fig. On the other hand, Oliveira et al. (2010) found for "Borrasota" Tradicional and "Preta Tradicional" varieties aldehyde content was 1.48 and 1.17 times higher in peel than pulp . But for "Verbera preta" the aldehyde content in pulp was 2.87 times higher than in peel.

The data in peel and pulp of breba and figs aroma compounds is limited, several works reported that aldehydes, alcohols and ketones were the main volatile compounds contributor's aroma of figs (Russo et al., 2017) being aldehydes the most important chemical family to the of this fruits (Gozlekci et al., 2011). These volatiles compound founded in fruits of *F. carica* are related with different aromatic descriptors including high fruity, green notes and a moderate sweet and floral aroma, as well as a slight note of fatty aroma (Zidi et al., 2021).

Aldehyde represented (73.62 %) of total composition in breba pulp, the main percentage was for CA variety (85.36 %). The alcohol represented (1.32–2.49 %) of total composition and no significant differences were found in the total percentage of alcohols between the varieties studied. While for alkane the range of percentages was from (24.19 %) for the CDN variety to (2.91 %) for the CA variety. However, for terpenes no significant differences were found between varieties but for terpenoids SF variety showed the higher percentage (17.21 %). Finally, CA variety showed the highest percentage of ketone (8.31 %). According to Lachtar et al. (2022) who analyzed volatile compounds in peel and pulp of dryed fig affected by two drying methods (open sun drying and drying in a greenhouse) and different varities ("Bither Abiadh", "Bouhouli" and "Bidhi"). Its volatile profile was dominated by aldehydes (24.12–54.61

Table 4
Differences in volatile compounds (%) between the pulp of figs and figs of different varieties.

Pulp (%) Code	ANOVA	SA	CA	CUMH	CDN	SF	FSA	FCA	FCUMH	FCDN	FSF
Hexanal	***	2.70 d	64.69 a	31.46 b	3.96 d	2.86 d	26.14 bc	57.86 a	4.61 d	10.22 cd	4.34 d
2-Hexenal	NS	5.01 a	2.06 a	1.90 a	3.38 a	3.63 a	6.23 a	6.41 a	3.69 a	7.35 a	4.47 a
Heptanal	NS	0.40 a	0.53 a	0.48 a	0.20 a	0.54 a	0.79 a	2.09 a	0.21 a	5.71 a	7.77 a
Benzaldehyde	***	20.76 bcd	3.68 cd	33.82 ab	43.20 a	23.81 abc	19.43 bcd	3.17 d	43.45 a	9.05 cd	34.38 ab
2,4-Heptadienal	**	0.09 b	0.87 ab	0.25 b	0.27 b	1.01 ab	2.01 a	1.68 ab	0.42 ab	0.20 b	0.13 b
Octanal	*	2.73 a	1.55 a	2.10 a	1.84 a	4.15 a	2.64 a	1.46 a	2.88 a	3.87 a	2.89 a
2-Octenal	**	0.78 bc	2.75 abc	4.31 ab	0.91 bc	0.44 c	3.19 abc	5.12 a	1.18 bc	1.56 abc	0.67 bc
Nonanal	**	11.45 ab	5.22 b	4.20 b	8.26 b	26.11 a	8.64 b	3.57 b	10.54 ab	17.71 ab	8.72 b
2-Nonenal	**	1.11 ab	0.49 b	1.01 ab	0.83 b	1.09 ab	0.92 b	0.62 b	1.84 a	0.92 b	1.17 ab
Decanal	NS	3.13 a	0.75 a	1.33 a	1.87 a	1.96 a	2.90 a	0.77 a	2.28 a	2.35 a	1.76 a
2,4-Nonadienal	NS	0.82 a	1.12 a	1.39 a	0.31 a	0.47 a	1.36 a	1.55 a	0.69 a	0.66 a	0.45 a
2-Decenal	NS	0.53 a	0.43 a	0.66 a	0.40 a	0.51 a	0.64 a	0.57 a	0.59 a	0.78 a	0.37 a
3-Phenyl 2-propenal	**	2.04 abc	1.04 bc	0.54 c	1.45 abc	1.28 abc	1.17 bc	0.49 c	1.62 abc	2.91 a	2.28 ab
1-Octen-3-ol	**	0.65 bc	1.11 abc	2.34 a	0.54 bc	0.63 bc	1.59 abc	2.00 ab	0.65 bc	1.04 abc	0.39 c
1-Dodecanol	*	1.88 a	0.51 b	0.57 b	0.85 ab	0.94 ab	0.90 ab	0.48 b	1.46 ab	1.39 ab	0.93 ab
2,2,4,6,6-Pentamethylheptane	**	12.51 abcd	8.27 bcd	2.06 d	23.07 ab	20.63 abc	5.12 cd	2.92 d	9.16 abcd	24.20 a	7.10 cd
Copaene	NS	2.12 a	0.99 a	0.35 a	1.03 a	1.51 a	0.18 a	0.39 a	1.85 a	3.07 a	2.19 a
Caryophyllene	NS	2.14 a	0.86 a	0.18 a	2.10 a	2.27 a	0.12 a	0.22 a	2.10 a	3.49 a	2.15 a
Linalool	***	27.98 a	0.39 d	7.19 bcd	4.04 cd	5.47 cd	12.24 bc	0.33 d	9.77 bcd	1.89 cd	17.21 ab
2,3-Octanedione	**	0.79 b	0.88 b	2.10 a	0.51 b	0.52 b	1.35 ab	1.42 ab	0.83 b	0.70 b	0.44 b
3,5-Octadien-2-one	***	0.17 b	1.51 b	1.68 b	0.26 b	0.10 b	1.82 b	5.20 a	0.11 b	0.35 b	0.11 b
2-Nonanone	**	0.23 b	0.31 b	0.10 b	0.73 ab	0.08 b	0.59 b	1.69 a	0.09 b	0.60 b	0.10 b

