EFFECT OF IRRADIATION PROCESS ON ASSESSMENTS OF COWPEA ATTRIBUTES DURING STORAGE BY USING GAMMA RAYS

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ABSTRACT

Cowpea seeds could be used as food for humans regarding their nutrients. Therefore, in order to extant the shelf life, quality improvement and reduce loss of cowpea seeds during storage of six months, Cowpea seeds were irradiated with 0, 5, 10 and 15kGy during 2024/2025season. Physical and chemical analysis properties were determined during storage. The obtained results show that the Gamma dose of 10kGy was the better dose because of the weights and protein percentage of seeds were of (18.600 to 18.100, 17.400, to 17.300, to 17.100, and 15.172 g), and (19.438, 18.969, 18.500, 16.234, 14.867 and 13.500 %) for 1, 2, 3, 4, 5 and 6 months, respectively. So, the weight of seeds and moisture content of cowpea seeds were decreased by increasing the storage period and decreasing gamma irradiation doses. Also, protein, carbohydrate, and total lipids contents of cowpea seeds were decreased with increasing the storage period and decreasing gamma irradiation doses. Also, results demonstrate that a hormonal balance at dose of 10 kGy, reflected in a moderate increase of ABA and stable GA3 levels, supported both storability and germination potential. Higher doses (15 kGy) led to excessive stress signals, elevated ABA, and reduced seed quality. Gamma irradiation extends the shelf-life of the cowpea seeds; reduce the loss of cowpea seeds during storage period of six months. Using gamma irradiation with low doses can preserve cowpea seeds with high quality.

Keywords: Cowpea seeds, chemical attributes, irradiation, gamma, quality and storage

INTRODUCTION

Cowpeas (Vigna unguiculata L. Walp) are legume seeds that are important sources of protein, vitamins, carbohydrates, fiber, and minerals. Egypt's production of cowpea in 2023 was 7274.2 tons, area cultivated was 4776.5feddans **(FAO, 2023)**. Cowpea (*Vigna unguiculata L.*) is an essential crop grown in Egypt and native from Africa. It is an extremely low-lipid and low-sodium dietary source, high amount of potassium, protein content, and both digestible and indigestible carbohydrates. Cowpea also contain antioxidant-active polyphenols and several important amino acids **(Patil et al., 2025 and El-Sawah et al., 2024).**

The traditional control of insect pests in stored products in Egypt, like in other countries, is using fumigants and other chemical insecticides. The use of fumigants leads to harmful residues in the treated foods and causes resistance to certain insect pests **(Hammad et al., 2025)**.

Shahat et al. (2017) found that cowpea seed with irradiated of gamma radiation at dose levels of 2.5, 5 and 10 kGy of reduced the oligosaccharide content of cowpea and increased the in vitro protein digestibility was dose-dependent manner up to 10 kGy.

Jayashri et al. (2022) investigated gamma irradiation might extend the grain cowpea's shelf life. With different doses of gamma ray—100, 200, 300, 400 and 500Gy, and control— of six treatments make up the experiment. At lower gamma-ray doses, the treatments displayed higher germination parameters than the control. The treatment with the highest percentage of seed germination (84.33%) was 200 Gy. At 200 Gy, the germination speed, seedling shoot length, and seedling dry weight reached their maximum values of 32.13, 11.83 cm, and 0.703 g. Seedling root length was highest at (100 Gy) with 13.84 cm.

Irradiation is a non-thermal, physical method used for food preservation and safety enhancement. This technique involves exposing food to controlled doses of ionizing radiation, similar to other physical processes like freezing or pasteurization. Gamma irradiation is particularly effective for microbialde contamination and pest control. **(Reddy et al., 2015, and Dhaka et al., 2025)**.

Some biological components and DNA of any bacteria were damages by Radiation, preventing them from reproducing **(Yamaga et al., 2024)**.

El-Beltagi et al. (2023) Gamma ray, UV-C, and UV-A (ultraviolet) seed priming on cauliflower head growth, yield, quality, and storage. The seeds were subjected to UV-C for 15, 30, and 45 minutes, UV-A for 15, 30, and 45 minutes, and 50 and 75 kGy (gamma ray). For sixteen days, the cauliflower heads were kept at 5° C to assess their shelf-life characteristics. The UVA treatment increased vitamin C and phenolic compounds in comparison to the control.

