



Asian Journal of Plant Sciences

ISSN 1682-3974

science
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Research Article

Ultraviolet Effect on Faba Bean Seed Quality During Storage

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Abstract

Background and Objective: Legumes play an important role in human nutrition since they are rich sources of protein, calories, minerals and vitamins and therefore can be good supplements. In order to extend shelf life and reduce loss of faba bean seeds during storage of 9 months, the different doses of ultraviolet irradiation were used. The main purpose of the present study was to observe the effect of Ultraviolet irradiation times on faba bean seed quality. **Materials and Methods:** The seeds of faba bean were investigated in the experiment. Three irradiation times of UVC investigated were of 30, 60 and 90 min of exposure times were used, also and 0 min for treatment without irradiation. During storage period, chemical, physical and mechanical analysis changes were determined. **Results:** (a) The main dimensions, mass and bulk volume and true volume were decreased by increasing the storage period and decreasing ultraviolet irradiation time. Meanwhile, the bulk and true density were increased by increasing storage period and decreasing ultraviolet irradiation time and (b) The protein, moisture content, fat and fiber were increased. While, the ash and carbohydrate were decreased with increasing storage period. **Conclusion:** This technique extend the shelf-life of the faba bean grains, reduce the loss of faba bean grains during storage period of nine months and use the Ultraviolet technique as a clean source without pesticide, which lead to keep the storage environment without any pollution. Our findings suggest that exposure for UV may favour external treatment with particular by light environment, to preserve faba bean seeds with high quality.

Key words: Faba bean, chemical properties, physical properties, irradiation, ultraviolet, seed quality and storage

Citation: Helmy El-Sayed Hassan Mohammed, Ahmed El-Raie Emam Suliman, Abd El-Rahman Abd El-Raouf Ahmed and Mahenor Arabiy Ebrahim, 2020. Ultraviolet effect on faba bean seed quality during storage. *Asian J. Plant Sci.*, 19: 26-34.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Thirty percent of the legumes, grains and seeds are lost during the handling and the post-harvest process, which includes (transport, storage and packing) due to insects, diseases, 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 seeds¹. Dry beans productions in Egypt were 98132 t and green bean were 283520 t in 2017 and the area harvested were 39665 and 27255 ha for dry beans and green beans, respectively².

Legumes (poor man's meat) play an important role in human nutrition since they are rich sources of protein, calories, minerals and vitamins and therefore can be good supplements. Faba bean (*Vicia faba* L.) is the most cultivated leguminous species in the world. Legumes are an important component of traditional diets of several regions all over the world as they are low in fat, rich in protein, dietary fiber and a variety of micronutrients and phytochemicals. Egypt is one of the largest consumers of pulses in the world³. Faba bean production and improving yield, quality is the major target to meet the demand of the increasing Egyptian population, since faba bean constitutes a major part of the diet of Egyptian people⁴. Sowing date and irrigation regimes are playing an vital role on water utilized and consequently on yield and quality of faba bean seeds. Faba bean (*Vicia faba* L.) is one of the oldest legume crops grown in Egypt. Now, the world's largest importer of faba bean. So, increasing faba bean production and improving yield, quality is a major target to meet the demand of the increasing Egyptian population⁵. He stated that the nutritional value of faba bean has always been traditionally attributed to its high protein content, which ranges from 27-34%, depend on genotypes⁶.

The moisture-dependent physical and mechanical properties of *Jatropha curcas* were studied. By determining the physical properties and some of the mechanical properties⁷. The average length, width, thickness, thousand grain mass increased as the moisture content increased and coefficient of friction of *Jatropha* increased linearly against various surfaces with increased in moisture content. The bulk density and true density were found to increase, while the porosity was found to increase. 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 29.2-27.3%, 26.8 and 26.3% after storage

for 3 months in Makamer, in tin cans after heating and in tin cans without heating, respectively. While, storage for 6 and 9 months resulted in gradual decreases in the protein contents of these samples to reach 23.4, 22.2 and 19.8%, respectively, after 9 months storage. These decreases in crude protein may be attributed to the activity of proteolytic enzymes⁸.

