Original Research Article

Do consumers recognize the positive sensorial attributes of extra virgin olive oils related with their composition? A case study on conventional and organic products.

~~Can consumers be trusted to choose the "best" extra virgin olive oil?~~

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Abbreviations: EVOO, extra virgin olive oil; LOX, lipoxygenase; JAR, just about right; VOO, virgin olive oil; LOX, lipoxygenase; P.D.O., protected designation of origin; IOC, International Olive Council; FA, free acidity; PV, peroxide value; ~~GC, gas chromatography;~~ FAME, fatty acid methyl esters; ~~FID, flame ionization detector;~~ SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; OA/LA, oleic acid/linoleic acid; ~~HPLC, high performance liquid chromatography; UV-VIS, ultraviolet and visible;~~ BI, bitterness index; ~~DAD, diode array detector; MSD, mass spectrometer detector;~~ ESI, electrospray interface; SPME, solid phase micro-extraction; ~~PCA, principal components analysis;~~ PREFMAP, preference mapping; BL, blind test; IN, informed test; CONV, conventional; ORG, organic; HU, heavy users; LU, light users; TP, total phenols; *o*-DPH, ortho-diphenols; HY, hydroxytyrosol; TY, tyrosol; VA, vanillic acid; SY, syringic acid; DOA,

decarboxymethyl oleuropein aglycon; LUT, luteolin; DLA+Acpin, decarboxymethyl ligstroside aglycon + acetoxypinoresinol; API, apigenin; Oagl, oleuropein aglycon; Lagl, ligstroside aglycon.

Keywords: extra virgin olive oil, phenolic compounds, volatile compounds, IOC Panel test, sensory acceptance, agricultural production method, ~~nutritional education;~~ health, food composition, food analysis.

Chemical compounds studied in this article

Tyrosol (PubChem CID: 10393); Hydroxytyrosol (PubChem CID: 82755); Apigenin (PubChem CID: 5280443); Luteolin (PubChem CID: 5280445); Decarboxymethyl ligstroside aglycon or Oleocanthal (PubChem CID: 11652416); 1-penten-3-ol (PubChem CID: 12020); (*E*)-2-hexenal (PubChem CID: 5281168)

Abstract

Consumers perceive the sensory characteristics of extra virgin olive oils (EVOOs), but they are not always able to ~~understand~~ relate the positive sensory attributes to the presence of healthy substances (e.g. polyphenols) and, in general, to appreciate the overall quality ~~which~~ of the oils. ~~oil is best for them in terms of nutrient composition and positive sensory attributes.~~ In the present~~is~~ work, consumers' preferences and ~~the~~ influence of information concerning the agricultural production method on consumer behavior were investigated. EVOOs samples were evaluated in terms of sensory attributes, basic chemical parameters, volatile and phenolic molecules. The results showed that the majority of the interviewed consumers appreciated "fruity" attribute, but disliked what they perceived as bitterness. Organic farming information did not affect their judgment. The chemical and sensory analyses confirmed the ~~close~~ relationships between the presence of minor compounds and the ~~main~~ positive sensory attributes; positive correlations were found among bitter, pungent vs. decarboxymethyl oleuropein aglycon (ranged from 23.8 to 143.8 mg kg^{-1}) and decarboxymethyl ligstroside aglycon, as well as between green notes and the volatile compound 1-penten-3-ol (C_5-LOX alcohols, 0.1-0.9 mg kg^{-1}). Nevertheless, consumers seemed indifferent to the more health-promoting EVOOs, ~~that were confirmed more health-promoting,~~ preferring an "uneducated" sweeter taste. This result points to the need for much more consumer education concerning "genuine" and "native" taste of extra virgin olive oil and its health related properties.

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1. Introduction

The flavor of extra v~~V~~irgin olive oil (EVOO)~~. is obtained by the pressing of olives using only physical and mechanical processes, and it can be used for direct human consumption without further refining steps. Its flavor,~~ which is the combined effect of odor (perceived via orthonasal and retronasal routes), taste and chemical responses (such as pungency), makes EVOO unique and distinguishable from other vegetable oils. It is well known that the sensory quality of VOO (virgin olive oil) is mainly due to the presence of minor compounds, such as volatile and phenolic molecules (Aparicio and Guadalupe, 2002); nevertheless, the evaluation of profiles in these minor compounds are not recognized among the numerous official chemical parameters provided by European Regulations on assessment of the quality and genuineness of VOO. The volatile compounds are primarily involved in the flavor of EVOOs and include the principal components responsible for the positive fruity attribute, characteristic of an oil obtained from healthy, fresh fruits, both ripe or unripe (Angerosa et al., 2004). Phenolic substances affect bitter taste and pungent perception (Bendini et al., 2007) and they also play a very important role in product stability against oxidative modification ~~-~~(Carrasco-Pancorbo et al., 2005; Gallina Toschi et al., 2005). Recently, the effect of phenolic compounds on the release and perception of volatile compounds of VOO, was studied by Genovese et al. (2015) by adopting simulated *in vitro* mouth conditions; such investigation lead to interesting findings about a possible "physicochemical trapping effect" performed by specific phenolic compounds on some defined aroma compounds. Several studies on the possible correlation between the sensory attributes and the qualitative and quantitative profile of phenolic compounds in VOOs have been carried out. In particular, bitterness and pungency perceptions have been linked to the content of specific secoiridoids (Andrewes et al., 2003; Bendini et al., 2007; Gutierrez-Rosales et al., 2003; Mateos et al., 2004). On the other hand, numerous volatile compounds formed by the lipoxygenase (LOX) pathway and chemically divided into different classes (aldehydes, alcohols, ketones, esters and penten dimers) are known to be responsible both for the fruity attribute and secondary pleasant olfactory notes in VOO, such as green notes (Kalua et al., 2007). On the contrary, the main off-flavours (sensorial defects) originates from sugar fermentation (winey), anaerobic microorganisms (muddy), branched amino acid production (fusty), enzymatic activities of molds (musty) and to auto-oxidative process (rancid) (Bendini et al., 2012).

Consumers are not always able to recognize, understand or appreciate the intrinsic attributes that define the quality of a specific food product such as EVOO: this is not due to their reduced sensory acuity, but to different traditions, culinary habits and nutritional education, which are all factors that may influence

consumer behavior (which is not always directed to the highest quality products) (~~Issanchou, 1996;~~ Tuorila et al., 1998). Some investigations have highlighted how positive sensory attributes for EVOO such as bitter and pungent are actually negative drivers of liking (Delgado and Guinard, 2011; Recchia et al., 2012; Valli et al., 2014). On the other hand, consumers defined bitter and pungent as the most appropriate attributes to describe this product (Caporale et al., 2006) and as drivers of their preferences (Hassine et al., 2015). Different attitudes towards bitterness, pungency and fruitiness are also seen in Italian consumers (Predieri et al., 2013) and these can be explained by different levels of familiarity with EVOO and eating habits; on the other hand, neither the involvement or the predilection for this product are able to guarantee consumer recognition of high quality products (Recchia et al., 2012). For example, even if most Californian consumers considered EVOO to be a 'healthy' food, most were also unaware of the bioactive components of EVOO or their specific health benefits (Santosa et al., 2013).

Many authors have emphasized the importance on several types of information on consumer behavior, especially those related to the geographical origin, brand, health, packaging, production method and processing technologies. Differences between ratings of satisfaction when expressed without (blind) or with information (informed) on the product have been reported by different authors, confirming that the perception of quality is strongly influenced by the expectations created by such information (Caporale et al., 2006; Cardello, 2003; Carrillo et al., 2012; Laureati et al., 2013; Varela et al., 2010). Recently, Caporaso et al. (2015) found particularly high polyphenols contents in Italian ~~extra virgin olive oils~~EVOOs covered by Protected Designations of Origin (PDOs), thus permitting, for some of them, also the inclusion in the label of the health claim that ''olive oil polyphenols contribute to the protection of blood lipids from oxidative stress'' (EU Reg. 432/2012).

Based on the above considerations, this study investigated selected EVOOs present on the Italian market and was performed to: *i)* evaluate the influence of information concerning organic or conventional production methods of extra virgin olive oils (EVOOs) on consumers behavior; *ii)* investigate the factors that can lead to product acceptability; *iii)* verify the relationship between the presence of minor compounds (volatile and phenols) with the associated sensory perceptions.

