LASER CLASSIFICATION OF OLIVE FRUITS DURING MATURITY ACCORDING TO OPTICAL PROPERTIES

H. E. Hassan [1], A. A. Abd El-Rahman [2], M. M. Attia [3]

ABSTRACT

The aim of this study was measuring and determination of the optical properties of olive maturity stages (Arbquina variety) using visible laser with 543.5 nm with power 4 mW. The obtained results were as follows: a) The intensity reflection percentages 1.36, 1.0 and 0.51% or absorption percentages 98.64, 99 and 99.49% not accepted for stages 1,2 and 3 respectively. Also, reflection percentage of 0.42% or absorption percentage of 99.58% for stage 5 was refused, b) The intensity reflection percentage 0.47% or the absorption percentage 99.53% was indicator to the best maturity index (2.65) of olive variety. This is considering optical properties instead of ideal maturity index to determine harvesting time., d) Stage 1 was high reflection intensity percentage or low absorption intensity percentage followed with high moisture content and low oil content percentages. Meanwhile, stage 5 with low reflection intensity percentage or high absorption intensity percentage was of low moisture content and high oil content percentages. So, the stage 4 was considered suitable for oil extracting, because of low moisture content 40.41 % and high oil content 19.22 %. It was standard to identify olive maturity stages to get high oil percentage according to optical properties.

Kewwords : Olive, maturity, optical properties, oil, laser, and quality.

INTRODUCTION

Oil content does not constitute a criterion of oil quality determination but especially a criterion to be considered during the varietal selection. In all studied varieties, the average oil content ranged between 18.3 and 25.4% on fresh matter basis.

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Gunasekaran (1996) mentioned that computer vision systems are being used increasingly in the food industry for quality assurance purposes. The system offers the potential to automate manual grading practices thus standardizing techniques and eliminating tedious human inspection tasks. Computer vision has proven successful for the objective; online measurement of several food products with applications ranging from routine inspection to the complex vision guided robotic control.

Mousa et al. (1996) found that the monounsaturated fatty acids have great importance because of their nutritional values. The differences observed between locations for the fatty acid composition may be explained by the different altitudes of the locations.

Gutierrez et al. (1999) reported that in the Mediterranean region, healthy, interesting nutritional and sensorial properties of olive oil have been known for a long time. Olive oil being the main fat source of the diet due to its use without refining, which attributes its distinguishable characteristics such as: aroma, taste, colour and nutritive properties than other vegetable oils**.**

Diaz et al. (2000) said that the colorimetric analysis has been carried out by means of a Miniscan Hunter Lab spectrocolorimeter MS/S-4000S with a D65 illuminant and a 10 ^{o} observation angle. The average colour of the defects were measured by cutting a certain number of olive pieces until filling the 80 mm circular box used for the reflection measurement .

Owen et al. (2000) mentioned that olive oil is a fine product with high nutritional value and significant health benefits. Quality olive oils are expensive owing to the hard and time- consuming tasks involved in the cultivation of olive trees, the harvesting of the fruits, and the extraction of the oil. For this reason, adulteration of higher quality olive oils with either seed oils or olive oils of lower quality is a relatively common fraudulent practice.

Roca and Mınguez-Mosquera (2001) clearly showed that the olive fruit, Olea europaea, a well-known and widespread species of the Oleacea family is a green, fleshy, edible drupe. During the ripening process, it darkens to purple-black at the same time as the oil content increases. As ripening progresses, photosynthetic activity decreases and the concentrations of both chlorophylls and carotenoids decrease progressively. At the end of the maturation process, the violet or purple colour of the olive fruit is due to the formation of anthocyanins.

Jamieson (2002) stated that there are many different sensors which can be used to generate an image, such as ultrasound, X-ray and near infrared spectroscopy. The monochrome and color cameras have been used throughout the food industry for a variety of applications. The X-ray radiography has been used for the generation of images for computer vision analysis of a variety products such as water core in apples and for the detection of bones in chicken and fish.

