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LASER RADIATION EFFECT ON FABA BEAN QUALITY DURING STORAGE

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Abstract

The main purpose of the present study the effect of laser exposure time on faba bean seed quality by study the properties (physical, mechanical and chemical) of faba bean during storage periods. A laser light source was Helium-Neon laser with wavelength 632.8nm and power 8m W. Three exposure time of laser irradiation were of 15, 30 and 45min and 0min for treatment without irradiation, on the Faba bean Giza 716 variety. After exposure seeds, they were stored for nine months and then three samples are taken from each treatment every three months and determined chemical, physical and mechanical analysis changes to observe the changes that occur during storage period. Result showed that the main dimensions, mass and bulk volume, true volume, protein, moisture content, fat and fiber were decreased by decreasing laser exposure time and increasing the storage period. Meanwhile, the bulk, true density, shear, penetration force, ash and carbohydrate were increased by increasing storage period and by decreasing laser exposure time.

Key words : *Vicia faba*, irradiation, physical, mechanical and chemical.

Introduction

Nearly thirty percent of the legumes; grains and seeds are lost during the handling and post harvest process, which includes (transport, storage and packing) due to insects, dieses, rodents and microorganisms. That processing period begins right at the time of attainment of the physiological maturity of seeds in the field till it was planted in the next season. Attention must be taken to preserve the germination capacity viability and vigor of the seeds (Parimala *et al.*, 2013).

Dry beans productions in Egypt were 98132 tonnes and green bean were 283520 tonnes in 2017 and the area harvested were 39665 and 27255 ha for dry beans and green beans, respectively (FAO/ faostat, 2019).

Legumes are a good source of vitamins (thiamine, riboflavin, niacin, vitamin B6, and folic acid) and certain minerals such as (Ca, Fe, Cu, Zn, P, K and Mg) and are a good source of polyunsaturated fatty acids. Different studies reported that the large consumption of legumes may be due to protect from diseases such as cancer, diabetes, osteoporosis, and cardiovascular diseases, among others (Annor *et al*., 2014).

Faba bean grain has a protein content of 24- 30%, depending on the variety. Just like other legumes, faba beans accumulate a lot of proteins through seed development. The amino acid compositions of the protein in faba beans are quite similar to other legumes and are characterized by a generally good nutritional quality with the exception of low sulphur amino acid and tryptophan concentration. In a diet, it is easily compensated for by eating it with grains (Ehsanzamir, 2018).

According to Altuntas and Yýldýz (2007) determined the effect of moisture content on some physical and mechanical properties behavior under compression load of faba bean grains. The average length, width, thickness, geometric mean diameter, unit mass of grain, sphericity, thousand grain mass, the grain volume, true density, porosity, surface area and angle of repose were

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increased as the moisture content increased. Meanwhile, the bulk density was found to decrease with increasing the moisture content.

Both storage methods and periods had noticeable effects on the protein contents of all parts of Faba bean seeds. Crude protein content of whole seed decreased from 29.2% to 27.3, 26.8 and 26.3% after storage for three months in Makamer, in tin cans after heating and in tin cans without heating, respectively. While, storage for six and nine months resulted in gradual decreases in the protein contents of these samples to reach 23.4, 22.2 and 19.8%, respectively, after nine months storage. These decreases in crude protein may be attributed to the activity of proteolytic enzymes (El-Refai *et al*., 1988).

Faba bean physical and mechanical attributes are so important in the design equipment for handling, drying, aeration, storing structures and processing (Shoughy and Amer, 2006).

Laser light has many applications in agriculture, but there is still much work to provide scientific evidence of its potential use as an alternative for the control of diseases originating within the seed, particularly for fungi that area unit internal. Even laser treatment has been reported to be effective, although since laser beams is narrow and the whole surface of the seed should be evenly exposed for good effect it is of limited practical interest (Sharma *et al*., 2015).

The stored product pests gain access to the grain storage from the standing crop in the field to various stages of grain processing and storage. Although, regarding one thousand species of insects are related to hold on merchandise in numerous elements of the globe, a few pests are considered as pests causing severe damage to the stored grains. The hold on grain insect pests are often classified on the premise of their feeding behavior as internal and external feeder or as major and minor pests supported the severity of damage, they cause (Srivastava and Sabtharishi, 2016).

The objectives of this study are :

- Study the physical, mechanical and chemical properties of faba bean during storage period.
- Using laser rays to conserve faba bean during storage period.
- Determine the most suitable dose of laser radiations to conserve the faba bean during storage.

Materials and Methods

Sample preparation

Faba bean seeds which used in this study were provided by Field Crops Research Institute, ARC. Faba bean (*Vicia faba*) Giza 716 variety quantities used 3kg/ treatment. The experimental study was including laser Irradiation treatments have three exposure times of Laser radiation and sample without irradiation (control). The exposure times they were 15, 30 and 45 min for laser treatments and 0 min for treatment without irradiation.

