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

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1 *Original Research Article*

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

4
5 Can consumers be trusted to choose the “best” extra virgin olive oil?

6
7 Sara Barbieri^a, Alessandra Bendini^{a,b}, Enrico Valli^{a*} and Tullia Gallina Toschi^{a,b}

8
9 ^aDepartment of Agricultural and Food Sciences, Alma Mater Studiorum - University of Bologna, piazza
10 Goidanich, 60, 47521 Cesena (FC), Italy.

11 ^bInter-Departmental Centre for Agri-Food Industrial Research (CIRI Agroalimentare), University of
12 Bologna, piazza Goidanich, 60, 47521 Cesena (FC), Italy.

13
14 *Corresponding author: Enrico Valli

15 e-mail address: enrico.valli4@unibo.it

16 Department of Agricultural and Food Sciences
17 Alma Mater Studiorum - University of Bologna
18 p.zza Goidanich, 60 - 47521 Cesena (FC) - Italy
19 Tel.: +390547338121; fax: +390547382348

20
21
22 *Abbreviations:* EVOO, extra virgin olive oil; LOX, lipoxygenase; JAR, just about right; VOO, virgin
23 olive oil; LOX, lipoxygenase; P.D.O., protected designation of origin; IOC, ~~I~~nternational ~~O~~live
24 ~~C~~ouncil; FA, free acidity; PV, peroxide value; ~~GC, gas chromatography~~; FAME, fatty acid methyl
25 esters; ~~FID, flame ionization detector~~; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids;
26 PUFA, polyunsaturated fatty acids; OA/LA, oleic acid/linoleic acid; ~~HPLC, high performance liquid~~
27 ~~chromatography~~; ~~UV-VIS, ultraviolet and visible~~; BI, bitterness index; ~~DAD, diode array detector~~; ~~MSD,~~
28 ~~mass spectrometer detector~~; ESI, electrospray interface; SPME, solid phase micro-extraction; ~~PCA,~~
29 ~~principal components analysis~~; PREFMAP, preference mapping; BL, blind test; IN, informed test;
30 CONV, conventional; ORG, organic; HU, heavy users; LU, light users; TP, total phenols; *o*-DPH, ortho-
31 diphenols; HY, hydroxytyrosol; TY, tyrosol; VA, vanillic acid; SY, syringic acid; DOA,

Field Code Changed

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

34
35 **Keywords:** extra virgin olive oil, phenolic compounds, volatile compounds, IOC Panel test, sensory
36 acceptance, agricultural production method, ~~nutritional education~~; health, food composition, food
37 analysis.

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38 39 **Chemical compounds studied in this article**

40 Tyrosol (PubChem CID: 10393); Hydroxytyrosol (PubChem CID: 82755); Apigenin (PubChem CID:
41 5280443); Luteolin (PubChem CID: 5280445); Decarboxymethyl ligstroside aglycon or Oleocanthal
42 (PubChem CID: 11652416); 1-penten-3-ol (PubChem CID: 12020); (*E*)-2-hexenal (PubChem CID:
43 5281168)

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44 45 **Abstract**

46 Consumers perceive the sensory characteristics of extra virgin olive oils (EVOOs), but they are not
47 always able to ~~understand-relate the positive sensory attributes to the presence of healthy substances (e.g.~~
48 ~~polyphenols) and, in general, to appreciate the overall quality which-of the oils. oil-is-best-for-them-in~~
49 ~~terms-of-nutrient-composition-and-positive-sensory-attributes.~~ In the presentis work, consumers'
50 preferences and-the influence of information concerning the agricultural production method on consumer
51 behavior were investigated. EVOOs samples were evaluated in terms of sensory attributes, basic chemical
52 parameters, volatile and phenolic molecules. The results showed that the majority of the interviewed
53 consumers appreciated “fruity” attribute, but disliked what they perceived as bitterness. Organic farming
54 information did not affect their judgment. The chemical and sensory analyses confirmed the ~~close~~
55 relationships between the presence of minor compounds and the ~~main~~-positive sensory attributes; positive
56 correlations were found among bitter, pungent vs. decarboxymethyl oleuropein aglycon (ranged from
57 23.8 to 143.8 mg kg⁻¹) and decarboxymethyl ligstroside aglycon, as well as between green notes and the
58 volatile compound 1-penten-3-ol (C₅-LOX alcohols, 0.1-0.9 mg kg⁻¹). Nevertheless, consumers seemed
59 indifferent to the ~~more health-promoting~~ EVOOs, ~~that-were-confirmed-more-health-promoting~~, preferring
60 an “uneducated” sweeter taste. This result points to the need for much more consumer education
61 concerning “genuine” and “native” taste of extra virgin olive oil and its health related properties.
62

63 **1. Introduction**

64 ~~The flavor of extra v~~Virgin olive oil (EVOO), ~~is obtained by the pressing of olives using only physical~~
65 ~~and mechanical processes, and it can be used for direct human consumption without further refining steps.~~
66 ~~Its flavor,~~ which is the combined effect of odor (perceived via orthonasal and retronasal routes), taste and
67 chemical responses (such as pungency), makes EVOO unique and distinguishable from other vegetable
68 oils. It is well known that the sensory quality of VOO (virgin olive oil) is mainly due to the presence of
69 minor compounds, such as volatile and phenolic molecules (Aparicio and Guadalupe, 2002); nevertheless,
70 the evaluation of profiles in these minor compounds are not recognized among the numerous official
71 chemical parameters provided by European Regulations on assessment of the quality and genuineness of
72 VOO. The volatile compounds are primarily involved in the flavor of EVOOs and include the principal
73 components responsible for the positive fruity attribute, characteristic of an oil obtained from healthy,
74 fresh fruits, both ripe or unripe (Angerosa et al., 2004). Phenolic substances affect bitter taste and pungent
75 perception (Bendini et al., 2007) and they also play a very important role in product stability against
76 oxidative modification -(Carrasco-Pancorbo et al., 2005; Gallina Toschi et al., 2005). Recently, the effect
77 of phenolic compounds on the release and perception of volatile compounds of VOO, was studied by
78 Genovese et al. (2015) by adopting simulated *in vitro* mouth conditions; such investigation lead to
79 interesting findings about a possible “physicochemical trapping effect” performed by specific phenolic
80 compounds on some defined aroma compounds. Several studies on the possible correlation between the
81 sensory attributes and the qualitative and quantitative profile of phenolic compounds in VOOs have been
82 carried out. In particular, bitterness and pungency perceptions have been linked to the content of specific
83 secoiridoids (Andrewes et al., 2003; Bendini et al., 2007; Gutierrez-Rosales et al., 2003; Mateos et al.,
84 2004). On the other hand, numerous volatile compounds formed by the lipxygenase (LOX) pathway and
85 chemically divided into different classes (aldehydes, alcohols, ketones, esters and penten dimers) are
86 known to be responsible both for the fruity attribute and secondary pleasant olfactory notes in VOO, such
87 as green notes (Kalua et al., 2007). On the contrary, the main off-flavours (sensorial defects) originates
88 from sugar fermentation (winey), anaerobic microorganisms (muddy), branched amino acid production
89 (fusty), enzymatic activities of molds (musty) and to auto-oxidative process (rancid) (Bendini et al.,
90 2012).

