Aromatic changes in home-made truffle products after heat treatments

Eva Tejedor-Calvo[1], Diego Morales[2], María Ángeles Sanz[3], Sergio Sánchez[1], Pedro Marco[1], Sergi García-Barreda[1]

[1]Department of Plant Science, Agrifood Research and Technology Centre of Aragón (CITA), Avda. Montañana 930, 50059, Zaragoza, Spain

[2]Nutrigenomics Research Group, Department of Biochemistry and Biotechnology, Universitat Rovira i Virgili, 43007 Tarragona, Spain

[3]Laboratories and Technological Assistance, Agrifood Research and Technology Centre of Aragon (CITA), Avda. Montañana, 50059, Zaragoza, Spain

Keywords: *Tuber melanosporum*, aroma, trained panel, volatile organic compounds, honey, sunflower oil

*Corresponding author:

Eva Tejedor Calvo

etejedorc@aragon.es

Abstract

Truffles are highly valued by their aromatic properties and can aromatize food products. However, the truffle aroma could be reduced or lost with heat treatments (pasteurization and sterilization) necessary for products security and safety. In this study, sunflower oil and honey were aromatized with black truffle (lyophilized and fresh) using two different concentrations (5 and 10%) for 24 h and then heat treatments (pasteurization and sterilization) were carried out. Truffle organic volatile compounds from products were investigated by SPME-GC-MS and sensory analysis by trained panel. More than 80 compounds were detected. Some of them were affected differently by heat process depending on the food matrix. Professional tasters scored higher key aromatic attributes such as sulphurous and olive oil in fresh truffle products, regardless the heat treatment applied.

1. Introduction

Truffles are gourmet mushrooms appreciated worldwide because of their unique aroma. Food industry has exploited the ability of truffles to transfer aroma to various food matrices for developing many truffle products and bring them an added value (Tejedor-Calvo et al., 2023). Among the product variety, fatty products such as oil, cheese, cream and butter are the most popular (Mustafa et al., 2020).

Food processing or preservation technologies reduce, modify or remove some of the key aromatic compounds of truffles (Campo, Marco, Oria, Blanco, & Venturini, 2017). To compensate this aroma loss, 2,4-dithiapentane (bis-(methylthio)-methane or BMTM) is commonly used as truffle flavoring (Pacioni, Cerretani, Procida, & Cichelli, 2014; Torregiani et al., 2017). This compound is characteristic of the white truffle (Tuber magnatum) aroma, so far has not been detected in other truffles species such as the black truffle (*Tuber melanosporum*). However, a mixture of DMS and 2-methyl-butanal (2-MB) is also used in black truffle products as a new formula to replicate black truffle aroma, as Tejedor-Calvo et al. (2023) studied. Since the aroma of these products is given by BMTM, the food industry tends to use cheaper truffle species instead of the valued *T. magnatum* or *T. melanosporum*. For this, they use species with morphological similarity such as *Tuber borchii* instead of *T. magnatum*, or *T. indicum* and *T. aestivum* instead of *T. melanosporum* (Oliach et al., 2021)

The use of synthetic flavours causes truffle price drops (Oliach et al., 2021) and increases consumer confusion (Tejedor-Calvo et al., 2023), among others. Therefore, a genuine truffle flavouring extract has a potential place in the truffle products market (Phong et al., 2022; Tejedor-Calvo et al., 2021).

The black truffle aroma is a complex mixture composed by numerous and different aromatic volatile compounds (VOCs). Among them, sulphur compounds such as dimethyl disulphide (DMDS) and dimethyl sulphide (DMS) are the most relevant (Costa et al., 2015; Culleré et al., 2010; Culleré, Ferreira, Venturini, Marco, & Blanco, 2013; Tejedor-Calvo et al., 2021). To aromatize products, in most of them, the truffle and the food matrix are mixed to enhance the aromatization process. This has the drawback that a sanitazing treatment (*e.g.* with heat) is required for food safety reasons, especially if fresh truffles are used (Rivera, Venturini, Oria, et al., 2011). Heat treatment of truffles severely changes their aroma, resulting in a product that is barely reminiscent of the original,but this treatment is necessary in case fresh or freeze-dried truffle are included because some microorganism might be present (Campo et al., 2017) Our hypothesis is that black truffle VOCs surrounded by a food matrix might not be as affected by heat treatment as fresh truffle VOCs, thus enhancing that some of the relevant truffle VOCs remain in the heat-treated truffle products. So, the main aim of our study was to evaluate the effect of two different heat treatments (pasteurization and sterilization) on the VOCs transferred by black truffle to two of the most common truffle products (sunflower oil and honey). As a secondary aim, we assessed whether heat treatments affected differently the aroma of truffle products when fresh and lyophilized truffle were added in two different amounts.

To date, the existing international recommendations concerning the marketing and commercial quality control of truffles (Nations, 2017) do not regulate the commercialization of truffle products. Among the major truffle-producing countries, France and Italy have their own specific regulations (Tejedor-Calvo et al., 2023). However, Spain –which is the world leader in black truffle production– and other countries lack regulation (Oliach et al., 2020)). Our study addresses this gap by providing scientific evidence to support the regulation of truffle products elaboration and information to consumers.

2. Materials and methods

2.1 Truffle and food matrices

Tuber melanosporum (Vittad.) ascocarps were harvested in Moncayo forests (Zaragoza, Spain). Fresh truffles (20 fruiting bodies) were identified, selected, and processed according to (Rivera, Venturini, Marco, et al., 2011). Half of the truffles were lyophilized (LyoBeta 15 lyophilizer, Telstar, Madrid, condenser temperature was -80 ºC), ground, mixed and sieved until a particle size lower than 0.5 mm was obtained. Powdered truffles were kept at −80 ºC until further use. The other half was sliced before their use using a mandolin slicer. Refined sunflower oil and mixed-flower honey products were purchased from a local supermarket (Zaragoza, Spain).

2.2 Aromatization process

In glass jars (100 mL), 50 mL of food matrix (oil or honey) were poured, with fresh (sliced) or lyophilized (powder) black truffle being added at two proportions (5 and 10%). The samples were homogenized in a digital rotator 220 V (LW Scientific, Spain) during 2 h. Afterwards, the samples were kept in refrigeration (4ºC) for 48 h for aromatization.

2.3 Heat treatments and storage

Two of the most used heat treatments in the food industry were selected: pasteurization and sterilization. For that, the jars were closed hermetically. The sterilization treatment was carried out in an autoclave (Micromar Mini autoclave, Marrodán, Lodosa, Spain) at 121 ºC for 30 min. The pasteurization process was carried out in a thermostatic water bath (Lab Systems, Barcelona, Spain) at 75 ºC during 5 min. Afterwards, the samples were kept at 4 ºC until their sensory analyses.

Two samples were prepared for each combination of food matrix (oil, honey), truffle preservation method (fresh, freeze dried), truffle content in the product (5%, 10%) and heat treatment of the product (no treatment, pasteurization and sterilization. Additionally, samples of the food matrices without truffle were prepared in duplicate for all the heat treatments. The VOC profile of the fresh and lyophilized truffles before use in food products were also analyzed, in order to check the differences between them and to compare these profiles with those of the truffle products.

2.4 VOCs analysis

2.4.1 VOCs extraction by SPME

The methodological approach was based on works carried out by (Culleré, Ferreira, Venturini, Marco, & Blanco, 2012)(Culleré, Ferreira, Venturini, Marco, & Blanco, 2012) with some modifications. A solid phase microextraction (SPME) was used to extract the aromatic compounds. For that, a fused silica fiber coated with a 50/30 mm layer of divinylbenzene/carboxen/polydimethylsiloxane from Supelco (Barcelona, Spain) was chosen. The samples (2 g of truffled product) were placed in a 20 mL glass vial closed with a septum. After the vial was conditioned at 50 ºC for 10 min. The fiber was then exposed to the headspace of the vial for 20 min.

2.4.2 GC-MS analysis

The VOCs profile of the different samples was analysed by static GC-MS using a gas chromatograph Agilent 6890N (Termoquest, Milan, Italy) coupled with a mass spectrometer detector. This instrument was equipped with a capillary column HP-5MS (Agilent Technologies, California, USA) of 30 m, 0.32 mm i.d., 0.25 μm film thickness and a flow of 1 mL/min with helium as a carrier gas. The oven temperature was 45 ºC held for 2 min, 45–200 ºC at a rate of 4 ºC/min, and finally to 225 ºC at 10 ºC/min, and held for 5 min (Gómez et al., 2022). The MS used the electron impact mode with an ionization potential of 70 eV and an ion source temperature of 200 ºC. The interface temperature was 220 ºC. The MS scanning was recorded in full scan mode (35–250 m/z). A TurboMass software was used for controlling the GC-MS system.

2.4.3 Data analysis

Peak identification of the VOCs was achieved by comparison of the mass spectra with mass spectral data from the NIST MS Search Program 2.0 library, and by comparison of previously reported Retention Indexes (RI) with those calculated using an n-alkane series (C6–C20) under the same analysis conditions. The n-alkane series and standards for MS identification (all standards of purity higher than 95%) were purchased from Sigma-Aldrich (Madrid, Spain). Semiquantification was done by integrating the area of one ion characteristic of each compound and normalization by calculating the relative percentage. This allowed comparison of each eluted compound between samples.

2.5 Sensory analysis

A panel of eight trained tasters (26-50 years old; 4 male and 4 female) evaluated the aroma of the samples before and after heat treatments. Tasters were previously trained for three sessions of 45 min. The analyses were conducted according to the ISO 11035:1994 and the following aromatic parameters were selected according to previous studies (Campo et al, 2017; Tejedor-Calvo et al., 2023): sulphur, mushroom, earthy, black olives, leather-animal, nuts and alcohol. Each parameter was assessed with a 9-point rating scale (1-minimum and 9 maximum aroma/taste). Samples were presented for each product in three sessions for three days (6 sessions in total). In total 30 samples were evaluated for each product (honey and sunflower oil), 5 products in each session. The experiment was carried out in one week for each product. The evaluation was carried out by olfactive and tasting phase, and between samples bread and apple was given to clean. The values presented for each truffle type (fresh or lyophilized), amount added, and heat treatment by duplicate.

