Misr J. Ag. Eng., 26(3): 1412- 1428 PROCESS ENGINEERING

OPTICAL AND ELECTRICAL PROPERTIES OF SOME GRAINS USING VISIBLE LASER

A. E. El-Raie[1], H. E. Hassan[2], and A. A. Abd El-Rahman[3]

ABSTRACT

The objective of the present study was to identify criteria of optical properties from sound grains using visible laser with wavelength of 632.8 nm and power 8 mw. The experiments and measurements for the optical and electrical properties were carried out for a random sample from four grain varieties. Obtained results are summarized as follows:

a) The absorption percentages were higher than reflection percentages, reflections were 18.61, 16.31, 9.61, 7.63, 7.00, and 6.90%. Meanwhile, absorption were 81.39, 83.69, 90.39, 92.38, 93.00, and 93.10% for hollow phase corn, flat phase corn, hollow phase wheat, flat phase wheat, and rice and bean grains, respectively, b) There is variation between reflection and absorption percentages for the same grains which had different two phases such as corn and wheat grain, c) The electrical reflection decreased gradually as follows: 5.88, 5.67, 5.46, 5.06, 3.94, and 3.62 mV for hollow phase corn, flat phase corn, hollow phase wheat, paddy rice, flat phase wheat, and bean grains, respectively according to the reflection intensity of laser, d) The values (high, low, and closed) of the reflection intensity for grains were (198, 119, and 148.9 lux), (189, 105, and 130.5 lux), (90, 55, and 76.9 lux), (86, 40, and 61 lux), (83, 35, and 56 lux), and (66, 46, and 55.2 lux). Meanwhile, the absorption intensities were (681, 602, and 651.1 lux), (695, 611, and 669.5 lux), (745, 710, and 723.1 lux), (760, 714, and 739 lux), (765, 717, and 744 lux), and (754, 734, and 744.8 lux) for hollow phase corn, flat phase corn, hollow phase wheat, paddy rice, flat phase wheat, and bean grains, respectively, e) The criteria of optical properties from sound grains are arranged descending order as follows: The reflections were: Bean (6.90%) >, Flat phase-Wheat (7.0%) >, Hollow phase-Wheat (7.63) >, Rice (9.61%) >, Flat phase-Corn (16.31) >, and Hollow phase-Corn (18.61%). Meanwhile, the absorptions were: Hollow phase-Corn (81.39.61%)

1- Prof. Dr., Agric. Eng. Dep., Fac. of Agric., Cairo Univ., Egypt.

2- Associate Prof., Nat. Inst. of Laser Enhanced Sc. (NILES), Cairo Univ., Egypt.

3- Senior Researcher, Agric. Eng. Res. Institute, Agric. Res. Center, Dokki, Egypt.

>, Flat phase-Corn (83.69%) >, Rice (90.39%) >, Hollow phase-Wheat (92.38%) >, Flat phase-Wheat (93.0%) >, and Bean (93.10%), and f) Sorting and separating different grains can be according to optical properties of laser.

INTRODUCTION

Gunasekaran et al. (1985b) presented a descriptive account of appropriate optical methods for nondestructive quality evaluation of agricultural and biological materials. Optical methods have been successfully used to detect defects in biological materials.

Gunasekaran et al. (1986) reported that when light is incident on any material it may be reflected, transmitted, and absorbed. The degree to which these phenomena take place depends on the nature of the material; particular wavelength of the electromagnetic spectrum used; and the angle of incidence. Based on its optical properties, an object may be transparent, translucent, or opaque. In general, agricultural products are opaque, although most transmit light at certain wavelengths.

Stokman and Gevers (1999) mentioned that the spectra obtained by the imaging spectrograph depend on the light source and subject characteristics. Therefore, these spectra may vary with a change in the intensity and energy distribution of the light source. The proposed spectra are illumination invariant (color constancy).

Dowell et al. (2002) mentioned that a high-speed sorter was tested to determine if infected kernels could be rapidly removed from 1,800-g wheat samples. When the sorter removed about 8% or more of the sample, the reject portion contained 100% of the bunted kernels. Concentrating the bunted kernels in a smaller sample size will reduce sample inspection time and should reduce inspection errors. One high-speed sorter can process up to 8,800 kg/h; thus, bunted kernels can be rapidly removed from samples or large lots. Each sample was sorted in less than one min. This technology provides the wheat industry with a tool to rapidly inspect samples to aid in regulating kernel bunt and to remove bunted grains from seed wheat and wheat destined for food or feed use.

Hassan (2002) showed that the optical properties were determined for the soundness and blemishes of oranges using helium-Neon (He-Ne) with wavelength 632.8 nm and Argon laser with wavelengths 514, 496 and 488 nm, respectively and power of 10 mw. The He-Ne laser is suitable to use because it gives high reflections and a criterion to identify defects for each variety of oranges.

The physical properties of seeds and splits, like those of other grains and seeds are essential for the design of equipment, especially for handling, processing and storing the grains. Investigations have been made for the physical properties of whole chickpea seeds **(Konak *et al.*, 2002).**

Kawamura et al. (2003) used a near-infrared (NIR) transmission instrument to obtain NIR spectra of damp rough rice and damp brown rice. Calibration models were developed from the original spectra and reference analysis data to determine moisture and protein contents of the samples. A visible light (VIS) segregator was used to determine sound whole kernel of brown rice. The precision and accuracy of the NIR instrument and the VIS segregator were found to be sufficiently high to determine moisture and protein content, and sound whole kernel ratio.

