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Removing Bitter Compounds from Green Olives using Different Concentrations of Citric Acid

Abd El-Hameed Abd El-Samie Ibraheem and Fouad Omer Fouad Abou-Zaid

Agric.-Industrialization Unit, Plant Production Department, Desert Research Center, Cairo, Egypt.

ABSTRACT

The main purpose of table olive processing is the removal of the natural bitterness compounds of the fruits in order to render it edible. The efficacy of different citric acid treatments (1, 2 and 3%) comparing to traditional and lye treatments on bitterness removing of four olive varieties (Picual, Manzanillo, Ascolano and Egazee) was evaluated. The obtained results illustrated that, soaking olive fruits (before pickling) in citric acid solutions (2 and 3% citric acid + 12 sodium chloride) had higher positive effect on bitterness removing comparing with the other treatments (1% citric acid, lye and traditional), for all studied varieties. Sensory evaluation of the final products showed that, citric acid treatments led to improve the sensory properties of all varieties under investigation, with slight differences, where 3 % citric acid treatment had the highest score in all sensory attributes for both Picual, Manzanillo and Ascolano variety, while 2 % citric acid treatment was the highest score for Egazee variety.

Key words Table olive; Debittering; Olive variety; Citric acid treatment.

Introduction

The olive tree is ubiquitous in the Mediterranean region where it has been cultivated since the Late Bronze Age (Riley, 2002). Pickling of green olives by traditional method (without using alkali to remove bitterness of green olive) needs more time in pickling process, as well as the quality attributes of produced olive is low compared to other methods of pickling.

The common procedure for preparing this product consists of treating the fruits with dilute Na OH solution, followed by one or two water washes to remove the excess alkali. Subsequently, a 10–13% (w/v) Na Cl solution is added to the fruits, in which they undergo to spontaneous lactic acid fermentation (Fernandez-Diez, 1985). The lye treatment causes complex chemical and physical changes in the fruits, and its extent also affects the subsequent diffusion of salt and the progress of the lactic fermentation (Rodriguez and Rejano,1979; Sciancalepore and Longone, 1984).

At the early ripening stages of olive fruit, from intense green to green–yellow, the color of the olives is due to the presence of chlorophylls a and b, and the typical chloroplastic yellow carotenoids (Minguez-Mosquera and Garrido-Fernndez, 1989). During the processing of table olives by Spanish-style, the chlorophylls degrade to several Mg-free derivatives (Minguez-Mosquera and Gallardo-Guerrero, 1995).

Removing of the bitterness from green olive using alkaline is the most common in the world, but this process requires highly skilled and extremely cautious and required to conduct frequent washing to get rid of (as much as possible) the residual alkaline in addition to the harmful effects of the remaining traces of alkali on general health which lead to strong need for getting a new style to rid of the Bitterness compounds found in olive. So, we planned to achieve this research by using different concentrations of citric acid with sodium chloride.

Materials and Methods

Materials

Olives

Four varieties (Picual, Manzanillo, Egazee shame and Ascolano) have been selected of green olive cultivated in El-Maghara Research Station - Desert Research Center, Sodium chloride was purchased from Al-Nasr Salines Co. - El Arish- North Sinai,Citric acid ($C_6H_8O_7H_2O$) E_{330} manufacture : TTCA OC., Ltd China

Methods

Traditional treatment

Two kg of each olive variety were placed in plastic jars and pickling brine solution (12% Sodium chloride + 0.5% Citric acid) was added then the jars were closed tightly and left for 60 days until the end of the pickling process. (Ibrahim, 2002 and Ross *et al.*, 2002).

