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ผลของรังสีแกมมาต่อคุณสมบัติทางกายภาพและการปนเปื้อนเชื้อราในเมล็ดข้าวโพด
Effect of Gamma Irradiation on the Physical Properties and Fungal Contamination of Maize Grains

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Abstract

The aim of this study was to investigate the effect of gamma irradiation on the physical properties and fungal contamination of maize grains. Maize grains (1 kg) were packed in polyethylene bags and afterwards exposed to gamma irradiation dose of 6 kGy. The non-irradiated maize served as the control. After irradiation, the physical properties and fungal contamination of the maize grains were evaluated. The results revealed that the moisture content, test weight and the *b** value (yellowness) of the maize grains were not affected by the irradiation. In addition, there was no change in the total sugar of irradiated maize compared to the control. However, a significant increase in *L** value of the maize grains was recorded after irradiation, enhancing bright yellow colour on comparison to the control. Moreover, the irradiation was able to inhibit approximately 95 % of fungal incidence of the maize grains. The results indicate that gamma irradiation at a dose of 6.0 kGy improved lightness of maize grains and reduced fungal contamination. Therefore, this technique can be used as a postharvest method for preserving quality and extending the storage life of maize grains.

Keywords: gamma irradiation, physical properties, fungal

บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาผลของรังสีแกมมาต่อคุณสมบัติทางกายภาพและการปนเปื้อนเชื้อราในเมล็ดข้าวโพด โดยบรรจุเมล็ดข้าวโพดปริมาณ 1 กิโลกรัมในถุงโพลีเอทิลีนแล้วนำไปฉายรังสีแกมมาที่ 6 กิโลเกรย์ โดยมีเมล็ดข้าวโพดที่ไม่ฉายรังสีเป็นชุดควบคุม หลังจากการฉายรังสีแล้ว นำเมล็ดข้าวโพดมาศึกษาการเปลี่ยนแปลงทางกายภาพและปริมาณการปนเปื้อนองเชื้อรา ผลการทดลองพบว่า การฉายรังสีไม่มีผลต่อความชื้น น้ำหนักเมล็ด และค่า b* (สีเหลือง) ของเมล็ดข้าวโพด นอกจากนี้การฉายรังสีไม่มีผลต่อปริมาณน้ำตาลทั้งหมดในเมล็ดข้าวโพดเมื่อเทียบกับชุดควบคุม อย่างไรก็ตาม การฉายรังสีส่งผลให้ค่า L* เพิ่มขึ้นจึงทำให้เมล็ดข้าวโพดมีความสว่างมากกว่าชุดควบคุม นอกจากนี้ การฉายรังสียังสามารถลดการปนเปื้อนเชื้อราในเมล็ดข้าวโพดร้อยละ 95 จากผลการวิจัยชี้ให้เห็นว่าการฉายรังสีที่ 6 กิโลเกรย์สามารถปรับปรุงความสว่างและลดการปนเปื้อนเชื้อราในเมล็ดข้าวโพดได้ ดังนั้น วิธีการนี้จึงสามารถนำไปใช้เพื่อการรักษาคุณภาพและยืดอายุการเก็บรักษาของเมล็ดข้าวโพดได้

คำสำคัญ : การฉายรังสีแกมม่า คุณสมบัติทางกายภาพ เชื้อรา

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Introduction

Maize is among the leading staple cereals across the globe after wheat and rice in terms of cultivation areas and total production. Maize has a worldwide distribution, including substantive areas in Sub-Saharan Africa, Asia and Latin America. It is the main food and income crop for many households in Sub-Saharan Africa. However, due to biotic and abiotic factors, there has been severe losses in quantity and quality (safety and nutritional value) of the grains available for consumption. Vast quantities of grains are lost as a result of mould infection and insect attack. Chemical fumigants such as methyl bromide and phosphine have been used for controlling pest and contamination of maize grains. However, the extensive use of these chemicals has been associated with residues and depletion of the ozone causing adverse effects on both food and environment. Gamma irradiation is a simple and effective food preservation technique that has been used to protect products from insect infestation and microbial contamination (Kume *et al*., 2009). A study by Falade and Kolawole (2012) reported that a dose level of 6 kGy had no effect on the physical factors of maize cultivars. Similarly, Gojiya and Vyas (2019) reported that a dose level of up to 10 kGy did not affect the moisture, protein, oil, carbohydrate, fibre and ash content of peanut kernels. Moreover, Ahmed *et al*. (2018) reported that gamma irradiation of sorghum grains at a dose level of up to 5 kGy lead to a significant reduction in the fungal growth. However, the effect of gamma irradiation on the physical properties and fungal contamination of maize grains has not been fully elucidated. Therefore, the objective of this research was to evaluate the effect of gamma irradiation on the physical properties of and fungal contamination of maize grains.

Materials and methods

1. Source of material

The maize grain sample used was acquired from local farmers in Thailand. The grains were cleaned manually to remove all foreign matter and defected grains.