Dowell et al. (2004) showed that common bunt (*T. tritici* and *T. laevis*) could be detected in single kernels, including kernels with low levels of infection, with greater than 93% accuracy using optical sensors. To reduce the sample processing time and the chance of missing bunted kernels, we examined the potential of high speed optical sorting technology for removing kernels from large samples and concentrating the kernels into a smaller sample for subsequent visual inspection.

Ministry of Agricultural and Land Reclamation (2007) reported that the total cultivated area in Egypt is about 1781544, 3062000, 1672712 and 175400 feddans, producing about 6140925, 8274300, 6868155, and 247492 tons of corn, wheat, rice and broad beans, respectively in Egypt.

The objective of this study was to measure and determine the following optical and electrical properties of corn, wheat, rice, and bean grains using visible laser. Optical properties are including reflection, absorption intensity, and electrical properties of reflection from various grains. Also, to establish a criterion to identify optical and electrical properties of grains, for sorting and grading grains using visible laser.

MATERIAL AND METHODS

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

Sample preparation: A random sample of four sound grain varieties included (single hybrid 10 corn, Giza 168 wheat, Giza 176 rice, and Giza 40 broad bean). They were obtained from Ministry of Agriculture. After cleaning, grains were exposured by visible laser to determine the optical and electrical properties of grains.

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 grains. The experimental setup consisted of laser type, lens, holders and digital luxmeter as shown in Fig. (1-a & b).

Laser type: Helium-neon (He-Ne) laser as a source light with wavelength 632.8 nm with power 8 mW was used. He-Ne laser specifications are shown in Table (1).

Table (1): Specifications of He-Ne laser.

No.	Specification	Helium –Neon laser
1	Source of manufacture	USA
2	Model	05- LHP-151
3	Type	Gas laser
4	Wavelength, nm	632.8
5	Beam	Continuous wave
6	Output power, mW	8
7	Beam diameter, mm	1.8
8	Beam polarization	Random
9	Input current, V, Amp &Hz	220, 3 & 50

Lens: Concave silica glass lens of 50 mm focal length with diameter 40 mm, was used. The lens collected the reflection intensity of light from grain sample with angle of 45 degree to the luxmeter detector.

Holders: Holders were designed and fabricated of copper to hold lenses, luxmeter and photo detector.

Digital luxmeter: A digital luxmeter with high accuracy and sensitivity was used to measure the intensity of reflection from grain surface and laser beam. Digital luxmeter specifications are shown in Table (2).

Table (2): Specifications of a digital luxmeter.

No.	Specifications	Luxmeter
1	Source of manufacture	Japan
2	Model	Lx-101
3	Display, mm	13 (LCD –Liquid Crystal Display).
4	Ranges, Lux	0-50,000
5	Operating temperature, ^{0}C	0 to 50.
6	Power supply, V, mA	9 , 2
7	Dimension (L*W*H), mm	108 x 73 x 23
8	Weight	160g including battery.

Optical properties: The laser beam cover on the grain surface had diameter 2 mm. The intensity of reflected light was measured by luxmeter from grain surface, collected by convex lens without transmission. The absorption of grain was calculated from the following equation, according conservation of energy:

$$I = R + A \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

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

Fig. 1-a : Experimental setup for measuring optical properties of grains.

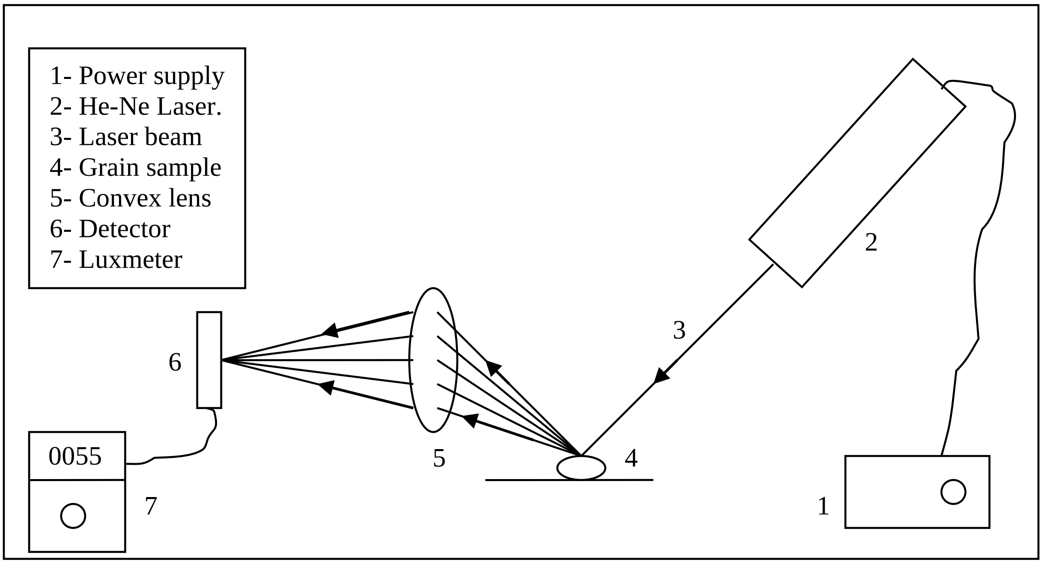

Fig. 1-b : Schematic diagram of set up for measuring optical properties of grains.