2.6 Statistical analysis

The sensory analysis was analyzed with one-way analysis of variance (ANOVA) followed by Tukey’s multiple comparison test. Differences were evaluated at 95% confidence level ($P \leq 0.05$). Statistical analysis was performed using GraphPad Prism version 9.3 (GraphPad Software, San Diego, CA).

The VOCs were analyzed with principal component analysis (PCA), performed with the statistical software R (R Core Team, 2022) and visualized using XLStat 2009 (Addinsoft, Paris, France) and the R package factoextra (Kassambara and Mundt, 2020).

3. Results and discussion

3.1 VOCs in fresh and lyophilized truffle

In the fresh truffle samples, a total of 32 VOCs were detected, with 2-propanone, DMS, 2-methyl-propanol, 3-methyl-1-butanol, 2-methyl-butanal, 2-methyl-butanol, octanal, 3-methylanisol and 3-methyl-1-butanal being amongst those with higher presence. In the lyophilized samples, a total of 41 VOCs were detected, with ethyl acetate, 1,3-butanediol, ethyl-2-methylbutanoate, anisol, isobutyl isobutyrate, 3-methyl-1-butanal and 3-methyl-1-butanol being amongst those with higher presence (Table 1). Twenty VOCs were found in both fresh and lyophilized samples, whereas 12 were found only in fresh truffle and 21 only in lyophilized samples. Truffle aroma can change dramatically depending on the postharvest treatment applied. Among them, lyophilization has been reported as the best one to preserve the main truffle odor compounds (Campo et al., 2017). When truffles are lyophilized, water is totally removed and moisture is reduced, so more compounds might be concentrated and therefore can be detected by gas chromatography in comparison to fresh truffles, for instance, 2.methylpropanal, 2.-methylbutanal and 3-methylbutanal (Campo et al., 2017; Palacios et al., 2014).

Sulphur compounds as DMS and DMDS are the main components of truffle aroma. DMS and DMDS have been reported in most truffle species and are thought to derive from the catabolism of L-methionine through the Ehrlich pathway (Liu et al., 2013; Splivallo et al., 2011). According to other studies, the freeze-drying process was able to retain DMS, but not DMDS (Palacios et al., 2014), as it is observed in our results (Table 1). This study reported many VOCs in the lyophilized truffle, mainly aldehydes like hexanal and methional. Both compounds were detected in higher value in lyophilized samples compared with fresh truffles (Table 1). Other volatiles were also very intense in the lyophilized truffle, mainly aldehydes such as 2- methylbutanal, hexanal, Z-4-heptanal (Campo et al., 2017). The remarkable differences in the VOC profile between fresh and lyophilized truffles are expected to be reflected in the truffle products using one or the other.

3.2 VOCs in truffle products and effect of heat treatment

Both sunflower oil and honey were characterized by ethanol, methylene chloride, acetic acid and hexane, in the latter case together with 2-propanone, 2-butanone-3-hydroxy and linalool oxide cis (Fig. 1, Fig. S1). As regards the truffle product samples, the VOC profiles showed similar patterns for the two food matrices and the two truffle proportions, but different patterns for fresh and lyophilized truffles (Fig. 1). Some key truffle VOCs such as 2-propanone, 3-methyl-1-butanol, 2-methyl-1-butanol, 2-methyl-butanal were detected in both matrices. However, the VOCs amount might vary depending on the matrix, as hexanal in sunflower oil and furfural for honey.

It is believed that the aromatic compounds involved in a food matrix are more protected due to some links or connections such as sulphur bonds (Seuvre et al., 2000), although some compounds could have higher affinity depending on the matrix. However, preservation processes as heat treatment could break the links and therefore volatilize them.

According to a previous study (Seuvre et al., 2000) 2-nonanone and isoamyl acetate present opposite behaviors in two media with same composition, one emulsified, and the other not. The volatility of isoamyl acetate was not affected by the change of the medium structure whereas that of 2-nonanone increased. The decrease of retention of 2-nonanone in an emulsified system may be due to a modification of the fixation site for this compound on the protein or to a competition between the lipid and the aroma compound while the protein is adsorbed at the lipid-water interface (Seuvre et al., 2000). In our results, 2-nonanone was only present in honey, the only product with proteins. In the same way, some molecules such as 2-methyl-butanal might be preferable retained by oil matrix due to their hydrophobicity.

In addition, simple matrices (oil, protein, polysaccharides) as well as combinations (emulsions) can retain certain molecules (Guichard, 2002, 2006; Mao et al., 2017). However, in some systems the impact of oil was so dominant that binding effects of other food ingredients (e.g., proteins) to volatile compounds were insignificant (Roberts et al., 2003; Seuvre et al., 2000). As an example, grapeseed oil helped to trap key truffle aromatic compounds using supercritical fluids as extraction method (Tejedor-Calvo et al., 2021).

After the heat treatments, several changes in the aromatic compounds were noticed regardless of the matrix used. Even oil and honey VOCs in control samples (without truffle) were modified. Some molecules appeared with the pasteurization (2-propanone-

1-hydroxy, 2,3-butanodione, acetaldehyde, pentanal) or the sterilization (2-propanone, 2,3-pentanodione, 2-pentanol, 3-methyl-butanalm 3-methyl-butanol). This indicates that some changes in the VOC profile of the truffled samples were related to the effect of heat on the matrix.

The amount of hexanal in sunflower oil and furfural in honey were higher in all the sterilized samples than in non-treated or pasteurized samples. These two compounds have grass and almond odorant properties (Tejedor-Calvo et al. 2023), therefore these aromatic notes might be clearly detected in an olfactometry. However, depending on the concentration and the perception threshold of these molecules the aroma detected by humans might be different. In general, pasteurization decreased methylene chloride, 3-methyl-1-butanol and 2-butanone; and increased 2-methyl-butanal and 1-propanol. Among them, 3-methyl-1-butanol molecule is described as malt and whiskey odorant (Tejedor-Calvo et al. 2023). These samples might have the absence of those aromatic properties. Conversely, sterilization increased primarily acetic acid, 2-methyl-butanal, hexanal and furfural. A previous study reported that canning preserved mainly ethyl esters such as ethyl-2- and ethyl-3-methyl butyrate (Campo et al., 2017), but in our treated samples slight amounts of them were detected. All these changes due to heat treatments, might change dramatically the aromatic properties (Campo et al., 2017).

Among key truffle aromatic compounds, DMS presence was reduced by sterilization in both matrices, but in honey the compound was in higher amount when lyophilized truffle was used. One of the reasons might be because DMS is more soluble or trapped by water-based products than lipidic ones. The presence of 2-butanone in oil was reduced with heat treatments, whereas it increased with pasteurization in honey with fresh truffle. Finally, 3-methyl-1-butanol was only affected by pasteurization in oil with fresh truffle, but not in the rest of samples, probably because the same reason as DMS.

3.3 Effect of heat treatment in sensory attributes

The sensory analysis carried out by the trained testers panel revealed significant effects of the food matrix, the addition of truffle to the matrices, and the heat treatment on several sensory attributes (Table 2).

Regarding the matrix effect, sunflower oil showed higher *per se* scores for “butter” and “black olives” (Table 2). This fact might be due to the presence of compounds that are close to margarine or butter VOCs and, moreover, specific phytochemicals that are shared between olives and sunflower oil such as, for instance, saturated and unsaturated aldehydes (Ontanón et al., 2013).

Truffle addition led to significant changes in specific attributes, although others that might be expected to increase, such as “mushrooms”, remained invariable, mainly in honey matrix. The case of “sulphur” is remarkable, since its scores were significantly increased after truffle addition, regardless of whether the aromatization was carried out with fresh or lyophilized truffles and being effective at both 5 and 10% concentrations (Table 2). This attribute score was increased in both matrices. This agrees with previous reports and is related to the richness of sulphured compounds in black truffle (Li et al., 2012; Liu et al., 2013). Another attribute that significantly increased its score when compared to the control was “leather-animal” when 10% lyophilized truffle was used to aromatize oil. This specific smell has been traditionally described for *T. melanosporum*, and sunflower oil seemed to be a more receptive environment than honey to trap and retain the associated VOCs (Allen & Bennett, 2021). This could be due to the lypophilic character of sunflower oil enhancing the trapping of a larger diversity of aromatic molecules than a high sugar content material as honey (Torregiani et al. 2017).

Regarding the effect of heat treatments to the potential loss of attributes, sulphur scores were not reduced for honey after any treatment. However, canning decreased sulphur scores in oil when 5% of fresh or lyophilized truffle was used, although not in 10% samples, suggesting that the highest concentration is required not to lose this feature (Table 2). Previous works have already described the detrimental effect of heat treatments on the typical aroma (mainly volatile sulphur compounds) of black truffle when applied directly to the fruitbody (Campo et al., 2017).

Interesting results were obtained for the “black olives” attribute, another of the typical ones in black truffle (Campo et al., 2017; Culleré et al., 2013): pasteurization reduced the score in the case of olive oil with fresh truffles (Table 2). However, no changes were observed in honey samples and, besides, the control sunflower oil sample (with no truffle aromatization) suffered a significant decrease in this attribute after canning. These facts suggest that the VOCs that are being affected in this case are molecules related to the oil and not the truffle. On the other hand, the other attribute that was linked to oil, “butter”, did not suffer any variation after heat treatments, as well as the other evaluated scores (mushroom, earthy, leather-animal, blue cheese, nuts, alcohol).

In short, sulphur compounds seemed to be the more sensitive to canning, particularly when a low concentration of truffle was used and specifically for oil matrix. This decrease could be avoided by using pasteurization instead or by adding at least a 10% of truffle in the aromatization step.

3.4 Multivariable analysis of truffle honey and oil

3.4.1 VOC profile

The possible correlations of heat treatments, truffle type and amount with the relative abundance of the VOCs detected by SPME-GC-MS was explored with PCA (Figs. 2, 3).

The two food matrices were investigated individually due to the differences described above (section 3.2). In both cases the PCA explained with the first two components only a 35-42% of the variability, thus indicating the complexity of the relationships between VOCs, type of truffle and heat treatment applied (Figs. 2, 3).

