American Journal of
Food Technology

ISSN 1557-4571

Academic
Journals Inc.

www.academicjournals.com

American Journal of Food Technology 10 (4): 176-183, 2015
ISSN 1557-4571 / DOI: 10.3923/ajft.2015.176.183

Effect of Pressing Techniques on Olive Oil Quality

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ABSTRACT
Different techniques of oil extraction are applied in Jordan, including traditional press, two- and three-phase systems. Results of the study indicated that there is a significant difference in olive oil quality obtained from different pressing systems in terms of free acidity, ultraviolet absorption, peroxide value, polyphenol content, organoleptic assessment and overall quality index. Olive oils obtained from the two-phase mills were classified as extra virgin olive oil. While, olive oils obtained from the three-phase mill were ranged from extra to ordinary virgin olive oil. In the contrary olive oils obtained from the three conventional mills were classified as lampante virgin olive oil. The two-phase decanters produce high quality olive oils with higher contents of total polyphenols which makes them more resistant to oxidation during storage. These decanters, also having an advantage of saving on wastewater disposal costs because they produce only a small amount of such waste.

Key words: Olive oil, polyphenol, quality index, peroxide, processing techniques

INTRODUCTION
Olive tree, (*Olea europaea* L.) is a major agricultural crop in the Mediterranean Basin and its economical role in the countries of these regions is well recognized. Jordan is considered as one of the natural habitat for cultivated olives. There are two main olive producing regions in the country; the north western region which is mainly rain-fed and the irrigated farming in the north east desert area. Approximately 20 million olive trees are cultivated in Jordan covering about 130,000 ha (MoA., 2010). There are more than 20 olive cultivars present in Jordan, however, the most predominant ones are: 'Nabali', 'Rasei' and 'Souri'. Olive sector in Jordan has several positive aspects including good indigenous varieties, hand picking, minimum use of pesticides and chemical fertilizers and modern mills based on continuous flow system. Jordanian extra virgin olive oil has some characteristics that distinguish it; high oleic acid content and natural antioxidants, an aroma of fresh olives with hints of apple and other mature fruits with almost total absence of bitterness.

There are many factors that affect olive oil quality and composition such as; the location (altitude, climatic conditions and soil type), cultivar, fruit maturity stage, fruit health, time and method of harvesting, olive storage, oil extraction technique (mill type, extraction temperature and duration), olive oil storage conditions and packaging (Ayoub, 2006).

Olive oil is greatly appreciated for its distinctive flavor and its nutritional and biological properties, all of which are closely linked to quality. However, many of the oils produced do not posses these characteristics, largely because of the way in which processing equipment is operated. While pressing can detract from oil quality owing to poor handling of the pressing mats, high mixing temperatures and the addition of large amounts of water to thin the olive paste can cause deterioration of the minor components of the oil, thus altering its flavor and keeping properties (Youssef *et al*., 2013).

Olive oil quality is affected by processing system and various stages in the olive oil extraction procedures. The traditional pressing systems have been gradually substituted by the three-phase centrifugal systems, while the dual-phase centrifugal systems are being used more recently (Torres and Maestri, 2006).

The traditional method for oil extraction is to spread the olive paste in layers 2-3 cm thick in pressing mats (made of synthetic or natural fiber) or on steel discs. It is more common, however, for the oil to be extracted by centrifuging the paste. The pressure method might be considered as the oldest process for obtaining olive oil. This method has disadvantages including discontinuity of the process, contamination of the oil diaphragms and high labour cost (Ayoub, 2006).

During the last 20 years, significant technological progress has been made in olive oil extraction industry. Manufacturers of processing equipment have developed the continuous centrifugation systems trying to improve processing efficiency and quality of olive oil. Currently, the majority of traditional olive mills have been replaced by integral centrifuge systems (Torres and Maestri, 2006).

The three-phase decanters requires the addition of water to the system which dilutes out water soluble compounds and separates the paste into three phases; oil, pomace and wastewater. One of the drawbacks of the three-phase system is the production of a considerable amount of wastewater which has a negative impact on the environment (Torres and Maestri, 2006).

