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Effect of Vacuum Sealing on Quality Attributes of Tomato Paste Assessed by Gamma Radiations

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ABSTRACT

The aim of this research study was to utilize two preservative techniques: vacuum sealing and irradiation for food-processed stuff, both playing a vital role in preservation. Vacuum sealing prevents the sample from further contamination from the environment, and irradiation deactivates and denatures the microorganisms already present in tomato samples. In this study, we sealed and applied different doses of gamma radiation, i.e., 1KGy, 2KGy, and 3KGy. We observed the effect of irradiation on the following parameters: total soluble solids (TSS), power of hydrogen-ion concentration (pH), titratable acidity (TA), and ascorbic acid concentration. The processed tomatoes were treated with gamma irradiation, and the processed samples were evaluated. Irradiation causes minimal modifications in flavor, color, nutrients, taste, and other quality attributes of food. Tomatoes were irradiated at 1KGy, 2KGy, and 3KGy doses. It was observed that variations occurred during processing in all processed samples. There were no significant differences noted in the weight of all processed samples. The overall results indicate that no nutrient loss was observed in experimental samples. In some samples, values were slightly increased, while in others, they were slightly decreased when compared to control samples. Gamma irradiation could be the best technique for quality evaluation in the processing of other agricultural products. This study found ionizing radiation effective in extending the shelf life of vacuum-packed tomato paste. Gamma radiation at 2KGy and 3KGy preserved nutritional properties while enhancing shelf life. Irradiation can minimize food loss by disinfecting grains, legumes, fruits, and tubers, reducing crop infestations caused by insects and spoilage.

INTRODUCTION

Tomatoes (*Solanum lycopersicum L.)*, one of the most widely consumed vegetables worldwide, are abundant in lycopene, phenolics, organic acids, vitamins, minerals, fiber, protein, essential amino acids, monounsaturated fatty acids, carotenoids, and phytosterols, among many other healthful ingredients (Ali et al. 2020). According to Kaur, Wani, Oberoi, and Sogi (2008), tomatoes are consumed as a variety of processed foods, including paste, juice, sauce, puree, and ketchup, in addition to being provided as a raw vegetable. Pakistan's main crops include rice, sugarcane, wheat, and cotton. While other crops, such as vegetables, tomatoes, and legumes, are grown on smaller plots, their significance in food culture and national food security makes them extremely important. Due to its perishability, the tomato is a crop that is crucial to both farmers and consumers. Its production swings can also cause social unrest and political unrest. According to statistics, the most recent FAO data indicated that tomato production worldwide and the area collected are increasing. China produces 56,400,000 tons of tomatoes, followed by America with 26,100,000 tones, India with 18,400,000 tones, and Turkey with 12,600,000 tones. Around 180,000,000 tons of tomatoes were produced in 2016 on an estimated 4,800,000 hectares of total planted land worldwide (FAO, 2016). Pakistan is ranked 11th in terms of producing area and 34th in terms of tomato production (GOP, 2015). Tomatoes are eaten in Pakistan in a variety of ways, including raw and as a component of numerous salads, sauces, meals, and beverages. In Pakistan, all four provinces cultivate tomatoes. An area of roughly 52,300 hectares is used to raise the different tomato cultivars. In 2011–12, Pakistan produced approximately 530,000 tonnes of tomatoes annually (GOP, 2011–12). Due to strong consumer demand for value-added goods like ketchup, sauces, fast food, and hotel chains, Pakistan's market for both fresh and processed tomato products is growing yearly (Khan and Ghafar, 2013).

Tomatoes are processed using a variety of methods to increase their shelf life. In order to keep food hygienic for an extended length of time, vacuum sealing involves sealing it in containers like cans, jars, or tetra packs (Holdsworth, 1997). In addition to raising tomato paste's demand as sterile food, radiation is an essential instrument for keeping it from spoiling. Ionizing radiation is a safe, effective, environmentally friendly, and energy-efficient method of food decontamination. The physical process of irradiating food goods involves direct exposure to electrons or electromagnetic radiation, which prolongs their shelf life and enhances their safety and quality. Similar to light, but with a lot more energy, cobalt emits electromagnetic γ-rays. The removal of harmful bacteria and parasites, insect control, fruit ripening delaying, and microorganism annihilation are all accomplished with this energy source (33, 2000). Many fruits and vegetables can have their shelf lives extended by low doses of irradiation because they slow down respiration, prevent microbiological spoiling, and delay ripening (Lacroix et al. 2000). Radiation treatment is a new technology in more and more nations, and more and more food approvals for radiation-decontaminated foods are being given or are anticipated soon. In order to produce a stable and safe product, the current study set out to assess the impact of gamma radiation on tomato paste.