Gamma irradiation is widely used in agriculture for seed improvement, food preservation, and controlling storage pests. Its effects on seeds are dose-dependent: low to moderate doses often stimulate physiological and biochemical responses, while high doses can cause cellular damage. Recent reviews emphasize that gamma irradiation can serve as an abiotic stress priming tool, enhancing antioxidant defenses **(Katiyar, 2022)** and improving metabolic resilience in plants **(Jeong et al., 2024; Abozahra et al., 2025).**

Thus the major purpose of the studying the effect of gamma rays on physical and chemical attributes of cowpea seeds during storage. Also, exploring the responses of seed hormones provides valuable insight into how gamma irradiation influences seed quality during storage.

MATERIALS AND METHODS

Gamma irradiation:

Seeds were irradiated with 0,5,10 and 15 kGy of gamma irradiation using the Indian gamma cell that uses 60Co as a radiation source at the National Center for Radiation Research and Technology, Nasr City, Cairo, Egypt.

After irradiation, three seed samples and one sample from control were taken from each treatment each treatment were 250 grams the sample were placed in a plastic bag and stored for six months at room temperature. Four samples were taken from each treatment every month to determine moisture, protein, carbohydrate, Fat and lipid content using the **(A.O.A.C. procedure 2000)** to analysis and observing changes in the quality of the cowpea seeds during storage.

A Hundred Seeds were tested the average mass was calculated from 4 replicates, using a digital balance before irritated, the weight of 100 seeds is calculated every month for the three irradiated treatments and the control one.

Cowpea seeds

Cowpea seeds cv. Black-Eyed (Qaha 1, Variety) were obtained from Field Crops Research Institute. The seeds quantities used were 3kg/treatment during 2024/2025 season.

Physical and Chemical characteristics:

Three seed samples from each treatment were collected to determined Seed weight and percentage of Moisture content of seed, Protein, Carbohydrate, and lipid content were done using the (A.O.A.C. 2000) procedure.

Hormone Analysis:

Abscisic Acid (ABA):

ABA was extracted from ground seed samples using 80% methanol containing 0.1% butylatedhydroxytoluene (BHT). After centrifugation and purification, ABA content was determined by HPLC-MS/MS or ELISA kits as described **by Seo and Koshiba (2002).**

Gibberellic Acid (GA3):

GA3 was extracted using a similar protocol to ABA. Quantification was performed using HPLC or HPLC-MS/MS against authentic standards, following **Hedden and Thomas (2012).** When advanced equipment was not available, ELISA kits were used as an alternative.

RESULTS AND DISCUSSIONS

Effect of gamma rays on weight of cowpea during storage:

An average weight of cowpea seeds was measured and indicated in the Fig. (1). By using three doses of applied gamma rays (5, 10 and 15kGy) and (control) treatment without irradiation, during storage periods (1, 2, 3, 4, 5 and 6 months). Figure (1) illustrated that weight decreased by increased storage periods. The weights were 19.800, 19.400, 18.600 and 19.300 g for first month and decreased throw the storage time until it reached 18.400, 18.252,15.172, and 16.897g for doses (Control, 5, 10 and 15kGy) (control) treatment without irradiation, respectively.

It was showed that weight of seeds was decreased by increased storage periods. The weight of seeds was decreased from 19.400 to 18.900, 18.800, to 18.600, to 18.479 and 18.252 g at exposure dose of 5 kGy, while, it’s were decreased from 18.600 to 18.100, 17.400, to 17.300, to 17.100, and 15.172 g at exposure dose of 10 kGy and they were decreased from 18.600 to 18.100, 17.400, to 17.300, to 17.100, and 15.172 g at exposure dose of 15 kGy for 1, 2, 3, 4, 5 and 6 months, respectively, comparison with control sample which was decreased from 19.300 to 18.700, 17.600, to 17.500, to 17.300 and 16.897 g for 1, 2, 3, 4, 5 and 6 months, respectively,.

From previous results, the gamma dose of 10kGy was the better dose because of the weight of seeds was the lowest of 18.600 to 18.100, 17.400, to 17.300, to 17.100, and 15.172 for 1, 2, 3, 4, 5 and 6 months, respectively,.

The results are in line with **Jayashri et al., (2022)** mentioned gamma irradiation in enhancing storage life of grain cowpea. six treatments (100 Gy, 200Gy, 300 Gy, 400 Gy, 500 Gy and control) with different doses of gamma rays were taken in the experment. All the treatments were effective in control of beetle infestation without any seed damage and consequently no weight loss compared to control with 56.333, 28.182 per cent seed damage andv weight loss. However, 200Gy among all the gamma doses, recorded the least seed damage, weight loss and improvement in germination compared to control.