Corresponding Author: Fouad Omer Fouad Abou-Zaid, Agric.-Industrialization Unit, Plant Production Department, Desert Research Center, Cairo, Egypt.
E-mail: fouadomer1@yahoo.com

Lye treatment

Olives of each variety (separately) were placed into tanks and soaked in a lye solution (1% w/v, sodium hydroxide) for about 8h for de-bittering. During this stage hydrolysis of oleuropein, which is labile under alkaline conditions, takes place. Lye is allowed to penetrate through three-quarters of the flesh, leaving a small volume around the stone unaffected. This part of the flesh provides the necessary sugars for subsequent fermentation and confers to the olives a slight bitter taste. Olives are washed with water twice in order to remove excess alkaline. Then, two kg of each olive variety were placed in plastic jars and pickling brine solution (12% sodium chloride + 0.5% citric acid) was added, then the jars were closed tightly and left for 60 days until the end of the pickling process. (Hurtado *et al.*, 2012).

Citric acid treatments

Three concentrations of citric acid were prepared as follow:
The first: 1 % Citric acid concentration +12% Sodium chloride.
The second: 2 % Citric acid concentration + 12% Sodium chloride.
The third: 3 % Citric acid concentration+12% Sodium chloride.

Olive fruits of each variety (separately) were divided to 3 parts as follow:

The first part was soaked in citric acid solution (1% Citric acid + 12% Na Cl)for 15 hr. followed by water soaking for 3hr. and repeated soaking in citric solution as well as soaking in water two times. The same procedure was repeated for the other two concentrations of citric acid with the other two parts of olive fruits for each variety separately.2 kg of each olive variety were placed in plastic jars and pickling brine solution (12% Sodium chloride + 0.5% Citric acid) was added then the jars were closed tightly and left for 60 days until the end of the pickling process.

Chemical analysis:

Olive fruits:

Total acidity, moisture, total lipids, chlorophyll (a) and (b), carotenoids and polyphenols were determined in olive fruits (fresh and pickled separately) of each variety as follow:

Total acidity: Total acidity was determined according to the AOAC (1970) and expressed as citric acid.

Polyphenols: bitter substances were estimated as total polyphenols using the method described in the AOAC (1970).

Moisture content: were determined according to the AOAC (1990) using oven at 70 C.

Chlorophyll (a) and (b), carotenoides

Chlorophyll (a) and (b), carotenoides were determined by using the method of Wettestein (1957).

Citric acid solutions

Total polyphenols were determined as described previous.

Soaking water:

Total polyphenols were determined as described previous.

Sensory evaluation:

Sensory properties were evaluated as described by Balatsouras and Doutsias, (1983), where the final products from all treatments of different varieties were presented to 10 untrained member panelists for organoleptic evaluation. The panelists were requested to assess the samples for taste, color, texture and over all acceptability by 10 points in scale levels of quality.

Statistical analysis:

All determinations were carried out in triplicate (except fatty acid composition) and data is reported as mean. Significant differences ($p<0.05$) were calculated using Duncan's multiple range test, followed the method reported by Steel and Torrie, (1980).

Results and Discussion

The Moisture content of the final product considered an important parameter related to firmness and other sensory properties. The moisture content of the fresh olives and pickled olives after pickling are determined and the results were tabulated in Table (1).

Table 1: The effect of different debittering treatments on moisture content (as %) of different green olive varieties end products.

Variety	Fresh	Citric acid			Lye treatment	Traditional treatment
		1%	2%	3%		
Picual	59.81[c]	60.30[b]	60.37[b]	61.07[a]	61.09[a]	61.01[a]
Manzanillo	62.85[b]	63.47[a]	63.65[a]	63.65[a]	63.72[a]	62.00[c]
Ascolano	53.06[c]	55.18[a]	55.19[a]	55.10[a]	55.29[a]	53.58[b]
Egazee shame	52.34[bc]	52.43[b]	52.92[a]	52.91[a]	52.95[a]	52.07[c]

Values bearing the same superscript within the same row are not significantly different (P> 0.05)

The moisture contents of fresh Picual, Manzanillo, Ascolano and Egazee shame were 59.81 ,62.85 ,53.06 and 52.34 %, respectively . Results in Table (1) Showed that, moisture content increased after the end of pickling process for all varieties under study, as well as in all treatments compared with fresh samples. This increase in moisture content was in agreement with data reported by Yassa, *et al.*, (1990) and Ibrahim, (2002). Data presented in the same table, showed also that, the rate of increase in moisture content of the olive fruits pickled by lye treatment was the highest compared to the other treatments, while moisture contents of different olive varieties in the end of traditional method were the lowest. The results showed also that, the rate of increase in the moisture content of Ascolano olive was the highest, while that of Egazee shame olive was the lowest compared to the other varieties under study.

