LEMON FRUITS CLASSIFICATION ACCORDING TO QUALITY IDENTIFICATION USING LASER TECHNIQUE

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ABSTRACT

The aim of this study was measuring and determination of the optical properties of lemon maturity stages (Baladi variety) using visible laser with 543.5 nm with power 4 mW. Five samples were classified according to color of skin, named Green 100%, Green 75%, Green/Yellow 50%, Yellow 75%, and Yellow 100%). Determination of physical characteristics of the fruit samples, and optical properties (reflection and absorption) were measured during 2010., at Institute of Laser Enhanced Science (NILES), Cairo University, Giza, Egypt. The obtained results were as follows:

1) For physical properties, the main dimensions (large and small diameters), mass, volume of lemon gradually decreased with increasing color percentage of fruit from green to yellow color. Meanwhile, the density of lemon increased., 2) For optical properties, the intensity reflection percentages decreased gradually from green to yellow color samples. Meanwhile, the absorption percentages increased., 3) For quality of lemon, the juice percentage, total soluble acid and acidity were gradually increased from green to yellow color fruit samples. Meanwhile, the pH decreased., 4) The lemon green 100% color (high intensity reflection and low intensity absorption) was less quality then lemon yellow 100% color (low intensity reflection and high intensity absorption)., and 5) Measuring standard of lemon quality according reflection intensity of visible leaser were 59.86, 52.93, 46.26, 40.06, and 32.06 Lux for Green 100%, Green 75%, Green/Yellow 50%, Yellow 75%, and Yellow 100%, respectively.

INTRODUCTION

Gunasekaran et al. (1985) mentioned that the chemical contents inside lemon fruits (i.e. sugars and acids) can be measured from the outside by means of the optical properties of the samples and the interaction between radiation and matter, specially in the infrared, which has been proven useful in many research labs.

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Yahia and Sanudo (1991) said that the control measures of citrus fruits should include, application of fungicides such as thiabendazole (TBZ), minimizing physical damage, the use of recommended storage temperature and relative humidity, the use of hot water treatment. However, recently biological control measures have been developed for citrus fruit. Citrus fruits are moderately perishable with a shelf life ranging between 2 and 20 weeks (depending on the type of fruit, lemons have the longest shelf life if picked green and stored at the recommended temperature).

Tamzini et al. (1992) reported that the post-harvest losses of oranges and lemons were 42.5 and 18.2 %, respectively. The causes of these high losses were: 1) Immaturity and over maturity at harvest, 2) Mechanical damage during harvest, transport and during distribution. 3) Water loss (wilting) due to poor handling system and 4) Decay (Blue and Green mold) and insect damage.

Elyatem (1995) mentioned that citrus fruits are non-climacteric and their respiration and ethylene production rates are low, their compositional changes are minimal and they do not continue to ripen after harvest. This necessitates that the fruits should be picked at the optimum maturity, immature or over-mature fruits tends to be of inferior quality. Maturity indices used for citrus include juice content, total soluble solids (TSS), titrable acidity (TA), and the ratio of TSS to TA. Fruit color and size are also used as a harvest index.

Xu et al. (1995) showed that the dynamic speckle phenomenon occurs when laser light is scattered by bodies exhibiting some activity, as the biological material does. The visual appearance of such a phenomenon is similar to a surface of a boiling liquid, originating the denomination of dynamical speckle, boiling speckle or bio speckle. The speckle pattern for different biological materials indicate the application of the dynamical speckle in correlation with mechanical properties, seed viability, staining and drying.

Abbott et al. (1997) mentioned that along the past years, destructive and non-destructive measurements of fruit quality have been a primary and widely established research objective. Many different techniques have been developed and applied to create sensors to measure quality parameters, as well as the subsequent mathematical models to predict quality evolution.

Valero and Ruiz (2000) noticed that when the fresh fruit reaches the final markets from the suppliers, its quality is not always as good as it should, either because it has been mishandled during transportation or because it lacks an adequate quality control at the producer level, before being shipped. This is why it is necessary for the final markets to establish their own quality assessment system if they want to ensure to their customers the quality they want to sell.

