GRASAS Y ACEITES, 63 (2),
ABRIL-JUNIO, 223-230, 2012,
ISSN: 0017-3495
DOI: 10.3989/gya.095811

Effect of drying, chemical and natural processing methods on black *Biancolilla* olives

By **F.V. Romeo**[a, b], **A. Piscopo**[c] and **M. Poiana**[c]

[a]*CRA* - Fodder and Dairy Productions Research Centre (FLC), Viale Piacenza 29, 26900 Lodi, Italy
[b]*CRA* - Olive growing and olive oil industry Research Centre (OLI), C.da Li Rocchi, 87036 Rende (CS), Italy
[b]*BIOMAA* - Department of Biotechnologies for Agricultural Food and Environmental Monitoring, Mediterranean University of Reggio Calabria, C.da Melissari, 89124 (RC), Italy
*Corresponding author: floravaleria.romeo@entecra.it

RESUMEN

Efecto del secado y de los métodos químicos y naturales para el procesamiento de aceitunas negras *Biancolilla.*

En el presente trabajo se han evaluado los efectos de los diferentes tratamientos de secado y salado para aceitunas pigmentadas *Biancolilla*. La variedad de aceituna seleccionada es considerada la típica de Sicilia y fue cosechada en el estadío de pigmentación. Los datos morfolóficos revelan su buena calidad como aceituna de mesa. Se ha aplicado a las muestras una fermentación preliminar. La mitad de ellas se secaron, mientras que las restantes fueron sometidas a tres tratamientos diferentes con lejía y procesos oxidantes. Después del lavado, las aceitunas se almacenan mediante una fermentación natural o proceso de secado, con o sin un pretratamiento de gluconato de hierro. Los pasos de fermentación y oxidación condicionan las características higiénicas del producto final afectando al valor del pH de la salmuera. El uso de la sal de hierro para mejorar la velocidad de oscurecimiento de las aceitunas procesadas influyó sobre los parámetros del color como se esperaba. La oxidación y la adición de la sal de hierro afectó a la textura de las aceitunas secas haciéndolas más blandas que las secadas directamente. Los resultados sugieren que la variedad *Biancolilla* es adecuada para la fermentación en salmuera, sin ningún tratamiento, tal como la oxidación.

PALABRAS CLAVE: Aceitunas de mesa – Biancolilla – Color – Fermentación natural – Secado – Textura.

SUMMARY

Effect of drying, chemical and natural processing methods on black *Biancolilla* olives.

In the present work, the effects of different drying and brining treatments on pigmented Biancolilla olives were evaluated. The olive cultivar considered is typical of Sicily and was harvested at pigmented state. The carpological data revealed its good quality as table olives. A preliminary fermentation in brine was applied to the samples. Half of the samples were dried whereas the remaining olives were subjected to three different lye treatments and oxidation steps. After washing, the olives were stored according to a natural fermentation or drying process with or without a pretreatment of iron gluconate. The fermentation and oxidation steps conditioned the hygienic characteristics of the final product affecting the pH value of the brine. The use of iron salt for improving the darkening rate of processed olives influenced the color parameters as expected. The oxidation and the addition of iron salt affected the texture of dried olives making them softer than those directly dried. The results suggest that the Biancolilla cultivar is suitable for fermentation in brine without any previous treatment such as oxidation.

KEY-WORDS: Biancolilla – Colour – Drying process – Natural fermentation – Table olives – Texture.

1. INTRODUCTION

The three main techniques for table olive treatment used in Italy concern 82% green olives, 16% black olives and 2% processed at the cherry ripened stage (UNAPROL, 2008). The black olives are mainly processed according to the California method or the Greek method (Marsilio, 1993). The Californian method includes lye treatment, washing, iron-salt treatment and air-oxidation, washing, canning and sterilization (Marsilio *et al.,* 2001). The Greek style is milder and includes washing, natural fermentation in brine, air-oxidation for color improvement, sizing and packing (Piga *et al.,* 2001).

Black olives present a high antioxidant activity because they contain higher concentrations of phenolic compounds than other commercial preparations (Boskou *et al.,* 2006). The phenolic fraction of table olives is very complex and can vary both in the quality and quantity of phenolic compounds (Uccella, 2001).

Throughout the lye treatment and air bubbling of the California method, the olives darken progressively due to the oxidation of orthodiphenols, hydroxytyrosol (3,4-dihydroxyphenyl ethanol) and caffeic acid (Brenes *et al.,* 1992). However, the surface color obtained is not stable and fades progressively after oxidation and during shelf life. To prevent this deterioration, several iron salts (ferrous gluconate or ferrous lactate) are used after the darkening step. The use of iron salt to improve the darkening rate in ripe olive processing could reduce the time of processing and the consequent volume of wastewater produced (Brenes *et al*., 1995). Ferrous gluconate provides for a uniform and profound coloring, the olive taste is not affected and it is approved in the EU as E579 for the coloring of olives (Lohmann, 2010).