Wang and Sun (2002) found that a computer vision system generally consists of five basic components: illumination, a camera, an image capture board and computer. The flexibility and non-destructive nature of this technique of a computer vision system can help to maintain its attractiveness for application in the food industry. Continued development of computer vision techniques such as X-ray, three dimensional and color vision will ensue higher implementation and uptake of this technology to meet the ever expanding requirements of the food industry.

Montgomery et al. (2003) mentioned that **i**nstrumental color measurement techniques can be classified by the way in which the light is treated in the measurement process. The three classifications are: 1) unaltered light, 2) three or four colored lights, and 3) monochromatic light. Instruments using three (or four) colored lights are called colorimeters, whereas instruments using monochromatic light (light of only one color) are called spectrophotometers and are capable of measuring the spectral reflectance (or transmittance) curve of a sample. The authors added that the color is not only a primary image feature, but also one of the most important features of food as it strongly affects the acceptance of products to customers.

Diaz et al. (2004) mentioned that three different algorithms have been applied to classify the olives in four quality categories. The results show that a neural network with a hidden layer is able to classify the olives with an accuracy of over 90%, while partial least squares discriminant and Mahalanobis distance are over 70% .

The aim of this study are: 1) Measurement and determination of the optical properties for olive (Arbquina variety) maturity stages using visible laser., 2) Relationship among maturity index, reflection or absorption percentages, moisture conten and oil contet of the olive fruits., and 3) Establish measurment to classify olive maturity stages according to optical properties.

MATERIAL AND METHODS

This study was executed at the Laboratory of Laser Application in the Agricultural Engineering at National Institute of Laser Enhanced Science (NILES), Cairo University, Egypt. The experiments and measurements for the optical properties of olive were carried out according to the following procedures:

Fruit sample: The study was carried out during season 2009 on olives of the Arbquina variety, from four olive trees, chosen in the plot owned by the Experimental Farm at Agricultural Faculty, Cairo University, Egypt. For each sampling, 5kg of olives were picked from the whole perimeter of olive trees selected. The olive fruit was divedid into five stages as shown in Fig. (1).

Maturity index:

Maturity index of olive fruit at different stages of ripeness is based on the maturity. The maturity index was determined on 100 randomly selected olives in each sample to obtain a numerical value for the olive sample appearance. The olives were sorted into categories using the following parameters:

0 = skin is a deep or dark green colour.
1 = skin is a yellow or yellowish-green colour.
2 = skin is a yellowish colour with reddish spots.
3 = skin is a reddish or light violet colour
4 = skin is black and the flesh is completely green
5 = skin is black and the flesh is a violet colour half way through.
6 = skin is black and the flesh is a violet colour almost through to the stone
7 = skin is black and the flesh is completely dark.

The total number of olives in each category was counted and recorded.
The following equation is then applied to determine the maturity index

$$\text{Maturity Index} = \frac{(0\times n_0)+(1\times n_1)+(2\times n_2)+(3\times n_3)+(4\times n_4)+(5\times n_5)+(6\times n_6)+(7\times n_7)}{100}\times 100$$

where n is the number of fruits with that score **(Boskou 1996).**

Fruit characteristics:

Moisture content was determined by measuring the mass difference when 10 g of olive fruits were dried in an oven at 105 ^{o}C for 5 h.

Oil content, oil content determination, 50 g of complete of fruit samples were dried in an oven at 80 ^{o}C to constant weight. The results were expressed as percentage of dry matter (% DM). the oil content was determined in the following eaquation:

Oil content , % = [(W1 – W2)/W2]X 100

Where : W1 : is the mass of fruits before drying, g and

W2 : is the mass of fruits after drying, g.