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

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

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

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

120 | **2. Material and Methods**

121 | *2.1. Samples*

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

125 number of conventional and organic samples; two samples belonging to an Italian protected designation
126 of origin (Italian P.D.O.) and one monocultivar EVOO (*cv* coratina, Apulia); samples sold in three price
127 ranges, at high (> 8 € per L), medium (5–8 € per L) and low price (< 5 € per L) and presence of samples
128 characterized by different intensities of fruitiness, bitterness and pungency (a preliminary sensory analysis
129 on a larger set of samples was performed as described in the paragraph below). All samples were stored at
130 12°C in the dark before analysis.

131 *2.2. Analytical sensory evaluation by a trained panel*

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

144 *2.3. Hedonic sensory evaluation by consumers*

145 The samples were subjected to an acceptance test carried out in an Italian supermarket (Liguria region) by
146 a group of 60 consumers. Participants were recruited and selected using predetermined screening criteria
147 based on purchasing frequency of organic food consumption: ~~heavy users (several times a week) light~~
148 ~~users (several times a month)~~, gender and age. In particular, they were split into two subgroups based on
149 high (heavy users) or low frequency (light users) of organic food consumption (according to their answer
150 about frequency of consumption as “several times a week or more” and “several times a month or less”,
151 respectively). The consumer group consisted of 70% heavy users and 30% light users; regarding sex, 57%
152 were female and 43% male; the main age groups were from 20–50 years (20–30 years old, 30%; 31–40,
153 30%; 41–50, 28%), whereas consumers older than 50 years old were less represented (51–60, 7%; 61–80,
154 5%). EVOOs were served at room temperature ($\pm 20^\circ\text{C}$) in plastic cups; white bread was provided as a
155 carrier. Consumers were asked to express their judgment on the degree of overall acceptability of each

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

171 2.4. Chemical solvents and reagents

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

178 2.5.4. Basic quality parameters

179 Basic quality parameters of samples, such as free acidity (FA) calculated as the percentage of oleic acid,
180 peroxide value (PV) expressed as meq of active oxygen per kg of oil (meq O₂ kg⁻¹), spectrophotometric
181 indices (K₂₃₂, K₂₇₀ and ΔK) were evaluated according to official methods (EC Reg. 61/2011). All analyses
182 were determined in triplicate for each sample.

183 2.6.5. Fatty acid composition

184 The fatty acid composition was determined as fatty acid methyl esters (FAMES) by ~~capillary~~ gas
185 chromatography (GC) analysis, after alkaline treatment according to the official method (EC Reg.
186 61/2011). FAMES were analyzed by using a Clarus 500 gas chromatograph from Perkin Elmer (Shelton,

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

192 | *2.76. Extraction of polar phenolic extracts*

193 | A liquid-liquid extraction, performed according to Carrasco-Pancorbo et al. (2007),₂ was used to extract
194 | the phenolic compounds from EVOOs. The dried extract was dissolved with 5 mL of methanol/water
195 | (50:50, v/v) and an aliquot was filtered through a 0.45 µm filter (VWR, West Chester, PA, USA) before
196 | HPLC analysis. For spectrophotometric determinations, the extract was further diluted 1:5 (v/v) using the
197 | same mixture mentioned above. Three replicates were analyzed for each sample. The extracts for
198 | spectrophotometric assays were stored at -18°C before use.

199 | *2.87. Determination of total phenols and ortho-diphenols by a spectrophotometric method*

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

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

209 | *2.98. Determination of bitterness index*

210 | Evaluation of bitterness index (BI K_{225}) in polar extracts was carried out spectrophotometrically at 225
211 | nm according to Gutiérrez et al. (1992), with some modifications. The phenolic extract, obtained as
212 | described previously, was diluted (1:250) with methanol/water (50:50, v/v) solution and the absorbance at
213 | 225 nm was measured against a solvent reference in a 1-cm quartz cuvette. Three replicates were
214 | measured out for each sample.

215 | *2.109. Determination of phenolic compounds by HPLC-DAD/MSD*

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

218 degasser, autosampler, HP Diode Array UV-VIS Detector (DAD) and HP Mass-Spectrometer Detector
219 (MSD). A Zorbax Eclipse XDB-C₁₈ (Phenomenex, St. Torrance, CA, USA) column (5 µm particle size,
220 25 cm × 3.00 mm ID) was used. All analyses were carried out at room temperature. The wavelengths
221 were set to 280 nm and 330 nm. Quantification of phenolic compounds (tentatively identified by
222 comparing retention times, UV-VIS and mass spectra with pure standards and data present in literature)
223 was performed using calibration curves of 3,4-dihydroxyphenylacetic acid for compounds with maximum
224 absorption at 280 nm (Fluka, Buchs, Switzerland) (5–1000 mg L⁻¹, ~~r²=0.9987~~) and caffeic acid for
225 compounds having maximum absorption at 330 nm (Fluka, ~~Buchs, Switzerland~~) (5–1000 mg L⁻¹,
226 r²=0.9995). The gradient elution was carried out using the conditions described by Carrasco-Pancorbo et
227 al. (2007). The detection was made using quadrupole MS with an electrospray (ESI) interface operating in
228 positive ion mode within m/z 50-800 range and adopting the following conditions: drying gas flow, 9 L
229 min⁻¹ at 350°C; nebulizer gas pressure, 50 psi; capillary voltage, 3000 V. Nitrogen was used as both
230 nebulizer and drying gas. Three replicates were analyzed for each sample.