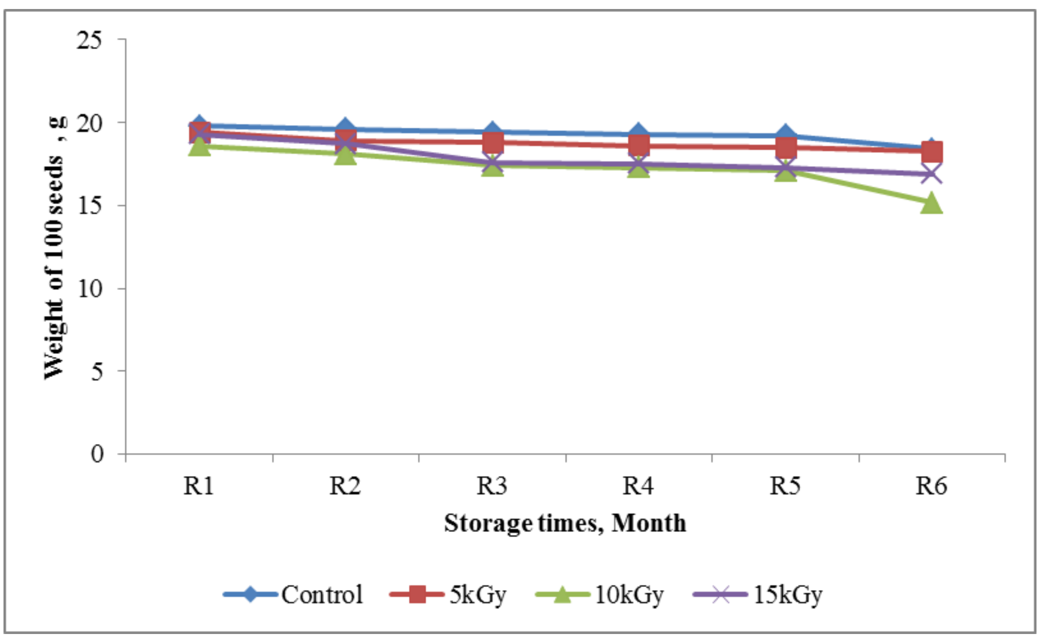

Fig. 1 : The relationship between the Weight of 100 seeds and gamma irradiation in the cowpea seed during storage periods

Similar results of the present experiments agree with those reported by **Akaagerger and Tsavnande (2024)**; they investigated the efficacy of food irradiation as a preservation method and assessed its impact on food quality and safety. Samples irradiated at higher doses of radiation had less percentage weight loss compared to those irradiated at lower doses. This indicated that the effectiveness of the preservation of cowpea increased as the dose of radiation increased.

Effect of gamma rays on Moisture Content of Cowpea during storage:

Figure (2) shows the reduction in moisture content percentage at (Control, 5, 10 and 15kGy of gamma rays irradiation) Control is un-irradiation for storage periods (1, 2, 3, 4, 5 and 6 months).Figure (2) showed that moisture content percentage decreased by increased storage periods. The weights were 7.4373, 6.2652, 5.9245 and 5.8300 % for first month and decreased throw the storage time until it reached 2.7406, 2.5001, 2.1259, and 2.0984 % for doses (Control, 5, 10 and 15kGy) (control) treatment without irradiation, respectively.

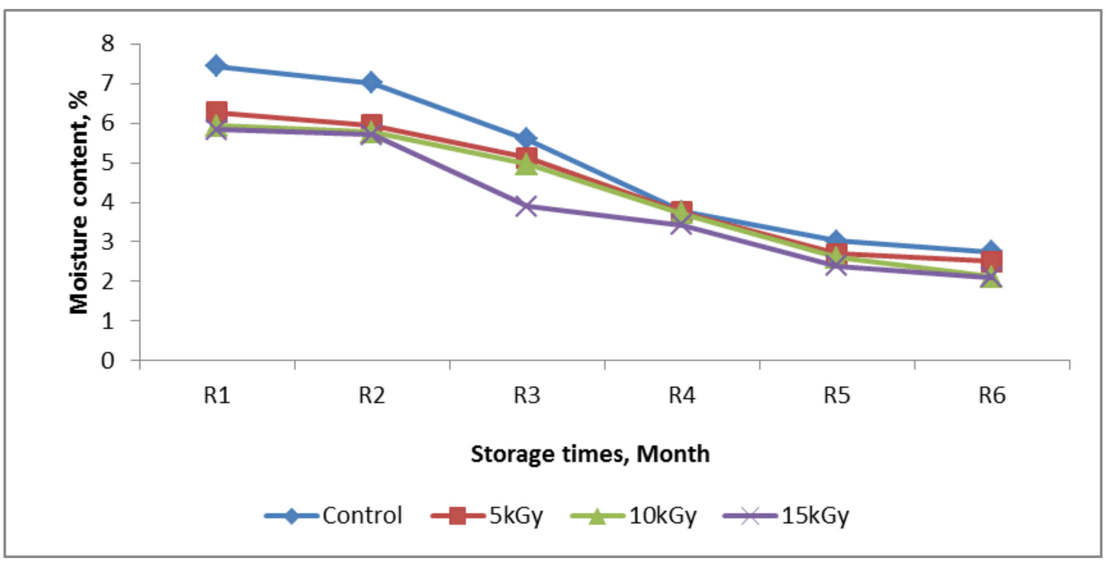

Fig. 2 : The relationship between the moisture content and gamma irradiation in the cowpea seed during storage periods