Cold press extraction :

Oil extraction was performed using a hydraulic piston model T. 20, made in Italy, measuring up to 20 tonnes as a cold extraction method in laboratory of NILS, Cairo University, and the olive paste at 28 ^{o}C for 30 min. The oil was filtered by filter paper and stored at 24 ^{o}C prior to analysis. A cold press extraction unit was used to extract olive oil. It consists of two units: hydraulic piston ranging between 0 – 400 bar and 1-16 ton and a centrifuge device (Figure 2). Approximately 250 g of fruit was ground to a paste using the hydraulic piston for mixing samples into a mixing jar. The obtained paste was centrifuged at 3500 rpm over 3 min, and then filtrated oil with filter paper, the quantity of oil was transferred to a vial and stored until analysis.

Optical properties:

Laser Setup: The experimental setup was adjusted at incident angle equal to reflected angle (45^{o}) to obtain high reflections and to establish criteria for identifying optical properties of olive fruits. The experimental setup was assymblied and consisted of laser type, lens, holders and digital luxmeter as shown in Fig. (3).

Laser type: helium-neon (He-Ne) laser in the visible light with wavelength 543.5 nm with power 4 mW was used in the present work as a light source. Laser was sitting on a vertical holder with mirror. The He-Ne laser used gives high reflection from olive fruit surface. The specifications of laser were continuous beam and beam diameter of 0.75.

Lens: convex silica glass lens of 100 mm focal length with diameter 75 mm was used. The lens was put beside the front with angle of 45 degree to focus the reflected light collected from the olive fruit surface one time onto the luxmeter detector.

Holders: Holders were designed and fabricated of copper to hold lens and luxmeter detector.

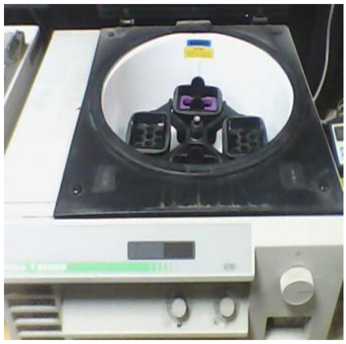
Digital luxmeter: A digital luxmeter with high accuracy and sensitivity was used to measure the intensity of reflection from olive fruit surface. Digital luxmeter with ranges of 0-50,000 Lux

Optical properties: The laser beam reflected on mirror to olive surface, then the beam was reflected from olive surface and collected by concave lens to luxmeter detector. The absorption of olive fruit was calculated from the following equation according to the law of conservation of energy: $I = R + A$ …………………… (1)

Where: I is the incident beam, lux; R - reflective beam, lux; and A- absorptive beam, lux.

MI-1 MI-2 MI-3 MI-4 MI-5

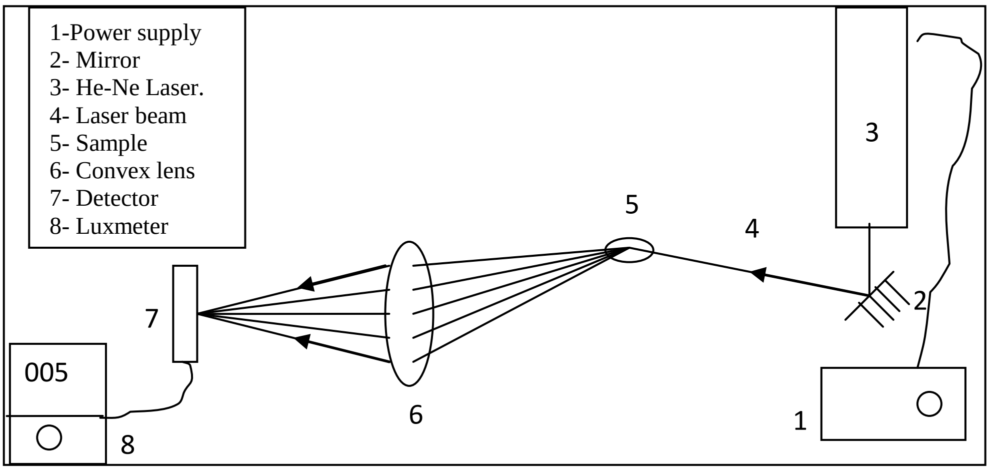
Fig. 1: Olive fruit at various stages of ripeness based on the maturity index (MI).



a) Hydraulic piston. b) Centrifuge device.