2. Material and Methods

2.1. Samples

Eight samples (coded as "S1−S8") sold as EVOOs were purchased from an Italian supermarket. Table 1 summarizes coding and information on the samples. These EVOOs were selected in order to represent the variety of EVOOs available on the Italian market, according to the following screening criteria: balanced

number of conventional and organic samples; two samples belonging to an Italian protected designation of origin (Italian P.D.O.) and one monocultivar EVOO (*cv* coratina, Apulia); samples sold in three price ranges, at high (> 8 € per L), medium (5−8 € per L) and low price (< 5 € per L) and presence of samples characterized by different intensities of fruitiness, bitterness and pungency (a preliminary sensory analysis on a larger set of samples was performed as described in the paragraph below). All samples were stored at 12°C in the dark before analysis.

2.2. Analytical sensory evaluation by a trained panel

The IOC (International Olive Council) Panel test method was carried out by a group consisting of nine trained assessors of the Professional Committee of DISTAL (Department of Agricultural and Food Sciences of University of Bologna, recognized by the Ministry of Agricultural, Food and Forestry Policies). Positive and negative descriptors were selected and adopted according to the official procedure (EC Reg. 640/2008). Moreover, evaluation of green notes and other positive attributes was carried out with reference to the list of descriptors established for P.D.O. EVOOs, according to the IOC standards (IOC/T.20/Doc. no 22., 2005). The level of intensity of each descriptor was graded by judges using a continuous unstructured line scale of 10 cm. Each 15 mL sample was tasted in a normalized cup (Menietti Enologia snc, Italy) at 28 ± 2°C in a tasting booth, regulated in terms of shape and equipment (IOC/T.20/Doc. no 5., 2007). Results were expressed as the median values of the tasters' sensory perceptions. The robust coefficients of variation were calculated and validated (acceptable values ≤ 20%), according to EC Reg. 640/2008.

2.3. Hedonic sensory evaluation by consumers

The samples were subjected to an acceptance test carried out in an Italian supermarket (Liguria region) by a group of 60 consumers. Participants were recruited and selected using predetermined screening criteria based on purchasing frequency of organic food consumption~~: heavy users (several times a week) light users (several times a month)~~, gender and age. In particular, they were split into two subgroups based on high (heavy users) or low frequency (light users) of organic food consumption (according to their answer about frequency of consumption as "several times a week or more" and "several times a month or less", respectively). The consumer group consisted of 70% heavy users and 30% light users; regarding sex, 57% were female and 43% male; the main age groups were from 20−50 years (20−30 years old, 30%; 31–40, 30%; 41–50, 28%), whereas consumers older than 50 years old were less represented (51–60, 7%; 61–80, 5%). EVOOs were served at room temperature (± 20ºC) in plastic cups; white bread was provided as a carrier. Consumers were asked to express their judgment on the degree of overall acceptability of each

sample (appearance, smell, taste, mouth-feeling) and on the intensity of selected attributes among those used by the Panel of experts (see ~~Table 2~~supplemntary material S1), using a 9-point hedonic scale ranging from 1 to 9 (1 = do not like at all and 9 = like very much). All evaluations, except for the degree of overall liking and the intensity of negative attributes, were also assessed using a 5-point just about right (JAR) scale from 1 to 5 (1 = way too little, 2 = too little, 3 = just about right, 4 = too much, 5 = way too much). The central location consumer test was realized in two sessions (blind and informed conditions) on two days to test if product information affected the consumer purchase decision. During the first tasting day, participants performed the blind test; the day after, the same participants were invited to perform the informed test (information on the production method were available during their evaluation). In the blind test, each consumer evaluated all the samples, in order to have 60 judgments for each of the 8 samples. In the informed test, consumers were asked to taste 10 samples with information about the organic/conventional farming system: actually, on the basis of the blind test results, the most liked conventional and organic EVOO were resubmitted for evaluation (during the second tasting day), but information on their production methods (organic or conventional) was inverted. For data collection, eight PCs with the FIZZ software ver. 1.31 (Biosystemes, Couternon, France) installed, were used.

2.4. Chemical solvents and reagents

Methanol and water for HPLC analysis (respectively purity ≥ 99.9% and non-volatile matter ≤ 0.0003%), clorophorm (purity > 99%), acetic acid (purity ≥ 99.7%), ethanol (purity ≥ 99.9%), isooctane for spectrophotometry (purity ≥ 99.9%), diethyl ether (purity > 99%), sodium thiosulfate (purity ≥ 98%), potassium iodide (purity ≥ 99%), Folin-Ciocalteu reagent, sodium carbonate anhydrous (purity ≥ 99.9%), sodium molybdate dehydrate (purity ≥ 99 %), potassium hydroxide (purity ≥ 98 %), phenolphthalein solution 2% in ethanol were all purchased from Sigma-Aldrich (St. Louis, MO, USA).

2.5~~4~~. Basic quality parameters

Basic quality parameters of samples, such as free acidity (FA) calculated as the percentage of oleic acid, peroxide value (PV) expressed as meq of active oxygen per kg of oil (meq O_2 kg^{-1}), spectrophotometric indices (K_{232}, K_{270} and ΔK) were evaluated according to official methods (EC Reg. 61/2011). All analyses were determined in triplicate for each sample.

2.6~~5~~. Fatty acid composition

The fatty acid composition was determined as fatty acid methyl esters (FAMEs) by ~~capillary~~ gas chromatography (GC) analysis, after alkaline treatment according to the official method (EC Reg. 61/2011). FAMEs were analyzed by using a Clarus 500 gas chromatograph from Perkin Elmer (Shelton,

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CT, USA) equipped with a flame ionization detector (FID), according to Bendini et al. (2006). For each chemical determination, three replicates were analyzed for each sample. FAMEs were identified by comparing the retention time of compounds with a Nu-Check GLC – 463 standard mixture (Nu Check, Elysian, MN, USA) injected in the same analytical conditions. Results were determined in triplicate for each sample and expressed as percentage of each fatty acid of the total.

2.7~~6~~. Extraction of polar phenolic extracts

A liquid-liquid extraction, performed according to Carrasco-Pancorbo et al. (2007), was used to extract the phenolic compounds from EVOOs. The dried extract was dissolved with 5 mL of methanol/water (50:50, v/v) and an aliquot was filtered through a 0.45 µm filter (VWR, West Chester, PA, USA) before HPLC analysis. For spectrophotometric determinations, the extract was further diluted 1:5 (v/v) using the same mixture mentioned above. Three replicates were analyzed for each sample. The extracts for spectrophotometric assays were stored at -18°C before use.

2.8~~7~~. Determination of total phenols and ortho-diphenols by a spectrophotometric method

The total phenolic content was spectrophotometrically determined at 750 nm by the Folin-Ciocalteu reagent following the protocol described by Bendini et al. (2006). The content of spectrophotometric *o*-diphenol was evaluated at 370 nm using the sodium molybdate dihydrate reagent, according to Mateos et al. (2001). Both assays were measured with a UV-VIS 1800 Shimadzu spectrophotometer (Shimadzu Corporation, ~~Kyoto~~Tokyo, Japan).

The total phenol and *o*-diphenol concentrations were quantified using two specific calibration curves ~~(r^2=0.997 and r^2=0.994, respectively)~~ built by using gallic acid (Fluka, Buchs, Switzerland) as standard. Data were expressed as mg of gallic acid per kg of oil and the analysis was carried out in triplicate for each sample.

2.9~~8~~. Determination of bitterness index

Evaluation of bitterness index (BI K_{225}) in polar extracts was carried out spectrophotometrically at 225 nm according to Gutièrrez et al. (1992), with some modifications. The phenolic extract, obtained as described previously, was diluted (1:250) with methanol/water (50:50, v/v) solution and the absorbance at 225 nm was measured against a solvent reference in a 1-cm quartz cuvette. Three replicates were measured out for each sample.

2.10~~9~~. Determination of phenolic compounds by HPLC-DAD/MSD

High performance liquid chromatography (HPLC) analysis was carried out using a HP 1100 Series instrument (Agilent Technologies, Palo Alto, CA, USA), equipped with a binary pump delivery system,

degasser, autosampler, HP Diode Array UV-VIS Detector (DAD) and HP Mass-Spectrometer Detector (MSD). A Zorbax Eclipse XDB-C_{18} (Phenomenex, St. Torrance, CA, USA) column (5 µm particle size, 25 cm × 3.00 mm ID) was used. All analyses were carried out at room temperature. The wavelengths were set to 280 nm and 330 nm. Quantification of phenolic compounds (tentatively identified by comparing retention times, UV-VIS and mass spectra with pure standards and data present in literature) was performed using calibration curves of 3,4-dihydroxyphenylacetic acid for compounds with maximum absorption at 280 nm (Fluka, Buchs, Switzerland) (5−1000 mg L^{-1}~~, r^2=0.9987~~) and caffeic acid for compounds having maximum absorption at 330 nm (Fluka~~, Buchs, Switzerland~~) (5−1000 mg L^{-1}, r^2=0.9995). The gradient elution was carried out using the conditions described by Carrasco-Pancorbo et al. (2007). The detection was made using quadrupole MS with an electrospray (ESI) interface operating in positive ion mode within m/z 50-800 range and adopting the following conditions: drying gas flow, 9 L min^{-1} at 350°C; nebulizer gas pressure, 50 psi; capillary voltage, 3000 V. Nitrogen was used as both nebulizer and drying gas. Three replicates were analyzed for each sample.

