Nigerian Journal of Physics (NJP)
ISSN online: 3027-0936
ISSN print: 1595-0611
DOI: https://doi.org/10.62292/njp.v33i3.2024.288
Volume 33(3), September 2024

Effect of Gamma Irradiation on Nutritional Quality and Shelf Life of Cowpea (*Vigna unguiculata*) Produced in Benue State Nigeria

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ABSTRACT
Cowpea plays an important role in the lives of millions of people in the developing world, providing a major source of dietary protein that nutritionally complements low-protein cereal and tuber crops. However, during storage, cowpea is attacked by a number of biological agents, which result in losses in the quality and quantity of stored seeds. This research investigated the application of Cobalt-60 gamma irradiation on the proximate composition and shelf life of locally produced cowpea seeds in Benue State, Nigeria. Cowpea seeds were irradiated at doses of 200 Gy, 300 Gy, 400 Gy, and 500 Gy and stored for four months. Proximate analysis revealed no significant difference ($p \geq 0.01$) in protein, fat, ash, crude fibre, and carbohydrate content between irradiated cowpea seeds and the control. However, a significant difference ($p \leq 0.01$) was observed in moisture content across all doses. After four months of storage, weight loss analysis indicated significant differences between irradiated and non-irradiated seeds of cowpea. Control samples experienced greater damage from insect infestation, resulting in the highest percentage of weight loss compared to irradiated samples. Notably, 500 Gy exhibited the least weight loss among irradiated samples, highlighting a dose-dependent effect of gamma irradiation on weight loss and its potential impact on shelf life. Irradiation doses, of 500 Gy for cowpea, can effectively preserve the nutritional components and extend the shelf life of cowpea, offering an alternative to chemical preservation methods.

Keywords:
Cowpea,
Dose,
Irradiation,
Nutrition,
Shelf life.

INTRODUCTION

Agriculture has long served as humanity's primary means of sustenance, providing essential resources such as food, clothing, shelter, and income (Monday, 2018). However, the gradual decline of the agricultural sector has become a significant contributor to food shortages in Nigeria. As the population continues to grow, there is an escalating demand for wholesome food with extended shelf life, necessitating effective preservation methods to maintain quality over time. The motivation behind food preservation extends beyond mere sustenance. It aims to address seasonal fluctuations in agricultural production, create value-added products, and diversify dietary options. Environmental factors such as light, temperature, humidity, and oxygen play pivotal roles in triggering various reaction mechanisms that lead to food deterioration, rendering them either undesirable or unsafe for consumption (Tsvetko & Stoyan, 2006). Foods are susceptible to spoilage through microbial, chemical, or physical actions, compromising their nutritional quality, color, texture, and edibility (Amit et al., 2017). Therefore, there is a pressing need to enhance food preservation techniques to extend shelf life and maintain value.

Food preservation involves strategic interventions to mitigate factors that contribute to spoilage, thereby preserving desired properties or characteristics for a designated period (Amit et al., 2017). Given the evolving demands for efficient preservation methods that ensure consumer satisfaction across nutritional, sensory, safety, environmental, and economic dimensions. Numerous preservation techniques have emerged. These include thermal processing, drying, freezing, chemical treatment, high-pressure processing, among others (Rahman, 2012). However, it is essential to recognize that each preservation method carries both benefits and drawbacks that affect food quality (Manzoor et al., 2014). In response to the growing consumer preference for fresh, nutritious, and safe food products with prolonged shelf life, food irradiation has emerged as a promising preservation method. By systematically exposing food to ionizing radiation, food irradiation effectively eliminates pathogens, extends shelf life, and preserves nutritional content, while maintaining organoleptic attributes (Manzoor et al., 2014). In this context, this study explore the efficacy of food irradiation as a preservation method and assesses its impact on food quality and safety. Through systematic analysis and experimentation, it seek to evaluate the potential of food irradiation in addressing the pressing challenges of food preservation in Benue State Nigeria and contribute to enhancing food security and safety in the region.

MATERIALS AND METHODS

Sample Preparation and Irradiation: Freshly harvested cowpea seeds were collected from farmers in Gwer-west local Government Area of Benue State. After the proper selection was done, the grains were taken to the Ahmadu Bello University Centre for Energy Research and Training (CERT) Zaria in sterile plastic bags and exposed to 200 Gy, 300 Gy, 400 Gy and 500 Gy of gamma irradiation using cobalt 60 source at the dose rate of 1.5 Gy/hr.