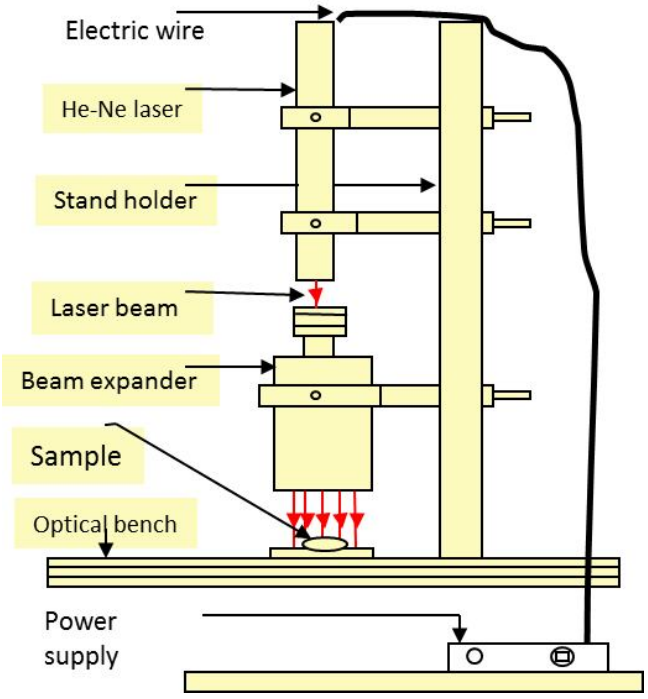

Fig. 1 : Setup of laser.

Laser setup

As a source of radiation, was used a Helium-Neon gas laser (He-Ne) with an output power of 8mW and 632.8nm wavelength. It was consisted of the laser source, holders and beam expander. The Opto –electronic apparatus is shown in fig. 1.

Physical and mechanical characteristics

- Hundred Seeds were tested for mean seed dimensions the length, width, thickness of Faba bean grains, using a digital-vernier caliper.
- The average mass of 100-seed was calculated from 4 replicates, using a digital balance.
- The maximum force to penetrate and shear compress seeds were measured by Digital force gauge in Newtons (N) was determined to represent seed hardness.

Chemical characteristics

Four samples of seeds (250g each) from each treatment to determine percentage of moisture contain, ash, protein, carbohydrates, fiber and fat were done using

the A.O.A.C. (2000) procedure.

After seeds were treated by Laser beam, each sample was placed in a plastic bag and stored for nine months at room temperature. Four samples are taken from each treatment every three months to determined chemical, Physical and mechanical analysis changes for observing the changes that occurred in faba bean quality during storage period.

Statistic analysis

A specialist statistical program (SPSS, Ver. 20) used to analyze the data to study the significant of deference between means of dependent and independent variables for faba bean seed by ANOVA and least significant difference (LSD).

Results and Discussion

Effect of laser exposure time on physical properties of faba bean during storage periods

Effect of laser exposure time on Principal Dimensions of faba bean : An average of the three principal dimensions (length, width and thickness) of faba bean seeds were indicated in figs. 2, 3 and 4 by using laser exposure time (15, 30 and 45min) and (0 min) treatment without irradiation, during storage periods of 0, 3, 6 and 9 months.

Fig. 2 indicated that length dimensions decreased by increased storage periods. The initial lengths at 0 months were 16.17, 16.18, 16.19 and 16.19mm and they were 15.6, 15.69, 15.74 and 14.72mm after 9months for 15, 30, 45min and 0min (control) for laser exposure time, respectively.

Fig. 3 illustrated that the width was increased by decreasing the storage time. The highest width at 0 months were 12.13 and 12.13mm can be achieved for (0 and 45min) and 12.1, 12.09mm for (30 and 15min), respectively and the lowest width were 11.33, 11.96, 11.78 and 11.67mm for (control, 45, 30 and 15min), respectively.

From the results introduced in fig. 4, it could be observed that the thickness reduction range from (0 month) to (9 months) were (5.73 – 5.46mm) and (5.76-5.47 mm) can be achieved for (15 and 30min), while (5.79-5.62mm) and (5.80-5.31mm) for (45 and 0min), respectively. Similar results of increased in the physical properties with moisture content are reported by Tavakoli *et al*. (2009), who evaluated the effect of four levels of moisture content ranging from 6.92 to 21.19% d.b. on some physical properties behaviour under compression load of soybean grains. Increased the average width, length, thickness, geometric mean diameter, arithmetic,

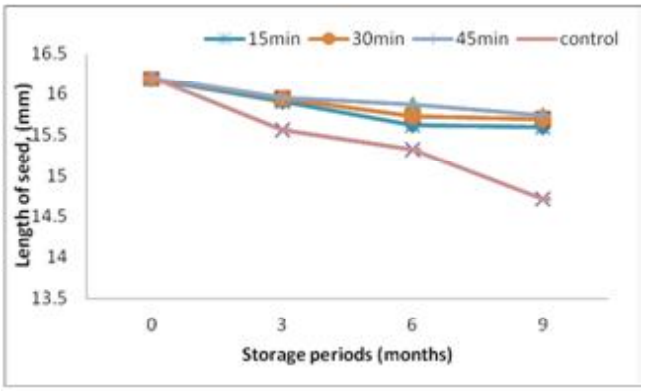

Fig. 2 : Effect of laser exposure time on length of faba bean seeds.