MATERIALS AND METHODS

Selection of food for vacuum sealing: It is crucial that the food being vacuum packed be chosen carefully. It is far more likely to stay fresh when packaged in a tetra pack if it is in good shape when it is vacuum sealed than if it is not. Food condition also has a significant impact on the final product's flavor (Anthon and Barrett, 2003). Ripe fruits taste their best, but right before they are fully ripened, they are in the best shape for vacuum sealing. Fruits and vegetables that are canned before they are fully ripe are obviously farther away from the conditions that tend to spoil them. The spoiling stage follows perfect ripeness.

Samples collection and research institute: This research was performed with the coordination of the Department of food science and technology, the University of Agriculture, Peshawar and Nuclear Institute for Food and Agriculture (NIFA), Peshawar, Khyber Pakhtunkhwa, Pakistan. Healthy, Fresh and matured red tomatoes were purchased from the local agricultural market of Peshawar, which were utilized for tomato paste for further analysis in order to evaluate the quality attributes after processing.

Grading/sorting: In order to get an acceptable outcome and lower the possibility of spoiling, the first step in the processing is grading, which involves removing the ruined, bruised, and immature tomatoes from the carton box.

Rinsing / washing: The the most important hygienic stage in food preparation is washing, which gets rid of dirt and bacteria. While tap water is also used for washing, a small amount of hot water is quite effective. The washing of all the machines are important to achieve the better results.

Cutting /slicing: In addition to cleaning the fruits, the slicing machine must be cleaned using a solution of potassium meta bi sulphate and water (5 liters of water to 3.3 grams of P.M.B.S.). To ensure that all of the contaminants have been removed, give it a thorough rinse. Now, place the tomatoes in the machine, press the power button to cut them into slices, gather the slices in the kettle, and protect them from pollution and pathogens.

Blanching: Now, place the kettle on the heater set to 115°C for 15 to 20 minutes, and then cover the head while steam is produced. Remove the head after every five minutes and use a wooden spatula or stirrer to mix the product. Stirring constantly will improve the outcome. After finishing the procedure, switch off the heat and let it cool for five minutes.

Pulping: Following the blanching process, the tomatoes are sent to the pulping room, where a pulper is used to remove the skin and seeds using meshes, leaving the tomatoes ready to be turned into paste. To avoid losing the tomatoes, make sure the machine is well cleaned, washed, and operating correctly.

Weighing: In order to obtain the precise weight of the tomato pulp for subsequent processing, place the kettle on a weighing scale while removing the peel and seeds.

Heating/ calculation: It is standard for making tomatoes paste to loss the weigh up to 65% and tomatoes left 35% at a result and the TSS should be 12-16ºBrix. We took 15 kgs of fresh tomatoes, as removing the skin, seeds and loss of water during blanching, the tomatoes pulp left 12 kgs. Now as by calculation;

100 kgs = 35kgs

12 kgs = ?

As by calculation, we need to get the weight of 4.2 kgs and hence the water will loss as by standard and finally we got the required degree brix i.e. 12.8ºBx (Milczarek and McCarthy 2006). It took several hours, depending upon the temperature and amount of tomatoes pulp.

Hot filling: Hot filling (90–92°C) is essential (Barreiro, 2003). Maintaining the sterilization of jars and packs against bacteria requires this temperature.

Labeling: After packing the samples of tomato paste, labeled the samples and passed to the vacuum sealing zone or vacuum sealing food chemistry lab at NIFA.

Vacuum sealing: Every sample was sealed using a vacuum sealer. At 25°C, the untreated tomato spoiled very fast but when it was packed in vacuum-sealed bags, it took long time to spoil at the same temperature because the air was removed from the sealing, making it extremely airtight against microbial contamination.

Irradiation (gamma rays): We make 4 lots of samples, each lot having 7 samples to study the paste for 7 weeks i.e. lot 1- controlled, lot 2- dose 1KGy, lot 3- dose 2KGy and lot 4- dose 3KGy. Labeled the samples by date and the doses given by ***Cobalt-60*** (***^{60}Co***), at NIFA, Nuclear Institute for Food and Agriculture, Peshawar. After completing the doses, the samples were passed to the Quality Control Lab, NIFA for further analysis.