Two-phase (or ecological) decanters have been introduced to the olive oil extraction market since 1992. In this type of centrifuge very small amounts of water are added to dilute the olive paste and the wastewater and pomace are discharged in one phase (Koutsaftakis and Stefanoudakis, 1995). The two-phase decanters produce oils with higher contents of total polyphenols which makes them more resistant to oxidation during storage. These decanters, also having an advantage of saving on wastewater disposal costs because they produce only a small amount of such waste. The only major drawback of this kind of equipment is that the pomace it produces is too wet (Di Giovacchino, 1996).

The percolation (Sinolea) method is used for the oil separation from the olive paste based on the differences of the surface tension between oil and wastewater when contacting a steel plate. The main advantages of Sinolea-type techniques are: they operate in continuous, automated cycle which require low labour and the oil of good aroma and flavour. The main drawback of the percolation method is that, it does not provide high oil yields, especially when pomace has a high content of water.

Lanzon *et al*. (1986) studied the effect of two processing systems (pressure and centrifugation) on olive oil composition and found that oil obtained by centrifugation contained a higher fatty and triterpene alcohols than that obtained by pressure. Nergiz and Unal (1991) reported that oil obtained by pressure contained higher amounts of polyphenols than that obtained by centrifugation. Di Giovacchino *et al*. (1994) found that olive oils obtained from good-quality olives did not differ in free fatty acids, peroxide value, ultraviolet absorption and sensory characteristics regardless of the processing system used. Olive oil produced by the two-phase process contains more phenolic compounds than oil from the three-phase process. Ranalli and Angerosa (1996) compared the oil obtained from three olive cultivars by two and three-phase processes. Oil obtained by the two-phase system was comparable to the oil obtained by the pressure process, but it had better quality characteristics than that of the three-phase decanter oil. They also found that oil obtained from the two-phase system has higher amounts of polyphenols and aroma volatile compounds than oil obtained by the three-phase system.

Sensory quality plays an important factor in olive oil overall quality. Aroma, taste and appearance are particularly significant for extra virgin olive oil. Flavour, olive oil quality and hence its commercial value varies markedly depending on several factors. The complex flavour of virgin olive oil is mainly produced by volatile and phenol compounds most of which have been identified (Morales *et al*., 1997). The quantities of these substances in olive depend on agronomic factors, olive ripeness, cultivar, olive storage conditions, handling, milling, malaxation and extraction processing (by pressing or centrifugation) (Tzia *et al*., 1997).

The objective of this study is to assess the difference in olive oil quality among the different pressing techniques (Traditional, Two-phase and Three-phase systems) that present in Jordan.

MATERIALS AND METHODS

This study was conducted in 2011/2012 crop season and concerned with three types of olive extraction systems; pressing (Traditional), two-phase and three-phase systems. For each type of these extraction systems, three mills were selected to conduct the study. The total number of olive mills represented in this study was 9, located in the same geographical area. The selected conventional mills are located in Tebneh/Irbid, Kafer Al-Maa'a/Irbid and Souf/Jarash. The two-phase and the three-phase mills are located in Baleela/Jarash and Sakhrah/Ajlun; Oil samples were obtained from each mill and conserved far from the light until their analysis.

Free acidity and peroxide value were determined according to ISO 660 and ISO 3960 methods, respectively. Oleic acid percentage denoted by free acidity was determined by titration of oil dissolved in ethanol with sodium hydroxide. Peroxide value expressed in milli-equivalents of active oxygen per kilogram of oil (meq O_2/kg), was obtained by reacting a mixture of oil and acetic acid-iso-octane with potassium iodide solution in darkness.

Ultra violet absorption was carried out according to IOOC Regulation COI/T20/Doc. No. 19/rev. 1 (IOOC., 2001). Using a UV spectrophotometer K_{232} and K_{270} extermination coefficients were determined from absorption at 232 and 270 nm, respectively, in a solution of oil in cyclohexane. The absorption coefficients at wavelengths around 270 nm were also used for determination of ΔK. Total polyphenols were obtained by extraction of oil solution in hexane with a mixture of 60% water and 40% methanol in triplicate.

