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RESEARCH ARTICLE

Effect of Gamma Irradiation on Nutrients and Shelf Life of Peach (*Prunus persical*) Stored at Ambient Temperature

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Abstract:

Introduction:

In the present study, the effects of gamma irradiation and packaging on storage quality of partially matured peach was studied. The fruit was irradiated in the dose range of 2.5 and 5.0 kGy and was stored in paper and wooden boxes at ambient temperature (25±2 °C).

Methods and Materials:

The samples were evaluated at regular intervals (weekly) for moisture, ash, ascorbic acid, crude carbohydrate, crude protein, crude fibre and crude fat. Maximum increase (0.23%) of ash content was recorded for sample irradiated with 5.0 kGy stored in wooden box during the second week. The decrease in moisture contents, crude protein, fat, fibre and ascorbic acid was observed in all packed and irradiated (5.0 kGy) samples.

Results:

The results clearly indicate the effect of paper packaging and radiation doses on fruit (peach) quality. The shelf life of peach was increased up to 17 days.

Conclusion:

Radiated Pakistani China peach grown in Khyber Pakhtunkhwa was studied for the first time. No significant difference was observed between controlled and irradiated peach samples. However, storage for more than two weeks is not advisable because of the loss of firmness of fruit.No adverse effect of gamma irradiation was observed in the current study. However, further studies are needed to explore the exact biochemical mechanism of actions.

Keywords: Gamma Irradiation, Peach and Nutritional Components, Peach, Radiation, Ambient Temperature.

1. INTRODUCTION

About one third of the world food is lost during its transportation to the consumer by spoilage and insect infestations. In the developing countries, 50% of the world food is lost due to tropical weather conditions [1]. During the ripening process, fruits become susceptible to fungal attack. As the PH of the tissue increases, skin layers soften and defense barrier weakens [2]. The contaminated fruits and vegetables are like vehicles for the transmission of pathogens [3]. These pathogens come from different sources like soil, irrigation water and workers handling, using contaminated equipment and utensils during storage [4].

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Literature revealed that fresh fruit and vegetables are the sources of healthy and important nutrients of a disease-fighting diet. The consumption of fruits and vegetables in the diet protects the human body from various diseases like cancer and heart problems *etc*. Furthermore, the consumption of these food materials has increased because of the public awareness of their health benefits. Keeping in view these healthy benefits, a consumer is strongly encouraged to consume more fruit and vegetables as a contribution to a healthy, nutritious and balance diet [5]. Consumer demands for fresh, natural, healthy, high nutritious foods with no or minimal chemical preservatives [6, 7]. This demand has increased along with the whole crop consumption or food processed minimally [8].

Peach (*Prunuspersica* L., family Rosaceae) is a climacteric fruit. The total area in Pakistan under peach cultivation is 15,800 hectares with a production of 83,700 tones. Khyber Pakhtunkhwa, the best producing area of peach, covers 39% (6,200 ha) of the total area in Pakistan and contributes 69% (57,800 tons) of the total annual production. Retaining freshness of these fruits is a challenge for researchers, growers, exporters and related businesses.

Several studies demonstrated that peach undergoes rapid ripening. The process is controlled by a plant harmone called ethylene. This is responsible for its short shelf life [9, 10]. Peach has a shelf life of about less than 7 days at ambient temperature. Loss of firmness and rot development are the main factors that lower the post-harvest quality of peach. During the ripening process, peach undergoes various changes in color, texture and taste [11].

Moreover, the post-harvest care of climacteric fruit is very important to get satisfactory quality [12]. The post-harvest losses of fruits and vegetables due to insect disinfection are as much as 30-40% or even more in some developing countries across the world. In order to reduce the cost production and increase the trade and distribution of these food materials, the post-harvest losses must be reduced. Besides, these food materials will be available to every inhabitant in our planet at lower prices [13].