RESULTS AND DISCUSSION

Figs. (2 and 3) show the intensity of reflection and absorption percentages of different grains using visible laser. It was noticed that the absorption percentages were higher than reflection percentages for all grains. Absorptions were 81.39, 83.69, 90.39, 92.38, 93.00, and 93.10%. Meanwhile, reflections were 18.61, 16.31, 9.61, 7.63, 7.00, and 6.90% for hollow phase corn, flat phase corn, hollow phase wheat, flat phase wheat, and paddy rice and bean grains, respectively.

Also, the same figures showed that the correlation factors (R-square) were in the allowed range. That means strong relation between all values of each reflection and absorption percentages for all grains. As well, it was noticed that the R–square values of reflection and absorption percentages were equal for each grain.

Fig. (4) shows that the percentages of absorption increased gradually while reflection percentages decreased gradually for hollow phase corn, flat phase corn, hollow phase wheat, flat phase wheat, and paddy rice and bean grains, respectively. That means, the bean grains has the largest absorption percentage and the lowest reflection percentages. Meanwhile, the hollow phase corn grains have the lowest absorption percentage and the largest reflection percentages. This is because the crust of bean grain was smoother than hollow phase corn grain.

Also, Fig. (4) shows comparison between reflection and absorption of various grains using visible laser. Variation was found between reflection and absorption percentages for the same grains which have two different phases such as corn and wheat grains. It was found that the intensity of reflection and absorption percentages for hollow phase corn and wheat grains were higher than the flat phase corn and wheat grains. So, reflections were (18.61 and 7.63%) and absorptions were (81.39 and 92.38%) for hollow phase corn and wheat grains. Meanwhile, reflections were (16.31 and 7.00%) and absorptions were (83.69 and 93.00%) for flat phase corn and wheat grains. This is because the hollow phase area of grain was larger than flat phase area of grain for all grains.

The main statistical values of optical properties are shown in Tables (3) and (4) for hollow and flat phases of corn and wheat grains such as: standard deviation (SD), standard error (SE) and coefficients of variance (CV), for hollow phase corn, flat phase corn, hollow phase wheat, flat phase wheat, and paddy rice and bean grains, respectively. It was noticed that the coefficient of variance (0.20 & 0.23 % and 0.26 & 0.29 % of reflection) were approximately equal for hollow and flat phases of corn and wheat grains The standard deviation and coefficient of variance for all grains were allowed under this experimental.

Fig. (5) shows the electrical signal for reflection intensity from grains. It was found that the electrical signals production decreased gradually as follows: 5.88, 5.67, 5.46, 5.06, 3.94, and 3.62 mV for hollow phase corn, flat phase corn, hollow phase wheat, paddy rice, flat phase wheat, and bean grains, respectively. This was because the reflection intensity of laser decreased gradually as follows 148.9, 130.5, 76.9, 61.0, 56.0 and 55.2 lux., for the same grains.