Faba bean physical and mechanical attributes are so important in the design equipment for handling, drying, aeration, storing structures and processing⁹. During the first few months of storage, insect infestation and the percentage loss recorded in samples may be low but the insect infestation typically increases with time and so at the end of the season there will be a very high percentage loss in the samples¹⁰. However, this high loss is only applicable to the small quantity of grain remaining in the store. Although the high figures serve to demonstrate the dramatic damaging nature of the pest, they do not accurately reflect the real loss experienced by the farmer. The storage of seeds is initiated at the time of attainment of physiological maturity and maintained till the next sowing season¹¹. Hence, the different stages involved in seed storage are as follows: (a) Period from physiological maturity to harvest, (b) Period from harvest to packaging, (c) Period from packaging to storing, (d) Period from storing to marketing of seeds and (e) On farm storage (Purchased seeds used for planting in the field).

The objectives of this study are:

- Study the physical, mechanical, chemical and biological properties of faba bean during the storage period to detect its quality
- Using UVC irradiation and determination the most suitable dose of UVC exposure time to conserve the faba bean during storage and extend the shelf life of seeds

MATERIALS AND METHODS

Study area: The experiments carried out in the 2017/2018 seasons, located in Giza Governorate at Agricultural Engineering Research Institute. Setup and constructed by Laser Application of Agricultural Engineering Lab., National Institute of Laser Enhanced Science, Cairo University.

Three irradiation times of UVC investigated were of 30, 60 and 90 min of exposure times were used, also and 0 min for treatment without irradiation. After exposure seeds, they were stored for 9 months, during the months of April, 2018 to January, 2019 and then 3 samples are taken



Fig. 1: Ultraviolet unit

from each treatment every 3 months and determined chemical, physical and mechanical analysis changes.

Samples and irradiation treatments: Faba bean seeds which used in this study were provided by (Field Crops Research Institute (FCRI), Agricultural Research Center (ARC). Faba bean (*Vicia faba*) of Giza716 variety quantities used 3 kg/treatment. The experimental study was included UVC Irradiation treatments have 3 exposure times of UVC radiation and sample without irradiation (control). The exposure times they were 30, 60 and 90 min for UVC treatments and 0 min for treatment without irradiation¹².

Treatments of seeds by UVC radiation were carried out in a lab scale by using 2 germicidal lamps (HRA 4384 Germany) emitting UVC at 253.7 nm and 2.5 cm diameter were placed on top of aluminum box, 60 cm length and output power of 18 Watt emitted at 253.7 nm for each one. Also, the UVC unit has timer to control in irradiation times of seeds as shown in Fig. 1.

Measurements:

- 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
- Four samples of seeds (250 g each) from each treatment to determine percentage of moisture contain, ash, protein, carbohydrates, fiber and fat were done using the procedure¹

After the seeds were treated with UVC light, each sample was placed in a plastic bag and stored for 9 months at room temperature. Four samples are taken from each treatment every 3 months to determine the chemical, physical and mechanical analysis changes for observing the changes that occurred in faba bean quality during storage period using standard methods¹³.

Statistical analysis: All experiments were carried out at different time scale to assure the authenticity of the results. Results are indicative of triplicate values expressed as Mean \pm SD.

RESULTS AND DISCUSSIONS

Effect of UVC irradiation on physical properties of faba bean during storage: An average of the 3 principal dimensions (length, width and thickness) of faba bean seeds was measured and indicated in the Table 1. By using UVC irradiation times (30, 60 and 90 min) and (0 min) treatment without irradiation, during storage periods of 0, 3, 6 and 9 months.

Table 1 illustrated that length dimensions decreased by increased storage periods and decreasing the irradiation times. The initial lengths at 0 months were 16.19, 16.09, 16.1 and 16.12 mm and they were 14.72, 14.79, 14.99 and 15.48 mm after 9 months for 30, 60, 90 min and 0 min (control) for UVC irradiation times, respectively.