Giovanni et al. (2005) evaluated that a new technology applied in quality tests of oranges. Evaluations were performed using a nondestructive and noninvasive method based on the interpretation of an optical phenomenon that occurs when the fruit is illuminated with coherent light, referred as bio speckle. The speckle patterns of laser light scattered in orange fruits have been measured through their quantification. These values were used as quality and senescence indicators for the specimens and were compared with other parameters, as total soluble solids, total acidity, the penetration force and the storage period.

Raji and Alamutu (2005) said that the computer vision has been used for quality inspection of fruits. Quality inspections of fruits have two different objectives: quality evaluation and defect finding. In recent years, computer machine vision and image processing techniques have been found increasingly useful in the fruit industry, especially for applications in quality inspection and shape sorting.

Lorestani et al. (2006) showed that in general, quality grading includes outer parameters (size, color intensity, color homogeneity, bruises, shape, stem identification surface texture and mass), inner parameters (sweetness, acidity or inner diseases) and freshness. Although, both outer and inner quality information can be collected by an automatic grading system in a factory, but machine vision is more effective for measuring outer parameters.

Antonio et al. (2008) mentioned that the vegetable quality is frequently referred to size, shape, mass, firmness, color and bruises from which fruits can be classified and sorted. However, technological by small and middle producers implementation to assess this quality is unfeasible, due to high costs of software, equipment as well as operational costs.

Chahidi et al. (2008) concluded that classification of lemons by size as well as the classification of tomatoes by color can be supported by image analysis open software. Sugar, organic acid, and carotenoid are the most important indicators of fruit taste and nutritional and organoleptic quality. These components were studied on fruit pulp of the cybrid between Willow leaf mandarin (Citrus deliciosa Ten.) and Eureka lemon [Citrus limon (L.) Burm.] and the two parents. Levels of organic acids were slightly higher in the cybrid fruit pulp than in Eureka lemon. No significant difference in sugar and carotenoid content was observed between the cybrid and the lemon.

Seglina et al. (2009) reported that the citrus fruits (oranges, grapefruits and lemons) and citrus juices are the most popular fruits and juices widely consumed around the world. In the world, three different kinds of citrus fruit juice are mainly produced: frozen concentrate, chilled and sterilized. Dry matter content of juice can be increased to 44–70% by concentration, and accordingly juice volume decreases 5– 6 times. It reduces storage space and costs, inhibits microbial growth and saves transportation costs. The quality of juices and concentrates depends on a number of factors such as citrus fruit sort, place of growing, harvesting time and processing manner.

Khojastehnazh et al. (2010) indicated that the grading systems give us many kinds of information such as size, color, shape, defect, and internal quality. Among these color and size are the most important features for accurate classification and/or sorting of citrus such as oranges, lemons and tangerines. Basically, two inspection stages of the system can be identified: external fruit inspection and internal fruit inspection. The former task is accomplished through processing of color images, while internal inspection requires special sensors for moisture, sugar and acid contents.

The objectives of this work are: 1) Measurements of the optical properties for lemon (Baladi variety) maturity stages using visible laser., 2) Relationship between reflection or absorption percentages, total soluble soiled content and juice percentage of the lemon fruits., 3) Laser technique developed to evaluate the maturity of fruits, based on its optical properties of fruits., and 4) Establishing measurement to classify lemon maturity stages according to optical properties.

MATERIAL AND METHODS

The experiments were carried out 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 lemon were carried out according to the following procedures:

Fruit sample: The study was carried out during season 2010 on lemon fruits (Baladi variety), from local market, Giza governorate. For each sampling, 5kg of lemon fruits.

Juice preparation, Freshly squeezed lemon fruit juice was made employing handle juice press. The following juice quality parameters were considered: total soluble solid, total soluble solid, % was measured using refract-meter, acidity was measured in lab, pH was measured by pH meter and juice percentage. To prevent quality change of juice, it was stored by the refrigerator at 10 °C. The lemon percentage was determined using the following equation:

Lemon juice , % = [(W1/ W2)]X 100

Where : W1 is the mass of lemon juice, g; and W2 mass of lemon fruits, g.

