EFFECT OF GAMMA IRRADIATION AND BIOPRESERVATIVE ON QUALITY OF TOMATO

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JUNE, 2020

EFFECT OF GAMMA IRRADIATION AND BIOPRESERVATIVE ON QUALITY OF TOMATO

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A Thesis

Submitted to the Faculty of Agriculture

Sher-e-Bangla Agricultural University, Dhaka,

In partial fulfillment of the requirements

For the degree of

MASTER OF SCIENCE

IN

HORTICULTURE

SEMESTER: JANUARY-JUNE, 2020

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Dedicated to

My Beloved Parents

Who has always helped me and believed that I could do it

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CERTIFICATE

*This is to certify that the thesis entitled, "**EFFECT OF GAMMA IRRADIATION AND BIOPRESERVATIVE ON QUALITY OF TOMATO**" submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **HORTICULTURE,** embodies the result of a piece of bona fide research work carried out by **SHARMIN AKTER,** Registration No. **13-05462**, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that such help or sources of information as has been availed of during the course of this investigation have been duly acknowledged.

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ACKNOWLEDGEMENTS

*All praises to the "**Almighty Allah**" who allow me to complete a piece of research work and prepare this thesis for the degree of Master of Science (M.S.) in Horticulture.*

*I feel much pleasure to express my gratefulness, sincere appreciation and heartfelt liability to my venerable research supervisor **Prof. Dr. Md. Nazrul Islam,** Department of Horticulture, Sher-e-Bangla Agricultural University (SAU), Dhaka- 1207, Bangladesh for his scholastic guidance, support, encouragement and valuable suggestions and constructive criticism throughout the study period.*

*I also express my gratitude, gratefulness and thankfulness to reverend co-supervisor, **Dr. Roksana Huque,** for her constant inspiration, valuable suggestions, cordial help, heartiest co-operation and supports throughout the study period.*

*It is also a boundless pleasure for the author to express her cordial appreciation and thanks to all **respected teachers** of the Department of Horticulture, Sher-e-Bangla Agricultural University, for their encouragement and assistance in various stages towards completion of this research work.*

The author deeply acknowledges the profound dedication to her beloved father, mother, brother and other family members for their moral support, perseverance and continuous prayer in all phases of academic pursuit from the beginning to the completion of study successfully.

*Finally, the author is deeply indebted to her friends and well-wisher specially **Atiqur Rahman Shaon**, **Romana Chowdhury**, **Md. Jannatus Sakib** and **Kazi Nawrin Antora** for their kind help, constant inspiration, co-operation and moral support which can never be forgotten.*

The Author

EFFECT OF GAMMA IRRADIATION AND BIOPRESERVATIVE ON QUALITY OF TOMATO

ABSTRACT

Tomato is one of the most economically important fruit vegetable facing greater problems in storage because of its perishable nature and reduction of quality. The irradiation technology plays an important role in controlling the food spoilage by microorganism, and also enhances the shelf life. The irradiation treatment was carried out at Institute of Food and Radiation Biology, Bangladesh Atomic Energy Research Establishment, Ganakbari, Savar, Dhaka, while the parameters were studied at Postharvest Laboratory of Department of Horticulture, Sher-e-Bangla Agricultural University. Tomatoes were treated with gamma irradiation of different doses i.e. Ra_0: 0.00 kGy, Ra_1: 0.25 kGy, Ra_2: 0.50 kGy, Ra_3: 0.75 kGy, Ra_4: 1.00 kGy. Three different concentrations of aloe vera gel e.g. A0: control, A1: 50% aloe vera gel, A2: 100% aloe vera gel were used in this present study. Results revealed that 0.75 kGy irradiated fruits reduced percentage of weight loss, disease severity, delay ripening, prevented moisture loss (%) and maintained better quality in terms of titratable acidity (TA), total soluble solids (TSS), p^H, lycopene, ascorbic acid content, β-carotene content, and prolonged shelf life compared to other gamma irradiation treatment. Aloe-vera gel also increase the shelf life of tomato and maintain better quality as irradiation. Significant variations were found in both shelf life and quality of tomato in Ra3A2 (100% aloe vera gel+ 0.75 kGy irradiation). The highest shelf life was 18 days where the lowest value were observed from control treatment. From this experiment it can be concluded that effect of 0.75 kGy radiation and 100% aloe vera gel coating is very much suitable for higher shelf life of tomato.

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LIST OF ACRONYMS

DAS	=	Days after storage
Mg	=	Milligram
CRD	=	Completely Randomized Design
LSD	=	Least Significant Difference
pH	=	Hydrogen ion conc.
DMRT	=	Duncan’s Multiple Range Test
BBS	=	Bangladesh Bureau of Statistics
DF	=	Degree of freedom
CV%	=	Percent of coefficient of variation
FAO	=	Food and Agriculture Organization
SAU	=	Sher-e-Bangla Agricultural University
SE	=	Standard Error
RH	=	Relative Humidity
AG	=	Aloe vera gel
kGy	=	Kilo-gray

CHAPTER I

INTRODUCTION

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INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a major horticultural crop produced and consumed worldwide (Nunes, 2008; Aghdam *et al*., 2019). Its consumption is second only to the potato as a vegetable (Javanmardi and Kubota, 2006; FAO, 2012). The total production of tomato is about 160 million tonnes around the world (FAO, 2016). The crop belongs to the Solanaceae family and has its origin in the South American Andes (Naika *et al*., 2005). Tomato is a versatile fruit vegetable that can be consumed fresh in salads or cooked in sauces, soups, and meat or fish dishes. It can also be processed into purees, juices, ketchup, powders, canned whole, or chopped.

Tomato is highly perishable as it is mainly composed of water, soluble, and insoluble solids (Pedro and Ferreira, 2007; Nikbakht *et al*., 2011). Organic acids mostly citric acid and other micronutrients, such as carotenoids, and vitamins A and C are also found in tomato (Pedro and Ferreira, 2007; Nikbakht *et al*., 2011). Its also rich in minerals, essential amino acids, sugars, and dietary fibres. Tomato contains some amounts of vitamins B, E, and K, as well as iron and phosphorus.

Tomato (*Solanum lycopersicum* Mill.) postharvest life as a climacteric fruit is relatively short since many processes cause loss of quality and storability, including high respiration rates, transpiration, postharvest diseases and acceleration in ripening process and senescence (Zapata *et al*. 2008). Tomato quality changes continuously after harvesting. Fruit quality aspects include firmness, flavour, colour and nutritional value, as well as shelf life, processing attributes and resistance to pathogens (Ju *et al*. 2000). It is necessary to explore the ways and means to prolong the shelf life of the fruit while keeping the quality high.

The Food and Agriculture Organization (FAO) of the United Nations has estimated that approximately 20-30% of harvested fruits and vegetables are lost due to decay**,**

although the damage can also be the result of physical injury during postharvest handling, especially in developing countries, as a result of poor storage conditions and transportation facilities (Droby, 2006). The main factors that affect shelf life of produce include proper handling, inadequate humidity, temperature abuse and ethylene exposure. (Workneh, *et al***.** 2010).

Several methods have been used as treatment measures to aid in the preservation of fruits and vegetables (Aghdam *et al*., 2018). These include hot air, drying (dehydration), blanching, use of chemicals like $CaCl_2$, the use of gamma irradiation, electron beams, and X-rays. Gamma irradiation has been used to extend the shelf life as well as improve some qualities of some tomato varieties (Desai and Joshi, 2018; Munir *et al*., 2018).

New tools to ensure the safety of fresh produce are required and irradiation is one of the most promising (Niemira and Fan, 2006). Irradiation technology proved to be efficient in reducing postharvest losses and controlling the stored product insects and the microorganisms. Ionizing radiation in the form of gamma radiation has been studied for over 30 years around the world as a food preservation technique.

To overcome this rapid loss of fruits or other foods, biopreservatives are novel food preserving compounds which help to enhance food safety (Ergun and Satici, 2012). The coating technology is one of the important and well known techniques used to prolong the shelf life and reduce their wastage. A number of edible coatings have been used and discussed by the scientists and efforts are still going on to find the best one (Zhu *et al*., 2008). These compounds do not have side effects and due to presence of antimicrobial compounds, increases the food quality and storage period (Ashwini and Desai, 2018).

In recent years, the use of aloe-vera gel has gained much attention for use as a safe and environmental friendly postharvest treatment. Aloe vera gel has been identified as a novel coating agent with good antimicrobial properties. (Castillo *et al*. 2010; Navarro *et al*. 2011; Nejatzadeh-Barandozi, 2013). Aloe vera gel based

biopreservatives has exhibited to prevent loss of moisture and firmness, control respiratory rate and maturation development, delay oxidative browning and reduce microorganism proliferation in fruits (Kumar and Bhatnagar, 2014).

Nowadays, irradiation and biopreservatives are widely used throughout the world for their excellent quality. However, in Bangladesh, there is limited information and experience to use radiation and biopreservatives as postharvest treatment to extend the shelf life of tomatoes. Therefore, the present study was undertaken to fulfill the following objectives:

- To determine the effect of irradiation and biopreservative on shelf life and quality of tomato.
- To study the physico-chemical changes during storage of tomato.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II
REVIEW OF LITERATURE

Tomato is a highly perishable vegetable crop which contains a very short shelf life and reach to respiration peak of ripening process on 4^{th} or 5^{th} day after harvesting at ambient temperature. It is one of the most important vegetable crops grown under field and greenhouse condition, which received much attention of the researchers throughout the world. The response of irradiation and biopreservatives on tomato has been investigated by numerous investigators in various parts of the world. In Bangladesh, there have not enough studies on the influence of radiation, biopreservatives or both in combination as postharvest treatment of tomato. However, the available research findings in this connection over the world have been reviewed in this chapter under the following headings.

Fruit Nutrition

Tomato is a store house of essential vitamins. These include Vitamin A [red fruits contains an average 100 International Units (IU) per 100g], Vitamin B1, B2, B6, Vitamin E (Alpha Tocopherol), Ascorbic acid (Vitamin C). Tomato is also rich in minerals such as Magnesium, Potassium, Zinc, Manganese, Phosphorus, Copper, Iron, Sodium, Calcium (Rahman *et al*., 2010) and high nutritive value due to the presence of carbohydrate, fibre, folic acid, niacin, thiamin, salicylic acid, tartaric acid and succinic acid. It also contains large amounts of water (93.5%), calcium (0.07%) and niacin, which are of ordinate importance in the metabolic activities of human beings (Olaniyi *et al*., 2010; Sgherri *et al*., 2008; Jaramillo *et al*., 2007). Tomato is a major source of lycopene, a potent and effective antioxidant which gives the vegetable its characteristic red colour and glutathione an antioxidant which aids in cleansing the body of toxic products and prevents the accumulation of heavy metals (Jaramillo *et al*., 2007). In fact tomato is ranked first as a source of lycopene

(71.6%), second source of vitamin C (12%), provitamin A carotenoids (14.6%) and third as a source of vitamin E (6.0%) (Garcia-closas *et al*. 2004).

2.1 Effect of irradiation on quality, performance and physico-chemical Changes of tomato:

Food irradiation has been the focus of intense and deep research for more than 40 years. Irradiation is the process of exposing an object or individual to some form of radiation. Food irradiation is the exposure of food, either pre-packaged or in bulk to a predetermined level of ionization radiation or to high energy particles from one of three types of ionizing energy: gamma rays (emitted from radioactive sources such as Cobalt 60 or Caesium-137), machine generated high electrons or X-rays from accelerators (Rahman, 2007; ICGFI, 1991). It is a technology that can be used to control contamination by destroying microorganisms such as bacteria, viruses, insects as well as moulds and yeast which may be present in food by causing lesions in genetic material of the cell (Murano, 1995). It reduces food losses due to deterioration by sprout inhibition and delay in ripening. Irradiation can be done in any state of the food (thawed or frozen, raw or cooked, solid or liquid) making it economical to use. Radiation doses administered to products are generally characterized as low, medium, high and higher doses. Low dose (less than 1kGy) for delay of ripening in mango, insect and parasite disinfestation and sprout inhibition in potatoes, ginger, onion, garlic and yam (IAEA, 2002); medium (1–10 kGy) for reduction of spoilage microorganisms, microbial reduction in dry products, reduction of non-spore pathogens and high (10-50 kGy) for sterilisation purposes and (10-500 kGy) for reduction in viral contamination (Lund *et al.* 2004). Different levels of radiation dose are required to achieve desired results for the products (Willemoti *et al.* 1996). The amount of radiation dose a product receives during irradiation is measured with a dosimeter; examples are ceri-cerous, fricke, alanine and dichromate (IAEA, 2002). Gamma radiation can extend the shelf life of many perishable fruits, including tomato (Zuleta, 1989), by controlling decay caused by

pathogenic microorganisms and delaying ripening and senescence. A joint FAO/IAEA/WHO Expert Committee on Food Irradiation (IJECFI) concluded that irradiation of food up to an overall average dose of 10 KGy causes no toxicological hazards and introduces no special nutritional or microbiological problems (WHO, 1994; WHO, 1988; WHO, 1980).

Rahman *et al*. (2007) outlined the main advantages of radiation processing as follows:

- It is highly effective and efficient and environmentally friendly.
- Gamma radiation is highly penetrating and reaches all deep places.
- Fresh or frozen products can be treated on line in their final packaging materials.
- Little or no heating of the food and therefore negligible change to sensory characteristics.
- Processing is automatically controlled and has low operating costs.
- Changes in nutritional value of foods are comparable with other methods of food preservation.
- It has considerable potential to increase international trade in agricultural commodities.
- It is very important to note that irradiation does not make irradiated food radioactive and does not introduce any chemical residues or toxicity to the treated product.

Irradiated foods must be handled properly to thwart loss of nutrients, deterioration and spoilage (Graham, 1980).

The radiation doses required for effective control of the fungi (C. paradoxa and P. purpurogenum) were above 1000 Gy, which was invariably much higher than could be tolerated by the host tissues, i.e., 250 Gy (Damayanti *et al.* 1990).

Tomatoes are climacteric in nature (Saltveit, 2005). Climacteric fruits submitted to gamma irradiation exhibit a delay of ripening (Akamine and Moy, 1983). In the specific case of tomatoes, irradiation generally delays ripening when the treatment is applied at the pre-climacteric stage (Abdel-Kader *et al*. 1968).

Irradiation has different effects on tomatoes at various stages of ripening. Unripe fruit keeps less well after irradiation than non-irradiated fruit. As for ripe fruit, irradiation makes it possible to prolong the storage period by three to four times in comparison with the control samples. Irradiation with a dose of 0.1-0.2 Mrad hardly reduces the degree of microbiological infection in tomatoes; a dose of 0. 3 Mrad considerably reduces the number of microorganisms; and 0.4-0.5 Mrad almost completely arrests the development of microflora.

The potential application of ionizing radiation in food processing is based mainly on the fact that ionizing radiations damage very effectively the DNA so that living cells become inactivated, therefore microorganisms, insect gametes, and plant meristems are prevented from reproducing, resulting in various preservative effects as a function of the absorbed radiation dose. At the same time, radiation-induced other chemical changes in food are minimal (Thayer, 1990).

For instance, gamma irradiation was employed to restrain potato sprouting, kill pests in grain, modify some ingredients, and bring about changes in the physical-chemistry and sensitization of food (Wang and Chao, 2002). Gamma irradiation has long been employed for decontamination and/or sterilization of dehydrated vegetables (Guo *et al*. 1993; Zhou *et al*. 1996), fruits (Li and Hao, 1993), seasonings (Chen *et al*. 1993), and animal feed (Yang *et al*. 1993).

According to Assi *et al*. (1997) mature green and pink tomato (*Lycopersicon esculentum* Mill.) fruit were subjected to ionizing irradiation in the range of 0.7 to 2.2 kGy from gamma- or X-ray sources. Fruit irradiated at the mature-green stage softened during post-irradiation storage (20◦C) but exhibited an apparently irreversible suppression in polygalacturonase activity, with levels remaining lower than 10% of those of non-irradiated fruit. Polygalacturonase activity was less strongly affected in irradiated pink fruit than in mature-green fruit, but activity remained reduced relative to the controls. Pectinmethylesterase and β-galactosidase activities were significantly enhanced in irradiated fruit of both ripening stages in the early period following irradiation, but reductions were noted after prolonged storage.

Assi *et al*. (1997) studied mature green and pink tomato (*Lycopersicon esculentum* Mill.) fruit that were subjected to ionizing irradiation in the range of 0.7 to 2.2 KGy from gamma or X-ray sources. Irradiation-induced softening was evident in mature-green and pink fruit within hours following irradiation, and differences between irradiated and control fruit persisted throughout post-irradiation storage (at 20◦C). Trends of firmness loss were more consistent and displayed much greater dose dependence on pericarp tissue than whole fruit.

Larrigaudiere *et al*. (1990) reported that ` γ -irradiation of early climacteric (breaker) cherry tomatoes (*Lycopersicon pimpinellifollium* L.) caused a sharp burst in ethylene production during the first hour. The extent of ethylene production was dose dependent and its maximum was at about 3 kGy. The content of 1-aminocyclopropane-1-carboxylic acid (ACC), followed the same evolution as ethylene production, while malonyl ACC increased steadily with time in irradiated fruits. The burst in ethylene production was accompanied with a sharp stimulation of ACC synthase activity which began 15 minutes after irradiation. γ -Irradiation

greatly inhibited the activity of ethyleneforming enzyme at doses higher than 1 kGy. Such sensitivity is in accordance with a highly integrated membrane-bound enzyme.

Mycotoxin production in fruits decreased with increasing irradiation dose and was not detected at 5.0 kGy. Pillai *et al*. (2006). According to Mohacsi-Farkas *et al*. (2006) a radiation dose of 1 kGy had no significant effect on total carotenoid and vitamin C content of sliced tomatoes (*Lycopersicon esculentum*).