Also, indicated that the width was increased by decreasing the storage period and increasing the irradiation times. The highest width at 0 months were 12.13 and 12.06 mm can be achieved for (0 and 90 min) and 12.02, 12.00 mm for (60 and 30 min), respectively and the lowest width were 11.33, 11.65, 11.63 and 11.55 mm for (control, 90, 60 and 30 min), respectively.

From the results introduced in Table 1, it could be observed that the thickness reduction range from 0 month to 9 months were 5.80-5.31 and 5.59-5.35 mm can be achieved for 0 and 30 min, while 5.63-5.40 mm and 5.66-5.48 mm for 60 and 90 min, respectively.

The results corresponded with authors, they studied the effect of 5 levels of moisture which ranging from 5.85-25.85% (dry basis, d.b.) on physical and mechanical properties of *Jatropha*. The average length, width, thickness, thousand grain mass determined by Standard methods. And found that they increased as the moisture content¹¹.

Authors were evaluated the physical and mechanical properties of 3 different varieties of faba bean seeds as a function of moisture content. The average length of faba bean seeds decreased from 16.46-13.55 mm, from 20.91-18.49 mm and from 22.24-20.52 mm, the width

Table 1: Effect of UVC irradiation times on principal dimensions of faba bean during storage

Storage period (Months)	UVC irradiation times (min)			
	0	30	60	90
Length (mm)				
0	16.19	16.09	16.10	16.12
3	15.56	15.62	15.75	15.86
6	15.33	15.41	15.55	15.70
9	14.72	14.79	14.99	15.48
Width (mm)				
0	12.13	12.00	12.02	12.06
3	11.69	11.66	11.71	11.83
6	11.46	11.59	11.68	11.77
9	11.33	11.55	11.63	11.65
Thickness (mm)				
0	5.80	5.59	5.63	5.66
3	5.49	5.50	5.53	5.56
6	5.44	5.44	5.47	5.50
9	5.31	5.35	5.40	5.48

Table 2: Effect of UVC irradiation times on principal dimensions of faba bean during storage

Storage period (Months)	UVC irradiation times (min)			
	0	30	60	90
Mass (mm)				
0	85.50	85.00	85.10	85.26
3	81.40	83.46	84.03	84.11
6	80.68	81.97	83.21	83.33
9	79.09	79.74	82.55	82.68
Bulk volume (cm³)				
0	77.89	73.52	73.79	74.89
3	74.15	72.21	72.77	72.90
6	71.95	70.73	71.06	71.26
9	67.18	68.49	70.09	70.50
Bulk density (g cm⁻³)				
0	1.098	1.156	1.153	1.138
3	1.098	1.156	1.155	1.154
6	1.121	1.159	1.171	1.169
9	1.177	1.164	1.178	1.173

decreased from 13.23-10.69 mm, from 15.53-13.26 mm and from 16.82-14.99 mm, the thickness from 8.42-6.29 mm, from 9.32-7.51 mm and from 16.82-14.99 mm for 1, 2 medium and large-seeds, respectively as the moisture content decreased ¹² from 26.5-9.8%.

Table 2 indicated that mass and bulk volume decreased by increasing storage periods and decreasing irradiation times. The lowest values of mass and bulk volume were (79.09 g, 67.18 cm³ and 79.74 g, 68.49 cm³) for (0 and 30 min). Meanwhile, they were (82.55 g, 70.09 cm³ and 82.68 g, 70.5 cm³) after 9 months for treatment (60 and 90 min), respectively.

From the results introduced in Table 2, it could be observed that the bulk density and true density increased by the increasing storage period and decreasing Ultraviolet irradiation time. These results compaying with authors, estimated the physical properties of pits and kernels of

Hacıhaliloğlu apricots as a function of moisture content. They summarized that the weight of 1000 grains, grain volume, true density and the projected area increased with change in moisture content¹⁴.

