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EFFECT OF THE PASTE FLOW RATE FEEDING TO AN OLIVE DECANTER ON THE EFFICIENCY OF EXTRACTION AND OIL QUALITY

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ABSTRACT: *The economic value of olive fruits is focused in its oil content. A practical study on peiralisi olive oil production line at Salhia was carried out to determine the effect of the paste feeding flow rate to the decanter on the extraction efficiency and oil quality. The decanter of theoretical capacity of 2000 kg olive paste hour was used. Different paste feeding flow rates of 2000, 1800, 1600 kg/hr. equal to 100.90 and 80% capacity were used to study the effect of paste feeding flow rate on the efficiency of extraction and oil quality. Four samples from different position (decanter, separators 1 and 2 "oily and water phases" and husk "sansa") during oil separation were collected. Acidity, peroxide value uv, absorbance at 232 and 270 nm. were determined for olive oil samples to evaluate the oil quality. Total polyphenols, tocopherols content and the stability were determined.*

Results showed that using flow rate of 80% (1600 kg/hr) gave the highest oil percent from olive paste and the least residual quantity in pomace.

Free fatty acid peroxide value and uv. absorbance at 232 and 270 nm. recorded a slight increased, but total polyphenols, total tocopherols and stability recorded a higher decrease for all samples by increasing the theoretical capacity. These high values of free fatty acid, peroxide value and uv absorbance at 232 and 270nm., and low values of total polyphenols, total tocopherols and stability with increasing the theoretical capacity indicated that low quality of the extraction olive oil. The best quality of olive oil was obtained by using 80% of theoretical capacity. Also the best quality of oil was obtained from horizontal centrifugal decanter compared with that from oily and water phases.

Key words: *Coratina olive oil, triple-phase, oil content, olive paste and pomace polyphenols, tocopherols and stability.*

INTRODUCTION

In 1955, olive oil began to be extracted by means of a three-phase centrifuge (with horizontal axle) which separates the oil, water and husk from the olive paste (Ranalli & Martinell 1995). Since the centrifuge system reduced the processing time, this in term reduced the excessive storage period of olives. The oils obtained were frequently of higher quality (Alba, 1997; Angerosa & Di Giovacchino, 1996, Ranalli & Martinell, 1995). Oils extracted by a two phase decanter have higher concentration of tocopherols and phenols and showed higher stability to oxidiation than those obtained by a three phase decanter (Angerosa & Di Giovaccino, 1996; Di giovacchino *et al.*, 1994, Ranalli & Martinell, 1995 and Gimeno *et al.*,2002).

Hermosos *et al.* (1994) stated that, similarly to the three-way decanter, the two-way one caused a decrease in the industrial yield as the paste flow increased, and the oil losses depend on the rheology of the olive fruit. Second, with the three-way decanter the oil losses were mainly due to an increase in the oil content of the olive vegetation water, while with the two-way one these losses were due to an increase in the oil content of the olive cake.

The α-tocopherol content decreased from the two-phase to the three-phase decanter and pressure systems, and also the concentration of total phenol, was slightly lower in the oils extracted using the three-phase decanter than those from the two-phase one (Salvador, *et al.*, 2003). After many years of trials big units have increased the labor capacity and reduced the need for labor force, and hence decreased, to a certain, the cost of olive oil production to certain extent. Those conditions have caused the expansion of this system nowadays. The continuous chains replaced the pressure system (creation of new units-reconverting the old ones) (Khilf, *et al.*, 2003). Also the results obtained by them showed that using theoretical capacity caused considerable loss in oil and polyphones. The least residual quantity of oil pomace (23. 19 kg/ton of olive), which means the highest extraction rate, has been obtained by using 90% of the theoretical capacity and 500 L/hr. as paste-diluting water flow. Catalano, *et al.* (2003) indicated that the potential for the optimization of oil extraction efficiency from paste obtained with a more precise choice of solid particle dimensions during the crushing phase.

The aim of this study is to determine the effect of different paste feeding flow rates to the decanter in comparison with the theoretical one on the efficiency of extraction and oil quality.