Sensory evaluation of the samples was done by 8-10 trained panellists from the Jordanian Olive Oil tasting Council, according to IOOC Regulation COI/T20/Doc. No. 15/rev. 1, (IOOC., 1996). Olive oils were classified as follows:

- **Extra virgin olive oil:** Virgin olive oil with a free acidity expressed as oleic acid of not more than 0.8% and a panel test score of 6.5 or more
- **Virgin olive oil:** Virgin olive oil with a free acidity expressed as oleic acid of not more than 2% and a panel test score of 5.5 or more
- **Ordinary virgin olive oil:** Virgin olive oil with a free acidity expressed as oleic acid of not more than 3.3% and a panel test score of 3.5 or more

- **Lampante virgin olive oil:** Virgin olive oil with a free acidity expressed as oleic acid of more than 3.3% and a panel test score of less than 3.5

For a global quality evaluation of virgin olive oil, the Overall Quality Index (OQI) (Kiritsakis *et al*., 1998) was used as follows:

$$QOI = 2.55+0.91\ SE-0.78\ AV-7.35\ K_{270}-0.066\ PV$$

Where:

SE : Sensory evaluation (from 3.5-9.0)
AV : Acid value (from 0.1-3.3)
K_{270} : Absorbance at 270 nm (from 0.08-0.22)
PV : Peroxide value (from 1.0-20.0)

All measurements were done in triplicate, using Complete Random Design. The results were statistically analyzed using MINITAB 2010 program (MINITAB., 2010). Means were compared using analysis of variance and Least Significant Difference (LSD) tests for multiple comparisons at a significant level of 0.05.

RESULTS AND DISCUSSION

Free acidity: Oil acidity is considered as a basic characteristic of olive oil quality. Free acidity is the content of free fatty acids determined according to the procedure specified in the method and expressed in grams of oleic acid for every 100 g of oil. Results of this study show that olive oil obtained from the three conventional mills exhibited significantly much higher free acidity values (3.68, 1.7 and 5.1%) compared to the two-phase and three-phase mills (Table 1). All of the three conventional mills produce oils with free acidity that exceed the IOOC limit of 0.8% required to meet Extra Virgin Olive Oil (EVOO) classification. Olive oils obtained from the conventional mills no. 1 and 3 are classified as lampante virgin olive oil regarding their acidity values, indicating very bad quality olive oil, not suitable for human consumption. Free acidity values for oil extracted from the two and three-phase mills were well under the IOOC limit standard of $\leq$0.8% required to meet EVOO status (Table 1).

Table 1: Quality characteristics of virgin olive oils obtained from pressing Traditional (conventional), two-phase and three-phase extraction systems

	Traditional			Two-phase			Three-phase		
Parameter	1	2	3	1	2	3	1	2	3
Free acidity (%)	3.680^{b}*	1.700^{c}	5.100^{a}	0.310^{gh}	0.280^{h}	0.340^{g}	0.450^{f}	0.740^{d}	0.560^{e}
Peroxide value (meq O_2/kg)	34.400^{a}	22.700^{c}	27.360^{b}	6.800^{f}	4.130^{h}	4.840^{g}	8.700^{e}	10.000^{d}	6.650^{f}
K_{232}	2.660^{b}	2.380^{c}	2.840^{a}	1.860^{d}	1.650^{e}	1.600^{e}	1.860^{d}	1.850^{d}	1.600^{e}
K_{270}	0.220^{b}	0.170^{c}	0.240^{a}	0.150^{d}	0.120^{f}	0.120^{f}	0.110^{g}	0.130^{e}	0.120^{f}
ΔK	0.004^{b}	0.003^{bc}	0.006^{a}	0.003^{bc}	0.004^{b}	0.001^{d}	0.001^{d}	0.002^{cd}	0.001^{d}
Total polyphenols (ppm)	51.920^{h}	151.700^{e}	120.400^{g}	244.100^{b}	240.800^{c}	251.200^{a}	126.900^{f}	239.100^{c}	193.000^{d}
Sensory evaluation	2.000^{e}	2.600^{e}	2.300^{e}	7.200^{ab}	7.500^{a}	6.800^{b}	6.600^{b}	4.400^{d}	5.700^{c}
Overall Quality Index (OQI)	1.930^{f}	1.280^{g}	2.960^{e}	7.310^{b}	8.010^{a}	7.270^{b}	6.920^{b}	4.590^{d}	5.980^{c}