Fig. 2: Hydraulic piston and centrifuge used to extract the oil from olives.

a): Experimental setup of of optical properties.



b) : Schematic diagram of optical properties.

Fig. 2: Experimental and schematic diagram of set up for measuring the optical properties of olive fruits.

RESULTS AND DISCUSSION

Table 1 and Fig. 3 show the optical properties during olive maturity stages using visible laser. It was noticed that the intensity of reflection light percentage decreased from 1.36, 1.0, 0.51, 0.47 and 0.42%. meanwhile, absorption light percentage increased from 98.64, 99.0, 99.49, 99.53 and 99.58% for olive maturity stages 1, 2, 3, 4 and 5, respectively.
From the previous results, the stage 1, the reflection intensity percentage was higher than other stages, while the stage 5 was lower than other stages. Stage 1 was higher in value of green color component, while stage 5 was lower in value of green component, with the same color of laser beam.

Table 1: Optical properties of olive maturity stages

Stages	Reflection intencity, LUX	Absorption intencity, Lux	Reflection intensity, %	Absorption intensity, %	Maturity index, unit	Moisture content,%	Oil content,%
Stage 1	62.45	4537.55	1.36	98.64	0.620	52.67	8.09
Stage 2	46.00	4578.86	1.00	99.00	1.08	49.94	16.3
Stage 3	23.59	4576.41	0.51	99.49	1.94	44.43	17.02
Stage 4	21.45	4578.55	0.47	99.53	2.65	40.41	19.22
Stage 5	19.55	4580.45	0.42	99.58	5.34	35.01	20.47

Table 1 and Fig. 4 show the optical properties and olive maturity index of olive using visible laser. It was found that there was an inverse relation between intensity reflection percentage and olive maturity index, while there was a proportional relation had been between intensity absorption percentage and olive maturity index.
Therefore, by increasing the maturity index values from 0.62, 1.08, 1.94, 2.65 and 5.34, the absorption intensity percentages increased from 98.64, 99.0, 99.49, 99.53 and 99.58%. meanwhile, the reflection intensity percentage decreased from 1.36, 1.0, 0.51, 0.47 and 0.42% for olive maturity stages 1, 2, 3, 4 and 5, respectively.

Therefore, according to harvesting time at stage 4., it was considered the ideal reflection intensity percentage of 0.47% or absorption intensity percentage of 99.53%, that are indicators to suitable harvesting time. In the other hand, both of reflection intensity percentages of 1.36 and 1.0% or absorption intensity percentages of 98.64 and 99% for stages 2 and 3

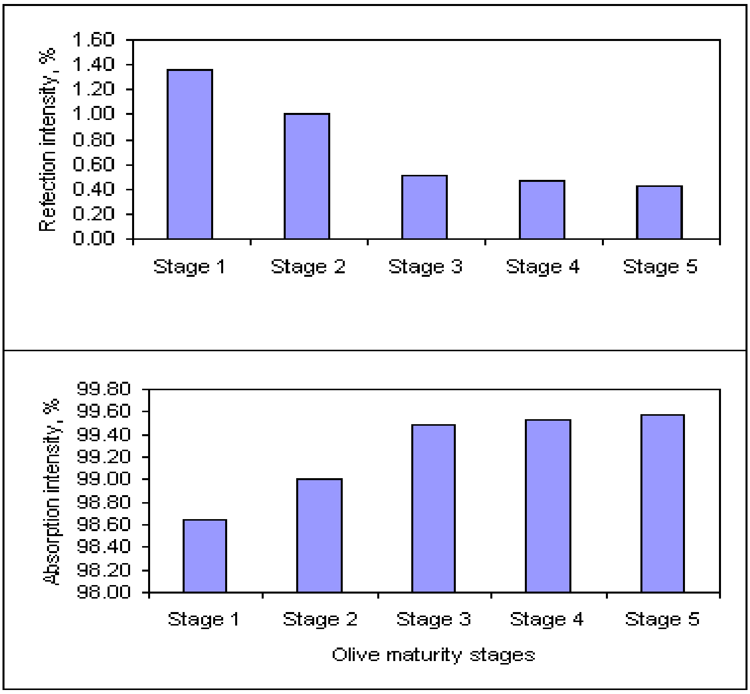


Fig. 3: Optical properties for olive maturity stages of fruits.