MATERIALS AND METHODS

Materials: Olive fruits variety Coratina were purchased from a private archard in Ismalia Governorate and the production line in Salhia with a decanter of theoretical capacity 2000 kg olive paste/ hr. was used in this study. Different flow rates of feeding paste to the decanter were used as follows:

Feeding flow rate	% of theoretical capacity
2000 kg olive paste/hr. (control)	100
1800 kg olive paste/hr.	90
1600 kg olive paste/hr.	80

Samples from four different points of processing line were obtained. These points are illustrated in figure (1).

Sample (1): Representing the horizontal centrifugal (decanter) which contained the oil and traces of water.

Sample (2): Representing the vertical separator (1) which contained the oil without water (oily phase).

Sample (3): Representing the vertical separator (2) which contained the oil as trace with the vegetable water after being separated by centrifugation (water phase).

Sample (4): Representing the olive pomace obtained. This sample was used to determine the residual oil in the pomace. Hence, it may determine the efficiency of the extraction process.

Methods:

Olive processing at industrial scale was carried out using a three-phase continuous extraction system. Olives (1600, 1800 and 2000 kg) were crushed using an Inox hammer mill, operating at 3000 r.p.m. and equipped with a sieve of 5-mm holes. Malaxation of pastes was made in a mixer at 14 rpm, and 30°c for 50 min solid-liquid separation of the paste into oil, pomace and vegetable water was performed by a three phase centrifugal decanter working at 3000 rpm. Finally, a vertical centrifuge [(Separator (1) and (2)] operating at 6200 rpm and fed with 0.25 L. tap water/kg oily must, was used to remove the remaining solids from the must. Oils from the decanter and separators (1) and (2) (oily and water phase) were filtered through sodium sulfate anhydrous before analysis.

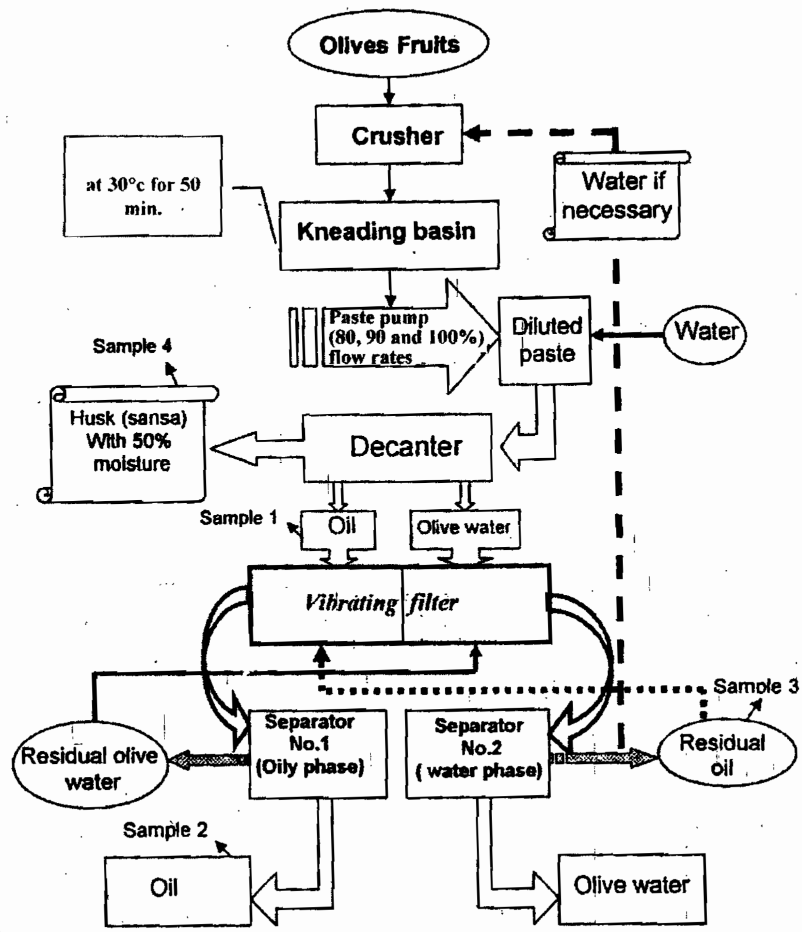

Fig. (1): Flow sheet of the three phase centrifugal extraction of olive oil

Preparation of oil samples for analysis:

Before the determination of oil quality the samples were centrifuged to eliminate water traces. The centrifugation was performed at 6000 r.p.m for 30 minutes. The centrifugations was done for the 1,2,3, samples of the decanter.