Physical properties : Fruit samples (100 fruits) of each mature stages were collected; fruit samples were subjected to the following measurements in Table. (1), to determine the physical properties of lemon fruits: 1) Fruit mass, g: was determined using a digital scale; its sensitivity was 0.01 grades., 2) Fruit length and width, cm : were measured using Vernier caliber., and 3) Fruit shape index (Fruit length/ Fruit width).

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 lemon fruits. The experimental setup was shown in Fig. (1-a & b).

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

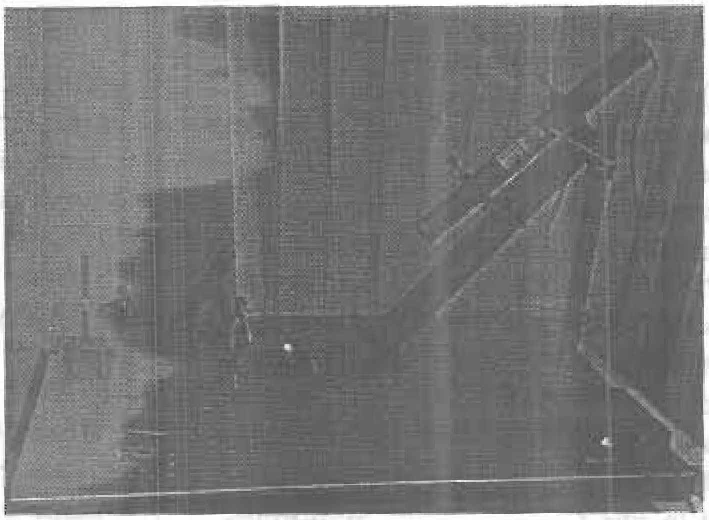
Lens: convex silica glass lens of 100 mm focal length with diameter 75 mm was used. The lens was put beside the front with angle of 45 degree to focus the reflected light collected from the lemon fruit surface one time onto the luxmeter detector .

Digital luxmeter: A digital luxmeter with high accuracy and sensitivity was used. Digital luxmeter with ranges of 0-50,000 Lux

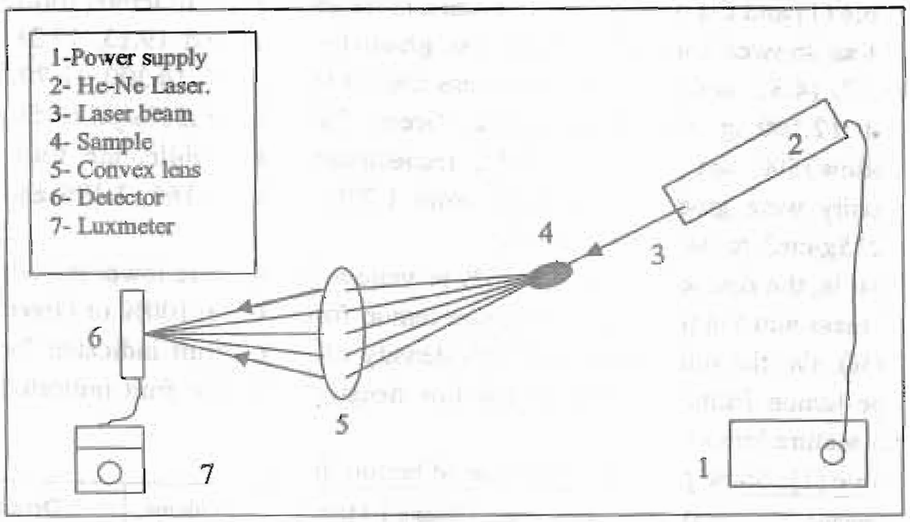
The laser beam was reflected from lemon surface and collected by concave lens to luxmeter detector. The absorption of lemon fruit was calculated from the following equation according to the law of conservation of energy:

$$I = R + A \quad \text{.......................} \quad (1)$$

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



a): Experimental setup of optical properties.



b) : Schematic diagram of optical properties.

Fig. 1: Experimental and schematic diagram of set up for measuring the optical properties of lemon fruits.