NS: not significant at $p > 0.05$, ** and ***: significant at $p < 0.01$ and 0.001, respectively. Values followed by different letters, within the same column, were significantly different ($p < 0.05$). SA –Breba San Antonio; CA – Breba Colar Albatera; CUMH – Breba Colar UMH; CDN – Breba Cuello Dama negro; SF – Breba Superfig; FSA – Fig San Antonio; FCA – Fig Colar Albatera; FCUMH – Fig Colar UMH; FCDN – Fig Cuello Dama negro; FSF – Fig Superfig.

%) and also detected alcohols (6.06–13.37 %) and ketone (2.46–3.42 %).

Aldehydes (95.74 %) represent the highest percentage of the composition of the breba peel, the two main varieties by their percentage of aldehyde are CUMH (98.07 %) and CDN (97.13 %). On the other hand, CA variety showed the highest percentages for esters (1.00 %), alcohols (2.65 %), terpenes (0.53 %) and ketones (0.82 %) content. However, for the terpenoids content, the highest percentage was obtained by SA (3.97 %). In recent years, some authors have reported that aldehydes were the most abundant volatile compounds in figs (Gozlekci et al., 2011; Lachtar et al., 2022; Pereira et al., 2020; Zidi et al., 2021). Moreover, the concentration of aldehydes was influenced by variety (Pereira et al., 2020).

For fig pulp, the families with the highest percentage of total compounds in order from highest to lowest were aldehydes (70.98 %), alkanes (13.31 %), terpenoids (9.01 %), terpenes (2.71 %), alcohols (2.00 %) and ketones (1.99 %). Significant differences between varieties have been found for aldehyde and terpenoids only. CA (85.18 %) and CUMH

Table 5
Differences in volatile compounds (%) between the peel of figs and figs of different varieties.