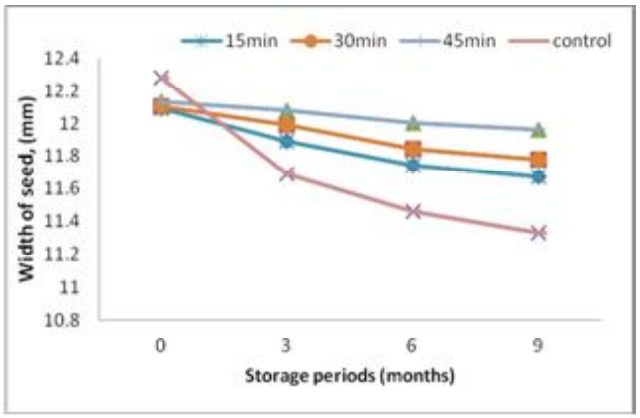

Fig. 3 : Effect of laser exposure time on width of faba bean seeds.

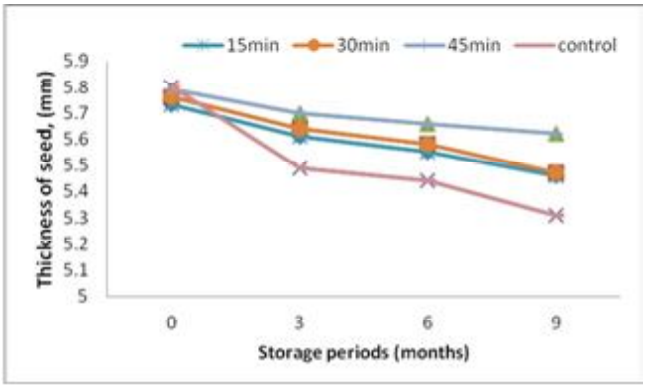

Fig. 4 : Effect of laser exposure time on thickness of faba bean seeds.

angle of repose surface area and thousand grain mass by increasing moisture content from 6.92 to 21.19%.

Shoughy and Amer (2006) evaluated the physical and mechanical properties of three different varieties of faba bean seeds as a function of moisture content. The average length of faba bean seeds decreased from 16.46 to 13.55mm, from 20.91 to 18.49mm and from 22.24 to 20.52mm; the width decreased from 13.23 to 10.69mm, from 15.53 to 13.26mm and from 16.82 to 14.99mm; the thickness from 8.42 to 6.29mm, from 9.32 to 7.51 mm

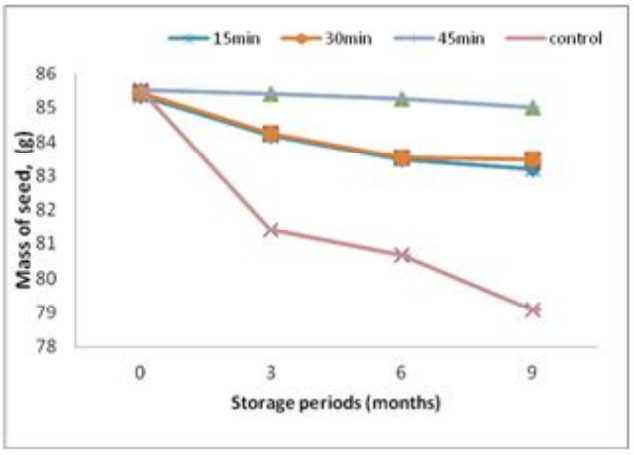

Fig. 5 : Effect of laser exposure time on mass of faba bean seeds.

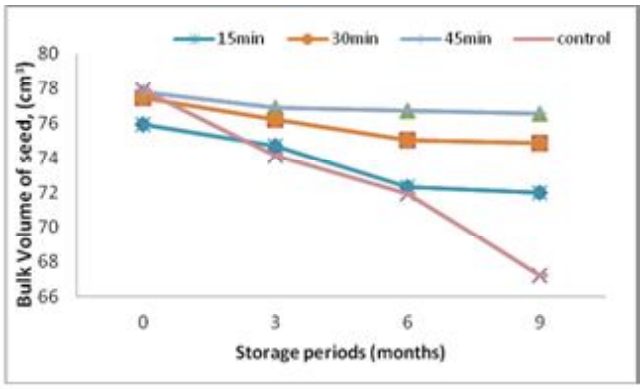

Fig. 6 : Effect of laser exposure time on bulk volume of faba bean.