231 *2.1.10. Analysis of volatile compounds*

232 Volatile compounds present in the headspace of samples were concentrated by SPME
233 (~~DVB/Carboxen/PDMS fiber~~) and separated by gas chromatography coupled with quadrupole mass-
234 selective spectrometry using an Agilent 6890N Network gas chromatograph and an Agilent 5973
235 Network detector (Agilent Technologies, ~~Palo Alto, CA, USA~~). In particular, a 1.5 g amount of sample
236 was weighed into a 10 mL vial. The oil sample was spiked with 0.15 g of the internal standard 4-methyl-
237 2-pentanone (Sigma Aldrich), prepared in refined olive oil at a concentration of 5 µg g⁻¹. The vial was
238 fitted with a silicone septum, placed in a water bath at 40°C (± 2°C) and here maintained under magnetic
239 stirring for 2 minutes. Then, a divinylbenzene/carboxen/polydimethylsiloxane (DVB/CAR/PDMS) SPME
240 fiber (50/30 µm, 2 cm long, from Supelco Ltd., Bellefonte, PA, USA) was exposed to the sample
241 headspace for 30 min and immediately desorbed for 3 min at 250°C in the gas chromatograph injector
242 port. Volatile compounds were separated on a ZB-WAX column (30 m, 0.25 mm i.d., 1.00 µm film
243 thickness, (Phenomenex). Column temperature was held at 40°C for 10 min and increased to 200°C (held
244 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
245 ion source and the transfer line temperatures were set at 230°C and 250°C, respectively. Electron impact
246 mass spectra were recorded at 70 eV ionization energy in the 30-250 amu mass range at 2 scans s⁻¹. The
247 identification of volatile compounds was first carried out by comparison of their mass spectral data with
248 the information from the National Institute of Standards and Technology (NIST) library (2005 version)

249 and later checked with pure standards. Relative amounts of volatile compounds were expressed as mg of
250 internal standard (4-methyl-2-pentanone) per kg of oil, according to the analytical protocol described by
251 Baccouri et al. (2008). Quantification of volatile compounds was carried out as a sum of specific classes
252 and single volatile compounds associated with flavor (aldehydes C₆, alcohols C₆, esters C₆, ketones C₅,
253 alcohols C₅, pentenic dimers, hydrocarbons, terpenes) and off-flavor compounds that mainly contribute to
254 sensory defects (winey: methyl acetate, ethyl acetate, methanol, ethanol and acetic acid; fusty-muddy: 3-
255 methyl-1-butanol acetate, 1-butanol, 2-methyl-1-butanol; musty: octanoic acid, octane, 1-octanol; rancid:
256 sum of saturated aldehydes, unsaturated aldehydes, furans, 6-methyl-5-hepten-2-one, butanoic acid and
257 hexanoic acid). All determinations were carried out in triplicate.

258 | 2.1.2.4. Statistical analysis

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

264 | 3. Results and Discussion

265 | 3.1. Sensory evaluation by the trained Panel

266 None of the samples included in this study presented any sensorial defects (EC Reg. 640/2008), and thus
267 all samples were classified as EVOO. The intensity of the most important positive sensory attributes
268 (fruity, bitter, pungent) evaluated by the Panel showed some differences among the analyzed samples
269 (Fig. 1) and allowed to describe EVOOs with the optional terms that could be used for labeling (EC Reg.
270 640/2008): with regard to fruity, there was a first group with medium intensity of this attribute (S2, S3,
271 S4, S6, S7, S8) and a second one with light intensity (S1, S5). S6 showed the highest intensity of fruity
272 (6.0), which is the limit value to define medium and intense levels. In terms of bitter and pungent
273 intensities, samples showed a similar trend: S1 and S6 were characterized by light intensities of these
274 attributes, while samples S3, S4, S5 and S7 were judged to have medium intensity. The exceptions were
275 samples S2 and S8, which showed an intense perception of bitter taste (6.1 and 6.4, respectively). In
276 summary, S6 was characterized by the highest intensity of fruity, green and other positive attributes
277 perceived by smell but, on the other hand, this sample was low in bitter and pungent taste; S8 was
278 characterized by the highest intensities of bitter and pungent taste and had medium intensities of fruity

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

281 3.2. Hedonic sensory analysis by consumers

282 ~~On the same set of samples analyzed by the IOC Panel test, a sensory acceptance test was also carried out~~
283 ~~in an Italian supermarket (Liguria region) with a group of 60 consumers. They were split into two~~
284 ~~subgroups based on high (heavy users) or low frequency (light users) of organic food consumption~~
285 ~~(according to their answer about frequency of consumption as “several times a week or more” and~~
286 ~~“several times a month or less”, respectively). The consumer group consisted of 70% heavy users and~~
287 ~~30% light users; regarding sex, 57% were female and 43% male; the main age groups were from 20–50~~
288 ~~years (20–30 years old, 30%; 31–40, 30%; 41–50, 28%), whereas consumers older than 50 years old were~~
289 ~~less represented (51–60, 7%; 61–80, 5%).~~ Considering data related to consumer preferences expressed in
290 the blind session (Fig. 2a), S6 (conventional) and S1 (organic) were significantly more liked than S2 and
291 S8, which were the least liked. The overall liking registered for S7 (conventional) was not significantly
292 different from the mean value obtained for S6. S1 and S7 were again proposed in the informed test with
293 the opposite information (the organic S1 was indicated as conventional and the conventional S7 was
294 passed off as organic). Significant differences were found for overall liking in the blinded versus
295 informed test: S6 and S1 were characterized by significant lower values of overall liking in the informed
296 test compared with the blind one; S3, S2 and S8 showed the opposite trend, so that the overall liking was
297 higher in the informed test. When S1 was labeled as conventional it was significantly better liked than S7
298 when it had been labeled as organic. For the other samples, no significant differences were found.

