

Research Article

Effect of Gamma Radiation on Tomato Quality during Storage and Processing

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Abstract: Fruits of two tomato cultivars Amani and Beto86 were exposed to gamma rays doses of 0.25, 0.50 and 1.00 KGy at mature green stage during 2010\2011 season to delay their ripening period and hence extend their shelf life. Tomato fruits were stored at $15\pm 1^{\circ}\text{C}$ (85-90% R.H) and examined for physiological and physicochemical changes during storage period. Organoleptic qualities were made for Beto86 tomato paste and fresh slices prepared from Amani tomato cultivar. Irradiation treatments doubled the shelf life of tomato fruits in both cultivars. Gamma radiation treatment at all doses has decreased significantly ($p\leq 0.05$) the weight loss, respiration rate and delay the softening of tomato fruits in both cultivars. The maximum level of ascorbic acid, total soluble solids and total sugars was reached in more time with irradiated fruits compared to untreated fruits. No significant difference was observed in tomato paste made from Beto 86 and fresh tomato slices prepared from Amani fruits among the treated fruits in terms of color, texture, taste and flavor and over all acceptability.

Keywords: Cultivars, irradiation, processing, quality, storage, tomato

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is one of the most important vegetable crops in Sudan and is grown commercially in every state in the country. The production of tomato in Sudan has been increasing steadily up to 145909 ha (FAO, 2009). Tomato is a winter crop in Sudan and is harvested during summer (March-April) which is characterized by high temperature and low relative humidity. These conditions generally result in excessive water loss, faster ripening and greater deterioration of the produce.

Tomatoes are climacteric in nature (Saltveit, 2005). Climacteric fruits submitted to gamma irradiation exhibit a delay of ripening (Akamine and Moy, 1983; Urbain, 1986; Thomas, 1988). 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; Lee *et al.*, 1968; Thomas, 1988).

This study was carried out to evaluate the effect of gamma irradiation on quality of fresh and processed tomato fruits.

MATERIALS AND METHODS

Mature green fruits of Amani and Beto 86 tomato cultivars were harvested from Demonstration farm of Agricultural Research Station, Khartoum North, Shambat ($15^{\circ}40'N$, $32^{\circ}22'E$) during 2010\2011 season. Fruits were selected for uniformity of size, color and

freedom from blemishes. Fruits were washed with tap water to remove latex and dust, dried and transported in carton boxes. The fruits of each cultivar were distributed among the three treatments in complete randomized design with three replications. The tomato fruits were exposed to three doses of gamma rays which included 0.25 KGy for 5 min 48 sec; 0.5 KGy for 11 min 38 sec and 1.0 KGy for 23 min 17 sec. Irradiation source was cobalt 60 (gamma cell 220 excel). The doses were calculated according to the International Atomic Energy Agency (IAEA) absorbed dose was measured as 0.25; 0.50 and 1.00 KGy and calculated in j/KGy IAEA (1982).

The irradiation treatments were carried out at the laboratory of Ali Kaila radiation processing lab, Chemistry and Nuclear Physics Institute, in Sudan Atomic Energy Commission (SAEC), Soba. All irradiated and non irradiated (control) tomato fruits were packed in carton boxes and stored in cold room ($15\pm 1^{\circ}\text{C}$ and 85-90% RH) at Food Research center (Khartoum North-Shambat).

The physiological and physicochemical tests were run immediately after irradiation treatment and during storage at suitable intervals.

Physiological analysis: Loss weight (%) in fruits was determined directly every 3 days according to the equation: $W1 = [(W0 - Wt)] / 100\%$; where W1 is the percentage weight Loss, W0 is the initial weight of fruits at harvested, Wt is the weight of fruits at the designated time. Respiration Rate (mgCO_2/kg

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fruit/hour) was determined every 3 days in 14 fruits from each replicate using the total absorption method of Charlimers (1956). Fruit flesh firmness was measured by the Magness and Taylor firmness tester (D. Ballan Meg. Co.) equipped with an 8mm diameter plunger tip. Flesh Firmness was expressed in Kilograms per square centimeter. Two readings were taken from the opposite sides of each fruit.

Physiochemical analysis: Total soluble solids was measured directly from the fruit juice using Krus hand refractometer (model HRN.32) at 20°C and expressed as percent or degree Brix (AOAC, 1990). Titratable acidity was determined according to the method described by Board (1988) and expressed as percent citric acid. Ascorbic acid (mg/100) was determined using the 2, 6-dichlorophenol-endophenol titration method of Ruck (1963). Total Sugar was determined, in the pulp extract according to the Anthrone method of Yem and Willis (1954). Total Sugars were expressed as percent of fresh weight.