Pomace samples:

Pomace samples which obtained from three phase centrifugal decanter were dried in an electric oven at 60°C till constant weight the oil content was determined according to the method described in the A.O.A.C. (2000).

Physicochemical properties of oil:

Refractive index, acidity (free fatty acid) and peroxide value were determined according to the method described in the A.O.A.C. (2000).

U.V. spectroscopy:

The absorption was read at K-232 and K-270 nm. in a quartz cell with 1cm path length against a solvent blank in a matching cell using a pyeunicem double-beam spectrophotometer (model SP 1800) according to the method described by Kates (1972).

Determination of total polyphenols:

The polyphenols were extracted from the oil by aqueous methanol (60% v/v) then the concentrated total polyphenols in the methanolic extract was estimated with a Folin-Coilcateu reagent according to the method described by Gutfinger (1981).

Determination of total tocopherols:

The total tocopherols content of the oil samples was determined in the virgin olive oils according to the method of Wong et al. (1988).

Rancimat method for oil stability:

The stability of virgin olive oil was determined by the Rancimat method using a 699 Rancimat (Metrohm Herisos, Switzerland/at 100° with an air flow rate of 20 l/hr. according to the method described by Mendez et al. (1997).

Color determination:

Color of the oil samples was determined using Lovibond model E, 5.25 cell according to the Egyptian standard specification for oils (1993).

Statistical analysis:

The analysis of variance of two factorial design was applied for all data under the present study according to the method onllined by snedecor and

Cochran (1980). The new LSD test was used to compare the significant difference between means of treatments (Waller and Duncan, 1969).

RESULTS AND DISCUSSION

Effect of varying decanter supply flow on the oil content of paste and pomace olive during extraction through three phase:

Data in table (1) show the effect of different speed of the pump that feeds the decanter with olive paste, 1600 kg/hr, 1800 kg/hr. and 2000 kg/hr (80%, 90% and 100% of theoretical capacity) an the oil content of pomace and paste of coration a olive. The results obtained show that using 100% of theoretal capacity (2000 kg/hr) there was a to considerable loss in oil content in pomace (860%). The least residual quantity of oil pomace (6.38%), which means the highest extraction rate prone olive paste (46-29%), has been obtained by using 80% of the theoretical capacity. The highest extraction rate by using 80% of the theoretical capacity my be due to increase the efficiency of the malaxation with decreasing the paste flow rate feeding, which it formation of alarge quantity of minute oil droplets coalesced which can be easily extracted. These findings are in accordance with those of Hermosos et al. (1994).

Effect of varying decanter supply flow on the physical properties of olive oil during extraction through three-phase decanter.

The data tabulated in tables (2,3 and 4) showed that the effect of different speeds of pump that feed the decanter with a paste (80, 90 and 100% capacity) on the physical properties of samples taken from decanter (sample one) and separators of oily and water phases (samples two and three). From the data in table (2) it could be noticed that no clear change in refractive index of all samples as a result of the using different speed pump. And also from the results in tables (3 and 4) it could be observed that, there no significant differences in color between samples one from and two in red and blue color, but there is remarkable difference in color between sample two and three. This is because sample three represents the traces of oil in vegetable water.

Table (1): Effect of varying decanter supply flow rate on oil contents of olive pastes and olive pomace during extraction through three-phase decanter.

Samples	Theoretical capacity		
	80%	90%	100%
Olive pomace	6.38c ±0.35	7.55b ±0.24	8.60a ±0.29
LSD at 5% 0.8015			
Olive pastes	46.29a ±0.3	45.62b ±0.25	44.83c ±0.4
LSD at 5% 0.801			

The values having the same letter are not significantly different at 5% level of probability.

Table (2): Effect of varying decanter supply flow rate on the refractive index of olive oil during extraction through three-phase decanter.

Samples	Theoretical capacity			Mean (A)
	80%	90%	100%	
Sample (1)	1.4682a ±0.0003	1.4682a ±0.0003	1.4685a ±0.0003	1.4683a
Sample (2)	1.4684a ±0.0001	1.4683a ±0.0003	1.4684a ±0.0001	1.4684a
Sample (3)	1.4683a ±0.0002	1.4683a ±0.0003	1.4686a ±0.0001	1.4684a
Mean (B)	1.4683a	1.4683a	1.4685a	1.4684a
LSD at 5%		A	B	AB
		0.0009993	0.0009993	0.001731

The values having the same letter are not significantly different at 5% level of probability.