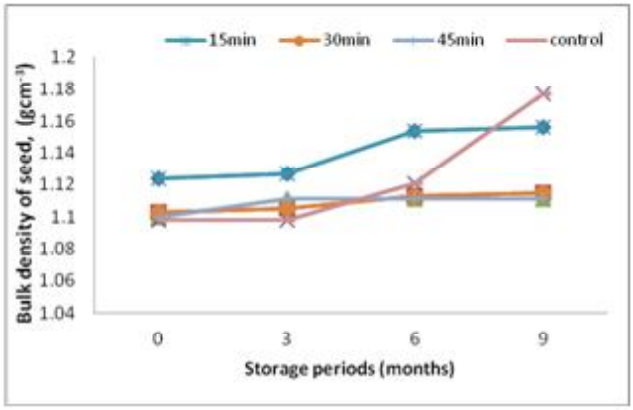

Fig. 7 : Effect of laser exposure time on bulk density of faba bean seeds.

and from 16.82 to 14.99mm for medium1, medium2 and large-seeds, respectively as the moisture content decreased from 26.5 to 9.8%. Altuntas and Yýldýz (2007) studied the effect of moisture content on some physical properties and mechanical behavior for faba bean grains. The average width, length and thickness ranged from 13.66 to 12.54mm, 19.77 to 18.40mm and 8.03 to 7.00 mm, respectively. And the unit mass of grain, grain volume, sphericity, thousand grain mass, angle of repose and true

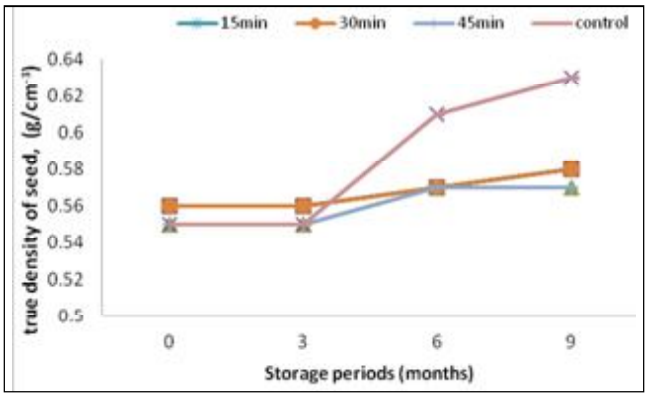

Fig. 8 : Effect of laser exposure time on true density of faba bean seeds.

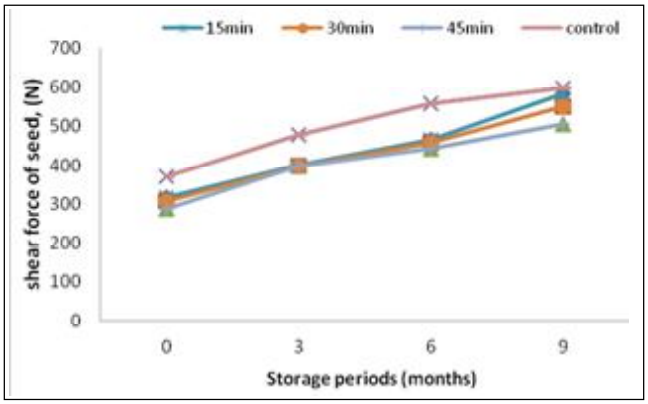

Fig. 9 : Effect of laser exposure time on shear of Faba bean seeds.

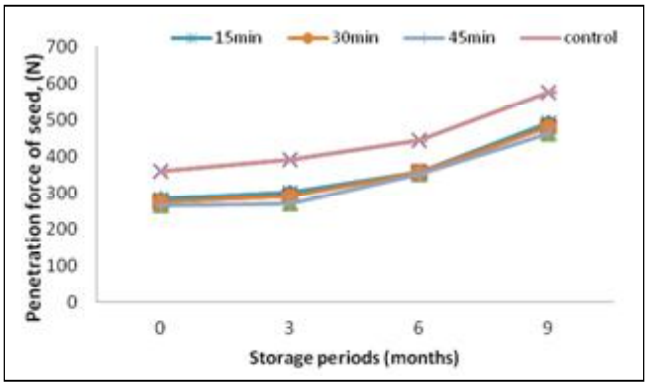

Fig. 10 : Effect of laser exposure time on penetration of faba bean seeds.

density of faba bean grains decreased from 1.301 to 1.147g, 1.099 to 0.998 Cm^3, 1332.67 to 1140.15g, 1206.21 to 1151.33 kgm^{-3} respectively as the moisture content decreased from 25.08% to 9.89% d.b.