In many countries, large quantities of food products are dried to improve shelf life, reduce packing costs, preserve original flavor and maintain nutritional value (Demir *et al.*, 2007). Convection drying is the conventional and most widely used technique for the production of dehydrated fruits and vegetables (Nicoleti *et al.*, 2001). It provides a substantial reduction in mass and volume, making storage of the product possible under ambient temperatures. Oven-drying is known to affect olive texture leading to a decrease in tissue firmness (Jiménez *et al.*, 1995) while the lye treatment leads to degradation and loss of pectic and hemicellulosic polysaccharides and cellulose (Cardoso *et al.*, 2009; Mafra *et al.*, 2006). However, the role of color and texture are highly significant attributes in the quality evaluation and choice made by consumers.

In Sicily, several olive varieties are harvested and most of them are suitable for table olives. In previous studies (Poiana and Romeo, 2006; Romeo *et al.*, 2010; Aponte *et al.*, 2010), the changes and features of some Sicilian olive cultivars during natural fermentation in brine were examined. Biancolilla is a typical olive cultivar (*Olea europea* L.) from which one of the three most important (Cerasuola, Nocellara, Biancolilla) single-variety virgin olive oils is produced in Sicily (Giuffrida *et al.*, 2007). At the same time, it shows good aptitude as a table olive because of its optimal flesh/pit ratio of higher than 5. Biancolilla cultivar has different genotypes whose color before full maturation lose their typical green, changing to a paler color (Caruso *et al.*, 2011).

The aim of this work was to evaluate the aptitude of the Biancolilla olive cultivar to several processes typically applied to black olives.

2. MATERIALS AND METHODS

2.1. Sampling

Biancolilla olives were harvested at the pigmented state of turning color in a specialized olive grove of Castelvetrano (Sicily) during the first week of December. The fruits were harvested at a maturity stage suitable for processing and immediately transported to the laboratory where only fruits without peel defects were selected. Calibration by weight was performed in order to have uniform fruit calipers. Carpological analyses were carried out on 50 fruits randomly sampled from the whole lot.

2.2. Preparation methods

In Figure 1, a flow sheet of the applied process and the different named samples is presented.

The olives (t0 in Figure 1) were put into 15 liter plastic containers (three fermentation vessels for each thesis) filled with freshly prepared 12% NaCl brine. Olives were brined with a fruit/brine ratio of 1 (7 Kg/7 L) approximately and maintained at ambient temperature. During the period of brining, salt concentration, pH and free acidity were monitored (t0-2 in Figure 1).

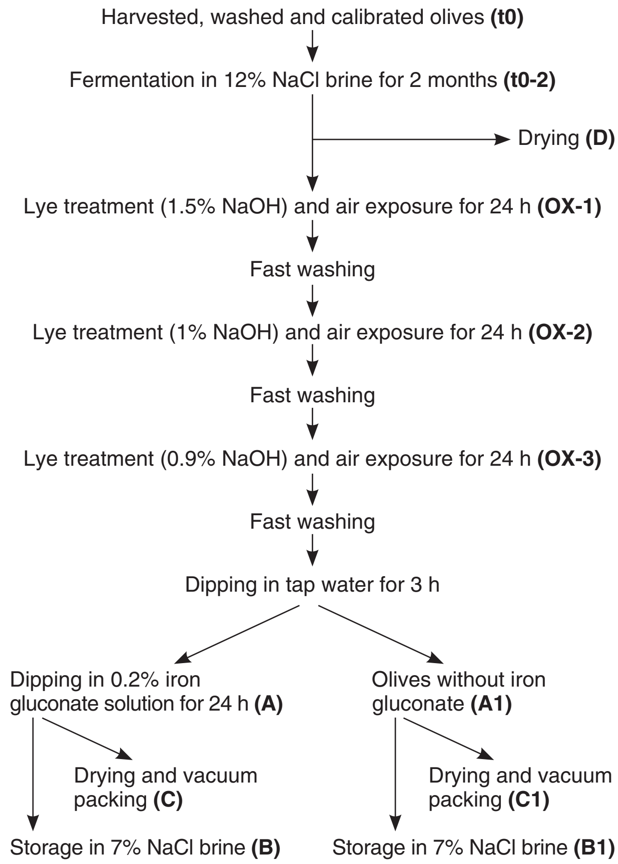

Figure 1
Flow-sheet of Biancolilla olives processing methods.

After 60 days, one part of olives were directly dried (sample D) in a tangential air-flow cabinet ("Scirocco" model, Società Italiana Essiccatoi, Milan, Italy), equipped with automatic temperature and air moisture control devices. Air flows tangentially to fruits, while a recycling system allows for mixing the exhaust air with fresh air. The fruits were placed on steel food trays and loaded into the drier. The drying process was applied until the olives reached a dry matter value of 80% (of final olive weight) estimated by weight loss calculation. The air temperature was set at 50 °C throughout the process.