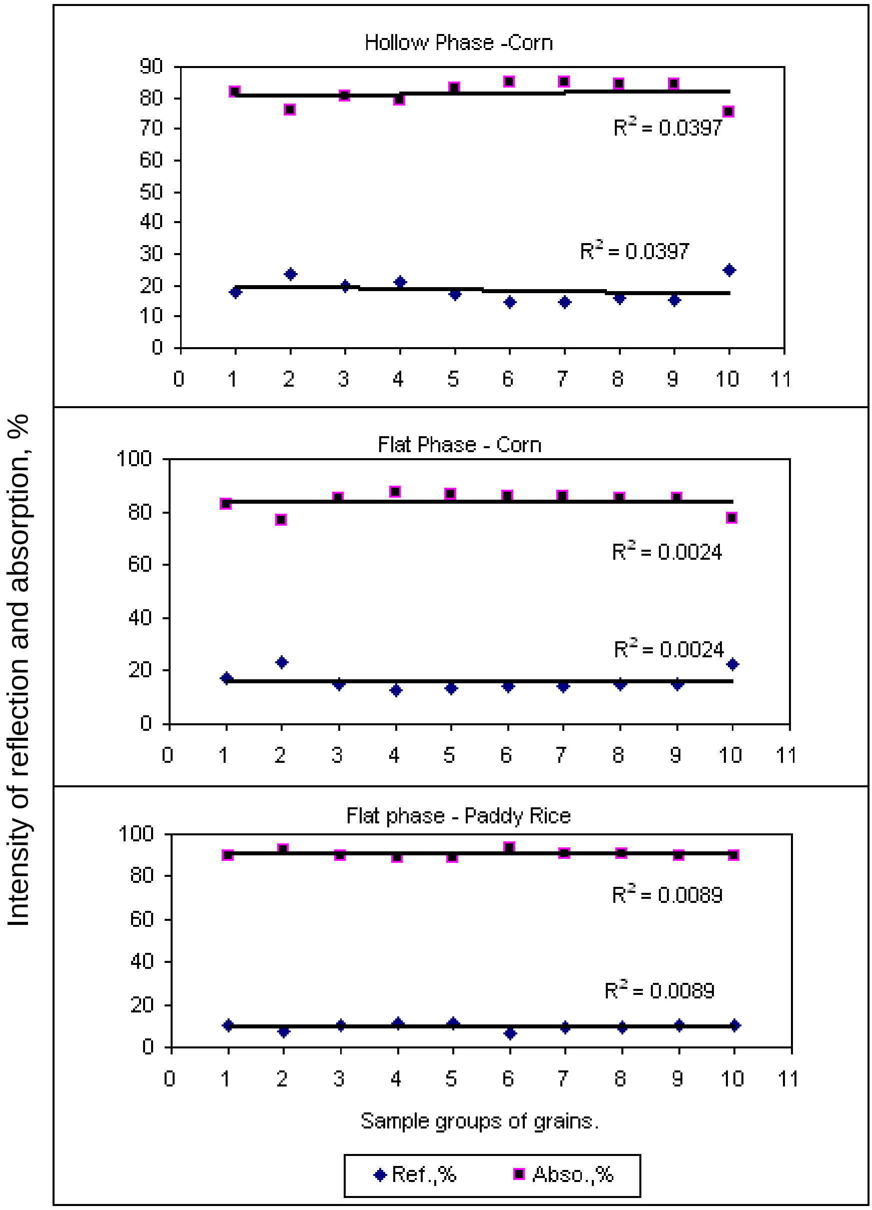

Fig. (2) : Intensity of reflection and absorption percentages of corn and paddy rice grains using visible laser.

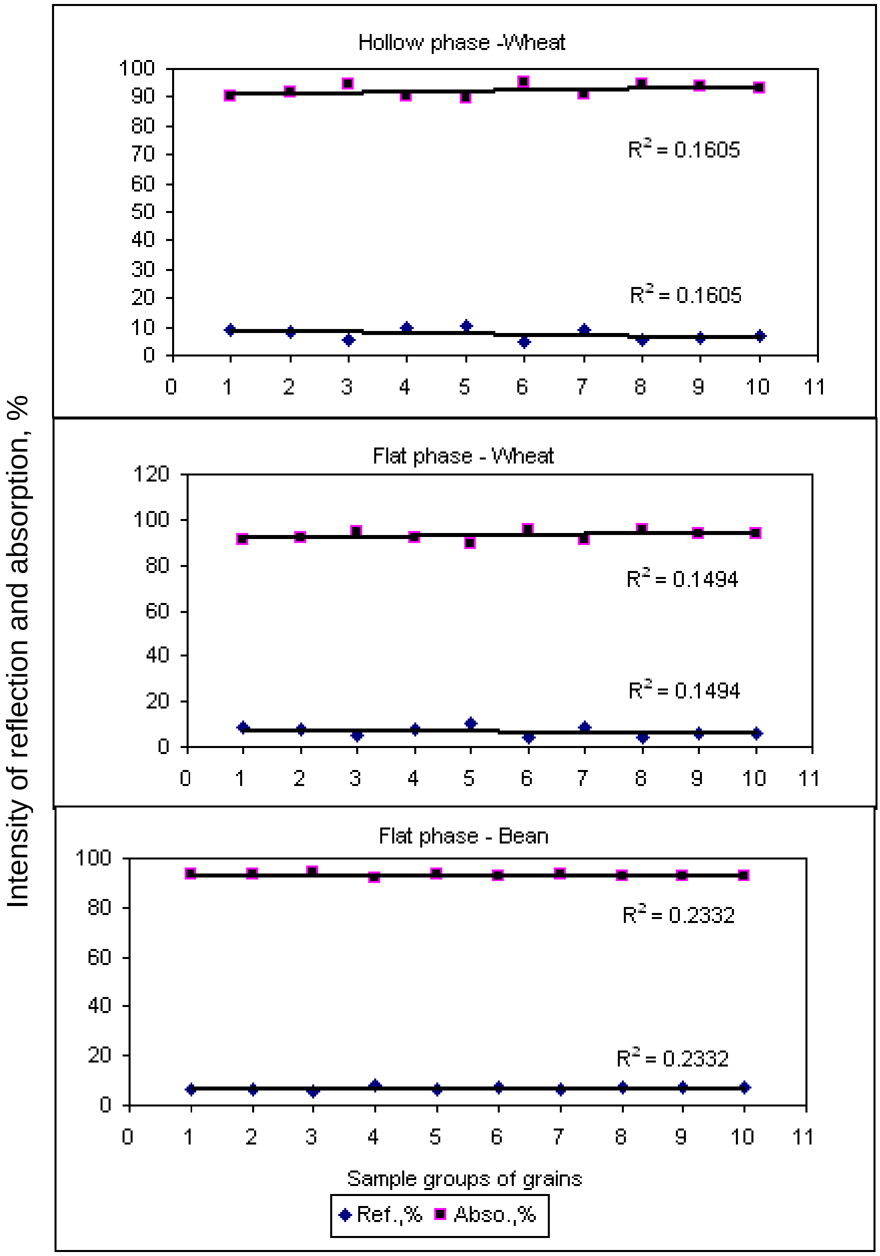

Fig. (3) : Intensity of reflection and absorption percentages of wheat and bean grains using visible laser.

Table (3): Statistical values of optical properties for hollow and flat phases of corn and wheat grains.

Statistical values	Elec. of Ref. mV		Ref., lux		Abso., lux		Ref.,%		Abso., %	
	Hollow phase	Flat phase	Hollow phase	Flat phase	Hollow phase	Flat phase	Hollow phase	Flat phase	Hollow phase	Flat phase
	Corn									
Mean ± S.E	5.88 ± 0.09	5.67 ± 0.18	148.9 ±9.24	131 ±9.44	651.1 ±9.24	669.5 ± 9.44	18.61 ±1.15	16.31 ± 1.18	81.39 ±1.15	83.69 ±1.18
S.D	0.28	0.55	29.19	29.82	29.19	29.82	3.65	3.73	3.65	3.73
C.V.%	0.05	0.10	0.20	0.23	0.04	0.04	0.20	0.23	0.04	0.04
Wheat										
Mean± S.E	5.06 ±0.12	3.94 ±0.34	61.0 ±5.01	56.0 ±5.17	739 ±5.01	744 ±5.17	7.625 ±0.63	7.00 ±0.65	92.38 ±0.63	93.0 ±0.65
S.D	0.39	1.06	15.85	16.33	15.85	16.33	1.98	2.04	1.98	2.04
C.V.%	0.08	0.27	0.26	0.29	0.02	0.02	0.26	0.29	0.02	0.02

SD = Standard deviation; S.E.. = Standard Error C.V. =Coefficient of variance.