Effect of laser exposure time on Mass , Volume and density of faba bean : Fig. 5 indicated that mass decreased by increasing storage periods. The lowest values of mass were (79.09 and 83.18g) for (0 and 15min). While they were (83.46 and 85g) after 9months for treatment (30, 45min), respectively.

Figs. 6 and 7, they were indicated that bulk volume and true volume decreased by increasing storage periods. The lowest values after 9 month were (67.18 and 126 cm^3) and (71.96 and 144 cm^3) for (0 and 15min). While they were (74.87 and 145cm^3) and (76.53 and 149 cm^3) after 9 months for treatment (30, 45min), respectively.

From the results introduced in figs. 5, 6, 7 and 8, it could be observed that the bulk density and true density increased by the increasing storage period.

Shoughy and Amer (2006) evaluated the physical and mechanical properties of three different varieties of faba bean seeds as a function of moisture content in the range of 9.8 to 26.5% (dry basis, d.b.). The volume of seed and thousand seed mass were linearly increased. While, the bulk and true densities have a negative relationship with moisture content. Altuntas and Yýldýz (2007) determined the effect of moisture content on some physical properties and mechanical behavior for faba bean grains. They found that as the moisture content decreased from 25.08% to 9.89%d.b., the bulk density was found to increase from 381.6 to 419.59kgm^{-3}. Yalçýn *et al*. (2007) the physical properties of pea seed were evaluated as a function of moisture content. They found that by decreasing the moisture content from 35.08 to 10.06%d.b. The true and bulk densities were increased.

Effect of laser exposure time on mechanical properties of faba bean during storage periods

Effect of laser exposure time on shear force of faba bean : Fig. 9 shows the Effect of laser exposure time on shear force of faba bean during storage periods. It was indicated that shear force was increased as the storage periods increase. Meanwhile, the shear force was found to decrease with increasing laser exposure time. The initial shear force at 0 months were 318.3, 308.8, 287.0 and 371.6N and they were 582.1, 550.4, 503.9 and 597.0N after 9months for 15, 30, 45min and 0min (control) for laser exposure time, respectively.

Effect of laser exposure time on Penetration force of faba bean : Fig. 10 illustrated that the effect of laser exposure time on the penetration force of faba bean during storage periods. It was indicated that the Penetration force was increased as storage periods increased. Meanwhile, the Penetration force was found to decrease with increasing laser exposure time. The highest Penetration force at 0 months were 576.1 and 490.1N can be achieved for (0 and 15min), and 480.9, 463.3N for (30 and 45min), respectively, and the lowest Penetration force were 358.8, 264.1, 273.9 and 282.7N for (control, 45, 30 and 15min), respectively. These results are consistent with Kingsly *et al*. (2006) who reported that the hardness and toughness of pomegranate seeds decreased with increase in moisture content.

Effect of laser exposure time on chemical properties of faba bean during storage periods

Effect of laser exposure time on protein percent of faba bean : Fig. 11 shows the reduction in protein percentage at 15, 30, 45 min and 0min of laser exposure time for storage periods (0, 3, 6 and 9 months). The results indicated that the highest reduction in protein percentages at (after 9 months) were (23.22 and 22.78%) for (45 and 30 min) and (21.92 and 20.15%) for (15 and 0 min), respectively.

The results were agreed with the range obtained by Abeer *et al*. (2013), which ranged from 26.65 to 30.72%. Likewise, Boghdady *et al*. (2017) also reported that the percentage of protein in faba beans ranged between 18-32%, which is consistent with the results obtained from the study. And Gezer *et al*. (2003) found that Protein content was 29.63%. While Al-Nouri and Siddiqi (1982) state the range of protein percentage between 24.2 - 29.2% for 12 faba bean cultivar.

Effect of laser exposure time on moister percent of faba bean : Fig. 12 show the reduction in Moisture content percentage for 15, 30, 45 min and 0min laser exposure time for storage time (0, 3, 6 and 9 months). The relationship between reduction in moisture content percentage for 45, 30, 15 and 0 min irradiation and storage period represented in fig. 12. It could be found that the moisture content percentages decreased by increasing storage period. The highest reduction (after 9 months) were (9.20 and 9.17%) can be achieved for (45, 30min) irradiation and (9.14 and 8.70%) for (15, 0min), respectively. The results agree with the range obtained by Abeer *et al*. (2013), which ranged from 9.15 to 10.45%.

Effect of laser exposure time on fat percent of faba bean : Fig. 13 shows the reduction in fat percentage for 15, 30, 45min and 0min of laser exposure time for storage periods (0, 3, 6 and 9 months).