It was showed that moisture content percentage was decreased by increased storage periods. The Moisture Content was decreased from 6.26 to 5.94, 5.12, to 3.74, to 2.69 and 2.50% at exposure dose of 5 kGy, while, it's were decreased from 5.92 to 5.76, 4.95, to 3.71, to 2.60 and 2.12% at exposure dose of 10 kGy and they were decreased from 5.83 to 5.71, 3.90, to 3.41, to 2.39, and 2.09% at exposure dose of 15 kGy for 1, 2, 3, 4, 5 and 6 months, respectively, comparison with control sample which was decreased from 7.43 to 7.01, 5.58, to 3.76, to 3.02 and 2.74% for 1, 2, 3, 4, 5 and 6 months, respectively,. From previous results, the gamma dose of 10kGy was the better dose because of the moisture content percentage of seeds was of 5.92, 5.76, 4.95, 3.71, 2.60 and 2.12**%** for 1, 2, 3, 4, 5 and 6 months, respectively,.

Effect of gamma rays on protein percent of cowpea during storage:

Figure (3) shows the reduction in protein percentage at (5, 10 and 15kGy of gamma rays irradiation) and (control) treatment without irradiation for storage periods (1, 2, 3, 4, 5 and 6 months).The results indicated that the highest reduction in protein percentages after 6 months, they were 13.062, 13.500, 12.125, and 10.563% for doses (Control, 5, 10 and 15kGy) during the first months and (control) treatment without irradiation, respectively. While, it was decreased of 13.062, 13.500, 12.125, and 10.563% for doses (5, 10 and 15kGy) during the sixth months and The result summarized that the protein percentage has an inverse relationship with storage period.

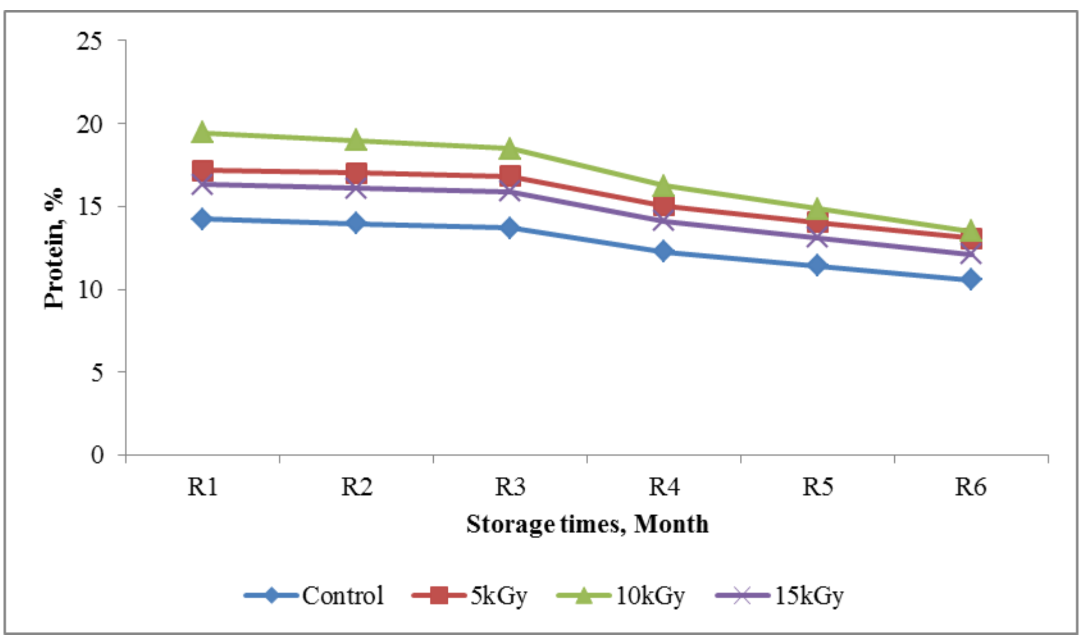

Fig. 3 : The relationship between the Protein and gamma irradiation in the cowpea seed during storage periods

It was showed that Protein percentage was decreased by decreased storage periods. The Protein percentage was decreased from 17.188 to 17.000, 16.813, to15.031, to 14.047 and 13.063% at exposure dose of 5 kGy, while, it's were decreased from 19.438 to 18.969, 18.500, to 16.234, to 14.867and 13.500 % at exposure dose of 10 kGy and they were decreased from 16.313 to 16.094, 15.875, to 14.109 , to 13.117, and 12.125% at exposure dose of 15 kGy for 1, 2, 3, 4, 5 and 6 months, respectively, comparison with control sample which was decreased from 14.25 to 13.969, 13.688, to 12.266, to 11.414and 10.563% for 1, 2, 3, 4, 5 and 6 months, respectively,.

