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Effective γ-radiation Dose on Chitosan for Preservation of Mangoes *(Mangifera indica)*

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Abstract
The effective dose of γ radiation on chitosan for mango preservation was studied in this work. The 2% chitosan solution was irradiated with at various total doses (50-200 kGy). The mature green mangoes were soaked in un-irradiated and irradiated chitosan solutions and then they were stored at normal room temperature. The percentage of weight loss, color change and percentage of spoilage were observed for 15 days in control, un-irradiated and irradiated chitosan coated mangoes. The overall results showed the superiority of 50 kGy and 100 kGy irradiated chitosan in extending shelf life of mango as compared to control, un-irradiated and 120 kGy to 200 kGy irradiated chitosan.

Keywords: *Gamma radiation, Chitosan, Shelf-life.*

Introduction
Along with the development of food industry, preserving the freshness of food has become more and more important. Preservation methods should prevent not only the biochemical activities of enzymes, but also oxidation of air. Synthetic chemicals are not largely used due to their more or less harm to health, so the food industries in many countries have been looking for natural and safe food preservatives (Sonti, 2003). Mango being a highly perishable fruit possesses a very short shelf life and reach to respiration peak of ripening process on 3rd or 4th day after harvesting at ambient temperature (Abbasi, 2009). This short period seriously limits the long distance commercial transport of this fruit.

Chitosan is well known coating material used in several fruits for prolonging their shelf life (Lan, 2000). Chitosan is a modified natural carbohydrate polymer and is deacetylated derivatives of chitin, which is the second most abundant naturally occurring biopolymer (after cellulose) and is found in the exoskeleton of crustaceans, in fungal cell walls and other biological materials (Bourtoom, *2008*). Chitosan is antimicrobial against a wide range of target organisms. Now chitosan has attracted attention as a potential food preservative of natural origin due to its antimicrobial activity against a wide range of food borne filamentous fungi, yeast, and bacteria (Sudharshan, 1992). Edible film of chitosan as food preservative has received considerable attention in recent years because of their advantages over synthetic film. The main advantage of edible films over traditional synthetics is that they can be consumed with the packaged products. There is no package to dispose even if the films are not consumed they could still contribute to the reduction of environmental pollution by degrading more readily than polymeric materials (Bourtoom, *2008*).

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High molecular weight and viscosity limits the use of chitosan in various applications. Gamma radiation is known to cause main chain scissions in polysaccharides and decrease the viscosity average molecular weight of the polymers. The decrease of viscosity suggests the decrease of thickness of coating film on fruit and improving of O_2, CO_2 and ethylene gas permeability so that the respiration of fruit is not restrained completely, ripening characteristics of fruit are not prevented (Rao, 2005). As huge amount of prawns and crabs grown in Bangladesh, especially in the mangrove areas, it is possible here to make chitosan available. Similarly, γ-irradiation is an economically viable technology for reducing postharvest losses and maintaining hygienic quality of fresh produce (Boylston *et al*., 2002). So preservation of food with irradiated chitosan could be a good concern in our country.

To date, use of this irradiated coating material has not yet been reported on fresh mango fruits in Bangladesh. Therefore, in this study it was attempted to evaluate the effective dose of irradiation of chitosan for long time preservation of mangoes and to evaluate the dose from which the coating will be less effective.

Materials and Methods

Mangoes (Ashina ilsha peti) were harvested from Paharbhanga, Thakurgaon district, Bangladesh and Chitosan was prepared from prawn shell in laboratory.

Sample preparation

The chitosan solution was prepared as 2 gm chitosan in 2% acetic acid (CH_3COOH) solution. Then the solution was irradiated by gamma radiation from Co- 60 source at 50 kGy, 100 kGy, 120 kGy, 150 kGy, 180 kGy and 200 kGy at a dose rate of 13 kGy/h. 24 mature-green mangoes without infection and mechanical injuries were selected. They were washed with water, then dip in hot water for 5 minutes and then dried in air. Mangoes were soaked in irradiated chitosan solutions for 2 minutes and dried naturally in air. Fruits were stored in cases at dust free condition in room temperature. Samples for preservation with un-irradiated chitosan solution were also prepared at the same time for comparison. 3 mangoes were stored without chitosan coating, which were known as control mangoes.

Two types of sample were prepared by chitosan solution.