Another amount of olives was subjected to three different oxidation steps (OX-1, 2 and 3) through lye treatments and air exposure directly on steel trays and then dried as described above or fermented with or without a dipping treatment in an iron gluconate solution (0.2% w/v) for 24 hours. The dried samples (C, C1 and D) were packed under vacuum. All the samples stored in brine or throughout the drying process were also analyzed after 30 and 90 days of storage at room temperature.

2.3. Physicochemical analyses

The NaCl, pH and free acidity values were determined by the routine methods (Fernández-Diez *et al.*, 1985). The pH was measured by a pHmeter

GRASAS Y ACEITES, 63 (2), ABRIL-JUNIO, 223-230, 2012, ISSN: 0017-3495, DOI: 10.3989/gya.095811

(Crison Basic 20), total acidity by titration with NaOH and expressed as mEq/L and chlorides by titration according to the Mohr method with $AgNO_3$. Total polyphenols of the raw olives were extracted according to the method reported by Amiot *et al.* (1986) and measured spectrophotometrically at 725 nm after reaction with the Folin-Ciocalteu's reagent and expressed as mg/kg of gallic acid. The water activity (aw) was measured by an Aqua lab (3TE, Decagon devices Inc., Washington) apparatus which uses the chilled-mirror dew point technique to measure the aw of the homogenized pulp samples. The dry matter content was determined by oven drying at 105 °C up to constant weight. These analyses were carried out on 10 homogenized olives.

2.4. Color determination

The color of the olives was measured using a reflection colorimeter (Minolta CR 300, Osaka, Japan). The CIE L*a*b* coordinates were measured using D65 illuminant. This analysis was assessed on two points of every olive and for ten olives randomly chosen for each sample. Chroma (C*) was calculated as $(a^{*2} + b^{*2})^{1/2}$.

2.5. Texture analysis

Hardness and its evolution in the olives was determined using a texture analyzer (TA.TX2, Stable Microsystems, Surrey, UK) equipped with a 2 mm diameter cylinder probe. Hardness measurements of the samples by puncturing involved plotting force (N) versus distance (mm) and three parameters were calculated: a) the force (F1) of the peak necessary to break the cuticle of olive; b) the area (Area-FD 0:2) under the curve between the time zero point and the maximum applied force F2; c) the last force F2 (see Figure 2 for graphical details).

The set parameters of each test were: pre-test speed 2 mm sec^{-1}, test speed 0,5 mm sec^{-1}, post-test speed 4 mm sec^{-1} and max force 1500 g.

2.6. Microbiological analyses

For the numbering of microorganisms, 10 g of the single homogenized sample were transferred into sterile stomaching bags (BagFilter P/10, 400 mL, Interscience), combined with 90 mL of sterile Ringer solution (BR0052G, OXOID) and then pummelled in a Stomacher (BagMixer 400, Interscience) at medium speed for 2 min. Dilutions of the samples were prepared and analyzed in the following selective media: total mesophilic bacteria in Plate Count Agar (Oxoid) incubated at 32 °C for 24 h, yeasts and moulds in SAB Chloramphenicol agar (VWR International) at 25 °C for 48 h, *Clostridium perfringens* in OPSPA (Oxoid) at 37 °C for 3-5 days in anaerobiosis, *Escherichia coli* in E. coli (Target DiagnosticaSrl) at 37 °C for 24 h. The analyses were done in triplicate and the plates were subjected to microbiological counting (CFU/g).

2.7. Statistical analysis

SPSS software (version 17.0, Inc.) was used for data processing. One-way analysis of variance (Anova) was used to test the effects of the different treatments on the measured factors. Duncan's multiple range test was used to compare means when a significant variation was highlighted by analysis of variance.

3. RESULTS AND DISCUSSION

3.1. Physicochemical analyses

The carpological parameters of Biancolilla cv, reported in Table 1, reveal that this cultivar is