The physical properties of pea seed were evaluated as a function of moisture content. They found that by decreasing the moisture content from 35.08-10.06% d.b. The true and bulk densities were increased¹⁵.

Effect of UVC times on mechanical properties of faba bean during storage

Effect of UVC irradiation times on shear force of faba bean:

Figure 2a shows the Effect of UVC irradiation times 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 increase by decreasing UVC irradiation times. The shear

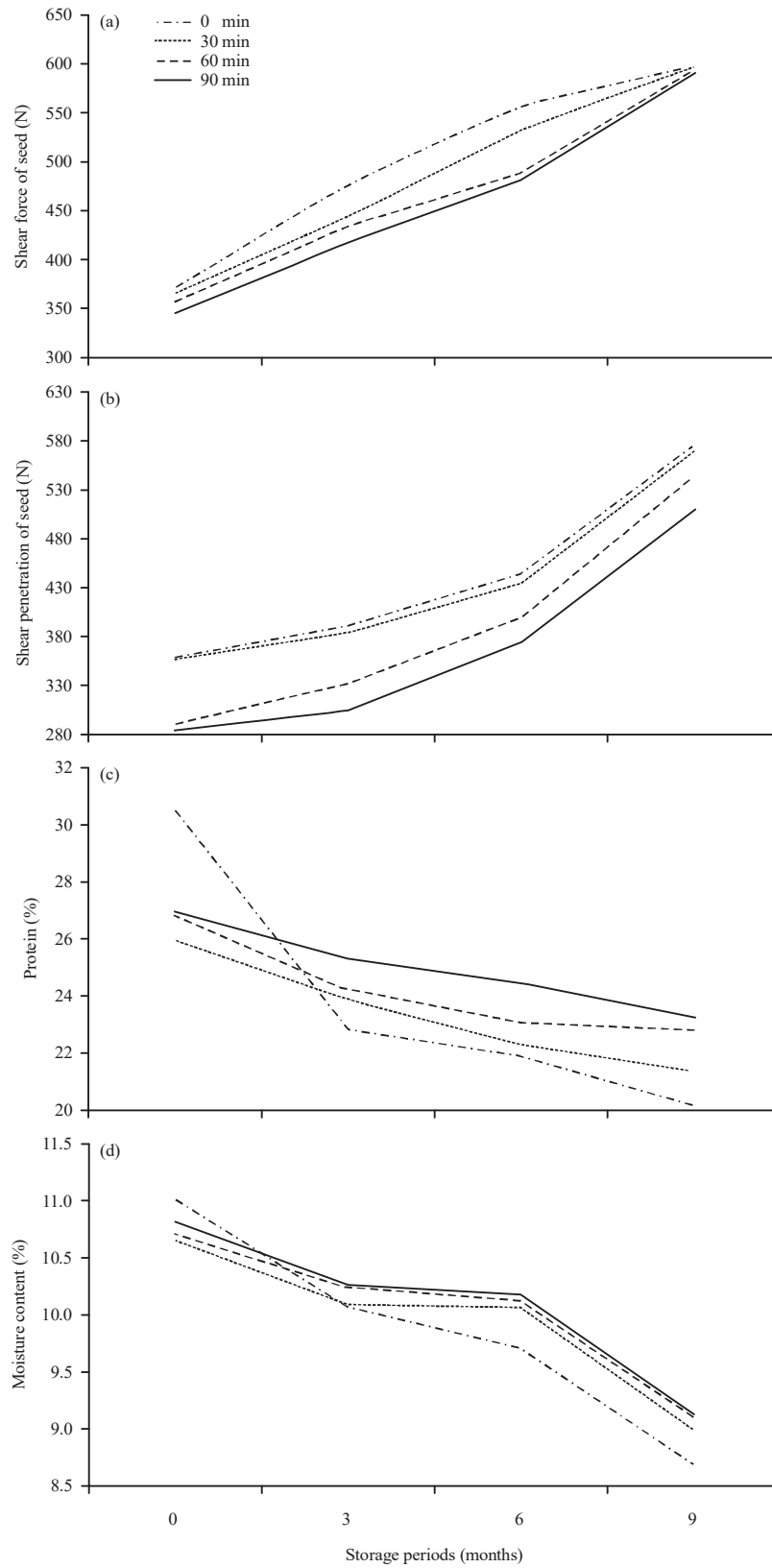


Fig. 2(a-h): Continue

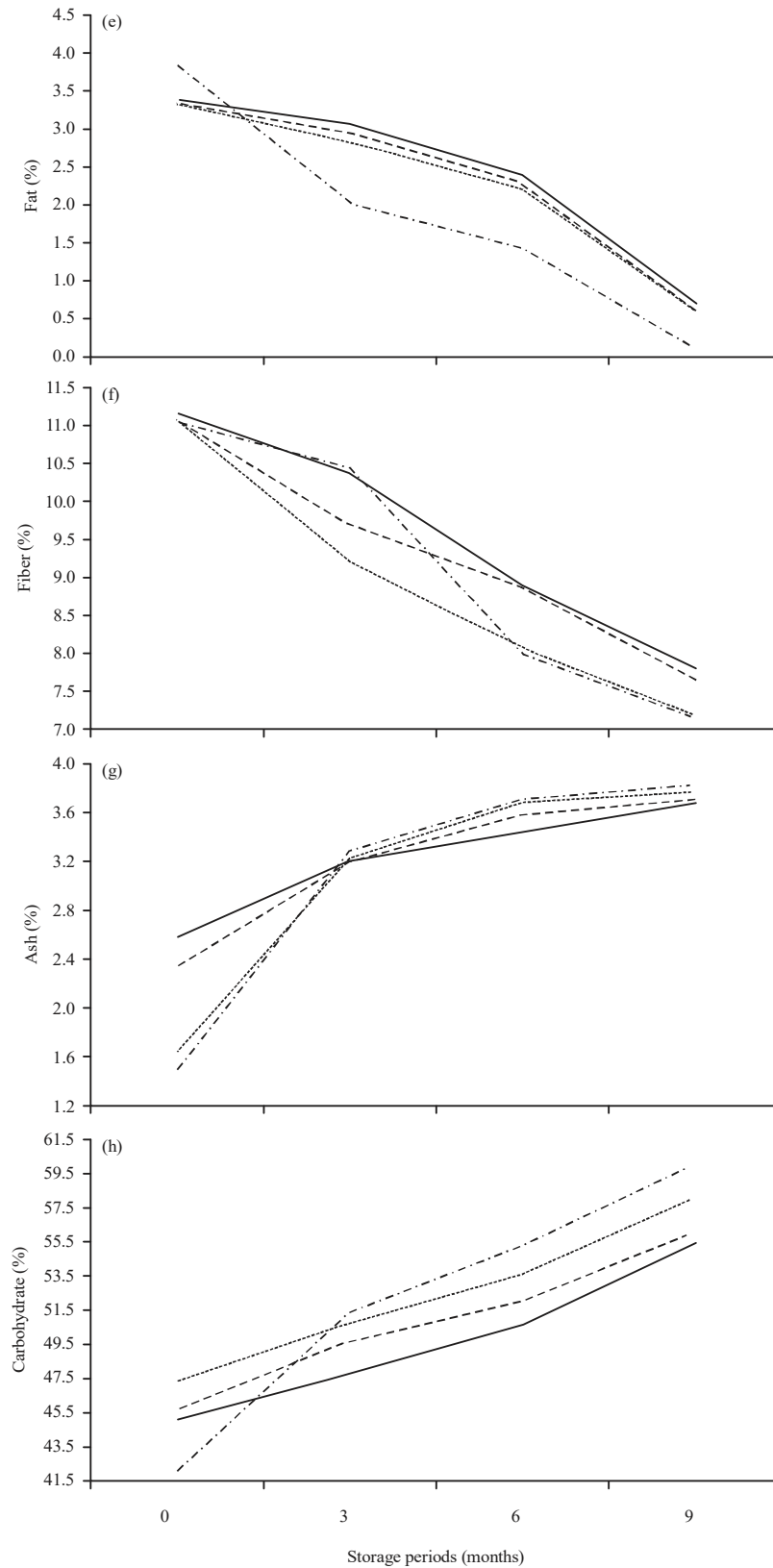


Fig. 2(a-h): Effect of UVC irradiation on (a) Shear force, (b) Penetration force, (c) Protein (%), (d) Moisture content (%), (e) Fat (%), (f) Fiber (%), (g) Ash (%) and (h) Carbohydrate (%) of faba bean during storage

forces at 0 months were 371.6 and 365.8 N can be achieved for (0 and 30 min) and 357.7, 343.4 N for (60 and 90 min), respectively and the highest shear force were 597, 596.9, 593.9 and 590.9 N for (0, 30, 60 and 90 min), respectively.

Effect of UVC irradiation times on penetration force of faba bean:

Figure 2b illustrated that the effect of UVC irradiation times on the penetrating 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 UVC irradiation times. The initial penetration forces at 0 months were 358.8, 356.4, 290.9 and 283.5 N and they were 576.1, 