- Type 1: mangoes were soaked for 2 minutes in chitosan solution at the day of storage and observed up to 15 days.
- Type 2: mangoes were soaked in chitosan solution at the day of storage and chitosan solutions were sprayed to these mangoes at 5 days interval and observed up to 15 days.

Properties measurement

Measurement of Weight Loss (%) in Mangoes

The weight of control, un-irradiated, and irradiated chitosan coated mangoes were measured. The measurements were taken after 5 days interval. The percentage of weight loss was determined by following equation.

The percentage of weight loss = ——— x 100

Where,

W_i = Initial weight of mango
W_t = Weight of mango at time t (t = 5th, 10th and 15th day)

Spoilage Test
Spoilage occurs because of microbial activities in it. The percentages of spoilage in mangoes were tested at 10th and 15th day of storage.
The percentage of spoilage was determined by using the following equation.

$$\text{Spoilage (\%)} = \frac{-}{} \times 100$$

Where,
d= 10th and 15th day.

Color Observation
Color change of the mangoes was also observed after 5 days interval.

Results

Measurements of weight losses (%)
In the study the lowest weight loss (%) was found in 50 kGy irradiated chitosan coated mangoes than the others. It was found that the percentages of weight loss of mangoes were higher in control mangoes than the un-irradiated and irradiated one. The percentages of weight loss after 5 days, 10 days and 15 days in Type 1 and Type 2 samples are presented in Table 1 and Table 2 respectively.

Table 1: Weight loss (%) in Type 1 samples

Sample	Control	Un-irradiated	50 kGy	100 kGy	120 kGy	150 kGy	180 kGy	200 kGy
5 days	15.4%	12.7%	10.9%	11.7%	12.1%	12.6%	13.1%	13.6%
10 days	25.6%	18.1%	16.1%	18.9%	19.2%	20.4%	22.2%	25.1%
15 days	32.8%	26.9%	25.2%	26.9%	27.8%	28.1%	33.1%	40.6%

Table 2: Weight loss (%) in Type 2 samples

Sample	Control	Un-irradiated	50 kGy	100 kGy	120 kGy	150 kGy	180 kGy	200 kGy
5 days	15.4%	9.9%	8.1%	8.9%	10.6%	11.5%	11.1%	11.6%
10 days	25.6%	18.9%	17.2%	18.0%	20.2%	21.5%	21.7%	22.0%
15 days	32.8%	26.5%	24.7%	25.6%	28.4%	29.8%	32.9%	32.8%

Spoilage Test
The percentage of spoilage after 10 days and 15 days in Type 1 and Type 2 samples are presented in Table 3 and Table 4 respectively. It was found that after 15 days the control mangoes were totally spoiled (100%) than the un-irradiated and irradiated ones. The percentages of spoilage were significantly lowest (0%) in 50 kGy dose irradiated chitosan coated mangoes than the

others. The spoilage percentages were increased in both onetime soaked and sprayed mangoes with increasing the radiation dose in chitosan.

Table 3: Spoilage (%) in Type 1 samples

Sample	Control	Unirradiated	50 kGy	100 kGy	120 kGy	150 kGy	180 kGy	200 kGy
10 days	50	0	0	0	13	16.7	25	50
15 days	100	16.7	14	17	33.3	40	45	75

Table 4: Spoilage (%) in Type 2 samples

Sample	Control	Unirradiated	50 kGy	100 kGy	120 kGy	150 kGy	180 kGy	200 kGy
10 days	50	0	0	0	10	13	25	40
15 days	100	16	13	15	40	50	70	80

Color observation

It was found that at the initial day of storage all mangoes were green and unripe. At the final day of storage, 50 kGy and 100 kGy dose irradiated chitosan coated mangoes were in ripe stage (yellow color) with no spot of spoilage but the 120 to 200 kGy dose irradiated chitosan coated mangoes were partially or totally black in color which was the indication of spoilage. The un-irradiated chitosan coated mangoes were not spoiled and not discolored whereas the control mangoes were totally discolored and spoiled at the final day of storage. The observation of color change of mangoes after 5 days interval up to the final day of storage is shown in the Table 5. The condition of mangoes at final day of observation (15^{th} day) is shown in the Figure 1.