From previous results, the gamma dose of 10kGy was the better dose because of the Protein percentage of seeds was of 19.438, 18.969, 18.500, 16.234, 14.867 and 13.500 % for 1, 2, 3, 4, 5 and 6 months, respectively.

The present experiments confirm with previous results of **Akaagerger and Tsavnande (2024)** were investigated the application of Cobalt-60 gamma irradiation on Cowpea seeds were irradiated at doses of 200 Gy, 300 Gy, 400 Gy, and 500 Gy and stored for four months. Proximate analysis revealed that Gamma irradiation at doses of 200 Gy to 500 Gy had no significant effect on the crude protein, crude fibre ash, fat and carbohydrate content of cowpea seeds but affected significantly the moisture content of cowpea seeds. 500 Gy was more effective in the preservation of cowpea seeds as compared to the other doses. This shows that the higher the dose of irradiation, the more effective it is in food preservation. It can be concluded that the gamma irradiation dose of 500 Gy can be effectively used in increasing the shelf life of cowpea seeds if other environmental factors remain same.

Shahat et al., (2017) cowpea seeds irradiated with gamma radiation at dose levels of 2.5, 5 and 10 kGy. This Radiation reduced the oligosaccharide content of and increased the in vitro protein digestibility was dose-dependent manner up to 10 kGy. The results corresponded with **Mohammed et al., (2009)** investigated the effect of gamma irradiation on the nutritional quality of maize and sorghum grains, packs were exposed to doses of 0 and 2 kGy in a 60 Co package irradiator. gamma irradiation caused no effect on proximate composition, minerals content . there is no significant differences For protein fractions, in both maize cultivars, except in prolamins and glutelins of Maize 75. While, significant increase in globulins, prolamins and glutelins for sorghum. While, gamma irradiation reduced the phytic acid and tannins contents significantly. The in vitro protein digestibility of maize cultivars was increased significantly, while the digestibility of sorghum was reduced.

Effect of gamma rays on carbohydrate of cowpea during storage:

Figure (4) shows the reduction in carbohydrate percentage for (control, 5, 10 and 15kGy) of gamma rays irradiation for storage periods (1, 2, 3, 4, 5 and 6 months). The results indicated that the reduction in total carbohydrate percentages after 6 months, they were 45.700, 53.200, 58.500, and 48.800% for doses (Control, 5, 10 and 15kGy) during the first months and (control) treatment without irradiation, respectively. While, it was decreased of 39.900, 44.800, 45.700, and 41.900 % for doses (5, 10 and 15kGy) during the sixth months. So, the result summarized that the total carbohydrate percentage has an inverse relationship with storage period.

It was showed that total carbohydratepercentage was decreased by decreased storage periods. The Total carbohydratepercentage was decreased from 53.200 to 51.750, 49.600, to 47.200, to 46.000 and 44.800% at exposure dose of 5 kGy, while, it's were decreased from 58.500 to 54.050, 50.300, to 48.000, to 46.850 and 45.700% at exposure dose of 10 kGy and they were decreased from 16.313 to 16.094, 15.875, to 14.109 , to 13.117, and 12.125% at exposure dose of 15 kGy for 1, 2, 3, 4, 5 and 6 months, respectively, comparison with control sample which was decreased from 45.700 to 44.550, 43.400, to 41.650, to 40.775 and 39.900% for 1, 2, 3, 4, 5 and 6 months, respectively,. From previous results, the gamma dose of 10kGy was the better dose because of the total carbohydrate percentage of seeds was of 58.500, 54.050, 50.300, 48.000, 46.850 and 45.700% for 1, 2, 3, 4, 5 and 6 months, respectively.