Organoleptic analysis: After the ripening of tomatoes, fruits were selected for processing paste from Beto 86 cultivar, tomato were washed and pulped then put in a boiler to reach the same soluble solids concentration of tomato paste and cold homogenized. After that paste was analyzed for organoleptic quality. Tomato fruits were assessed organoleptically following the ranking test according to the procedure described by Ihekononye and Ngoddy (1985). The panelists were asked to evaluate color, flavor, taste, texture and recorded overall acceptability preference.

Statistical Analysis System (SAS) followed by least significant difference with a significance level of ($p \leq 0.05$) were performed on all data.

RESULTS AND DISCUSSION

Physiological parameters:

Weight loss: Compared to the control (non treated tomato fruits), irradiation has significantly ($p \leq 0.05$) reduced weight loss in both tomato cultivars. After twelve days of ripening period, the control fruits in both cultivars were discarded due to complete rotten whereas irradiated fruits continued to kept well up to 24 days. There were no significant differences ($p \leq 0.05$) in loss of weight among fruits irradiated using the three doses of 0.25, 0.50 and 1.00 KGy (Table 1). Weight loss in tomato decreased with increasing irradiation dose as was found by Sparks and Iritani (1964).

Respiration rate: The untreated fruits of both cultivars reached the maximum climacteric peak after nine days (47.43 and 56.19 mgCO₂/kg fruit/hour) for Amani and Beto86 respectively (Table 2). There were no significant differences ($p \leq 0.05$) among the respiration rates of the fruits treated with different irradiation doses (0.25, 0.50 and 1.00 KGy) and kept for 24 days. This would suggest that gamma radiation treatment at all doses has decreased significantly ($p \leq 0.05$) the respiration rate of tomato fruits in both cultivars. Larrigaudiere *et al.* (1990) reported that, early climacteric in cherry tomatoes following irradiation at 1.00 KGy is due to the stimulation of translation of pre existing mRNAs enzymes whereas at higher doses

Table 1: Loss* in weight (%) of Amani and Beto86 tomato cultivars during ripening** as affected by irradiation dose

Storage (days)	Cultivars							
	Amani				Beto86			
	Level of irradiation dose(kGy)							
	(0.00)	0.25	0.50	1.00	(0.00)	0.25	0.50	1.00
0	0±0.00 ⁱ	0±0.00 ⁱ	0±0.00 ⁱ	0±0.00 ⁱ	0±0.00 ⁱ	0±0.00 ⁱ	0±0.00 ⁱ	0±0.00 ⁱ
3	2.99±0.08 ^g	1.46±0.02 ^h	1.45±0.03 ^h	2.36±0.81 ^h	3.27±1.10 ^g	1.93±0.84 ^h	1.40±0.00 ^h	1.43±0.06 ^h
6	6.53±1.01 ^{e,f}	2.92±0.03 ^g	3.89±0.90 ^g	3.78±0.81 ^g	6.43±0.84 ^e	3.43±0.84 ^g	2.87±0.06 ^g	2.93±0.06 ^g
9	9.11±2.76 ^{c,d}	4.39±0.04 ^f	5.35±0.92 ^f	5.21±0.80 ^f	9.43±0.84 ^c	4.97±0.81 ^e	4.33±0.11 ^e	4.43±0.06 ^f
12	11.63±1.92 ^b	6.34±0.88 ^e	7.28±0.12 ^e	6.63±0.80 ^f	11.93±1.50 ^b	6.93±0.99 ^e	6.27±0.90 ^e	5.93±0.06 ^f
15	-	7.80±0.88 ^d	8.74±0.14 ^d	8.05±0.79 ^d	-	8.47±1.02 ^d	7.73±0.93 ^d	7.43±0.06 ^d
18	-	9.27±0.89 ^d	10.19±0.17 ^c	9.47±0.79 ^d	-	9.97±1.02 ^c	9.33±1.19 ^{c,d}	8.96±0.11 ^d
21	-	11.21±0.80 ^b	11.65±0.20 ^b	10.89±0.78 ^b	-	11.47±1.11 ^b	10.63±0.93 ^b	10.47±0.11 ^b
24	-	12.68±0.80 ^{a,b}	13.10±0.22 ^a	12.31±0.78 ^{a,b}	-	13.13±1.24 ^a	12.10±0.96 ^{a,b}	11.97±0.13 ^{a,b}