Many studies have shown that fruits and vegetables can be preserved by their treatment with heat, cold storage fumigation and gamma irradiation *etc*. The hot air drying method and cold storage used for food preservation are free from chemicals but have many disadvantages like production of chilling injuries, loss of quality and low energy efficiency *etc* [14]. Among the methods tested, gamma irradiation has proved to be most effective in reducing mold and bacterial contamination as well as delaying the ripening and senescence of fruits [15, 16]. Gamma irradiation is a well-known, environmentally friendly, phytosanitary and decontamination treatment of food stuff and other plant materials [17 - 19]. This technology is very useful for controlling the post-harvest losses of fresh fruit and vegetables by delaying their developmental process [20]

In addition, the irradiation technology plays an important role in controlling the food spoilage by microorganism, and also enhances the shelf life of various food stuffs [21, 22]. This technique is a well-established as physical, non-thermal mode that process foods at or nearly ambient temperature. This technique causes minimal modification in the flavor, color, nutrients, taste and other quality attributes of food [23].

The literature studies indicate that there hardly seems any information available regarding the radiation processing of peach varieties of District Peshawar, Khyber Pakhtunkhwa, Pakistan. Therefore, the present study was conducted to investigate the effect of gamma irradiation on storage quality, shelf-life extension and facilitating the marketing of fresh peaches from District Peshawar to distant places other than the local market.

2. EXPERIMENTAL

2.1. Sample Collection

The partially matured fresh peaches were collected from the local fruit market of District Peshawar, Khyber Pakhtunkhwa, Pakistan.

2.2. Irradiation Treatment and Storage

The irradiation process was carried out by Co-60 gamma ray source at the rate of 71.4 krad/h. The peach samples were irradiated with 2.5 and 5 kGy as per procedure [17].

Both untreated and treated peach samples were separately packed in six boxes (3 paper and 3 wooden boxes) and were labeled. Each box contained 5 peaches. The peach intended for analysis were stored at ambient temperature (25 ±2 °C) and were analyzed after each week for selected parameters.

2.3. Chemical Analysis

2.3.1. Moisture

The moisture content was determined by the method of literature [24].

2.3.2. Crude Fat

Crude fat was analyzed by the Soxhelt apparatus using an organic solvent [25].

2.3.3. Ascorbic Acid

Standard literature method was used for the exploration of ascorbic acid [24].

2.3.4. Ash Content

The samples were heated at 525 °C in a Muffle furnace till white ash was obtained. The ash contents were studied after achieving constant weight [24].

2.3.5. Crude Protein

James *et al.*, 1985 method was followed for the estimation of crude protein percentage on the basis of total nitrogen content [25].

2.3.6. Crude Carbohydrate

The crude carbohydrate in the fresh peach samples was determined by the following formula [25].

Crude Carbohydrates = 100 – Fat + Protein +Fiber +Ash +10

2.3.7. Crude Fibre

The fiber percentage was estimated using the Fiber-Tech apparatus [24].

3. RESULTS AND DISCUSSION

3.1. Quality Parameters

Peach fruits cannot be stored for longer time due to hot humid climatic condition such as prevailing in Khyber Pakhtunkhwa, Pakistan and microorganism's growth. The short shelf life causes a problem in efficient handling in transportation and most of the peach fruits go to waste. For peach exportation to local markets, it is needed to increase the shelf life of peach which was increased up to 17-days at ambient temperature.

Compared with the peaches stored in paper boxes, peaches in wooden boxes lost their firmness earlier. This was probably due to high respiration rate and ripening. The peaches stored in paper boxes maintained an extractable juice level as compared to peaches in wooden boxes during the two weeks of storage.

In general, the rapid ripening of peaches in wooden boxes due to higher respiration rate as compared with the peaches in paper boxes led to reducing firmness of fruit. The skin color of peaches irradiated with 2.5 kGy stored in paper and wooden boxes turned from light green to light yellow while the color of peaches irradiated with 5.0 kGy and that of control sample stored in paper and wooden boxes was changed from light green to light brown during the storage period. These colors developed deep towards the end time of storage. The % amount of various parameters before and after irradiation is shown in the (Tables **1**-**3**).