2.1~~0~~. Analysis of volatile compounds

Volatile compounds present in the headspace of samples were concentrated by SPME ~~(DVB/Carboxen/PDMS fiber)~~ and separated by gas chromatography coupled with quadrupolar mass-selective spectrometry using an Agilent 6890N Network gas chromatograph and an Agilent 5973 Network detector (Agilent Technologies~~, Palo Alto, CA, USA~~). In particular, a 1.5 g amount of sample was weighed into a 10 mL vial. The oil sample was spiked with 0.15 g of the internal standard 4-methyl-2-pentanone (Sigma Aldrich), prepared in refined olive oil at a concentration of 5 µg g^{-1}. The vial was fitted with a silicone septum, placed in a water bath at 40°C (± 2°C) and here maintained under magnetic stirring for 2 minutes. Then, a divinylbenzene/carboxen/polydimethylsiloxane (DVB/CAR/PDMS) SPME fiber (50/30 µm, 2 cm long, from Supelco Ltd., Bellefonte, PA, USA) was exposed to the sample headspace for 30 min and immediately desorbed for 3 min at 250°C in the gas chromatograph injector port. Volatile compounds were separated on a ZB-WAX column (30 m, 0.25 mm i.d., 1.00 µm film thickness, (Phenomenex). Column temperature was held at 40°C for 10 min and increased to 200°C (held for 2 min) at 3°C min^{-1}; then the temperature increased at 10°C min^{-1} up to 250°C (held for 2 min). The ion source and the transfer line temperatures were set at 230°C and 250°C, respectively. Electron impact mass spectra were recorded at 70 eV ionization energy in the 30-250 amu mass range at 2 scans s^{-1} The identification of volatile compounds was first carried out by comparison of their mass spectral data with the information from the National Institute of Standards and Technology (NIST) library (2005 version)

and later checked with pure standards. Relative amounts of volatile compounds were expressed as mg of internal standard (4-methyl-2-pentanone) per kg of oil, according to the analytical protocol described by Baccouri et al. (2008). Quantification of volatile compounds was carried out as a sum of specific classes and single volatile compounds associated with flavor (aldehydes C_6, alcohols C_6, esters C_6, ketones C_5, alcohols C_5, pentenic dimers, hydrocarbons, terpenes) and off-flavor compounds that mainly contribute to sensory defects (winey: methyl acetate, ethyl acetate, methanol, ethanol and acetic acid; fusty-muddy: 3-methyl-1-butanol acetate, 1-butanol, 2-methyl-1-butanol; musty: octanoic acid, octane, 1-octanol; rancid: sum of saturated aldehydes, unsaturated aldehydes, furans, 6-methyl-5-hepten-2-one, butanoic acid and hexanoic acid). All determinations were carried out in triplicate.

2.12~~1~~. Statistical analysis

The software XLSTAT 2011.1.03 version (Addinsoft, USA) was used to elaborate chemical and sensory data by analysis of variance (ANOVA), principal component analysis (PCA) and preference mapping (PREFMAP). Student's *t*-tests ($p < 0.05$) were also carried out in order to establish if there was a significant difference for ~~-~~the hedonic ratings between the blind and informed tests and between heavy (frequent) and light (infrequent) consumers of organic food.

3. Results and Discussion

3.1. Sensory evaluation by the trained Panel

None of the samples included in this study presented any sensorial defects (EC Reg. 640/2008), and thus all samples were classified as EVOO. The intensity of the most important positive sensory attributes (fruity, bitter, pungent) evaluated by the Panel showed some differences among the analyzed samples (Fig. 1) and allowed to describe EVOOs with the optional terms that could be used for labeling (EC Reg. 640/2008): with regard to fruity, there was a first group with medium intensity of this attribute (S2, S3, S4, S6, S7, S8) and a second one with light intensity (S1, S5). S6 showed the highest intensity of fruity (6.0), which is the limit value to define medium and intense levels. In terms of bitter and pungent intensities, samples showed a similar trend: S1 and S6 were characterized by light intensities of these attributes, while samples S3, S4, S5 and S7 were judged to have medium intensity. The exceptions were samples S2 and S8, which showed an intense perception of bitter taste (6.1 and 6.4, respectively). In summary, S6 was characterized by the highest intensity of fruity, green and other positive attributes perceived by smell but, on the other hand, this sample was low in bitter and pungent taste; S8 was characterized by the highest intensities of bitter and pungent taste and had medium intensities of fruity

and green by smell. S5 and S1 were balanced for the taste attributes, but low in green notes and other positive attributes (median values < 2).

3.2. Hedonic sensory analysis by consumers

~~On the same set of samples analyzed by the IOC Panel test, a sensory acceptance test was also carried out in an Italian supermarket (Liguria region) with a group of 60 consumers. They were split into two subgroups based on high (heavy users) or low frequency (light users) of organic food consumption (according to their answer about frequency of consumption as "several times a week or more" and "several times a month or less", respectively). The consumer group consisted of 70% heavy users and 30% light users; regarding sex, 57% were female and 43% male; the main age groups were from 20−50 years (20−30 years old, 30%; 31−40, 30%; 41−50, 28%), whereas consumers older than 50 years old were less represented (51−60, 7%; 61−80, 5%).~~ Considering data related to consumer preferences expressed in the blind session (Fig. 2a), S6 (conventional) and S1 (organic) were significantly more liked than S2 and S8, which were the least liked. The overall liking registered for S7 (conventional) was not significantly different from the mean value obtained for S6. S1 and S7 were again proposed in the informed test with the opposite information (the organic S1 was indicated as conventional and the conventional S7 was passed off as organic). Significant differences were found for overall liking in the blinded versus informed test: S6 and S1 were characterized by significant lower values of overall liking in the informed test compared with the blind one; S3, S2 and S8 showed the opposite trend, so that the overall liking was higher in the informed test. When S1 was labeled as conventional it was significantly better liked than S7 when it had been labeled as organic. For the other samples, no significant differences were found.

Observing the mean of the overall liking scores given by the judges with different frequency of organic food consumption (heavy or light users), a slightly tendency of light users to score less than heavy users in both conditions (blinded and informed) was seen (Fig. 2b~~3~~). In the informed test, when S1 was labeled as conventional, both heavy and light users scored higher. On the other hand, when S7 was labeled as organic there were no clear difference concerning overall liking. Also while the number of interviewed consumers was limited, the results indicated that organic farming information did not affect the judgment of consumers surveyed, who, however, differentiated and rewarded only the products that best met their expectations concerning the sensory characteristics of the products. It is possible that this result may also be due to the test situation in which consumers are forced to evaluate sensory quality of the products, whereas in the real purchase conditions at the grocery or supermarket they may be more influenced by information contained on the labels.

Considering the information of the JAR scales in the consumer test, the results related to the intensity of bitter (Fig. 34) were particularly interesting: all samples were rated as "just about right" by 30−40% of consumers; only S8 and S2 were perceived as "too much" or "way too much" bitter by about 50% of consumers. On the other hand, concerning the intensity of pungent, all samples were perceived as "too little" or "way too little" pungent by about 50% of consumers (data not shown).

3.3. Quality indices

The values of chemical quality parameters are presented in Table 23. Concerning the FA, K_{232}, K_{270} and ΔK, all samples showed values under the respective limits fixed for EVOOs (EU Reg. 61/2011); PV were also generally under the limits, except for S4 which presented a higher content (around 28 meq O_2 kg^{-1} oil) than the limit for EVOOs, suggesting poor oxidative status. Fatty acid composition (Table 34) of all EVOOs was generally characterized by a high percentage of monounsaturated fatty acids (MUFA, 73.8-75.6%) and relatively low percentage in saturated fatty acids (SFA, 15.6-16.6%) and polyunsaturated (PUFA, 8.6- 9.8%), according to the typical range for EVOOs (EU Reg. 61/2011).