Acidity:

Titratable acidity (expressed as % citric acid) for all studied treatments and varieties after pickling was determined and the results were presented in table (2).

Table 2: The effect of different debittering treatments on Total acidity (% citric acid) of different green olive varieties end products.

Variety	Fresh	Citric acid			Lye	Traditional
		1%	2%	3%		
Picual	0.90[d]	1.25[c]	1.40[b]	1.42[b]	0.96[d]	1.60[a]
Manzanillo	0.85[f]	1.77[c]	1.91[b]	2.03[a]	1.01[e]	1.66[d]
Ascolano	1.09[d]	1.38[c]	1.61[b]	1.62[b]	1.38[c]	1.71[a]
Egazee shame	0.92[e]	1.34[c]	1.72[a]	1.74[a]	1.06[d]	1.38[b]

Values bearing the same superscript within the same row are not significantly different (P> 0.05)

From the presented data in table 2, it could be observed that, all pickling treatments led to increase in total acidity of the end product. Also, all fresh olive samples had total acidity lower than 1% , except Ascolano variety, which had 1.09% acidity.

From the same table, it could be noticed also that, the higher the citric acid concentration, the higher the total acidity of the end product. This may be due to the residual traces of citric acid after treatment. These findings are in agreement with those of Chammem, *et al.* (2005), who found that acidity increased from 0.033% in the first day of fermentation to 0.312 % after 26 days of fermentation and to 0.636 % after 114 days of fermentation. Also, the results of lye treatment, recorded the lowest increment in acidity for all studied varieties, this may be due to the residual traces of soda.

Polyphenol Content of flesh:

The bitter principles of olive which are responsible for the unacceptable taste of both green and ripe olive fruits varied according to the variety and stage of maturity .These bitter principles are polyphenol compounds (Cruess, 1941)

The results of different soaking treatments influence on flesh polyphenol content before and after pickling of picual olives were determined and presented in Table (3).

Table 3: The effect of different debittering treatments on flesh polyphenol content (ppm) before and after olives pickling

Variety	Fresh	After different soaking treatments				End product				
		Citric acid			Lye	Citric acid			lye	Traditional
		1%	2%	3%		1%	2%	3%		
Picual	3460[a]	2940[c]	2560[e]	2405[f]	2950[b]	2200[g]	2070[h]	2000[i]	2200[g]	2600[d]
Manzanillo	3135[a]	2400[c]	2370[d]	2250[f]	2360[e]	2100[g]	2000[i]	1950[j]	2070[h]	2850[b]
Ascolano	3240[a]	2640[c]	2580[d]	2420[f]	2500[e]	2250[h]	2120[i]	2035[j]	2340[g]	2700[b]
Egazee shame	2840[a]	1840[c]	1670[d]	1540[g]	1850[b]	1635[e]	1380[h]	1200[i]	1630[e]	1560[f]

Values bearing the same superscript within the same row are not significantly different (P> 0.05)

The presented data in Table (3) showed that polyphenol content of picual olives were reduced after all studied soaking treatments, but the most decline was recorded for 3% citric acid soaking treatment (2405 ppm) followed by 2% citric acid soaking treatment (2560 ppm), while the lowest decrease was recorded for lye soaking treatment (2950 ppm), followed by 1% citric acid soaking treatment (2940 ppm). From the same table it could be observed that polyphenol content of end products of all studied treatments was decreased comparing to traditional one, where the highest decrease were recorded for 3% citric acid end product(2000 ppm) followed by 2 % citric acid end product (2070 ppm) , then both 1% citric acid end product and lye end product (2200 ppm).