Peel (%) Code	ANOVA	SA	CA	CUMH	CDN	SF	FSA	FCA	FCUMH	FCDN	FSF
Hexanal	***	7.60 c	52.72 a	5.23 c	4.62 c	8.89 c	2.09 c	28.08 b	9.57 c	4.56 c	2.91 c
2-Hexenal	***	36.78 abc	11.86 bc	51.36 a	54.86 a	45.68 ab	37.16 abc	14.36 bc	6.24 c	37.55 abc	25.24 abc
2,4-Hexadienal	**	0.27 abc	0.44 ab	0.13 abc	0.48 a	0.04 c	0.30 abc	0.33 abc	0.15 abc	0.13 abc	0.09 bc
Benzaldehyde	***	40.59 ab	9.72 b	37.74 ab	32.72 ab	33.29 ab	47.12 ab	28.74 ab	62.48 a	48.91 ab	65.63 a
2,4-Heptadienal	***	3.27 a	3.74 a	0.51 cd	0.28 d	1.59 bc	0.36 cd	1.33 bcd	1.82 b	0.46 cd	0.53 cd
Octanal	***	0.66 bc	1.44 a	0.50 bc	0.34 c	0.80 abc	0.59 bc	1.39 a	1.15 ab	0.35 c	0.29 c
2-Octenal	***	0.90 bc	5.42 a	0.39 c	0.48 c	0.82 bc	0.56 c	2.89 b	1.87 bc	0.32 c	0.24 c
Nonanal	***	1.89 bc	4.05 b	1.14 c	1.60 bc	2.18 bc	1.38 bc	9.39 a	2.71 bc	1.72 bc	1.20 c
2,6-Nonadienal	***	0.36 d	2.06 a	0.55 cd	1.02 bcd	1.30 b	1.03 bcd	1.08 bcd	0.60 bcd	1.10 bc	0.39 cd
Benzenepropanal	***	0.16 b	0.01 e	0.01 e	0.05 cde	0.03 de	0.15 b	0.70 a	0.11 bcd	0.18 b	0.11 bc
Decanal	***	1.40 bc	1.98 ab	0.37 d	0.63 cd	0.84 cd	0.48 d	2.47 a	0.57 cd	0.44 d	0.27 d
2-Decenal	NS	0.10 a	0.24 a	0.12 a	0.02 a	0.03 a	0.38 a	0.29 a	0.10 a	0.08 a	0.06 a
Undecanal	***	0.13 cde	0.21 bc	0.02 f	0.03 f	0.06 ef	0.16 cd	0.28 ab	0.31 a	0.05 ef	0.09 def
Methyl hexanoate	***	0.19 b	0.37 a	0.06 b	0.08 b	0.10 b	0.03 b	0.47 a	0.42 a	0.02 b	0.02 b
Methyl octanoate	***	0.17 bc	0.18 b	0.07 d	0.02 d	0.01 d	0.09 cd	0.29 a	0.32 a	0.06 d	0.05 d
2-Phenethyl acetate	**	0.01 b	0.02 b	0.14 ab	0.21 ab	0.57 a	0.11 b	0.08 b	0.29 ab	0.06 b	0.05 b
Methyl hexadecanoate	***	0.10 b	0.42 a	0.01 c	0.01 c	0.01 c	0.01 c	0.10 b	0.13 b	0.01 c	0.01 c
1-Octen-3-ol	***	0.61 c	2.46 b	0.36 c	0.35 c	0.84 c	0.67 c	3.38 a	2.07 b	0.52 c	0.33 c
Phenylethyl Alcohol	***	0.24 b	0.19 b	0.52 ab	0.64 ab	1.03 a	0.63 ab	0.41 b	0.47 b	0.25 b	0.11 b
1-Tetradecanol	***	0.01 b	0.00 b	0.00 b	0.00 b	0.00 b	0.10 a	0.11 a	0.04 b	0.03 b	0.03 b
Copaene	***	0.14 de	0.52 b	0.08 e	0.17 de	0.29 bcde	0.36 bcd	0.47 bc	0.26 bcde	0.84 a	0.24 cde
Aromandendrene	***	0.02 d	0.02 d	0.01 d	0.02 d	0.01 d	0.06 c	0.36 a	0.04 cd	0.12 b	0.03 cd
Linalool	***	3.79 bc	0.65 cd	0.52 d	1.00 cd	1.26 cd	5.46 ab	1.79 cd	7.63 a	1.49 cd	1.91 cd
Pinocarveol	***	0.18 bcd	0.48 ab	0.09 d	0.20 bcd	0.14 cd	0.31 bcd	0.67 a	0.22 bcd	0.42 abc	0.06 d
β-Ionone	***	0.45 bcd	0.82 a	0.07 e	0.17 cde	0.22 cde	0.43 bcd	0.58 ab	0.45 bc	0.32 bcde	0.13 de

NS: not significant at $p > 0.05$, ** and ***: significant at $p < 0.01$ and 0.001, respectively. Values followed by different letters, within the same column, were significantly different ($p < 0.05$). SA –Breba San Antonio; CA – Breba Colar Albatera; CUMH – Breba Colar UMH; CDN – Breba Cuello Dama negro; SF – Breba Superfig; FSA – Fig San Antonio; FCA – Fig Colar Albatera; FCUMH – Fig Colar UMH; FCDN – Fig Cuello Dama negro; FSF – Fig Superfig.