3.4. Phenolic compounds

The amount of phenolic compounds is fundamental to assess the quality of EVOO due to their involvement in protection from oxidation and their contribution to bitter and pungency (Bendini et al., 2007). The concentration of total phenols, *o*-diphenols (calculated using gallic acid calibration curves, respectively with $r^2 = 0.997$ and $r^2 = 0.994$, see paragraph 2.8) and bitter index (BI K_{225}) are presented in Table 23. Samples S2, S3, S4, S5 and S8 can be considered as "medium rich" in phenolic compounds with values higher than 200 mg kg^{-1} but lower than 500 mg kg^{-1} (according to the range proposed by Montedoro et al., 1992); in particular, it should be noted that the sample S8, obtained from olives of the Coratina variety (typical of the south of Italy), was characterized by the highest presence of these compounds (428.1 mg gallic acid kg^{-1}). On the other hand, S6 showed the lowest concentration of total phenolic compounds and, according to the sensory results from the trained Panel, was rated as one of the least bitter EVOO (Fig. 1). By evaluating the total phenolic content of a set of 30 samples of EVOO purchased in the Italian market, similar results were recently obtained by Caporaso et al. (2015). The *o*-diphenols content showed a trend similar to total phenols and ranged from 46.6 (S4) mg kg^{-1} to 114.0 (S8) mg kg^{-1}. Bitter index (BI K_{225}) values followed the same pattern as total phenol and *o*-diphenol, confirming that the phenolic fraction of EVOO is mainly responsible for the bitter taste.

Five different classes of phenolic compounds were tentatively identified and quantified in samples: phenolic acids (especially derivatives of benzoic acids), flavones (luteolin and apigenin), lignans [(+)-

pinoresinol and (+)-acetoxypinoresinol], phenyl-ethyl alcohols (hydroxytyrosol, tyrosol) and secoiridoids (aglycon derivatives of oleuropein and ligstroside); the quantification was performed using calibration curves built as described in paragraph 2.9 (r^2 = 0.9987 for the one related to 3,4-dihydroxyphenylacetic acid at 280 nm and r^2 = 0.9995 for the other related to caffeic acid at 330 nm). With regards to the secoiridoid derivatives, DOA concentration ranged from 23.8 to the most interesting aspect observed was the highest concentration of decarboxymethyl oleuropein aglycon (DOA) in S8, which was considered the most bitter in sensory tests: this compound showed an average value that was significantly higher than that of the other seven samples (Table 34). The concentration of decarboxymethyl ligstroside aglycon (DLA), previously associated with the sensory perception of pungent (Andrewes et al., 2003), was quantitatively –- even if in co elution with Acpin- more relevant in S2, S4 and S8 with values significantly higher than other EVOOs. These latter samples were the most pungent of the set (Fig. 1). DLA, more commonly known as oleocanthal, appears to be responsible for the burning sensation in the back of the throat when consuming EVOOs and has anti-inflammatory properties similar to ibuprofen (Beauchamp et al., 2005).

3.5. Volatile profile

The volatile compounds identified and quantified in the headspace of EVOOs are reported in Table 34, and divided into positive flavors and off-flavors compounds. Among the C_6-LOX aldehydes, generally associated with positive sensory notes like “green”, “almond” and “cut grass” (Aparicio and Morales, 1998; Morales et al., 1996), the most representative were (*Z)*-3-hexenal and (*E)*-2-hexenal. Sample S5, judged by the Panel as the EVOO with the lowest intensity of fruity and devoid of green notes (Fig. 1), showed the lowest content in the C_6-LOX aldehydes, and in particular (*E*)-2-hexenal. Sample S7, showing a high value for C_6 aldehydes, was one of the EVOOs of the set with the highest intensity of fruity (together with S6) according to the Panel results. Sample S8 was the richest in (*E*)-2-hexenal and characterized by a medium intensity of fruity (Fig. 1) but with poor acceptability by consumers (Fig. 2a) who perceived it as too bitter (Fig. 34). On the other hand, the concentration of C_6-LOX alcohols (hexanol, (*Z*)-3-hexenol (*E*)-2-hexenol) and C_6-LOX esters (hexyl acetate, (*E*)-2-hexenyl acetate, (*Z*)-3-hexenyl acetate), both related to several positive notes of EVOOs (Kalua et al., 2007), were quantitatively low in all the examined samples. Considering the C_5-LOX ketones, the content in 3-pentanone (data not shown) was significantly higher in the samples that were more liked by consumers (S1, S6 and S7), but also in S8, that was the least well accepted in blind tests (Fig. 2a). As already explained, the low value of the overall-liking of S8 was due to its high intensity of bitterness. Sample S5, characterized by a poor

sensory quality, was very low in molecules that are enzymatically produced by the LOX pathway and showed greater amounts of typical off-flavor compounds. Although in almost all samples there were components which contribute to off-flavor, it is necessary to keep in mind that volatile molecules, even if perceived in small amounts (µg ~~per~~ kg^{-1} or ppb), do not all show the same contribution to the global aroma of ~~E~~VOO; which is influenced both by their concentrations and by their sensory threshold values (Angerosa et al., 2004; Kalua et al., 2007).

3.6. Principal component analysis

Phenolic compounds, the volatile molecules responsible for pleasant notes, and the positive attributes assessed by trained tasters were elaborated by principal component analysis (PCA) and showed as vectors in a plane composed of four quadrants (Fig. 4~~5~~a and 4~~5~~b). The first two components were responsible for 76.5% of variance (45.7% for F1 and 30.8% for F2). As seen in Fig. 4~~5~~a, it is possible to highlight that Oagl, DOA, DLA, hexanal and 1-penten-3-one, as well as bitter and pungent perceived by trained judges (IOC Panel test) were distributed in the first quadrant. In the second quadrant, fruity, green and positive sensations and the main volatile compounds related to positive flavors of EVOOs can be found: C_6-LOX compounds ((*E*)-2-hexenal, hexyl acetate,1-hexanol, (*E*)-2-hexenol) and C_5-LOX compounds (3-pentanone, 1-penten-3-ol, (*Z*)-2-penten-1-ol). In the third quadrant, opposite to the first, (*Z*)-3-hexen-1-ol was present, while (*Z*)-3-hexen-1-ol acetate and Lagl was placed in the fourth quadrant. Fig. 4~~5~~b shows a projection on the plane of all samples. The approximate position of the product near sensory attribute/chemical parameter vector(s) allows for the assumption that the product expresses these attribute/chemical substances. Therefore, S8 is located between the first and the second quadrant and it is characterized by the richest content in phenolic and "positive" volatile compounds (Tables 2 and 3~~, 4~~) as well as by high intensity of bitter, pungent, fruity, green and other positive notes perceived by odor (Fig. 1). The position of sample S6, between the second and third quadrant, reflects the high content in (*Z*)-3-hexen-1-ol and the low content of phenolic compounds responsible for bitter and pungent. The presence of sample S5 in the fourth quadrant is mainly due to the low intensities of positive olfactory sensations.

Moreover, positive correlations exist between DOA and DLA with the attributes bitter (0.910, $p < 0.05$) and pungent (0.899, $p < 0.05$) while, considering the volatile compounds, a positive correlation (0.712, $p < 0.05$) between green notes and 1-penten-3-ol was found. The PCA results also show that the considered parameters (phenolic compounds, volatile molecules responsible for pleasant notes and positive sensory attributes) were not effective to discriminate EVOOs produced by different agricultural methods (organic and conventional).

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3.7. Preference map

The results of sole sensory analysis, obtained by both trained judges and consumers (overall liking evaluated in blind tests), can be summarized in a preference map (Fig. 5~~6~~) that clearly showed that S1, the least bitter and pungent sample, was also the most liked, and that S2 and S8 (the most bitter and pungent) were the least liked by the consumers: according to other authors (Delgado and Guinard, 2011; Recchia et al., 2012), consumers preferred EVOOs characterized primarily by sweet taste and low intensity of bitterness and pungency. It is highly likely that they are unaware that these attributes are linked to richness in phenolic compounds, which are responsible for some of the healthy characteristics of EVOO (EU Reg. 432/2012). Such a lack of knowledge about high quality EVOOs was also confirmed considering samples S6, S8 and S5. In fact, only a moderate degree of appreciation for the pleasant olfactory notes was demonstrated by the consumers' preference. Sample S6 was characterized by the highest intensity of fruity, green and other positive olfactory sensation, but poor in bitter and pungent taste (Fig. 1); it was positioned where the majority of consumers (60−70%) have a preference and acceptability above average. On the other hand, sample S8 was one of the most bitter and pungent and showed medium intensities of fruity and positive olfactory sensations; it was placed in an area where only 20−30% of consumers have a preference above average. Moreover, sample S5, which was characterized by low intensities of all positive attributes, was appreciated by consumers, reaching 50–60% of above average overall liking.

4. Conclusions

The results obtained from the judges interviewed in this study, allow to observe a gap between consumers subjective preference and consumers knowledge (objective) about EVOO consumption.

No significant impact of the information dealing with the agricultural method used (organic and conventional) for EVOO production on consumer preference, was showed. This could indicate that the consumers interviewed do not have a specific image linked to an organic EVOO~~product~~ in terms of expectations concerning its sensory characteristics.