In the PCA performed for the oil, the first component (explaining 24.8% of the variability) was mainly correlated to the truffle type used. Samples with freeze-fried truffle grouped with non-truffled samples, whereas samples with fresh truffle were clearly separated by the PCA (Fig. 2a). The second component (explaining an additional 17.2% of data variability) only separated the sterilized sample with 10% lyophilized truffles, although the 5% sample seemed to point in the same direction (Fig. 2a). Among the VOCs that showed more positive loadings with the first PCA component (*i.e.* those correlated to aromatization with fresh truffle), there were several VOCs with high presence in truffles (Table 1): 2-methyl-1-butanol, 2-methyl-1-propanol, 2-methyl-propanal, 3-methyl-butanal, 2-methyl-butanal, ethanol, 3-methyl-1-butanol, and 3-methyl-2-butanone (Fig. 2b). Among the VOCs that showed more negative loadings with the first PCA component (*i.e.* those correlated to non-truffled samples or to aromatization with lyophilized truffle), there were several already present in lyophilized truffles such as 1,3-butanediol (Fig. 2b). Among the VOCs that showed more positive loadings with the second PCA component (*i.e.* those correlated to the sterilized samples with lyophilized truffle), there were many VOCs that were not present or very rare in the remaining oil samples, such as heptanal, 2-methyl-butyl-acetate or 3-methylanisol (Fig. 2b).

In the PCA performed for honey, the first PCA component (explaining 19.2 % of the variability) was correlated mainly with the truffle type used. Samples with freeze-fried truffle grouped with non-truffled samples, whereas samples with fresh truffle were clearly separated (Fig. 3a). To a lesser degree, this component also separated samples with 5%

fresh truffle from samples with 10% fresh truffle. The second component (explaining an additional 16.3 % of the variability) was slightly correlated with the sterilization treatment (positive loadings), although only the sterilized sample with 10% lyophilized truffles was clearly separated from the rest (Figure 3a). Among the VOCs that showed more positive loadings with the first PCA component (*i.e.* those correlated to aromatization with fresh truffle), there were several VOCs with high presence in truffles (Table 1): 2-methyl-1-butanol, propanal-2-methyl, 3-methyl-1-butanol, and 2-methyl-1-propanol (Fig. 3b). According to previous studies, these compounds among others were reported as key molecules in fresh truffle aroma (Tejedor-Calvo et al., 2021). Among the VOCs that showed more negative loadings with the first PCA component (*i.e.* those correlated to non-truffled samples or to aromatization with lyophilized truffle), there were several VOCs linked to the VOC profile of honey, such as 3-hidroxy-2-butanone, methylene chloride, hexane or acetic acid. There was also the DMS, present in truffles but also detected in non-truffled honey after being heated (Fig. 1, 3b). Finally, within the VOCs that showed more positive loadings with the second PCA component (*i.e.* those correlated to the sterilized sample with 10% lyophilized truffle), there were VOCs already present in truffles, such as butanal-2-methyl, 3-methylanisole, anisole or isobutyl isobutyrate (Fig. 3b).

3.4.1 Aromatic profile

PCA was also used to explore the correlations of the treatments with the results of the sensory analysis (Fig. 4). The first two principal components explained 81.1% of the total variability. All the sensory attributes showed strong positive loadings corresponding to the first component (63.7% of variability), whereas butter and leather animal showed correspondingly the more positive and the more negative loadings with the second component (17.4% of variability). The PCA allowed to clearly separate the samples into four clusters. The west group (grey) grouped honey and oil samples without truffle. This cluster was clearly associated with lower values for all the sensory attributes, further suggesting that heat treatments in control samples did not affect the sensory profile. The middle-down group (orange) included all the honey samples. In this group, samples with lyophilized truffle tended to concentrate at the bottom, correlating with leather and earthy attributes which had been linked to lyophilized truffles in previous studies (Campo et al., 2017; Tejedor-Calvo et al., 2021). All the oil samples were placed in the right-side of the PCA. Those with fresh truffle grouped in the middle-left cluster, whereas those with lyophilized truffle were divided in two clusters (both yellow): the up cluster (low truffle concentration) and down cluster (high truffle concentration). The latter was related to alcohol and earthy attributes, whereas the other two oil clusters were associated with butter, black olives, sulphur, blue cheese and mushroom attributes, particularly samples with no treatment.

4. Conclusions

An aromatization step was included in sunflower oil and honey products with fresh and lyophilized truffle. However, fresh truffle is a better suitable material since key truffle aromatic compounds were detected in the products. Pasteurization treatment is recommended to preserve sulphur compounds after aromatization step in truffle products. On the contrary, strong heat treatments can reduce or lose some key truffle volatiles. For the first time aromatic profiles of truffled products, and their changes in conservation processes have been investigated. In order to create knowledge about truffle use and truffle products processing further studies testing other food matrices and food postharvest treatments are needed.

Declaration of competing interest

None

Acknowledgements

This research was supported by Diputación Provincial de Zaragoza (DPZ) in Spain to provide the samples. Authors also want to recognize the participation of trained panel in the sensory analysis. This research was supported by Diputación Provincial de Zaragoza (DPZ) in Spain (project "Mejora de la Eficiencia de la Producción y la Innovación Agroalimentaria de la Trufa en la Provincia de Zaragoza")

CRediT authorship contribution statement

Eva Tejedor-Calvo: Conceptualization, Investigation, Methodology, Writing - original draft. **Diego Morales:** Formal analysis, Data curation, Methodology**,** Writing - original draft**.** **María Ángeles Sanz:** Formal analysis. **Sergio Sánchez:** Funding acquisition, Supervision**. Pedro Marco:** Supervision, Validation, Visualization, Writing - review & editing. **Sergi García-Barreda:** Data curation, Software, Visualization, Writing - review & editing.

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Tables

Table 1. List of volatile organic compounds identified by SMPE-GC-MS in truffles samples, sunflower oil and honey. Relative percentage of area values (%) obtained in the GC-MS for the fresh truffles (F) and the lyophilized truffles (L) used to aromatize the samples.

Nº	**Name**	**CAS nº**	**RT**	**RI** $_{exp}$	**RI** $_{lit}$	**Mass (*m/z*)**			**F**	**L**
1	Ethanol	64-17-5	1.33	<500	427	45	46	43	3.83	2.11
2	2-propanone	67-64-1	1.378	<500	500	43	58	42	2.80	0.51
3	Dimethyl sulphide	75-18-3	1.474	521	521	62	61	47	3.76	1.57
4	Methylene chloride	75-09-2	1.503	532	531	49	86	84	-	-
5	1-propanol	71-23-8	1.568	555	548	31	29	42	-	-
6	Propanal-2-methyl	78-84-2	1.575	558	560	43	72	41	2.69	2.99
7	2,3-butanedione	431-03-8	1.626	577	587	43	87	86	-	2.13
8	Isopropyl formate	625-55-8	1.64	582	-	45	73	42	-	-
9	Butanal	123-72-8	1.676	595	598	44	72	57	-	-
10	3-methyl-2-butanone	563-80-4	1.683	597	-	43	86	41	1.59	3.46
11	Acetic acid	64-19-7	1.69	600	602	43	60	45	-	-
12	2-butanone	78-93-3	1.719	603	602	43	72	57	2.05	-
13	Hexane	110-54-3	1.726	604	-	57	86	56	-	-
14	Ethyl acetate	141-78-6	1.77	609	607	43	80	70	-	9.42
15	2-methyl-1-propanol	78-83-1	1.878	622	626	43	42	41	7.91	0.77
16	Acetaldehyde	75-07-0	1.899	624	-	44	43	42	-	-
17	3-methyl-butanal	590-86-3	2.08	645	646	44	71	58	10.70	6.68
18	Butanol	71-36-3	2.101	648	656	56	55	43	-	-
19	2-methyl-butanal	96-17-3	2.123	653	653	57	86	58	7.23	2.64
20	2-propanone-1-hydroxy	116-09-6	2.224	662	-	43	74	42	-	0.34
21	1-penten-3ol	616-25-1	2.23	663	680	57	58	55	-	-
22	Metylpropylformate	589-40-2	2.31	672	-	45	73	59	0.97	0.31
23	2-pentanone	107-87-9	2.368	679	687	43	86	71	0.61	-
24	2,3-pentadione	600-14-6	2.454	689	696	43	100	57	-	-
25	Pentanal	110-62-3	2.469	691	704	44	58	57	-	-
26	2-pentanol	6032-29-7	2.483	692	700	45	73	55	-	-
27	2-butanone,3-hidroxy	513-86-0	2.613	704	707	45	88	55	-	0.65
28	3-methyl-1-butanol	123-51-3	2.966	723	737	55	70	57	28.32	7.00
29	2-methyl-1-butanol	137-32-6	3.045	728	743	57	70	56	4.07	4.19
30	Dimethyl-disulphide	624-92-0	3.103	731	733	94	79	61	0.51	-
31	2-methyl-pentanal	123-15-9	3.18	735	-	43	58	41	-	-
32	Propanoic-ac-2methyl-esther	97-62-1	3.434	775	760	43	29	71	-	1.30
33	Isobutylacetate	110-19-0	3.737	783	770	43	56	41	-	0.26
34	Propanoic-ac-2methyl	79-31-2	3.989	735	753	43	88	73	-	0.41
35	1,3-butanediol	513-85-9	4.3	785	803	45	27	43	-	6.18
36	Octane	111-65-9	4.342	800	800	43	85	71	-	3.25
37	Hexanal	66-25-1	4.378	802	801	44	57	56	1.64	3.25
38	ethylbutanoate	105-54-4	4.443	803	803	71	43	29	-	-
39	Furfural	98-01-1	5.394	830	830	96	95	67	-	0.62
40	2-methylthio-ethanol	5271-38-5	5.639	873	-	61	92	47	0.08	-
41	ethyl-2-methylbutanoate	7452-79-1	6.086	849	853	102	85	74	0.69	5.19
42	ethyl-3-methylbutanoate	108-64-5	6.208	853	851	88	85	60	-	0.87
43	4-pentenal	2100-17-6	6.392	858	-	55	29	41	-	-
44	Hexanol	111-27-3	6.75	868	867	56	69	55	0.24	-
45	2-methyl-butyl-acetate	624-41-9	7.167	880	880	43	70	55	-	-