Table (3): Effect of varying decanter supply flow rate on red color of olive oil during extraction through three-phase decanter.

Samples	Theoretical capacity			Mean (A)
	80%	90%	100%	
Sample (1)	4.4a ±0.1	4.3ab ±0.1	4.4a ±0.17	4.37a
Sample (2)	4.1ab ±0.1	4.07b ±0.15	4.3ab ±0.44	4.16b
Sample (3)	3.7c ±0.1	3.6c ±0.17	3.7c ±0.1	3.67c
Mean (B)	4.07a	3.99a	4.13a	4.07
LSD at 5%		A	B	
		0.1870	0.1870	

The values having the same letter are not significantly different at 5% level of probability.

Table (4): Effect of varying decanter supply flow rate on blue color of olive oil during extraction through three-phase decanter.

Samples	Theoretical capacity			Mean (A)
	80%	90%	100%	
Sample (1)	4.3a ±0.1	4.4a ±0.2	4.4a ±0.17	4.37a
Sample (2)	4.2a ±0.17	4.2a ±0.20	4.2a ±0.20	4.20a
Sample (3)	3.7b ±0.2	3.7b ±0.17	3.7b ±0.1	3.70b
Mean (B)	4.07a	4.10a	4.10a	4.09
LSD at 5%		A	B	AB
		0.1815	0.1815	0.3144

The values having the same letter are not significantly different at 5% level of probability.

Effect of varying decanter supply flow on the chemical properties of olive oil during extraction.

Data in tables (5,6,7 and 8), show the effect of different speeds of the pump that feed the decanter with a paste (80, 90 and 100% full capacity) on the chemical properties of oils obtained from horizontal centrifugal decanter (sample one), vertical separator of oily phase (sample two) and vertical separator of water phase (sample three).

It is clear from results shown in tables (5,6,7 and 8) that the acidity peroxide value and UV. absorbance at 232 and 270 nm. increased by increasing the paste flow rate feeding to decanter for most samples taken from the decanter and separators (oily and water phases). This increase in the previous parameters may be due to the oxidative degradation and hydrolysis of oils by increasing theoretical capacity.

On the other hand, sample three recorded a higher increase as compared to samples one and two. This increase in free fatty acid, peroxide value and uv. absorbance at 232 and 270 nm. of sample three may be due to occurrence of vegetable water in this sample.

Table (5): Effect of varying decanter supply flow rate on acidity (%) of olive oil during extraction through three-phase decanter.

Samples	Theoretical capacity			Mean (A)
	80%	90%	100%	
Sample (1)	0.69e ±0.01	0.68e ±0.02	0.72e ±0.02	0.70c
Sample (2)	0.78d ±0.03	0.84c ±0.04	0.84c ±0.02	0.82b
Sample (3)	1.14d ±0.05	1.24a ±0.04	1.24a ±0.02	1.21a
Mean (B)	0.87b	0.92a	0.93a	0.91
LSD at 5%		A	B	AB
		0.0316	0.0316	0.05474

The values having the same letter are not significantly different at 5% level of probability.

Table (6): Effect of varying decanter supply flow rate on peroxide value (meq/kg oil) of olive oil during extraction through three-phase decanter.

Samples	Theoretical capacity			Mean (A)
	80%	90%	100%	
Sample (1)	9.33d ±0.03	9.85bcd ±0.05	9.96bc ±0.06	9.71b
Sample (2)	9.66cd ±0.06	9.38d ±0.47	10.00abc ±0.63	9.68b
Sample (3)	10.35ab ±0.21	10.40ab ±0.36	10.55a ±0.22	10.43a
Mean (B)	9.78b	9.88ab	10.17a	9.94
LSD at 5%		A	B	AB
		0.3223	0.3223	0.5582

The values having the same letter are not significantly different at 5% level of probability.

Table (7): Effect of varying decanter supply flow rate on K-232nm. of olive oil during extraction through three-phase decanter.