Determination of Proximate Composition of Samples

Moisture, crude protein, crude fat, ash, crude fibre, and carbohydrates contents of irradiated (200 Gy, 300 Gy, 400 Gy, and 500 Gy) and non-irradiated Cowpea seeds were determined using the methods as outlined by AOAC (2000).

Determination of Shelf life

The control and irradiated samples of Cowpea were stored in the laboratory for four months. The shelf life of both the control and the irradiated samples were determined by physical examination and by weighing the samples weekly with a digital weighing balance for the whole period to determine the percentage loss in weight.

$$\%\,weight\ loss = \frac{initial\ weight - final\ weight}{intial\ weight} \times 100 \quad (1)$$

Statistical analysis: The proximate compositions of Cowpea seeds were determined in triplicates and the mean value were evaluated. Data obtained from the Proximate and weight analysis were subjected to analysis of variance (ANOVA) using SPSS 20.0. The significance level was set at 1%.

RESULTS AND DISCUSSION

Result

Table 1: Proximate Composition in Percentage of Cowpea

Dose (Gy)	Moisture	Protein	Crude fibre	Fats	Ash	Carbohydrate
0	13 ± 0.08	9.51 ± 0.02	8.17 ± 0.15	7.81 ± 0.04	1.05± 0.01	60.32 ± 0.09
200	12.24 ± 0.04	9.50 ± 0.10	8.30 ± 0.10	7.10 ± 0.10	1.13 ± 0.12	60.72 ± 0.18
300	12.23 ± 0.04	9.55 ± 0.23	8.58 ± 0.07	8.35 ± 0.03	1.65 ± 0.02	59.64 ± 0.21
400	12.25 ± 0.02	9.26 ± 0.12	8.50 ± 0.20	8.72 ± 0.04	1.50 ± 0.10	59.77 ± 0.27
500	12.20 ± 0.10	9.43± 0.15	8.73 ± 0.15	9.03 ± 0.06	1.64 ± 0.01	58.96 ± 0.38

Table 2: Percentage Weight Loss of Cowpea Samples

Dose (Gy)	0 Gy	200 Gy	300 Gy	400 Gy	500 Gy
1st month	0.70 ± 0.49	0.71 ± 0.19	0.49 ± 0.57	0.40 ± 0.32	0.22 ± 0.13
2nd month	2.31 ± 0.81	1.84 ± 1.03	1.47 ± 0.14	1.27 ± 0.55	0.47 ± 0.17
3rd month	4.26 ± 0.47	3.71 ± 0.66	2.88 ± 0.53	2.44 ± 0.52	1.39 ± 0.06
4th month	5.91± 0.30	4.45 ± 0.23	4.10 ± 0.38	3.71 ± 0.19	2.45 ± 0.67
Average % weight loss	3.30 ± 2.10	2.68 ± 1.63	2.23 ± 1.47	1.96 ± 1.34	1.13 ± 0.96

Table 3: Games Howell Post Hoc comparison of Proximate Composition of Cowpea

Dependent Variable	(I) Dose (Gy)	(J) Dose (Gy)	Mean Difference (I-J)	Std. Error	Sig.	99% Confidence Interval	
						Lower Bound	Upper Bound
Moisture	0	200	.89333*	.05217	.002	.3899	1.3968
		300	.91000*	.04888	.004	.2796	1.5404
		400	.88667*	.04807	.006	.2029	1.5705
		500	.93667*	.07424	.001	.3939	1.4794
Protein	0	200	.01333	.05840	.999	-.9244	.9510
		300	-.03667	.13556	.998	-2.3682	2.2948
		400	.25667	.07040	.190	-.9033	1.4166
		500	.08000	.08863	.877	-1.4122	1.5722

Crude fibre	0	200	-.13333	.10541	.726	-.9854	.7188
		300	-.41333	.09752	.096	-1.3922	.5656
		400	-.33333	.14530	.314	-1.4190	.7523
		500	-.56667	.12472	.047	-1.4449	.3116
Fats	0	200	.71000	.06137	.011	-.0218	1.4418
		300	-.54000*	.02708	.000	-.7361	-.3439
		400	-.91333*	.02539	.000	-1.1113	-.7153
		500	-1.22333*	.03930	.000	-1.5502	-.8965
Ash	0	200	-.08333	.06692	.744	-1.2203	1.0537
		300	-.60000*	.01291	.000	-.7246	-.4754
		400	-.45000	.05802	.047	-1.4269	.5269
		500	-.59000*	.00816	.000	-.6475	-.5325
Carbohydrate	0	200	-.40000	.11382	.141	-1.4713	.6713
		300	.68000	.13275	.066	-.7399	2.0999
		400	.55333	.16566	.192	-1.5099	2.6166
		500	1.36333	.21858	.060	-1.7484	4.4750

The mean difference is significant at the 0.01 level.