*Means within each row followed by the same letter are not significantly different at 5% probability level

All of the conventional mills in Jordan are very old and don't follow any means for cleanness or quality control. They stack up layers of olive paste under pressure which pushes the oil and vegetable-water through a filter leaving the solids behind. The major difficulty is to keep the filter mats clean without oxidized oil and fermentation defects. In addition, all the farmers bring their olives in plastic sacks and wait for several days in the mill before pressing.

The reason for rapid development of acidity in olives stored for long time in plastic sacks could be enzymatic lipolysis of the fruit triacyglglycerols as a result of fungal growth, decay incidence and increasing fruit storage temperature (Al-Addasi *et al*., 2005; Agar *et al*., 1998; Kiritsakis *et al*., 1998). All of these factors are possibly the reason for the high acidity of olive oil obtained from the conventional mills.

Peroxide value: The peroxide value is caused hydroperoxides which are products of the primary stage of oxidation of unsaturated fatty acids of the triglycerides. Peroxide value is used as an indicator for revealing defects related to enzymatic and oxidative deterioration in oils. Also, it is used to monitor production problems occur after harvest and during processing and storage.

Peroxide values for oil obtained from the three conventional mills were higher than the limit 20 meq O_2/kg, set by the IOOC for EVOO. These values were also much higher than the two-and three-phase mills (Table 1). There were no significant differences between the two and the three-phase mills in peroxide values and they were all under the IOOC limit for EVOO.

The low peroxide values for olive oil obtained from the two-phase mill were correlated with the high phenol content compared to olive oil obtained from conventional and three-phase mills (Table 1).

All the factors that affect the acidity as discussed previously, may explain the high peroxide values for olive oil obtained from the conventional mills. The low peroxide values for oils obtained from the two and three-phase mills could be explained by good processing techniques and suitable storage conditions for the oil. The application of good practices in the cultivation, harvesting, storage and processing the olives during the production of olive oil results in olive oils with low peroxide value. In addition, olive oils with low peroxide value are obtained by protecting the olive oil from light, temperature, air and traces of metallic elements.

Ultraviolet absorption: Ultraviolet absorption is an expression about the extent of extinction coefficient at wavelength 232 and 270 nm. It is an indication of oxidation degree of the oil. Spectrophotometric absorption values at 232 nm were significantly higher for oil obtained from conventional mills than for oil obtained from the two-and three-phase mills (Table 1). Olive oils obtained from the conventional mills No. 1 and 3 have high absorption values at 232 nm that exceed the limit of 2.5, set by the IOOC for EVOO. However, all of the other olive mills had values for their oil below the limit of 2.5 set by the IOOC. The absorbency at 232 nm is caused by hydro peroxides which are produced in a primary stage of oxidation and conjugated dines which are produced in an intermediate stage of oxidation.

Spectrophotometric absorption values at 270 nm for oils from all olive mills under study were below the limit of 0.22, set by the IOOC for EVOO (Table 1). The absorbency at 270 nm is caused by carbonylic compounds (ketones and aldehydes) which are produced in a secondary stage of oxidation.

The absorption coefficient (ΔK) for oils from all olive mills were below the limit of 0.01, set by the IOOC for EVOO (Table 1). The (ΔK) index is a criterion of discrimination between a bad quality virgin olive oil and refined olive oil. The observed increase in K_{232} and K_{270} for olive oil obtained from conventional mill was correlated with the low polyphenol content. However, the low K_{232} and K_{270} for olive oil obtained from the two-phase mill paralleled the increase in total polyphenol content (Table 1).