Chemical Analysis: A digital pH meter was used to measure the pH of each tomato paste sample in accordance with AOAC (2012) standard procedure no920.183. Titratable acidity was measured using AOAC (2012) standard procedure no. 920.183. Using an ATAGO Japan hand refractometer (Range 0 – 90 B), the total soluble solids (TSS) were measured at room temperature using the standard AOAC (2012) method number 920.183. The standard procedure described in AOAC (2012) method number 967.21 was used to determine the ascorbic acid (Vitamin C) content.

Statistical analysis: All experiments were set up using a completely randomized design, and the data was statistically analyzed using the CRD 1 factorial, as suggested by Gomez and Gomez (1984). The means were then separated using the LSD Test at the 5% possibility level, as specified by Steel and Torrie (1997).

RESULTS AND DISCUSSION

Titratable Acidity

Initially, the Titratable acidity of sample T_0, T_1, T_2, and T_3 was 1.83, 1.72, 1.65 and 1.54% respectively which gradually decreased to 1.23, 1.11, 1.08, and 1.00 respectively during the storage period. The average mean for Titratable acidity significantly decreased 1.69% to 1.11% during storage time. For treatments maximum mean value were recorded in sample T_0 (1.54) followed by T_1 (1.45) while minimum mean value was observed in sample T_3 (1.27) followed by T_2 (1.35). During storage maximum decrease was observed in sample T_1 (35.47%) followed by T_3 (35.06%) and while minimum decrease was found in sample T_0 (32.79%) followed by T_2 (34.55%) in (Table 01) statistical analysis showed that storage interval had a significant effect on the Titratable acidity of gamma irradiated tomato paste during storage.

The decreasing trend of Titratable acidity during storage period of tomato was reported by Charles et al. (2005). He also found the similar results. According to them, acidity was reduced during storage and gamma radiations treatment.

Table 1

Effect of vacuum sealing and gamma radiations on Titratable acidity (%)

Treatments	Storage Intervals (One Week / 7 days)							% Decrease	Average
	1st	2nd	3rd	4th	5th	6th	7th		
T_0	1.83	1.75	1.66	1.54	1.49	1.31	1.23	32.79	1.54a
T_1	1.72	1.67	1.59	1.41	1.37	1.27	1.11	35.47	1.45b
T_2	1.65	1.53	1.42	1.37	1.22	1.15	1.08	34.55	1.35c
T_3	1.54	1.44	1.39	1.29	1.17	1.08	1.00	35.06	1.27d
Average	1.69a	1.60b	1.52c	1.40d	1.31e	1.20f	1.11g		

Total soluble solids (TSS)

Initially the TSS of sample T_0, T_1, T_2, and T_3 was 10.0, 11.0, 12.35 and 13.81^0 Brix respectively which were gradually increased to 16.10, 17.09, 18.11 and 18.90^0 Brix respectively during the storage. The average mean for TSS significantly increased from 11.79 to 17.55% during storage. For treatments maximum mean value were recorded in sample T_3 (16.17) followed by T_2 (15.15) while minimum mean value was observed in sample T_0 (13.06) followed by T_1 (14.08). During storage maximum increase was observed in sample T_0 (37.89%) followed by T_1 (35.63%) and while minimum increase was found in sample T_3 (26.93%) followed by T_2 (31.81%) in (Table 2) statistical analysis showed that storage interval had a significant effect on the TSS of gamma irradiated tomato paste during storage.

Higher percentage of TSS during storage in the mango was reported by (M. S. Ahmed and S. Singh, 2000). The same result was observed by (Absar et al. 1993) reported that TSS was increased with maturity of fruit. Saltveit et al. (2005) also observed same trend in tomatoes.