*: Any two mean values having similar superscript letter in all rows and columns are insignificantly ($p \leq 0.05$) different; **: At 15±1°C (RH of 90-85%)

Table 2: Changes in respiration rate* (mgCO₂/kg fruit/hour) of Amani and Beto86 tomato cultivars during ripening** as affected by irradiation dose

Storage (days)	Cultivars							
	Amani				Beto86			
	Level of irradiation dose(kGy)							
	(0.00)	0.25	0.50	1.00	(0.00)	0.25	0.50	1.00
0	32.91±2.215 ^{e,f}	26.13±2.511 ^h	24.20±0.837 ^{h,i}	23.71±0.837 ⁱ	28.07±0.843 ^{d,e}	24.68±0.00 ^e	23.71±0.837 ^e	22.26±0.837 ^e
3	37.76±2.506 ^d	30.97±0.837 ^f	28.53±1.651 ^g	29.42±1.703 ^f	31.96±1.45 ^d	28.07±0.843 ^{d,e}	27.96±0.333 ^e	25.63±2.186 ^e
6	44.53±0.837 ^b	34.36±0.837 ^e	31.94±1.45 ^f	31.87±0.837 ^f	34.79±3.946 ^d	30.47±1.45 ^{d,e}	29.02±1.43 ^{d,e}	27.76±0.318 ^{d,e}
9	47.43±0.837 ^a	36.30±1.455 ^d	34.85±1.46 ^e	33.31±0.00 ^d	56.19±15.608 ^a	33.39±1.45 ^d	32.91±0.837 ^d	31.56±2.888 ^d
12	44.34±1.155 ^b	37.75±0.00 ^d	35.82±0.849 ^e	35.23±0.837 ^d	42.10±1.455 ^b	35.33±0.849 ^d	35.82±0.849 ^d	33.85±2.523 ^d
15	-	38.20±0.00 ^d	37.23±0.837 ^d	36.24±0.837 ^d	-	36.27±0.831 ^{b,c}	36.27±0.831 ^{b,c}	34.62±0.635 ^c
18	-	39.13±0.837 ^c	38.17±0.837 ^c	37.07±0.837 ^c	-	38.72±0.837 ^{b,c}	38.72±0.837 ^{b,c}	35.58±1.068 ^{b,c}
21	-	40.20±0.00 ^d	38.75±0.865 ^d	37.62±0.231 ^d	-	39.33±0.849 ^{c,d}	38.82±0.849 ^{c,d}	36.33±0.849 ^d
24	-	36.79±0.831 ^{d,e}	35.39±1.649 ^f	34.36±0.837 ^e	-	31.27±0.764 ^d	31.42±0.837 ^d	30.44±1.453 ^e

*: Any two mean values having similar superscript letter in all rows and columns are insignificantly ($p \leq 0.05$) different; **: At 15±1°C (RH of 90-85%)

Table 3: Changes in flesh firmness* (kg/cm²) of Amani and Beto86 tomato cultivars during ripening** as affected by irradiation dose

Cultivars									
		Amani				Beto86			
Storage (days)	Level of irradiation dose(kGy)								
	(0.00)	0.25	0.50	1.00	(0.00)	0.25	0.50	1.00	
0	0.35±0.011 ^{ab}	0.33±0.012 ^b	0.34±0.013 ^{ab}	0.33±0.023 ^b	0.36±0.006 ^a	0.36±0.018 ^a	0.28±0.045 ^b	0.34±0.036 ^a	
3	0.26±0.016 ^c	0.25±0.007 ^d	0.24±0.007 ^c	0.23±0.00 ^a	0.28±0.011 ^b	0.27±0.013 ^b	0.25±0.006 ^c	0.27±0.010 ^a	
6	0.22±0.008 ^d	0.21±0.011 ^d	0.22±0.011 ^d	0.21±0.006 ^{cd}	0.22±0.023 ^{cd}	0.23±0.007 ^c	0.22±0.00 ^{cd}	0.26±0.00 ^b	
9	0.17±0.011 ^e	0.17±0.020 ^e	0.18±0.007 ^e	0.16±0.006 ^f	0.15±0.018 ^f	0.19±0.007 ^d	0.19±0.007 ^d	0.22±0.01 ^{cd}	
12	0.07±0.007 ^{ik}	0.16±0.020 ^g	0.15±0.006 ^f	0.15±0.020 ^g	0.10±0.027 ^g	0.16±0.007 ^e	0.15±0.013 ^e	0.19±0.007 ^d	
15	-	0.14±0.018 ^{gh}	0.12±0.014 ^g	0.11±0.011 ^{gh}	-	0.13±0.012 ^f	0.13±0.018 ^{ef}	0.16±0.012 ^e	
18	-	0.11±0.023 ^{gh}	0.10±0.018 ^h	0.09±0.018 ^g	-	0.10±0.007 ^g	0.10±0.020 ^{fg}	0.13±0.012 ^f	
21	-	0.08±0.029 ^{hik}	0.08±0.024 ^{hik}	0.08±0.007 ^{hi}	-	0.07±0.006 ^{gh}	0.07±0.013 ^{gh}	0.10±0.013 ^g	
24	-	0.06±0.018 ^{ik}	0.06±0.020 ^{ik}	0.05±0.007 ^{ik}	-	0.05±0.007 ^h	0.05±0.007 ^h	0.06±0.018 ^h	

