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Research Article

Radiation Preservation of Hog-plum (*Spondias pinnata*) in Combination with Chemicals

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Abstract

Background and Objective: Hog-plum is a very popular seasonal fruit in Bangladesh. In this study, an attempt was to establish a suitable radiation preservation technique in combination of chemicals of peeled hog-plum sold by road-side vendors. **Methodology:** The popular fruit was found to have a high number of total viable bacterial count, total *Aeromonas* count, total staphylococcal count, total coliform count and total fungal count. Among four treatments used in this study, combination of radiation, 2% NaCl and 0.05% sorbic acid was found to be the most effective approach for long term preservation according to microbiological and sensory evaluation. **Results:** The present study shows that combination of gamma radiation can be adopted for long term preservation of a very popular seasonal fruit of Bangladesh, which is generally sold in very unhygienic way. **Conclusion:** The preservation approach can be implemented to lower microbial load as well as extend the shelf-life of the fruit and make it available throughout the year. The application of the technique can be extended to other seasonal fruits as well.

Key words: Microbiological analysis, radiation, hog-plum, shelf-life, storage

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Hog-plum (local name Amra, scientific name *Spondias pinnata*) is one of the most popular seasonal fruits of Bangladesh. It is very sweet, juicy, delicious, low in calories and high in fiber[1,2]. This popular fruit is only available in summer season and in most cases sold in peeled state on roads under very unhygienic conditions. Therefore, it is necessary to assess the microbiological quality of the fruit to estimate the possible health risk. It is also valuable to extend the shelf life to make it available throughout the year. There are several reports on the preservation of fruits by radiation and its combination techniques. However, presently there are very few reports on the preservation of peeled fruits like hog-plum by using these techniques.

Microorganisms use food material as source of nutrients that ends with the deterioration of that food material[3]. To prevent this, it is desirable to minimize the contact between microorganisms and our foods (prevent contamination) or eliminate microorganisms from our foods or at least adjust conditions of storage to prevent their growth (preservation). The main reason for preserving fruits and vegetables is to make them available throughout the year. There are a number of ways of food spoilage and prevention of spoilage. Salt in fruit substrates exerts a growth repressing action on certain microorganisms by limiting available moisture and causes plasmolysis[4]. The Cl^- of NaCl reduces oxygen tension and interferes with the action of enzymes[5]. Sorbic acid and its salts are most effective[6] at low pH. These chemicals are more efficient in inhibiting the growth of yeast and mould than that of bacteria. Ionizing radiation such as gamma rays may play a role in producing foods that are free of spoilage microorganisms (radappertization) or pathogens (radicidation) or contain a greatly diminished number of spoilage organisms (radurization). The action of radiation on fruits is influenced by the dose of radiation, type and number of spoilage microorganisms, physical state and chemical composition of the fruits and post-irradiation storage conditions[7]. It was previously reported that combination of two or more treatments is more effective than a single one to reduce microbial load[8]. Another report of Etchelis and Jones[9] showed that the application of irradiation and the addition of common salt (NaCl) singly or in combination with sorbic acid to fruits served to reduce undesirable organisms and hence, encouraged lactic acid fermentation. Lactic acid bacteria play a role in preservation of foods, fruits and vegetables by producing acid and/or antimicrobial compounds and may also contribute to preventing undesirable flavor and development of desirable flavor in food materials[10].

In this study, the degree of contamination of peeled hog-plum was determined to clarify the potential health risk of hog-plum available in the local markets. This study was also designed to establish a suitable preservation technique of this nutritious and tasty fruit to make it available through most of the time of the year.

MATERIALS AND METHODS

Determination of bacteriological and fungal quality: Peeled hog-plums were collected to assess their microbiological quality from three areas near Dhaka city named Gabtali, Savar and Nabinagar. Three samples of each type were collected from each area.