Horak *et al*. (2006) investigated the following minimally processed conventional and organic vegetables: conventional and organic chicory (*Chicorium endive),* organic rugola (*Eruca sativa* Mill), soy sprouts (*Glycine max*), alfalfa sprouts (*Medicago sativa*), and a mixed salad composed of cherry tomatoes (*Solanum lycopersicum*), carrots (*Daucus carota* L.), lettuce (*Lactuca sativa),* and cabbage *(Brassica oleracea).* In the case of conventional chicory and soy sprouts, the sensorial evaluation showed that these products had a higher general acceptability after irradiation with at least twice the disinfection dose (1.2 and 2 kGy, respectively). This dose seemed to considerably improve the shelf life of these products. Bibi *et al.* (2006) found that the appearance and flavor scores for tomatoes (*L. esculentum)* showed similar trends as that for cucumbers (*Cucumis sativus*) stored at 5°C. The appearance score was lower for non-irradiated samples than for 3.0 kGy treated samples. The flavor of tomatoes was enhanced with irradiation. The non-irradiated samples had a lower mean score than 3.0 kGy treated samples. Although the flavor deteriorated during storage, the data did not indicate a clear trend. The trend of changes in firmness of tomatoes was also similar to that of cucumbers. The firmness of 0.5 kGy treated samples was similar to that of control samples whereas the 3.0 kGy irradiated samples displayed the minimum firmness.

Horak *et al*. (2006) studied the effect of irradiation on conventional and organic chicory (*Chicorium endive*), organic rugola *(Eruca sativa* Mill), soy sprouts

(Glycine max), alfalfa sprouts *(Medicago sativa)*, and a mixed salad composed of cherry tomatoes (*Solanum lycopersicum)*, carrots (*Daucus carota* L.), lettuce (*Lactuca sativa*), and cabbage (*Brassica oleracea*) stored at 4◦C. The investigated microorganisms were Listeria monocytogenes ATCC 15313, Salmonella Enteritidis ATCC 13076, and Staphylococcus aureus ATCC 6538P. The most radiation-resistant microorganism in the products was Listeria monocytogenes in organic chicory and rugola, conventional chicory, alfalfa and soy sprouts, and Staphylococcus aureus in mixed salad. Based on the application of five times the D10 determined value, the minimum disinfection doses proposed for the products were 1.2 KGy for chicory and mixed salad, 1.3 kGy for organic chicory, 1.4 kGy for rucula, and around 2 kGy for soy and alfalfa sprouts

Shurong *et al*. (2006) determined the D10-values of E. coli 0157:H7, Listeria innocua and Salmonella Enteritidis. D10- values of E. coli O157:H7 inoculated in cherry tomato and fresh pre-cut carrot were 0.08 kGy and 0.13 kGy, respectively; D10- values of Salmonella Enteritidis inoculated in cherry tomato, fresh pre-cut carrot, a mixture of blanched celery, and peanut were in the range of 0.24 kGy to 0.33 kGy. Irradiation with doses less than 2.0 kGy dose could ensure a 5 log reduction of the most resistant examined pathogen, Salmonella Enteritidis. Moreover, irradiation could effectively control the growth of pathogens during storage period. The effects of low-dose irradiation on the microbiota of pre-cut tomato (lycopersicon syn. L. esculentum) was investigated by Mohacsi-Farkas *et al*. (2006). Challenge testing with pathogens such as E. coli O157:H7 and L. monocytogenes were also carried out. Doses of 1–3 kGy were able to reduce considerably the microbiological contamination of tomato.

Studying the source of ethylene in infected tomatoes by Barkai-Golan *et al*. (1989) found that the ethylene recorded in the host–pathogen systems is produced by the host in response to fungal infection. Because ethylene has a stimulatory effect on

the pathogen growth and on rot development (Barkai-Golan *et al.* 1989), it was suggested that the exposure of fruits to ethylene via their exposure to irradiation may stimulate disease development both directly and indirectly, via stimulation of the ripening process.

The treatments like gamma radiaion, microwave treatment or their combination treatments have beneficial effect in reducing the storage loss of cucumbers when kept at 25°C for the period of 15 days. Irradiation treatment extends the shelf life of minimally processed cabbage, cucumber and bitter gourd (Khattak, A.B. *et al*. 2005, Khattak, M.K. *et al*. 2005). Prakash *et al*. (2000) also reported that low dose gamma irradiation increased shelf life of diced celery. D'innocenzo and Lajolo (2001) used irradiation treatment as an imposed stress to cause changes in firmness. Physiologically mature papaya fruits were irradiated (0.5 kGy) and allowed to ripen at 22◦C and 90% RH. Irradiation caused a two-day delay on the onset of ripening time. The total soluble solids (◦Brix) of both treated and control fruits, increased from 8% to 12% and were not affected by irradiation. Susheela *et al*. (1997) found no significant loss of sugar and ascorbic acid contents in three-quarter ripe and fully ripe pineapple fruit (*Ananas comosus)* irradiated at 0.15 kGy.

Rubio *et al*. (2001) studied the effects of irradiation (0.50, 0.75, and 1.00 kGy) on the vitamin C content of lettuce (*Lactuca sativa*), cabbage (*Brassica oleracea),* and celery (*Apium graveolens).* There was a marked difference in the natural total ascorbic acid content of the vegetables studied with cabbage showing the highest. Irradiation did not decrease these initial concentrations, and in the case of cabbage, it actually increased them. For lettuce, cabbage, and celery the initial ascorbic acid content was 2.357, 3.085, and 0.549 mg/100 g, respectively and after irradiation was 2.036, 5.018, and 0.616 mg/100 g, respectively irradiated with 1.00 kGy.

Lopez *et al*. (2006) determined similar the D10 values for two different strains of E. coli (an ATTC and a wild type), in celery (*Apium graveolens*) and cabbage (*Lactuca sativa* var. *capitata*) (0,18–0,23 KGy). The same situation was observed for Listeria innocua in carrots (*Daucus carota* L.), iceberg lettuce (*Lactuca sativa* var. *capitata*), Toscana (containing chopped iceberg lettuce) and, Four Seasons salads (containing a mixture of chopped romaine lettuce, iceberg lettuce, Butterhead lettuce and spinach) (0.19–0.22 kGy). However, a higher D10 value was obtained for the same microorganism, when inoculated in spinach (*Spinacia oleracea*) (0.32 KGy). E. coli O157:H7 displayed a greater radio sensibility, presenting a D10 value of 0.09 ± 0.01 KGy in both mixed salads. Shurong *et al*. (2006) determined the D10-values of E. coli 0157:H7, Listeria innocua and Salmonella Enteritidis. D10- values of E. coli O157:H7 inoculated in cherry tomato and fresh pre-cut carrot were 0.08 KGy and 0.13 KGy, respectively; D10- values of Salmonella Enteritidis inoculated in cherry tomato, fresh pre-cut carrot, a mixture of blanched celery, and peanut were in the range of 0.24 kGy to 0.33 kGy. Irradiation with doses less than 2.0 kGy dose could ensure a 5 log reduction of the most resistant examined pathogen, Salmonella Enteritidis. Moreover, irradiation could effectively control the growth of pathogens during storage period.

The effects of low-dose irradiation on the microbiota of pre-cut tomato (*lycopersicon* syn. L. *esculentum*) was investigated by Mohacsi-Farkas *et al*. (2006). Challenge testing with pathogens such as E. coli O157:H7 and L. monocytogenes were also carried out. Doses of 1–3 kGy were able to reduce considerably the microbiological contamination of tomato.

Application of gamma irradiation has resulted in successful hygienization of minimally processed fresh produce without affecting the nutritional, textural and sensory qualities (Song *et al.*, 2007; Dhokane *et al.*, 2006; Mishra *et al.*, 2004). Literature review demonstrates that application of ionizing radiations to control

spoilage microorganisms increases shelf-life of irradiated strawberries, lettuce, sweet onions and carrots (Thayer and Rajkowski, 1999); fresh-cut celery (Lu *et al.* 2004); minimally processed garlic, green onion, soybean sprouts and watercress (Park *et al.* 1998); minimally processed carrot, cabbage, bitter gourd and cucumber (Khattak *et al.,* 2005; Chaudry *et al.,* 2004). Combination treatments of gamma irradiation, calcium ascorbate dip, anti-browning and antioxidant agents have also been used to maintain the quality of minimally processed fruits and vegetables (Artes *et al.,* 2009; Prakash *et al.* 2000).

Akanbi and Oludemi (2004) stated that Lycopene is an efficient antioxidant and quenches highly reactive singlet oxygen radicals and acts as a preventive agent for cancer. Yadav *et al* (2009) determined Lycopene needs to be protected from excessive heat and extreme pH conditions, exposure to light, oxygen and lipid degrading enzymes in order to prevent its oxidation and isomerization.

Lycopene is especially effective at quenching a free radical known as singlet oxygen. It is 100 times more efficient in test tube studies of singlet-oxygen quenching action than vitamin E, which in turn has 125 times the quenching action of glutathione (water soluble) and has therefore been described as the world's most powerful antioxidant and may be the most powerful carotenoid of singlet oxygen (Di Mascio *et al.* 1989). Singlet oxygen is a highly reactive free radical formed during normal metabolic processes that reacts with polyunsaturated fatty acids, which are major constituents of cell membranes (Clinton, 1998). Singlet oxygen produced during exposure to ultraviolet light is a primary cause of skin aging (Berneburg *et al.,* 1999). Given its antioxidant properties, substantial scientific and clinical research has been devoted to a possible correlation between lycopene consumption and general health.

Radiation doses administered to products are generally characterized as low, medium, high and higher doses. Low dose (less than 1kGy) for delay of ripening in mango, insect and parasite disinfestation and sprout inhibition in potatoes, ginger, onion, garlic and yam (IAEA, 2002); medium (1–10 kGy) for reduction of spoilage microorganisms, microbial reduction in dry products, reduction of non-spore pathogens and high (10-50 kGy) for sterilisation purposes and (10-500 kGy) for reduction in viral contamination (Lund *et al.*, 2004). Different levels of radiation dose are required to achieve desired results for the products (Willemoti *et al.* 1996). The amount of radiation dose a product receives during irradiation is measured with a dosimeter; examples are ceri-cerous, fricke, alanine and dichromate (IAEA, 2002). The radiosensitivity of microorganism to radiation is dependent on certain factors such as presence of oxygen, irradiation temperature, food composition and vegetative form (Jo *et al.*, 2004).

A dose of 2.5 kGy has been found to reduce the *Clostridium*, *Staphylococcus*, *Bacillus*, *Aspergillus* and *Fusarium* species by 2 log cycles and 7.5 kGy eliminated the fungal population of whole and ground pepper (Rahman *et al.* 2007). For fruits such as cherries and blue berries, low radiation doses have been found to extend the post-harvest shelf life. Blue berries irradiated at 0.25, 0.5, 0.75, or 1.0 kGy stored for 1, 3 and 7 days at 1ºC respectively (Miller and McDonald, 1994).

Charles *et al*. (2005) reported that UV treatment did not affect the taste of tomato fruit. Salunkhe *et al*. (1974) reported that most of the pigments are found to be sensitive to irradiation treatment, but the sensitivity of each treatment was differ significantly.

UV radiation was found to delay the softening of whole tomato fruits significantly during storage (Liu *et al.* 1993; Maharaj *et al.* 1999).

Effect of biopreservatives on quality and performance of tomato: Biopreservatives could be defined as compounds, from natural sources or formed in food, able to restrict or retard spoilage related with chemical or biological deterioration that prolong product shelf life. Edible coatings are thin layers of edible substances applied to the product surface in addition to or as a replacement for natural protective waxy coatings and provide a barrier to moisture, oxygen and solute movement for the food (Avena-Bustillos *et al.* 1997 and Mchugh and Senesi, 2000). They are used directly on the food surface by dipping, spraying or brushing (Mchugh and Senesi, 2000). Edible coatings are used to create a modified atmosphere and to decrease weight loss during transport and storage (Baldwin *et al.* 1995). In fact, the barrier features of gas exchange for films and coatings are the subjects of much recent interest (Sumnu and Bayindirli, 1994).

2.2 Effect of Aloe vera on quality, performance and physico-chemical changes of tomato:

Aloe vera is a stem less and very short- stemmed succulent plant belongs to family Liliaceae (Surjushe A, 2008 and Ni *et al.,* 2004). Aloe vera has medicinal properties, is a tropical and subtropical plant that has been used from ancient time (Eshun and He, 2004). The gel of Aloe vera leaves is the colorless mucilaginous, obtained from the parenchymatous cells. Application of aloe vera gel in the food industry is increasing day by day as resource of drinks, beverages and ice creams (Eshun and He, 2004). In recent years, the use of Aloe vera gel has gained much attention for use as a safe and environment-friendly postharvest treatment. Aloe vera gel has been applied as edible coating material for raw produce including nectarines (Ahmed *et al*., 2009; Navarro *et al*., 2011; Palanides *et al*., 2014), mangoes (Dang *et al*., 2008), apples (Ergun & Satici, 2012), strawberries (Singh *et al*., 2011), cherries (Martinez-Romero *et al*., 2006; Palanides *et al*., 2014), papayas (Marpudi *et al*., 2011), peaches and plums (Guillen *et al*., 2013; Palanides *et al.* 2014), tomatoes (Athmaselvi *et al*., 2013; Chauhan *et al*., 2015) and table grapes (Serrano *et al*., 2006). Typically, the

Aloe vera concentration used in these studies ranged between 50% and 100%, although it was much lower for apples (0%–10%). There are some reports on the antifungal activity of Aloe vera gel against various pathogenic fungi including Botrytis cinerea (Jasso de Rodriguez *et al.*, 2005; saks and Barkai-Golan, 1995). There has been increasing interest in the use of Aloe vera gel in the food industry as a functional component (Moore *et al.*, 2005). Aloe vera based edible coatings have been shown to restrict loss of moisture and firmness, control respiration rate and maturation development, delay oxidative browning, and reduce microorganism proliferation in fruits such as sweet cherry, table grapes and recterones (Matinez-Romero *et al.*, 2005). Aloe vera gel has been identified as a novel coating agent with good antimicrobial properties (Castillo *et al*., 2010; Navarro *et al*., 2011; Nejatzadeh-Barandozi, 2013). The results of these studies have indicated that Aloe vera gel reduces the respiration rate, ethylene production, weight loss, softening, total acidity and prevents colour development. Interestingly, the antifungal activity of Aloe gel from several species has been correlated with the content of aloin, one of the major phenolic compounds of Aloe leaves (Zapata *et al*., 2013). The medical uses of the gel juice (orally) are against skin diseases, constipation, radiation injury gastrointestinal, kidney and cardiovascular problems (Leila Akbari *et al*. 2013), reduce the cholesterol and triglyceride levels in blood. Recently other important property of Aloe vera has been reported such as anti-inflammatory and antibiotic activities against some diseases like diabetics, cancer, allergy and AIDS (Eshun *et al.* 2004; Reyhlds *et al.* 1999; Arowora *et al.*, 2013). Aloe vera gel is also used in the cosmetic industry, including treatment of burns and scars and in wound healing (Aburjai *et al.*, 2004). Edible coatings have been used since ancient time to protect perishable food stuffs from deterioration by retarding dehydration, suppressing respiration, improving textural quality to retain volatile flavor compounds, and reducing microbial growth (Debeaufort *et al*., 1998). Due to consumer demand for food without chemical preservatives has resulted in application of natural antimicrobials preservatives and antimicrobial films and fungicide application can

be reduced (Elmer and Reglinski, 2006). To avoid fruit spoilage it is essential to preserve fruits and it has been estimated that around 25% to 80% of harvested fresh fruits are wasted due to spoilage (Quezada *et al.* 2003). There are natural preservatives which are used as edible surface coatings for vegetables and fruits such as waxes but these coatings commonly contain ingredients such as polyethylene, carnauba and candelilla (Hagenmaier and Baker, 1995; Debeaufort *et al.* 1998; Alleyne and Hagenmaier, 2000). Amarante *et al*. (2001); Jeong *et al.* (2003) have studied wax coating as fruits preservatives and increase the shelf life , slows down ripening, retards water loss, reduces decay and enhances visual quality. The Aloe gel is made up of water, amino acids, vitamins, lipids, sterols, tannins, and enzymes (Shelton, 1991) and contains phenol, saponin, anthraquinones components, have anti-bacterial, antiviral and antifungal properties. Aloe vera has shown antibacterial property against gram positive and gram negative pathogens (Adetunji *et al.*, 2012).

Ethylene production of mature-green cherry tomatoes exposed to gamma irradiation increased sharply during the first 24 h. This stimulation was dose-dependent and was associated with an increase in ACC synthase activity. a post-transcriptional stimulation of ACC sythase activity occurred that was responsible for the rapid increase in ethylene production during the first 15 min after irradiation (Larrigaudiere *et al.* 1990).

In a similar study by Chrysargyris *et al*. (2016) tomato fruit was coated with 0%, 5%, 10%, 15%, and 20% AG and fruit quality maintenance was examined up to 14 days at 11°C and 90% relative humidity. Results showed that 10% and 15% Aloe vera coating reduced fruit ethylene production. Chauhan *et al*. (2015) gave experimental results showing tomato fruits showed a shelf life of 9 and 12 days, respectively, for shellac alone and shellac with aloe vera gel coated fruits against the shelf life of 6 days for uncoated fruits at ambient temperature (26-32°C).

Aloe vera gel based edible coatings have been shown to prevent loss of moisture and firmness, control respiratory rate and maturation development, delay oxidative browning, and reduce microorganism proliferation in fruits such as sweet cherry, table grapes, and nectarines. (Simple and Tripti, 2014).