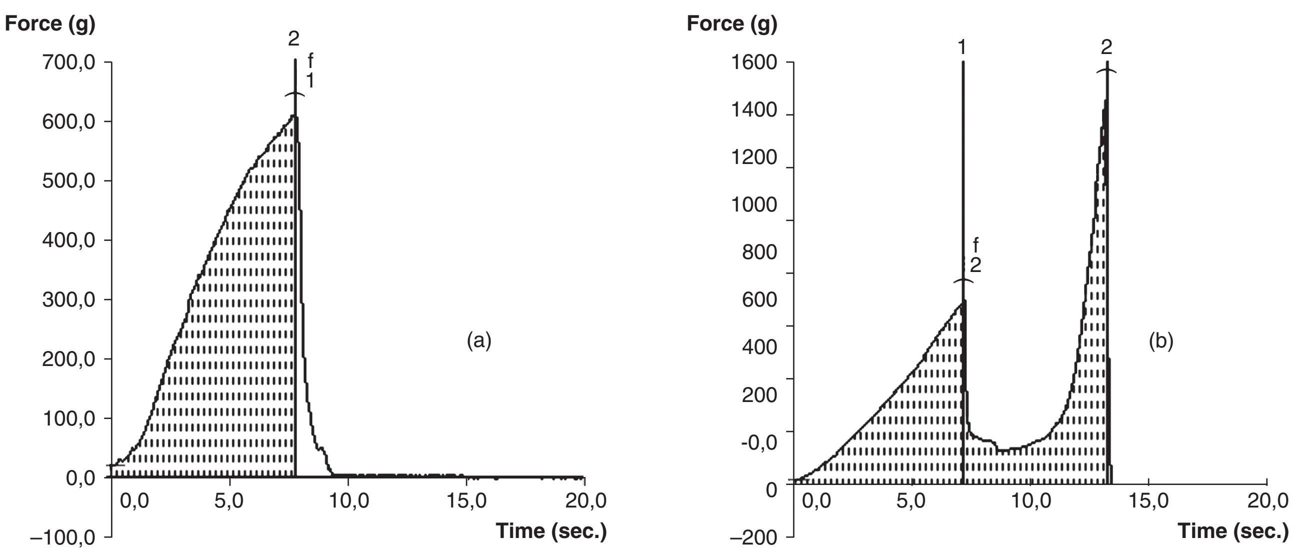

Figure 2
Hardness measurement of olives by puncturing involved plotting force versus time. (a) graph of the starting material and (b) B sample stored in brine.

Table 1
Carpological characteristic of olive fruits

Parameter	Biancolilla
lenght (mm)	21.2 ± 0.19
diameter (mm)	16.1 ± 0.16
fruit (g)	7.02 ± 1.28
stone (g)	1.06 ± 1.26
flesh (g)	5.95 ± 1.08
flesh/pit	5.72 ± 0.78

suitable for processing as table olives according to the IOOC (2000); these olives, in fact, can be classified as high weight fruits because they weigh more than 5 g (7 g of average). Other technological parameters, such as flesh to pit ratio, are very interesting according to the classification proposed by Brighigna (1998), because the cultivar has a flesh/pit > 5 (flesh percentage 84.7%) and so it can be considered very good for table olives. Moreover, the raw material of this cultivar showed a low level of total polyphenols (2556 mg/Kg), which makes this cultivar suitable for fermentation with starter cultures of lactic acid bacteria. In fact, the polyphenols inhibit lactic acid bacteria growth because the presence of oleuropein and related compounds induces a specific inhibitory effect (Ruiz Barba *et al.*, 1990; 1993). This low level of polyphenols could also prevent overbrowning during the drying process.

In Table 2, the physicochemical analyses of the samples subjected to the treatments are shown. As reported in the first column, the pH was monitored only in the brine of the fermented samples. The initial pH value, obtained after 2 months of fermentation in 12% NaCl brine, is under the hygienic limit of 4.5, while samples B and B1, after oxidation and storage in 7% NaCl brine, showed increasing pH values without any influence from the addition or not of iron gluconate salt. The lye treatment increased the pH value and so a sterilization of the olives is necessary in order to obtain a safe product.

Regarding the water activity, after the first fermentation (t0-2) of the olives, it decreased and then, after oxidation and washing, the olives showed an increase in moisture with no influence from iron salt (A and A1 samples). The samples B and B1 showed statistical differences at 30 days of brining. The time of storage showed the effect of lowering the hydration of the dried samples, reaching the highest loss in D-90 and C1-90 samples.

The same results were obtained with the dry matter analysis, reaching the highest values on the dried samples after 90 days of storage without significant difference with respect to the iron salt

Table 2
Chemical analyses results of Biancolilla olives

Samples$^{\psi}$	pH§	aw	dry matter
t0		0.996 ± 0.001 a	34.60 ± 0.20 gh
t0-2	4.28 ± 0.02 c	0.957 ± 0.001 de	37.46 ± 0.16 e
D		0.736 ± 0.001 i	74.80 ± 0.10 b
D 30		0.735 ± 0.002 i	75.10 ± 0.05 b
D 90		0.719 ± 0.005 l	78.28 ± 0.29 a
A		0.974 ± 0.001 b	35.70 ± 0.01 fg
A1		0.971 ± 0.001 b	35.55 ± 0.05 fg
B 30	5.72 ± 0.16 b	0.961 ± 0.006 cd	36.23 ± 1.42 ef
B 90	6.41 ± 0.08 a	0.960 ± 0.005 cd	33.02 ± 1.93 i
B1-30	5.43 ± 0.47 b	0.953 ± 0.003 e	35.60 ± 1.64 fg
B1-90	6.57 ± 0.21 a	0.964 ± 0.001 c	34.06 ± 1.34 hi
C		0.795 ± 0.001 g	70.42 ± 0.03 d
C 30		0.743 ± 0.002 h	75.50 ± 0.01 b
C 90		0.735 ± 0.006 i	77.60 ± 0.44 a
C1		0.802 ± 0.005 f	69.13 ± 0.03 d
C1-30		0.739 ± 0.004 hi	73.21 ± 0.10 c
C1-90		0.719 ± 0.001 l	78.33 ± 0.06 a
Sig.$^{¥}$	***	***	***