571, 543 and 510.4 N after 9 months for 0, 30, 60 min and 90 min for UVC irradiation times, respectively this results may be related to decrease the moisture content by increasing storage times. These results are consistent with authors who reported that the hardness and toughness of pomegranate seeds decreased with increase in moisture content¹⁶.

Effect of UVC times on chemical properties of faba bean during storage

Effect of UVC irradiation times on protein (%) of faba bean:

Figure 2c shows the reduction in protein percentage at 0, 30, 60 min and 90 min of UVC irradiation times for storage periods (0, 3, 6 and 9 months). The results indicated that the highest reduction in protein percentages after 9 months, they were (20.15 and 21.36%) for (0 and 30 min) and (22.77 and 23.25%) for (60 and 90 min), respectively. The result summarized that the protein percentage has an inverse relationship with storage period and positive relationship with irradiation times.

The results were agreed with the range obtained¹⁷, which ranged from 26.65-30.72%. Also, reported that the percentage of protein in faba beans ranged between 18-32%, which is consistent with the results obtained from the study¹⁸. And they were analyzed the chemical composition of the seeds of land-races maize keeps underneath totally different conditions¹⁹. Also, the results it had been summarized that the content of crude protein content at the top of the storage period. Authors stated that storage methods and periods had noticeable effects on the protein contents of all parts of faba bean seeds¹⁴.

Effect of UVC irradiation times on moisture (%) of faba bean:

Figure 2d shows the reduction in moisture content percentage for 0, 30, 60 and 90 min of UVC irradiation times for storage periods of 0, 3, 6 and 9 months.

From the relationship between moisture content percentage for 0, 30, 60 and 90 min irradiation and storage period represented in Fig. 2d, It could be found that the moisture content percentages decreased by increasing the storage period and decrease irradiation times. The highest decrease of moisture content percentages (after 9 months) were (8.70 and 9%) can be achieved for (0 and 30 min) irradiation and (9.11 and 9.13%) for (60 and 90 min), respectively. The results agree with the range obtained¹⁸, which ranged from 9.15-10.45%.

Effect of UVC irradiation times on fat (%) of faba bean:

Figure 2e show the reduction in fat content percentage for 0, 30, 60 and 90 min of UVC irradiation times for storage periods of 0, 3, 6 and 9 months.

From Fig. 2e, it could be observed that the fat percentage decrease range (from 0-9 months) were (3.84-0.10%) and (3.32-0.60%) can be achieved for (0 and 30 min), while (3.34-0.62%) and (3.40-0.71%) for (60 and 90 min), respectively.