For microbiological analysis, Total Viable Bacterial Count (TVBC) was done by the standard spread plate method using nutrient agar. Total Coliform Count (TCC), Total Fecal Coliform Count (TFCC), Total Staphylococcal Count (TSC) and Total *Aeromonas* Count (TAC) were done in the same way using McConkey agar medium, mFc agar medium, *Staphylococcus* agar medium and starch ampicillin agar medium, respectively[11]. Bacterial isolates were then identified according to the criteria described in Bergey's manual of determinative bacteriology[12]. Malt Yeast Glucose (MYG) chloramphenicol agar medium was used for fungal count. The plates were incubated at 28°C and counts were recorded after 5 days of growth.

Preservation of hog-plum by radiation and combination technique: To analyze the preservation effect on microbiological, chemical and sensory quality of hog-plums, intact fruits having uniform size, shape and no mould growth were collected from Savar area. Defective and ripe hog-plums were removed and the remaining hog-plums were peeled and washed with tap water for several times. Then the following treatments were used for preservation of hog-plums.

Treatment A (0.9% NaCl): In a capped glass container, peeled hog-plums were taken (7 hog-plums, total weight 453.17 g). Then the sterile 0.9% NaCl solution was poured in the container to dip them in the solution.

Treatment B (combination of 0.9% NaCl and 0.5 kGy gamma radiation): The weighed (439.57 g) hog-plums were dipped in 0.9% NaCl solution as previously described and the samples were irradiated at a dose of 0.5 kGy.

Treatment C (2% NaCl solution): In this case, 2% NaCl solution was used to dip the hog-plums (467.90 g).

Treatment D (combination of 2% NaCl solution and 0.5 kGy gamma radiation): A preparation same as treatment C (450.42 g hog-plum) was irradiated at a dose of 0.5 kGy.

Treatment E (combination of 2% NaCl solution, 0.5 kGy gamma radiation and 0.05% sorbic acid): Hog-plum preparation (434.09 g) was treated as treatment D and then 0.05% sorbic acid solution was added on the upper layer of the fruits. All the treated samples were kept in sterilized polythene bag at room temperature for 180 days.

Microbiological, chemical and sensory analysis of stored hog-plums: Microbiological analysis were performed on the 0, 7th, 15th, 30th, 60th, 90th, 120th, 150th and 180th day of preservation. Biochemical and organoleptic analysis were performed on the 1st and 180th day of preservation. For microbiological analysis, a portion of the preserved samples were taken and the concentration of different surviving bacterial population was determined according to the methods described before. Additionally, Lactic Acid Bacterial Counts (LABC) were determined on MRS agar (Oxoid, UK) plates.

The pH of the fruits was determined by a pH meter at distinct intervals throughout the storage period. Reducing sugar and soluble protein contents of the fruit samples were determined by dinitrosalicylic acid (DNS) method[13] and Lowry *et al.*[14] method, respectively. Sensory evaluation with respect to appearance, color, texture, flavor and taste of un-treated and treated fruits were performed by 52 un-trained panelists (staffs and students of the Institute of Food and Radiation Biology, IFRB). The samples were coded and presented to a single sensory judge in a clean and odor-free glass plate at room temperature under normal light conditions. The sensory qualities of the samples were scored on a 9 point hedonic scale as described in a previous report[15]. A score of four or below was regarded as un-acceptable. Samples of each product on the same time of sampling were used as reference control.

Statistical analysis: Data from microbial, chemical and sensory analysis of different treated samples at different periods of storage were subjected to one-way analysis of variance (ANOVA) followed by Duncan's multiple range test. Analysis were performed using statistical application and differences and were considered significant at an alpha level of 0.05.

RESULTS AND DISCUSSION

Microbial load of the studied samples: Generally, hog-plums are peeled by hawkers in open market places and kept in very unhygienic conditions before selling. The study was undertaken to determine the present scenario of the sanitary conditions of the fruit and to determine the effects of radiation treatment in combination of chemicals on the contaminating microbes and chemical and sensory attributes throughout the storage period.