From the results introduced in fig. 13, it could be observed that the fat percentage decrease range from 0 to 9 months were (3.69 - 2.00%) and (3.52- 1.95%) can be achieved for (45 and 30 min), while (3.50 - 1.73%) and (3.84 - 1.73%) for (15 and 0min), respectively. The results of this study are equal to those reported by Abreu *et al*. (2013), working with sunflower seed concluded that oil content in the seeds declined over time regardless of storage condition. Stefanello *et al*. (2015) stated that the percentage of lipids of maize seeds decreased

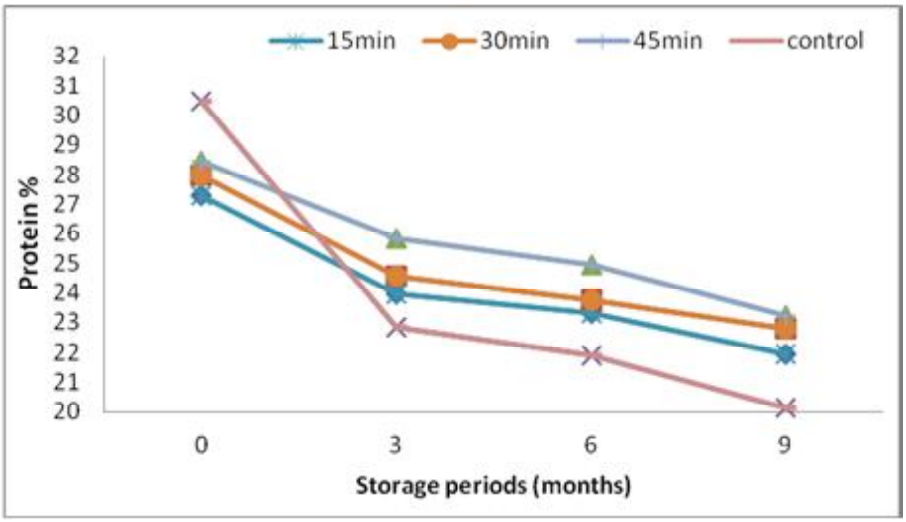

Fig. 11 : Effect of laser exposure time on protein percentage of Faba bean during storage time.

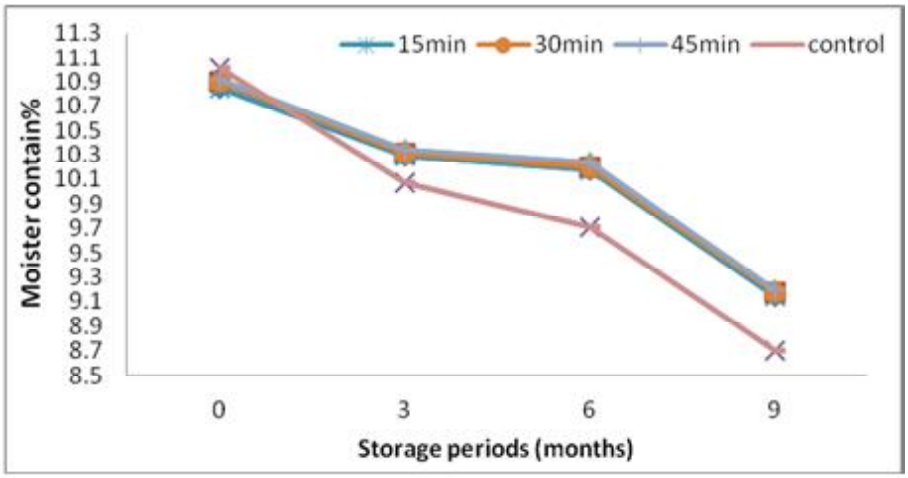

Fig. 12 : Effect of laser exposure time on moisture percentage of Faba bean during storage time.

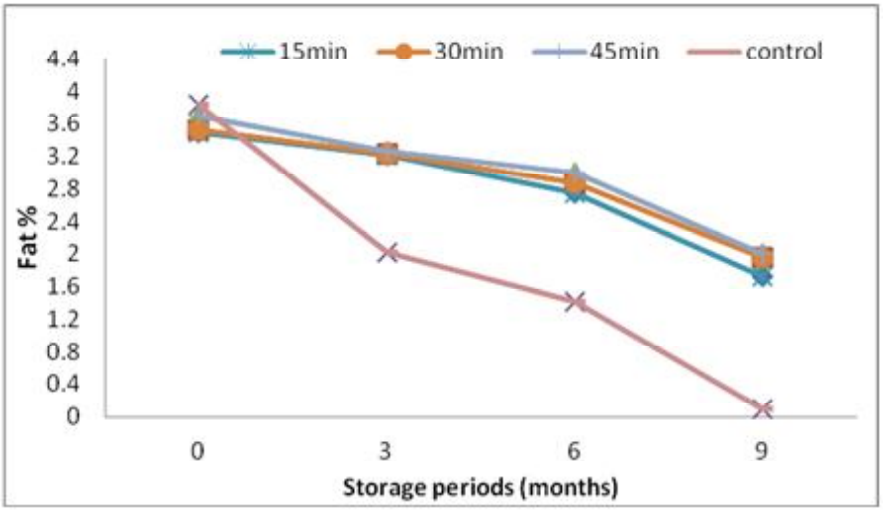

Fig. 13 : Effect of laser exposure time on fat percentage of Faba bean during storage time.

significantly at the end of the storage period, regardless of storage conditions used, And they cited the explanation of the great difference in the percentage of lipids occur thanks to the increased consumption of reserve substances seeds, due to the occurrence of biochemical processes in seed mass.