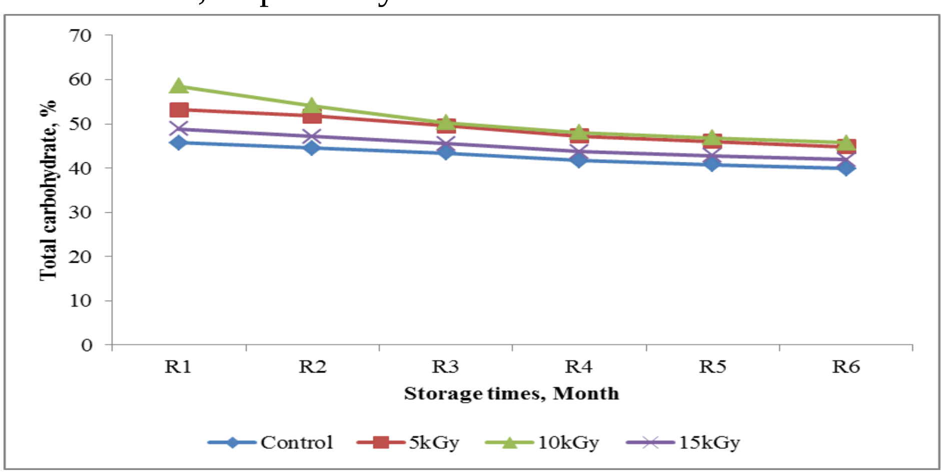

Fig. 4 : The relationship between the carbohydrate and gamma irradiation in the cowpea seed during storage periods

The lower reduction in carbohydrate was achieved for treatment with 10kGy after 6 months of storage which was 44.800g mean while it were (41.900 and 45.700%) can be achieved for (15 and 5kGy.) and 39.900% for control treatment. **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.

Effect of gamma rays on protein lipids of cowpea during storage:

Figures. (5) Shows the reduction in lipids percentage 5, 10, 15kGy and control of gamma rays radiation for storage periods (1, 2, 3, 4, 5, and 6 months).From these results introduced in Fig. (5), it could be observed that the lipid percentage decrease range from 0 to 6 months was (1.020 - 0.604%) and (1.960 - 0.932%) for (0 and 5kGy), while (2.440 - 1.303%) and (1.820 - 0.830%) for (10 and 15kGy), respectively.

It was showed that Total lipids percentage was decreased by decreased storage periods. The Total lipids percentage was decreased from 1.960 to 1.696, 1.432, to 1.182, to 1.057 and 0.932% at exposure dose of 5 kGy, while, it's were decreased from 2.440 to 2.272, 2.103, to 1.703, to 1.503, and 1.303% at exposure dose of 10 kGy and they were decreased from 1.820 to 1.675, 1.530, to 1.180, to 1.005, and 0.830% at exposure dose of 15 kGy for 1, 2, 3, 4, 5 and 6 months, respectively, comparison with control sample which was decreased from 1.020 to 0.962, 0.904, to 0.754, to 0.679and 0.604% for 1, 2, 3, 4, 5 and 6 months, respectively.

From previous results, the gamma dose of 10kGy was the better dose because of the Total lipids percentage was higher of 2.440, 2.272, 2.103, 1.703, 1.503, and 1.303% for 1, 2, 3, 4, 5 and 6 months, respectively,.

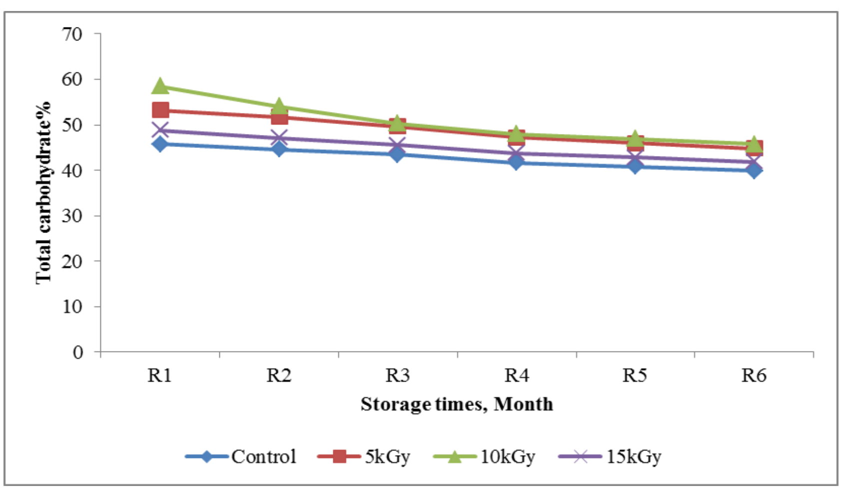

Fig. 5 : The relationship between the total lipids and gamma irradiation in the cowpea seed during storage periods

Regardless of the storage conditions used, **Stefanello et al. (2015)** reported that the percentage of lipids in maize seeds decreased significantly at the end of the storage period. They cited the occurrence of biochemical processes in seed mass as the reason for the significant difference in the percentage of lipids, which they attributed to the increased consumption of reserve substances seeds.