Table 2

Effect of vacuum sealing and gamma radiations treatment on Total soluble solids

Treatments	Storage Intervals (One Week / 7 Days)							%Increase	Average
	1st	2nd	3rd	4th	5th	6th	7th		
T_0	10.00	11.12	12.01	13.02	14.00	15.15	16.10	37.89	13.06d
T_1	11.00	12.22	13.00	14.02	15.08	16.17	17.09	35.63	14.08c
T_2	12.35	13.11	14.12	15.10	16.12	17.12	18.11	31.81	15.15b
T_3	13.81	14.10	15.07	16.01	17.23	18.10	18.90	26.93	16.17a
Average	11.79g	12.64f	13.55e	14.54d	15.61c	16.64b	17.55a		

Power of Hydrogen (P^H)

Initially the P^H of sample T_0, T_1, T_2, and T_3 was 4.30, 4.42, 4.51 and 4.72 respectively which were gradually increased to 4.90, 5.10, 5.21 and 5.31 respectively during the storage. The average mean for P^H significantly increased from 4.49 to 5.13 during storage. For treatments maximum mean value were recorded in sample T_3 (4.95) followed by T_2 (4.85) while minimum mean value was observed in sample T_0 (4.64) followed by T_1 (4.74%). During storage maximum increase was observed in sample T_2 (13.44%) followed by T_1 (13.33%) and while minimum increase was found in sample T_3 (10.92%) followed by T_0 (12.24%) in (Table 03) statistical analysis showed that storage interval had a significant effect on the P^H of gamma irradiated tomato paste during storage.

Paulson and Stevens (1994) showed that pH was highly correlated with [H+] and TA with citric acid and malic acid, while the correlation between pH and TA was very low in some cases. Values of pH are crucial for processing tomatoes since values higher than 4.4 mean susceptibility of the pulp to thermophilic pathogens (Paulson and Stevens, 1994).

Table 3

Effect of vacuum sealing and gamma radiations treatment on P^H

Treatments	Storage Intervals (One Week / 7 Days)							%Increase	Average%
	1st	2nd	3rd	4th	5th	6th	7th		
T_0	4.30	4.45	4.51	4.67	4.78	4.86	4.90	12.24	4.64d
T_1	4.42	4.54	4.63	4.75	4.81	4.93	5.10	13.33	4.74c
T_2	4.51	4.63	4.72	4.84	4.95	5.07	5.21	13.44	4.85b
T_3	4.73	4.72	4.81	4.95	5.03	5.10	5.31	10.92	4.95a
Average	4.49g	4.59f	4.67e	4.80d	4.89c	4.99b	5.13a		

Ascorbic Acids (Vitamin C)

Initially the Ascorbic acids of sample T_0, T_1, T_2, and T_3 was 55.32, 52.03, 51.02 and 54.0% respectively which were gradually decreased to 33.11, 34.02, 39.95 and 28.61 respectively during the storage. The average mean for Tetratable acidity significantly decreased 53.09 to 34.21% during storage. For treatments maximum mean value were recorded in sample T_0 (47.71) followed by T_1 (46.42) while minimum mean value was observed in sample T_2 (43.57) followed by T_3 (45.06). During storage maximum decrease was observed in sample T_0 (40.15%) followed by T_2 (38.95%) and while minimum decrease was found in sample T_3 (28.61%) followed by T_1 (34.61%) in (Table 04) statistical analysis showed that storage interval had a significant effect on the Ascorbic acids of gamma irradiated tomato paste during storage.

The similar results were also obtained by (Adam et al. 2014). Ascorbic acid content with respect to time and storage were determined using gamma radiations.

Table 4

Effect of vacuum sealing and gamma radiations treatment on Ascorbic acids (%)

Treatments	Storage Intervals (One Week / 7 Days)							%Decrease	Average%
	1st	2nd	3rd	4th	5th	6th	7th		
T_0	55.32	53.11	52.81	50.03	49.51	40.11	33.11	40.15	47.71a
T_1	52.03	51.07	50.40	49.51	48.72	39.16	34.02	34.61	46.42ab
T_2	51.02	50.20	47.22	45.31	43.12	37.00	31.15	38.95	43.57bc
T_3	54.00	48.55	46.50	44.51	43.15	40.14	38.55	28.61	45.06c
Average	53.09a	50.73ab	49.23bc	47.34cd	46.13d	39.10e	34.21f		

CONCLUSION

According to this study, ionizing radiation was a useful tool for extending the shelf life of vacuum-packed tomato paste, and gamma radiation dosages were found to be safe for nutritional properties. The most effective doses were 2KGy and 3KGy, which exhibited greater shelf life and minimal nutritional losses, while control and 1KGy showed low shelf life in comparison to 2KGy and 3KGy. The loss of both fresh and processed foods can be minimized by using irradiation to disinfect and extend shelf life. Foods including grains, legumes, fruits, and tubers can be radiation-treated to reduce and manage the loss of a significant amount of crop infestation caused by insects.

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