RESULTS AND DISCUSSIONS

Table (1) and Fig. (2) show the main dimensions, mass, shape index, volume and density of lemon fruits. It was showed that the large and small diameters of lemon fruits were gradually decreased. Large diameter were decreased 30.5, 30.4, 29.9, 29.3 and 28.8 mm and small diameter were decreased 34.55, 33.65, 31.8, 30.75 and 30.47 mm for Green 100%, Green 75%, Green50%/yellow50, Yellow75%, and Yellow 100%., respectively. Meanwhile, the shape index increased gradually from 0.884, 0.908, 0.942, 0.965 and 0.970 for the same lemon fruits.

That is, the ripe lemon (yellow 75% or yellow 100%) were lower in both of large and small diameters than the mature lemon fruits (Green100% or Green 75%). On the other hand, the high shape index of lemon fruit was indicated to ripe of lemon fruits. Meanwhile, the low shape index of lemon fruit was indicated to mature of lemon fruits.

Table (1) and Fig. (3) show the volume, mass and density of lemon fruits. It was showed that the volume was gradually decreased 19.13, 17.38, 15.77, 14.81 and 14.54 cm^3 and mass was 17.600, 15.47, 14.300, 12.700 and 12.100 g for Green 100%, Green 75%, Green50%/yellow50, Yellow75%, and Yellow 100%, respectively. Meanwhile, the fruits density were gradually increased from 1.079, 1.131, 1.166, 1.196 and 1.235g/cm3 for same lemon fruits.

That is, the ripe lemon (yellow 75% or yellow 100%) were lower in both of mass and volume than the mature lemon fruits (Green100% or Green 75%). On the other hand, the high density of lemon fruit indicated for ripe lemon fruits. Meanwhile, the low density of lemon fruit indicated for mature lemon fruits.

Table (1): Some physical properties of lemon fruits.

Lemons	Ds, mm	DL, mm	Shape index	Mass, g	Volume, cm3	Density, g/cm3
Green, 100%	30.5	34.55	0.088	19.13467	17.600	1.097
Green, 75%	30.4	33.65	0.908	17.38533	15.467	1.131
Green/Yellow, 50%	29.9	31.8	0.942	15.76867	14.300	1.166
Yellow, 75%	29.35	30.75	0.965	14.806	12.700	1.196
Yellow, 100%	28.8	30.47	0.970	14.53533	12.100	1.235

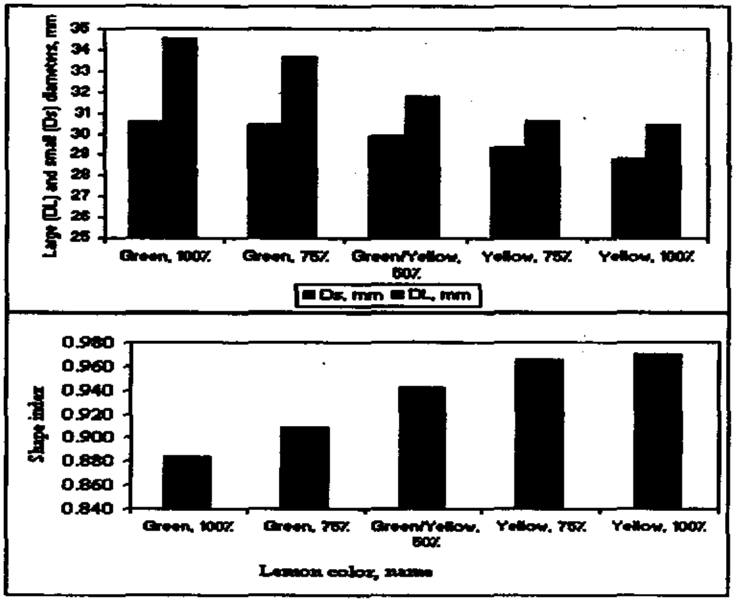


Fig. (2): Main dimensions and shape index of lemon fruits.