Total polyphenols: Total polyphenol content of the olive oil showed significant differences between the three types of olive mills with the highest level obtained from the two-phase system. Olive oil from conventional mills show lower polyphenol content compared to other mill types (Table 1).

Virgin olive oil is virtually contains large amounts of natural phenolic compounds. These compounds are responsible for its distinctive bitter yet fruity taste and largely determine its stability by enhancing its resistance to oxidation. This parameter is very important, particularly to the organoleptic quality and keeping properties of the oil. Virgin olive oils obtained from the three-phase decanter, have a lower content of polyphenols because water was used to dilute the olive paste. The water partially dissolves the polyphenols and their content, therefore, diminishes. It is worth to mention that excessively high temperature and prolonged mixing of the paste have a detrimental effect on oil quality and cause the breakdown of polyphenols particularly which lends the oil its keeping properties and aroma (Khlif *et al*., 2003).

Organoleptic assessment (sensory evaluation): Organoleptic assessment is the detection and the description of both qualitative and quantitative flavour characteristics of virgin olive oil using human senses and the classification of this virgin olive oil according to its flavour characteristics. Results of sensory evaluation for this study indicated that total scores generally were higher for olive oil obtained from two-phase systems than the other olive mills (Table 1).

The organoleptic characteristics of virgin olive oil are divided into positive and negative attributes. The compounds which are responsible for the negative attributes are not found in good quality olive oil. These compounds are secondary products of oxidation or of enzymatic reactions and they could be due to the extraction of olive oil from poor quality olives, olives stored in bad conditions, defective storage of olive oil or the bad manufacturing and processing procedures. Consequently, virgin olive oils with positive organoleptic attributes are obtained by applying good practices in the cultivation, harvesting, storage, processing the olives and so, avoiding the enzymatic and chemical oxidations.

Olive oils obtained from the three conventional mills were characterized by the absence of fruity aroma and the presence of several negative attributes including fusty, muddy sediment, vegetable water and the most pronounce pressing mat defect. These defects were due to fermentation of the olives, presence of sediments, poor decantation and prolonged contact with the vegetable water. The pressing mat defect which was clearly detected in the oil samples from the conventional mills, could be explained by the use of dirty pressing mats in which fermented residues have been left.

The fruity positive attribute was present in olive oil obtained from the two and three-phase mill. However, the intensity of the fruity attribute was higher for olive oil obtained from the two-phase mill. The intensity of the bitter positive attribute was much higher in the oil obtained from the two-phase mill than the three-phase mill. This is may be due to high content of polyphenols in the oil obtained from the two-phase mill. Phenolic compounds contribute to oil flavour and aroma which characterize by bitter taste of olive oil (Rosales *et al*., 1992).

According to the sensory evaluation score, olive oil obtained from the three two-phase mills and from the three-phase mill (No. 1) is classified as EVOO. However, olive oil obtained from the three-phase mill (No. 3) is virgin olive oil and from mill No. 2 is ordinary virgin olive oil. On the other hand olive oil obtained from the three conventional mills is classified as lampante virgin olive oil (Table 1). Lampante virgin olive oil is not suitable for eating without refining.

Overall quality index: The highest values of OQI were ranked for olive oil obtained from two and three-phase systems, indicating high quality olive oil. However, olive oils obtained from the conventional mills were of low OQI values, indicating very low quality olive oil (Table 1).

CONCLUSION

The best olive oil quality is obtained from the two-phase mills, followed by the three-phase mills. Conventional mills produce very bad quality oil not suitable for human consumption. Based on these findings, it is recommended to upgrade the conventional mills present in Jordan. This can be done, by replacing the old pressing lines with new full-automatic pressing lines. It is strongly recommended to apply the two-phase decanter system. Changing to the 2-phase system will bring several advantages. While water consumption and wastewater production decrease, the quality of the olive oil improves (higher polyphenol content).

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