Table (4): Statistical values of optical properties for flat phase of rice and bean grains.

Statistical values	Elec. Ref., mV	Ref., lux	Abso., lux	Ref.,%	Abso., %
	Rice				
Mean± S.E	5.46±0.16	76.9±3.38	723.1±3.38	9.6±0.42	90.39±0.42
S.D.	0.51	10.69	10.69	1.34	1.34
C.V.%	0.09	0.14	0.01	0.14	0.01
Bean					
Mean± S.E	3.62±0.34	55.2±2.04	744.8±2.04	6.9±0.26	93.1±0.26
S.D.	1.09	6.46	6.46	0.81	0.81
C.V.%	0.30	0.12	0.01	0.12	0.01

SD = Standard deviation; S.E.. = Standard Error C.V. =Coefficient of variance.

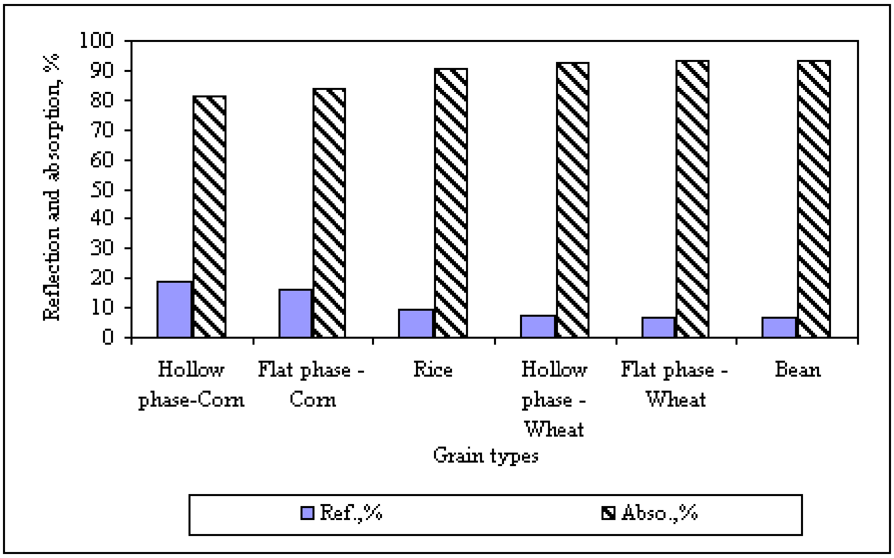

Fig. (4): Comparison between intensity of reflection and absorption percentages of various grains using visible laser.

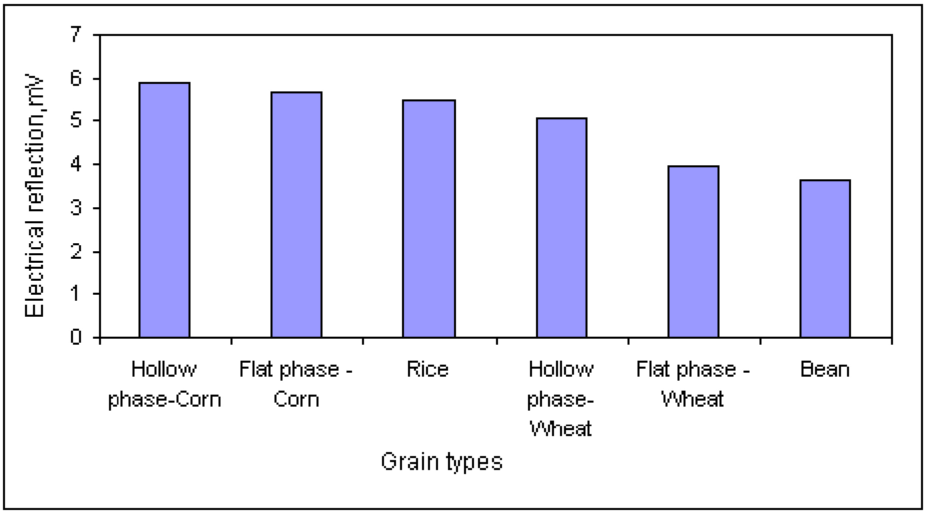

Fig. (5) : Electrical reflection of different grains using visible laser.

Fig. (6) shows the values (high, low, and closed) of the reflection intensity for grains using visible laser. They were found as follows (198, 119, and 148.9 lux), (189, 105, and 130.5 lux), (90, 55, and 76.9 lux), (86, 40, and 61 lux), (83, 35, and 56 lux), and (66, 46, and 55.2 lux) for hollow phase corn, flat phase corn, hollow phase wheat, paddy rice, flat phase wheat, and bean grains, respectively.