Brishti *et al*. (2013) carried out an experiment on effect of bio preservatives on storage life of papaya fruit where Aloe vera gel (100%) had been used to preserve papaya fruit at room temperature 25°C-29°C and 82-84% relative humidity. All specimens demonstrated a gradual loss of weight during storage. Throughout storage, the weight loss of uncoated fruit (sample) was remarkably greater than that of Aloe gel coated fruit. At the end of the storage, uncoated papaya displayed 22.5 % loss in weight, but the weight losses of samples coated with Aloe vera gel was 7.93%. Tripathi and Dubey (2004) conducted an experiment to maintain quality and safety of table grapes by coating with Aloe vera gel in cold storage (1°C, 95%). Weight loss enhanced during cold storage and it was remarkably greater in control (uncoated fruits) than in Aloe coated grapes. At the end of cold storage, control fruits lost 15.51 ± 0.32%, but the loss of weight in Aloe-treated grapes was 8.13 ± 0.59%.Togrul and Arslan (2004) stated that the coating helps to reduce moisture loss and gaseous exchange from the fruits due to formation of a film on the top of the skin acting as an additional barrier. Similar results were reported by Thai *et al*. (2002) who showed that wax coating reduced the rate of respiration and transpiration and resulted in reduced weight loss, shriveling and increased shelflife.Fruits are important for the proper maintenance of human health. Fruits are foods affluent in vitamins, minerals and supply arrays of colors, flavor, texture and bulkiness to the pleasure of eating. Tripathi and Dubey (2004) stated that Aloe vera led to a lower rise in TSS (Total Soluble Solid) and greater TA content (Titrable Acidity) retention of coated berries, which indicated that control (uncoated fruits) fruits presented a more pronounced maturation development than coated berries during storage periods (1°C, 95% RH+ 4 days at 20°C, 90% RH). In case of Aloe

coated and uncoated oranges (12ºC, 96-98% RH), there were no significant variations in TSS and TA content of fruits during storage periods. The value of ascorbic acid content for coated oranges was found to be more than that of uncoated fruits (Arowora *et al.*, 2013).

Sharafat *et al*. (1990) also found that as storage is prolonged, the rate of respiration, transpiration and other metabolic changes are increased in control fruits in comparison with edible coated mango fruits.

Decay percentage was used to observe the effectiveness of coated substance on fruit in retarding fruit disease. Aloe vera gel was successful in decreasing microorganism proliferation in table grape, the effect being higher for yeast and molds than for mesophillic aerobics (Tripathi and Dubey, 2004). Interestingly, the Aloe vera gel coating was effective in controlling microbial growth of "Starking" cherry and "Crimson" table grape without incorporating other antimicrobial compounds such as garlic oil, potassium sorbate and nisin to enhance the activity (Pranoto *et al.*, 2005 and Brishti *et al.* 2013) found that in case of Aloe vera coated papaya fruits, no disease signs were observed until 1 week after the beginning of the storage period. At the end of the storage period, 100% disease incidence was found in uncoated fruits, whereas for Aloe gel coated fruits disease incidence was only 27%. This was due to the antimicrobial potentiality of coated substances which has been discussed earlier.

Singh *et al*. (2011) studied the effect of various concentration of Aloe vera gel coating on refrigerated strawberry quality and shelf life with the aim to extend the shelf life of strawberries without hampering the sensory attributes under cold storage uncoated fruits showed increase in weight loss, colour changes, loss of firmness and quality deterioration during the storage (16 days). However, strawberries treated with Aloe vera gel (1:3 ratio) significantly decreased weight

loss (9.95 ± 2.1 %) compared to 13.79 ± 0.13 % in control), maintained colour, firmness, quality characterstics (TSS of 8.4°B compared to 7.0° B in control, acidity of 1.37 % compared to 0.83% in control and ascorbic acid of 45 ± 0.4 mg/100g compared to 30± 0.5 mg/100g) in control and ultimately extend storability upto 16 days when stored at 5° C and RH 95%. Aloe vera gel probably had some effects on the decrease of cell wall degrading enzymes responsible for pineapple softening. These results show beneficial effects of the Aloe vera coating on enhancing the pineapple shelf life, since it has been postulated that fruit softening and texture changes during pineapple storage determine fruit storability and shelf life, as well as reduced incidence of decay and less susceptibility to mechanical damage (Batisse *et al.,* 1996; Vidrih *et al.,* 1998).

From the above reviews, it is clear that quite large volumes of works have been done in various parts of the world. Various issues related to the physiochemical changes, shelf life extension, and diseases have been cited above. Similar statements are scanty in Bangladesh. Very little information is present in Bangladesh regarding the use of radiation and biopreservative as a postharvest treatment on physiochemical changes, shelf life and diseases during storage and ripening.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III
MATERIALS AND METHODS

This chapter is comprised of a brief description about experimental period, storage room, its controlled condition, planting material, treatments used in this experiment, experimental design and layout, data collection and statistical analysis.

3.1 Experimental location:

This experiment was conducted from September to November 2019 in the postharvest Laboratory of Horticulture Department at Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

3.2 Experimental materials:

Mature fresh tomatoes were obtained from BARI, Gazipur, Bangladesh. Uniform sized, undamaged, healthy fruits were selected and transferred to the central Laboratory, Sher-e-Bangla Agricultural University as early as possible with careful handling to avoid injury.

3.3 Treatments of the experiment:

The experiment consisted of two factors:

Factor A: Radiation Doses

i. Control (Ra_0)
ii. 0.25 KGy (Ra_1)
iii. 0.50 KGy (Ra_2)
iv. 0.75 KGy (Ra_3)
v. 1 KGy (Ra_4)

Factor B: Aloe vera gel as Postharvest biopreservatives

i. Control (A_0)
ii. 50% Aloe vera gel (A_1)
iii. 100% Aloe vera gel (A_2)

3.4 Experimental design and treatment application:

The two factor experiment was laid out in a completely randomized design (CRD) with three replications. Based on the available literature on radiation processing of foods, 0.25, 0.50, 0.75 and 1 kGy were chosen for the current study and the samples were irradiated. The postharvest bio preservatives were assigned randomly in each replication. Under each replication, five fruits were collected for physical and destructive analysis. A total number of 15×3×5= 225 matured, uniform sized, undamaged healthy fruits were selected. Then the fruits were washed, surface sanitized with ozonized water for 20 minutes and subjected to various treatments. For coating purposes, the fruit was dipped once in the coating material and retained in it for less than 1 min to have a uniform thin layer of the material over the surface of the fruit. The coated and uncoated (control) fruits were stored at room temperature.

3.5 Preparation of aloe vera extract

Extraction of aloe vera gel was done according to the traditional hand filleted method narrated by Ramachandra and Rao, (2008). Twenty aloe vera leaves were obtained from local town hall market, Dhaka. All were fully extended and mature enough. They were completely free from any defects. The fresh gel was made from collected aloe vera leaves. 100% aloe vera gel was prepared and for this at first they were cleaned with tap water and then with distilled water to free from dust. Then each of one side of skin was peeled off, scoop out the gel of the leave, this colorless hydro parenchyma was homogenized in a blender machine. No water was added here. In case of 50% aloe vera gel it was diluted by water. The gel was then filtered

by sieve to remove all unwanted lump and to get 100 percent and 50% fresh aloe gel (Plate 1). As the gel is susceptible to enzymatic degradation so the extract was kept in a glass jar in refrigerator.

Plate 1. Preparation of aloe vera extract in the postharvest laboratory

3.6 Irradiation of samples

Tomatoes were irradiated using gamma-rays emitted from Co 60 irradiator on the following day of collection. All fruits were packed by zip lock bag. Samples were then irradiated at doses of 0.25, 0.50, 0.75 and 1 kGy at a dose rate of 75 Gray/min. samples were kept 15 cm away from the machine and different doses were given by using Cobalt-60 source at the Institute of Food and Radiation Biology, Atomic Energy Research Establishment , Savar, Dhaka, Bangladesh (Plate 2). The Lithium fluoride photo-flourescent film was used to determine the absorbed dose.

Plate 2. Irradiation of samples

3.7 Observation:

During the entire postharvest storage period the experimental fruits were keenly observed every day to observe any special change. Physical observations (weight loss, shrinkage %, browning or black spot %, disease severity and shelf life) and moisture content % were recorded upto 18 days of storage. For estimating chemical analysis total soluble solids (TSS), titratable acidity (TA), lycopene content, β-carotene, ascorbic acid and pH of each samples were drawn on 19 days of storage.

3.8 Methods of studying physico-chemical parameters:

3.8.1 Physical parameters

3.8.1.1 Estimation of weight loss

Tomato fruits were placed on a digital weighing balance and throughout the storage period each reading was recorded to calculate the weight loss during storage and then percentage of weight loss was calculated as:

$$\text{Weight loss (\%)} = \frac{\text{weight of fresh fruit (g)} - \text{weight after interval (g)}}{\text{weight of fresh fruit (g)}}$$

3.8.1.2 Estimation of moisture content

One fruit was weighed in a porcelain crucible (which was previously cleaned, dried and weighed) from each treatment and replications. The crucible was placed in electric oven at 80°C for 72 hours until the weight became constant. It was then cooled in desiccators and weighed again. Percent moisture content was calculated by using the formula

$$\text{Moisture content (\%)} = \frac{\text{Fresh wt.of fruit} - \text{Dry wt.of fruit}}{\text{Fresh wt. of fruit}} \times 100$$

3.8.1.3 Visual scoring of tomato skin

Visual scoring of tomato skin was done on the basis of shrinkage severity, browning or black spots severity and disease severity. These parameters were taken by eye estimation. Tomato fruits skin was scored from 0-5, whereas, 0 = no shrinkage, 1 = 1- 10% shrinkage, 2= >10-20% shrinkage, 3= >20-30% shrinkage, 4= >30-40% shrinkage, 5= >40% shrinkage. In case of disease severity 0= no disease, 1=1-10% disease, 2= >10-20% disease, 3= >20-30% disease, 4= >30-40% disease, 5= >40% disease.

Assessment of percentage of shrinkage and disease severity

The percentage of fruit skin shrinkage, browning or black spots and disease severity was recorded from 6^{th} day of storage as visual symptom was visible. Fruits were stored till >30% fruit skin considered commercially unacceptable. All the infected fruits were selected to determine percent of fruit area infected.

3.8.2 Chemical parameters

3.8.2.1 pH

pH was measured using a phs-25 pH meter. An electrolytic cell comprise of two electrodes (calomel electrode and glass electrode) was standardized with buffer solution of pH 4. Buffer solution of any known pH value may be used here. Then the electrodes were dipped into the test sample. A voltage corresponding to the pH of the solution was identified by the instrument. For preparing sample solution of fruits, tomatos were chopped into small pieces and ground into a fine paste by mortar and pestle. The tomato juice was transferred into a test tube and the pH of the paste was determined by inserting the electrodes into the paste and stabilized readings were recorded.

3.8.2.2 Total soluble solid (TSS)

Total soluble solids content of tomato pulp was estimated by using hand refractometer. Two drop of tomato juice squeezed from the fruit pulp on the prism of the refractometer. Percent TSS was obtained from direct reading of the instrument.

3.8.2.3 Titratable acidity (TA)

Titratable acidity was estimated by chemical analysis process using tomato pulp. Titratable acidity was declined slowly when stored in low temperature. The titratable acidity of tomato pulp was determined by method of Ranganna (2004). From tomato 24 fruit small piece of 5 gram was chopped, blended by mortar and pestle then the juice was filtered by sieve in a beaker. The volume was made up to 100 ml by adding distilled water. 2 drops phenolphthalein indicator was added. From this solution 10 ml was taken in a conical flask and titrated against 0.1N NaOH. 0.1N NaOH was added drop wise and the solution shaken thoroughly until a pink color was obtained. It was repeated 3 times. The acid content of the tomato sample was calculated using the formula below:

$$\text{TA\%} = \frac{(\text{Titrate} \times \text{Normality of alkali} \times \text{Volume made up} \times \text{Equivalent wt. of acid} \times 100)}{(\text{Volume of sample taken for estimation} \times \text{Wt. of sample taken} \times 1000)}$$

0.1N solution preparation

To make 0.1N solution, 4.0 g of sodium hydroxide was added in water to make 1 liter volume.

Phenolphthalein indicator preparation

To prepare phenolphthalein indicator 0.5g phenolphthalein was weighted. 50% ethanol was prepared by adding 50 ml ethanol and 50 ml distilled water. Then 0.5 g phenolphthalein was dissolved in 50% ethyl alcohol solution.

3.8.2.4 Ascorbic acid

Ascorbic acid content (ascorbic acid) was estimated by using 2,6-Dichlorophenol indophenol (DCPIP) visual titration method (Rangana, 2004). 5gm tomato fruit sample was blended, juice was filtered by sieve. Volume was made up to 100 ml by adding oxalic acid.10 ml from solution was taken in conical flask and titrated against DCPIP (Standard dye) to a pink end point which should persist for at least 15 seconds. Ascorbic acid content in terms of mg/100 g pulp weight was calculated using the following formula:

Ascorbic acid (mg/100g):

$$= \frac{\text{Titra} \times \text{dye factor} \times \text{Volume made up}}{\text{Aliquot of extract taken for estimation} \times \text{wt. or vol. of sample taken for estimation}} \times 100$$

Oxalic acid solution preparation

It was prepared by dissolving 50 g oxalic acid powder in 1000 ml distilled water

Dye solution preparation

It was prepared by dissolving 260 mg of the sodium salt of 2,6-dichlorophenol indophenol in approximately 1000 ml of hot distilled water containing 210 mg of sodium bicarbonate.

Standardization of dye solution

Ten milliliters (10 ml) of standard ascorbic acid solution was taken in a conical flask and 5 ml of oxalic acid was added to it. A micro burette was filed with the dye solution. The content of the conical flask was titrated with dye solution. The content of conical flask was titrated with dye till the pink colored end point appeared. The milliliters of dye solution required to complete the titration was recorded. Dye factor was calculated using the following formula: Dye factor = 0.5/ titrate value

3.8.2.5 Lycopene content

Lycopene extraction was based on the method of Fish *et al.* (2002) with slight modifications. Lycopene in the tomato was extracted using hexane: ethanol: acetone (2:1:1) ($^{v}/_{v}$) mixture. One gram juice of the each sample were homogenized with 25 ml of hexane: ethanol: acetone, which were then placed on the orbital shaker for 30 min, adding 10 ml distilled water and was continued agitation for another two min. The solution was then left to separate into distinct polar and non-polar layers. The absorbance was measured at 472 nm and 502 nm, using hexane as a blank. The lycopene concentration was calculated using its specific extinction coefficient (E 1%, 1cm) of 3450 in hexane at 472 nm and 3150 at 502 nm. The lycopene concentration was expressed as mg/ 100 g product.

At $\lambda = 472$ nm: lycopene content (mg/100g) = $\frac{E}{3.45} \cdot \frac{20}{m}$

At λ = 502 nm: lycopene content (mg/100g) = $\frac{E}{3.15} \cdot \frac{20}{m}$

Where, m = the weight of the product (g)

E= extinction coefficient

3.8.2.6 β-carotene content

β-carotene in tomato pulp was determined according to the method of (Nagata and Yamashita, 1992). One gram of pulp was mixed with 10 ml of acetone: hexane mixture (4:6) and vortex for 5 minutes. The mixture was filtered and absorbance was measured at 453nm, 505nm and 663nm wave length. The calculation was done by following method:

β-carotene (mg/100gm) = 0.216 A663-0.304 A505+0.452 A453

3.8.3 Shelf life

Shelf life of tomato fruits were influenced by different radiation doses and different concentration of AG. When 30% shrinkage severity, browning or black spots and disease severity occur it considered to be the end of shelf life.

3.9 Statistical analysis

The collected data were statistically analyzed by STATISTIX 10 software. The mean of different parameters was compared by DMRT (Duncans Multiple Range Test). The significance of difference between the pairs of means was compared by least significant difference (LSD) test at the 1% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV
RESULTS AND DISCUSSION

This chapter accounts for the presentation of the results acquired from the present study. The results of the study on physico-chemical changes during postharvest losses of tomato are represented and discussed from Table 1 to Table 11 and Figure 1 to Figure 22 in this chapter. These results are explained under the following headings:

4.1 Weight loss

In the postharvest life of fruits, weight loss is used as one of the main quality parameters during storage. The different radiation dozes, biopreservatives, their concentration exhibited more pronounced effect on total weight loss of tomato during storage. The weight loss percent calculating for each radiation and biopreservative showed significant variation (Table 1, Appendix I).