299 Observing the mean of the overall liking scores given by the judges with different frequency of organic
300 food consumption (heavy or light users), a slightly tendency of light users to score less than heavy users
301 in both conditions (blinded and informed) was seen (Fig. 2b3). In the informed test, when S1 was labeled
302 as conventional, both heavy and light users scored higher. On the other hand, when S7 was labeled as
303 organic there were no clear difference concerning overall liking. Also while the number of interviewed
304 consumers was limited, the results indicated that organic farming information did not affect the judgment
305 of consumers surveyed, who, however, differentiated and rewarded only the products that best met their
306 expectations concerning the sensory characteristics of the products. It is possible that this result may also
307 be due to the test situation in which consumers are forced to evaluate sensory quality of the products,
308 whereas in the real purchase conditions at the grocery or supermarket they may be more influenced by
309 information contained on the labels.

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

315 3.3. Quality indices

316 The values of chemical quality parameters are presented in Table 23. Concerning the FA, K_{232} , K_{270} and
317 ΔK , all samples showed values under the respective limits fixed for EVOOs (EU Reg. 61/2011); PV were
318 also generally under the limits, except for S4 which presented a higher content (around 28 meq O_2 kg^{-1}
319 oil) than the limit for EVOOs, suggesting poor oxidative status. Fatty acid composition (Table 34) of all
320 EVOOs was generally characterized by a high percentage of monounsaturated fatty acids (MUFA, 73.8-
321 75.6%) and relatively low percentage in saturated fatty acids (SFA, 15.6-16.6%) and polyunsaturated
322 (PUFA, 8.6- 9.8%), according to the typical range for EVOOs (EU Reg. 61/2011).

323 3.4. Phenolic compounds

324 The amount of phenolic compounds is fundamental to assess the quality of EVOO due to their
325 involvement in protection from oxidation and their contribution to bitter and pungency (Bendini et al.,
326 2007). The concentration of total phenols, *o*-diphenols (calculated using gallic acid calibration curves,
327 respectively with $r^2 = 0.997$ and $r^2 = 0.994$, see paragraph 2.8) and bitter index (BI K_{225}) are presented in
328 Table 23. Samples S2, S3, S4, S5 and S8 can be considered as “medium rich” in phenolic compounds
329 with values higher than 200 $mg\ kg^{-1}$ but lower than 500 $mg\ kg^{-1}$ (according to the range proposed by
330 Montedoro et al., 1992); in particular, it should be noted that the sample S8, obtained from olives of the
331 Coratina variety (typical of the south of Italy), was characterized by the highest presence of these
332 compounds (428.1 $mg\ gallic\ acid\ kg^{-1}$). On the other hand, S6 showed the lowest concentration of total
333 phenolic compounds and, according to the sensory results from the trained Panel, was rated as one of the
334 least bitter EVOO (Fig. 1). By evaluating the total phenolic content of a set of 30 samples of EVOO
335 purchased in the Italian market, similar results were recently obtained by Caporaso et al. (2015). The *o*-
336 diphenols content showed a trend similar to total phenols and ranged from 46.6 (S4) $mg\ kg^{-1}$ to 114.0 (S8)
337 $mg\ kg^{-1}$. Bitter index (BI K_{225}) values followed the same pattern as total phenol and *o*-diphenol,
338 confirming that the phenolic fraction of EVOO is mainly responsible for the bitter taste.

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

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

355 3.5. Volatile profile

356 The volatile compounds identified and quantified in the headspace of EVOOs are reported in Table 34,
357 and divided into positive flavors and off-flavors compounds. Among the C₆-LOX aldehydes, generally
358 associated with positive sensory notes like “green”, “almond” and “cut grass” (Aparicio and Morales,
359 1998; Morales et al., 1996), the most representative were (Z)-3-hexenal and (E)-2-hexenal. Sample S5,
360 judged by the Panel as the EVOO with the lowest intensity of fruity and devoid of green notes (Fig. 1),
361 showed the lowest content in the C₆-LOX aldehydes, and in particular (E)-2-hexenal. Sample S7, showing
362 a high value for C₆ aldehydes, was one of the EVOOs of the set with the highest intensity of fruity
363 (together with S6) according to the Panel results. Sample S8 was the richest in (E)-2-hexenal and
364 characterized by a medium intensity of fruity (Fig. 1) but with poor acceptability by consumers (Fig. 2a)
365 who perceived it as too bitter (Fig. 34). On the other hand, the concentration of C₆-LOX alcohols
366 (hexanol, (Z)-3-hexenol (E)-2-hexenol) and C₆-LOX esters (hexyl acetate, (E)-2-hexenyl acetate, (Z)-3-
367 hexenyl acetate), both related to several positive notes of EVOOs (Kalua et al., 2007), were quantitatively
368 low in all the examined samples. Considering the C₅-LOX ketones, the content in 3-pentanone (data not
369 shown) was significantly higher in the samples that were more liked by consumers (S1, S6 and S7), but
370 also in S8, that was the least well accepted in blind tests (Fig. 2a). As already explained, the low value of
371 the overall-liking of S8 was due to its high intensity of bitterness. Sample S5, characterized by a poor