Also, Fig. (6) shows the values (high, low, and closed) of the absorption intensity for grains using visible laser. They were found as follows: (681, 602, and 651.1 lux), (695, 611, and 669.5 lux), (745, 710, and 723.1 lux), (760, 714, and 739 lux), (765, 717, and 744 lux), and (754, 734, and 744.8 lux) for hollow phase corn, flat phase corn, hollow phase wheat, paddy rice, flat phase wheat, and bean grains, respectively.

Fig. (7) shows the electrical signals production from reflection intensity of grains using visible laser. It was found that the values (high, low, and closed) of electrical reflection from grains were as follows: (6.2, 5.3, and 5.88 mV), (6.9, 4.8, and 5.67 mV), (6.5, 5.0, and 5.46 mV), (6.1, 4.8, and 5.06 mV), (5.7, 2.8, and 3.94 mV), and (5.3, 2.2, and 3.62 mV) for hollow phase corn, flat phase corn, hollow phase wheat, paddy rice, flat phase wheat, and bean grains, respectively.

Table (5): Optical properties criteria for sound grain crops using He-Ne Laser with wavelength 632.8 nm and power 8 mW.

Optical properties	Grain crops					
	Hollow phase-Corn	Flat phase-Corn	Flat phase-Rice	Hollow phase-Wheat	Flat phase-Wheat	Flat phase-Bean
Reflection, Lux	119-198	105-189	55-90	40-86	35-83	46-66
Absorption, Lux	602-681	611-695	710-745	714-760	717-765	734-754
Reflection, mV	5.3-6.2	4.8-6.9	5.0-6.5	4.8-6.1	2.8-5.7	2.2-5.3
The means:						
Reflection, Lux	148.9	13.50	76.9	61.00	56	55.2
Absorption, Lux	651.1	669.5	723.1	739	744	744.8
Reflection, mV	5.88	5.67	5.46	5.06	3.94	3.62
Reflection, %	18.61	16.31	9.61	7.63	7.00	6.90
Absorption, %	81.39	83.69	90.39	92.38	93.00	93.10

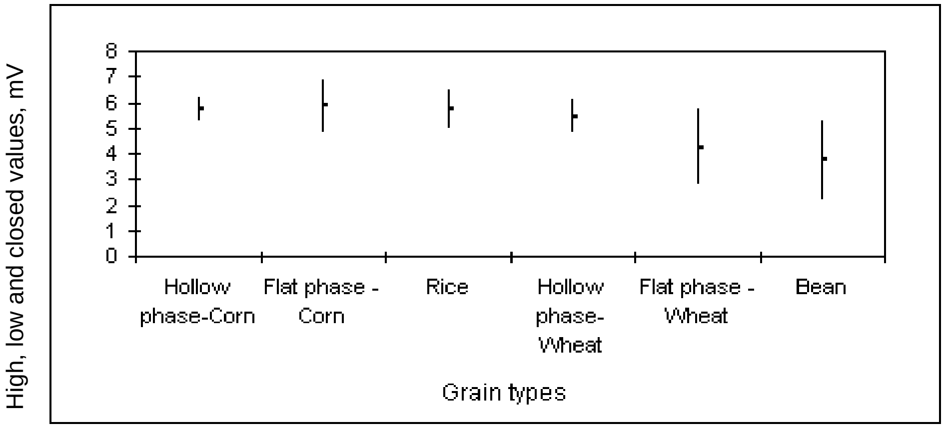

Fig. (6): The range and closed value of electrical reflection intensity for various grains using visible laser

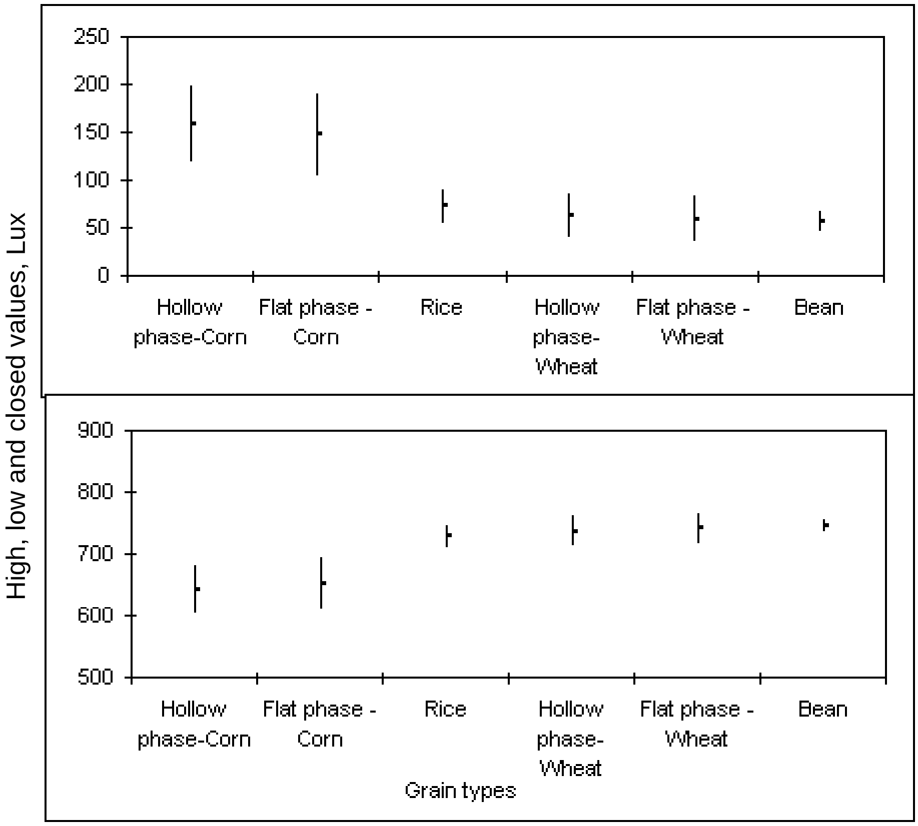

Fig. (7): The range and closed value of reflection and absorption intensity for various grains using visible laser