In relation to Manzanillo results in same table, it could be noticed that, all studied soaking treatments led to decrease the polyphenol content, where 3% citric acid soaking treatment had the most decline (2250 ppm), while the lowest decrease was recorded for 1% citric acid soaking treatment (2400 ppm) followed by 2% citric acid soaking treatment (2370 ppm) and then lye soaking treatment (2360 ppm).

On the other hand, polyphenol contents of end products of all studied treatments were decreased comparing to the traditional one, where the best results were recorded for 3% and 2% citric acid treatments end products (1950 and 2000 ppm, respectively) .

Concerning to Ascolano olive results presented in table (3) , which showed an obvious reduction in polyphenol contents as a result of all studied soaking treatments, where the most reduction was observed for 3% citric acid soaking treatment followed by lye soaking treatment, while the lowest reduction was observed for 1% and 2% citric acid soaking treatments, respectively.

On the other side, the results of end product polyphenol contents showed higher reduction for 3% citric acid followed by 2% citric acid, 1% citric acid and lye treatments, respectively, comparing to traditional end product. These results were in agreement with those reported by Kiai and Hafidi, (2014), who found that, the total reduction of phenolic content after 71 days of processing were 40% for Ascolano variety.

The tabulated results of Egazee in table (3), showed that 1% citric acid and lye soaking treatments had the same effect on polyphenol content either for olive flesh after soaking process or for end product, while 3% citric acid soaking treatment recorded the best results comparing with the other studied treatments either for olive flesh after soaking or olive end product.

The variation between the obtained results may be partially due to the variety characteristics, where the efficiency of the hydrolyzing enzymes located in the different varieties of olive fruits are varied (Ciafardini, *et al.*, 1994).

Chlorophylls and carotenoids:

The contents of chlorophyll a, b and carotenoids were determined for different pickled studied olive varieties, and the results were presented in table (4).

From the results tabulated in table (4) it could be noticed that, all studied treatments had obvious effect on degradation of chlorophyll pigments, while carotenoids content was increased for all studied olive varieties.

For picual olives, it could be observed that the degradation rate of chlorophyll a and chlorophyll b, reached the maximum value for 3% citric acid treatment, while the minimum degradation rate was recorded for lye treatment followed by traditional treatment. These results agreed with those of Froni, *et al.*(1988) and Baadseth and Hvan, (1989), who reported that, most common color changes that takes place during processing is due to the conversion of chlorophyll a and b to their respective pheophytins.

Table 4: The effect of different debittering treatments on chlorophyll a, b and carotenoids (mg/Kg) of different green olive varieties end products

	Fresh	Citric acid			Lye	Traditional
		1%	2%	3%		
Picual olives						
Chlorophyll a	10.5694^{a}	1.9062^{d}	1.7550^{e}	1.5731^{f}	2.0612^{b}	1.9154^{c}
Chlorophyll b	4.4845^{a}	1.3428^{d}	1.2867^{e}	0.6297^{f}	1.6783^{b}	1.5429^{c}
Carotenoids	1.2086^{f}	2.2680^{c}	2.4360^{b}	2.9952^{a}	1.6023^{e}	2.1877^{d}
Manzanillo olives						
Chlorophyll a	12.7157^{a}	2.1050^{d}	1.8639^{e}	1.6921^{f}	2.4715^{c}	2.7316^{b}
Chlorophyll b	4.2532^{a}	1.5270^{d}	1.3884^{e}	1.0325^{f}	1.8352^{c}	1.9079^{b}
Carotenoids	1.0473^{f}	2.4795^{c}	2.8393^{b}	3.1895^{a}	1.6339^{e}	1.8085^{d}
Ascolano olive						
Chlorophyll a	11.5908^{a}	1.9933^{b}	1.4607^{e}	1.2134^{f}	1.4703^{d}	1.5838^{c}
Chlorophyll b	4.1032^{a}	1.5734^{c}	1.2633^{e}	1.1472^{f}	1.3779^{d}	1.7165^{b}
Carotenoids	1.8293^{f}	2.8345^{c}	2.9924^{b}	3.2402^{a}	2.6886^{e}	2.8262^{d}
Egazee olives						
Chlorophyll a	10.3772^{a}	1.9908^{c}	1.6699^{e}	1.6571^{f}	1.8565^{d}	2.7501^{b}
Chlorophyll b	3.8094^{a}	0.9747^{b}	0.8426^{e}	0.8793^{d}	0.7661^{f}	0.8851^{c}
Carotenoids	1.4719^{f}	2.8482^{d}	2.9992^{c}	3.4777^{a}	3.2183^{b}	2.2671^{e}