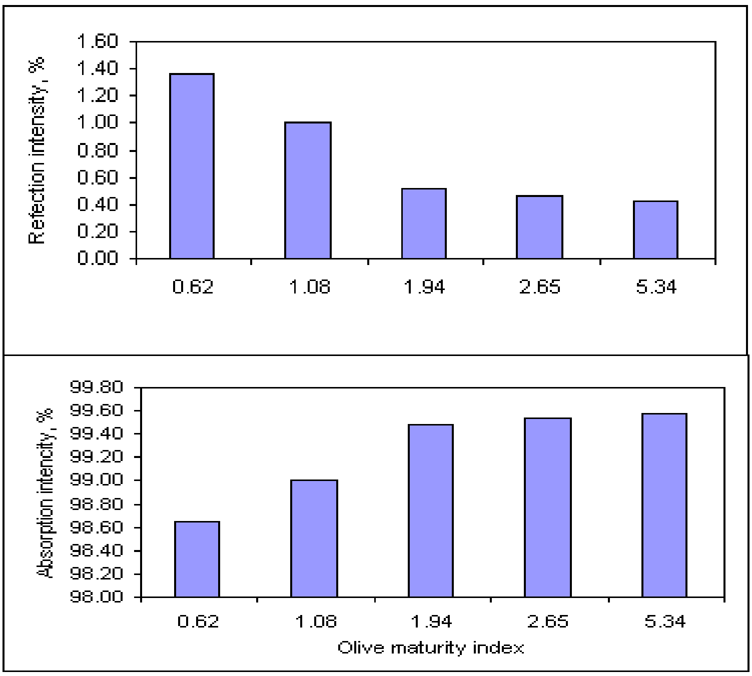


Fig. 4: Optical properties and maturity index for olive maturity stages.

Table 1 and Fig. 5 show the reflection and absorption intensities percentages from olive maturity index using visible laser. It noticed there is inverse relationship between reflection and absorption intensities percentages, because of by increasing absorption intensity percentage from 98.64 to 99.58%, the reflection intensity percentages were decreased from 1.36 to 0.42%.

From previous results, the stage 1 was high intensity reflection percentage and low intensity absorption percentage at maturity index of 0.62. While, the stage 5 was lower intensity reflection percentage and high intensity absorption percentage at maturity index of 5.34.

Table 1 and Fig. 6 show the relationship between moisture content and oil content in different olive maturity stages. It noticed that there are inverse relation between moisture content and oil content. Because of decreasing moisture content from 52.67 to 35.01% , while oil content was increased from 8.09 to 20.47 % .

That mean, the stage 1 was lower oil content 8.09 %, while stage 5 high oil content of 20.47 %. But, it prefer to harvest the olive fruit at maturity stage 4, because the oil content was of 19.22 % approximetly equally in stage 5 (20.47 %). So, it can be save about 10 days from harvesting time.

Table 1 and Fig. 7 show the relation among reflection intensity percentage and both of moisture content and oil content, it noticed that the by decreasing reflection intensity percentage from 1.36, 1.0, 0.51, 0.47 and 0.42 %, the moisture content was decreased from 52.67, 49.94, 44.43, 40.41 and 35.01%, while the oil content was increased from 8.09, 16.3, 17.02, 19.22 and 20.47 % for olive maturity stages 1, 2, 3, 4 and 5, respectively. That mean, there are proportional relation between intensity reflection percentage and moisture content, while was inverse relation between intensity reflection percentage and oil content percentage.