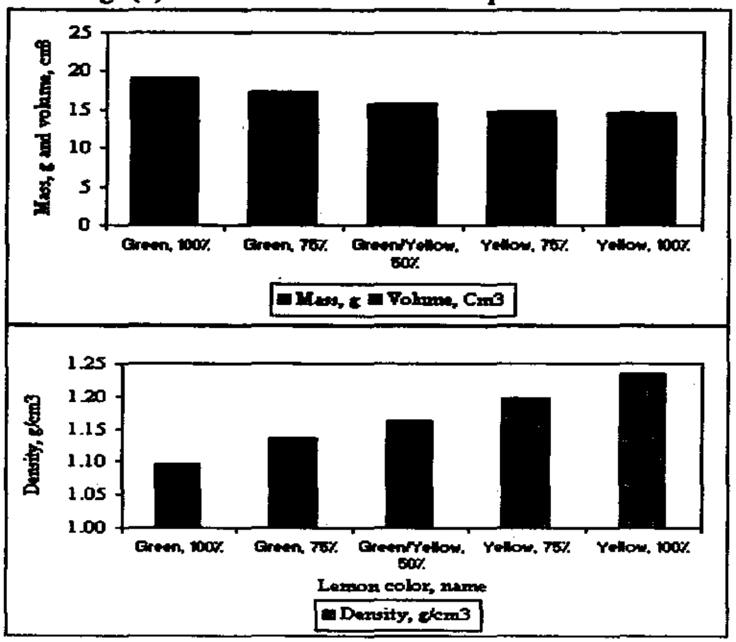


Fig. (3): Relationship between maturity and density of lemon fruits.

Table (2) and Fig. (4) show the relationship between maturity fruits, juice and total soluble solid percentages of lemon fruits. It was noticed that there is a proportional relation between juice and total soluble solid percentages. By increasing juice percentage for 32.41, 39.37, 44.06, 45.20 and 46.26 % followed with total soluble solid percentages increased from 3.5, 4.4, 5.3, 6.5 and 7.2 % for Green 100%, Green 75%, Green50%/yellow50, Yellow75%, and Yellow 100%., respectively.
That is, the ripe lemon (yellow 75% or yellow 100%) were high percentages in both juice (45.20 and 46.26 %) and total soluble solid percentage (6.5 and 7.2 %). Meanwhile, the maturity lemon fruits (G100% and G57%) had low percentages in both of juice (32.41 and 39.37%) and total soluble solid (3.5 and 4.4 %).

Table (2) : Maturity fruits and quality parameters of lemon fruits.

Lemons	Density, g/cm³	Juice, %	pH, Value	TSS ,%	Acid., %	Ref., %	Abs., %	Ref., Lux	Abs., Lux
Green, 100%	1.098	32.41	2.8	3.5	2.5	0.139	99.861	59.86	59.86
Green, 75%	1.166	39.37	2.7	4.4	3.5	0.123	99.877	52.93	52.93
Green/Yellow , 50%	1.132	44.06	2.6	5.3	4.5	0.108	99.892	46.26	46.26
Yellow, 75%	1.197	45.20	2.5	6.5	5.5	0.093	99.907	40.06	40.06
Yellow, 100%	1.236	46.26	2.4	7.2	6.5	0.075	99.925	32.06	32.06

Table (2) and Fig. (5) show the relationship of maturity fruits and quality parameters of lemon fruits. It was noticed that there is proportional relation between acidity and total soluble solid percentages. By increasing acidity percentage for 2.5, 3.5, 4.5, 5.5 and 6.5 % followed with increases of total soluble solid percentages from 3.5, 4.4, 5.3, 6.5 and 7.2 % for Green 100%, Green 75%, Green50%/yellow50, Yellow75%, and Yellow 100%, respectively.
That is, the ripe lemon (yellow 75% or yellow 100%) were high in both of acidity (5.5 and 6.5 %) and total soluble solid percentage (6.5 and 7.2%). Meanwhile, the maturity lemon fruits (G100% and G57%) were low in both acidity (2.5 and 3.5%) and total soluble solid (3.5 and 4.4%).

