Effect of Mixing Leaves with Olives on Organoleptic Quality of Oil Obtained by Centrifugation

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ABSTRACT: Variable quantities of leaves were added to ripe olives prior to extraction to determine their effect on the quality of the resulting olive oil. The addition of 1–3% w/w leaves improved the organoleptic quality. An increase in *trans*-2-hexenal aldehyde content occurred, giving the pleasant flavor of "freshly cut grass." This compound was produced by the enzymatic breakdown of 13-L-hydroperoxide of linolenic acid in leaf homogenates.

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KEY WORDS: Metal crusher, mixed olives-leaves, olive oil quality.

Olive oil is extracted from olives by either pressure or centrifugation methods. In a pressure extraction system, olives are crushed with a stone mill, and it is not necessary to remove the leaves. Because leaves are only partially crushed in the process, they do not significantly affect organoleptic characteristics of the oil. With centrifugation, olives are generally ground by a metal crusher, which effects violent fruit breakage, especially if a "fixed hammer" type is used. In this latter process, defoliation is both desirable and necessary. Leaves could cause mechanical problems associated with the flow of olive paste and add an excessive leafy flavor to the oil. Such oil, especially if obtained from unripe olives, has a rather aggressive fruity and unpleasant taste. The presence of leaves only worsens the organoleptic characteristics of that oil. Conversely, oil obtained from ripe olives is lightly aromatic because substances that confer a typically fresh and herbal flavor tend to disappear in the course of ripening (1,2). Incorporating leaves prior to crushing may further enhance flavor of such oils. Here we report results of an experiment designed to measure effects that varied amounts of leaves, added to ripe olives, have on the chemical and organoleptic properties of the olive oil and its stability and on the mechanical aspect of the oil extraction process.

METHODS

Ripe olives from the cv (cultivar) "Dritta" and a "Leccino-Castiglionese" mixture (1:1) were harvested in December–January. After picking, olives from each cv were divided into five 300-kg lots. The following percentages of olive leaves by weight (treatments) were added to separate lots: 0 (control), 1, 2, 3, and 5%. These were fresh leaves, separated from each cv at picking and then added when the olives were fed into the crusher. The experimental "mixes" of olives and leaves were crushed with a "fixed hammer," metal crusher, and the resulting paste was kneaded for 60 min at 24°C. The paste was then centrifuged in a horizontal decanter at a flow of 550 kg/h, using 350 L/h water at 22°C (we used a continuous centrifuge manufactured by Pieralisi, Jesi, Italy). Oil from the oily must was separated with an automatic discharge vertical centrifuge.

The following analytical determinations were carried out on oil samples of each treatment from each cv: acidity; peroxide value and spectrophotometric absorption in the ultraviolet (UV) region (3); total polyphenols (4) and *o*-diphenols (5) from the solution after extraction with methyl alcohol; induction time, measured by Rancimat apparatus (6); chlorophyll pigments (7); and high-resolution gas-chromatographic analysis of volatile substances at 37°C extracted by nitrogen flow, concentrated on activated carbon, and eluted with diethyl ether (8).

The olfactory, gustatory, tactile, and kinesthetic perceptions of olive oil samples were evaluated in an isolated sensory panel room at 21 ± 1°C, according to EC standardized method (3) by eight experienced tasters, who were skilled in recognizing, identifying, and quantifying the sensory attributes of virgin olive oils. The oil samples (15 mL each) were presented in covered blue glasses (diameter, 70 mm; capacity, 130 mL) at 28 ± 2°C. The glass was warmed and, after removing the cover, the sample was smelled and then tasted, by the panelist to judge its flavor. The different attributes of the oils were assessed, and their intensities were evaluated to produce a score between 1 and 9. Results obtained from the eight panelists were averaged.

RESULTS AND DISCUSSION

Mixing leaves and olives at all tested percentages caused no mechanical problems in the flow of olive paste through the pump when crushed with a fixed hammer metal crusher. Such a crusher reduces leaves to small pieces that become well amalgamated with the olive paste.

The usual analytical determinations, carried out on oils arising from direct centrifugation of pastes with different percentages of leaves, are presented in Table 1. Free acidity, peroxide value, and specific absorptions in the UV region were not

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TABLE 1
Effect of Leaves on the Chemical Characteristics of Virgin Olive Oils