Therefore, stage 1 was high reflection intensity percentage followed with high moisture content and low oil content. While, stage 5 was low intensity reflection percentage, low moisture content and high oil content. It was considered the reflection intensity percentage of 0.47% in stage 4 was indicator to low moisture content 40.41% and high oil content 19.22 % at the suitable harvesting time and oil extraction.

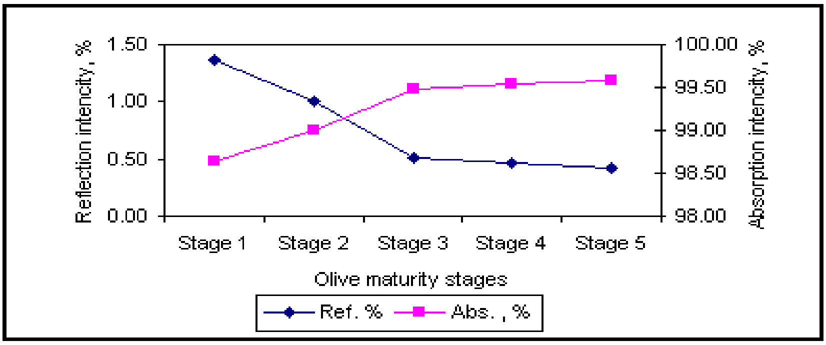


Fig. 5: Reflection and absorption percentages of olive maturity stages.

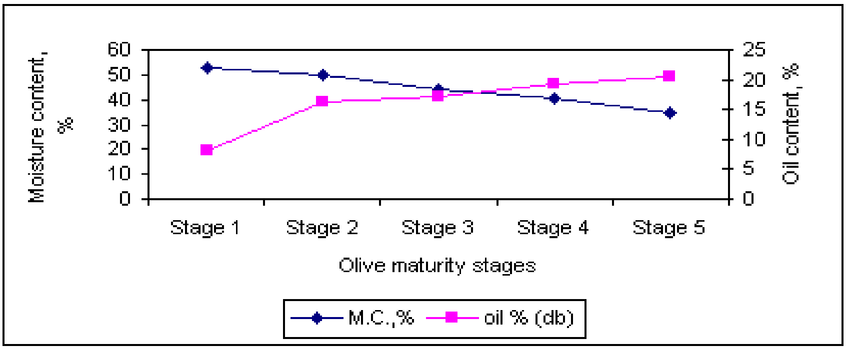


Fig. 6 : Moisture content and oil content of olive maturity stages.

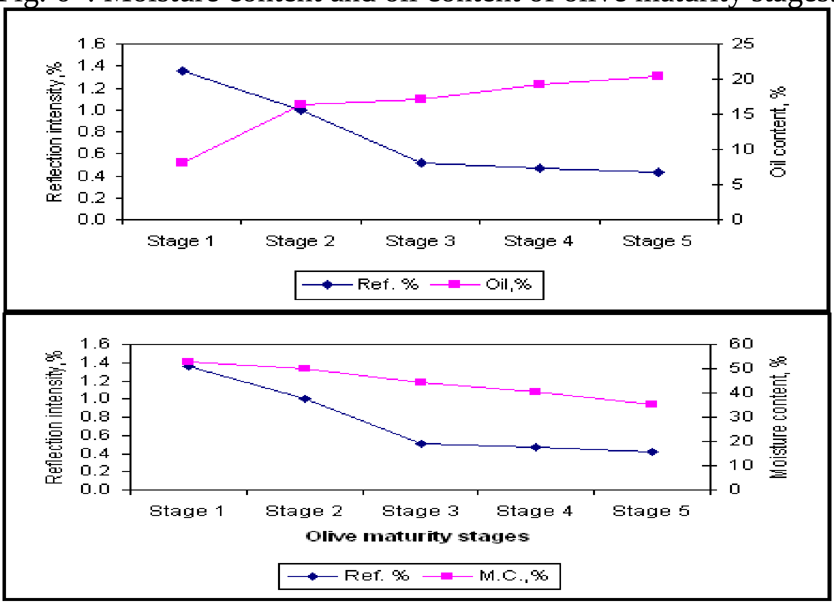


Fig. 7: Relation among reflection intensity, moisture content and oil content of olive maturity stages.