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

378 3.6. Principal component analysis

379 Phenolic compounds, the volatile molecules responsible for pleasant notes, and the positive attributes
380 assessed by trained tasters were elaborated by principal component analysis (PCA) and showed as vectors
381 in a plane composed of four quadrants (Fig. 45a and 45b). The first two components were responsible for
382 76.5% of variance (45.7% for F1 and 30.8% for F2). As seen in Fig. 45a, it is possible to highlight that
383 Oagl, DOA, DLA, hexanal and 1-penten-3-one, as well as bitter and pungent perceived by trained judges
384 (IOC Panel test) were distributed in the first quadrant. In the second quadrant, fruity, green and positive
385 sensations and the main volatile compounds related to positive flavors of EVOOs can be found: C₆-LOX
386 compounds ((E)-2-hexenal, hexyl acetate, 1-hexanol, (E)-2-hexenol) and C₅-LOX compounds (3-
387 pentanone, 1-penten-3-ol, (Z)-2-penten-1-ol). In the third quadrant, opposite to the first, (Z)-3-hexen-1-ol
388 was present, while (Z)-3-hexen-1-ol acetate and Lagl was placed in the fourth quadrant. Fig. 45b shows a
389 projection on the plane of all samples. The approximate position of the product near sensory
390 attribute/chemical parameter vector(s) allows for the assumption that the product expresses these
391 attribute/chemical substances. Therefore, S8 is located between the first and the second quadrant and it is
392 characterized by the richest content in phenolic and "positive" volatile compounds (Tables 2 and 33-4) as
393 well as by high intensity of bitter, pungent, fruity, green and other positive notes perceived by odor (Fig.
394 1). The position of sample S6, between the second and third quadrant, reflects the high content in (Z)-3-
395 hexen-1-ol and the low content of phenolic compounds responsible for bitter and pungent. The presence
396 of sample S5 in the fourth quadrant is mainly due to the low intensities of positive olfactory sensations.
397 Moreover, positive correlations exist between DOA and DLA with the attributes bitter (0.910, $p < 0.05$)
398 and pungent (0.899, $p < 0.05$) while, considering the volatile compounds, a positive correlation (0.712, p
399 < 0.05) between green notes and 1-penten-3-ol was found. The PCA results also show that the considered
400 parameters (phenolic compounds, volatile molecules responsible for pleasant notes and positive sensory
401 attributes) were not effective to discriminate EVOOs produced by different agricultural methods (organic
402 and conventional).

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403

404 3.7. Preference map

405 The results of sole sensory analysis, obtained by both trained judges and consumers (overall liking
406 evaluated in blind tests), can be summarized in a preference map (Fig. 56) that clearly showed that S1, the
407 least bitter and pungent sample, was also the most liked, and that S2 and S8 (the most bitter and pungent)
408 were the least liked by the consumers: according to other authors (Delgado and Guinard, 2011; Recchia et
409 al., 2012), consumers preferred EVOOs characterized primarily by sweet taste and low intensity of
410 bitterness and pungency. It is highly likely that they are unaware that these attributes are linked to
411 richness in phenolic compounds, which are responsible for some of the healthy characteristics of EVOO
412 (EU Reg. 432/2012). Such a lack of knowledge about high quality EVOOs was also confirmed
413 considering samples S6, S8 and S5. In fact, only a moderate degree of appreciation for the pleasant
414 olfactory notes was demonstrated by the consumers' preference. Sample S6 was characterized by the
415 highest intensity of fruity, green and other positive olfactory sensation, but poor in bitter and pungent
416 taste (Fig. 1); it was positioned where the majority of consumers (60–70%) have a preference and
417 acceptability above average. On the other hand, sample S8 was one of the most bitter and pungent and
418 showed medium intensities of fruity and positive olfactory sensations; it was placed in an area where only
419 20–30% of consumers have a preference above average. Moreover, sample S5, which was characterized
420 by low intensities of all positive attributes, was appreciated by consumers, reaching 50–60% of above
421 average overall liking.

422 4. Conclusions

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

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

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

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

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

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460

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567

568 **Figure captions**

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

571

572 **Fig. 2.** (a) Comparison of overall liking results (n = 60): blinded versus informed consumers data (results
573 marked with an asterisk differ significantly). Samples are shown listed in decreasing order according to
574 the degree of overall liking expressed during the blinded session. S1 (organic); S2 (conventional); S3
575 (organic); S4 (organic); S5 (conventional); S6 (conventional); S7 (conventional); S8 (organic). BL =
576 blind test; IN = informed test; conv = conventional; org = organic (b) comparison of overall liking
577 results: heavy (n = 42) and light users (n = 18) both in informed test. HU = heavy users; LU = light users.
578 Conv = conventional; org = organic. Results marked with an asterisk differ significantly, Fisher LSD, $p <$
579 0.05 .