46	2-heptanone	110-43-0	7.57	890	889	43	71	59	-	1.59
47	Heptanal	111-71-7	7.945	902	894	70	57	55	0.26	-
48	Methional	3268-49-3	8.111	906	908	48	104	47	-	0.39
49	Anisole	100-66-3	8.485	916	918	108	93	78	2.51	7.30
50	isobutyl isobutyrate	97-85-8	8.55	917	914	71	89	57	-	7.47
51	dimethyl-sulfone	67-71-0	8.795	924	924	79	15	94	-	-
52	isobutyl butyrate	539-90-2	10.085	957	961	71	56	43	-	-
53	Benzaldheyde	100-52-7	10.102	957	961	77	106	105	0.23	1.85
54	1-heptanol	111-70-6	10.617	971	967	70	69	56	-	-
55	1-octen-3-ol	3391-86-4	10.97	980	978	57	72	55	2.06	-
56	3-octanone	106-68-3	11.245	987	988	43	57	29	0.35	-
57	2-octen-4-ona	4643-27-0	11.49	993	-	69	41	84	0.36	0.66
58	hexanoic acid, ethyl ester	123-66-0	11.757	1000	998	88	29	27	-	0.33
59	Butyric acid	2445-67-2	11.8	1002	1002	57	85	103	-	0.31
60	Octanal	124-13-0	11.822	1002	1003	43	84	56	2.90	4.20
61	3-methyl-acid butanoic	589-59-3	12.016	1003	1004	85	57	41	0.62	0.51
62	3-methylanisole	100-84-5	12.384	1018	1028	122	107	92	4.96	1.25
63	Benzeneacetaldehyde	122-78-1	13.277	1043	1047	91	120	92	0.62	-
64	E-2-octenal	2548-87-0	13.803	1058	1059	41	83	70	-	1.24
65	1-octanol	111-87-5	14.286	1071	1067	56	84	70	-	0.65
66	linalool oxide cis	60047-17-8	14.336	1073	1074	59	94	93	-	-
67	3-methyl-phenol	108-39-4	14.502	1088	1083	118	107	79	-	-
68	linalool oxide trans	34995-77-2	14.89	1088	1090	59	94	55	-	-
69	2-nonanone	821-55-6	15.028	1091	1090	43	58	41	-	-
70	isoamyl-2methylbutyrate	27625-35-0	15.331	1101	1103	70	103	85	-	0.37
71	Nonanal	124-19-6	15.424	1103	1106	57	98	70	1.72	-
72	2-methyl-butanoic acid	2445-78-5	15.453	1104	1105	70	57	85	-	1.37
73	Benzeneethanol	60-12-8	15.72	1113	1113	91	122	65	0.33	0.63
74	Benzene, 1,2-dimethoxy-	91-16-7	16.88	1147	-	138	95	77	0.65	-
75	Benzene, 1,3-dimethoxy-	151-10-0	17.507	1167	-	138	109	95	-	-
76	ethyl caprylate	106-32-1	18.516	1198	1196	88	101	57	0.32	-
77	2,4-nonadienal	5910-87-2	18.997	1213	1214	81	41	67	-	0.30
78	2-undecanone	112-12-9	21.412	1293	1296	68	43	59	-	-

RT= retention time

RI_{exp} = Retention Index experimental.

RI_{lit} = Retention Index Literature database NIST

Table 2. Scores and standard deviation obtained in the sensory analysis. For each sensory attribute (column) and food matrix (honey or oil), letters denote significant differences ($P \leq 0.05$): capital letters (A-D) denote differences among aromatization processes and/or truffle concentration (for samples with the same heat treatment), whereas lowercase letters (a-d) denote differences among heat treatments (for samples with the same aromatization process and truffle concentration).

	Sensory attributes								
	Sulphur	Mushroom	Earthy	Butter	Black olives	Leather-animal	Blue cheese	Nuts	Alcohol
HONEY Non treatment									
Control	1.0 ± 0.0C,a	1.0 ± 0.0B,a	1.5 ± 1.1A,a	1.8 ± 1.2B,a	1.0 ± 0.0B,b	1.0 ± 0.0B,a	1.0 ± 0.0A,a	1.4 ± 0.7A,ab	1.3 ± 0.5A,a
F_5	3.1 ± 1.6BC,b	1.8 ± 1.0AB,b	1.8 ± 0.7A,a	2.0 ± 1.2B,b	2.3 ± 1.5B,ab	1.8 ± 1.5AB,a	1.4 ± 0.7A,a	1.8 ± 1.2A,a	1.4 ± 0.5A,a
F_10	3.0 ± 1.4BC,a	2.4 ± 1.4AB,a	2.8 ± 1.9A,a	1.9 ± 1.4B,a	2.1 ± 1.2B,b	2.5 ± 1.5AB,a	1.6 ± 0.9A,a	1.5 ± 0.9A,a	1.6 ± 0.8A,a
L_5	3.1 ± 1.1BC,b	2.1 ± 0.8AB,a	2.4 ± 0.9A,a	2.5 ± 1.3B,ab	2.6 ± 1.8B,ab	2.0 ± 0.8AB,a	2.1 ± 1.1A,a	1.5 ± 1.1A,ab	2.0 ± 1.1A,a
L_10	3.6 ± 1.1B,a	2.3 ± 1.4AB,a	2.9 ± 2.0A,a	2.1 ± 1.6B,a	2.8 ± 1.7B,ab	3.8 ± 2.3A,a	1.9 ± 1.6A,a	2.1 ± 1.8A,a	2.1 ± 1.6A,a
HONEY Heat treatment 1 (Pasteurization)									
Control	1.0 ± 0.0B,a	1.0 ± 0.0B,a	1.1 ± 0.3A,a	1.9 ± 1.3A,a	1.1 ± 0.3B,b	1.1 ± 0.3B,a	1.0 ± 0.0A,a	1.0 ± 0.0A,b	1.2 ± 0.7A,a
F_5	3.2 ± 1.7AB,ab	1.9 ± 0.9AB,b	1.3 ± 0.7A,a	2.1 ± 1.5A,b	1.4 ± 0.7B,b	1.8 ± 0.8AB,a	1.2 ± 0.7A,a	1.4 ± 0.9A,a	1.3 ± 0.7A,a
F_10	2.9 ± 1.3AB,a	2.1 ± 1.3AB,a	2.8 ± 2.3A,a	2.1 ± 2.1A,a	1.8 ± 1.4B,b	2.7 ± 1.9AB,a	1.3 ± 1.0A,a	1.8 ± 1.1A,a	1.6 ± 1.1A,a
L_5	4.2 ± 1.6AB,b	1.9 ± 1.6AB,a	2.3 ± 1.9A,a	2.3 ± 1.7A,b	1.6 ± 1.0B,b	2.4 ± 1.9AB,a	1.4 ± 1.0A,a	1.9 ± 1.5A,ab	1.6 ± 1.1A,a
L_10	3.2 ± 1.8AB,a	2.3 ± 1.8AB,a	3.3 ± 2.1A,a	2.2 ± 1.7A,a	2.1 ± 1.7B,b	3.0 ± 1.4AB,a	1.4 ± 1.0A,a	1.6 ± 1.3A,a	2.0 ± 1.5A,a
HONEY Heat treatment 2 (Canning)									
Control	1.3 ± 0.7B,a	1.3 ± 0.7B,a	1.3 ± 0.7B,a	1.8 ± 1.2A,a	1.0 ± 0.0B,b	1.1 ± 0.4B,a	1.1 ± 0.4A,a	1.4 ± 0.5A,ab	1.3 ± 0.7AB,a
F_5	3.1 ± 1.6AB,b	1.9 ± 1.0B,b	1.9 ± 0.6B,a	2.0 ± 1.3A,b	1.3 ± 0.7B,b	2.1 ± 0.8AB,a	1.1 ± 0.4A,a	1.4 ± 0.5A,a	1.3 ± 0.7AB,a
F_10	2.9 ± 0.8AB,a	2.0 ± 1.2B,a	2.8 ± 1.3AB,a	2.1 ± 1.0A,a	1.8 ± 1.0B,b	3.1 ± 2.0AB,a	1.3 ± 0.7A,a	1.8 ± 1.2A,a	1.6 ± 1.1AB,a
L_5	2.9 ± 1.1AB,b	2.0 ± 1.0B,a	2.8 ± 1.4AB,a	2.1 ± 1.4A,b	1.8 ± 1.1B,b	3.1 ± 1.6AB,a	1.3 ± 0.8A,a	1.8 ± 1.2A,ab	1.6 ± 0.7AB,a
L_10	4.0 ± 1.1A,a	2.0 ± 1.0B,a	3.5 ± 1.4AB,a	2.1 ± 1.4A,a	2.1 ± 1.1AB,b	3.5 ± 1.6AB,a	1.4 ± 0.8A,a	1.9 ± 1.2A,a	2.1 ± 0.7AB,a
OIL Non treatment									
Control	1.1 ± 0.4C,a	1.9 ± 1.9AB,a	1.6 ± 1.1A,a	3.7 ± 1.7AB,a	3.1 ± 2.4AB,a	1.3 ± 0.8B,a	1.0 ± 0.0A,a	1.9 ± 0.7A,a	1.3 ± 0.5A,a
F_5	4.9 ± 1.2AB,a	3.7 ± 1.4A,a	2.3 ± 1.0A,a	3.4 ± 1.3AB,ab	4.4 ± 2.4AB,a	2.0 ± 1.4AB,a	2.0 ± 1.3A,a	1.6 ± 0.5A,a	1.3 ± 0.5A,a
F_10	4.0 ± 2.0AB,a	2.7 ± 2.0AB,a	2.9 ± 2.0A,a	4.6 ± 1.4A,a	5.9 ± 1.3A,a	2.7 ± 2.2AB,a	1.9 ± 1.2A,a	2.0 ± 1.2A,a	2.7 ± 2.6A,a
L_5	6.4 ± 1.7A,a	3.6 ± 2.1A,a	2.6 ± 2.1A,a	4.6 ± 1.1A,a	4.6 ± 2.0AB,a	1.4 ± 0.5AB,a	3.0 ± 1.5A,a	3.3 ± 1.6A,a	2.0 ± 1.4A,a
L_10	4.4 ± 2.6AB,a	3.0 ± 1.3AB,a	3.7 ± 2.7A,a	4.4 ± 1.8AB,a	5.1 ± 2.3AB,a	3.9 ± 2.4A,a	2.9 ± 2.5A,a	2.4 ± 2.0A,a	3.3 ± 2.6A,a
OIL Heat treatment 1 (Pasteurization)									
Control	1.0 ± 0.0B,a	1.0 ± 0.0B,a	1.3 ± 0.8A,a	3.3 ± 1.3A,a	1.0 ± 0.0B,b	1.3 ± 0.8B,a	1.0 ± 0.0A,a	1.0 ± 0.0A,b	1.1 ± 0.4A,a
F_5	4.1 ± 1.9AB,ab	3.1 ± 1.5AB,ab	2.1 ± 1.1A,a	3.7 ± 1.3A,ab	3.3 ± 1.6AB,ab	1.3 ± 0.5B,a	1.6 ± 1.0A,a	1.3 ± 0.8A,a	1.4 ± 0.8A,a
F_10	3.4 ± 1.6AB,a	2.0 ± 1.4AB,a	2.4 ± 1.1A,a	3.7 ± 1.9A,a	3.9 ± 1.3AB,ab	2.3 ± 1.8AB,a	1.9 ± 1.2A,a	1.7 ± 1.0A,a	2.9 ± 1.8A,a