$^{\psi}$D = dried; A = oxidized; B = brined after oxidation; C = dried after oxidation. The Data are showed as means and standard deviations. §pH values were measured on olive brines. $^{¥}$Data followed by different letters are significantly different by Duncan's multiple range test. ***Significance at $P < 0.001$.

addition. Water activity decrease and dry matter increase could be due to a loss of water in the storage bags because of water redistribution after the drying process.

The samples B and B1 were influenced only by the time, in fact, there is no difference between B 30 and B1-30 or between B 90 and B1-90.

In Table 3, several parameters of Biancolilla olive chromaticity are shown. The t0-2 sample, through the first fermentation, reached the highest value in every one of the four parameters. The highest lightness (L*) values were reached by oxidized A and A1 and stored B and B1 samples without any difference resulting from iron salt addition. The dried samples (D, C and C1) reached the highest L* value after 90 days of storage. In particular, the sample D, without lye treatment, better preserved the lightness. With regards to the a* parameter, the index of green/red coloring, the values of the oxidized and fermented samples (A, A1, B and B1) highlighted the influence of the different treatment on color, because the samples without iron salt showed the highest significant rise. Among the dried olives, D samples showed a higher red pigmentation in the color. Regarding the b* parameter, the index of blue/yellow coloring, the samples treated with iron salt (A, B and C) showed little difference with respect to those untreated, showing a higher trend towards blue (decrease in b* value) as expected. Regarding the chroma (C*) of the samples, which represents the colorfulness, the iron salt led to a decrease in C* value in the A and B samples. Among the dried samples, C and C1 had a lower C* value than D, showing a minor intensity in the color (a decrease in this parameter is a browning index).

Figure 2 shows the results of texture analysis conducted on whole olives, the first Figure (a) is the graph of raw material and the second Figure (b) of a B stored sample. Initially there is an increasing trend, due to the application of an ever rising force until breakage of the drupe occurs (F1). After the breakage of the cuticle, a force is required which increases in proportion to the hardness of the pulp, up to the application of the maximum force (F2), reached in correspondence to the stone. The peak of force F1 was considered as the hardness index of the cuticle (Lin & Chang, 2005) while the index of pulp consistency was considered as the area subtended from the curve between time zero and F2 because not all the samples showed an F1 peak.

In table 4, the results of the area, representing the pulp consistency and forces 1 and 2 are shown. The directly dried sample D, the raw material (t0) and the initially fermented product (t0-2) reached the highest area values. The addition of ferrous gluconate in sample A gave more consistency to the olive pulp with respect to A1 olives. The other samples showed no significant difference without any influence of either time or treatment. The D and B 90 samples showed the highest cuticle hardness (F1 values). The D dried samples showed the F1

Table 3
Determination of colorimetric properties of Biancolilla olives

Samples[Ψ]	L*		a*		b*		C*	
t0	30.31 ± 6.93	d	8.00 ± 5.13	cd	2.96 ± 4.91	de	9.11 ± 6.33	bc
t0-2	52.66 ± 7.20	a	12.99 ± 3.92	a	21.30 ± 8.57	a	25.93 ± 6.16	a
D	22.46 ± 2.20	gh	5.73 ± 2.23	de	4.10 ± 1.74	cd	7.06 ± 2.78	def
D 30	23.16 ± 1.40	fgh	4.09 ± 1.56	fg	3.31 ± 1.22	cd	5.27 ± 1.96	ef
D 90	26.03 ± 2.04	def	4.76 ± 1.68	ef	3.01 ± 1.61	cde	5.67 ± 2.23	ef
A	26.96 ± 3.27	bcd	4.24 ± 2.58	fg	3.61 ± 2.60	cd	5.62 ± 3.58	ef
A1	28.53 ± 3.38	bc	6.11 ± 1.97	de	5.59 ± 2.23	bc	8.33 ± 2.83	cd
B 30	26.71 ± 1.28	bcde	5.17 ± 1.41	ef	4.58 ± 1.23	bc	6.95 ± 1.86	def
B 90	26.39 ± 1.83	cdef	4.85 ± 1.30	ef	4.87 ± 1.12	bc	6.93 ± 1.67	def
B1-30	30.04 ± 0.82	bc	9.27 ± 1.11	b	7.52 ± 1.02	b	11.96 ± 1.49	b
B1-90	28.97 ± 0.92	bc	8.29 ± 0.55	bc	7.27 ± 0.30	b	11.06 ± 0.51	bc
C	19.06 ± 2.26	i	1.67 ± 1.86	h	1.75 ± 1.62	de	2.50 ± 2.38	g
C 30	19.78 ± 1.58	hi	1.84 ± 1.61	h	1.87 ± 1.30	de	3.95 ± 2.02	fg
C 90	22.62 ± 1.61	gh	2.04 ± 1.31	h	1.17 ± 1.13	e	2.43 ± 1.63	g
C1	20.16 ± 2.34	hi	3.08 ± 2.28	gh	2.97 ± 1.83	de	4.34 ± 2.84	fg
C1-30	20.35 ± 1.82	hi	2.84 ± 1.73	h	2.71 ± 1.39	de	3.95 ± 2.17	fg
C1-90	22.98 ± 1.67	fgh	2.07 ± 1.29	h	1.21 ± 0.97	e	2.42 ± 1.59	g
Sig.[§]	***		***		***		***	