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580

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

585

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

589

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

593

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

596

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

Table 1. Information, features and coding of extra virgin olive oil (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	<i>o</i> -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); K₂₃₂, K₂₇₀ (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 K₂₂₅ (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 C₆	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 C₆	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 C₆	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 C₆ 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 C₅	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 C₅	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 C₅ 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 (C₅-LOX and C₆-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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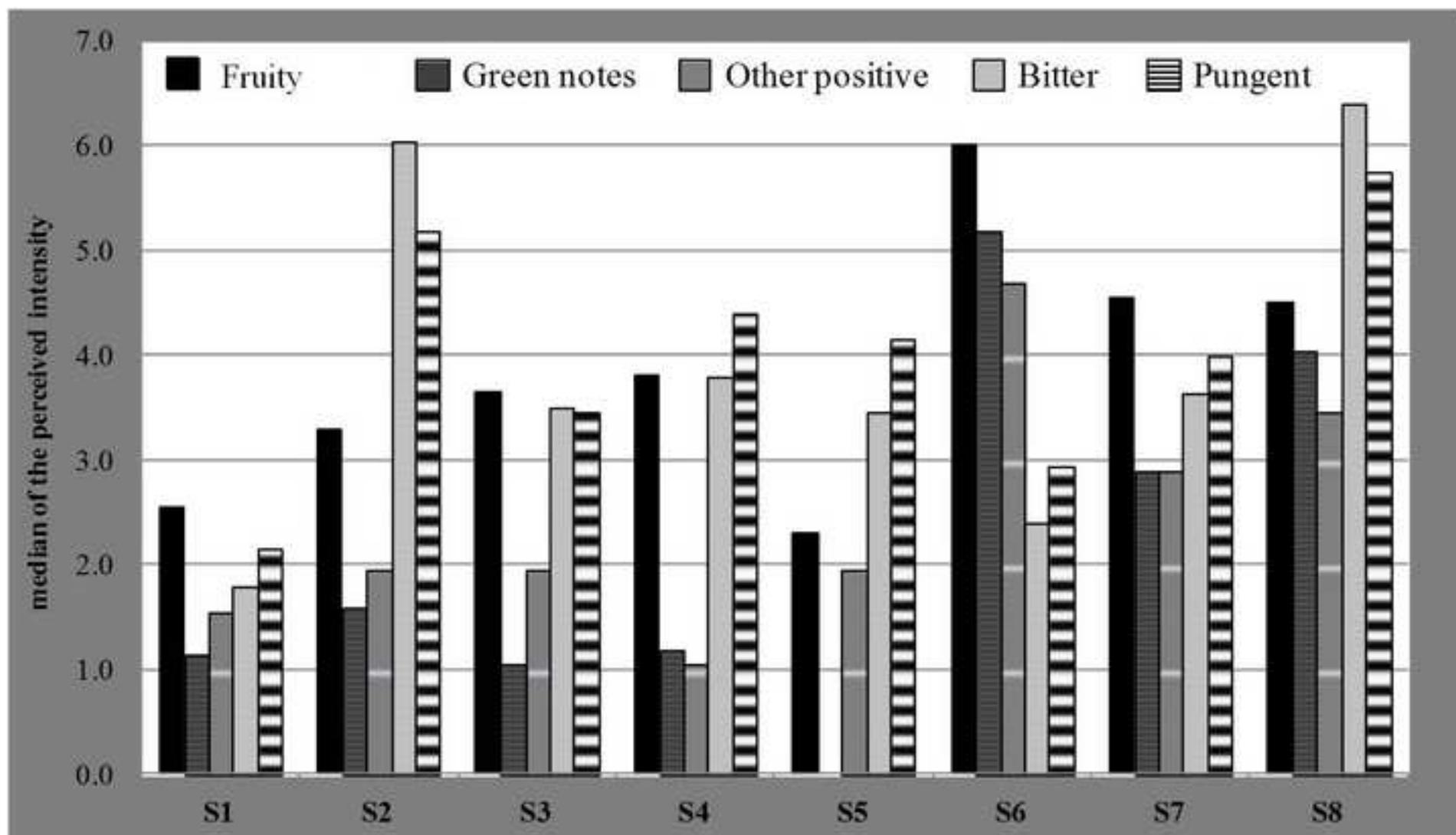


Figure 2
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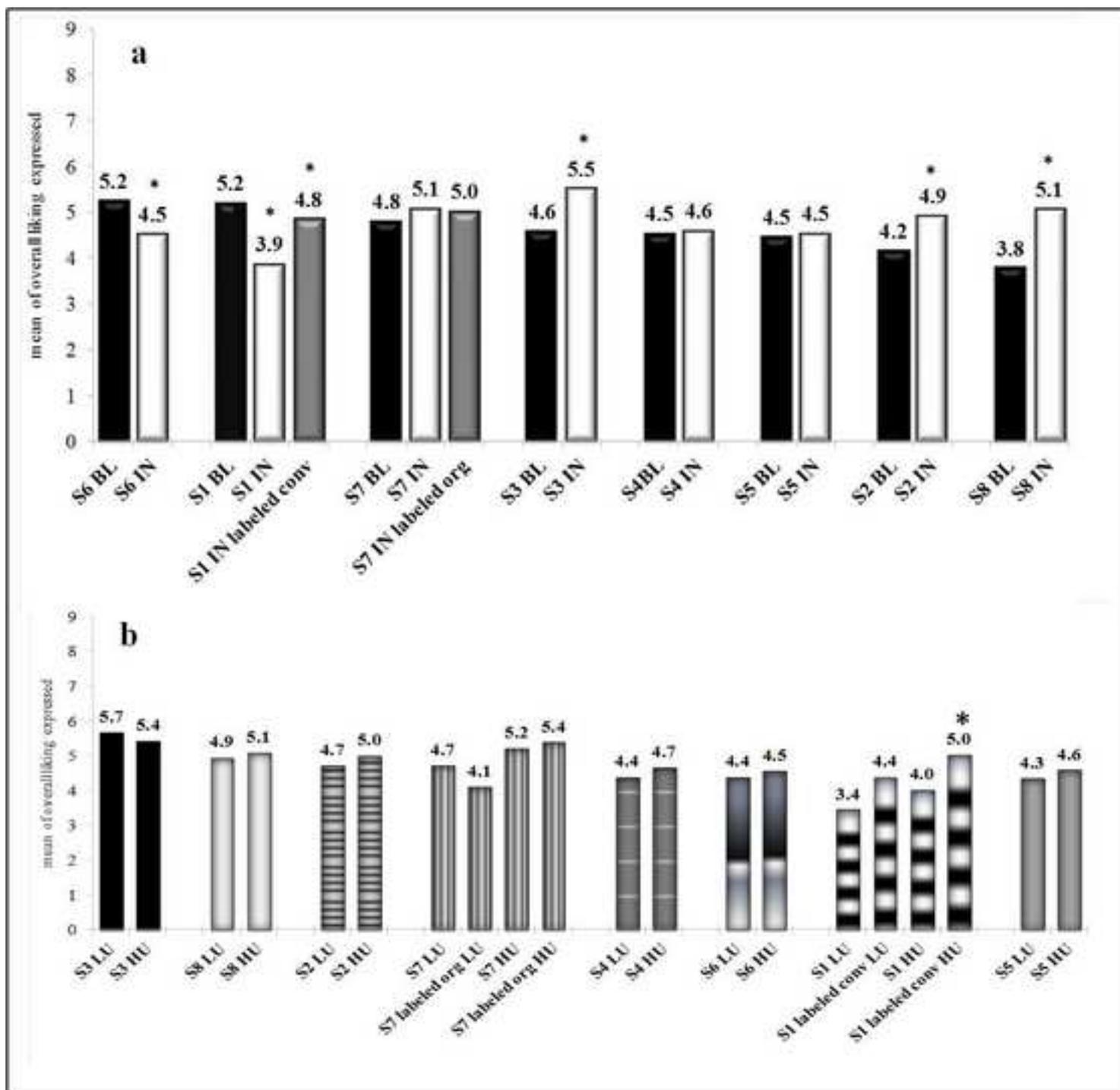