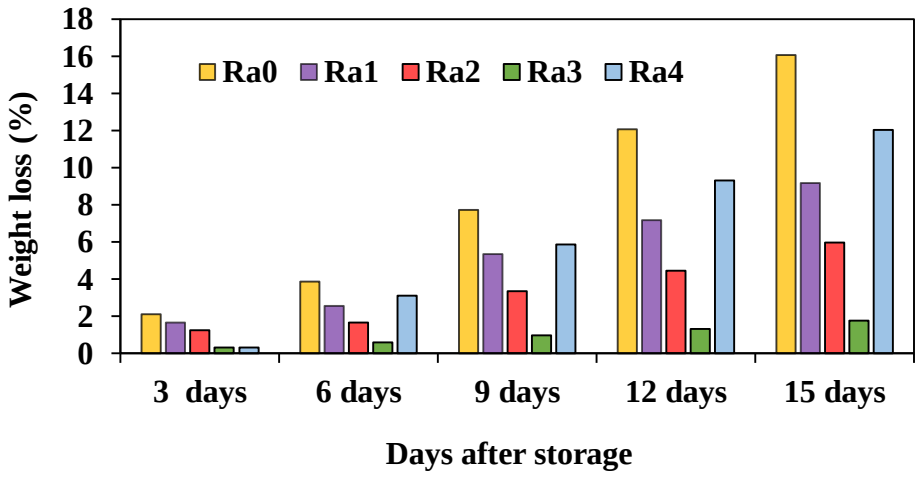
It was seen that the maximum {2.11%, 3.88%, 7.72%, 12.07% and 16.07% at 3^{rd}, 6^{th}, 9^{th} , 12^{th} and 15^{th} days after storage (DAS)} percentage of weight loss of tomato under different radiation dozes was found in Ra0 (Controlled fruit) followed by Ra4 (Radiation doze), Ra1, Ra2 and minimum (0.29%, 0.59%, 0.97%, 1.33% and 1.79% at 3^{rd}, 6^{th}, 9^{th}, 12^{th} and 15^{th} DAS) was in Ra3 (Radiation doze treated fruit) (Figure1). Unirradiated fruits had the highest weight loss throughout the study period. A general rise in weight loss as the doses of gamma irradiation increased as the storage days increased was recorded. The highest weight loss was recorded in samples irradiated at 1.3 kGy throughout the storage period reaching 14.55% on the final day whilst fruits treated with 1 kGy showed the least weight loss (6.78%) on the final day of assessment which is similar to what was recorded by Bhattarai and Gautam (2006). This may be due to the ability of climacteric fruits like tomato to generate heat that contributes to weight loss. The heat lost to the environment

contributes to increased evaporation of water. Under ambient conditions, the heat generated is more rapid as a result of increased respiration rate. This leads to a rapid weight loss of the fruit characterized by excessive softness making the fruit no longer marketable (Davies and Hobson,1981; Padmini, 2006).

It was revealed that highest (1.55%, 2.93%, 5.87%, 8.30%, and 10.97% at 3rd, 6th, 9th, 12th, and 15th, DAS) weight loss was occurred in A0 (controlled fruit) and lowest (0.95%, 1.79%, 3.72%, 5.18% and 6.91% at 3rd, 6th, 9th, 12th and 15th DAS) weight loss was occurred in A2 (100% aloe vera gel treated fruit) (Figure 2).

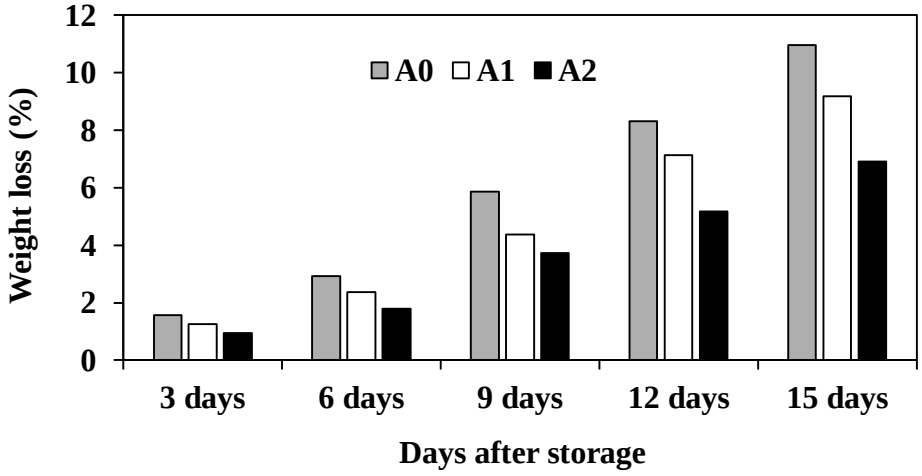
The physiological loss weight was less in pure aloe vera gel coated as compared to the control tomatoes. The percentage of weight loss, regardless of all biopreservatives was increased with the advancement of storage time and it was highest at the end of the storage day. The physiological loss weight was less in pure aloe vera gel coated as compared to the control tomatoes.

In a similar study by Chrysargyris *et al.* (2016), tomato fruit were coated with 0%, 5%, 10%, 15% and 20% aloe vera gel and fruit quality maintenance was examined up to 14 days at 11°C and 90% relative humidity. Results showed that 10% and 15% aloe vera coating reduced fruit ethylene production. Chauhan *et al.* (2015) gave experimental results showing tomato fruits showed a shelf life of 9 and 12 days, respectively for shellac alone and shellac with aloe vera gel coated fruits against the shelf life of 6 days for uncoated fruits at ambient temperature (26–32°C). The coating made up of shellac alone gave lesser shelf life due to excessive ethanol formation caused by anaerobiosis.



Ra0: Control, Ra1: 0.25 kGy, Ra2: 0.50 kGy, Ra3: 0.75 kGy, Ra4: 1 kGy

Figure 1: Effect of irradiation on weight loss (%) of tomato at different days after storage (DAS)



A0: Control, A1: 50% aloe vera gel, A2: 100% aloe vera gel

Figure 2: Effect of aloe vera gel on weight loss (%) of tomato at different days after storage (DAS)

The data showed that the combined effect between the radiation dozes and postharvest biopreservative were found statistically significant at 3rd, 6Th , 9th , 12th and 15th Days after storage. The maximum (2.53%, 4.48%, 9.30%, 14.28% and 18.60% at 3rd, 6th, 9 th, 12th and 15th DAS) rate of weight loss was recorded in Ra0A0 (Controlled fruits and no radiation) combination and minimum (0.00%, 0.26%, 0.52%, 0.66% and 0.80% at 3rd, 6th, 9th, 12th and 15th DAS) rate was recorded in Ra3A2 (radiation doze and 100% aloe vera gel treated fruit) combination (Table 1).

Table 1. Combined effect of radiation dozes and postharvest biopreservatives on weight loss (%) of tomato at different days after storage (DAS)

Treatments	**Weight loss %**				
	3 DAS	**6 DAS**	**9 DAS**	**12 DAS**	**15 DAS**
Ra_0A_0	**2.53** a^z	**4.48** a	**9.30** a	**14.28** a	**18.60** a
Ra_0A_1	2.08 b	4.08 ab	7.67 b	12.65 b	17.23 b
Ra_0A_2	1.74 bc	3.08 b	6.17 c	9.27 de	12.38 d
Ra_1A_0	1.52 cd	3.03 bc	5.96 cd	8.15 ef	10.46 e
Ra_1A_1	1.18 de	2.48 cd	5.32 ef	7.33 fg	9.03 f
Ra_1A_2	1.07 ef	2.20 de	4.80 gh	6.07 g	8.07 f
Ra_2A_0	1.11 def	2.29 d	5.13 fg	6.12 g	8.43 f
Ra_2A_1	0.85 efg	1.63 ef	2.22 j	3.54 h	4.98 g
Ra_2A_2	0.72 fgh	1.12 fg	2.74 i	3.67 h	4.58 g
Ra_3A_0	0.60 gh	0.90 g	1.33 k	1.93 i	2.51 h
Ra_3A_1	0.38 hi	0.60 gh	1.05 k	1.39 i	2.05 h
Ra_3A_2	**0.00** i	**0.26** h	**0.52** l	**0.66** i	**0.80** i
Ra_4A_0	2.00 b	3.98 ab	7.63 b	11.02 c	14.79 c
Ra_4A_1	1.73 bc	3.04 bc	5.63 de	10.70 cd	12.54 d
Ra_4A_2	1.23 de	2.28 d	4.37 h	6.24 g	8.74 f
LSD (0.01)	0.44	0.57	0.48	1.5	1.19
SE	0.1017	0.1017	0.1335	0.3520	0.2747
CV (%)	9.96	6.91	2.95	6.27	3.73

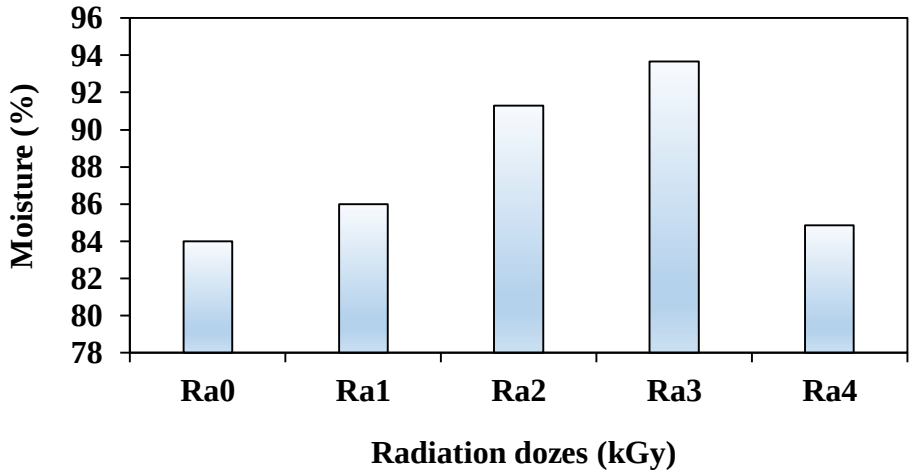
Ra_0: Control, Ra_1: 0.25 kGy, Ra_2: 0.50 kGy, Ra_3: 0.75 kGy, Ra_4: 1 kGy, A_0: Control, A_1 : 50% Aloe vera, A_2 : 100% Aloe vera; [z]Means with different letters significantly differ at LSD's test at $P \leq 0.01$; CV: Coefficient of Variation; SE: Standard Error; LSD: Least Significant Difference.

4.2 Moisture content of tomato pulp

Various radiation dozes are adopted in the study showed significant variation in relation to moisture content at 15 days after storage (Table 2, Appendix II). The maximum (85.437%) moisture content was noticed in Ra3 (0.75 kGy irradiated fruits) followed by Ra2 (kGy irradiated fruits) where moisture content was 84.462%. But minimum (79.076%) moisture content was found in Ra0 (Controlled fruits) (Figure 3).

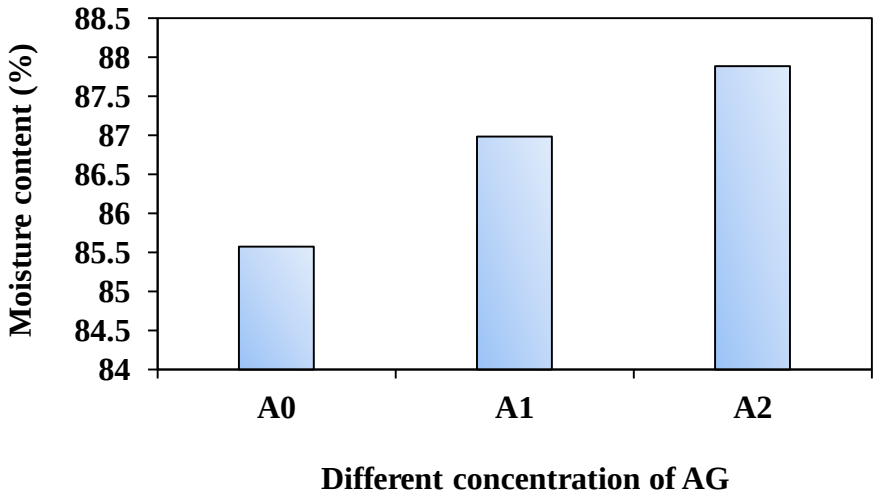
In general the moisture content reduced with the increase in storage time under different radiation doze and postharvest biopreservatives. The above outcome was in partial agreement with the findings of Joshi and Roy (1988). Wilkerson *et al.* (2013) reported that moisture content of foods is influenced by type taken, variety and storage condition of tomatoes or any fruit/vegetable. Some times in market different types of varieties are mixed, that may affect the nutrient proportion of that particular fruit/vegetable. The reduction in percent moisture content was due to transpiration and starch hydrolysis. Total decrease was probably more than the increase in water due to osmotic withdrawal of water from peel to pulp and complete failure of starch to CO_2.

It was recorded that highest (83.338%) moisture content was recorded in 100% aloe vera gel treated fruits (A2), followed by 50% aloe vera gel (AG) treated fruits (81.765%) and lowest (81.44%) moisture content was recorded in controlled fruits (Figure 4).



Ra0: Control, Ra1: 0.25 kGy, Ra2: 0.50 kGy, Ra3: 0.75 kGy, Ra4: 1 kGy

Figure 3. Effect of irradiation on moisture content (%) of tomato pulp at 15 days after storage



A0: Control, A1: 50% aloe vera gel, A2: 100% aloe vera gel.

Figure 4. Effect of aloe vera gel on moisture content (%) of tomato pulp at 15 days after storage

The combined effect of radiation and biopreservatives in respect of moisture content were found to be significant. The maximum (95.65%) moisture content was recorded in Ra3A2 (100% Aloe vera coated fruit irradiated with 0.75 kGy) combination followed by Ra3A1 (50% Aloe vera coated fruits irradiated with 0.75 kGy) combination where the value was 93.40%. On the other hand, minimum (83%) moisture content was recorded in Ra0A0 (Controlled fruits) combination (Table 2).

Table 2. Combined effect of radiation dozes and different concentration of AG on moisture content (%) of tomato pulp at 15 days after storage

Treatments	**Moisture content (%)**
Ra_0A_0	**83 j^z**
Ra_0A_1	84.41 hij
Ra_0A_2	85.41 gh
Ra_1A_0	85.01 g
Ra_1A_1	86.01 g
Ra_1A_2	87.93 f
Ra_2A_0	89.88 e
Ra_2A_1	91.13 d
Ra_2A_2	92.93 bc
Ra_3A_0	91.9 cd
Ra_3A_1	93.40 b
Ra_3A_2	**95.65 a**
Ra_4A_0	83.72 ij
Ra_4A_1	84.42 hij
Ra_4A_2	85.67 g
LSD (0.01)	1.15
SE	0.2629
CV (%)	0.37

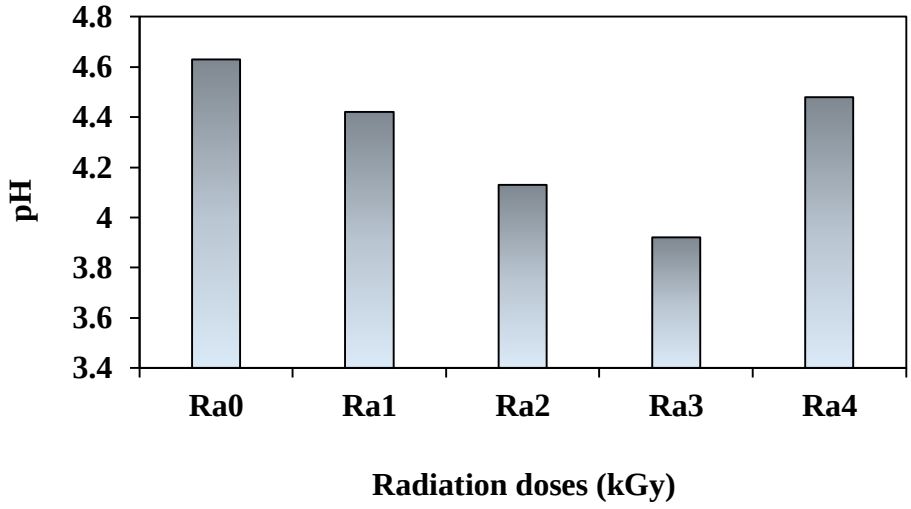
Ra_0: Control, Ra_1: 0.25 kGy, Ra_2: 0.50 kGy, Ra_3: 0.75 kGy, Ra_4: 1 kGy, A_0: Control, A_1 : 50% Aloe vera, A_2 : 100% Aloe vera; [z]Means with different letters significantly differ at LSD's test at $P \leq 0.01$; CV: Coefficient of Variation; SE: Standard Error; LSD: Least Significant Difference.

4.3 pH

Wide variations in pH of tomatoes under different postharvest treatments were recorded during successive days of storage (Table 3, Appendix II). The pH value of different dozes of radiation and aloe vera gel coated fruits showed significant differences. The highest (4.63) pH value was recorded in Ra0 (controlled or untreated fruits) followed by Ra4 (4.48), Ra1 (4.42), Ra2 (4.13) and the lowest (3.92) value was recorded in Ra3 (0.75 kGy Radiation doze). 100% Aloe vera treated fruits also showed lower pH value and that was 4.20 (Figure 5).

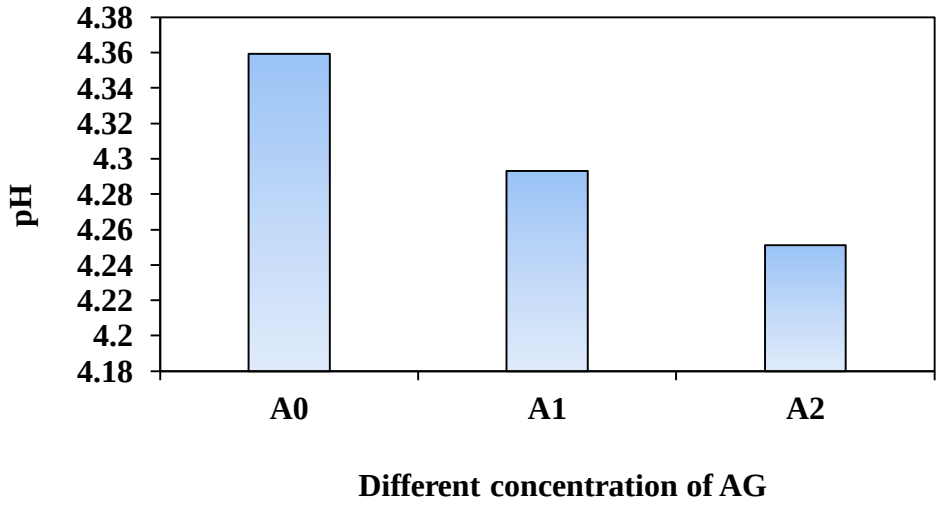
There were significant differences in pH among irradiation doses. Immediately after radiation treatment, recorded significant reductions in pH as radiation dose increased. Similar findings were made by Hussain *et al.* (2011) in irradiated dried apricot and Ladaniya *et al.* (2003), who realized that pH reduced with increasing radiation dose. The pH of the unirradiated fruits was significantly different from irradiated fruits. These results contradict those obtained by Youssef *et al.* (2011) who reported that irradiating tomato fruits at 1.5, 3.0, and 4.5 kGy had no significant ($P > 0.05$) effect on the acidity (pH) of tomato juice, working at a storage temperature of 4ºC. pH recorded for all irradiated fruits varied significantly but inconsistently during the storage period.