Table 1 and Fig. 8 show relation among absorption percentage and both of moisture content and oil content percentages using visible laser. It noticed that by increasing intensity absorption percentage from 98.64, 99.0, 99.49, 99.53 and 99.58%, the moisture content percentage was decreased, while oil content percentage was increased. That mean, there are proportional between absorption intensity and oil content percentages, while was inverse relationshipe between absorption intensity and moisture content percentages.

Therefore, stage1 was low absorption percentage followed with high moisture content and low oil content percentages. While, stage 5 was high absorption intensity percentage was low moisture content and high oil content percentages.

From previous results, it was considered the intensity absorption percentage 99.53 % of stage 4, that was indicator to low moisture content percentage of 40.41 % and high oil content percentage 19.22 % at the suitable harvesting time.

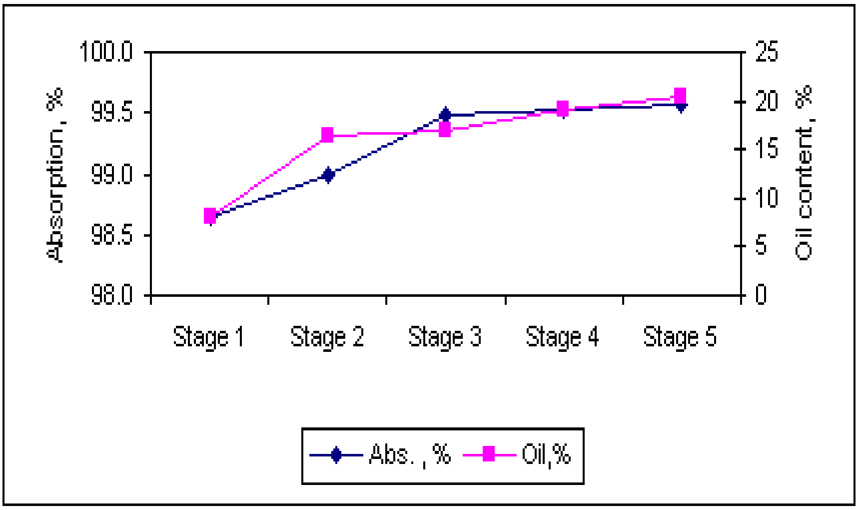
CONCLUSION

The obtained results were as follow:

a) The intensity reflection percentages 1.36, 1.0 and 0.51% or absorption percentages 98.64, 99 and 99.49% are not accepted for stages 1,2 and 3 respectively, because they did not arrive to full ripeness. Also, reflection percentage of 0.42% or absorption percentage of 99.58% for stage 5 was refused, because of it was full ripe.

b) The intensity reflection percentage 0.47% or the absorption percentage 99.53% was indicator of the best maturity index (2.65) of olive variety, considering optical properties instead of ideal maturity index to determine harvesting time.

c) Stage 1 has high reflection intensity percentage or low absorption intensity percentage followed with high moisture content and low oil content percentages. Meanwhile, stage 5 with low reflection intensity percentage or high absorption intensity percentage has low moisture content and high oil content percentages. So, stage 4 was considered suitable for oil extracting, because of low moisture content 40.41 % and high oil content 19.22 %.