Table 1 shows different microbial counts in hog-plum samples collected from three different areas of Dhaka, Bangladesh. The samples were rich in almost all types of microbial load except fecal coliform. Highest average total viable bacterial count of hog-plum samples was 5.60 ± 0.59 log CFU g^{-1} and was obtained from Gabtali area. The high number of total viable bacterial count may be due to transportation, improper washing, unhygienic handling and unwholesome processing[16]. The highest *Aeromonas* counts from hog-plum were also from this area and these counts were 5.41 ± 0.07 log CFU g^{-1}. *Aeromonas hydrophila* is now regarded as pathogenic for human and the reports for the association of the bacteria and food borne diarrhea are increasing[17]. Highest staphylococcal count was 4.89 ± 0.51 log CFU g^{-1} in hog-plum collected from Gabtali area. Presence of *Staphylococcus* sp., suggested higher level of environmental contamination and its presence indicated possible risk of food poisoning[18]. The highest coliform and fungal count was 4.49 ± 0.54 and 2.66 ± 0.08 log CFU g^{-1}, respectively, in hog-plum collected from Nabinagar.

Isolation and identification of the associated bacteria: The bacterial population isolated from hog-plums is listed in

Table 1: Different types of bacterial counts in the collected hog-plum

	Log (Mean±SD) viable count					
Collection areas	TVBC	TAC	TSC	TCC	TFCC	TFC
Gabtali	5.60±0.59	5.41±0.07	4.89±0.51	4.46±0.54	Nil	2.59±0.05
Savar	4.66±0.11	3.99±0.04	3.49±0.17	4.06±0.60	Nil	2.63±0.13
Nabinagar	5.09±0.19	5.08±0.35	4.44±0.61	4.49±0.54	Nil	2.66±0.08

Each value is the Mean±Standard Deviation of the mean of three replicates, TVBC: Total viable bacterial count, TAC: Total aeromonas count, TSC: Total staphylococcal count, TCC: Total coliform count, TFCC: Total faecal coliform count, TFC: Total fungal count, Nil: No bacterial growth at dectection limit $<10^2$ CFU g^{-1} and SD: Standard deviation

Table 2. Fifty two bacterial isolates belonged to 10 species were identified from the fruit. The identified bacterial species were *Escherichia coli*, *Staphylococcus aureus*, *Aeromonas hydrophila*, *Pseudomonas mallei*, *Lactobacillus plantarum*, *Streptococcus lactis*, *Lactobacillus brevis*, *Achromobacter pestifer*, *Leuconostoc mesenteroides* and *Pediococcus cerevisiae*. The presence of many indicator and pathogenic bacteria and their high number indicate the unhygienic condition of the fruit processing and selling. Presence of *E. coli* and *Klebsiella ozaenae* indicated the possible fecal contamination in the samples. Usage of water for washing the fruit from sources free of pathogenic microorganisms may solve this problem to a great extent. However, the presence of *E. coli* and *S. aureus* in the food item was alarming since these bacterial species are recognized as potential cause of food poisoning[18].

Table 2: Distribution of isolated bacteria in hog-plums

Bacteria isolated from peeled hog-plum	
Bacterial isolates (n = 52)	Isolation frequency No. (%)
Escherichia coli	15 (28.846)
Staphylococcus aureus	12 (23.077)
Aeromonas hydrophila	9 (17.308)
Pseudomonas mallei	6 (11.538)
Lactococcus plantarum	3 (5.769)
Streptococcus lactis	1(1.923)
Lactobacillus brevis	2 (3.846)
Achromobacter pestifer	1 (1.932)
Leuconostoc mesenteroids	2 (3.846)
Pediococcus cerevisiae	1 (1.932)

Effect of different treatments on microbial counts: During the course of storage five different treatments (A-E) were applied, where treatment A was used as control (Table 3). Just after the treatments, all count changed significantly except lactic acid bacterial count (Table 3). In case of treatment E, *Aeromonas* and fungal count became undetectable after 7 days of preservation, whereas staphylococcal count became undetectable just after application of the treatment. The attainment of highest count during the storage period varies with the treatments and types of bacterial populations. The TVBC reached maximum value within 15, 30, 15, 30 and 90 days after application of treatment A, B, C, D and E, respectively. The TAC reached maximum value within 15, 60, 15 and 30 days after application of treatment A, B, C and D, respectively. The TSC was nil in B, D and E treated samples.