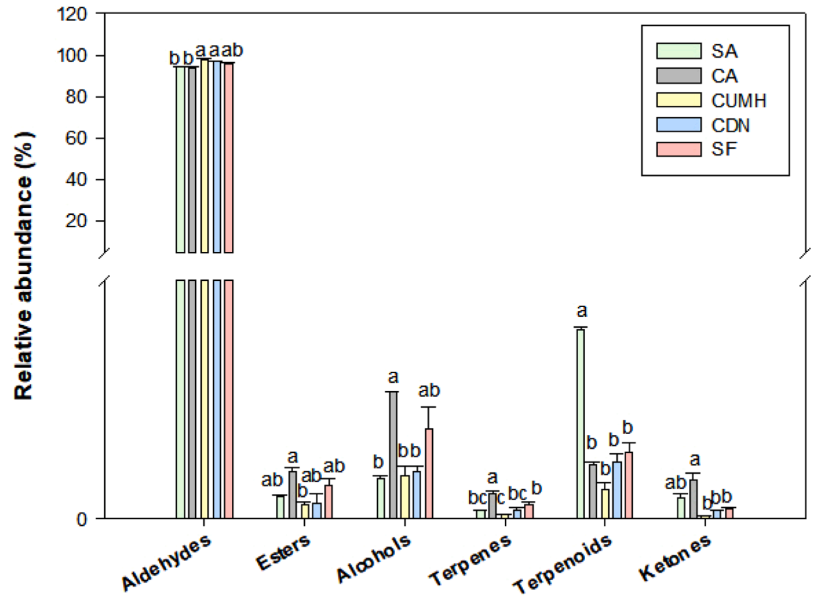

Fig. 2. Group of volatile compounds of breba peel. SA – San Antonio; CA – Colar Albatera; CUMH – Colar UMH; CDN – Cuello Dama negro; SF – Superfig.

(83.45 %) showed the highest percentage of aldehyde while SA variety (27.98 %) showed the highest percentage of terpenoids. Similar chemical classes were reported by Russo et al. (2017) for Italian oven dried figs: Aldehydes, furans, ketones, alcohols, terpenes, and esters in descending order of concentration.

The three main families of compounds in breba peel, in order of relevance, were aldehyde (92.72 %), terpenoids (3.99 %), and alcohols (1.8 3 %). SF (97.04 %) was the varieties with the highest percentage of aldehydes. For terpenoids, the CUMH variety (7.84 %) showed the highest percentage. Finally, for alcohols CA variety (3.89 %) showed the highest percentage. This same variety also obtained the highest percentages for the ketones (0.58 %). Moreover, aldehydes, terpenes and alcohols were also the main family compounds detected by (Andreu-Coll et al., 2020) in prickly pear fruit pulp from Spanish varieties. These results suggest that not only does the variety of brebas and figs influence the volatile compounds, but there are also significant differences between the edible (pulp) and non-edible (peels) parts of the fruit. These authors (Del Caro and Piga, 2008; Harzallah et al., 2016; Hssaini et al., 2021) indicated differences in contain concentrations of nutrients and bioactive compounds between different parts of the fruit of brebas and figs.