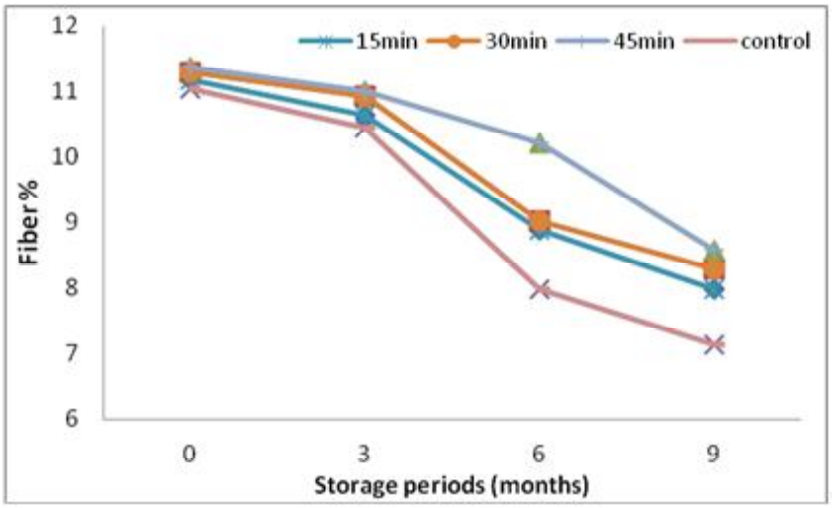

Fig. 14 : Effect of laser exposure time on fiber percentage of Faba bean during storage time.

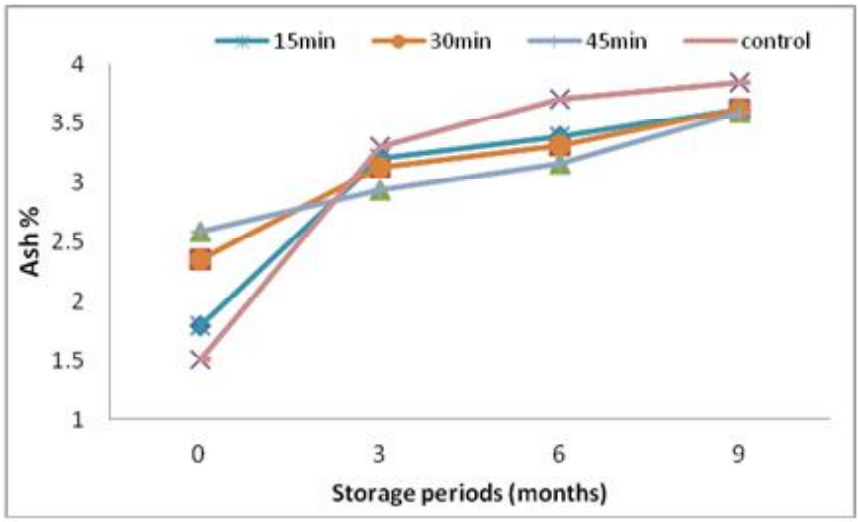

Fig. 15 : Effect of laser exposure time on ash percentage of Faba bean during storage time.

Effect of laser exposure time on Fiber percent of faba bean : Fig. 14 show the reduction in fiber content percentage for 15, 30, 45 and 0min of laser exposure time for storage periods (0, 3, 6 and 9 months). The results presented in fig. 14 show the change in faba bean fiber percentage for treatments 45, 30, 15 and 0min with time storage period, it could be indicated that the fiber percentage decreased by increased storage period. The highest decreased after 9months was (8.58 and 8.30 %) can be achieved for (45, 30min) and (7.99 and 7.14%) for treatments (15, 0min), respectively. The average Fiber content of twelve faba bean cultivar was 6.1% it reported by Al-nouri and Siddiqi (1982).

Effect of laser exposure time on ash percent of faba bean : Fig. 15 shows the reduction in ash content percentage for 15, 30, 45 and 0min of laser exposure time for storage periods (0, 3, 6 and 9 months).