*: Any two mean values having similar superscript letter in all rows and columns are insignificantly (p<0.05) different; **: At 15±1°C (RH of 90-85)

Table 4: Changes in level of ascorbic* acid (mg/100 g) of Amani and Beto86 tomato cultivars during ripening** as affected by irradiation dose

Cultivars									
		Amani				Beto86			
Storage (days)	Level of irradiation dose (kGy)								
	(0.00)	0.25	0.50	1.00	(0.00)	0.25	0.50	1.00	
0	14.47±0.404 ^g	13.53±0.404 ^h	13.77±0.404 ^h	15.33±1.097 ^g	13.33±0.651 ^g	14.47±0.404 ^f	15.33±1.097 ^f	14.03±1.155 ^f	
3	17.62±0.404 ^f	18.32±0.803 ^f	17.86±1.059 ^f	17.85±0.803 ^f	19.27±1.016 ^d	17.83±0.381 ^e	18.97±0.445 ^d	17.96±0.45 ^d	
6	21.34±0.404 ^d	19.25±0.404 ^e	19.94±0.803 ^e	18.32±0.398 ^f	21.80±0.398 ^b	19.71±0.398 ^d	19.71±0.398 ^d	20.17±0.695 ^c	
9	23.08±0.514 ^{cd}	19.94±0.398 ^e	21.33±0.803 ^d	19.71±0.803 ^e	23.09±0.508 ^b	21.57±0.695 ^c	20.87±0.7 ^c	20.77±0.552 ^c	
12	22.49±0.404 ^d	22.03±1.064 ^d	23.77±0.999 ^e	21.40±0.918 ^d	21.33±1.065 ^c	22.85±0.86 ^b	22.42±0.398 ^b	22.03±0.398 ^b	
15	-	23.41±0.936 ^{ab}	23.81±0.803 ^b	23.25±0.687 ^{cd}	-	24.51±0.398 ^a	23.82±0.404 ^a	23.65±0.695 ^b	
18	-	25.80±0.577 ^a	24.28±0.803 ^b	23.94±1.028 ^{bc}	-	25.00±0.225 ^a	24.77±0.624 ^a	24.70±0.624 ^a	
21	-	25.85±0.695 ^b	24.35±0.508 ^d	24.55±0.854 ^c	-	23.37±1.576 ^b	22.55±0.7 ^b	22.35±0.7 ^b	
24	-	22.26±1.843 ^d	21.01±0.404 ^{ef}	21.10±0.404 ^c	-	21.39±2.463 ^{cd}	21.12±1.399 ^c	21.9±1.065 ^c	

*: Any two mean values having similar superscript letter in all rows and columns are insignificantly (p<0.05) different; **: At 15±1°C (RH of 90-85%)

irradiation greatly inhibited the activity of ethylene forming enzyme. Irradiation increased fruit respiration immediately after treatment, but delayed the time to attain the climacteric respiratory peak and reduced the magnitude of this peak rate (Dharkar *et al.*, 1966).