Samples	Theoretical capacity			Mean (A)
	80%	90%	100%	
Sample (1)	0.310h ±0.002	0.316g ±0.002	0.322f ±0.002	0.316c
Sample (2)	0.362e ±0.003	0.374d ±0.004	0.382c ±0.003	0.373b
Sample (3)	0.382c ±0.002	0.393b ±0.002	0.395a ±0.003	0.390a
Mean (B)	0.351c	0.361b	0.366a	0.36
LSD at 5%		A	B	AB
		0.00009993	0.00009993	0.001731

The values having the same letter are not significantly different at 5% level of probability.

Table (8): Effect of varying decanter supply flow rate on K-270nm. of olive oil during extraction through three-phase decanter.

Samples	Theoretical capacity			Mean (A)
	80%	90%	100%	
Sample (1)	0.048f ±0.002	0.045g ±0.001	0.048f ±0.002	0.047c
Sample (2)	0.053e ±0.003	0.055d ±0.001	0.062c ±0.001	0.057b
Sample (3)	0.074b ±0.002	0.078a ±0.001	0.078a ±0.002	0.077a
Mean (B)	0.058c	0.059b	0.063a	0.060
LSD at 5%		A	B	AB
		0.00009993	0.00009993	0.001731

The values having the same letter are not significantly different at 5% level of probability.

Effect of varying decanter supply flow on the natural antioxidant of olive oil during extraction through three-phase decanter

From the results in table (9,10 and 11), it could be noticed that total polyphenole (table 9) of oils taken from water phase (sample 3) was recorded the lowest content of polyphenols a compared to oils taken from horizontal centrifugal decanter and oily phase (samples 1,2) respectively. The decrease in total polyphenols of water phase may be explained by their water - solubility higher water paste ratio are used in triple-phase centrifugation. And therefore a larger amounts of phenols were eliminated with water wastes (Salvador, et al., 2003).

The results obtained in the same table show that using 100% of theoretical capacity (2000 kg/hr.) lead to a considerable loss in total polyphenols of samples one and two, similar data are reported by (Khilf et al., 2003).

On the other hand total tocopheral content (table 10) of samples taken from vertical separators oily and water phases were decreased compared to that taken from horizontal centrifugal decanter. Results in the same table show that total tocopherols of all samples were decreased as a results of increasing the theoretical capacity.

The stability of the oil samples (table 11) taken from decanter and oily and water phases were decreased by increasing the theoretical capacity. This decrease in the stability may be due to certain enzymes such as polyphenoloxidase and peroxidase which may play an important rol in this phenomenon (Servili et al., 1999).

Table (9): Effect of varying decanter supply flow rate on total polyphenols (ppm) of olive oil during extraction through three-phase decanter.

Samples	Theoretical capacity			Mean (A)
	80%	90%	100%	
Sample (1)	478.440a ±2.00	468.783b ±1.15	458.590c ±2.00	468.604a
Sample (2)	448.393d ±1.53	444.227e ±3.51	437.750f ±2.75	443.457b
Sample (3)	243.297g ±2.08	239.810h ±0.57	239.103h ±0.66	240.737c
Mean (B)	390.043a	384.273b	378.481c	384.266
LSD at 5%		A	B	AB
		1.951	1.951	3.379

The values having the same letter are not significantly different at 5% level of probability.

Table (10): Effect of varying decanter supply flow rate on total tocopherol (ppm) of olive oil during extraction through three-phase decanter.

Samples	Theoretical capacity			Mean (A)
	80%	90%	100%	
Sample (1)	243.323a ±1.93	232.327b ±2.14	223.627d ±2.51	233.092a
Sample (2)	228.813c ±1.08	224.520d ±1.02	219.730e ±3.00	224.354b
Sample (3)	204.650f ±2.84	204.103f ±0.73	203.737f ±0.23	204.163c
Mean (B)	225.596a	220.317b	215.698c	220.537
LSD at 5%		A	B	AB
		1.608	1.608	2.786

The values having the same letter are not significantly different at 5% level of probability.

Table (11): Effect of varying decanter supply flow rate on stability (hr) of olive oil during extraction through three-phase decanter.