Table (5) shows the criteria to identify optical properties for sound grain crops using He-Ne Laser with wavelength 632.8 nm and power 8 mW. The values of absorption were higher than the values of reflection for all examined grains. The descending of arrangement different varieties according to the optical properties of sound grains are as the follows: The reflection of Bean (6.90%) >, Flat phase-Wheat (7.0%) >, Hollow phase-Wheat (7.63) >, Rice (9.61%) >, Flat phase-Corn (16.31) >, and Hollow phase-Corn (18.61%). Meanwhile, the absorption were: Hollow phase-Corn (81.39.61%) >, Flat phase-Corn (83.69%) >, Rice (90.39%) >, Hollow phase-Wheat (92.38%) >, Flat phase-Wheat (93.0%) >, and Bean (93.10%).

CONCLUSIONS

From the obtained results, the following conclusions can be made:

1 - The absorption percentages were higher than reflection percentages. Reflections were 18.61, 16.31, 9.61, 7.63, 7.00, and 6.90%. Meanwhile, absorption were 81.39, 83.69, 90.39, 92.38, 93.00, and 93.10% for hollow phase corn, flat phase corn, hollow phase wheat, flat phase wheat, and rice and bean grains, respectively.

2- There are strong relations between R-square values of each reflection and absorption percentages for all grains, and the R–square values of reflection and absorption percentages were equal for each grain.

3- There is variation between reflection and absorption percentages for the same grains which have two different phases such as corn and wheat grain.

4- The electrical reflections decreased gradually as follows: 5.88, 5.67, 5.46, 5.06, 3.94, and 3.62 mV for hollow phase corn, flat phase corn, hollow phase wheat, paddy rice, flat phase wheat, and bean grains, respectively according to the reflection intensity of laser.

5- The values (high, low, and closed) of the reflection intensity for grains were (198, 119, and 148.9 lux), (189, 105, and 130.5 lux), (90, 55, and 76.9 lux), (86, 40, and 61 lux), (83, 35, and 56 lux), and (66, 46, and 55.2 lux). Meanwhile, the absorption intensities were (681, 602, and 651.1 lux), (695, 611, and 669.5 lux), (745, 710, and 723.1 lux), (760, 714, and 739 lux), (765, 717, and 744 lux), and (754, 734, and 744.8 lux) for hollow phase corn, flat phase corn, hollow phase wheat, paddy rice, flat phase wheat, and bean grains, respectively.

6 - The criteria to identify optical properties from sound grains are arranged descending order as follow: The reflection were: Bean (6.90%) >, Flat phase-Wheat (7.00%) >, Hollow phase-Wheat (7.63%) >, Rice (9.61%) >, Flat phase-Corn (16.31%) >, and Hollow phase-Corn (18.61%). Meanwhile, the absorption were: Hollow phase-Corn (81.39%) >, Flat phase-Corn (83.69%) >, Rice (90.39%) >, Hollow phase-Wheat (92.38%) >, Flat phase-Wheat (93.00%) >, and Bean (93.10%).

LITERATURE CITED

Dowell, F. E., T. N. Boratynski , R. E. Ykema, A. K. Dowdy and R. T. Staten (2002). Use of optical sorting to detect wheat kernels infected with *Tilletia indica*. Plant Dis. 86:1011-1013.

Dowell, F. E., D. Wang, J. E.Baker, J. E.Throne, J. L. Steele and S. R. Delwiche (1997). Automated single wheat kernel quality measurement using near-infrared reflectance. Presented at the Aug. 1997 ASAE Ann. Int. Meet. Paper No. 973022.

Gunasekaran, S., M. R. Paulsen, and G. C. Shove (1985b). Optical methods for nondestructive quality evaluation of agricultural and biological materials. J. Agric. Eng. Res. 32(3):209-241.

Gunasekaran, S., M. R. Paulsen and G. C. Shove (1986) A Laser optical method for detecting corn kernel defects**.** Vol. 29(l) January-February, 1986. Trans. ASAE 29 : 294-304

Hassan, H. E. (2002). Study of sorting and grading operations of Egyptian mature oranges using visible laser. Ph.D. Th., Nat. Inst. of Laser In Enhanced Sc. (NILES), Cairo U.: 12-15.

Kawamura S., M. Natsuga, K. Takekura, and K. Itoh (2003). Development of an automatic rice-quality inspection system. Ag. Process Eng. Lab, Grad. Sch. Ag. Sc., Hokkaido U., Sapporo 060-8589, Japan. Computers and Electronics in Agriculture 40 : 115- 126

Konak, M., K. Carman and C. Aydin (2002). Physical properties of Chick Pea seeds. Biosyst. Eng., 82(1): 73-78.

Ministry of Agricultural and Land Reclamation (2007). Study of important indicators of the Ag. Stat. Crops. Ec. Affairs Sector: 425-427.