Fruit flesh firmness: During ripening, tomato cultivars in all treatments had shown a continuous decline in tomato fruit flesh firmness. The untreated fruits reached an undesirable soft stage (kg/cm² shear resistance) after 12 days (Table 3), compared with fruits treated with different doses (0.25, 0.50 and 1.00 KGy) which reached final soft stage after 24 days of ripening period. There were no significant differences (p<0.05) in flesh firmness among the irradiated tomato fruits at 24 days of storage. UV radiation was found to delay the softening of whole tomato fruits significantly during storage (Liu *et al.*, 1993; Maharaj *et al.*, 1999).

PHYSIOCHEMICAL ANALYSIS

Ascorbic acid: During ripening the level of ascorbic acid in tomato fruits increased and eventually decreased with all treatments. Worth mentioning that the maximum level of vitamin C is reached in more time with irradiated fruits compared to untreated ones (Table 4). The loss in ascorbic acid content beyond the climacteric stage during storage could be attributed to the increase in ascorbate oxidase activity (Cordello, 1998). Destruction of vitamin C is a consequence of alteration of fruits metabolic oxidation pathways by radiation, which can convert vitamin C into dehydro-

ascorbic acid, which can still be metabolized as vitamin C (Snauwart, 1973).

Total Soluble Solids (T.S.S): Showed continuous increase during ripening in all tested fruits. The untreated fruits of Amani tomato cultivar recorded 5.67% T.S.S in 12 days of storage, whereas similar values of T.S.S were reached in 21 days (6.0; 5.67; and 6.0% T.S.S) in fruits treated with 0.25; 0.50; and 1.00 kGy dose, respectively. On the other hand the untreated fruits of Beto 86 tomato cultivar reached maximum T.S.S value (6.33%) in 12 days of storage. The same T.S.S value recorded in tomato fruits treated with 1.00 kGy dose (6.33%) in 21 days of storage (Table 5) which means that 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).

Titrateable acidity: During ripening tomato fruits had shown an increase in titrateable acidity in all treatments shortly after the breaker stage and progressively decreased afterwards (Table 6). Charles *et al.* (2005) observed a lower titrateable acidity and higher pH in UV treated tomatoes.

Total sugars content: increased gradually till the end of the ripening period in all tomato fruits (Table 7). Sugars constitute about 65-70% of the total soluble solids in tomato fruits (Hobson and Kilby, 1985). Total soluble solids and titrateable acidity are important components of flavor. They exert their effect not only

Table 5: Changes in total soluble solids* (T.S.S) % of Amani and Beto86 tomato cultivars during ripening as affected by irradiation dose**

Storage (days)	Cultivars							
	Amani				Beto86			
	Level of irradiation dose(kGy)							
	(0.00)	0.25	0.50	1.00	(0.00)	0.25	0.50	1.00
0	3.00±0.00 ^d	3.33±0.577 ^{c,d}	3.00±0.00 ^d	3.33±0.577 ^{c,d}	3.33±0.577 ^{d,e}	3.33±0.577 ^{d,e}	3.33±0.577 ^{d,e}	3.33±0.577 ^{d,e}
3	3.67±0.577 ^{c,d}	3.33±0.577 ^{c,d}	3.33±0.577 ^{c,d}	3.67±0.577 ^{c,d}	3.67±0.577 ^{d,e}	3.67±0.577 ^{d,e}	3.67±0.577 ^{d,e}	3.67±0.577 ^{d,e}
6	4.00±0.00 ^c	4.00±0.00 ^c	4.00±0.00 ^c	4.00±0.00 ^c	4.00±0.00 ^{c,d,e}	4.00±0.00 ^{c,d,e}	4.00±0.00 ^{c,d,e}	4.00±0.00 ^{c,d,e}
9	4.33±0.577 ^{b,c}	4.33±0.577 ^{b,c}	4.00±0.00 ^c	4.33±0.577 ^{b,c}	4.67±0.577 ^c	4.33±0.577 ^d	4.67±0.577 ^c	4.33±0.577 ^{c,d}
12	5.67±0.577 ^{a,b}	4.33±0.577 ^{b,c}	4.67±0.577 ^{b,c}	4.67±0.577 ^{b,c}	6.33±0.577 ^{a,b}	5.00±0.00 ^{b,c}	5.00±0.577 ^{b,c}	4.67±0.577 ^c
15	-	4.67±0.577 ^{b,c}	5.00±0.00 ^b	5.00±0.00 ^b	-	5.33±0.577 ^{b,c}	5.33±0.577 ^{b,c}	5.33±0.577 ^{b,c}
18	-	5.33±0.577 ^{a,b}	5.33±0.577 ^{a,b}	5.33±0.577 ^{a,b}	-	5.67±0.577 ^b	5.67±0.577 ^b	5.67±0.577 ^b
21	-	6.00±0.00 ^a	5.67±0.577 ^a	6.00±0.00 ^a	-	6.67±0.577 ^a	6.67±0.577 ^a	6.33±0.577 ^{a,b}
24	-	4.67±0.577 ^{b,c}	4.67±0.577 ^{b,c}	4.67±0.577 ^{b,c}	-	4.67±0.577 ^c	5.00±0.00 ^{b,c}	4.67±0.577 ^c