Samples	Theoretical capacity			Mean (A)
	80%	90%	100%	
Sample (1)	42.19a +0.17	41.55b +0.33	41.27b +0.20	41.67a
Sample (2)	40.61c +0.10	40.70c +0.14	39.95d +0.05	40.42b
Sample (3)	36.90e +0.02	36.49f +0.09	36.51f +0.08	36.64c
Mean (B)	39.90a	39.58b	39.25c	39.58
LSD at 5%		A	B	AB
		0.1642	0.1642	0.2844

The values having the same letter are not significantly different at 5% level of probability.

Effect of varying decanter supply flow on the total polyphenols of vegetable water during extraction through three-phase decanter.

Data in table (12) show the effect of difference in the theoretical capacity (80, 90 and 100%) on the polyphenols of waste-water of coration olive. From the data in this table, it could be noticed that total polyphenols of vegetable water was decreased by increasing the theoretical capacity. This decrease may be due to the increase of polyphenols solubility in oily phase with increasing the theoretical capacity.

Table (12) Effect of varying decanter supply flow rate on the total polyphenols of vegetable water during extraction through three-phase decanter.

Theoretical capacity (%)	Polyphaenols (ppm)
1600 (80%)	479.60a + 0.71
1800 (90%)	478.31b + 0.53
2000 (100%)	476.83c + 0.23
LSD at 5% 0.7135	

The values having the same letter are not significantly different at 5% level of probability.

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تأثير معدل انسياب عجينة الزيتون المحقونة فى الديكانتر على كفاءة استخلاص الزيت وجودته

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الملخص العربى:

تتركز القيمة الاقتصادية لثمار الزيتون فى محتواها من الزيت، وقد تم إجراء دراسة عملية على خط لإنتاج زيت الزيتون ماركة براليزى الإيطالية بالصالحية وذلك لمعرفة تأثير معدل الانسياب لعجينة الزيتون فى الديكانتر على كفاءة عملية الاستخلاص وجودة الزيت، ولقد كان لوحدة الديكانتر سعة نظرية هى ٢٠٠٠ كجم من عجينة الزيتون فى الساعة. وقد تم تشغيل معدلات مختلفة لتغذية الديكانتر بكمية ٢٠٠٠، ١٨٠٠، ١٦٠٠ كجم/ساعة (١٠٠، ٩٠، ٨٠%) لدراسة تأثير معدل انسياب العجينة على كفاءة استخلاص وجودة الزيت وتم تجميع عينات الدراسة من أربع مواضع [الديكانتر و Separators No. (1 and 2) (الطور الزيتى والمائى) و Husk (sansa)] خلال عملية الاستخلاص لتقدير الحموضة ورقم البروكسيد والامتصاص فى منطقة الـ UV على طول موجى ٢٣٢ و ٢٧٠ نانوميتر وذلك لتقييم جودة الزيت الناتج ولقد قدر أيضا محتواها من البولى فينول والتوكوفيرول وثباتها.

وتوضح النتائج المتحصل عليها أن استخدام معدل انسياب العجينة فى الديكانتر ١٦٠٠ كجم/ ساعة (٨٠%) أعطى أعلى نسبة زيت مستخلصة (٤٦,٢٩%) من عجينة الزيتون وأقل كمية فاقد فى الكسب (٦,٣٨%) مقارنة بالمعدلات الأخرى.

كما سجلت درجة الحموضة والبيروكسيد والقياس فى منطقة الـ U.V. على طول موجى ٢٣٢، ٢٧٠نانوميتر زيادة بسيطة بزيادة معدل انسياب عجينة الزيتون المحقونة فى الديكانتر وعلى العكس سجلت الفينولات والتوكوفيرولات الكلية والثبات نقص كبير بزيادة السعة النظرية للديكانتر. وتشير هذه الزيادة فى أرقام الحموضة والبيروكسيد والقياس فى منطقة الـ

.U.V والنقص فى الفينولات والتوكوفيرولات الكلية والثبات بزيادة السعة النظرية للديكانتر إلـــى انخفاض جودة زيت الزيتون المستخلص.

وقد وجد أن أفضل خواص لزيت الزيتون باســتخدام ٨٠% مـــن الـــسعة النظريـــة للديكانتر.

كما وجد أيضا أن زيت الزيتون المأخوذ من الديكانتر أكثر جـــودة مقارنـــة بـــالزيوت المأخوذة من الطور الزيتى والمائى.