Table 3: Effect of different treatments on different types of microbial counts during preservation

		Log CFU g^{-1} at different period of preservation								
Type of count	Type of treatments	0	7	15	30	60	90	120	150	180
		Days								
TVBC	A	4.72±0.00^{a}	6.29±0.02^{a}	7.20±0.03^{b}	6.00±0.02^{d}	4.96±0.01^{e}	5.59±0.05^{e}	5.70±0.04^{b}	5.55±0.05^{bc}	4.45±0.04^{d}
	B	3.47±0.05^{c}	3.64±0.05^{d}	4.73±0.02^{d}	6.82±0.02^{b}	6.97±0.02^{b}	5.90±0.02^{c}	5.77±0.01^{b}	5.73±0.03^{a}	4.82±0.04^{c}
	C	4.53±0.03^{b}	5.40±0.05^{b}	7.39±0.03^{a}	6.61±0.00^{c}	6.01±0.02^{c}	5.79±0.02^{d}	5.61±0.04^{c}	5.48±0.01^{cd}	2.36±0.04^{e}
	D	3.59±0.03^{c}	4.30±0.16^{c}	5.65±0.03^{c}	7.60±0.01^{a}	7.27±0.03^{a}	6.05±0.03^{b}	5.99±0.02^{a}	5.58±0.03^{b}	5.41±0.09^{a}
	E	2.22±0.17^{d}	2.52±0.07^{e}	3.05±0.06^{e}	4.29±0.06^{e}	5.34±0.05^{d}	6.36±0.04^{a}	5.38±0.07^{d}	5.46±0.06^{d}	5.19±0.01^{b}
LABC	A	2.12±0.17^{a}	2.23±0.17^{b}	2.28±0.17^{e}	3.37±0.28^{e}	4.36±0.08^{e}	5.46±0.06^{d}	5.63±0.02^{d}	5.54±0.09^{a}	3.29±0.03^{d}
	B	2.23±0.17^{a}	2.65±0.09^{c}	4.39±0.09^{b}	6.72±0.02^{b}	6.63±0.04^{b}	5.55±0.06^{d}	5.11±0.09^{d}	5.56± 0.07^{a}	4.50±0.05^{b}
	C	2.24±0.17^{a}	2.22±0.17^{b}	4.09±0.09^{c}	5.55±0.06^{c}	5.47±0.04^{c}	5.73±0.02^{c}	5.55±0.02^{c}	5.27±0.06^{b}	4.32±0.09^{c}
	D	2.37±0.28^{a}	3.20±0.10^{a}	5.55±0.02^{a}	7.49±0.05^{a}	7.16±0.05^{a}	6.10±0.07^{b}	5.11±0.03^{b}	5.56±0.06^{a}	4.36±0.04^{c}
	E	2.00±0.00^{a}	2.17±0.17^{b}	3.02±0.02^{d}	4.33±0.06^{d}	5.30±0.06^{d}	6.33±0.02^{a}	5.36±0.01^{a}	5.44±0.03^{a}	5.21±0.06^{a}
TAC	A	3.49±0.05^{a}	4.14±0.11^{d}	5.66±0.04^{b}	4.52±0.05^{d}	4.84±0.03^{d}	3.54±0.07^{d}	4.49±0.03^{b}	4.44±0.05^{c}	3.08±0.06^{b}
	B	2.27±0.17^{c}	3.49±0.07^{c}	4.27±0.10^{d}	6.16±0.02^{b}	6.78±0.01^{a}	5.70±0.03^{b}	5.69±0.02^{a}	5.59±0.02^{a}	4.47±0.04^{a}
	C	2.67±0.19^{b}	5.10±0.04^{a}	7.03±0.01^{a}	5.72±0.07^{c}	4.93±0.02^{c}	4.66±0.04^{c}	3.51±0.04^{a}	3.22±0.06^{d}	2.13±0.17^{c}
	D	2.24±0.17^{c}	2.70±0.06^{d}	4.78±0.05^{c}	6.76±0.02^{a}	5.06±0.06^{b}	6.55±0.00^{a}	5.67±0.02^{c}	4.55±0.02^{b}	3.21±0.09^{b}
	E	2.39±0.10^{c}	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
TSC	A	2.14±0.17^{b}	2.51±0.17^{b}	2.12±0.17^{b}	Nil	Nil	Nil	Nil	Nil	Nil
	B	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	C	4.12±0.14^{a}	4.70±0.02^{a}	2.95±0.08^{a}	Nil	Nil	Nil	Nil	Nil	Nil
	D	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	E	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
TFC	A	3.00±0.05^{a}	5.79±0.03^{a}	7.93±0.05^{a}	6.75±0.05^{b}	5.72±0.04^{c}	4.62±0.02^{d}	4.52±0.03^{c}	3.35±0.07^{d}	2.14±0.17^{c}
	B	2.37±0.10^{b}	3.52±0.05^{c}	7.24±0.09^{b}	8.93±0.03^{a}	6.07±0.11^{b}	5.56±0.05^{c}	5.32±0.01^{b}	4.52±0.05^{b}	2.40±0.10^{b}
	C	2.92±0.14^{a}	3.70±0.10^{b}	4.56±0.10^{d}	6.13±0.05^{d}	6.39±0.05^{a}	5.99±0.07^{a}	5.83±0.04^{a}	5.46±0.05^{a}	3.36±0.03^{a}
	D	2.12±0.17^{c}	3.52±0.07^{bc}	5.71±0.03^{c}	6.48±0.07^{c}	5.80±0.06^{c}	5.64±0.02^{b}	5.37±0.03^{b}	3.90±0.17^{c}	2.14±0.17^{c}
	E	2.00±0.00^{c}	Nil	Nil	Ni	Nil	Nil	Nil	Nil	Nil