The maximum (4.41) pH value was recorded in A0 followed by A1 (50% aloe vera gel treated fruits) and minimum (4.20) pH value was recorded in A2. So, from the above discussion it was concluded that untreated fruits showed highest value and 100% aloe vera gel treated fruits showed lowest value. Moreover after 100% aloe vera gel treated fruit 50% aloe vera coating made its remark (Figure 6).



Ra0: Control, Ra1: 0.25 kGy, Ra2: 0.50 kGy, Ra3: 0.75 kGy, Ra4: 1 kGy

Figure 5. Effect of irradiation on pH of tomato at different days after storage (DAS)



A0: Control, A1: 50% aloe vera gel, A2: 100% aloe vera gel

Figure 6. Effect of on aloe vera gel pH of tomato at different days after storage (DAS)

The combined effect of different radiation dozes and biopreservatives also showed significant result. The maximum (4.68) pH value was noticed from Ra0A0 (controlled fruits with no radiation doze) combination and minimum (3.74) value was recorded in Ra3A2 (100% aloe vera gel coating with 0.75 kGy radiation doze) combination proceeded by Ra3A1 (100% Aloe vera coated fruits with 0.75 kGy radiation doze) combination where pH value was 3.94 very much near to Ra3A2 combination (Table 3).

Table 3. Combined effect of radiation dozes and different concentration of aloe vera gel on the pH of tomato pulp at 15 days after storage

Treatments	**pH**
Ra_0A_0	**4.68 a^z**
Ra_0A_1	4.64 a
Ra_0A_2	4.57 b
Ra_1A_0	4.51 c
Ra_1A_1	4.44 d
Ra_1A_2	4.32 f
Ra_2A_0	4.25 g
Ra_2A_1	4.15 h
Ra_2A_2	4.01 j
Ra_3A_0	4.07 i
Ra_3A_1	3.94 k
Ra_3A_2	**3.74 l**
Ra_4A_0	4.55 b
Ra_4A_1	4.49 c
Ra_4A_2	4.39 e
LSD (0.01)	**0.0321**
SE	**0.0232**
CV (%)	**0.21**

Ra_0: Control, Ra_1: 0.25 kGy, Ra_2: 0.50 kGy, Ra_3: 0.75 kGy, Ra_4: 1 kGy, A_0 : Control, A_1 : 50% Aloe vera, A_2 : 100% Aloe vera; [z]Means with different letters significantly differ at LSD's test at $P \leq 0.01$; CV: Coefficient of Variation; SE: Standard Error; LSD: Least Significant Difference.

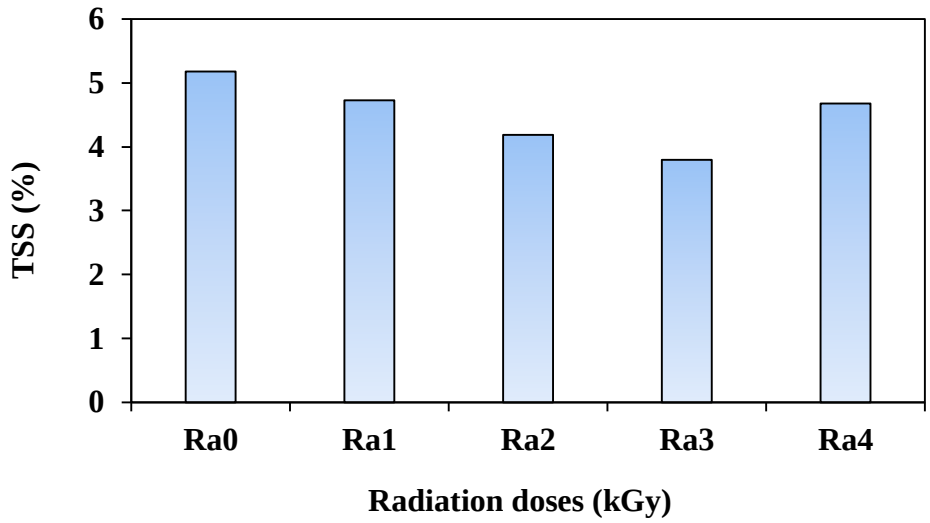
4.4 Total Soluble Solids (TSS)

The total soluble solids content of tomato was affected by the biopreservatives as the treatments showed various results on the basis of tomato variety, environmental condition and waxing material. There was a significant variation in TSS during storage due to radiation and biopreservatives. (Table 4, Appendix III). The fruits irradiated with 0.75 kGy (Ra3) maintained the lowest TSS value (3.79%) followed by 0.50 kGy (4.19%), while untreated control fruits (Ra0) maintained the highest TSS value (5.17%) (Figure 7).

Maximum level of T.S.S is reached in more storage time with irradiated fruits. Total soluble solids are predominantly influenced by the amount of sugars in the fruits (Saltviet, 2005).

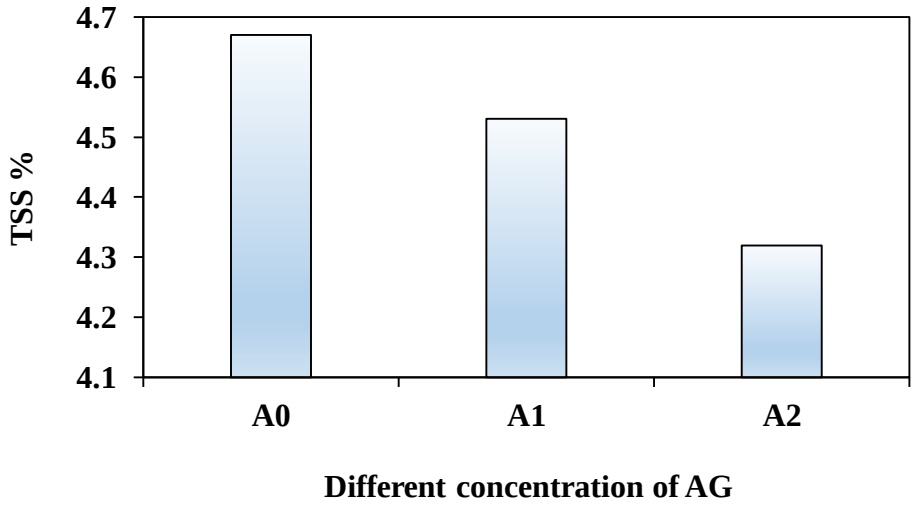
Aloe vera gel showed significant variation as the highest value (4.67%) was recorded in controlled fruits (A0) and lowest value was recorded in fruits treated with 100% aloe vera gel (A2) where the TSS value was 4.32% (Figure 8).

The delay in TSS content upon coating application could be related with the oxygen barrier property of edible coating and reduction of respiration. Similar observation was reported by Yonemoto *et al.* (2002) who explained that lower levels of total soluble solids in fruits coated with aloe vera may be due to protective oxygen barrier that reduces oxygen supply to the fruit surface which in turn inhibited respiration. Sharafat *et al.* (1990) also recorded that as storage is prolonged, the rate of respiration, transpiration and other metabolic changes are increased in control fruits in comparison with edible coated tomato fruits.



Ra0: Control, Ra1: 0.25 kGy, Ra2: 0.50 kGy, Ra3: 0.75 kGy, Ra4: 1 kGy

Figure 7. Effect of irradiation on TSS (%) of tomato at different days after storage (DAS)



A0: Control, A1: 50% aloe vera gel, A2: 100% aloe vera gel

Figure 8. Effect of aloe vera gel on TSS (%) of tomato at different days after storage (DAS)

The combined effect of radiation and biopreservatives in respect of TSS were found to be significant. The maximum (5.24%) TSS value was recorded in Ra0A0 (Controlled fruits with no irradiation) combination and minimum (3.44%) TSS value was recorded in Ra3A2 (0.75 kGy radiation with 100% aloe vera gel) combination (Table 4).

Table 4. Combined effect of radiation dozes and different concentration of aloe vera gel on the TSS of tomato pulp at 15 days after storage

Treatments	TSS (%)
Ra_0A_0	**5.24 a[z]**
Ra_0A_1	5.19 ab
Ra_0A_2	5.09 bc
Ra_1A_0	4.84 bc
Ra_1A_1	4.72 cd
Ra_1A_2	4.61 cde
Ra_2A_0	4.37 ef
Ra_2A_1	4.20 fg
Ra_2A_2	3.99 gh
Ra_3A_0	4.09 gh
Ra_3A_1	3.84 h
Ra_3A_2	**3.44 i**
Ra_4A_0	4.82 c
Ra_4A_1	4.72 cd
Ra_4A_2	4.50 def
LSD (0.01)	0.2626
SE	0.06
CV (%)	1.63

Ra_0: Control, Ra_1: 0.25 kGy, Ra_2: 0.50 kGy, Ra_3: 0.75 kGy, Ra_4: 1 kGy, A_0 : Control, A_1 : 50% Aloe vera, A_2 : 100% Aloe vera; [z]Means with different letters significantly differ at LSD's test at $P \leq 0.0$; CV: Coefficient of Variation; SE: Standard Error; LSD: Least Significant Difference

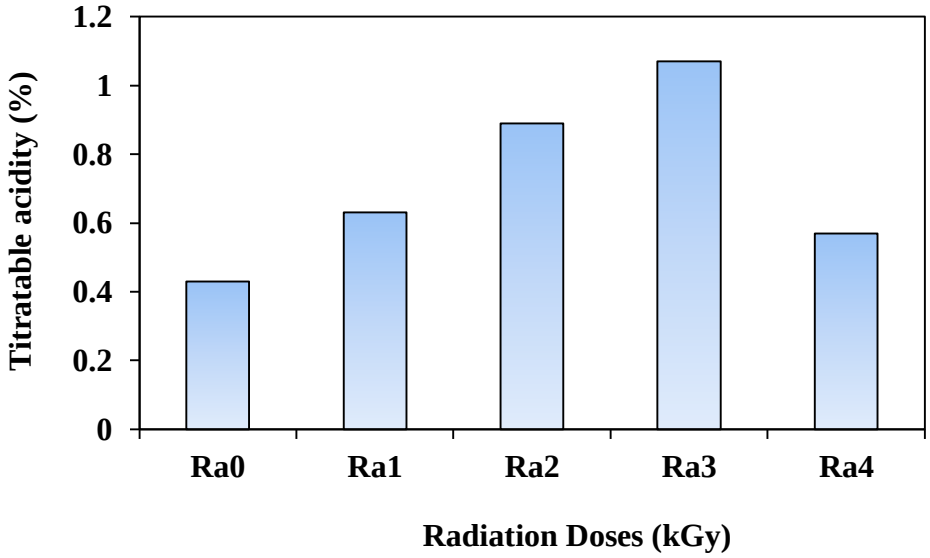
4.5 Titratable Acidity (TA)

There was a significant variation in TA (%) of tomato during storage due to effective coatings and radiation dozes. (Table 5, Appendix III). The maximum value (1.07%) of titratable acidity for tomato fruits was recorded for 0.75 kGy radiation (Ra3), followed by 0.50 kGy radiation (Ra2), the value was 0.89% and the minimum (0.43%) value was recorded for control fruits (Ra0) (Figure 9).

During ripening tomato fruits had shown an increase in titratble acidity in all treatments shortly after the breaker stage and progressively decreased afterwards. Charles *et al.* (2005) recorded a lower titratable acidity and higher pH in UV treated tomatoes.

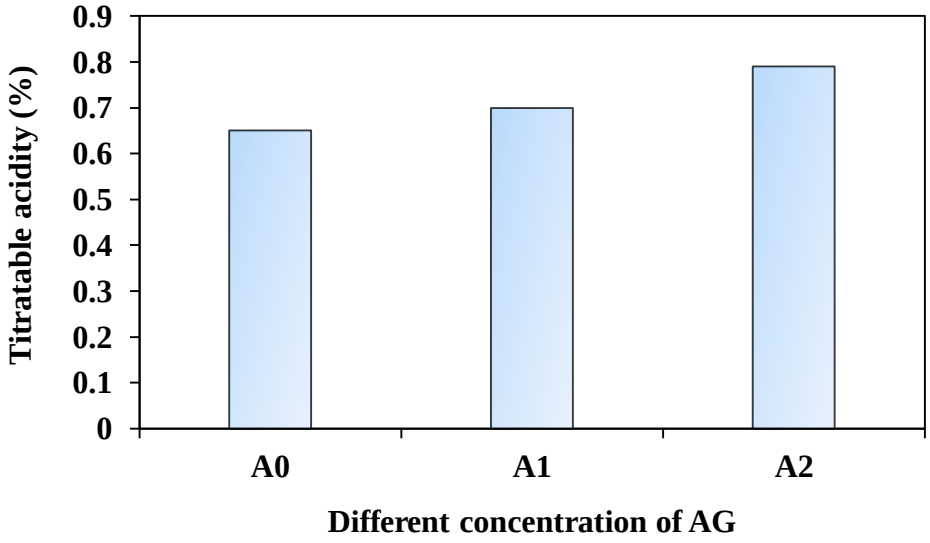
In case of aloe vera coatings, the maximum value (0.78%) of titratable acidity was recorded for tomato fruits treated with 100% aloe vera gel (A2), followed by (0.70%) fruits treated with 50% aloe vera gel (A1) and the minimum (0.65%) value was recorded for control fruits (A0) (Figure 10).

Fruit coating at higher concentration slowed down fruit respiration and the utilization of respiratory product like organic acid was minimal. So coated fruits have higher TA value than control fruits. Tefera *et al.* (2008) found similar findings that fruit acidity is decreased because of postharvest treatments as they delay respiration and utilization rate of respiratory substrates such as organic acids.



Ra0: Control, Ra1: 0.25 kGy, Ra2: 0.50 kGy, Ra3: 0.75 kGy, Ra4: 1 kGy

Figure 9. Effect of irradiation on TA (%) of tomato at different days after storage (DAS)



A0: Control, A1: 50% aloe vera gel, A2: 100% aloe vera gel

Figure 10. Effect of aloe vera gel on TA (%) of tomato at different days after storage

Combined effect of radiation and aloe vera gel appeared significant differences. The above interaction table showed that highest (1.13%) TA value was recorded in Ra3A2 (100% Aloe vera treated fruits irradiated with 0.75 kGy radiation) combination followed by Ra3A1 (50% aloe vera gel treated fruits irradiated with 0.75 kGy radiation) combination with TA value of 1.06% and the lowest (0.39%) value of TA was noticed in Ra0A0 (Controlled fruits) combination (Table 5).

Table 5. Combined effect of radiation dozes and different concentration of aloe vera gel on the TA (%) of tomato pulp at 15 days after storage

Treatments	**TA (%)**
Ra_0A_0	**0.39** n^z
Ra_0A_1	0.43 m
Ra_0A_2	0.47 l
Ra_1A_0	0.55 j
Ra_1A_1	0.60 h
Ra_1A_2	0.72 g
Ra_2A_0	0.83 f
Ra_2A_1	0.88 e
Ra_2A_2	0.95 d
Ra_3A_0	1.02 c
Ra_3A_1	1.06 b
Ra_3A_2	**1.13** a
Ra_4A_0	0.49 k
Ra_4A_1	0.56 j
Ra_4A_2	0.65 h
LSD (0.01)	0.0769
SE	0.0177
CV (%)	1.04

Ra_0: Control, Ra_1: 0.25 kGy, Ra_2: 0.50 kGy, Ra_3: 0.75 kGy, Ra_4: 1 kGy, A_0 : Control, A_1 : 50% Aloe vera, A_2 : 100% Aloe vera; [z]Means with different letters significantly differ at LSD's test at $P \leq 0.01$; CV: Coefficient of Variation; SE: Standard Error; LSD: Least Significant Difference.

4.6 Ascorbic acid content:

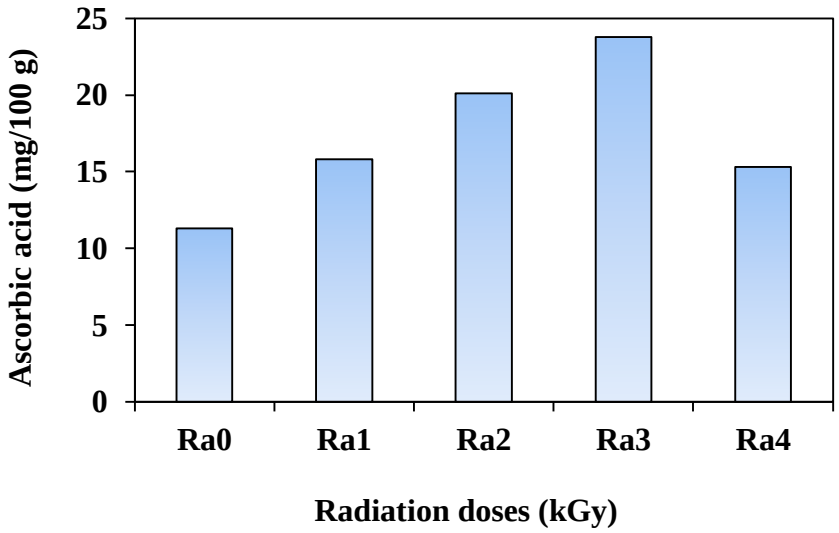
Fruits are the natural source of ascorbic acid and loss of ascorbic acid is very much common in fresh fruits. It is very responsive to degradation due to its oxidation (Veltman *et. al.* 2000) compared to other nutrient during food processing, preservation and storage. As the fruits proceed towards ripening process, the level of acid gradually decreased. In general, a gradual decline was recorded both treated and untreated controlled tomato fruits. The significant variation was recorded in radiation and aloe vera gel coating (Table 6, Appendix III).