L_5	5.4 ± 1.5A,ab	3.7 ± 1.6A,a	2.0 ± 1.0A,a	4.4 ± 1.7A,a	4.4 ± 2.4A,ab	1.6 ± 0.8B,a	2.4 ± 1.4A,a	1.4 ± 0.8A,b	1.7 ± 1.0A,a
L_10	2.9 ± 2.0B,a	3.1 ± 2.4AB,a	3.3 ± 2.1A,a	4.3 ± 2.8A,a	3.7 ± 1.8AB,ab	4.1 ± 3.0A,a	2.1 ± 2.2A,a	2.7 ± 2.2A,a	3.0 ± 2.6A,a
OIL Heat treatment 2 (Canning)									
Control	1.0 ± 0.0B,a	1.0 ± 0.0B,a	1.3 ± 0.5B,a	3.0 ± 1.4A,a	1.0 ± 0.0B,b	1.3 ± 0.8B,a	1.3 ± 0.8A,a	1.1 ± 0.4A,ab	1.0 ± 0.0B,a
F_5	3.0 ± 2.0AB,b	3.0 ± 0.8AB,ab	2.1 ± 0.7AB,a	4.3 ± 1.6A,a	3.0 ± 2.2AB,ab	1.4 ± 0.5AB,a	2.0 ± 1.5A,a	1.3 ± 0.8A,a	1.7 ± 1.2AB,a
F_10	3.4 ± 2.5AB,a	3.9 ± 2.5AB,a	3.3 ± 2.0AB,a	3.4 ± 2.6A,a	3.6 ± 1.9AB,b	3.0 ± 2.0AB,a	1.9 ± 1.2A,a	1.7 ± 1.0A,a	2.4 ± 1.6AB,a
L_5	3.9 ± 1.7A,b	3.6 ± 1.7AB,a	1.7 ± 0.8B,a	4.1 ± 1.2A,ab	3.6 ± 2.4AB,ab	1.6 ± 0.8AB,a	1.7 ± 1.0A,a	1.6 ± 0.8A,ab	1.6 ± 1.0AB,a
L_10	3.9 ± 1.8A,a	4.4 ± 1.8A,a	4.7 ± 2.7A,a	3.6 ± 2.2A,a	4.6 ± 2.9A,ab	4.0 ± 3.2A,a	2.6 ± 2.1A,a	2.3 ± 1.9A,a	2.9 ± 2.1A,a

Figures

Figure 1. Heatmap of the volatile profile of truffled products before and after heat treatments, according to the relative percentage of area values detected by SPME-GC-MS. Colors range from white to green (sunflower oil) or orange (honey), showing the highest 90 percentile in the darkest color. In the sample names, C refers to control (without truffle), F and L indicate aromatization with fresh or lyophilized truffle, 5 and 10 correspond to truffle amount, and T0-T2 to heat treatment (T0: none, T1: pasteurization, T2: sterilization).

Figure 2. PCA results for truffled oil samples: (a) score plot for VOC profile variation among samples, and (b) loading plot for the VOCs detected by HS-GC-MS. In (a), sample color indicates the quality of representation for the sample (cos2). In the sample names, C refers to control (without truffle), F and L indicate aromatization with fresh or lyophilized truffle, 5 and 10 correspond to truffle amount, and T0-T2 to heat treatments (T0: none, T1: pasteurization, T2: sterilization). In (b), compounds are identified with numbers corresponding to those in Table 1, and arrow color indicates the contribution of a compound to the PCA components (contrib).

Figure 3. PCA results for truffled honey samples: (a) score plot for VOC profile variation among samples, and (b) loading plot for the VOCs detected by HS-GC-MS. In (a), sample color indicates the quality of representation for the sample (cos2). In the sample names, C refers to control (without truffle), F and L indicate aromatization with fresh or lyophilized truffle, 5 and 10 correspond to truffle amount, and T0-T2 to heat treatments (T0: none, T1: pasteurization, T2: sterilization). In (b), compounds are identified with numbers corresponding to those in Table 1, and arrow color indicates the contribution of a compound to the PCA components (contrib).

Figure 4. PCA biplot corresponding to odorous attributes in the sensory analysis of the truffle products. Arrow color indicates the contribution of a compound to the PCA components (contrib) and sample color indicates the quality of representation for the sample (cos2). In the sample names, O corresponds to oil and H to honey products, C refers to control (without truffle), F and L indicate aromatization with fresh or lyophilized truffle, 5 and 10 correspond to truffle amount, and T0-T2 to heat treatments (T0: none, T1: pasteurization, T2: sterilization).

Figure 1

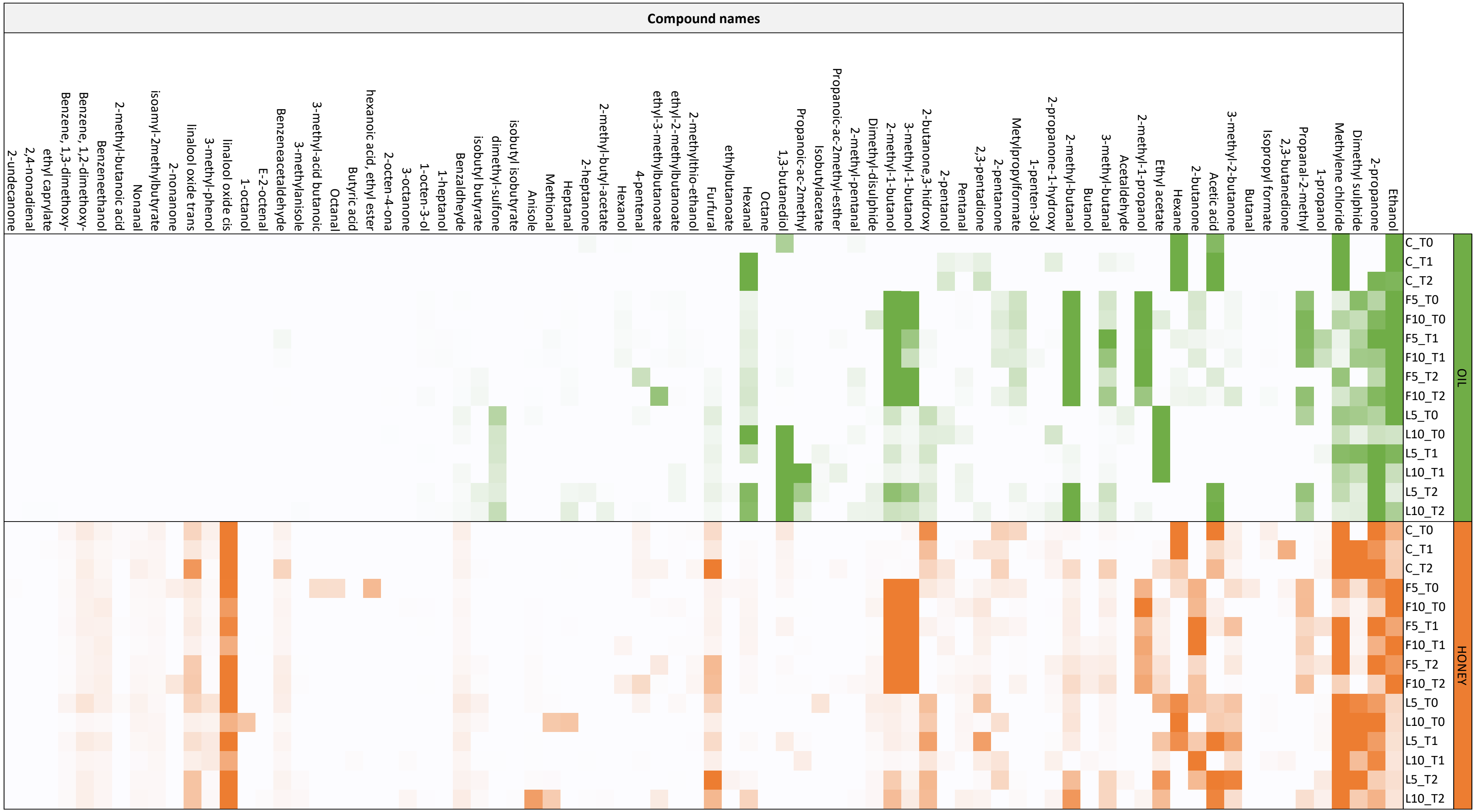
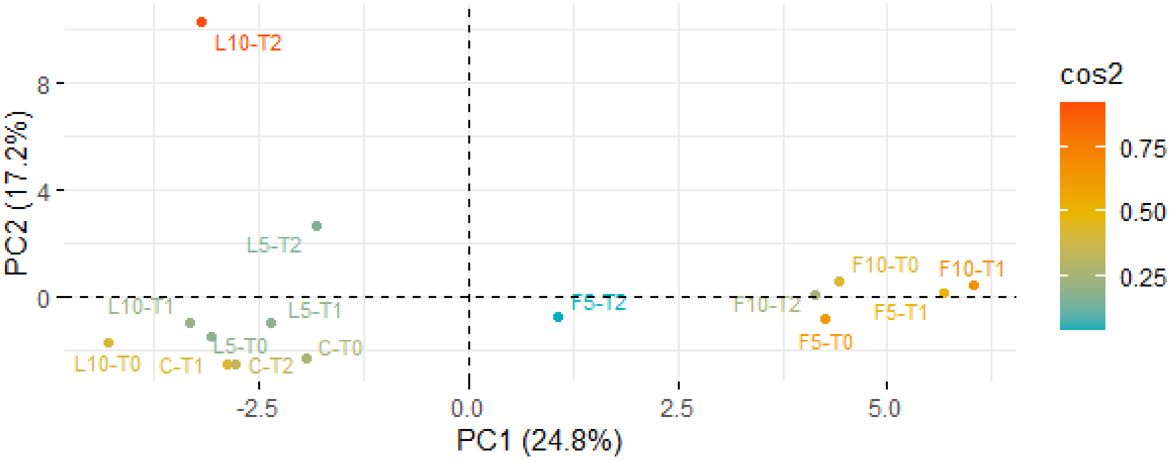