More in general, it is well known that specific composition of EVOOs, related with the qualitative and quantitative profiles in minor compounds and ~~As is known, differences among samples in terms of sensory characteristics are due to qualitative and quantitative variations in minor compounds that can be~~ linked to several factors (e.g. olive variety, ripeness degree, technological and related to the oil storage factors), rather than the agricultural system alone, can influence their sensory profiles.

The composition in specific minor compounds (phenols and volatiles) of the selected EVOOs effectively differentiated samples belonging to the same commercial class but having different sensory characteristics. The well-known relationships between phenolic components and bitterness and pungency in EVOOs were also confirmed. Good correlations were found between these sensory attributes and the content of phenolic compounds as determined by spectrophotometric methods and HPLC. In particular, considering the single compounds analyzed in HPLC, it ~~was possible to show~~appeared clear how the attribute of bitter ~~is~~ was mainly related to the dialdehydic form of oleuropein aglycone, while the pungent sensation was ~~is~~ related to the presence of the dialdehydic form of ligstroside aglycone. With regards to the determination of volatile compounds, the positive correlation between green notes and 1-penten-3-ol ~~can be~~was highlighted.

~~However,~~ As regards the consumers~~preference~~, a preference map~~ping~~ allowed the identification of drivers of liking and disliking. Consumers appreciated the fruity attribute and, in part, the pungent sensation, but ~~disliked~~ did not recognize bitterness as a positive attribute. This could be related to the common aversion reaction towards the majority of bitter substances or to the degree of familiarity with this kind of sensation due to food habits. In the olive oil sector, it is well known among scientists and experts that bitterness and pungency are positive attributes for EVOO due to their close link with the phenolic substances responsible for healthy properties (in particular in protection of blood lipids from oxidative stress) and antioxidant activity towards the lipid matrix. In the years to come, future efforts should be addressed towards dissemination of accurate information about the relationship between EVOO composition and sensory characteristics, for example in terms of labeling, in order to improve consumer awareness, introducing more relevant factors that may help them to properly appreciate this peculiar ~~food product.~~vegetable oil.

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567

Figure captions

Fig. 1. Positive attributes and their intensity (median values) estimated by the recognized professional committee DISTAL (Department of Agricultural and Food Sciences of University of Bologna).

Fig. 2. (a) Comparison of overall liking results (n = 60): blinded versus informed consumers data ~~(results marked with an asterisk differ significantly)~~. Samples are shown ~~listed~~ in decreasing order according to the degree of overall liking expressed during the blinded session. ~~S1 (organic); S2 (conventional); S3 (organic); S4 (organic); S5 (conventional); S6 (conventional); S7 (conventional); S8 (organic).~~ BL = blind test; IN = informed test; ~~conv = conventional; org = organic~~ (b) comparison of overall liking results: heavy (n = 42) and light users (n = 18) both in informed test. HU = heavy users; LU = light users. Conv = conventional; org = organic. Results marked with an asterisk differ significantly, Fisher LSD, $p < 0.05$.~~.~~

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~~**Fig. 3.** Comparison of heavy (n = 42) and light users (n = 18) of overall liking results in the informed test (results marked with an asterisk differ significantly). S1 (organic); S2 (conventional); S3 (organic); S4 (organic); S5 (conventional); S6 (conventional); S7 (conventional); S8 (organic). HU = heavy users; LU = light users.~~

Fig. 34. Results of the JAR scale consumer test (n = 60) regarding intensity of bitter attribute in the blind test. S1 (organic); S2 (conventional); S3 (organic); S4 (organic); S5 (conventional); S6 (conventional); S7 (conventional); S8 (organic).

Fig. 45. (a) PCA loadings; (b) PCA score plot. Oagl, oleuropein aglycon; Lagl, ligstroside aglycons; DLA+Acpin, decarboxymethyl ligstroside aglycon + acetoxypinoresinol; DOA, decarboxymethyl oleuropein aglycons.

Fig. 56. Preference mapping resulting from the elaboration of IOC Panel test and consumer preference data (blind session).

Tables

SAMPLE CODE	SAMPLE INFORMATION	GEOGRAPHICAL ORIGIN	PRICE RANGE
S1	EVOO (organic)	ITALY	M
S2	EVOO (conventional)	ITALY	M
S3	EVOO (organic)	ITALY	M
S4	EVOO (organic)	ITALY	M
S5	EVOO (conventional)	European Union	L
S6	EVOO P.D.O. (conventional)	ITALY (Sicily)	H
S7	EVOO P.D.O. (conventional)	ITALY (Emilia-Romagna)	H
S8	EVOO *cv* Coratina (organic)	ITALY (Apulia)	M

Table 1. Information, features and coding of extra virgin olive olis (EVOOs) samples. P.D.O., EVOOs produced according to Protected Denomination of Origin; price range: L, low price (< 5 € per L); M, medium price (5−8 € per L); H, high price (> 8 € per L).

Quality indices	FA%	PV	K_{232}	K_{270}	TP	*o*-DPH	BI K_{225}
Sample	Mean	Mean	Mean	Mean	Mean	Mean	Mean
S1	0.3_{bc}	15_{c}	1.74_{b-d}	0.14_{ab}	197.7_{e}	57.1_{e}	0.28_{c}
S2	0.5_{a}	17_{b}	2.01_{ab}	0.18_{a}	254.0_{c}	80.0_{c}	0.34_{b}
S3	0.3_{c-e}	17_{b}	2.34_{a}	0.17_{ab}	231.3_{d}	90.2_{b}	0.35_{b}
S4	0.2_{e}	28_{a}	2.29_{a}	0.19_{a}	327.9_{b}	46.6_{f}	0.43_{a}
S5	0.4_{b}	14_{d}	1.38_{d}	0.19_{a}	218.3_{d}	68.9_{d}	0.33_{bc}
S6	0.3_{bc}	13_{e}	1.81_{b-d}	0.14_{ab}	94.7_{g}	47.2_{f}	0.20_{d}
S7	0.3_{b-d}	11_{f}	1.46_{cd}	0.11_{b}	159.6_{f}	61.0_{de}	0.32_{bc}
S8	0.3_{de}	13_{d}	1.89_{a-c}	0.15_{ab}	428.1_{a}	114.0_{a}	0.48_{a}
EU Reg. 61/2011	≤ 0.8	≤ 20	≤ 2.50	≤ 0.22	np	np	np

Table 2. Chemical data (mean values, three replicates) of samples. Free acidity, FA (expressed as g oleic acid per 100 g of oil); peroxide values, PV (expressed as meq of active oxygen per kg of oil); K_{232}, K_{270} (expressed as specific extinctions); total phenols, TP and *o*-diphenols, *o*-DPH (both expressed as mg gallic acid per kg of oil) and bitter index, BI K_{225} (expressed as specific extinction); not provided = np. Different letters in the same column indicate significant differences (Fisher LSD, $p < 0.05$).