Figure 3
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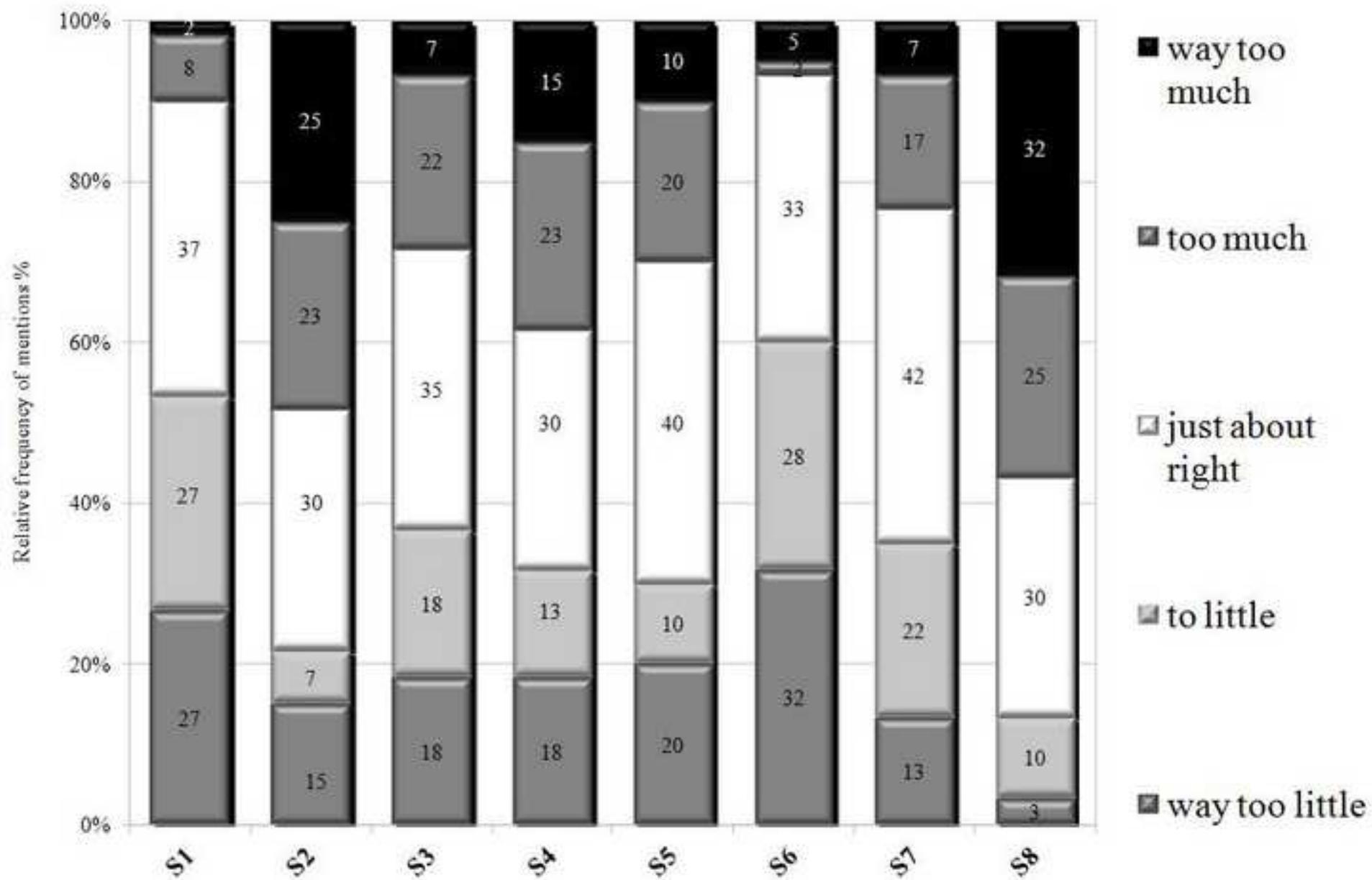