Values bearing the same superscript within the same row are not significantly different (P> 0.05)

Concerning to carotenoids, it could be observed that, its increasing rate was the highest for 3% citric acid treatment, while, lye treatment had the lowest increasing rate.

The results of Manzanillo variety in the same table showed that, all treatments under investigation led to degradation of chlorophyll a and b, where 3% citric acid treatment had the highest degradation rate, while the lowest degradation rate was recorded for traditional treatment.

On the other hand, carotenoids content of Manzanillo variety was increased, where the highest increasing rate was recoded for 3% citric acid treatment, while, lye treatment had the lowest increasing rate.

Regarding to the results of Ascolano variety in the same table, it could be noticed that, all treatments under investigation led to degradation of chlorophyll a and b, where 3% citric acid treatment had the highest degradation rate (for both chlorophylls a and b), while the lowest degradation rate was recorded for 1% citric acid treatment (for chlorophyll a) and traditional treatment (for chlorophyll b).

On the other hand, carotenoids content of Ascolano variety was increased, where the highest increasing rate was recoded for 3% citric acid treatment, while, lye treatment had the lowest increasing rate.

Concerning to Egazee results presented in table (4), it could be noticed that, all treatments under investigation led to degradation of chlorophyll a and b, where 3% citric acid treatment had the highest degradation rate (for chlorophyll a), while the lowest degradation rate was recorded for traditional treatment (for chlorophyll a). At the same time lye treatment had the highest degradation rate (for chlorophyll b), while the lowest degradation rate was recorded for 1% citric acid treatment.

On the other hand, carotenoids content of Egazee variety was increased, where the highest increasing rate was recoded for 3% citric acid treatment, while, traditional treatment had the lowest increasing rate

These findings are in agreement with Gallardo-Guerrero, *et al.* (2013), who reported that, an initial loss in green pigments and color degradation was observed during processing and later, storage caused a progressive degradation of chlorophylls and carotenoids.

Polyphenol content of soaking solutions:

Polyphenol content of different citric acid solutions (1, 2 and 3%), where different olive varieties were soaked in each separately, were determined after each soaking period (3 soaking periods) and the same procedure was repeated for soaking water, which occurred after each citric acid treatment (to remove the acid traces) and the results were tabulated in table (5).

The mentioned data (of all studied olive varieties) showed that, the higher the concentration of citric acid solution the higher the content of polyphenol for each soaking period, separately. While the polyphenol content decreased for the same concentration of citric acid solution after each soaking period comparing to the previous one.

Also, the percent of removing polyphenol, increased by increasing citric acid concentration and so on in relation to end product.

On the other hand, the polyphenol contents of soaking water increased by increasing the concentration of citric acid solution, while the polyphenol contents increased for the same concentration of citric acid solution after each soaking period comparing to the previous one.

Data presented in the same table (5) showed obviously that, the highest percent of removed polyphenol for all studied olive varieties was recorded for Egazee variety, treated by 3% citric acid (57.75 %) followed by 2% citric acid of the same variety (51.41%), while the lowest percent of removed polyphenol was recorded for Ascolano variety, treated with 1% citric acid (30.55 %) followed by Manzanillo variety, treated with 1% citric acid (33.01 %).