2. Gamma irradiation treatment

The irradiation treatment was conducted using a Cobalt-60 gamma source at Thailand Institute of Nuclear Technology (Public organization). Maize grains (1 kg) were packed in 100 μm thickness polyethylene bags, sealed and irradiated at 6 kGy. The non irradiated (0 kGy) maize grains served as the control. The samples were then analyzed as follows: The colour was determined using a Chromameter and expressed as *L*, a** and *b** values according to the CIE color system. The kernel test weight was determined by randomly selecting one hundred maize grains of the samples and weighed on a digital top loading electronic balance. Determination of proximate composition was analyzed according to the methods of AOAC (2019) and the Methods of Analysis for Nutrition Labeling (Darryl and Carpenter, 1993). Amylose content was determined according to Juliano (1971) and Tuano *et al*. (2021) and absorbance determined at 620 nm. Total sugar absorbance determined at 490 nm. Total fungal contamination was measured using the blotter method and fungal contamination was visually observed and reported in percentage. Four replicates per treatment were carried out. Comparison of two means was analyzed using independent samples *t*-Test.

Results

After irradiation, the results revealed there was no significant change in *a** value and *b** value of the irradiated maize samples in comparison to the control. However, a significant increase in the *L** value of the irradiated maize was observed (Table 1). A non-significant increase in the hundred kernel weight (31.89) of the irradiated maize was observed compared to the control (30.53). The dose level of 6 kGy did not change the proximate composition of the maize grains (Table 2). The maize moisture (11.99 %), protein (6.88 g/100g) and

fat content (4.40 g/100g) showed a non-significant decrease while the carbohydrates (75.73 g/100g) and ash content (1 g/100g) recorded a non-significant increase after irradiation. Similarly, the amylose (11.31 %) and total sugar content (9.4 mg/100g) were not greatly affected by irradiation (Table 2). On the other hand, the fungal contamination percentage of the maize grains drastically decreased from 92 % to 5 % after irradiation (Figure 1). The 6 kGy dose level led to approximately 95% inhibition of the fungal incidence.

Table 1 Effect on colour and hundred kernel weight of maize grains after irradiation

Dose level (kGy)	Colour value			Hundred kernel weight (g)
	L*	a*	b*	
0	61.65b	9.41	39.58	30.53
6	64.27a	8.68	38.34	31.89

Means in a column with different letters are significantly different ($p \leq 0.05$)

Table 2 Effect on proximate composition, amylose content and total sugar of maize grains after irradiation

Dose level (kGy)	Proximate composition					Amylose content (%)	Total sugar (mg/100g)
	Moisture (g/100g)	Protein (g/100g)	Fat (g/100g)	Carbohydrates (g/100g)	Ash (g/100g)		
0	12.09	7.21	4.61	75.10	0.99	12.28	9.64
6	11.99	6.88	4.40	75.73	1.00	11.31	9.40

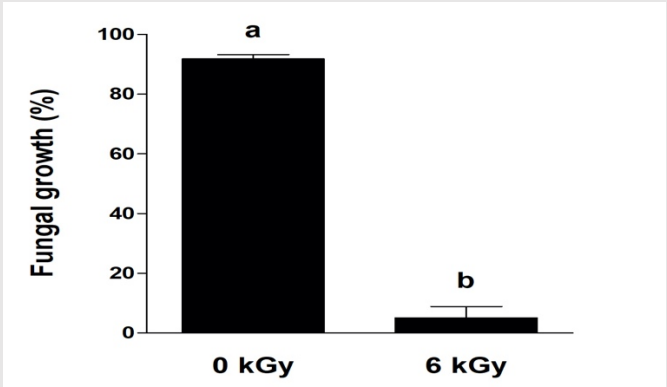

Figure 1 Fungal contamination percentage of maize grains after irradiation. Error bars show standard errors of the means (n = 4). Column bearing different letters indicate significant difference ($p \leq 0.01$).

Discussion

From the obtained results, the exposure of maize grains to gamma irradiation dose level of 6 kGy had no significant effect on the colour (*b** and *a** value) of the maize grains. This research contradicts the present findings. Nonetheless, results obtained agreed with the findings of Kang *et al*. (1999) who reported no noticeable changes in *a** value of corn starch sample with gamma irradiation. However, irradiation led to a significant increase in *L** value enhancing its the maize bright yellow colour. Similarly, Falade and Kolawole (2012) reported an increase in *L** value of maize with an increase in irradiation dose. The proximate composition of the irradiated maize grains was not affected by the irradiation (6 kGy). These findings agree with Amro *et al*. (2009) who found no change in proximate composition of maize and sorghum grains treated with gamma irradiation levels of up to 2 kGy. El-Niely (2007) also reported no change in proximate composition of peas, kidney beans and chickpea treated with irradiation dose levels of 5 to 10 kGy. Sabularse *et al*. (1991) demonstrated that the amylose content of brown rice was not greatly affected by irradiation

doses of up to 3 kGy. This was also observed in our study that amylose and total sugar content were not altered by irradiation even at 6 kGy. The application of irradiation dose level of 6 kGy greatly reduced the fungal incidence of the maize grains. The inhibition of the fungal contamination in maize grains after irradiation might be due to the destruction of their DNA as they are highly sensitive to gamma radiation (McNamara *et al*., 2003). Our results agree with Ahmed *et al*. (2018) findings the irradiation of sorghum grains of up to 5.0 kGy caused a significant reduction in fungal incidence.

Conclusion

In conclusion, the exposure to gamma ray at the dose of 6 kGy increased the brightness of the maize grains but had mild to no effect on the yellowness, hundred kernel weight, proximate composition, amylose and total sugar content. Other than that, the results also highlighted that gamma irradiation at 6 kGy led to a significant reduction in the fungal contamination of the maize grains. Thus, the outcome of this research suggests that gamma irradiation at 6 kGy could be applied to maize for preservation and as a safe alternative method for eliminating the fungal incidence.

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