Sample	S1	S2	S3	S4	S5	S6	S7	S8
Phenolic compounds								
HY	30.9±1.6	9.7±0.3	35.7±1.3	9.7±0.1	28.5±0.7	4.9±0.2	4.6±0.3	10.3±0.1
TY	12.1±0.8	10.8±0.4	21.7±0.9	10.8±0.1	16.9±0.5	9.5±0.3	3.9±0.2	7.4±0.2
VA	2.9±0.2	2.0±0.2	2.2±0.1	1.7±0.3	1.5±0.1	2.8±0.2	1.6±0.2	2.9±0.1
SY	4.8±0.6	2.4±0.1	2.2±0.1	4.4±0.4	3.2±0.1	7.9±0.3	2.7±0.2	3.3±0.2
DOA	45.7±5.5	85.3±4.2	48.0±1.4	64.2±2.5	61.3±2.5	23.8±3.5	47.0±2.2	143.8±8.9
LUT	3.7±0.2	0.8±0.2	2.1±0.5	2.9±0.3	1.6±0.3	0.5±0.0	3.1±1.0	2.4±1.0
DLA+Acpin	54.0 ±5.9	130.0±11.4	88.4±4.4	134.0±2.2	69.7±4.8	49.5±6.4	79.7±2.0	135.1±12.9
API	1.9±0.1	0.7±0.0	1.1±0.2	1.6±0.1	0.8±0.1	0.5±0.1	1.8±0.6	1.1±0.4
Oagl	30.8±2.2	64.7±8.1	52.4±2.1	67.5±1.1	87.7±6.5	24.4±1.0	36.1±0.3	66.5±3.0
Lagl	5.9±0.6	20.4±2.8	12.6±0.7	28.4±0.2	27.0±3.9	4.4±0.2	9.0±1.2	14.3±1.1
TOT	192.7±17.7	339.1±4.7	266.4±8.9	325.1±5.9	298.3±19.4	128.2±3.3	189.8±5.3	387.0±27.0
Fatty acids composition (%)								
SFA	15.3±0.09	14.3±0.13	13.5±0.02	16.3±0.10	14.4±0.10	17.8±0.10	16.6±0.15	15.0±1.23
MUFA	75.3±0.08	77.8±0.10	77.0±0.06	76.4±0.16	79.3±0.16	70.9±0.08	76.8±2.86	76.8±0.14
PUFA	9.5±0.05	7.9±0.03	9.5±0.05	7.4±0.05	6.4±0.06	11.4±0.03	6.6±0.29	8.2±1.09
OA/LA	8±0.05	11±0.03	9±0.06	11±0.10	14±0.11	7±0.01	12±0.17	10±1.12
Volatile compounds (flavour and off-flavour)								
Aldehydes C_6	4.3±0.2	11.0±1.5	4.1±0.6	8.6±1.3	2.1±0.4	4.7±0.4	21.4±0.1	22.5±3.0
Alcohols C_6	3.6±0.2	3.0±0.4	1.9±0.3	2.2±0.4	1.6±0.3	4.9±0.2	2.0±0.1	5.9±0.8
Esters C_6	0.9±0.1	0.4±0.1	0.3±0.1	1.0±0.3	0.5±0.1	0.5±0.0	0.7±0.0	0.7±0.1
TOT C_6 LOX	8.9±0.4	14.5±2.0	6.4±0.8	11.9±2.0	4.2±0.7	10.1±0.7	24.1±0.1	29.1±3.9
Ketones C_5	0.7±0.1	0.5±0.1	0.5±0.0	0.7±0.1	0.4±0.0	0.7±0.0	1.0±0.0	1.3±0.1
Alcohols C_5	0.4±0.0	0.4±0.0	0.3±0.0	0.4±0.1	0.1±0.0	0.5±0.0	0.3±0.0	0.9±0.1
Pentenic dimers	1.5±0.2	1.2±0.2	0.9±0.2	0.7±0.0	0.3±0.0	0.9±0.1	1.7±0.1	2.3±0.3
TOT C_5 LOX	2.6±0.3	2.1±0.3	1.7±0.2	2.0±0.4	0.8±0.2	2.1±0.1	3.0±0.1	4.6±0.5
Hydrocarbons	0.4±0.1	0.3±0.1	0.3±0.1	0.3±0.0	0.8±0.4	0.2±0.0	0.4±0.1	0.4±0.1
Terpenes	0.2±0.0	0.2±0.1	0.1±0.0	0.1±0.0	0.2±0.0	0.3±0.0	0.2±0.0	0.4±0.1
Winey	9.1±0.7	3.4±1.2	4.2±0.8	3.3±0.2	10.0±1.3	0.8±0.1	1.8±0.1	7.9±0.7
Fusty/Muddy	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	n.d.	0.1±0.0
~~**Musty**~~	~~n.d~~	~~n.d~~	~~n.d~~	~~n.d~~	~~n.d~~	~~n.d~~	~~n.d~~	~~n.d~~
Rancid	0.6±0.1	0.8±0.1	0.5±0.1	0.8±0.1	0.8±0.2	0.5±0.0	0.7±0.1	0.7±0.2

Table 34. Percentages of the fatty acids grouped as SFA (saturated fatty acids), MUFA (monounsaturated fatty acids), PUFA (polyunsaturated fatty acids). OL/LA (oleic acid/linoleic acid). Phenolic compounds were determined by HPLC-DAD/MSD and expressed as mg I.S. per kg of oil. HY, hydroxytyrosol; TY, tyrosol; VA, vanillic acid; SY, syringic acid; DOA, decarboxymethyl oleuropein aglycon; LUT, luteolin; DLA+Acpin, decarboxymethyl ligstroside aglycon (oleocanthal) + acetoxypinoresinol; API, apigenin; Oagl, oleuropein aglycon; Lagl, ligstroside aglycon. Volatiles responsible for flavor (C_5-LOX and C_6-LOX) and off-flavors (sum of compounds that mainly contribute to sensory defects, see the related paragraph in Materials and Methods), expressed as mg of 4-methyl-2-pentanone per kg of oil. Not detected, n.d. (LOD for volatile compounds = 0.01 mg of 4-methyl-2-pentanone per kg of oil). All results are reported as the mean of three replicates.

Figure 1

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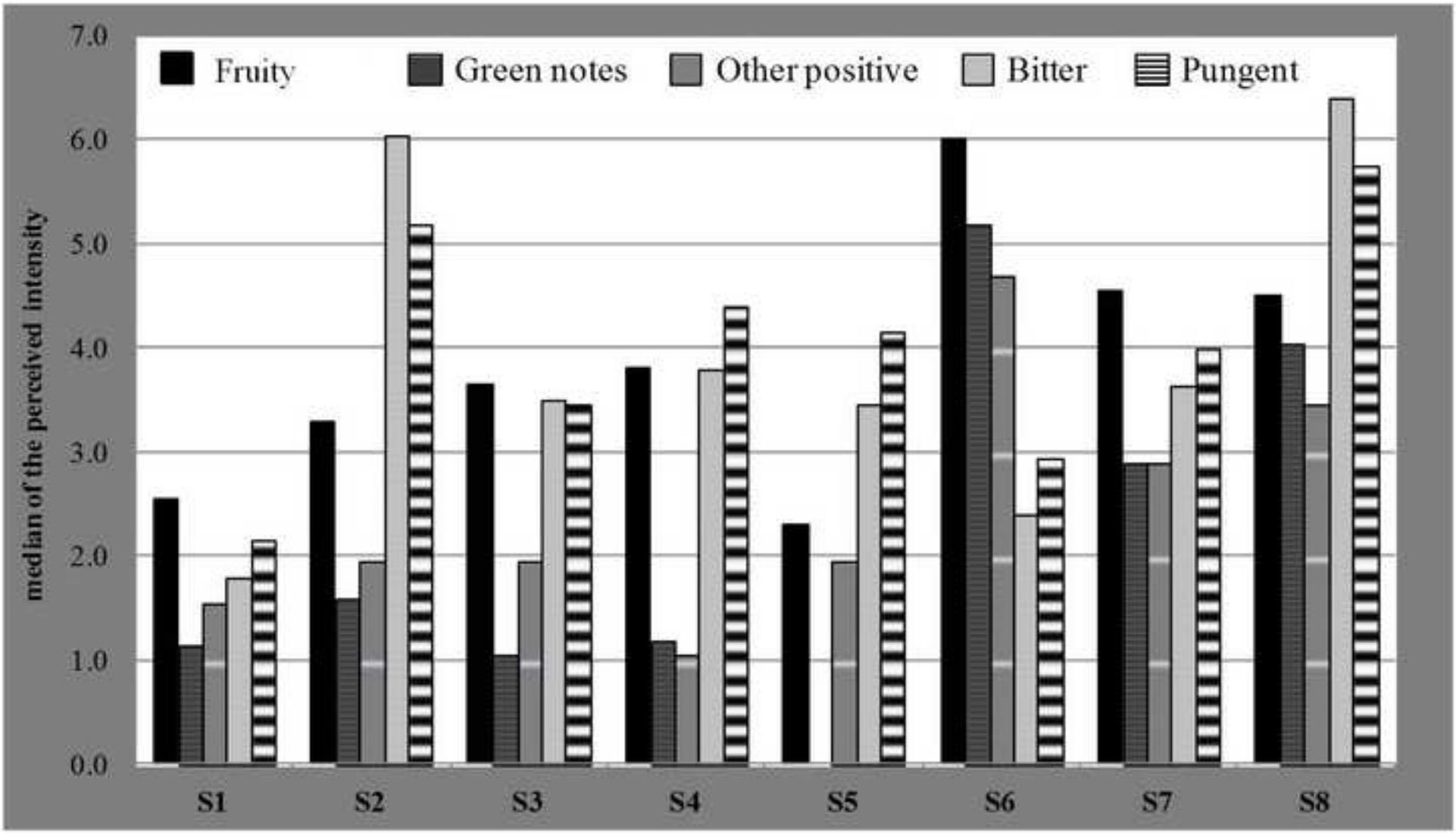