Table 1. Percent amount of different parameters of controlled peach sample.

Parameter	% Amount
Moisture	91.29
Ash	0.34
Crude Protein	1.92
Crude Fiber	0.96
Crude Fat	1.39
Ascorbic Acid	7.8

(Table 1) contd.....

Parameter	% Amount
Crud Carbohydrate	84.0

3.2. Effect on Ash Contents

Results on the ash content revealed that the controlled sample contained 0.34% (Table **1**) ash initially which was recorded as 0.36% and 0.40% during the first and second week packed in paper box while no results were recorded for controlled sample stored in wooden box as it was contaminated by fungus after four days of storage. In case of samples irradiated with 2.5 and 5.0 kGy irradiation, the amount of ash contents was 0.43%, 0.48%, 0.44% and 0.47% during the first and second week respectively. In case of samples irradiated with 2.5 and 5.0 kGy irradiation stored in wooden boxes, the amount of ash contents was 0.48%, 0.52% and 0.57% respectively during the first and second week respectively.

3.3. Effect on Moisture

The main problem in the storage of peach and other fruits is the loss of water content and its shrinkage. The current study focused on the effect of gamma irradiation on the moisture content of peach. Results are given in Tables **1**-**3**. Results showed that moisture content was affected to a small extent when the samples were irradiated with 2.5 and 5.0 kGy doses. However, the peach samples kept in wooden boxes showed more decrease in moisture content as compared to those stored in a paper box. The moisture content of the non-radiated fresh peach was 91.295% (Table **1**) which then reduced to 88.86% after first week and 88.72% after the second week. After irradiation with 2.5 kGy gamma radiation, the moisture content decreased to 89.62% after the first week and 85.06% after the second week in samples packed in paper box whiles the decrease found in a wooden box was 87.54% in the first week and 83.25% in the second week. In peach samples irradiated with 5.0 kGy the moisture content was noted as 89.21% in the first week and 83.52% in the second week in case of paper box while the moisture content in the wooden box was noted 86.06% in the first week and 81.33% in the second week. Similarly, Imdadullah *et al.*, (2010) reported no significant decrease in the moisture content of dates placed in polyethene bags of various colors and irradiated with various doses of gamma rays [17]. Zaman *et al.*, (2007) also reported that the moisture contents of both irradiated and non-irradiated bananas were very close during the storage period [13].

3.4. Effect on Crude Protein Contents

The effect of gamma irradiation on the crude protein content of peach was also studied. The data obtained are shown in Tables (**1**-**3**). The crude protein content of freshly analyzed peach was 1.92% which reduced to 1.59% in the first week and 1.56% in the second week in the sample packed in paper boxes. The samples irradiated with 2.5 kGy, the crude protein content was noted as 1.90% in the first week and 1.85% in the second week stored in a paper box while in case of wooden box the crude protein content was 1.87% in the first week and 1.84% after two weeks storage. The peach irradiated with 5.0 kGy the crude protein content was 1.91% after one week and 1.87% after the second week, stored in a paper box. While the crude protein content in peach samples stored in a wooden box was 1.94% after the first week and 1.91% after the second week. No significant change in crude protein contents was observed in the present study. A similar effect of gamma irradiation was studied by Dianxiang Wu *et al.* (2004) on rice. The change in protein content of rice was from 8.3% before irradiation to 8.0% at the highest dose of irradiation [26]. Imdadullah *et al.*, (2010) also reported the decrease in protein content in dates irradiated with different doses of gamma radiations which showed a decrease of protein content up to one percent [17].

3.5. Effect on Crude Sugar Contents

The dry matter of most fruits contains sugar contents around 91% of fruits. They are produced during photosynthesis by green plants and play an important role in significance of fruits. They vary in their structures, shape, size and both physical and chemical properties. They contain C, H and O atoms. The common sugars found in fruits include, fructose, sucrose and glucose. Literature exposed that the fruits of different types and even the same fruits from different areas have varied amounts of these sugars. The climatic fruits usually have different amounts of sugars at the time of eating ripeness as compare to harvesting time [27].