Generally the results of polyphenols were in agreement with those reported by Marsilio, *et al.* (2006), who reported that, processing of olive resulted in a 35-40 % loss of total phenols (during 7 months) , where the results indicated that they were lost more during the first 3 months of fermentation.

Sensory Evaluation:

Sensory evaluation is the most important factor that determines the consumer acceptance. Where, he always interests in good appearance, attractive color, firm texture and good organoleptic qualities of a foodstuff many more than the nutritive and biological value.

Sensory properties of different pickled olive varieties by different studied treatments were tested and the results were presented in table 6.

Data presented in Table (6) showed that, picual olive fruits pickled by traditional method had the lowest sensory attributes comparing to all other studied treatments.

In relation to both taste and color it could be noticed that, all citric acid treatments recorded higher score comparing to both traditional and lye treatments, while textures of lye and 3% citric acid treatments were the highest comparing to other studied treatments. Also, there were no differences recorded for acceptance for all investigated treatments except, the traditional one, which recorded the lowest acceptance.

Table 5: polyphenol content of different citric acid solutions and soaking water for different periods before pickling process of different green olive varieties.

	Fresh	Citric acid solutions			Soaking water		
		1%	2%	3%	1%	2%	3%
Picual olives							
1^{st} period	3460	116^{c}	210^{b}	300^{a}	28^{f}	35^{e}	48^{d}
2^{nd} period		100^{c}	170^{b}	275^{a}	35^{f}	47^{e}	55^{d}
3^{rd} period		27^{f}	158^{b}	210^{a}	43^{e}	50^{d}	60^{c}
Sum		243	538	785	106	132	163
% removing		7.02	15.55	22.69	3.06	3.81	4.71
End product		2200	2070	2000			
% removing of end product		36.42	40.17	42.20			
Manzanillo olives							
1^{st} period	3135	240^{c}	265^{b}	280^{a}	65^{f}	75^{e}	80^{d}
2^{nd} period		165^{c}	200^{b}	210^{a}	72^{f}	80^{e}	85^{d}
3^{rd} period		162^{b}	160^{b}	180^{a}	75^{e}	95^{d}	105^{c}
Sum		567	625	670	212	250	270
% Removing		18.09	19.93	21.37	6.76	7.97	8.61
End product		2100	2000	1950			
% Removing of end product		33.01	36.20	37.80			
Ascolano olive							
1^{st} period	3240	265^{c}	280^{b}	375^{a}	40^{e}	53^{d}	55^{d}
2^{nd} period		100^{c}	150^{b}	185^{a}	39^{f}	50^{e}	60^{d}
3^{rd} period		62^{d}	90^{b}	111^{a}	45^{f}	53^{e}	75^{c}
Sum		427	520	671	124	156	190
% Removing		13.18	16.05	20.71	3.83	4.81	5.86
End product		2250	2120	2035			
% Removing of end product		30.55	34.57	37.19			
Egazee olives							
1^{st} period	2840	205^{c}	297^{b}	355^{a}	35^{e}	40^{de}	45^{d}
2^{nd} period		181^{c}	275^{b}	320^{a}	43^{f}	47^{e}	55d
3^{rd} period		147^{c}	170^{b}	230^{a}	60^{f}	100^{e}	110^{d}
Sum		533	742	905	138	187	210
% Removing		18.77	26.13	31.87	4.86	6.58	7.39
End product		1635	1380	1200			
% Removing of end product		42.43	51.41	57.75			

Values bearing the same superscript within the same row are not significantly different (P> 0.05)

Regarding to The results of sensory evaluation of Manzanillo olive variety in the table (6), it could be observed that, taste of pickled olives after soaking in 2% and 3% citric acid solutions recorded the highest value (7.5), while, pickled olives by traditional method recorded the lowest score (5.0).

Also, the results of Manzanillo color illustrated that the highest color value was recorded for treated olives by 3% citric acid solution followed by 2% citric acid treatment and then the other three treatments.