Compound names
2-undecanone
2,4-nonadienal
ethyl caprylate
Benzene, 1,3-dimethoxy-
Benzene, 1,2-dimethoxy-
Benzeneethanol
2-methyl-butanoic acid
Nonanal
isoamyl-2methylbutyrate
2-nonanone
linalool oxide trans
3-methyl-phenol
linalool oxide cis
1-octanol
E-2-octenal
Benzeneacetaldehyde
3-methylanisole
3-methyl-acid butanoic
Octanal
Butyric acid
hexanoic acid, ethyl ester
2-octen-4-ona
3-octanone
1-octen-3-ol
1-heptanol
Benzaldehyde
isobutyl butyrate
dimethyl-sulfone
isobutyl isobutyrate
Anisole
Methional
Heptanal
2-heptanone
2-methyl-butyl-acetate
Hexanol
4-pentenal
ethyl-3-methylbutanoate
ethyl-2-methylbutanoate
2-methylthio-ethanol
Furfural
ethylbutanoate
Hexanal
Octane
1,3-butanediol
Propanoic-ac-2methyl
Isobutylacetate
Propanoic-ac-2methyl-esther
2-methyl-pentanal
Dimethyl-disulphide
2-methyl-1-butanol
3-methyl-1-butanol
2-butanone,3-hidroxy
2-pentanol
Pentanal
2,3-pentadione
2-pentanone
Metylpropylformate
1-penten-3ol
2-propanone-1-hydroxy
2-methyl-butanal
Butanol
3-methyl-butanal
Acetaldehyde
2-methyl-1-propanol
Ethyl acetate
Hexane
2-butanone
Acetic acid
3-methyl-2-butanone
Butanal
Isopropyl formate
2,3-butanedione
Propanal-2-methyl
1-propanol
Methylene chloride
Dimethyl sulphide
2-propanone
Ethanol
C_T0
C_T1
C_T2
F5_T0
F10_T0
F5_T1
F10_T1
F5_T2
F10_T2
L5_T0
L10_T0
L5_T1
L10_T1
L5_T2
L10_T2
OIL
C_T0
C_T1
C_T2
F5_T0
F10_T0
F5_T1
F10_T1
F5_T2
F10_T2
L5_T0
L10_T0
L5_T1
L10_T1
L5_T2
L10_T2
HONEY

Figure 2

A)


L10-T2
L5-T2
L10-T1
L5-T1
L5-T0
C-T0
L10-T0
C-T1
C-T2
F5-T2
F10-T2
F10-T0
F10-T1
F5-T1
F5-T0
PC2 (17.2%)
PC1 (24.8%)
8
4
0
-2.5
0.0
2.5
5.0
cos2
0.75
0.50
0.25

B)

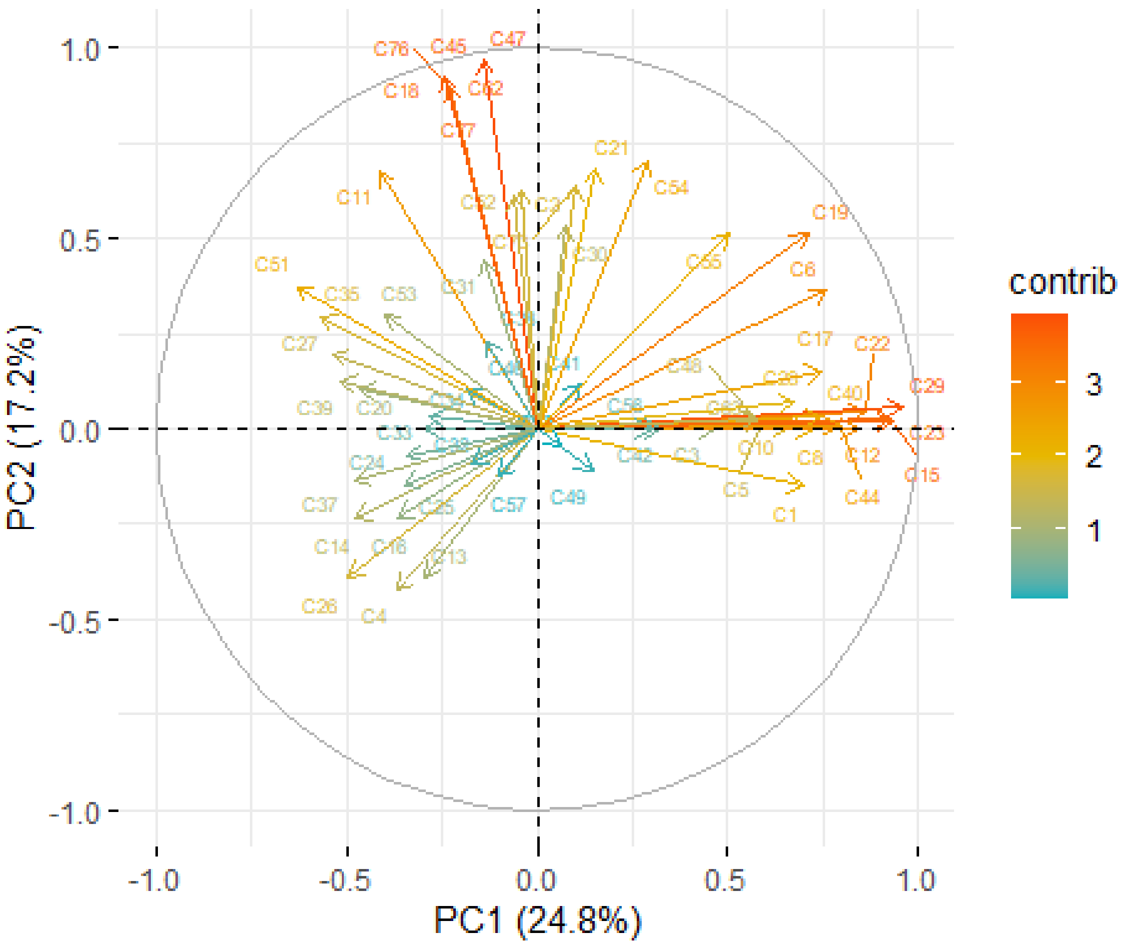

C76
C45
C47
C18
C62
C77
C21
C11
C54
C52
C3
C19
C51
C30
C55
C6
C35
C53
C31
C27
C17
C22
C48
C41
C39
C20
C29
C40
C58
C33
C23
C24
C42
C10
C8
C12
C15
C37
C25
C57
C49
C5
C1
C44
C14
C16
C13
C26
C4
PC2 (17.2%)
PC1 (24.8%)
1.0
0.5
0.0
-0.5
-1.0
contrib
3
2
1