Results showed that the crude sugar content of fresh peach was 84.0% (Table **1**). In case of controlled sample packed in a paper box, this amount was noted as 85.94% and 86.42% after first and second week respectively. When the samples packed in paper box were irradiated with 2.5 kGy radiation, the amount of crude sugar content was 85.32% after the first week and 85.48% after the second week. In case of a wooden box, this amount was noted as 85.21% and

85.36% after one and two weeks of storage respectively. Peach samples irradiated with 5.0 kGy stored in a paper box contained 85.27% and 86.33% sugar while those in a wooden box the values were 84.96% and 85.62% sugar after the first and second week respectively. Table **5** shows a slight increase in the sugar contents of peach with the passage of time.

Mitchell *et al.* (1992) reported that no change occurs in sucrose and fructose contents of apples at 75 and 300 kGy gamma irradiation doses however, a little increase in glucose level of irradiated apples was noted [28]. In another study carried out by El-Samahy *et al.* (2000) there was a slight increase in the level of reducing sugars in mangoes but the gamma irradiation had no effect on total sugar contents [29].

3.6. Effect on Crude Fat Contents

Tables **1-3** presents the results of crude fat contents of both irradiated and non-irradiated peach samples. The crude fat content of freshly taken peach samples was 1.33% which reduced to 1.33% and 1.31% after first and second week respectively. After irradiation of samples packed in a paper box with 2.5 kGy, the amount of crude fat content was noted as 1.36% and 1.34% after first and second week respectively. Similarly, the peach samples packed in a wooden box after irradiation with 2.5 kGy showed fat content values as 1.37% and 1.34% after first and second week respectively. When the radiation dose was increased to 5.0 kGy the fat content noted in samples from paper box was 1.37% and 1.36% after first and second week respectively. Samples from the wooden box irradiated with 5.0 kGy showed the fat content of 1.35% after one week and 1.33% after two weeks. Results indicated a slight change in fat content of peach with irradiation but this change is not gradual.

Table 2. Percent number of different parameters of peach sample stored in paper boxes after irradiation.

Dose (kGy)	Parameter (%) in Paper Boxes													
	Moisture		Ash		Crude Fiber		Crude Protein		Crude Fat		Crude Ascorbic Acid		Crude Carbohydrate	
	Week		Week		Week		Week		Week		Week		Week	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
0	88.86	88.72	0.36	0.40	0.87	0.84	1.59	1.56	1.33	1.31	7.20	6.30	85.94	86.42
2.5	89.60	85.06	0.43	0.48	0.94	0.90	1.90	1.85	1.36	1.34	6.60	5.80	85.32	85.48
5.0	89.21	83.52	0.44	0.47	1.09	1.06	1.91	1.87	1.37	1.36	6.20	5.50	85.27	86.33
Parameter (%) in Wooden Boxes														
Dose (kGy)	**Moisture**		**Ash**		**Crude Fiber**		**Crude Protein**		**Crude Fat**		**Crude Ascorbic Acid**		**Crude Carbohydrate**	
	Week		**Week**		**Week**		**Week**		**Week**		**Week**		**Week**	
	1	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.5	87.54	83.25	0.48	0.52	0.92	0.83	1.87	1.84	1.37	1.34	6.00	5.40	85.21	85.36
5.0	86.06	81.33	0.52	0.57	1.12	1.10	1.94	1.91	1.35	1.33	5.70	5.10	84.96	85.62

Table 3. Percent amount of different parameters of peach sample stored in wooden boxes after irradiation.

Dose (kGy)	Parameter (%)													
	Moisture		Ash		Crude Fiber		Crude Protein		Crude Fat		Crude Ascorbic Acid		Crude Carbohydrate	
	Week		Week		Week		Week		Week		Week		Week	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.5	87.54	83.25	0.48	0.52	0.92	0.83	1.87	1.84	1.37	1.34	6.00	5.40	85.21	85.36
5.0	86.06	81.33	0.52	0.57	1.12	1.10	1.94	1.91	1.35	1.33	5.70	5.10	84.96	85.62

Note: Values are not shown for controlled sample because it was completely spoiled by fungus after 4 days.