3.2. Comparation of volatile compounds between breba and figs of different varieties

For the volatile compounds detected in the pulp (Table 4), significant differences have been found between breba and figs of the different cultivars studied in 15 of the 22 volatile compounds detected. In general, for most of the volatile compounds detected in the pulp, the highest percentages have been found in figs. Fig CDN variety obtained the highest percentages for six compounds 2-hexenal (7.35 %), 2-decenal (0.78 %), 3-phenyl 2-propenal (2.91 %), 2,2,4,6,6-pentamethylheptane (24.19 %), copaene (3.07 %) and caryophyllene (3.48 %) but for hexanal compound, breba of CA variety (64.69 %) showed highest percentage and for benzaldehyde was fig of CUMH variety (43.45 %) the one with the highest percentage. In addition, breba SA showed a high linalool content up to 84.42 times higher than the content detected in fig CA, although fig CA variety stood out for its content in ketone compounds, especially 3,5-Octadien-2-one and 2-Nonanone with percentages 50.01 and 21.68 times higher, respectively for other varieties such as breba SF. All the varieties studied have shown a greater amount of 2-hexenal in breba than figs, in addition the SA variety showed a percentage 9.67, 23.66 and 10.82 times higher in fig pulp compared to breba pulp for the compounds hexanal, 2,4- heptadienal and 3,5-octadien-2-one, while for the compounds copaene and caryophyllene it was the opposite, higher values were obtained in breba than in fig. Regarding the CA and CUMH variety, both have shown higher results in breba than in fig for hexanal and 3,5-octadien-2-one, but the results of breba CUMH were 16.08 times higher than those detected in fig for 3,5-octadien-2-one. In summary, the composition of these compounds varies between breba and figs, as well as among different fig varieties studied. The genotype factor has a more prominent influence on the composition of volatile compounds in breba and figs compared to the different environmental conditions at the time when the brebas and figs are harvested. This highlights the importance of genetics in determining the sensory characteristics of brebas and figs varieties.

In other hand, attend to peel (Table 5), the fig of the variety CA was the fruit that obtained the highest percentage in the highest number of compounds (nonanal, benzenepropanal, decanal, methyl hexanoate, 1-octen-3-ol, 1-tetradecanol, aromandendrene and pinocarveol) followed by breba CA (hexanal, 2,4-heptadienal, octanal, 2-octenal, 2,6-nonadienal, methyl hexadecanoate and β-ionone) and follow by fig CUMH (undecanal, methyl octanoate and linalool). Although for the main compounds, benzaldehyde, 2-hexenal and hexanal the highest percentages were detected for fig SF (65.63 %), breba CDN (54.86 %) and breba CA (52.72 %), respectively. Hexanal and 2-hexenal contribute to different flavors, with hexanal giving a fresh, cut grass aroma, and 2-hexenal providing almond, apple, green, sweet, and vegetable notes (SAFC, 2012). In addition, fig of the SA variety obtained one of the highest percentages for the compound 2-decenal (0.38 %), while the breba SF showed the highest percentage for 2-phenethyl acetate (0.57 %) and phenylethyl alcohol (1.03 %) and fig CDN showed the highest percentage for copaene compound (0.84 %). On the other hand, it has been detected that the compounds benzaldehyde, undecanal, 1-tetradecanol, aromandendrene and linalool the percentage obtained in fig was higher than in breba in all varieties. However, the SA variety showed higher percentages in breba than in fig for the compounds 2,4-heptadienal, methyl hexanoate and methyl hexadecanoate 9.01, 5.49 and 8.90 times higher, respectively. In addition, the SF variety showed higher values in breba than in fig up to 12.51 times for the compound 2-phenethyl acetate. The peel of brebas and figs exhibits significant differences in the main compounds detected. The findings imply that, unlike