It was seen that the irradiation showed significant differences. The highest value (23.76 mg/ 100 g) was recorded for 0.75 kGy (Ra3) irradiated fruits followed by 0.50 kGy (20.10 mg/ 100 g), 0.25 kGy (15.83 mg/ 100 g), 1 kGy (15.33 mg/ 100 g) and lowest (11.29 mg/ 100 g) value was recorded in controlled fruits (Ra0) (Figure 11).

The maximum level of vitamin C is reached in more time with irradiated fruits compared to untreat ones. The loss in ascorbic acid content beyond the climacteric stage during storage could be attributed to the increase in as corbate oxidase activity. Destruction of vitamin C is a consequence of alteration of fruits metabolic oxidation pathways by radiation, which can convert vitamin C into dehydroascorbic acid, which can still be metabolized as vitamin C (Snauwart, 1973).

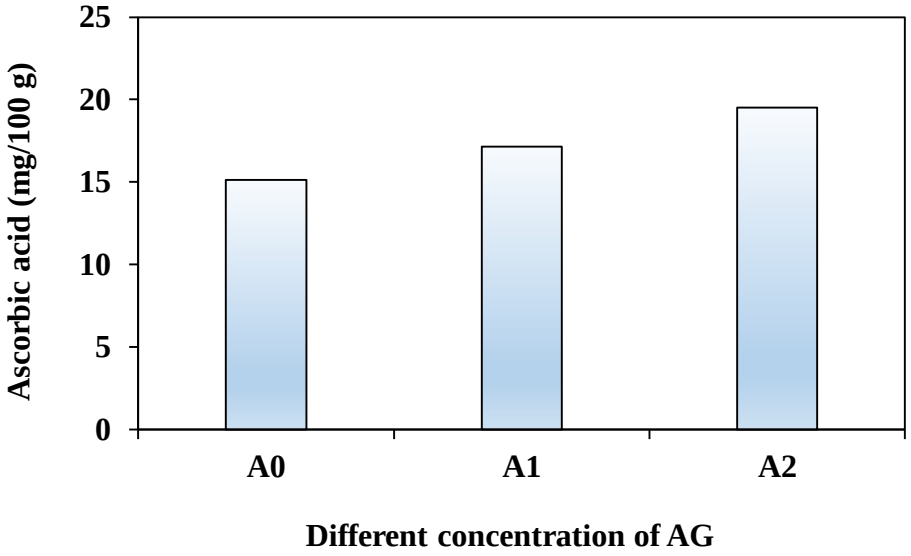
Significant variation was reported in case of different concentration of aloe vera gel like highest (19.52 mg/100g) value of ascorbic acid was noticed in fruits treated with 100% aloe vera gel followed by 50% aloe vera gel treated fruits (17.16 mg/100 g) and lowest (15.12 mg/100 g) value was recorded in control condition (Figure 12).

The results are in agreement with the research findings narrated by Bristi *et al.* (2013) that ascorbic acid content was higher in Aloe vera coated papaya fruits (86.55 mg) than the control fruits (61.10 mg) during the storage period at temperatures 25°C-29°C and 82-84% RH. This was because low oxygen permeability of coating delayed the deteriorative oxidation reaction of ascorbic acid content (Ayranci and Tunc 2003). Srinu *et al.* (2012) stated that coating reduces respiration of the fruits and retains the ascorbic acid in the fruits.



Ra0: Control, Ra1: 0.25 kGy, Ra2: 0.50 kGy, Ra3: 0.75 kGy, Ra4: 1 kGy

Figure 11. Effect of irradiation on vitamin C content of tomato at different days after storage (DAS)



A0: Control, A1: 50% aloe vera gel, A2: 100% aloe vera gel

Figure 12. Effect of aloe vera gel on vitamin C content of tomato at different days after storage (DAS)

The combined effect of biopreservatives and radiation in respect of ascorbic acid were found to be significant. The maximum (26 mg/100 g) value was recorded in Ra3A2 (100% Aloe vera coated fruits irradiated with 0.75 kGy radiation) combination followed by Ra3A1 (50% aloe vera gel treated fruits irradiated with 0.50 kGy radiation) combination where the value was 23.30 mg/100 g. On the other hand, minimum (10.08 mg/100 g) value was recorded in Ra0A0 (control) fruits (Table 6).

Table 6. Combined effect of radiation dozes and different concentration of aloe vera gel on the Ascorbic acid content of tomato pulp at 15 days after storage

Treatments	Ascorbic acid (mg/100 g)
Ra_0A_0	**10.08 k^z**
Ra_0A_1	11.20 j
Ra_0A_2	12.60 i
Ra_1A_0	12.30 i

Ra_1A_1	16.20 g
Ra_1A_2	19.00 f
Ra_2A_0	19.20 f
Ra_2A_1	20.00 e
Ra_2A_2	21.00 d
Ra_3A_0	22.00 c
Ra_3A_1	23.30 b
Ra_3A_2	**26.00 a**
Ra_4A_0	12.00 i
Ra_4A_1	15.00 h
Ra_4A_2	19.00 f
LSD (0.01)	0.7547
SE	0.1740
CV%	1.23

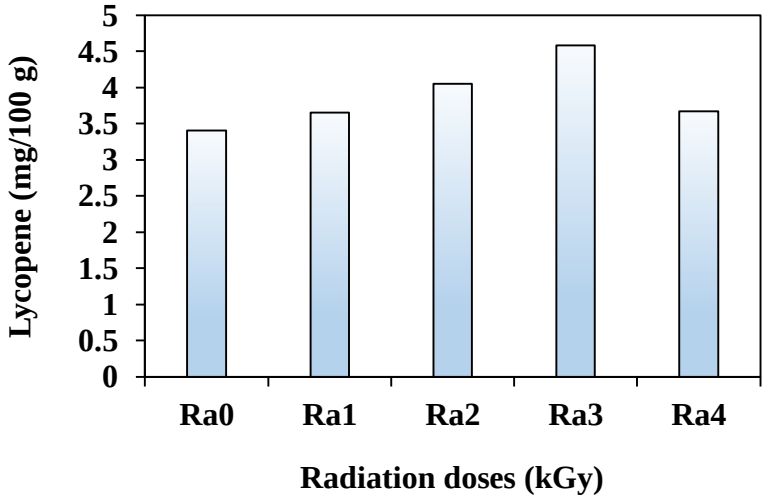
Ra_0: Control, Ra_1: 0.25 kGy, Ra_2: 0.50 kGy, Ra_3: 0.75 kGy, Ra_4: 1 kGy, A_0 : Control, A_1 : 50% Aloe vera, A_2 : 100% Aloe vera; [z]Means with different letters significantly differ at LSD's test at $P \leq 0.01$; CV: Coefficient of Variation; SE: Standard Error; LSD: Least Significant Difference.

4.7 Lycopene content

There was a significant variation in lycopene content of tomato during storage due to radiation and coatings. (Table 7, Appendix III). The maximum value (4.58 mg/100g) of lycopene was recorded for Ra3 (0.75 kGy radiation) followed by Ra2 (0.50 kGy irradiated fruits), the value was 4.05 mg/100 g and the minimum (3.40 mg/100 g) value was recorded for control fruits (Ra0) (Figure 13).

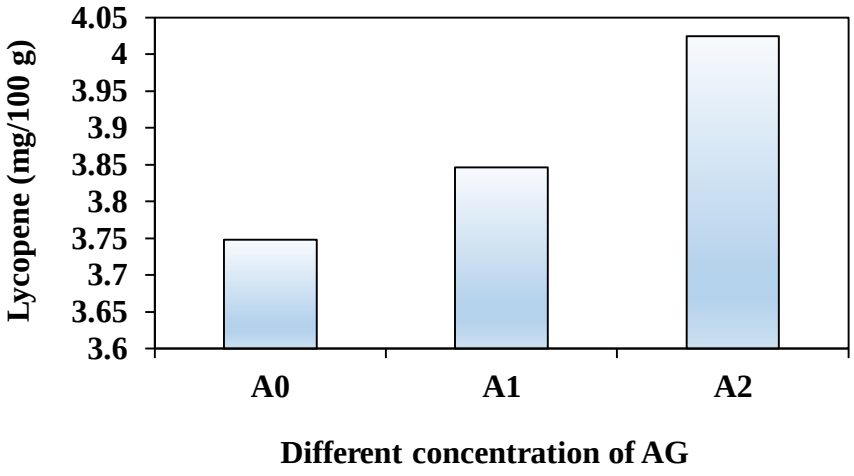
The maximum value (4.02 mg/100 g) was recorded in 100% aloe vera gel coated fruits (A2) followed by 3.85 mg/100 g in 50% aloe vera gel coated fruits whereas minimum value (3.75 mg/100 g) was recorded for controlled fruits (Figure 14).

Drastic breakdown of chlorophyll was recorded as ripening progressed. The destruction of chlorophyll from green to ripe stages may be due to the extensive accumulation of the carotenoids such as β-carotene and lycopene at turner and ripe stages (Rabinowitch *et. al*). As tomatoes developed from mature green to ripe, the increase in carotenoids content was related to the increase in lycopene content (Fraser *et. Al.,* 1994). The lycopene content can said to be a good index to the level of maturation.



Ra0: Control, Ra1: 0.25 kGy, Ra2: 0.50 kGy, Ra3: 0.75 kGy, Ra4: 1 kGy

Figure 13. Effect of irradiation on lycopene content of tomato at different days after storage (DAS)



A0: Control, A1: 50% aloe vera gel, A2: 100% aloe vera gel

Figure 14. Effect of aloe vera gel on lycopene content of tomato at different days after storage (DAS)

Combined effect of radiation and aloe vera gel appeared significant differences. The above interaction table showed that highest (5.00 mg/100 g) lycopene content was recorded in Ra3A2 (100% aloe vera gel coated fruits irradiated with 0.75 kGy) combination followed by Ra3A1 (50% aloe vera gel coated fruits irradiated with 0.50 kGy) combination with 4.46 mg/100 g lycopene and the lowest lycopene content (3.25 mg/100 g) of tomato was noticed in Ra0A0 (Controlled fruits) combination (Table 7).

Table 7. Combined effect of radiation and AG on the lycopene content of tomato pulp at 15 days after storage

Treatments	Lycopene content (mg/100 g)
Ra_0A_0	**3.25 i^z**
Ra_0A_1	3.43 h
Ra_0A_2	3.52 gh
Ra_1A_0	3.61 fg
Ra_1A_1	3.65 fg
Ra_1A_2	3.69 ef

Ra_2A_0	4.00 d
Ra_2A_1	4.05 d
Ra_2A_2	4.12 d
Ra_3A_0	4.29 c
Ra_3A_1	4.46 b
Ra_3A_2	**5.00 a**
Ra_4A_0	3.59 fg
Ra_4A_1	3.64 fg
Ra_4A_2	3.79 e
LSD (0.01)	0.13
SE	0.0302
CV(%)	0.95

Ra_0: Control, Ra_1: 0.25 kGy, Ra_2: 0.50 kGy, Ra_3: 0.75 kGy, Ra_4: 1 kGy, A_0 : Control, A_1 : 50% Aloe vera, A_2 : 100% Aloe vera; [z]Means with different letters significantly differ at LSD's test at $P \leq 0.01$; CV: Coefficient of Variation; SE: Standard Error; LSD: Least Significant Difference.

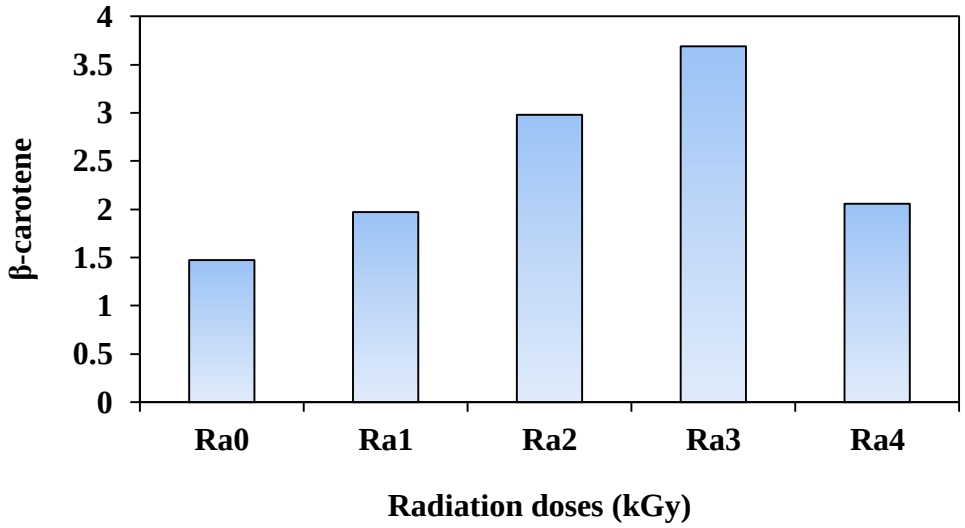
4.8 β-carotene

β-carotene content of tomato pulp showed significant variations in case of radiation and aloe vera gel and their combined effects also appeared to be significant (Table 8, Appendix III).

The highest (3.69 mg/100g) β-carotene content was recorded in 0.75 kGy irradiated fruits followed by 0.50 kGy irradiated fruits, 1 kGy, 0.25 kGy and lowest (1.47 mg/100g) β-carotene content was recorded in controlled (Ra0) fruits (Figure 15).

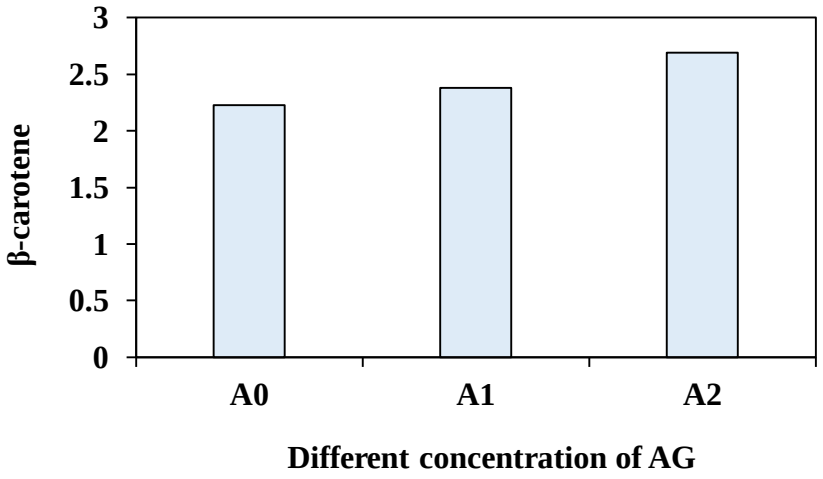
The highest (2.69 mg/100g) β-carotene content was recorded in 100% AG (A2) coated fruits followed by (2.38 mg/100g) 50% AG (A1) treated fruits and lowest (2.23 mg/100g) β-carotene content was noticed in controlled (A0) fruits (Figure16). Aloe vera gel formed a layer on the fruit; it kept the fruit temperature low as a result the respiration rate was slow. So, the coated fruits reached to their best edible stage

in 15 days. On the contrary, as fruit temperature was high the respiration rate was high in control or untreated fruits, so they reached to ripen stage earlier than coated fruits and get spoiled before.



Ra0: Control, Ra1: 0.25 kGy, Ra2: 0.50 kGy, Ra3: 0.75 kGy, Ra4: 1 kGy

Figure 15. Effect of irradiation on β-carotene content of tomato at different days after storage (DAS)



A0: Control, A1: 50% aloe vera gel, A2: 100% aloe vera gel

Figure 16. Effect of aloe vera gel on β-carotene content of tomato at different days after storage (DAS)

It was seemed that highest (3.83 mg/100 g) β-carotene content was recorded in Ra3A2 (100% Aloe vera treated fruits irradiated with 0.75 kGy radiation) combination and lowest (1.22 mg/100 g) value was recorded in Ra0A0 (Controlled fruits) combination. Moreover, Ra3A1 (50% aloe vera gel treated fruits irradiated with kGy) where the value was 3.78 mg/100 g also showed significantly higher β-carotene content (Table 8).

Table 8. Combined effect of radiation and aloe vera gel on the β-carotene content of tomato pulp at 15 days after storage

Treatments	**β-carotene content (mg/100 g)**
Ra_0A_0	**1.22 i**[z]
Ra_0A_1	1.39 h
Ra_0A_2	1.80 g
Ra_1A_0	1.82 g
Ra_1A_1	1.86 g
Ra_1A_2	2.23 g
Ra_2A_0	2.80 f
Ra_2A_1	2.97 d
Ra_2A_2	3.15 cd
Ra_3A_0	3.48 c
Ra_3A_1	3.75 ab
Ra_3A_2	**3.83 a**
Ra_4A_0	1.83 g
Ra_4A_1	1.90 g
Ra_4A_2	2.45 e
LSD (0.01)	**0.2161**
SE	**0.0498**
CV(%)	**2.50**

Ra_0: Control, Ra_1: 0.25 kGy, Ra_2: 0.50 kGy, Ra_3: 0.75 kGy, Ra_4: 1 kGy, A_0 : Control, A_1 : 50% Aloe vera, A_2 : 100% Aloe vera; [z]Means with different letters significantly differ at LSD's test at $P \leq 0.01$; CV: Coefficient of Variation; SE: Standard Error; LSD: Least Significant Difference.