Figure 2

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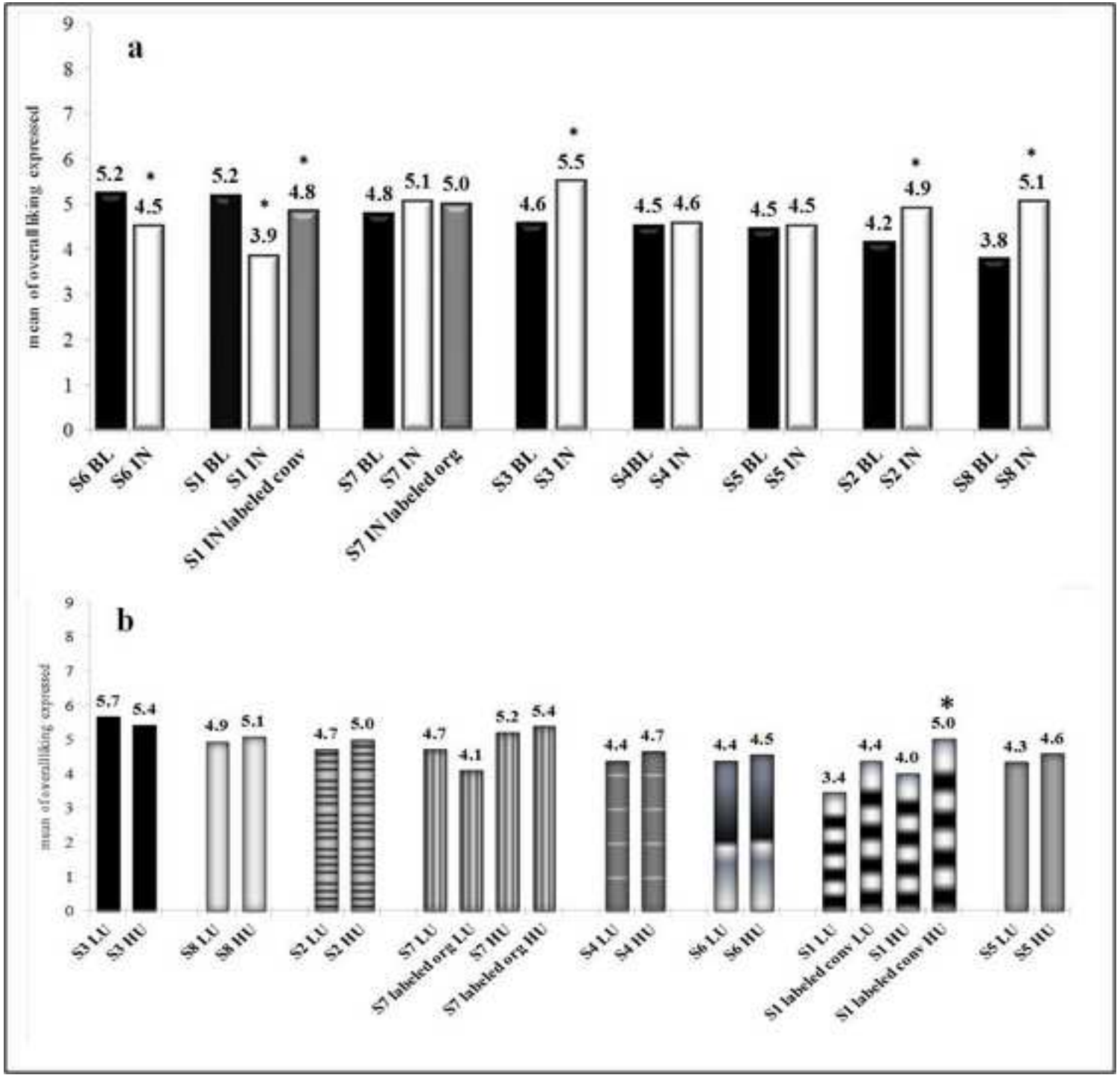

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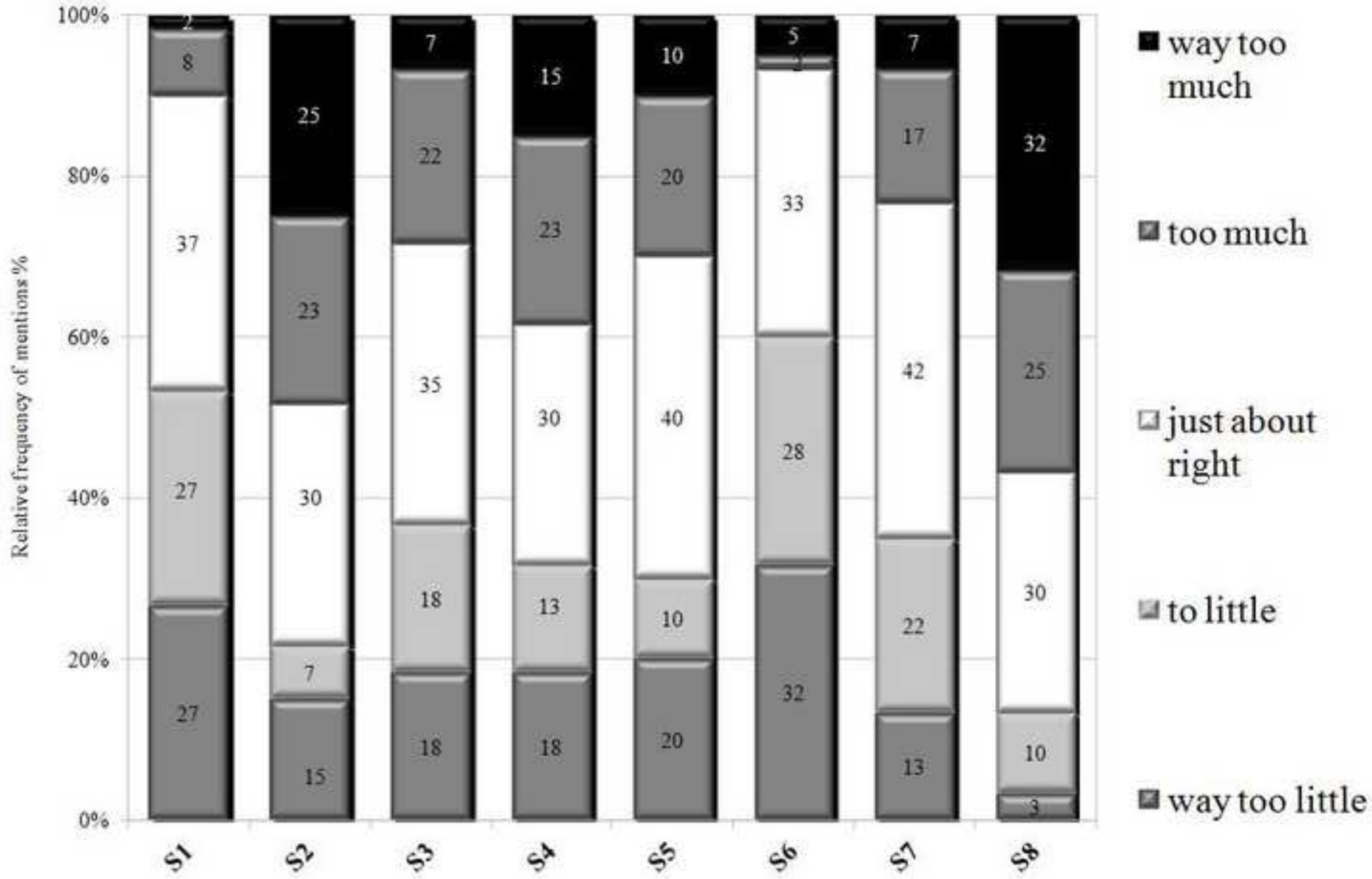