Each value is the Mean±Standard Deviation of the mean of three replicates, Values within a column for each type of microorganism followed by the same letter (a–e) are significantly not different (p>0.05), A: 0.9% NaCl, B: 0.9% NaCl+0.5 kGy gamma radiation, C: 2% NaCl, D: 2% NaCl+0.5 kGy gamma radiation and E: 2% NaCl+0.5 kGy gamma radiation+0.05% sorbic acid, TVBC: Total viable bacterial count, LABC: Total lactic acid bacterial count, TAC: Total aeromonas count, Nil: No bacterial growth at dectection limit <10^2 CFU g^{-1} and SD: Standard deviation

The TCC and TFCC were nil in all the treated samples. The TFC became nil in only E treated samples within 7 days of treatment. In case of other treatments it reached its peak value within 15, 30, 60 and 30 days after application of treatment A, B, C and D, respectively. Based on the microbiological analysis only treatment E was found to be effective to eliminate all the pathogenic microorganisms.

Preservation of fruits and vegetables with salt solution has been practiced since immemorial. On the other hand, sorbic acid has been reported to inhibit the growth of bacteria, yeast and mold which act as membrane-perturbing agents[19-21]. However, due to some complications WHO Expert Committee on Food Additives (JECFA) suggested not to take more than 0-5 mg kg^{-1} b.wt. of benzoic acid and benzoate salts, benzyl acetate, benzyl alcohol and benzaldehyde and 0-25 mg kg^{-1} b.wt. of sorbic acid and sorbic salts[22]. Therefore, a combination of sorbic acid and other preservative can be helpful to get the effective preservative effect without crossing the limit of sorbic acid. Gamma radiation which is being used in more than 35 countries for preservation of different food including fruits and vegetables has been investigated in this study to show its efficiency for extending the shelf life of hog-plum. A combination of gamma radiation and other food preservation methods like, temperature (high and low), water activity (a_w), low pH, redox potential, antimicrobial agents has been reported to significantly improve the stability, microbial safety and sensory quality of food products[11,23,24]. In combination with other treatments the radiation treatment has been reported to give more efficient role in shelf life extension of food items[25]. Swailam *et al.*[26] reported a very efficient preservation approach for shelf-life extension of minimally processed pear by combined treatment of gamma irradiation of 2 kGy with 2% ascorbic acid and 1% calcium lactate, where TVBC was reduced by 99.58% and total lactic acid bacteria, mould and yeast counts reduced to undetectable limit during preservation in refrigerated condition. All these reports were in accordance with the findings of this present study.