Table 5: Color change of the mangoes

Samples	Initial color	Type 1			Type 2		
		5 days	10 days	15 days	5 days	10 days	15 days
Control	Green	Yellowish	Blackish yellow	Black	Yellowish	Blackish yellow	Black
Un-irradiated	Green	Green	Yellowish	Yellow	Green	Yellowish	Yellow
50 kGy	Green	Yellowish	Yellow	Yellow	Yellowish	Yellow	Yellow
100 kGy	Green	Yellowish	Yellow	Yellow	Yellowish	Yellow	Yellow
120 kGy	Green	Yellowish	Yellow	Yellow	Yellowish	Yellow	Black
150 kGy	Green	Yellowish	Yellow	Black	Yellowish	Yellow	Black
180 kGy	Green	Yellowish	Yellow	Black	Yellowish	Yellow	Black
200 kGy	Green	Yellowish	Yellow	Black	Yellowish	Yellow	Black

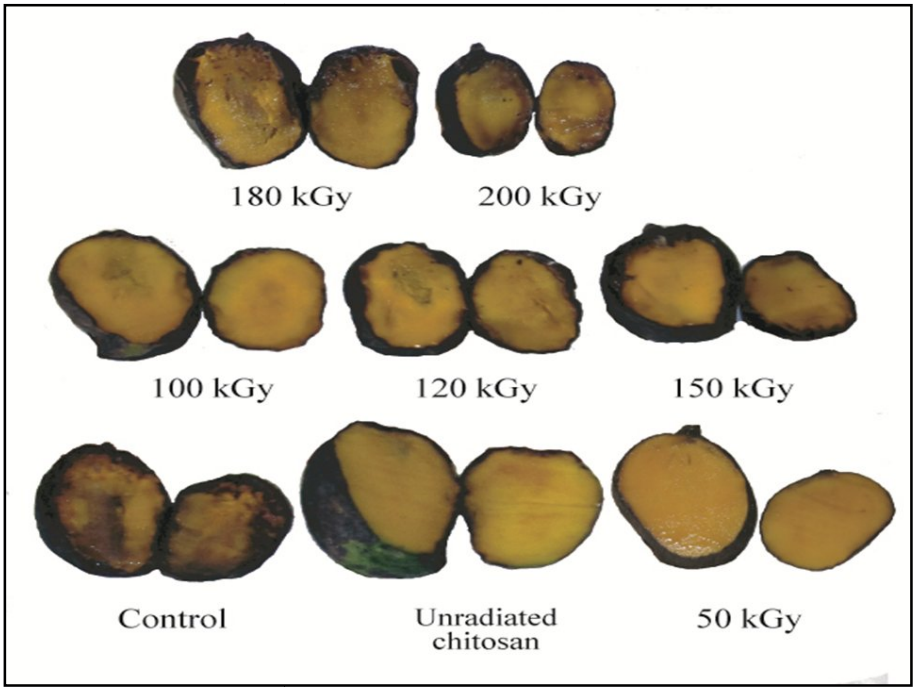

Figure 1. Color observation of mangoes at the final day of storage

Discussion

It was found that the irradiated chitosan can preserve mangoes by extending the shelf life. But percentages of weight loss and spoilage of mangoes were increased in high doses (from 120 kGy) of ionizing radiation in both of type of samples. It is well known that ionizing radiation can break the chitosan polymer in to oligomer. It has been demonstrated that lower molecular weight chitosans (of less than 10kDa) have greater antimicrobial activity than native chitosans (Uchida Y., 1989). However, a degree of polymerization of at least seven is required; lower molecular weight fractions have little or no activity (Kume T. and Takehisa M., 1982). Thus very high dose of radiation breaks the polymer of chitosan into lower fractions which causes the decrease of antimicrobial activity as well as other properties of preservative. It was also found that the two types of samples i.e. the mangoes which were soaked in chitosan solution for onetime at the initial day of storage and the mangoes in which chitosan solution was sprayed after 5 days interval up to 15 days showed similar results.

Conclusion

In this study, it was found that the shelf life of 50 kGy and 100 kGy irradiated chitosan coated mangoes were higher than 120 kGy to 200 kGy irradiated chitosan coated mangoes. The percentage of weight losses and percentage of spoilage were higher in 120 kGy to 200 kGy irradiated chitosan coated mangoes than 50 kGy and 100 kGy irradiated chitosan coated mangoes. Further, it was found that the mangoes which were soaked in chitosan solution for only one time

at the initial day of storage and the mangoes which were sprayed with chitosan solution after 5 days interval showed similar results.

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