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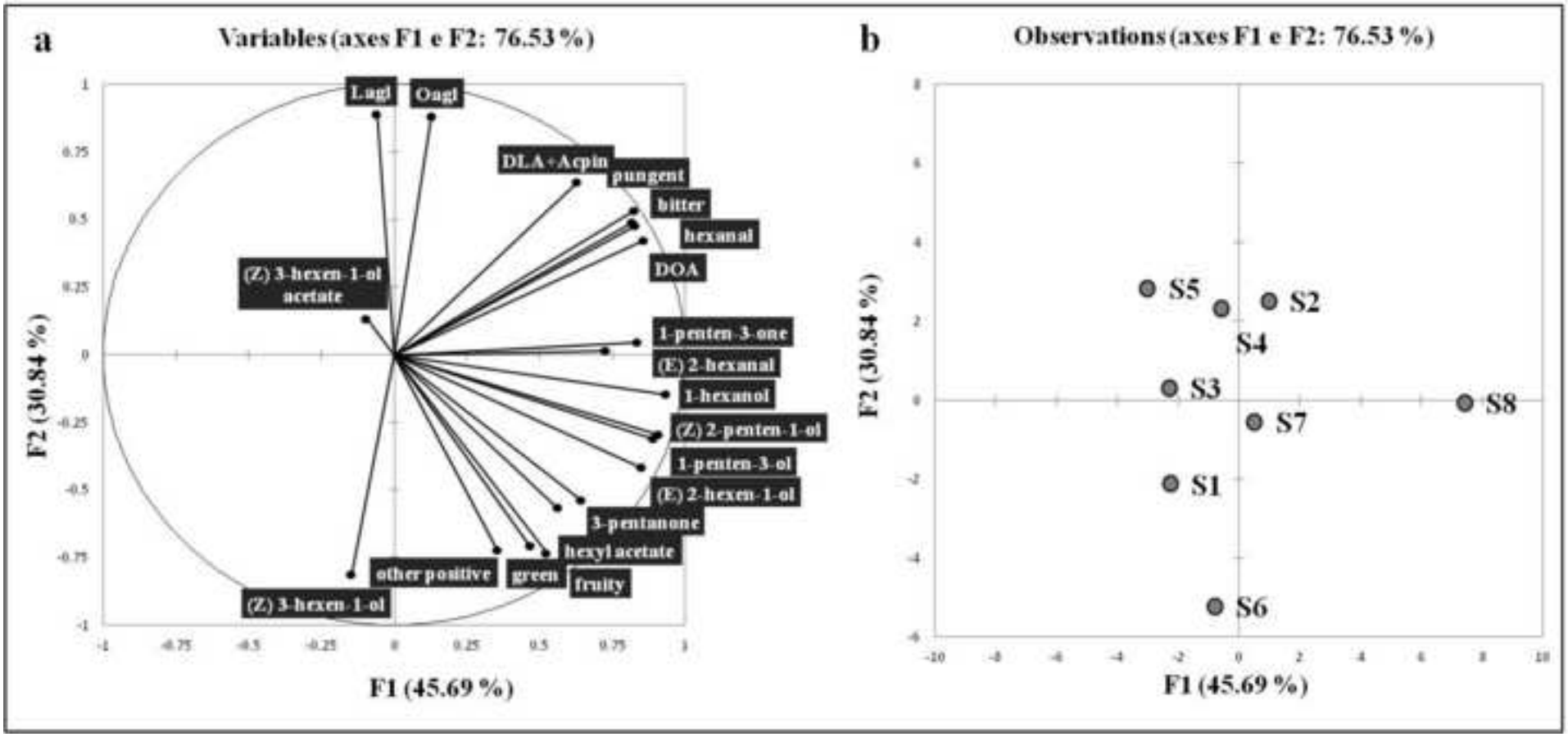

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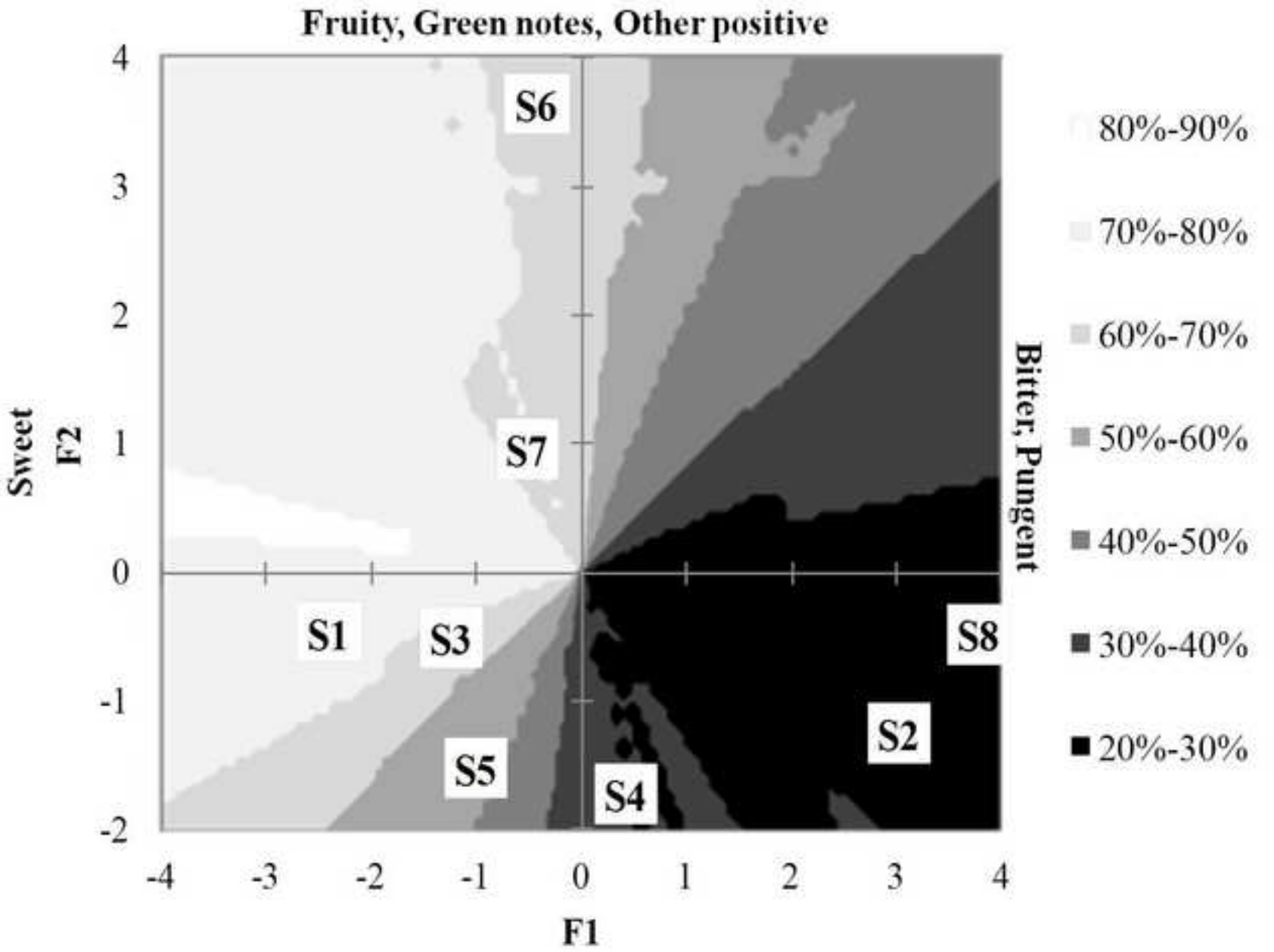

Figure captions (if needed)

Figure captions

Fig. 1. Positive attributes and their intensity (median values) estimated by the recognized professional committee DISTAL (Department of Agricultural and Food Sciences of University of Bologna).

Fig. 2. (a) Comparison of overall liking results (n = 60): blinded versus informed consumers data. Samples are shown in decreasing order according to the degree of overall liking expressed during the blinded session. BL = blind test; IN = informed test; (b) comparison of overall liking results: heavy (n = 42) and light users (n = 18) both in informed test. HU = heavy users; LU = light users.

Conv = conventional; org = organic. Results marked with an asterisk differ significantly, Fisher LSD, $p < 0.05$.

Fig. 3. Results of the JAR scale consumer test (n = 60) regarding intensity of bitter attribute in the blind test. S1 (organic); S2 (conventional); S3 (organic); S4 (organic); S5 (conventional); S6 (conventional); S7 (conventional); S8 (organic).

Fig. 4. (a) PCA loadings; (b) PCA score plot. Oagl, oleuropein aglycon; Lagl, ligstroside aglycons; DLA+Acpin, decarboxymethyl ligstroside aglycon + acetoxypinoresinol; DOA, decarboxymethyl oleuropein aglycons.

Fig. 5. Preference mapping resulting from the elaboration of IOC Panel test and consumer preference data (blind session).

Supplementary material S1

ATTRIBUTE	SCALE	QUESTION	ANCHORING-POINT
odor liking	9-point-hedonic	How much do you like the odor of this product?	very little/neither nor/very much
fruity	JAR	The intensity of the fruity is:	way too little/too little/just about right/too much/way too much
taste liking	9-point-hedonic	How much do you like the taste of this product?	very little/neither nor/very much
bitter	JAR	The intensity of the bitter is:	way too little/too little/just about right/too much/way too much
pungent	JAR	The intensity of the pungency is:	way too little/too little/just about right/too much/way too much
sweet	JAR	The intensity of the sweet is:	way too little/too little/just about right/too much/way too much
overall liking	9-point-hedonic	How much do you like this product?	very little/neither nor/very much

Supplementary material S1. List of attributes, scales, questions and anchoring-points used for the consumer test. JAR: just about right.

Highlights

- Information on organic system did not influence the overall liking of EVOO
- Sensory characteristics of EVOOs are linked to the presence of minor compounds
- A preference map allowed identification of drivers for liking and disliking of EVOO
- The majority of interviewed consumers preferred EVOOs characterized by ~~a~~ sweet taste