4.9 Visual scoring of tomato skin

A significant change in the skin of tomato was recorded. Tomato skin was scored by eye estimation (Plate 3, 4).

4.9.1 Severity on the basis of shrinkage

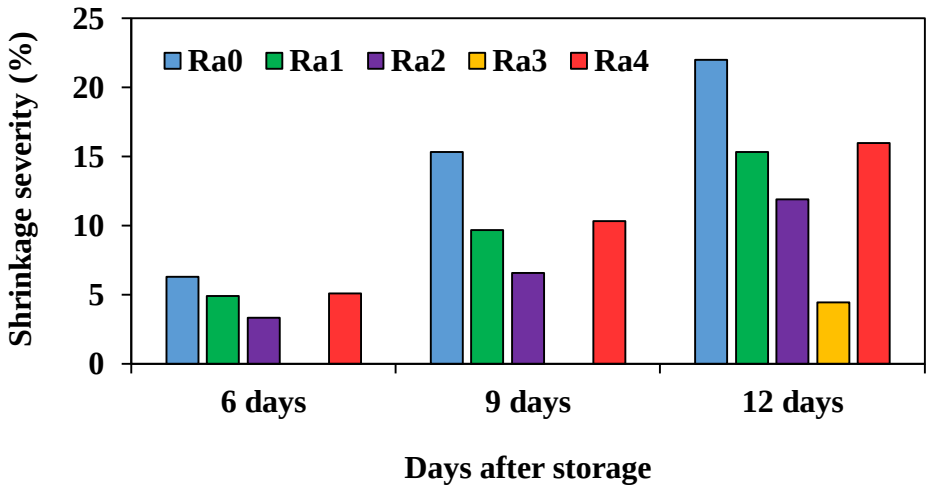
Shrinkage of fruits is sometimes referred as deformation of material, and it is an obvious physical phenomenon commonly recorded during storage. Radiation and Postharvest biopreservatives had significant effect on shrinkage severity in tomato skin (Table 9, Appendix IV).

The maximum (7%, 14.56%, 21.33% and 27.22% at 6th, 9th, 12th and 15th DAS) shrinkage severity was recorded in Ra0 (Controlled fruits) and minimum (0%, 3.44%, 7.00% and 11.33% at 6th, 9th, 12th and 15th DAS) value was noticed in Ra3 (0.75 kGy irradiated fruits). 0.50 kGy (Ra2) irradiated fruits also showed the second lowest (0%, 4.44%, 8.33% and 12.33% at 6th, 9th, 12h and 15th DAS) shrinkage value (Figure 17).

Highest (4.40%, 11.47%, 20.40% and 30.20% at 6 th, 9th, 12th and 15th DAS) severity occurred in controlled fruits (A0) and lowest (0% up to 15th day) value was recorded in (A2) 100% aloe vera gel coated fruits (Figure 18).

The above finding is supported by Touil *et al.* (2014). She stated that shrinkage occurs as a result of volume reduction due to evaporation of the moisture contained in the solid. She included that coating improves physical condition of fruits against shrinkage. As controlled fruits lost high amount of water they got huge shrinkage. But aloe vera provided with barrier reduce water loss through lenticel. Thus

shrinkage was lowest. Like as, high radiation doze activates water loss and promote shrinkage.

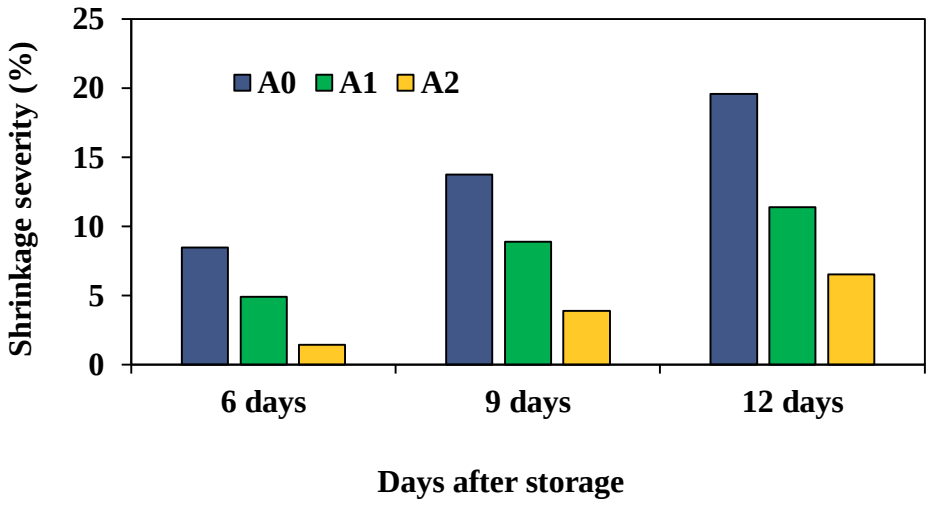


Ra0: Control, Ra1: 0.25 kGy, Ra2: 0.50 kGy, Ra3: 0.75 kGy, Ra4: 1 kGy

Figure 17. Effect of irradiation on shrinkage severity (%) of tomato at different days after storage (DAS)

0 1 2 3 4 5

Plate 3: Visual scoring of tomato on the basis of shrinkage at 15 days after storage, Where, 0= no shrinkage, 1= 1-10% shrinkage, 2= >10-20% shrinkage, 3= >20-30% shrinkage, 4= 30-40% shrinkage, 5= >40% shrinkage of mango skin



A0: Control, A1: 50% aloe vera gel, A2: 100% aloe vera gel

Figure 18. Effect of aloe vera gel on shrinkage severity (%) of tomato at different days after storage (DAS)

The significant variation recorded in combined effect of radiation and aloe vera gel on shrinkage severity of tomato. The highest (9.33%, 15.00%, 24.00% and 33.33% at 6^{th},9^{th},12^{th} and 15^{th} DAS) value was recorded in Ra0A0 combination and lowest value (0 up to 15th day) was recorded in Ra3A2 (100% aloe vera gel coated fruits irradiated with kGy), Ra3A1 (50% Aloe vera treated fruits irradiated with 0.75 kGy), Ra3A0 (fruits irradiated with 0.75 kGy) and Ra2A2 (100% aloe vera gel coated fruits irradiated with 0.75 kGy) combinations (Table 9).

Table 9. Combined effect of radiation and aloe vera gel on shrinkage severity (%) of tomato at different days after storage (DAS)

Treatments	Shrinkage severity (%)		
	6 DAS	9 DAS	12 DAS
Ra_0A_0	**9.50** a^z	**20** a	**27.67** a
Ra_0A_1	7.33 bc	15 b	22.33 ab
Ra_0A_2	2.67 g	11 cde	16 cde

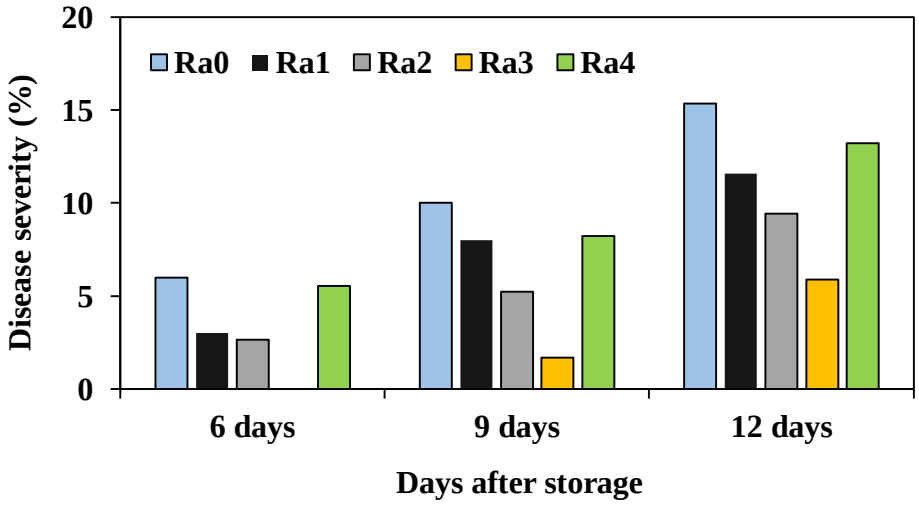
Ra_1A_0	2.33 g	12.67 bcd	20.33 bcd
Ra_1A_1	5.00 de	10 cdef	15 def
Ra_1A_2	2.33 g	6.33 f	10.67 ef
Ra_2A_0	7.00 bc	11 cde	18.67 bcd
Ra_2A_1	3.00 fg	8.67 def	12 ef
Ra_2A_2	**0.00** h	**0** g	5 gh
Ra_3A_0	**0.00** h	**0** g	10 fg
Ra_3A_1	**0.00** h	**0** g	3.33 h
Ra_3A_2	**0.00** h	**0** g	**0** h
Ra_4A_0	8.67 ab	13.33 bc	21.33 bc
Ra_4A_1	4.67 ef	10.67 cdef	16 cde
Ra_4A_2	2.00 g	7 ef	10.67 ef
LSD (0.01)	1.88	4.35	5.61
SE	0.4346	1.0037	1.2939
CV (%)	13.57	14.67	11.37

Ra_0: Control, Ra_1: 0.25 kGy, Ra_2: 0.50 kGy, Ra_3: 0.75 kGy, Ra_4: 1 kGy, A_0 : Control, A_1 : 50% Aloe vera, A_2 : 100% Aloe vera; [z]Means with different letters significantly differ at LSD's test at $P \leq 0.01$; CV: Coefficient of Variation; SE: Standard Error; LSD: Least Significant Difference.

4.9.2 Severity on the basis of disease

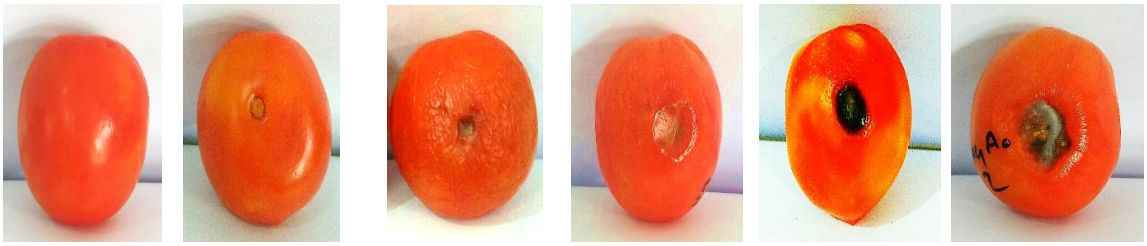
Different doses of irradiation have significant variation to disease severity. (Table 10, Appendix V). It was recorded that irradiation had significant effect on disease severity of tomato skin. The highest (6%, 10.00% and 15% at 6^{th}, 9^{th} and 12^{th} DAS) value was recorded in Ra0 (Controlled fruits) and lowest (0%, 1.67% and 5.88% at 6^{th}, 9^{th} and 12^{th} DAS) value was obtained from Ra3 (0.75 kGy irradiated fruits) (Figure 19).

It was recorded that aloe vera gel had significant effect on disease severity of tomato skin. The highest (5.73%, 10.2% and 15.2% at 6th, 9th and 12th DAS) value was recorded in A0 and lowest (1.2%, 3.13% and 6.73% at 6th, 9th and 12th DAS) value was obtained from A2 (100% aloe vera gel coated fruits) (Figure 20). From the above discussion it is clear that severity of disease on tomato fruits increased with the advancement of time. It is seemed coated fruits are tend to infect less than controlled fruits. This finding is similar with Molla *et al.* (2011). Fungal diseases account for one of the main causes of loss during commercialization of tropical fruits. The extracts collected from different medicinal plants like neem, garlic and aloe vera were found most effective to check the mycelial growth of C. *gloeosporioides* and these findings were strongly supported by Raheja and Thakore (2002). Scientist EI-Ghaouth *et al.* (1992) who reported that aloe vera coating prevent attack of tomatoes by *Penicillium* spp., *Aspergillus* spp., *Rhizopus stolonifer* and *Botrytis cinerea*. It helps to extend the shelf life by limiting the growth of fungi and decrease the spoilage without affecting ripening process of fruits.



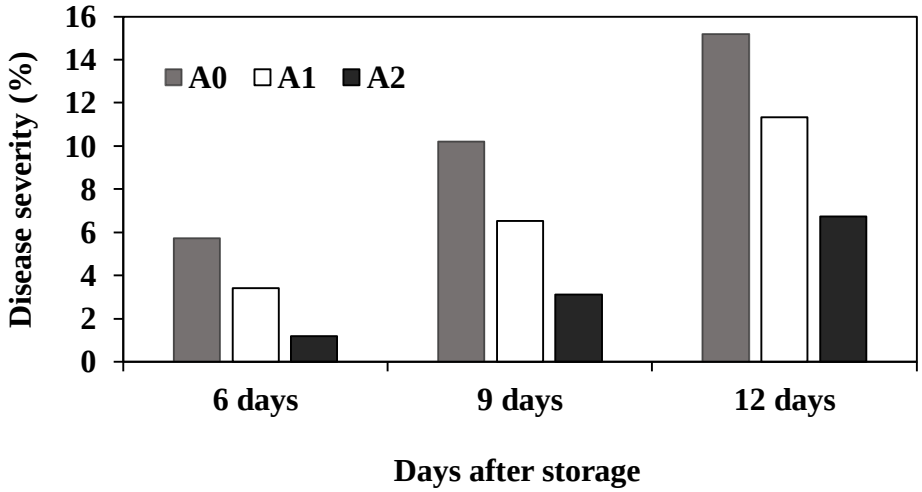
Ra0: Control, Ra1: 0.25 kGy, Ra2: 0.50 kGy, Ra3: 0.75 kGy, Ra4: 1 kGy

Figure 19. Effect of irradiation on disease severity (%) of tomato at different days after storage (DAS)



0 1 2 3 4 5

Plate 4: Visual scoring of mango on the basis of disease severity at 15 days after storage where, 0= no infection, 1= 1-10% infected, 2= >10-20% infected, 3= >20-30% infected, 4= >30-40% infected, 5= >40% infected by disease.



A0: Control, A1: 50% aloe vera gel, A2: 100% aloe vera gel

Figure 20. Effect of aloe vera gel on disease severity (%) of tomato at different days after storage (DAS)

The combined effects of irradiation and aloe vera gel were statistically significant (Table 10). Highest (9.67%, 15% and 22.00% at 6^{th}, 9^{th} and 12^{th} DAS) disease severity was recorded in Ra0A0 combination. On the contrary, Lowest (0,0 and 2.00% at 6^{th},9^{th} and 12^{th} DAS) disease severity was recorded in Ra3A2 (Table 10).

Table 10. Combined effect of radiation and aloe vera gel on disease severity (%) of tomato at different days after storage (DAS)

Treatments	**Disease severity (%)**		
	6 DAS	**9 DAS**	**12 DAS**
Ra_0A_0	9.67 a[z]	15 a	22 a
Ra_0A_1	5 d	10 b	16.33 b
Ra_0A_2	2 g	5.00 de	7.67 ef
Ra_1A_0	6 c	11.33 b	14 bc
Ra_1A_1	3 f	8.0 b-e	12 cd
Ra_1A_2	0 h	4.67 ef	8.67 def
Ra_2A_0	5 d	8.33 bcd	12.67 bcd
Ra_2A_1	3 f	6.0 cde	10.67 cde
Ra_2A_2	0 h	1.33 fg	5.00 fg
Ra_3A_0	0 h	5.00 de	10.67 cde
Ra_3A_1	0 h	0 g	5.00 fg
Ra_3A_2	0 h	0 g	2.00 g
Ra_4A_0	8 b	11.33 b	16.67 b
Ra_4A_1	6 c	8.67 bc	12.67 bcd
Ra_4A_2	4 c	4.67 ef	10.33 cde
LSD (0.01)	**0.5281**	**3.4628**	**4.1915**
SE	**0.1217**	**0.7981**	**0.9661**
CV (%)	**4.33**	**14.76**	**10.67**

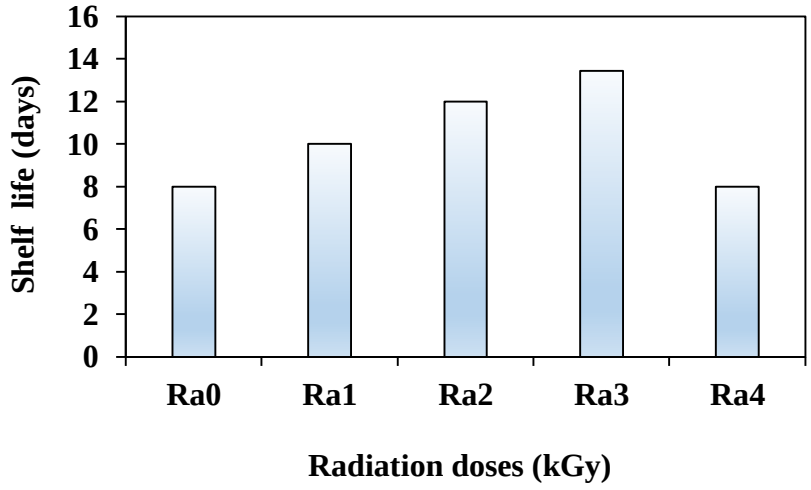
Ra_0: Control, Ra_1: 0.25 kGy, Ra_2: 0.50 kGy, Ra_3: 0.75 kGy, Ra_4: 1 kGy, A_0: Control, A_1 : 50% Aloe vera, A_2 : 100% Aloe vera; [z]Means with different letters significantly differ at LSD's test at $P \leq 0.01$; CV: Coefficient of Variation; SE: Standard Error; LSD: Least Significant Difference.