[Ψ]D = dried; A = oxidized; B = brined after oxidation; C = dried after oxidation. The Data are showed as means and standard deviations. [§]Data followed by different letters are significantly different by Duncan's multiple range test. ***Significance at $P < 0.001$.

Table 4
Texture analyses of Biancolilla olives: consistency of olives (area) and hardness measurement by force of cuticle breakage (F1) and maximum applied force (F2)

Samples$^{\Psi}$	Area		Force 1		Force 2	
t0	39.91 ± 9.41	ab	0.00 ± 0.00	e	5.68 ± 0.46	bc
t0-2	40.05 ± 9.11	ab	0.00 ± 0.00	e	5.65 ± 0.45	bc
A	31.21 ± 21.57	bc	0.00 ± 0.00	e	4.21 ± 1.65	cd
A1	16.46 ± 13.84	d	0.00 ± 0.00	e	3.35 ± 1.09	d
C	21.53 ± 8.47	cd	4.00 ± 0.93	bcd	4.85 ± 0.89	bc
C 30	21.30 ± 7.48	cd	0.00 ± 0.00	e	5.11 ± 1.21	bc
C 90	16.30 ± 10.12	d	0.00 ± 0.00	e	4.37 ± 1.44	cd
C1	22.32 ± 9.02	cd	4.12 ± 1.18	bcd	5.32 ± 1.40	bc
C1-30	16.29 ± 8.38	d	0.00 ± 0.00	e	4.40 ± 1.04	cd
C1-90	18.79 ± 8.33	cd	0.00 ± 0.00	e	5.05 ± 1.25	bc
D	44.67 ± 21.40	a	4.44 ± 0.97	ab	6.19 ± 1.56	b
D 30	27.29 ± 9.24	cd	4.36 ± 0.96	bc	5.39 ± 1.17	bc
D 90	17.18 ± 9.64	d	3.59 ± 1.21	cd	4.24 ± 1.39	cd
B 30	19.84 ± 8.79	cd	3.42 ± 1.43	d	4.40 ± 1.48	cd
B 90	23.08 ± 5.13	cd	5.10 ± 1.55	a	14.34 ± 0.83	a
B1-30	24.79 ± 10.78	cd	4.27 ± 1.41	bc	14.43 ± 0.14	a
B1-90	22.14 ± 8.24	cd	3.97 ± 2.78	bcd	4.24 ± 1.13	cd
Sig. §	***		***		***	

$^{\Psi}$D = dried; A = oxidized; B = brined after oxidation; C = dried after oxidation. The Data are showed as means and standard deviations. §Data followed by different letters are significantly different by Duncan's multiple range test. ***Significance at $P < 0.001$.

force throughout the storage while C and C1 after the drying process only. The F1 force was always observed in B and B1 samples, proving an increase in cuticle hardness. On the contrary, t0-2, the oxidized A and A1, and those stored after drying C and C1 samples did not show the cuticle hardening with respect to raw material. The addition of iron salt also influenced the hardness of fermented B and B1 samples, which reached the highest F2 values, showing that the oxidized olives became harder after brining. F2, in fact, is an index of hardening of the pulp around the stone. However, B and B1 showed an opposite behavior during storage confirming the F1 results. Among the dried olives, those directly dried (D) showed a higher F2 mean value than C1-30, C 90 and D 90 samples.

3.2. Microbiological analyses

In table 5, the results of microbiological analyses of the olive samples are shown. The mesophilic aerobic bacteria clearly reached the highest value in B and B1 samples, showing an increase during the time of sampling without the influence of the iron salt addition. The drying process had a killing effect on vegetative microorganisms and some colonies were detected after 90 days. However, yeast and mould populations were present at the