Discussion

Percentage Proximate composition of cowpea

Moisture content: The moisture content of cowpea, revealed significant ($p < 0.001$) variation between the 400 Gy and 500 Gy irradiation doses compared to the control (Table 1 and Table 3). However, the 200 Gy and 300 Gy doses did not exhibit significant ($p > 0.001$) variation from the control. Indications point to the impact of the 400 Gy and 500 Gy irradiation doses on the moisture content of cowpea. This agrees with the findings of (Reddy & Viswanath, 2019), who reported that Gamma irradiation significantly reduced the moisture content of finger millet flour and with the findings of Oluwaseun & Charles, (2013) who reported variation in the moisture content of radiated and non-irradiated pigeon pea grains**.**

Crude Protein: The result for crude protein shows no significant ($p > 0.001$) difference between the crude protein content of the control group (0 Gy) and the irradiated group (200 Gy, 300 Gy , 400 Gy , 500 Gy) as shown in Table 1 and Table 3. This suggests that the different doses of gamma irradiation did not have statistically significant impact on the crude fibre content of the cowpea seeds. However, they were little variations in the crude protein content of the samples. The 500 Gy sample had the highest crude protein content followed by the 200 Gy, 400 Gy and the control. The 300 Gy sample had the percentage of crude protein, compared to the other samples ((Table 1 and Table 3). This indicates that irradiation of cowpea seeds did not reduce the crude protein content of cowpea seeds.

Crude fibre: No significant ($p > 0.001$) difference was observed between the crude protein content of the control and the irradiated groups (Table 1 and Table 3). This indicated that the various doses of gamma irradiation did not affect the crude fibre content of the cowpea seeds. However, there were variations in the crude fibre of the samples. The 300 Gy sample had the highest crude fibre content compared to the other samples while the 500 Gy sample had the least crude fibre content. This variation did not have a noticeable difference in the crude fibre content of both the control and the irradiated samples of cowpea. This finding corresponds to that of Hassan *et al*, (2009) who reported no significant difference in the crude fibre composition of irradiated samples of maize and sorghum.

Fat content **:** The results of the percentage fat content analysis indicated that irradiation doses of 200 Gy, 300 Gy, 400 Gy, and 500 Gy did not show a significant ($p > 0.001$) difference when compared to the non-irradiated (0 Gy) Cowpea seeds as shown in Table 3. This finding shows that gamma radiation did not affect the percentage fat content of cowpea when exposed to these specific doses. This aligns with the findings of Hassan *et al*., (2009), who reported in their study that gamma irradiation had no significant effect on the fat content of maize and sorghum irradiated at 0 to 2 kGy.

Ash content: The percentage ash content irradiated (200 Gy, 300 Gy, 400 Gy, and 500 Gy) seeds of Cowpea did not vary significantly ($p > 0.001$) from the non-irradiated (0 Gy) seeds of cowpea (Table 1 and Table 3). This finding suggests that gamma radiation did not affect the percentage ash content of cowpea when exposed to these doses. This finding agrees with the research of Liu *et al.*, (2018) who reported in their study that the ash contents of peanut cultivars were not affected by gamma irradiation.

*Carbohydrate content***:** The results of the percentage carbohydrate content in the samples, as depicted in Table 1 and Table 3, suggest that there was no significant difference between the non-irradiated and irradiated cowpea. This is evident as the carbohydrate content at 200 Gy, 300 Gy, 400 Gy, and 500 Gy did not exhibit any significant variation from the control. This finding aligns with the research conducted by Liu et al. (2018), who reported in their study that the carbohydrate content of peanut cultivars remained unchanged following gamma irradiation.

Effects of Gamma Irradiation on Shelf life of Cowpea

The result of the percentage weight loss of the samples of cowpea obtained using equation 1, and shown in Table 2 indicates a difference in weight loss of the irradiated (200 Gy, 300 Gy , 400 Gy , 500 Gy) and non-irradiated (0 Gy) seeds . The percentage of weight lost in the control was higher compared to the irradiated samples in all the months of storage. The higher damage rate was due to insect infestation of the control compared to the other samples. Samples irradiated at higher doses of radiation, had less percentage weight loss compared to those irradiated at lower doses. The sample irradiated with 500 Gy, had the lowest percentage weight loss when compared with the other samples for four months of storage. This indicated that the 500 Gy dose had the most effect on the shelf life of the cowpea. This shows that the effectiveness of the preservation of cowpea increased as the dose of radiation increased.

CONCLUSION

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.

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