Figure 3

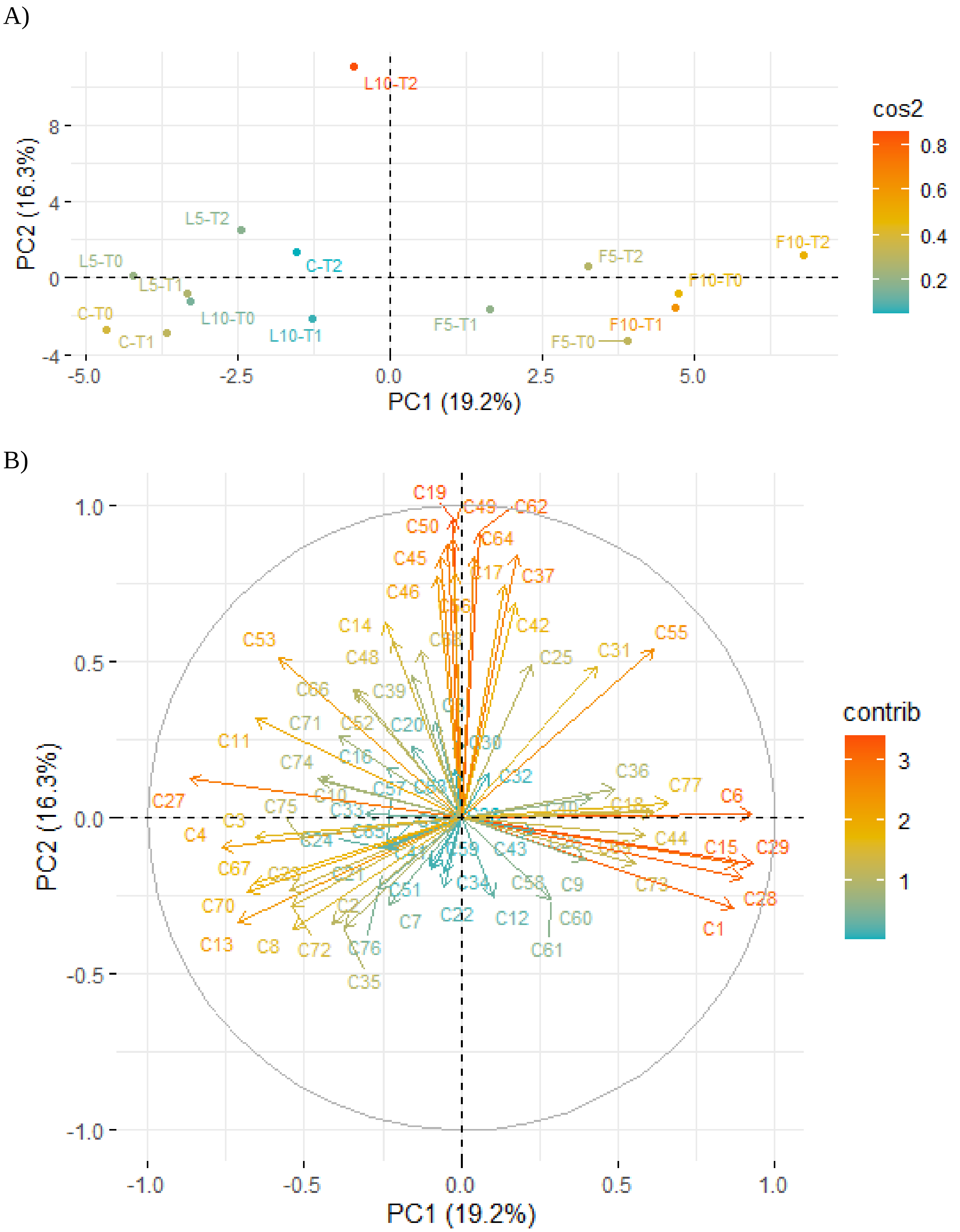
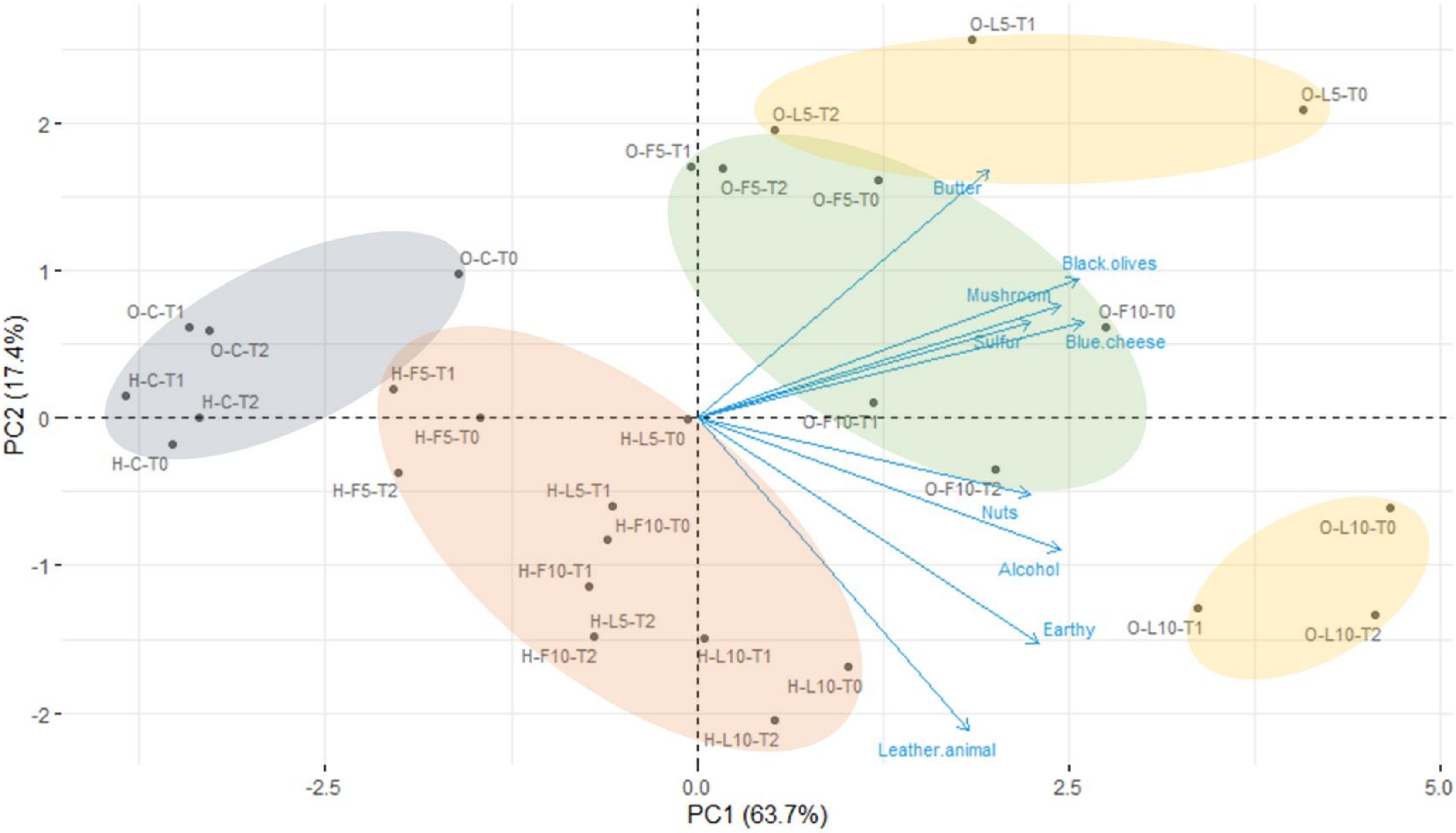

A)
L10-T2
L5-T2
C-T2
L5-T0
L5-T1
L10-T0
C-T0
C-T1
L10-T1
F5-T1
F5-T2
F10-T2
F10-T0
F10-T1
F5-T0
PC2 (16.3%)
PC1 (19.2%)
8
4
0
-4
-5.0
-2.5
0.0
2.5
5.0
cos2
0.8
0.6
0.4
0.2
B)
C19
C49
C62
C50
C64
C45
C17
C37
C46
C56
C14
C42
C53
C68
C55
C48
C25
C31
C66
C39
C71
C52
C20
C30
C11
C16
C74
C32
C36
C57
C77
C10
C6
C27
C75
C18
C3
C33
C4
C24
C63
C44
C15
C29
C67
C23
C21
C59
C43
C41
C51
C34
C58
C9
C73
C70
C2
C28
C7
C22
C12
C60
C1
C13
C8
C72
C76
C61
C35
PC2 (16.3%)
PC1 (19.2%)
1.0
0.5
0.0
-0.5
-1.0
contrib
3
2
1

Figure 4


O-L5-T1
O-L5-T0
O-L5-T2
O-F5-T1
O-F5-T2
O-F5-T0
Butter
O-C-T0
Black.olives
Mushroom
O-F10-T0
Sulfur
Blue.cheese
O-C-T1
O-C-T2
H-C-T1
H-C-T2
H-F5-T1
H-F5-T0
H-L5-T0
O-F10-T1
H-C-T0
H-F5-T2
O-F10-T2
Nuts
H-L5-T1
H-F10-T0
O-L10-T0
Alcohol
H-F10-T1
Earthy
O-L10-T1
O-L10-T2
H-L5-T2
H-F10-T2
H-L10-T1
H-L10-T0
H-L10-T2
Leather.animal
2
1
0
-1
-2
-2.5
0.0
2.5
5.0
PC1 (63.7%)
PC2 (17.4%)

Supplemenrary material

Figure S1.