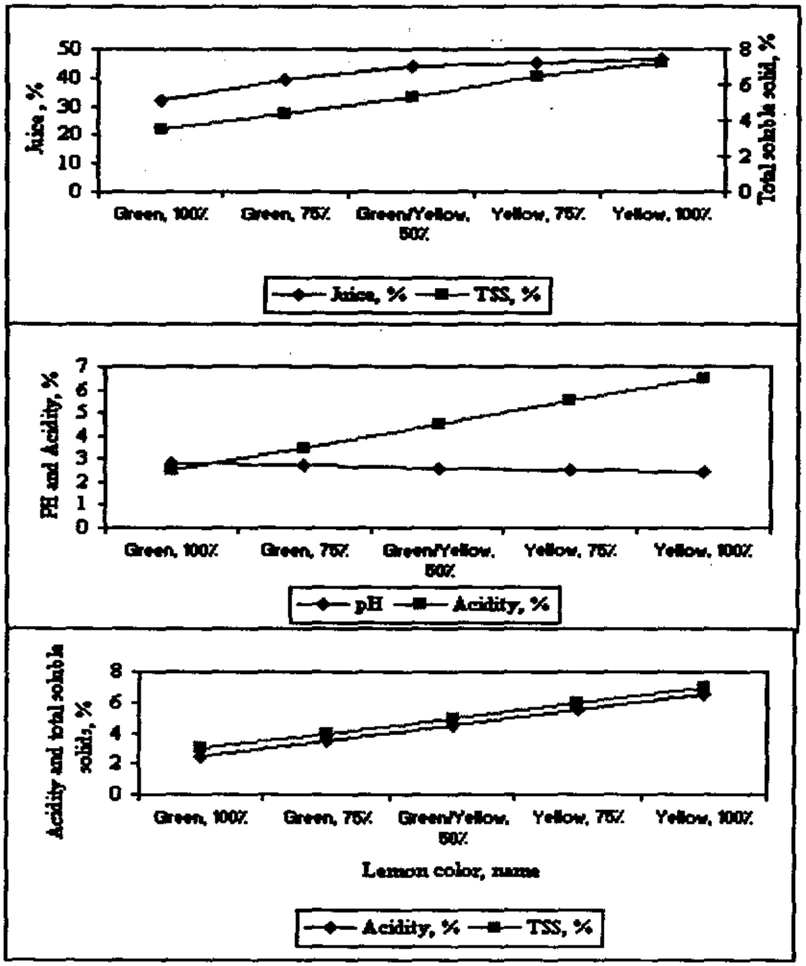


Fig. (4): Relationship between maturity and quality parameters of lemon fruits

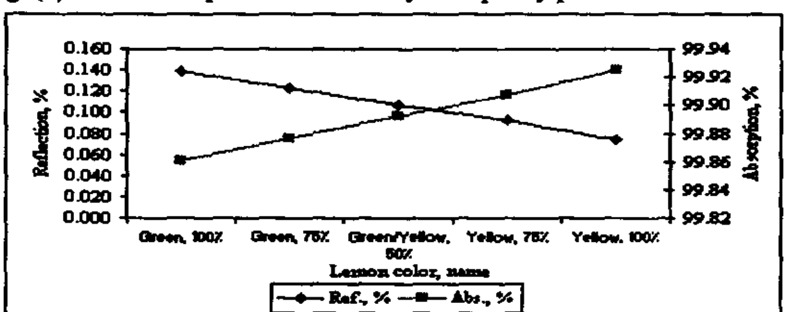


Fig. (5): Reflection and absorption percentages of maturity lemon fruits.

CONCLUSION

1) For physical properties, the dimensions, mass, volume of lemon were gradually decreased with increasing color percentage of fruit from green to yellow color. Meanwhile, the density of lemon was increased., 2) For optical properties, the intensity reflection percentages were decreased gradually from green to yellow color samples. Meanwhile, the absorption percentages were increased., 3) For quality of lemon, the juice percentage, total soluble acid and acidity gradually increased from green to yellow color samples. Meanwhile, the pH decreased., 4) The lemon green 100% color (high intensity reflection and low intensity absorption) had less quality than lemon yellow 100% color (low intensity reflection and high intensity absorption)., and 5) Measuring standard of lemon quality according reflection intensity of visible leaser were 59.86, 52.93, 46.26, 40.06, and 32.06 Lux for Green 100%, Green 75%, Green/Yellow 50 %, Yellow 75%, and Yellow 100%, respectively.