Stokman, H. and T. Gevers (1999). Hyperspectral edge detection and classification. In Proc. 10th British Machine Vision Con., 2: 643-651. Nottingham, U.K.: 12-15

الملخص العربي

الخصائص الضوئية والكهربية لبعض الحبوب باستخدام شعاع الليزر المرئى

أحمد الراعى إمام سليمان [١] ، حلمى السيد حسن [٢] ، عبدالرحمن عبدالرؤف عبدالرحمن [٣]

تهدف هذه الدراسة إلى انشاء مقياس ثابت للتعرف على الخصائص الضوئية والكهربية لحبوب الذرة ، والقمح ، الأرز ، و الفول باستخدام شعاع ليزر الهيليوم نيون المرئى ذى الطول الموجي ٦٣٢,٨ نانو متر وقدرة ٨ ملى وات.

وتم إجراء التجارب والقياسات بمعمل تطبيقات الليزر فى الهندسة الزراعية بالمعهد القومى لعلوم الليزر ، جامعة القاهرة وذلك بإنشاء وحدة لقياس الخصائص الضوئية تتكون من : مصدر الليزر ، ومجموعة بصرية لتجميع الشعاع المنعكس من سطح الحبوب على المقياس الضوئى (لكسميتر) لقياس كمية الضوء المنعكس.. حيت تم قياس الكثافة الضوئية للانعكاس من سطح الحبوب .. كما تم حساب الكثافة الضوئية الممتصة فى الحبوب باستخدام قانون بقاء الطاقة بدون أى نفاذية وكانت النتائج المتحصل عليها للخصائص الضوئية(الانعكاس والامتصاص) و الكهربية كالتالى:

١) وجد أن الكثافة الضوئية الممتصة فى الحبوب كانت أعلى من المنعكسة من سطح الحبوب ، حيث كانت نسبة الأنعكاس ١٨,٦١ ، ١٦,٣١ ، ٩,٦١ ، ٧,٦٣ ، ٧,٠ ، ٦,٩ % بينما كانت نسبة الأمتصاص ٨١,٣٩ ، ٨٣,٦٩ ، ٩٠,٣٩ ، ٩٢,٣٨ ، ٩٣,٠٠ % لحبوب الذرة من الجانب المجوف ، والمسطح ، و القمح من الجانب المجوف ، والسطحى ، والأرز الشعير ، والفول البلدى على التوالى.

٢) وجدت علاقة قوية لقيم معامل الارتباط بين الأشعة المنعكسة و الممتصة من سطح الحبوب .. حيث تساوى معامل الأرتباط للأشعة المنعكسة والممتصة للنوع الواحد من الحبوب.

١- أستاذ الهندسة الزراعية – كلية الزراعة – جامعة القاهرة – مصر.

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

٣- باحث أول بمعهد بحوث الهندسة الزراعية – مركز البحوث الزراعية - الدقى - مصر.

٣) الاشارات الكهربية الناتجة من إنعكاس شعاع الليزر من سطح الحبوب تقل تدريجيا على النحو التالى : ٥,٨٨ ، ٥,٦٧ ، ٥,٤٦ ، ٥,٠٦ ، ٣,٩٤ ، ٣,٦٢ ملى فولت لحبوب الذرة من الجانب المجوف ، والمسطح ، و القمح من الجانب المجوف ، والسطحى ، والأرز الشعير ، والفول البلدى على التوالى.

٤) وجد أن القيم العليـا و الـدنيا (المـدى) والوسـط للأشـعة المنعكسـة مـن الحبـوب كانـت كالتـــالى: (١٩٨ ، ١١٩ ، ١٤٨,٩) ، (١٨٩ ، ١٠٥ ، ١٣٠,٥) ، (٩٠ ، ٥٥ ، ٧٦,٩) ، (٨٦ ، ٤٠ ، ٦١) ، (٨٣ ، ٣٥ ، ٥٦) ، (٦٦ ، ٤٦ ، ٥٥,٢ لكـس) بينمـا كانـت للأشـعة الممتصـــــــــة (٦٨١ ، ٦٠٢ ، ٦٥١,١) ، (٦٩٥ ، ٦١١ ، ٦٦٩,٥) ، (٧٤٥ ، ٧١٠ ، ٧٢٣,١) ،(٧٦٠ ، ٧١٤ ، ٧٣٩) ،(٧٦٥ ، ٧١٧، ٧٤٤)، (٧٥٤ ، ٧٣٤ ، ٧٤٤,٨ لكس) للحبوب على الترتيب.

٥) تم وضع مقياس ثابت للحبوب السليمة طبقا لخصائصها الضوئية باستخدام شعاع الليزر المرئى وكان ترتيبها التصاعدى للأشعة المنعكسة كالتالى : الفول البلدى (٦,٩٠ %) ، القمح من الجانب السطحى (٧,٠٠ %) ، القمح من الجانب المجوف (٧,٦٣ %) ، الأرز الشعير (٩,٦١ %) ، الذرة من الجانب المسطح (١٦,٣١٪) ، الذرة من الجانب المجوف (١٨,٦١٪) بينما كان الترتيب التصاعدى للأشعة الممتصة كالتالى : الذرة من الجانب المجوف (٨١,٣٩ %) ، الذرة من الجانب المسطح (٨٣,٦٩ %) ، الأرز الشعير (٩٠,٣٩ %) ، القمح من الجانب المجوف (٩٢,٣٨ %) ، القمح من الجانب السطحى (٩٣,٠٠ %) ، الفول البلدى (٩٣,١٠ %).

٦) أوضحت الدراسة أنه من الممكن فرز وفصل الحبوب المختلفة طبقا لخصائصها الضوئية باستخدام الليزر المرئى .