Fig. 15 indicated that the ash content increased by increased the storage period. The highest values (9months) were (3.95, 3.62%) can be achieved (45, 30 min) and (3.62, 3.84%) for (15, 0) min, respectively. Similar results were obtained by Stefanello *et al*. (2015) that is during the storage period, the metabolic activity of seeds and associated microorganisms consume the organic matter metabolizing it to carbon dioxide, without changing the mineral composition. Consequently, increasing the intake of organic material the ashes will raise. While Al-nouri and Siddiqi (1982) found the average Ash for twelve faba bean cultivar was 3.2%.

Effect of laser exposure time on carbohydrate percent of faba bean : Fig. 16 shows the reduction in carbohydrate percentage for 15, 30, 45 min and 0min of laser exposure time for storage periods (0, 3, 6 and 9 months).

Fig. 16 indicated that the carbohydrate percentage increased by increasing the storage time. The high

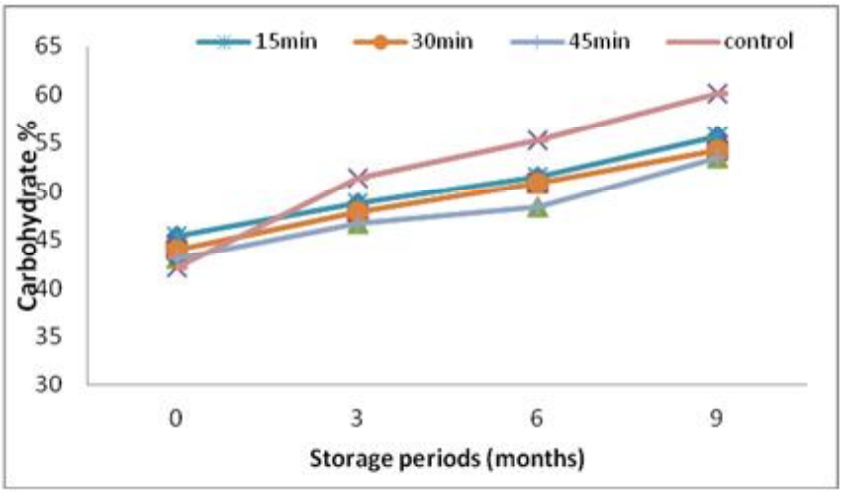

Fig. 16 : Effect of laser exposure time on carbohydrate percentage of Faba bean during storage time.

Table 1 : Least significant difference (LSD) results.

Items	Average of laser exposure time (min)			
	0	**15**	**30**	**45**
Length (mm)	15.45	15.82*	15.88*	15.94*
Width (mm)	11.65	11.85*	11.93*	12.04*
Thickness (mm)	5.51	5.59	5.61*	5.69*
Mass (g)	81.67	84.04*	84.16*	85.29*
Bulk Volume (cm^3)	72.79	73.73	75.90*	76.98*
Bulk density (g/cm^3)	1.12	1.14*	1.11*	1.11*
True density (g/cm^3)	0.59	0.57*	0.57*	0.56*
Shear (N)	500.85	441.68	428.90*	408.13*
Penetration (N)	442.73	357.85*	350.50*	336.95*
Fat %	1.85	2.80*	2.89*	2.99*

* The mean difference is significant at the 0.05 level.

carbohydrate after 9 month were (60.07 and 55.60%) can be achieved for (0 and 15min) and (54.18 and 53.4%) for (30 and 15min), respectively. Stefanello *et al*. (2015) stated that the increase in the percentage of carbohydrates is related to the decrease between the protein and lipid fractions during storage. The carbohydrates content of faba beans ranged from 55-63% was reported by Boghdady *et al*. (2017). Abeer *et al*. (2013) obtained 58 to 62.25.8% for carbohydrates of faba beans.

Figs. 11, 12, 13, 14, 15 and 16 indicated that the effect of irradiation treatment with storage time on chemical properties of faba bean. Results show that protein, moisture content, fat, and fiber increased. While the ash and carbohydrate was decreased with increase storage time. That may be occurring because of the chemical characteristics of degradation and/or of a request of its constituents during storage.

Statistic analysis

ANOVA test outlined that the correlation between laser treatment and physical and mechanical properties and fat percentage of faba beans seeds is worth mentioning because calculated F is significant, meanwhile, for the rest chemical properties were none statistically significant at the 0.05 level. Which means that laser treatment preserve the quality of the physical and mechanical properties of bean seeds and does not effect the chemical content of the seeds.

From table 1, the single most conspicuous observation to emerge from the data comparison was no significant differences between 30min and 45min for faba bean seeds for all indicators.

Conclusion

The different quality properties of faba bean after Laser irradiation time found to be :

The main dimensions, mass and bulk volume and true decreased by increasing the storage period and decreasing laser exposure time. Meanwhile, the bulk and true density increase by increasing the storage period, and increasing laser exposure time. While the shear and Penetration force was increased as the storage periods increase, and decreasing laser exposure time. Main whiles that protein, content, fat and fiber increased. While the ash, moisture and carbohydrate was decreased with increase storage time and decreasing laser exposure time.

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