Table 5
Microbiological analyses results of Biancolilla olives

Samples$^{\Psi}$	Mesophilic aerobic Bacteria (Log CFU g^{-1})		Yeasts and moulds (Log CFU g^{-1})	
t0-2	7.11 ± 0.11	c	6.92 ± 0.03	a
D	0.00 ± 0.00	f	0.00 ± 0.00	d
D 30	0.00 ± 0.00	f	0.00 ± 0.00	d
D 90	1.30 ± 0.10	de	0.97 ± 0.15	c
B 30	7.09 ± 0.24	c	6.85 ± 0.22	a
B 90	7.53 ± 0.12	ab	6.30 ± 0.29	b
B1-30	7.38 ± 0.27	bc	6.87 ± 0.27	a
B1-90	7.88 ± 0.37	a	6.12 ± 0.49	b
C	0.00 ± 0.00	f	0.00 ± 0.00	d
C 30	0.00 ± 0.00	f	0.00 ± 0.00	d
C 90	1.00 ± 0.10	e	0.00 ± 0.00	d
C1	0.00 ± 0.00	f	0.00 ± 0.00	d
C1-30	0.00 ± 0.00	f	0.00 ± 0.00	d
C1-90	1.60 ± 0.40	d	0.60 ± 0.53	c
Sig. §	***		***	

$^{\Psi}$D = dried; B = brined after oxidation; C = dried after oxidation. The Data are showed as means and standard deviations. §Data followed by different letters are significantly different by Duncan's multiple range test. ***Significance at $P < 0.001$.

 GRASAS Y ACEITES, 63 (2), ABRIL-JUNIO, 223-230, 2012, ISSN: 0017-3495, DOI: 10.3989/gya.095811

first stage in the fermented samples and then decreased. Yeasts and moulds were affected more than the mesophilic aerobic bacteria by the drying process, which had a strong lethal effect.

4. CONCLUSIONS

The use of iron salt for improving the darkening rate of processed olives influenced the color parameters as expected. The addition of iron salt showed a slight influence on L*, a* and b* parameters, while this salt clearly influenced the chroma of the A and B samples, affecting the intensity of the color with significant differences. This fact is due to the function attributed to ferrous salt: it provides a catalytic action on the darkening reaction because of the stable complexes formed (Brenes *et al.*, 1995).

The addition of salts should influence the olive texture especially when the olives are dipped into water or brine. The salt changes the osmotic condition and consequently the water distribution into the pulp. It is well known that the added salts could also preserve the original consistency of the pulp (Romeo *et al.*, 2009).

The oxidant conditions influenced the hygienic characteristics of Biancolilla olives affecting the pH value. Moreover, the oxidation and washing steps affected the texture of oxidized and dried olives making them softer than those directly dried which, in fact, reached the highest level of dehydration. This could be a discriminating factor that determines the destination of the products: the directly dried olives can be used as semi-processed products to send to food industries because of their hardness. According to previous works (Cardoso *et al.*, 2009; Mafra *et al.*, 2007), the texture of dried olives can be greatly influenced by the applied processes such as blanching, brining, use of lye and oven-drying.

The results of this work suggest that the Biancolilla cultivar is suitable for fermentation in brine. Further treatments such as oxidation, iron salt addition and brine storage need anapplication of an appropriate heat treatment in order to guarantee the safety of the product. Finally, storage in brine is not recommended because of the textural changes to the olive flesh.

REFERENCES

Amiot MJ, Fleuriette A, Macheix JJ. 1986. Importance and Evolution of Phenolic Compounds in Olive during growth and maturation. *J. Agric. Food Chem.* **3**, 823-826.

Aponte M, Ventorino V, Blaiotta G, Volpe G, Farina V, Avellone G, Lanza CM, Moschetti G. 2010. Study of green Sicilian table olive fermentations through microbiological, chemical and sensory analyses. *Food Micro.* **27**, 162-170.

Boskou G, Salta FN, Chrysostomou S, Mylona A, Chiou A, Andrikopoulos NK. 2006. Antioxidant capacity and phenolic profile of table olives from the Greek market. *Food Chem.* **94**, 558-564.

Brenes M, García P, Garrido A. 1992. Phenolic compounds related to the black color formed during the processing of ripe olives. *J. Agric. Food Chem.* **40**, 1192-1196.

Brenes M, Romero C, García P, GarridoFernández A. 1995. Catalytic effect of metal cations on the darkening reaction in ripe olive processing. *Z. Lebensm. Unters For.* **201**, 221-225.

Brighigna A. 1998. Valutazione commerciale delle olive da tavola, in Edagricole, *Le olive da tavola: Varietà, lavorazioni, legislazione, impiantistica e analitica di controllo (Table olives: cultivars, processing, law, plants and analytical control)*, Bologna, 55-60.

Cardoso SM, Mafra I, Reis A, Barros AS, Nunes C, Georget DMR, Smith AC, Saraiva J, Waldron KW, Coimbra MA. 2009. Traditional and industrial oven-dry processing of olive fruits: influence on textural properties, cell wall polysaccharide composition, and enzymatic activity. *Eur. Food Res. Technol.* **229**, 415-425.