	OIL															HONEY														
	C_T0	C_T1	C_T2	F5_T0	F10_T0	F5_T1	F10_T1	F5_T2	F10_T2	L5_T0	L10_T0	L5_T1	L10_T1	L5_T2	L10_T2	C_T0	C_T1	C_T2	F5_T0	F10_T0	F5_T1	F10_T1	F5_T2	F10_T2	L5_T0	L10_T0	L5_T1	L10_T1	L5_T2	L10_T2
Ethanol	9.32	7.51	6.49	16.35	9.96	10.46	23.74	27.10	18.12	8.40	2.24	6.44	2.67	1.38	4.16	4.33	2.65	2.84	10.00	11.22	4.93	9.21	5.76	9.89	2.14	1.83	1.59	1.32	1.68	1.41
2-propanone	0.00	0.00	6.72	3.59	6.37	9.09	4.80	3.29	6.33	3.82	2.49	11.75	8.67	14.78	12.49	11.28	5.95	8.64	5.80	2.33	9.22	4.31	8.56	2.41	5.50	7.99	5.44	6.66	2.64	4.18
Dimethyl sulphide	0.00	0.00	0.00	5.97	2.83	3.94	4.68	0.00	3.79	4.56	1.02	6.32	2.75	1.33	1.41	0.00	17.44	9.07	1.55	0.45	0.46	0.38	0.82	0.00	6.63	19.43	14.09	3.60	12.67	2.76
Methylene chloride	58.61	52.08	41.73	1.20	3.64	0.89	0.64	5.24	2.01	4.89	2.73	6.01	3.65	3.04	1.29	26.09	34.44	12.90	4.74	1.40	11.97	10.24	11.71	2.43	25.27	26.41	17.33	38.37	11.11	21.15
1-propanol	0.00	0.00	0.00	0.00	0.00	3.48	2.44	0.00	0.00	0.00	0.00	0.50	0.04	0.00	0.00	0.22	0.33	0.55	0.00	0.00	1.54	0.00	1.16	0.00	0.17	0.25	0.28	0.00	1.03	0.69
Propanal-2-methyl	0.00	0.00	0.00	5.51	6.52	6.41	6.12	0.00	5.54	3.98	0.00	0.00	0.00	5.24	3.43	0.00	0.00	0.00	3.70	3.74	2.09	2.55	1.72	3.35	0.00	0.00	0.00	0.00	0.00	1.68
2,3-butanedione	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.42	0.00	0.48	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00
Isopropyl formate	0.00	0.00	0.00	0.12	0.07	0.06	0.10	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.00	0.23	0.00	0.00
Butanal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-methyl-2-butanone	0.00	0.00	0.00	0.47	0.45	0.22	0.58	0.00	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0.88	0.43	1.75	0.00	3.37	0.54	1.13	0.13	3.20	2.48	5.05	1.72	6.92	1.72
Acetic acid	6.20	14.15	7.85	0.00	0.00	0.31	0.00	1.57	0.28	0.00	0.00	0.00	0.00	6.99	27.55	9.77	1.94	3.90	0.00	0.69	0.95	0.00	0.00	0.00	2.52	2.75	10.02	0.00	8.82	6.79
2-butanone	0.00	0.00	0.00	1.93	1.75	0.65	1.43	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.25	3.91	9.75	7.26	2.00	3.28	3.32	0.00	2.86	30.26	3.80	0.00
Hexane	20.97	11.53	14.30	0.00	0.00	0.88	0.00	0.54	0.67	0.00	0.00	0.00	0.00	0.00	0.00	9.00	8.16	2.84	1.74	0.00	0.00	0.00	0.00	0.00	6.43	11.65	6.28	0.00	0.00	0.00
Ethyl acetate	0.00	0.00	0.00	0.06	1.35	0.00	0.04	0.00	0.10	58.84	30.93	49.46	27.75	0.00	0.00	0.00	0.18	1.68	0.00	0.98	0.71	0.75	1.43	1.85	4.38	0.00	3.18	0.83	5.79	3.74
2-methyl-1-propanol	0.00	0.00	0.00	8.40	8.82	7.22	8.21	7.39	4.99	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00	0.00	4.17	9.27	3.93	4.90	4.41	4.90	0.00	0.00	0.00	0.00	0.00	0.50
Acetaldehyde	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.29	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00
3-methyl-butanal	0.00	0.65	0.00	2.12	1.83	11.66	5.23	2.27	4.60	0.28	0.12	0.20	0.38	2.40	1.51	0.25	0.11	2.53	0.50	0.81	0.37	0.56	0.90	1.49	0.36	0.37	0.26	0.13	2.22	2.21
Butanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.81	0.86	0.00	0.00	0.00	0.31	0.00	0.00
2-methyl-butanal	0.00	0.00	0.00	11.81	12.32	11.72	9.70	9.36	8.35	0.00	0.00	0.54	0.38	14.31	9.46	0.39	0.08	1.92	0.60	0.84	0.86	0.72	1.24	1.93	1.22	1.38	0.92	0.00	3.67	5.77
2-propanone-1-hydroxy	0.00	1.27	0.00	0.00	0.00	0.16	0.02	0.00	0.00	0.04	2.03	0.15	0.00	0.19	0.89	0.29	0.63	0.46	0.01	0.07	0.04	0.05	0.61	0.30	0.21	0.00	0.11	0.67	0.00	0.52
1-penten-3ol	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metylpropylformate	0.00	0.00	0.00	2.38	2.50	1.79	1.46	2.49	1.68	0.16	0.02	0.00	0.00	0.69	0.20	2.13	0.05	0.00	0.83	0.14	0.41	0.08	0.07	0.55	0.00	0.01	0.00	0.00	0.11	0.23
2-pentanone	0.00	0.00	0.00	1.09	1.51	1.12	1.53	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00	2.56	1.36	2.37	0.95	0.00	0.60	0.00	0.00	0.00	0.00	1.68	0.00	1.38	2.15	0.00
2,3-pentadione	0.00	1.17	2.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	1.34	0.00	0.53	1.21	0.76	0.67	0.38	0.86	3.11	0.18	5.31	0.91	0.20	0.56
Pentanal	0.00	0.66	0.00	0.10	0.11	0.03	0.02	0.46	0.27	0.00	0.66	0.00	0.76	0.71	0.00	0.00	0.21	0.00	0.17	0.65	0.00	0.00	0.33	0.48	0.33	0.42	0.36	0.00	0.00	0.67
2-pentanol	0.00	0.91	1.91	0.00	0.00	0.00	0.00	0.00	0.00	0.88	1.35	0.00	0.00	0.00	0.00	0.00	0.00	1.29	0.75	0.29	0.23	0.60	0.17	0.33	0.00	0.00	0.00	0.31	0.00	0.00
2-butanone,3-hidroxy	0.00	0.00	0.00	0.00	0.00	0.39	0.22	0.00	0.00	2.74	1.41	2.10	1.03	1.76	1.24	6.35	3.55	2.28	1.20	0.00	0.57	0.00	0.00	0.00	3.53	2.86	5.20	1.27	3.92	3.72
3-methyl-1-butanol	0.00	0.00	0.00	14.82	16.87	4.95	2.72	15.49	13.30	0.53	0.43	0.56	0.46	4.57	2.25	0.37	0.10	0.13	11.17	17.06	12.28	21.90	12.58	12.83	0.44	0.40	0.55	0.19	0.57	1.00
2-methyl-1-butanol	0.00	0.00	0.00	22.47	19.62	21.21	23.08	18.15	16.86	2.29	0.72	1.87	0.77	5.64	2.53	0.00	0.16	0.10	22.53	32.79	22.00	25.04	21.30	24.14	0.89	0.76	0.81	0.29	2.78	3.65
Dimethyl-disulphide	0.00	0.00	0.00	0.00	1.71	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.09	1.02	0.86	0.00	0.15	0.17	0.22	0.51	0.09	0.11	0.42	0.45	0.84	0.59	0.25	0.15	0.35	0.35
2-methyl-pentanal	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.45	0.00	0.45	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.14
Propanoic-ac-2methyl-esther	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.12	0.95	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Isobutylacetate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.28	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36	0.00	0.00	0.01	0.00	0.00
Propanoic-ac-2methyl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.46	4.59	1.58	0.00	0.00	0.09	0.00	0.04	0.03	0.08	0.00	0.07	0.00	0.00	0.13	0.87	0.00	0.00
1,3-butanediol	4.10	0.00	0.00	0.00	0.00	0.15	0.11	0.27	0.05	0.00	18.46	7.97	24.67	18.87	13.16	1.16	0.49	0.43	0.29	0.06	0.52	0.00	0.20	0.10	0.00	0.00	0.91	0.00	0.00	0.00
Octane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hexanal	0.00	9.74	18.64	0.82	0.97	1.27	1.17	1.87	2.05	1.36	31.53	2.38	0.00	6.25	5.97	0.00	0.17	0.20	0.38	0.45	0.49	0.48	0.23	0.26	0.00	0.00	0.22	0.00	0.31	2.30
ethylbutanoate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00
Furfural	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.43	1.32	0.63	0.86	0.60	0.92	0.45	1.89	1.17	11.39	0.63	0.62	0.64	0.46	3.81	3.65	2.23	0.83	1.91	0.76	7.72	3.92
2-methylthio-ethanol	0.00	0.00	0.00	0.03	0.03	0.10	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.39	0.03	0.03	0.06	0.08	0.33	0.45	0.00	0.00	0.06	0.00	0.00	0.00
ethyl-2-methylbutanoate	0.00	0.00	0.00	0.17	0.15	0.17	0.20	0.00	0.10	0.00	0.00	0.00	0.55	0.55	0.00	0.07	0.07	0.00	0.00	0.18	0.00	0.10	0.00	0.00	0.25	0.00	0.00	0.00	0.04	0.00
ethyl-3-methylbutanoate	0.00	0.00	0.00	0.15	0.00	0.02	0.11	0.00	5.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.12	0.00	0.00	1.08	0.11	0.00	0.00	0.00	0.00	0.00	1.00
4-pentenal	0.00	0.00	0.00	0.00	0.00	0.14	0.00	2.58	0.00	0.32	0.00	0.00	0.00	0.00	0.11	0.61	0.49	0.54	0.29	0.00	0.00	0.00	0.00	1.93	0.55	0.00	0.00	0.10	0.00	0.00
Hexanol	0.08	0.00	0.00	0.18	0.34	0.25	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00

2-methyl-butyl-acetate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.13
2-heptanone	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.10
Heptanal	0.00	0.00	0.00	0.05	0.09	0.07	0.07	0.18	0.21	0.00	0.00	0.00	0.00	0.53	1.31	0.00	0.00	0.06	0.00	0.00	0.06	0.02	0.00	0.00	0.00	3.18	0.00	0.00	0.00	0.00
Methional	0.00	0.00	0.00	0.00	0.00	0.23	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.03	0.04	0.08	2.97	0.00	0.00	0.18	2.78
Anisole	0.00	0.00	0.00	0.02	0.05	0.03	0.06	0.00	0.05	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.06	0.06	0.07	0.15	0.15	0.15	0.00	0.04	0.05	0.16	5.37
isobutyl isobutyrate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
dimethyl-sulfone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.60	2.14	2.03	1.66	1.42	2.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
isobutyl butyrate	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.38	0.50	0.00	0.00	0.00	0.00	1.00	0.58	0.00	0.00	0.09	0.00	0.03	0.03	0.03	0.20	0.11	0.63	0.30	0.00	0.04	0.41	0.25
Benzaldheyde	0.00	0.00	0.00	0.09	0.03	0.08	0.07	0.15	0.16	0.60	0.29	0.00	0.41	0.24	0.35	0.79	0.46	0.53	0.25	0.38	0.30	0.29	0.39	0.62	1.03	0.53	0.84	0.44	0.59	0.95
1-heptanol	0.00	0.00	0.00	0.00	0.00	0.09	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-octen-3-ol	0.00	0.00	0.00	0.08	0.09	0.09	0.09	0.00	0.19	0.00	0.00	0.08	0.00	0.18	0.10	0.00	0.00	0.00	0.00	0.06	0.04	0.03	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.07
3-octanone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.45
2-octen-4-ona	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
hexanoic acid, ethyl ester	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Butyric acid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00
Octanal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-methyl-acid butanoic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-methylanisole	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.10	0.00	0.00	0.00	0.00	0.18	0.31
Benzeneacetaldehyde	0.00	0.00	0.00	0.00	0.00	0.45	0.15	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.38	2.27	0.39	0.47	0.43	0.41	0.82	0.90	0.81	0.28	0.48	0.29	0.55	0.41
E-2-octenal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
1-octanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.18	0.00	0.00	0.00	0.00
linalool oxide cis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.09	8.20	20.60	7.23	5.58	6.70	4.47	10.29	11.30	14.74	4.26	9.93	4.62	12.99	12.70
3-methyl-phenol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.48	0.16	0.25	0.20	0.28	0.17	0.11	0.11	1.42	0.56	1.09	1.03	0.24	0.29
linalool oxide trans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	1.25	5.77	1.17	0.85	1.05	0.69	2.80	2.92	2.29	0.73	1.62	0.77	3.25	3.22
2-nonanone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00	0.00	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00
isoamyl-2methylbutyrate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.42	0.46	0.33	0.26	0.31	0.25	0.28	0.28	0.30	0.41	0.44	0.33	0.31	0.31
Nonanal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.37	0.70	0.26	0.23	0.19	0.17	0.31	0.36	0.61	0.46	0.33	0.17	0.30	0.37
2-methyl-butanoic acid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.19	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Benzeneethanol	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.55	0.32	0.39	0.55	0.89	0.67	0.78	0.69	0.79	0.76	0.27	0.78	0.41	0.44	0.41
Benzene, 1,2-dimethoxy-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.62	0.85	0.69	0.68	0.69	0.52	0.56	0.60	1.42	0.35	1.00	0.47	0.77	0.80
Benzene, 1,3-dimethoxy-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.19	0.15	0.22	0.18	0.23	0.14	0.12	0.16	0.53	0.10	0.32	0.19	0.21	0.22
ethyl caprylate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4-nonadienal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00
2-undecanone	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00