On the other hand, texture and acceptance results showed obviously that, the highest value (7) were recorded for both 2% and 3% treatments, while the lowest value (5) was recorded for both traditional and lye treatments.

The sensory properties of Ascolano variety tabulated in table (6), demonstrated obviously that, 3% citric acid treatment had the best sensory attributes comparing to the all other treatments. From the same table, it could be noticed that, different treatments of citric acid led to an improvement in all sensory attributes comparing to traditional and lye treatments.

Concerning to sensory properties of Egazee variety in table (6), it could be noticed that, different treatments of citric acid led to an improvement in all sensory attributes comparing to traditional and lye treatments.

From the same table, it could be noticed that, the best treatment concerning to both taste and color of Egazee variety, was 2% citric acid treatment comparing to all other studied treatments.

Regarding to taste results, it could be observed that pickled olives after soaking in 2% citric acid solution had the highest taste score (7.0) while pickled olives by traditional method had the lowest score (5.0)

Results of the same table, showed that, Egazee pickled olives after soaking in 2% citric acid solution was the best in terms of color where it scored 7.5, while pickled olives by traditional method and lye treatment were the lowest (6.0).

On the other hand, results of texture illustrated that pickled olives after soaking in 2% and 3% citric acid solutions had better textures (7.0) than pickled olives by other methods.

In relation to public acceptance results, it could be observed that pickled olives after soaking in citric acid solutions (1%, 2 % and 3 %) had better public acceptance (7.0) than the other treatments.

Table 6 : The effect of different debittering treatments on Sensory properties of different green olive varieties end products .

	Traditional treatment	Lye treatment	Citric acid treatments		
			1%	2%	3%
Picual olives					
Taste	5.0^{d}	5.5^{c}	6.0^{b}	6.0^{b}	7.0^{a}
Color	4.5^{d}	5.0^{c}	6.0^{b}	7.0^{a}	7.0^{a}
Textures	6.0^{b}	7.0^{a}	6.0^{b}	6.0^{b}	7.0^{a}
Acceptance	5.0^{b}	6.0^{a}	6.0^{a}	6.0^{b}	6.0^{a}
Manzanillo olives					
Taste	5.0^{d}	6.0^{c}	7.0^{b}	7.5^{a}	7.5^{a}
Color	6.0^{c}	6.0^{c}	6.0^{c}	7.0^{b}	7.5^{a}
Textures	5.0^{c}	5.0^{c}	6.0^{b}	7.0^{a}	7.0^{a}
Acceptance	5.0^{c}	5.0^{c}	6.0^{b}	7.0^{a}	7.0^{a}
Ascolano olive					
Taste	6.0^{d}	7.0^{c}	8.0^{b}	8.0^{b}	9.0^{a}
Color	6.5^{d}	7.0^{c}	8.0^{b}	8.0^{b}	9.5^{a}
Textures	7.5^{c}	7.0^{d}	8.0^{b}	8.0^{b}	9.0^{a}
Acceptance	6.0^{d}	7.0^{c}	8.0^{b}	8.0^{b}	9.0^{a}
Egazee olives					
Taste	5.0^{d}	6.0^{c}	6.5^{b}	7.0^{a}	6.5^{b}
Color	6.0^{c}	6.0^{c}	7.0^{b}	7.5^{a}	7.0^{b}
Textures	5.0^{d}	6.0^{c}	6.5^{b}	7.0^{a}	7.0^{a}
Acceptance	6.0^{c}	6.5^{b}	7.0^{a}	7.0^{a}	7.0^{a}

Values bearing the same superscript within the same row are not significantly different (P> 0.05)

Conclusion

Results of the present study demonstrated that, soaking olive fruits in brine citric acid solutions before pickling process could be used as debittering process of olive fruits, leading that, to improving sensory properties of the end products. At the same time these new techniques could reduce using of lye treatment and its healthy concerns.

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