According to the study by Zaman *et al.*, (2007) the fat content of gamma irradiated banana remained almost unchanged as compared to controlled banana and ranged from 0.1-0.25% during storage period [13]. Imdadullah *et al.*, (2010) studied the decrease in crude fat content of controlled dates sample. The decrease was 0.53% after six months as compared to the initial amount which was 1.56%. According to their results, no significant change was observed in the fat content of dates after irradiation with different doses of gamma irradiation [17].

3.7. Effect on Crude Ascorbic Acid

The amount of crude ascorbic acid in controlled peach was 7.8% initially (Table **1**) which was measured as 7.20% and 6.30% after first and second week respectively (Tables **1**-**3**). After irradiation of sample stored in paper box with 2.5 kGy, the amount of crude ascorbic acid determined was 6.60% and 5.80% after first and second week respectively. Similarly, sample from wooden boxes showed the crude ascorbic acid content as 6.0% and 5.40% after first and second week respectively. After the irradiation of samples with 5.0 kGy, the crude ascorbic acid content of paper-packed samples was 6.20% and 5.50% after two consecutive weeks and that of wooden samples were 5.70% and 5.10% after first and second week respectively. The data revealed that regular decrease was observed in the amount of crude ascorbic acid with time and dose of irradiations.

Fan *et al.*, (2005) reported that gamma irradiation (0.5 and 1.0 kGy) has no effect on vitamin C content of apple slices which were also treated and non-treated with calcium ascorbate [30]. A decrease in vitamin C content of orange (15.84%), mandarin (26.80%) and acid lime (29.20%) was also reported by Landana *et al.*, (2003) when the fruits were irradiated with 1.5 kGy gamma radiations [31]. Similarly, vitamin C reduction was observed in lyceum fruits by Hsiao-Ping *et al.*, (2006) by the application of gamma irradiation [32].

3.8. Effect on Crude Fibre Contents

The amount of crude fiber in fresh peach was 0.96% (Table **1**) which decreased to 0.87% and 0.84% during first and second week respectively. The % of crude fiber content in peach samples irradiated with 2.5 kGy packed in paper determined was 0.94% and 0.90% after first and second respectively. The wooden packed samples showed the % values of crude fibre as 0.92 and 0.83 after first and second week respectively. At 5.0 kGy dose of gamma radiation, the crude fibre content of samples in paper box was noted as 1.09% and 1.06% during the first and second week respectively. The crude fibre content of samples stored in wooden box after 5.0 kGy irradiation was noted as 1.12% and 1.10% during the first and second week respectively as shown in (Table **3**).

Ihsanullah *et al.*, (2005) studied the fibre content in radiated and non-radiated date samples and showed that it decreased to 2.40% from its initial value of 3.02% at the fifth month of storage and there was no significant difference in the controlled and irradiated dates [1]. Furthermore, Imdadullah *et al.*, (2010) reported the results of different doses of gamma irradiation on fibre contents of dates stored in polyethylene bags of various colors and showed no valuable difference in the fibre contents of both irradiated and controlled dates [17].

CONCLUSION

Conservation and preservation of peach and other food materials are of primary importance for food security. It also has positive impact on a country's economy. Radiation is one of the most reliable methods of food preservation. Conclusively, radiated Pakistani China peach grown in Khyber Pakhtunkhwa was studied for the first time. No significant difference was observed between controlled and irradiated peach samples. However, storage for more than two weeks is not advisable because of the loss of firmness of fruit. Moreover, packing in paper boxes is recommended to avoid injuries as in case of wooden boxes. No adverse effect of gamma irradiation was observed in the current study. However, further studies are needed to explore the exact biochemical mechanism of actions.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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