4.10 Shelf life:

The basic quality index of fruit is shelf life and it is the most important parameter in loss of biochemical reaction of fruit. This shelf life period begins from the time of harvesting and extends up to the start of rotting of fruit. In this present study shelf life was determined by eye estimation. Highly significant variation was recorded in respect of shelf life of tomato due to the effect of different radiation dose and different concentration of aloe vera gel (Table 11, Appendix VI). Throughout the present work, the shelf life of tomato was significantly enhanced after gamma radiation treatment. The effect of gamma irradiation on the shelf life of tomatoes was significantly increased. It could be mentioned that highest (18 Days) shelf life of tomato fruits was belong to 0.75 kGy irradiation dose (Ra3) followed by 0.50 kGy (Days) irradiated fruits and lowest (Days) shelf life was declared in controlled fruits (Ra0) (Figure 21). In a similar study, Jeong *et al.*, (2015) achieved shelf life extension of pepper by subjecting them to different doses of gamma radiation. During their work Santor *et al.*, (2016) also reported enhanced shelf life after treatment with gamma radiation at a dose of 3.2 kGy.

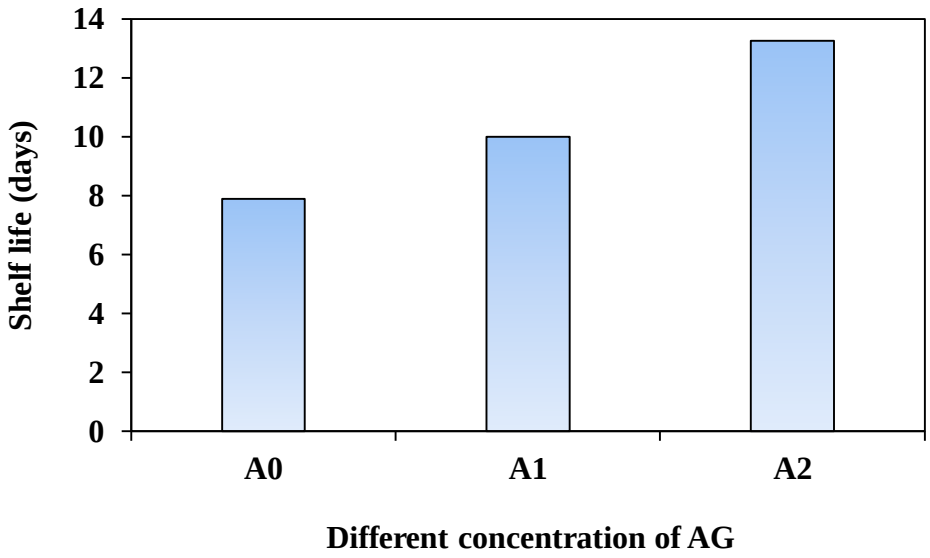
The highest (13 Days) shelf life was noted down in A2 and lowest (7 Days) shelf life was found in A0 (controlled fruit) (Figure 22). In 100% aloe vera gel (A2) coated fruits almost all the fruits were remained in their excellent condition except slight spots on the untreated control fruits. But the control fruits were slightly spoiled due to lack of any treatment. The aloe vera gel based edible coatings were found superior in maintaining all the physiological parameters compared with untreated fruits. The mature green fruits not coated with aloe vera gel showed higher weight loss, Respiration rate and least membrane integrity compared with the aloe gel coated coated mature green fruits. Similar results reveals that aloe vera gel coating was found effective in controlling water loss from commodities like, sweet cherry (Martinez *et al.,* 2006), Granny Smith and Red Chief apple (Ergun, and Satici, 2012). The least weight loss and respiration rate resulted in more integrity for the membranes and thereby giving a better firmness for the fruits. The loss in

firmness or higher membrane integrity of the tomato fruits was due to the delay in softening due to the effect of aloe vera gel. This was Supported by (Aguiar *et al.*, 2011) that aloe vera gel modified The internal gas composition of mangoes causing reduction of cell wall degrading-enzymes responsible for mango softening Similar to the present results, aloe vera gel based edible coatings was effective to prevent loss of moisture and firmness, control respiratory rate in fruits such as table grapes (Castillo *et al.*, 2010), sweet cherries (Martinez *et al.*, 2006) and nectarines (Ahmed *et al.*, 2009). Sophia *et al.*, (2014) revealed that the potential of using aloe vera gel as a coating for improved postharvest shelf life and maintaining quality of tomato fruits and hence reduced postharvest losses.



Ra0: Control, Ra1: 0.25 kGy, Ra2: 0.50 kGy, Ra3: 0.75 kGy, Ra4: 1 kGy

Figure 21. Effect of irradiation on shelf life of tomato



A0: Control, A1: 50% aloe vera gel, A2: 100% aloe vera gel

Figure 22. Effect of aloe vera gel on shelf life of tomato

The combination effect also showed significant differences among irradiation and aloe vera gel. As 0.75 kGy radiation provided with 100% aloe vera gel coatings had no disease or other quality deterioration. It was also spotted down in combination table. Fruits irradiated with 0.75 kGy and 100% aloe vera gel coatings (Ra3A2) combinations showed 19 days of shelf life and lowest (6.67 days) shelf life was recorded in Ra0A0 (Controlled fruits) (Table 11).

Table 11. Combined effect of radiation and aloe vera gel on shelf life of tomato

Treatments	Shelf life (Days)
Ra_0A_0	**6.67 h[z]**
Ra_0A_1	7.67 gh
Ra_0A_2	10.0 e
Ra_1A_0	8.00 fg
Ra_1A_1	10.00 e
Ra_1A_2	13.00 c
Ra_2A_0	9.00 ef
Ra_2A_1	11.67 d
Ra_2A_2	16.00 b
Ra_3A_0	9.00 ef
Ra_3A_1	13.00 c
Ra_3A_2	**18.33 a**
Ra_4A_0	7.00 gh
Ra_4A_1	8.00 fg
Ra_4A_2	9.00 ef
LSD (0.01)	1.05
SE	0.2434
CV(%)	2.86

Ra_0: Control, Ra_1: 0.25 kGy, Ra_2: 0.50 kGy, Ra_3: 0.75 kGy, Ra_4: 1 kGy, A_0 : Control, A_1 : 50% Aloe vera, A_2 : 100% Aloe vera; [z]Means with different letters significantly differ at LSD's test at $P \leq 0.01$; CV: Coefficient of Variation; SE: Standard Error; LSD: Least Significant Difference.

CHAPTER V

SUMMARY AND CONCLUSION

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SUMMARY AND CONCLUSIONS

5.1 Summary

The experiment was carried out at the Postharvest Laboratory of Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka during the period from August to October, 2019. The objectives of the present study were to investigate the effect of different irradiation doze and different concentration of aloe vera gel on shelf life of tomato and to evaluate the quality parameters of tomato after storage. In this two factorial experiment different irradiation dozes were denoted as Factor A and different concentration of aloe vera gel were denoted as Factor B. Four different irradiation dozes used in this study are: i) 0.25 kGy (Ra1), ii) 0.50 kGy (Ra2), iii) 0.75 kGy (Ra3), iv) 1 kGy (Ra4), untreated fruits marked as control (Ra0) and three different concentrations of aloe vera gel such as i) No aloe vera gel (A0) ii) 50% aloe vera gel (A1) and iii) 100% aloe vera gel (A2) were used in this experiment. The experiment was laid out in Completely Randomized Design (CRD). In this study observations were made on external and internal fruit attributes, physiochemical properties such as total weight loss, moisture content, pH, total soluble solid content, Ascorbic acid, lycopene content, visual scoring of mango skin on the basis of shrinkage severity, disease severity and shelf life. In this research work tomato of each treatments were collected randomly at three, six, nine, twelve and fifteen days after harvest for physiochemical studies. The data were statistically analyzed and elucidated. The results of the experiment expressed that almost all the parameters studied were significantly influenced by the above factors. Total fifteen postharvest treatments were applied in this experiment with control. Among all those treatments highest total weight loss (2.11%, 3.88%, 7.71%, 12.07% and 16.07% at 3^{rd}, 6^{Th}, 9^{th}, 12^{th} and 15^{th} DAS) was observed in controlled fruits (Ra0) and lowest value (0.%, 0.59%, 1.33% and 1.79% at 3^{rd}, 6^{Th}, 9^{th}, 12^{th} and 15^{th}

DAS) was noticed in 0.75 kGy irradiated fruits (Ra3). The highest moisture content (93.65%) was found in 0.75 kGy radiation doze (Ra3) and lowest (84%) was found in controlled fruits. Again, pH was found to be the highest (4.63) at the end of shelf life in untreated fruits (Ra0) whereas 0.75 kGy (Ra3) represented the lowest value(3.92). TSS value was mostly influenced by irradiation to keep its peak lowest level (3.79%) and highest value (5.18%) was obtained by untreated controlled fruits (Ra0). Lycopene content which was an important quality parameter of tomato showed maximum value (4.58%) for 0.75 kGy irradiated fruits and minimum value (3.40%) for controlled fruits (Ra0). TA value of tomato showed maximum value (1.07) for Ra3 (0.75 KGy irradiated fruits) and minimum value (0.43) was obtained from controlled (Ra0) fruits. Ascorbic acid content was found to be the highest (23.76 mg/100g) at the end of shelf life in case of 0.75 kGy irradiated fruits where controlled treatment (Ra0) represented the lowest ascorbic acid content (11.29 mg/100g). However, 0.75 kGy irradiated fruits represented the highest β-carotene content (3.69 mg/100 g) and controlled fruits represented lowest (1.47 mg/100g) βcarotene content. Shrinkage severity was maximum (6.28%, 15.33% and 22% at 6^{th}, 9^{th} and 12^{th} DAS) in Controlled fruits (Ra0) and minimum (0%, 0% and 4.44% at 6^{th}, 9^{th} and 12^{th} DAS) in 0.75 kGy irradiated fruits (Ra3). Disease severity was recorded to be significantly maximum (6%, 10.00% and 15.33% at 6^{th}, 9^{th} and 12^{th} DAS) in Ra0 (Controlled fruits) fruits and minimum (0%, 1.67% and 5.88% at 6^{th}, 9^{th} and 12^{th} DAS) in Ra3 (0.75 kGy irradiated fruits). Above parameter indicated that highest shelf life of mango (18 days) was belonged to 0.75 kGy irradiated fruits and lowest (8 days) shelf life was declared in controlled fruits (P0).

Total weight loss (1.55%, 2.93%, 5.87%, 8.30%, and 10.96% at 3^{rd}, 6^{Th}, 9^{th}, 12^{th} and 15^{th} DAS), moisture content of pulp (89.52%), pH value (4.41), TSS (4.67%), Lycopene (4.024), shrinkage severity (6.5%, 11.40% and 19.6% at 6^{th}, 9^{th} and 12^{th} DAS), disease severity (5.73%, 10.2% and 15.2% at 6^{th} , 9^{th} and 12^{th} DAS) value was found to be the highest in controlled (A0) fruits and lowest weight loss (0.95%, 1.79%, 3.72%, 5.18% and 6.91% at 3^{rd}, 6^{Th}, 9^{th}, 12^{th} and 15^{th} DAS), Moisture

content of pulp (86%), pH value (4.20), TSS (4.32%), shrinkage severity (1.4%, 4.87% and 8.47% at 6^{th} , 9^{th} and 12^{th} DAS), disease severity (1.2%, 3.13% and 6.73% at 6^{th}, 9^{th} and 12^{th} DAS) was recorded in 100% AG treated fruits (A2). On the other hand, highest value of TA (0.%), ascorbic acid (19.52 mg/100g), shelf life (13.26 Days) was found in 100% AG treated (A2) fruits and lowest TA (0.65%), ascorbic acid (15.11 mg/100g), shelf life (7.93 days) was found in controlled (A0) fruits.

The combined effect between irradiation and aloe vera gel as postharvest biopreservative were found that maximum (2.53%, 4.48%, 9.30%, 14.28% and 18.60% at 3^{rd}, 6^{Th}, 9^{th}, 12^{th} and 15^{th} DAS) rate of weight loss, pH value (4.68), β-carotene (3.83 mg/100 g) was observed in Ra0A0 and minimum weight loss (0%, 0.26%, 0.52%, 0.66% and 0.80% at 3^{rd} , 6^{Th}, 9^{th}, 12^{th} and 15^{th} DAS), pH value (3.74), β-carotene (mg/100 g) was recorded in Ra3A2. In case of moisture content 95.65% was observed in Ra3A2 and lowest was determined in Ra0A0 combination. Again the significant effect of treatments on TSS gave the maximum value (5.24%) in Ra0A0 and minimum (3.44%) in Ra3A2. In case of interaction effect, highest (1.13%) TA value was recorded in and the lowest (0.39%) value was noticed in combination. In the present study, the maximum (26 mg/100 g) value of Ascorbic acid was observed in Ra3A2 and minimum (10.08 mg/100ng) in Ra0A0 combination. In case of shrinkage severity maximum value (9.5%, 20.00% and 27.67% at 6^{th} , 9^{th} and 12^{th} DAS) was determined in Ra0A0. Lowest (0%, 0% and 2% at 6^{th}, 9^{th} and 12^{th} DAS) disease severity was recorded in Ra3A2 combination and highest disease severity was recorded in Ra0A0 combination. Maximum Lycopene content (5.00 mg/100 g) was recorded in Ra3A2 combination and minimum lycopene (3.25 mg/100 g) was recorded in controlled fruits. Combined effect declared that highest shelf life (18.33 days) was recorded in 0.75 kGy irradiated fruits coated with 100% aloe vera gel and lowest (6.67 days) was found in controlled fruits.

5.2 Conclusion

Aloe vera gel and irradiation effectively reduced weight loss, delayed ripening, locked up moisture, and checked the pH, TA, ascorbic acid content of tomato. But considering the appearance and quality both, Aloe vera should be the best option as it reduced loss of moisture, lowered TSS value, shrinkage severity and disease severity and improved shelf life. Moreover, no skin browning was appeared. So, it can be concluded that to maintain the freshness and quality of tomato fruits, 0.75 kGy irradiation doze with 100% aloe vera gel coated fruits seemed to be the best preservative.

CHAPTER VI

REFERENCES

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CHAPTER VII

APPENDICES

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Appendix I: Effect of irradiation and AG on weight loss (%) of tomato at different Days after storage (DAS)

Mean square	Degrees of freedom	Mean square of weight loss at different days after harvest				
		3	6	9	12	15
Replication	2	0.1348**	0.2370**	0.219**	0.966**	0.846**
Factor A	4	4.2539**	14.657**	59.96**	156.84**	270.5**
Factor B	2	1.3562**	4.9365**	18.21**	37.16**	61.67**
AB	8	0.0343**	0.1664**	1.499**	3.66**	4.650**
Error	28	0.007**	0.0117**	0.004**	0.13**	0.061**

**Significant at 1% level of significance

Appendix II: Effect of irradiation and AG on moisture content and pH of tomato at different days after storage (DAS)

Mean square	Degrees of freedom	Mean square at the end of shelf life	
		Moisture	pH
Replication	2	14.437**	0.01094**
Factor A	4	154.503**	0.73815**
Factor B	2	26.266**	0.15869**
AB	8	0.654**	0.00558**
Error	28	1.059**	0.00080**

**Significant at 1% level of significance

Appendix III: Effect of irradiation and AG on TSS, TA, vitamin C, lycopene and β-carotene of tomato at different days after storage (DAS)

Mean square	Degrees of freedom	Mean square at the end of shelf life				
		TSS	TA	Vit-C	Lycopene	β-carotene
Replication	2	0.079**	0.0107**	0.107**	0.0027**	0.035**
Factor A	4	0.453**	0.5966**	206.4**	1.9161**	7.1257**
Factor B	2	2.573**	0.6030**	72.83**	0.2936**	0.8282**
AB	8	0.028**	0.0013**	4.456**	0.0558**	0.0344**
Error	28	0.01034**	0.000**	0.045**	0.0013**	0.0037**

**Significant at 1% level of significance

Appendix IV: Effect of postharvest radiation and AG on shrinkage severity (%) of tomato at different days after storage (DAS)

Mean square	Degrees of freedom	Mean square of shrinkage severity (%) of tomato skin at different days after harvest		
		6	9	12
Replication	2	1.2708**	9.483**	7.781**
Factor A	4	34.1818**	187.422**	243.057**
Factor B	2	95.628**	163.08**	465.267**
AB	8	16.3962**	62.9857**	70.380**
Error	28	0.2068**	0.921**	1.819**

**Significant at 1% level of significance

Appendix V: Effect of postharvest radiation and AG on disease severity (%) of tomato at different days after storage (DAS)

Mean square	Degrees of freedom	Mean square of disease severity (%) of tomato at different days after harvest		
		6	9	12
Replication	2	0.0222**	2.822**	12.422**
Factor A	4	53.22**	95.36**	118.18**
Factor B	2	77.08**	187.356**	269.48**
AB	8	6.42**	4.46**	11.23**
Error	28	0.02**	0.95**	1.4**

**Significant at 1% level of significance

Appendix VI: Effect of postharvest radiation and AG on shelf life of tomato

Mean square	Degrees of freedom	Mean square of Shelf life
Replication	2	0.089**
Factor A	4	53.078**
Factor B	2	108.089**
AB	8	6.478**
Error	28	0.089**

**Significant at 1% level of significance