Variety	Leaves (%)	Free acidity (as oleic acid %)	Peroxides value (meq O_2/kg)	Polyphenols (as ppm of caffeic acid)	*o*-Diphenols (as ppm of caffeic acid)	Induction time (h)	Chlorophyll pigment (ppm)	K_{232}	K_{270}
Dritta	0	0.66	8.1	56	22	7.2	3.7	2.01	0.12
	1	0.76	9.0	56	19	6.7	5.6	1.88	0.11
	2	0.64	7.2	63	20	7.1	6.0	1.84	0.11
	3	0.70	8.8	61	28	6.7	6.8	1.95	0.13
	5	0.62	8.4	69	26	7.0	8.7	1.99	0.12
Leccino	0	0.54	4.2	69	18	8.0	3.4	1.43	0.07
+	1	0.63	4.8	66	20	8.2	5.5	1.51	0.09
Castiglionese	2	0.61	4.6	68	18	8.2	6.6	1.53	0.09
	3	0.58	4.9	68	22	8.7	8.4	1.57	0.10
	5	0.56	5.2	71	23	8.2	12.1	1.66	0.12

affected by leaves added in any percentage to the olives, regardless of cv; the parameters depended on the quality of the olives. Addition of leaves also did not affect total polyphenols, *o*-diphenols, or induction time. The phenolic substances are present in leaves as glycosides, soluble in water but not in oil.

The results confirm those previously reported by Solinas *et. al.* (9). The processing technique under study instead affected chlorophyll pigment content. Use of a fixed hammer metal crusher increased breakage of the leaf cells, thereby releasing their chlorophyll and pheophytin content.

Furthermore, the addition of leaves brings about a significant influence on the organoleptic evaluation of the oil (Table 2). In fact, virgin olive oils obtained from olives with leaves show higher intensities of "green fruity" and "bitter taste." For this reason, control samples (without leaves) were classified as "virgin" olive oils as a consequence of defects evidenced by a flattening of the flavor. The addition of leaves, even in amounts as low as 1–2%, resulted in oils classified as "extra virgin," an improvement in both taste and commercial rating.

Some volatile compounds, expressed as ppm 1-nonanol, of oils from each cv, processed as described, are presented in Table 3. The ratio of 2-hexenal/hexanal, an important measurement in evaluating virgin olive oil quality (8), also is presented. As an example, aromagrams of the oils obtained from olives of cv "Leccino-Castiglionese" processed with 0 and 3% leaves are presented in Figure 1.

Oils resulting from samples without added leaves contained small quantities of 2-hexenal due to advanced maturity of the fruits (10) (Table 3). This aldehyde is responsible for the pleasant aroma of "freshly cut grass" and is the most plentiful component of substances that give oil its characteristic flavor; its content is always high in fresh and good-quality oil and is correlated with the intensity of the aromatic properties of an oil. An oil rich in aroma is considered of better quality. Recently, it has been found that a compound that contributes to the "green" flavor of olive oil is *cis*-3-hexenal (11), which usually is present in small quantities due to molecular isomerization to *trans*-2-hexenal. However, we were unable to separate *cis*-3-hexenal in our analyses because other substances had the same retention time.

Increasing the percentage of leaves did not distort the aroma of the oil. Analyses of the volatile components of the oil, in fact, show no newly formed substances or considerable changes in the majority of volatile components. An exception is a noticeable increase in the *trans*-2-hexenal, hexanal content, and some alcohols, such as *cis*-3-hexenol, *trans*-2-hexenol, and 1-hexanol (Table 3). Such an increase could be explained by release of chloroplasts from crushing olive leaves. It has been shown (12–14) that enzymatic conversion of 13-*L*-hydroperoxides from linoleic and linolenic acids to *cis*-3-hexenal, *trans*-2-hexenal, hexanal, and corresponding alcohols occurs primarily in lamellae of chloroplasts (Scheme 1).

Increasing *trans*-2-hexenal content, directly correlated with the quality of virgin olive oil, is more noticeable as the percentage of leaves added to olives prior to crushing is increased. This

TABLE 2
Effect of Leaves on the Organoleptic Characteristics of Virgin Olive Oils

Olive variety	Leaves added (%)	Organoleptic determinations: Green fruity	Organoleptic determinations: Bitter taste	Organoleptic evaluation (panel test)
Dritta	—	—	—	6.0
	1	0.2	0.1	6.4
	2	1.0	0.4	6.7
	3	1.2	0.5	6.9
	5	1.2	0.5	6.5
Leccino	—	—	—	6.3
+	1	0.8	0.3	6.6
Castiglionese	2	1.3	0.5	6.7
	3	1.6	0.8	7.2
	5	1.6	0.8	6.8

TABLE 3
Effect of Leaves on the Volatile Compounds (ppm of 1-nonanol) of Headspace of Virgin Olive Oils