Hormone levels in cowpea seeds under different gamma irradiation doses at 0 and 6 months of storage:

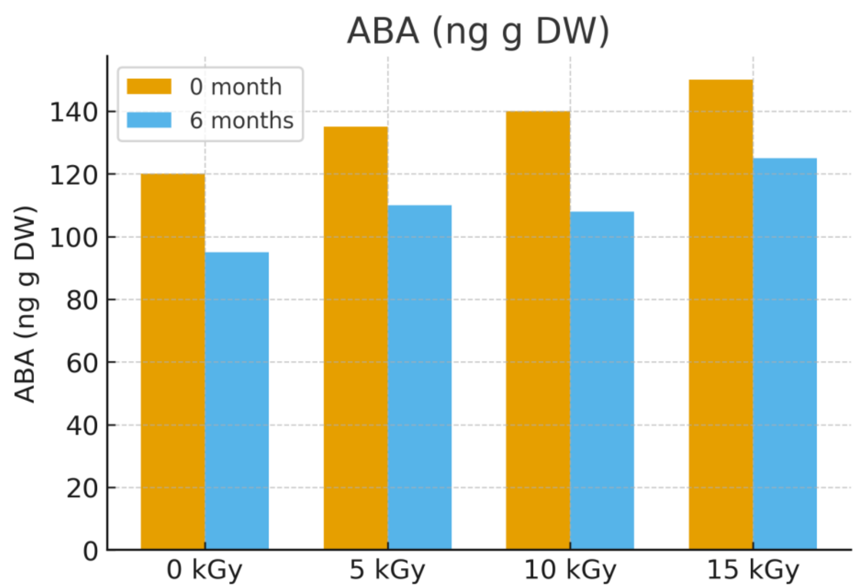

Fig. 6: ABA (ng g DW) across gamma irradiation doses at 0 and 6 months of storage.

ABA levels increased with irradiation, with the highest levels at 15 kGy. As noted by **Jeong et al. (2024),** and **Abozahra et al. (2025).** ABA accumulation under stress promotes seed dormancy and limits germination. However, the moderate rise at 10 kGy may provide protection without severely reducing viability.

The study of the effect of low doses of ionizing radiation on the germination and initial growth of different seeds, with gamma rays and X-rays. The use of this type of energy can generate an increase in germination percentages, an increase in germination speed, and changes in the length and area of roots and shoots, which will depend both on intrinsic factors of the nature of the energy (dose, dose rate, energy, etc.) as well as aspects of the irradiated seeds (water content, sensitivity, etc.). In addition to morphological effects, radio-stimulation due to low doses of ionizing radiation (a phenomenon also described as radio-hormesis) generates changes at physiological, biochemical, metabolic, and molecular levels. by **Ertan Yıldırım et al., (2023).**

Wang et al. (2018) examined changes in abscisic acid (ABA), indole-3-acetic acid (IAA), Gibberellin A3 (GA3), and trans-Zeatin-riboside (ZR) content in the seeds of Idesia polycarpa Maxim. The results will contribute to understanding the role of these hormones during seed dormancy release in Idesia polycarpa Maxim. The contents and balance of endogenous hormones in I. Polycarpa seeds changed during the chilling treatment. The contents of IAA, GA3 , and ZR and the dynamic ratios of hormones were higher in the chilling treatment than in the control. The ABA content was lower than in the control.

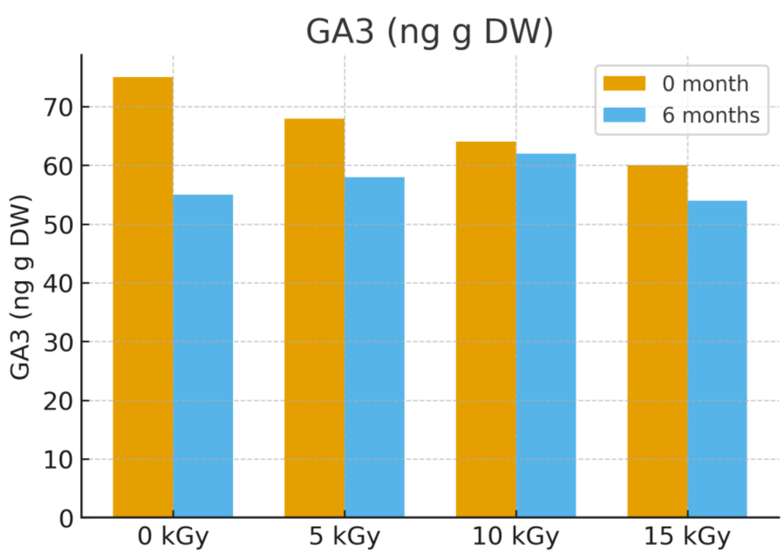

Fig. 7: GA3 (ng g DW) across gamma irradiation doses at 0 and 6 months of storage.