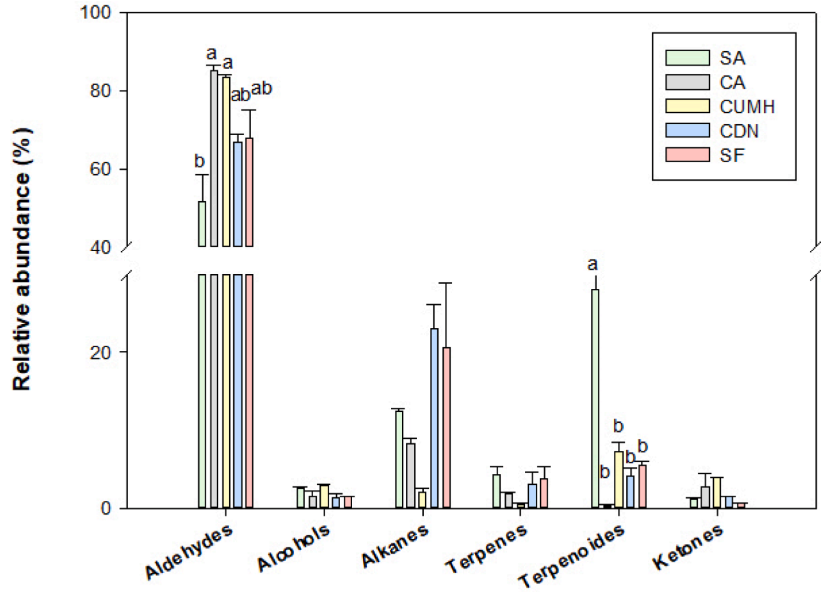

Fig. 3. Group of volatile compounds of fig pulp. SA – San Antonio; CA – Colar Albatera; CUMH – Colar UMH; CDN – Cuello Dama negro; SF – Superfig.

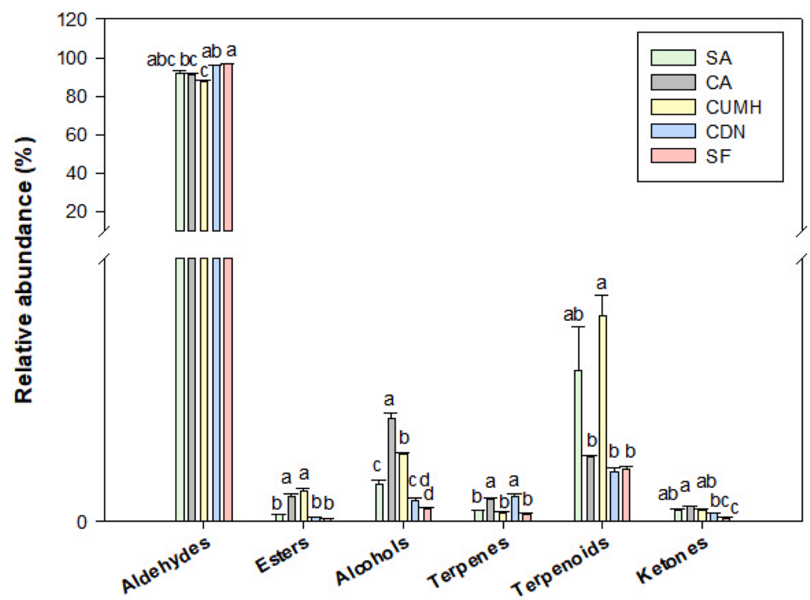

Fig. 4. Group of volatile compounds of fig peel. SA – San Antonio; CA – Colar Albatera; CUMH – Colar UMH; CDN – Cuello Dama negro; SF – Superfig.

the pulp fruit composition where genotype played a more prominent role, the peel composition is more susceptible to variations influenced by environmental conditions (temperature, humidity, sunlight exposure) during the time of harvest. As previously reported by Najafian et al. (2022) who studied the phytochemical diversity in lavender plants across different seasons. The variation in phytochemical content across seasons is a common phenomenon in many plant species. In addition El-Zaeddi et al. (2020) reported that there was a significant effect of harvest date on the volatile compounds of four aromatic herbs (dill, parsley, coriander, and mint) and suggests that the timing of harvest can influence the chemical composition, flavor, and potentially the medicinal properties of these herbs. No previous studies have been found that compare volatile compounds between breba and fig, which makes it difficult to discuss these results (Figs. 2,3 and 4).

4. Conclusion

This is the first study comparing peels and pulps of breba and figs fruits to help improve the knowledge of volatile profile in four different Spanish varieties. The CA variety demonstrated a higher content of key volatile compounds, suggesting that different varieties may exhibit distinct aromatic characteristics. Notably, the peel was richer in key volatile compounds compared to the pulp, especially in the CA variety. This variation could be attributed to genetic biotypes and pedo-climatic differences related to the location. Therefore, it is underscoring the importance of considering the entire fruit for consumption fresh, including its non-edible parts. The findings from this study have implications for selecting varieties with desirable volatile profiles and potentially minimizing food waste. In fact, understanding how volatile compounds impact brebas and figs fruits can have implications for agriculture, horticulture, and the pharmaceutical industry.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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