Effect of different treatments on pH and other chemical parameters: During preservation of hog-plums, the decrease of pH (Table 4) was the indication of acid production as a result of fermentation and the presence of lactic acid bacterial count (Table 3) confirmed the lactic acid fermentation, which ultimately played an important role in preservation. This finding was supported by a previous report[27], where the authors suggested that the growth of lactic acid bacteria resulted in inhibition of the growth of undesirable microorganisms and prevention of spoilage. The low radiation dose applied in this study caused significant reduction of spoilage bacteria without hampering the growth of this food grade bacteria, which is known as Generally Recognized As Safe (GRAS) thereby allowing the commencing of lactic acid fermentation. Therefore, the application of low-dose gamma irradiation has been increasingly gaining importance in industry, restaurants and airline catering for the extension of the shelf-life and retention of the microbiological quality in minimally processed vegetables and fruits[28].

Table 4: Effect of different treatments on the contents of soluble protein and reducing sugar in hog-plums during storage

		Storage period (months)	
Parameters	Type of treatments	0	180
pH	A	4.630 ± 0.02^{ax}	3.920 ± 0.01^{ay}
	B	4.600 ± 0.02^{ax}	3.400 ± 0.02^{by}
	C	4.560 ± 0.01^{ax}	3.680 ± 0.02^{by}
	D	4.540 ± 0.00^{ax}	3.180 ± 0.00^{cy}
	E	4.590 ± 0.01^{ax}	3.050 ± 0.02^{cy}
Reducing sugar (g/100 g)	A	9.363 ± 0.003^{ax}	0.158 ± 0.003^{ay}
	B	9.549 ± 0.004^{ax}	0.063 ± 0.005^{cy}
	C	8.955 ± 0.004^{ax}	0.107 ± 0.002^{by}
	D	9.595 ± 0.004^{ax}	0.042 ± 0.003^{dy}
	E	9.606 ± 0.004^{ax}	0.037 ± 0.004^{dy}
Soluble protein (g/100 g)	A	0.904 ± 0.002^{ax}	0.434 ± 0.002^{dy}
	B	0.884 ± 0.002^{ax}	0.621 ± 0.003^{ay}
	C	0.874 ± 0.002^{ax}	0.384 ± 0.004^{ey}
	D	0.868 ± 0.003^{ax}	0.589 ± 0.004^{cy}
	E	0.897 ± 0.003^{ax}	0.602 ± 0.003^{by}

Each value is the Mean±Standard Deviation of the mean of three replicates, Values within a column for each parameter followed by the same letter (a-e) are significantly not different and values within a row followed by the same letter (x-y) are not significantly different ($p>0.05$), A: 0.9% NaCl, B: 0.9% NaCl+0.5 kGy gamma radiation, C: 2% NaCl, D: 2% NaCl+0.5 kGy gamma radiation and E: 2% NaCl+0.5 kGy gamma radiation+0.05% sorbic acid

Table 4 shows that the amount of reducing sugar reduced more in case of combination treatments (B, D and E). This can be explained by the presence of more number of lactic acid bacteria during the fermentation course[29]. Soluble protein also decreased with time in case of all the treatments. Similar finding was also reported previously[30], where a decrease of total amino acids occurred from 272.5-241 mg g^{-1} after 6 months of cold storage and a decrease to 256.2 mg g^{-1} after the irradiation process of dehydrated ostrich eggs.