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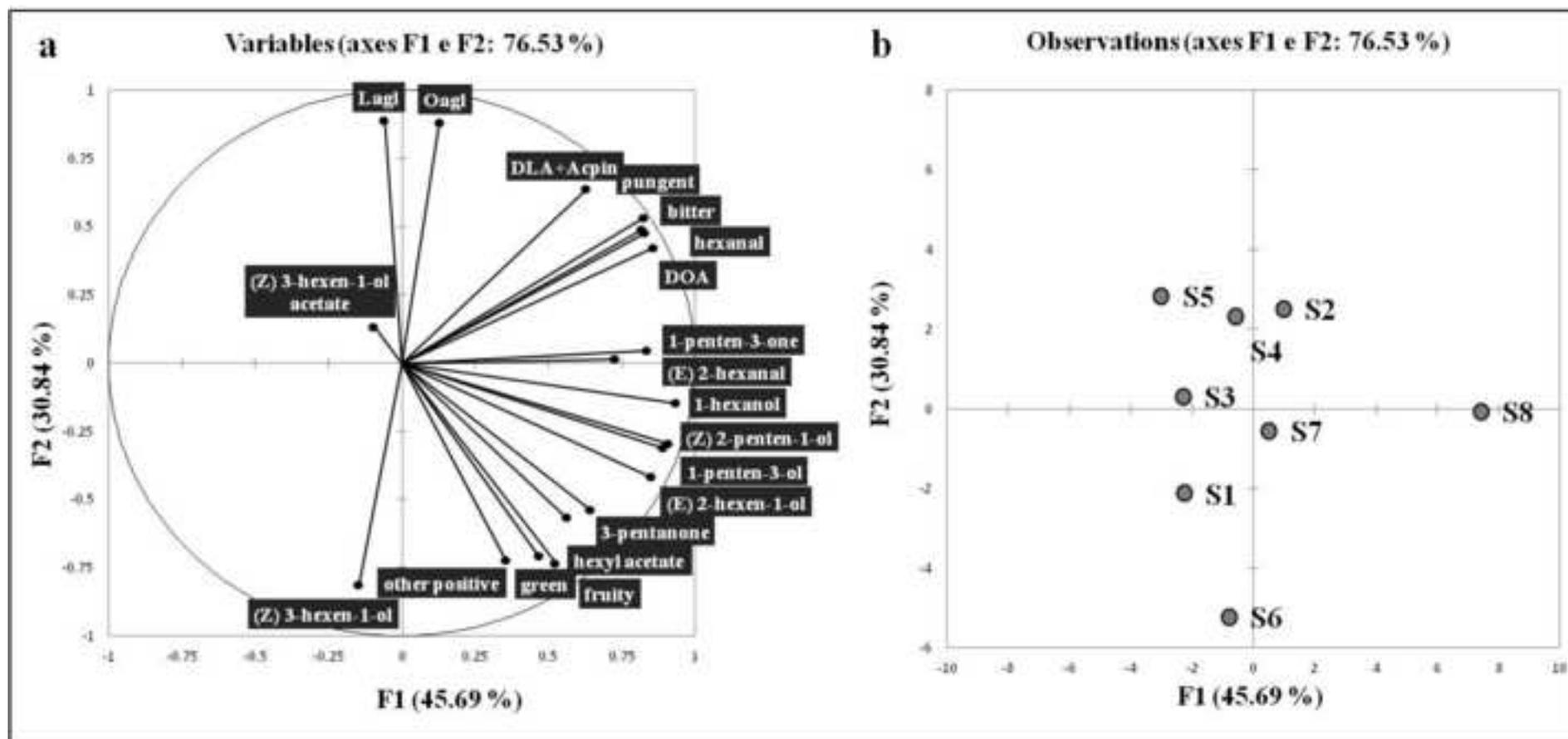


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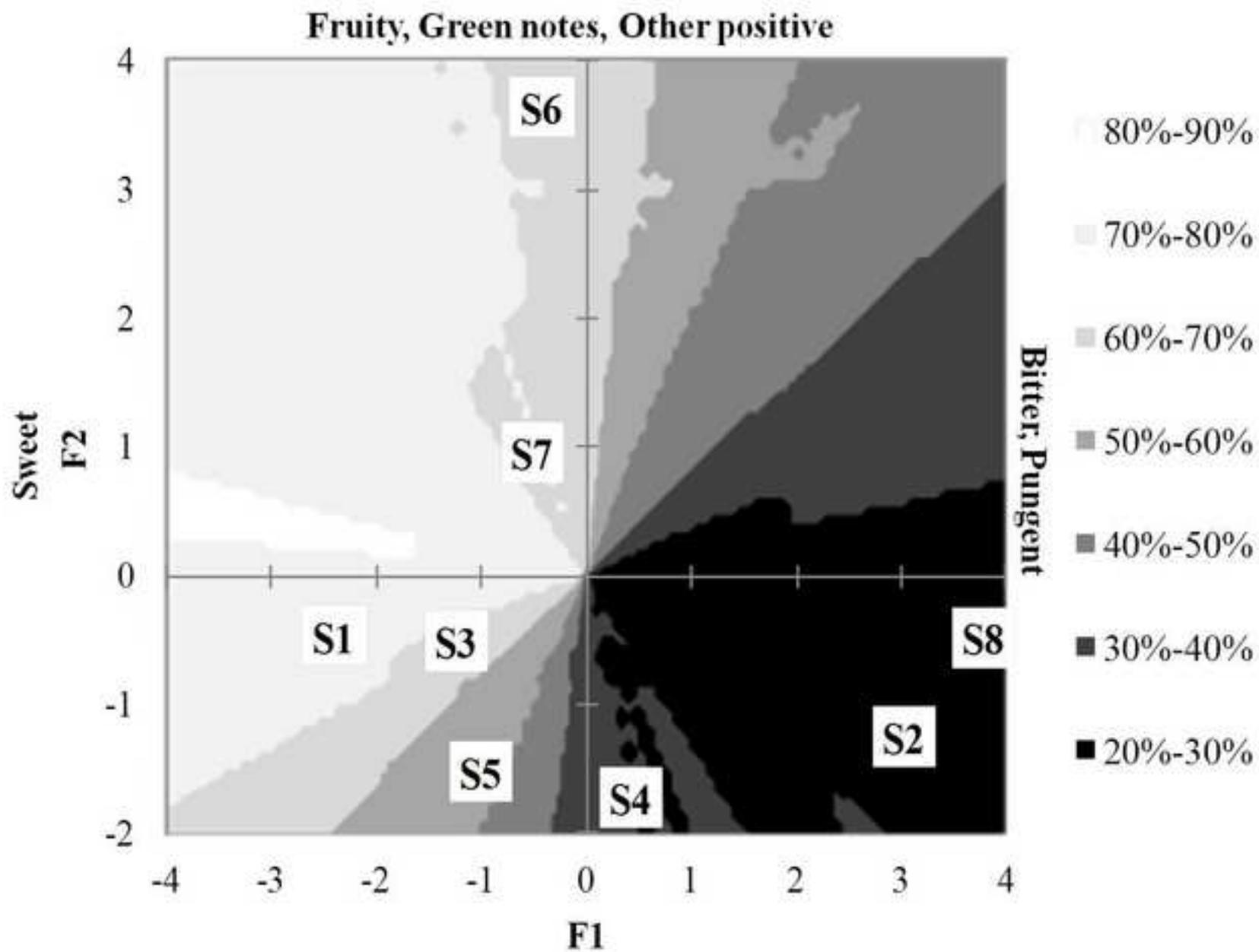


Figure captions

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).

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 ~~-~~ sweet taste