The results of this study are corresponding with those reported²⁰, working with sunflower seed concluded that oil content in the seeds declined over time regardless of storage condition. They were stated that the percentage of lipids of maize seeds decreased significantly at the end of the storage period¹⁷, 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. The results were higher than those found¹⁸, which ranged from 1.93-2.05%. Also, reported that the fat percentage in faba beans ranged between 05-5.6%, which is agreeing with the results¹⁹.

Effect of UVC irradiation times on fiber percent of faba bean:

Figure 2f shows the reduction in fiber content percentage for 0, 30, 60 and 90 min of UVC irradiation times for storage periods of 0, 3, 6 and 9 months.

The illustrated results in Fig. 2f show the changing percentage of fiber in faba bean for treatments 0, 30, 60 and 90 min with time storage period, it could be indicated that the fiber percentage has an Inverse relationship with

storage period and positive relationship with irradiation times which mean that it was decreased by increased storage period and decreasing UVC irradiation times. The decrease range from 0-9 months were (11.05-7.14%) and (11.08-7.18%) can be achieved for (0 and 30 min), while (11.11-7.65%) and (11.15-7.80%) for (60 and 90 min), respectively. The average fiber content of 12 faba bean was 6.1% it reported²¹.

Effect of UVC irradiation times on ash (%) of faba bean:

Figure 2g shows the reduction in ash content percentage for 0, 30, 60 and 90 min of UVC irradiation times for storage periods of 0, 3, 6 and 9 months.

Figure 2 g, it could be indicated that the ash content increased by increased the storage period and decreasing irradiation times. The highest values (9months) were (3.84, 3.77, 3.71, 3.68%) can be achieved (0, 30, 60 min) and 90 min, respectively. Similar results were obtained¹⁷, who stated that during the storage period, the metabolic activity of seeds and associated microorganisms consume the organic matter. So, increasing the intake of organic material the ashes will raise. While, they found the average Ash for 12 faba bean cultivar²¹ was 3.2%. The results were agreed with those found¹⁸, which ranged from 3-3.35%.

Effect of UVC irradiation times on carbohydrate (%) of faba bean: Figure 2h shows the reduction in carbohydrate percentage for 0, 30, 60 and 90 min of UVC irradiation times for storage periods of 0, 3, 6 and 9 months.

The results illustrated in Fig. 2f show the carbohydrate percentage which increased by increasing the storage time and decreasing irradiation times. The increase range from 0-9 months were (42.1-60.07%) and (47.36-58.09%) can be achieved for (0 and 30 min), while (45.67-56.14%) and (45.1-55.43%) for (60 and 90 min), respectively.

They were stated that there is an inverse relationship between carbohydrates and with protein and lipid fractions during storage¹⁷. The carbohydrate percentage of faba beans ranged from 55-63% was reported¹⁹. They obtained 58-62% for carbohydrates of faba beans¹⁸.

Figure 2c-h indicated that the effect of irradiation treatment with storage period 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. The applying of UV radiation can be extend shelf life of faba bean grains, therefore the recommendations are to provide the treatments for others grain to decrease losses of grains during storage.

CONCLUSION

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

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

SIGNIFICANCE STATEMENT

The present research focusing on preserve the faba bean grains using irradiation by ultraviolet in different doses to extend shelf life of grains. Selecting the suitable doses to use irradiation process in order to preserve the faba bean grains for long time. The study of physical , mechanical and chemical properties in grains ensures the food safety. The idea of irradiation faba bean grains has the potential to provide a improve grain quality. The present research opens up vistas to carry further research in preserve grains to reduce grain losses and increase shelf life of grains in a novel way with low cost.

ACKNOWLEDGMENTS

The authors wish to thank the assistance of Prof. Ahmed El-Raie at Department of Agricultural Engineering, Faculty of Agriculture, Cairo University. We also wish to appreciate the assistance of the staff in the Department of Handling and Processing of Agricultural Products at Agricultural Engineering Research Institute, Agriculture Research Center and Laser applications in Agricultural Engineering at National Institute of Laser Enhanced Science, Cairo University.

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