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الملخص العربى

تصنيف ثمار الليمون طبقا لميزات الجودة باستخدام تقنية الليزر

عبدالرحمن عبدالرؤف عبدالرحمن [١]

الهدف من الدراسة تحديد الخصائص الضوئية لثمار الليمون لصنف " البلدى " للتعرف على خصائص الجودة الداخلية لثمار الليمون الناضج خلال مراحل ، وامكانية اجراء عمليات فرز و تدريج لثمار الليمون وتحديد سعر يناسب كل مرحلة طبقا لجودتها موسم ٢٠١٠. ، وذلك باستخدام الليزر المرئى بطول موجى (٥٤٣,٥ نانوميتر) للتعرف على جودة الثمار الناضجة ، وتم تصنيف ثمار الليمون الى خمسة مجموعات بناء على لون القشرة الخارجيه وكانت كالتالى: أخضر بنسبة ١٠٠ % أخضر بنسبة ٧٥ % ، أخضر/وأصفر بنسبة ٥٠ % ، أصفر بنسبة ٧٥ % ، وأصفر بنسبة ١٠٠% ، وقد أجريت القياسات بالمعهد القومى لعلوم الليزر ، جامعة القاهرة. ، وأوضحت النتائج الآتى:

١ ــ بالنسبة للخصائص الطبيعية ، ازدادت تدريجيا كل من (أكبر و أصغر قطر) ، وكتلة ، وحجم الثمار الليمون ، بزيادة نسبة لون القشرة الخارجية للثمار من اللون الأخضر الى الأصفر، بينما إنخفضت كثافة ثمار الليمون.

٢ ــ بالنسبة للخصائص الضوئية ، أنخفضت تدريجيا نسبة الكثافة الضوئية المنعكسة من ثمار الليمون بزيادة نسبة لون القشرة الخارجية للثمار من اللون الأخضر الى الأصفر، بينما إزدادت نسبة الكثافة الضوئية الممتصة فى ثمار الليمون.

٣ ــ بالنسبة لخصائص جودة الثمار ، ازدادت تدريجيا نسبة كل من العصير ، والمواد الصلبة الذائبة ، والحموضة فى ثمار الليمون ، بينما إنخفضت قيمة الأس الهدروجينى لثمار الليمون بزيادة نسبة لون القشرة الخارجية للثمار من اللون الأخضر الى الأصفر.

٤ـ كانت ثمار الليمون ذات لون القشرة أخضر بنسبة ١٠٠ % أقل جودة (مصحوبة باعلى نسبة كثافة ضوئية منعكسة وأقل نسبة كثافة ضوئية ممتصة) من ثمار الليمون ذات لون القشرة أصفر بنسبة ١٠٠% طبقا لخصائص الجودة (مصحوبة بأقل نسبة كثافة ضوئية منعكسة وأعلى نسبة كثافة ضوئية ممتصة).

٥ـ تم وضع مقياس لجودة ثمار الليمون طبقا للكثافة الضوئية المنعكسة باستخدام شعاع الليزر المرئى بطول موجى (٥٤٣,٥ نانوميتر) و بقدرة (٤مللى وات) وكان كالتالى : ٥٩,٨٦ ، ٥٢,٩٣ ، ٤٦,٢٦ ، ٤٠,٠٦ ، و ٣٢,٠٦ لكس بالنسبة لثمار الليمون ذى لون قشرتها أخضر بنسبة ١٠٠ % ، أخضر بنسبة ٧٥ % ، أخضر/وأصفر بنسبة ٥٠ % ، أصفر بنسبة ٧٥ % ، و أصفر بنسبة ١٠٠% ، على التوالى.

٦ـ يمكن استخدام مقياس الخصائص الضوئية المنعكسة عمليات الفرز و التدريج لثمار الليمون طبقا لجودتها الخارجية والداخلية باستخدام الليزر المرئى.

١ـ باحث أول بمعهد بحوث الهندسة الزراعية ــ مركز البحوث الزراعية ـ الدقى ـ مصر.