Variety	Leaves (%)	Pentanal + 3-pentanone	Hexanal	*Iso*-butyl alcohol	1-Penten-3-ol	*Iso*-amyl alcohol	*trans*-2-Hexenal	Amyl alcohol	2-Penten-1-ol	1-Hexanol	*cis*-3-Hexen-1-ol	*trans*-2-Hexen-1-ol	*trans*-2-Hexenal/Hexanal
Dritta	0	21.4	16.7	2.7	12.0	12.8	77.8	1.4	4.3	9.8	4.3	17.4	4.6
	1	19.7	17.0	3.2	12.2	9.4	95.6	1.1	5.1	12.6	12.9	20.2	5.6
	2	28.6	17.6	4.1	13.2	12.4	122.6	1.8	6.7	23.7	18.6	34.7	7.0
	3	23.2	14.9	4.2	12.1	13.0	130.7	1.7	7.2	28.2	19.3	41.0	8.8
Leccino	5	23.5	26.9	3.3	12.1	12.3	171.1	1.8	8.5	23.7	17.0	49.9	6.4
+	0	8.9	23.2	4.2	4.4	7.3	130.5	0.4	2.2	9.9	2.2	9.5	5.6
Castiglionese	1	9.3	22.4	3.5	5.2	6.4	202.6	0.4	3.3	11.0	2.8	13.6	9.0
	2	8.2	25.3	3.4	5.1	7.7	241.7	0.4	3.3	11.7	3.3	13.8	9.6
	3	8.3	26.9	3.5	4.6	7.8	288.0	0.4	3.4	10.8	3.6	14.1	10.7
	5	8.6	34.4	2.9	4.4	6.4	287.1	0.3	4.7	13.0	5.8	18.9	8.4

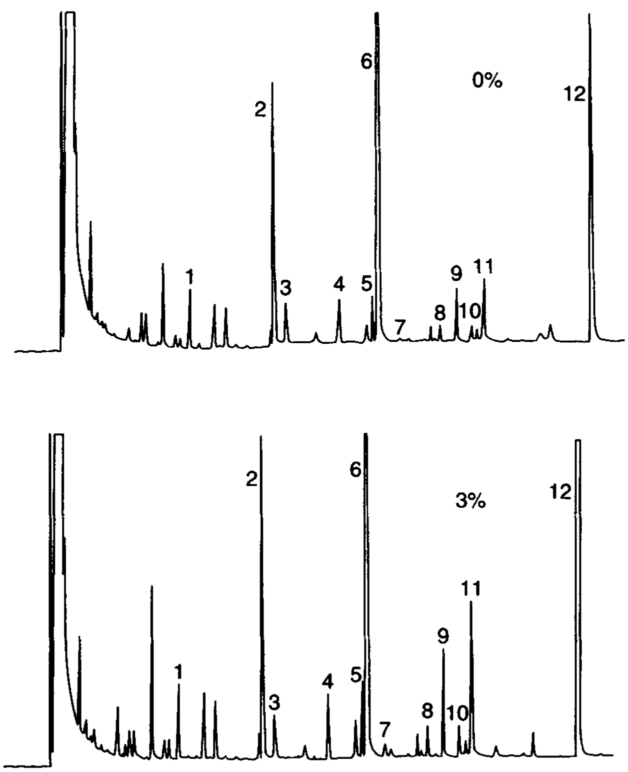
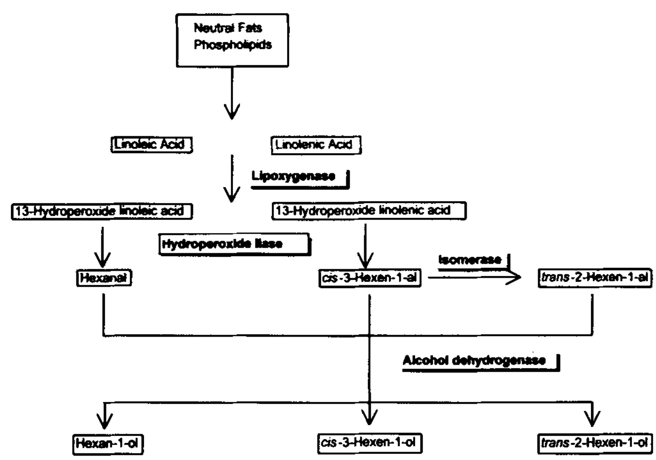


FIG. 1. Aroma high-resolution gas-chromatographic analysis of olive oil from cultivar "Leccino-Castiglionese" processed with 0 and 3% leaves. Peaks: 1 = pentanal + 3-pentanone; 2 = hexanal; 3 = *iso*-butyl alcohol; 4 = 1-penten-3-ol; 5 = *iso*-amyl alcohol; 6 = *trans*-2-hexenal; 7 = amyl alcohol; 8 = 2-penten-1-ol; 9 = 1-hexanol; 10 = *cis*-3-hexen-1-ol; 11 = *trans*-2-hexen-1-ol; and 12 = 1-nonanol (internal standard).



SCHEME 1

unsaturated aldehyde confers a greater freshness and liveliness to the oil.

Indeed, the taste panel found a quality improvement in oil when the percentage of leaves added to olives was increased, even though there was a slight decrease in the evaluation of oil obtained from olives containing 5% leaves. This result can be explained by the increase in the content of hexanal, an aldehyde unpleasant to taste (Scheme 1). Therefore, when evaluating olive oil quality, it is important to study the ratio between *trans*-2-hexenal and hexanal content. This ratio increases significantly as the percentage of leaves is increased up to 3%, according to results of organoleptic evaluation.

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