GA3 levels declined at high irradiation doses but remained relatively stable at 10 kGy. This balance between GA3 and ABA is critical for maintaining seed viability. Reviews (Katiyar, 2022; Jeong et al., 2024) suggest that moderate irradiation preserves GA3 levels, ensuring germination capacity is not lost.

CONCLUSION

The different quality properties of cowpea seeds after gamma irradiation during storage found to be:

Gamma dose of 10kGy was the better dose because of the weight of seeds was of (18.600 to 18.100, 17.400, to 17.300, to 17.100, and 15.172 g) for 1, 2, 3, 4, 5 and 6 months, respectively. Also, Gamma dose of 10kGy was the better dose because of the total lipids percentage, carbohydrate percentage, and Protein percentage of cowpea seeds was higher of 2.440, 2.272, 2.103, 1.703, 1.503, and 1.303%, (58.500, 54.050, 50.300, 48.000, 46.850 and 45.700%), (19.438, 18.969, 18.500, 16.234, 14.867 and 13.500 %) for 1, 2, 3, 4, 5 and 6 months, respectively. So, the weight of seeds and moisture content contents of cowpea seeds were decreased by increasing the storage period and decreasing gamma irradiation doses. Also, protein, carbohydrate, and total lipids contents of cowpea seeds were decreased with increase storage time and decreasing gamma irradiation doses.

This study highlights the significant role of gamma irradiation in preserving cowpea seed quality during storage. The results demonstrate that a hormonal balance at dose of 10 kGy, reflected in a moderate increase of ABA and stable GA3 levels, supported both storability and germination potential. Higher doses (15 kGy) led to excessive stress signals, elevated ABA, and reduced seed quality.

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CONFLICT OF INTERESTS

The authors declare that there are no conflicts of interest related to this article.

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الملخص العربي

تأثير عملية التشعيع على تقييم خصائص اللوبيا أثناء التخزين باستخدام أشعة جاما

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يمكن استخدام بذور اللوبيا كغذاء للإنسان نظرًا لمحتواها الغذائي. ولإطالة مدة صلاحيتها وتحسين جودتها وتقليل الفاقد منها خلال فترة تخزين ستة أشهر، عُرِّضت بذور اللوبيا للإشعاع بجرعات ٠، ٥، ١٠، و١٥ كيلوجراي خلال موسم ٢٠٢٤/٢٠٢٥. وتم تحديد خصائصها الفيزيائية والكيميائية خلال فترة التخزين. أظهرت النتائج أن جرعة أشعة جاما ١٠ كيلوجراي كانت الأفضل، حيث بلغت أوزان البذور ونسبة البروتين فيها (١٨.٦٠٠ إلى ١٨.١٠٠، ١٧.٤٠٠، ١٧.٣٠٠، ١٧.١٠٠، و١٥.١٧٢ جرامًا) و(١٩.٤٣٨، ١٨.٩٦٩، ١٨.٥٠٠، ١٦.٢٣٤، ١٤.٨٦٧، و١٣.٥٠٠%) على التوالي لفترات التخزين ١، ٢، ٣، ٤، ٥، و٦ أشهر. لذلك، انخفض وزن البذور ومحتوى الرطوبة في بذور اللوبيا عن طريق زيادة فترة التخزين وتقليل جرعات أشعة جاما. كذلك، انخفض محتوى البروتين والكربوهيدرات والدهون الكلية في بذور اللوبيا مع زيادة مدة التخزين وانخفاض جرعات أشعة جاما. كما أظهرت النتائج أن التوازن الهرموني عند جرعة ١٠ كيلوجراي، والذي انعكس في زيادة معتدلة في حمض الأبسيسيك (ABA) ومستويات مستقرة من حمض الجبريليك (GA3)، يدعم كلاً من قابلية التخزين وإمكانية الإنبات. أما الجرعات الأعلى (١٥ كيلوجراي) فقد أدت إلى إشارات إجهاد مفرطة، وارتفاع في مستوى حمض الأبسيسيك، وانخفاض في جودة البذور. يُطيل تشعيع جاما فترة صلاحية بذور اللوبيا، ويقلل من فقدانها خلال فترة التخزين التي تصل إلى ستة أشهر. ويمكن استخدام تشعيع جاما بجرعات منخفضة للحفاظ على بذور اللوبيا بجودة عالية.