Organoleptic evaluation: None of the treatments caused any significant changes in the average scores of appearance, colour, flavor, texture and taste at zero time of storage (Table 5). All sensory attributes were changed for both non-treated and treated samples. The samples treated with only 0.9% NaCl (control) reached below the acceptable limit in case of all sensory attributes. Among the treated samples, C treated samples were most adversely affected. The B treated samples were more affected than D and E treated samples.

Table 5: Effect of different treatments on the sensory evaluation of hog-plums during room temperature storage

		Storage period (days)	
Parameters	Type of treatments	0	180
Appearance	A	8.24±0.32^{ax}	1.00±0.22^{ey}
	B	8.25±0.28^{ax}	5.49±0.50^{cy}
	C	8.23±0.30^{ax}	5.03±0.46^{dy}
	D	8.25±0.31^{ax}	6.75±0.53^{by}
	E	8.22±0.31^{ax}	7.60±0.52^{ay}
Colour	A	8.23±0.31^{ax}	2.27±0.45^{ey}
	B	8.24±0.28^{ax}	5.78±0.55^{cy}
	C	8.16±0.53^{ax}	4.74±0.49^{dy}
	D	8.21±0.37^{ax}	7.26±0.51^{by}
	E	8.26±0.32^{ax}	7.62±0.56^{ay}
Flavor	A	7.69±0.45^{ax}	1.46±0.53^{ey}
	B	7.70±0.46^{ax}	3.39±0.52^{cy}
	C	7.72±0.45^{ax}	2.45±0.60^{dy}
	D	7.68±0.46^{ax}	4.01±0.56^{by}
	E	7.69±0.47^{ax}	5.60±0.62^{ay}
Texture	A	8.34±0.45^{ax}	1.08±0.43^{ay}
	B	8.22±0.47^{ax}	7.07±0.65^{by}
	C	8.22±0.47^{ax}	5.71±0.58^{cy}
	D	8.21±0.56^{ax}	8.24±0.48^{ay}
	E	8.23±0.49^{ax}	4.74±0.79^{dy}
Taste	A	8.31±0.43^{ax}	1.32±0.71^{dy}
	B	8.19±0.44^{ax}	5.50±0.75^{by}
	C	8.21±0.50^{ax}	4.56±0.59^{cy}
	D	8.19±0.54^{ax}	5.65±0.66^{by}
	E	8.23±0.66^{ax}	6.32±0.73^{ay}

Each value is the Mean±Standard Deviation of the mean of three replicates, values within a column for each parameter followed by the same letter (a-e) are significantly not different and values within a row followed by the same letter (x-y) are not significantly different (p>0.05), A: 0.9% NaCl, B: 0.9% NaCl+0.5 kGy gamma radiation, C: 2% NaCl, D: 2% NaCl+0.5 kGy gamma radiation and E: 2% NaCl+0.5 kGy gamma radiation+0.05% sorbic acid

In case of taste and flavor E treated samples were the best and C treated samples were better than A treated samples. Most effected attribute for all the treated samples was flavor and the score of this attribute was highest for E treated samples at the end of preservation period. However, the texture of E treated samples was lowest among the treated sample although it was not below the acceptable limit. Considering all the sensory evaluations, E treated samples were the best at the end of preservation period. With respect to all the studied sensory attributes on the initial and 180th day of storage, the desired effect of the treatments can be arranged as E>D>B>C>A.

CONCLUSION

Finally, although all the studied treatments were efficient in reduction of microbial population in hog-plums the combination of 2% NaCl, 0.05% sorbic acid and gamma radiation was most efficient in microbial reduction and extension of the shelf-life. This treatment was effective not only to eliminate all microbial count other than lactic acid bacteria, but also maintained the sensory attributes better than any other treatments. Thus, this combination treatment can be used for microbial decontamination of hog-plums for long term preservation. However, it is necessary to keep the fruit in sealed pack from the period of applying radiation to just before eat. It will not be easy to implement such technique by the hawkers who are selling the fruit without having any knowledge about the microbiological quality of fruit. The government and public health authority should work to create general awareness on this issue and help the hawkers to apply the preservation technique in convenient way.

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