Caruso T, Cartabellotta D, Motisi A. 2011. Biancolilla di Caltabellotta, in Università degli Studi di Palermo e Assessorato Agricoltura e Foreste della Regione Siciliana, Dipartimento di Colture Arboree, *Cultivar di olivo siciliane,* 29-34. Accessed 09 Feb. 2011: http://www.unipa.it/germolive/cultivar/biancolilla.pdf.

Demir V, Gunhan T, Yagcioglu AK. 2007. Mathematical modeling of convection drying of green table olives. *Biosyst. Eng.* **98**, 47-53.

Fernández-Díez MJ, Castro R, Fernàndez A, Cancho FG, Pellissò FG, Vega MN, Moreno AH, Mosquera IM, Navarro LR, Quintana MCD, Roldàn FS, Garcìa PG, Castro A. 1985. *Biotecnologìa de la aceituna de mesa*. Ed CSIC, Madrid, Spain.

Giuffrida D, Salvo F, Salvo A, La Pera L, Dugo G. 2007. Pigments composition in monovarietal virgin olive oils from various Sicilian olive varieties. *Food Chem.* **101**, 833-837.

International Olive Oil Council (IOOC) 2000.*Catalogo mondiale delle varietà di Olivo (World catalogue of olive cultivars).* International Olive Oil Council, Madrid.

International Olive Oil Council (IOOC) 2004. COI/OT/NC n° 1: Trade Standard Applying To Table Olives, Madrid, España.

Jiménez A, Guillén R, Sánchez C, Fernández-Bolãnos J, Heredia A. 1995. Changes in texture and cell wall polysaccharides of olive fruit during “Spanish green olive” processing. *J. Agric. Food Chem.* **43**, 2240-2246.

Lin CH, Chang CY. 2005. Textural change and antioxidant properties of broccoli under different cooking treatments. *Food Chem.* **90**, 9-15.

Lohmann P. 2010.Ferrous gluconate in olives. Accessed 20 Apr. 2011: http://www.lactate-gluconate.com/view-article/items/ferrous-gluconate-in-olives. html.

Mafra I, Barros AS, Coimbra MA. 2006. Effect of black oxidizing table olive process on the cell wall polysaccharides of olive pulp (*Oleaeuropaea* L. var. Negrinha do Douro). *Carbohyd. Polym* .**65**, 1-8.

Mafra I, Barros AS, Coimbra MA. 2007. The combined eVects of black oxidising table olive process and ripening on the cell wall polysaccharides of olive pulp. *Carbohyd. Polym.* **68**, 647-657.

Marsilio V. 1993. Produzione, trasformazione e normativa delle olive da tavola in Italia. Olivæ, **49**, 6-16.

Marsilio V, Campestre C, Lanza B. 2001. Phenolic compounds change during California-style ripe olive processing. *Food Chem.* **74**, 55-60.

Nicoleti JF, Telis-Romero J, TelisVRN. 2001. Air-drying of fresh and osmotically pre-treated pineapple slices: fixed air temperature versus fixed temperature drying kinetics. *Dry. Technol.* **19**, 2175-2191.

Piga A, Gambella F, Vacca V, Agabbio M. 2001. Response of three Sardinian olive cultivars to Greek-style processing. *Ital. J. Food Sci.* **13**, 29-40.

Poiana M, Romeo FV. 2006. Changes in chemical and microbiological parameters of some varieties of Sicily olives during natural fermentation. *Grasas Aceites* **57**, 402-408.

Romeo FV, De Luca S, Piscopo A, Perri E, Poiana M. 2009. Effects of post fermentation processing on the stabilization of naturally fermented green table olives (cv NocellaraEtnea). *Food Chem.* **116**, 873-878.

Romeo FV, Piscopo A, Poiana M. 2010. Effect of acidification and salt concentration on two black brined olives from Sicily (cv Moresca and Giarraffa). *Grasas Aceites* **61**, 251-260.

Ruiz-Barba JL, Ríos Sánchez JM, Fedraiani-Iriso C, Olías JM, Ríos JL, Jimenez Diaz R. 1990. Bactericidal effect of phenolic compounds from green olives on *Lactobacillus plantarum*. *System Appl. Microbiol.* **13**, 199-205.

Ruiz-Barba JL, Brenes-Balbuena M, Jiménez-Díaz R, García-García P, Garrido-Fernández A. 1993. Inhibition of *Lactobacillus plantarum* by polyphenols extracted from two different kinds of olive brine. *J. Appl. Bacteriol.* **74**, 15-19.

Uccella N. 2001. Olive biophenols: novel ethnic and technological approach. *Food Sci and Technol.* **11**, 328-339.

UNAPROL. 2008. Filiera olivicola - Analisi strutturale e monitoraggio di un campione di imprese. Campagna 2007-2008, Reg. CE 2080/2005. Accessed 05 Dec. 2011: http://www.unaprol.it/Pubblicazioni/FILIERA%20OLIVICOLA%20CAMP.%202007-08.PDF.

Recibido: 20/9/11
Aceptado: 25/1/12