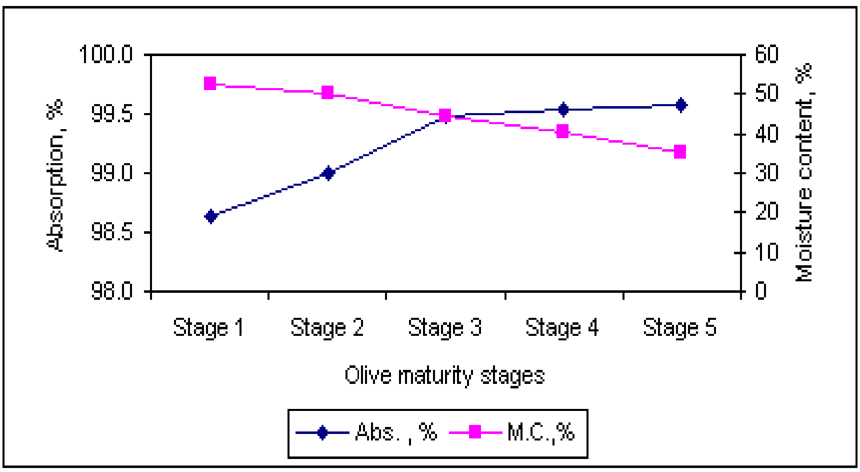


Fig. 8: Relation among absorption, moisture content and oil content of olive maturity stages.

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الملخص العربى

تصنيف الليزر لثمار الزيتون خلال النضج طبقا للخصاص الضوئية

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الهدف من الدراسة تحديد الخصائص الضوئية لثمار الزيتون لصنف " الاربكوينا " خلال مراحل نضجه لموسم حصاد ٢٠٠٩ باستخدام الليزر المرئى بطول موجى (٥٤٣.٥ نانوميتر) و بقدرة (٤مللى وات) لتصنيف نضج الثمار ، وأجريت قياسات الخصائص الضوئية بالمعهد القومى لعلوم الليزر ، جامعة القاهرة ، خلال موسم ٢٠٠٩ . ، لتصنيف ثمار الزيتون خلال مراحل النضج لتحديد انسب ميعاد الحصاد وإمكانية اجراء عمليات الفرز و التدريج للثماروقد أوضحت النتائج الآتى:

١- - تم تقدير دليل النضج لمراحل نضج الثمار وكانت قيمها كالتالى ٠.٦٢ ، ١.٠٨، ١.٩٤، ٢.٦٥، ٥.٣٤ لمراحل النضج من الأولى حتى الخامسة على التوالى.

٢- وجدت علاقة عكسية بين نسبة الكثافة الضوئية للانعكاس والامتصاص فكانت نسب الكثافة الضوئية للانعكاس كالتالى (١.٣٦، ١.٠٠، ٠.٥١، ٠.٤٧، ٠.٤٢ %) بينما كانت نسب الكثافة الضوئية للامتصاص (٩٨.٦٤، ٩٩.٠٠، ٩٩.٤٩، ٩٩.٥٣، ٩٩.٥٨%) لمراحل النضج من الأولى حتى الخامسة على التوالى.

٣- وجد ان المحتوى الرطوبى لثمار الزيتون نسبته (٥٢.٦٧، ٤٩.٩٤، ٤٤.٤٣، ٤٠.٤١، ٣٥.٠١%) بينما قدرمحتوى الزيت و كانت نسبته (٨.٠٩، ١٦.٣٠، ١٧.٠٢، ١٩.٢٢، ٢٠.٤٧%) لمراحل النضج من الأولى حتى الخامسة على التوالى.

٤- وجد أنه بانخفاض المحتوى الرطوبى وزيادة محتوى الثمار من الزيت قد أدى ذلك الى انخفاض الكثافة الضوئية المنعكسة من سطح الثمار.

٥- يمكن استخدام نظام يربط بين مراحل نضج الثمار و جودة الزيت الناتج باستخدام الخصائص الضوئية ، كما يمكن ادخال هذا النظام فى عمليات الفرز و التدريج لثمار الزيتون بالاعتماد على الكثافة الضوئية المنعكسة من الثمار باستخدام الليزر المرئى.

١- أستاذ مساعد تطبيقات الليزر فى الهندسة الزراعة - المعهد القومى لعلوم الليزر- جامعة القاهرة - مصر
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