*: Any two mean values having similar superscript letter in all rows and columns are insignificantly ($p \leq 0.05$) different; **: At 15±1°C (RH of 90-85%)

Table 6: Changes in Titratable acidity*(%citric) of Amani and Beto86 tomato cultivars during ripening as affected by irradiation dose**

Storage (days)	Cultivars							
	Amani				Beto86			
	Level of irradiation dose(kGy)							
	(0.00)	0.25	0.50	1.00	(0.00)	0.25	0.50	1.00
0	0.68±0.04 ^c	0.65±0.04 ^{b,c}	0.65±0.04 ^{b,c}	0.65±0.04 ^{b,c}	0.70±0.00 ^c	0.65±0.04 ^{c,d}	0.65±0.04 ^{c,d}	0.68±0.04 ^{c,d}
3	0.79±0.081 ^{c,d}	0.75±0.081 ^{c,d}	0.79±0.081 ^{c,d}	0.79±0.081 ^{c,d}	0.79±0.081 ^{b,c}	0.79±0.081 ^{b,c}	0.75±0.081 ^c	0.79±0.081 ^{b,c}
6	0.54±0.04 ^{b,c}	0.79±0.081 ^{c,d}	0.89±0.04 ^{d,e}	0.91±0.00 ^{d,e}	0.49±0.121 ^{d,e}	0.86±0.04 ^b	0.86±0.04 ^b	0.89±0.04 ^b
9	0.47±0.04 ^{a,b}	0.93±0.04 ^{d,e}	1.00±0.04 ^{d,e}	1.05±0.07 ^e	0.40±0.04 ^e	1.03±0.04 ^a	1.00±0.04 ^a	1.03±0.04 ^a
12	0.44±0.04 ^{a,b}	0.55±0.445 ^{b,c}	0.89±0.04 ^{d,e}	1.03±0.081 ^{d,e}	0.37±0.04 ^e	1.00±0.04 ^a	0.79±0.202 ^{b,c}	1.00±0.04 ^a
15	-	0.61±0.04 ^{b,c}	0.86±0.04 ^d	0.75±0.162 ^{c,d}	-	0.71±0.04 ^d	0.58±0.04 ^d	0.83±0.04 ^{a,b}
18	-	0.46±0.064 ^{a,b}	0.61±0.04 ^{b,c}	0.51±0.04 ^{b,c}	-	0.57±0.04 ^e	0.53±0.04 ^{d,e}	0.55±0.04 ^d
21	-	0.40±0.04 ^a	0.44±0.107 ^{a,b}	0.40±0.081 ^{a,b}	-	0.44±0.04 ^e	0.41±0.04 ^e	0.40±0.081 ^e
24	-	0.37±0.04 ^a	0.36±0.04 ^{a,b}	0.33±0.04 ^{a,b}	-	0.37±0.04 ^e	0.36±0.04 ^e	0.35±0.04 ^e

*: Any two mean values having similar superscript letter in all rows and columns are insignificantly ($p \leq 0.05$) different; **: At 15±1°C (RH of 90-85%)

Table 7: Changes in total sugar* content (%) of Amani and Beto86 tomato cultivars during ripening as affected by irradiation dose**

Storage (days)	Cultivars							
	Amani				Beto86			
	Level of irradiation dose(kGy)							
	(0.00)	0.25	0.50	1.00	(0.00)	0.25	0.50	1.00
0	1.47±0.115 ^{h,i}	1.37±0.404 ⁱ	2.00±0.40 ^h	1.73±0.231 ^{h,i}	1.80±0.20 ^h	1.67±0.306 ^h	2.00±0.20 ^h	2.20±0.20 ^h
3	2.67±0.231 ^g	2.40±0.40 ^{g,h}	2.87±0.416 ^g	2.73±0.306 ^g	3.27±0.306 ^{f,g}	2.13±0.306 ^h	2.33±0.306 ^{g,h}	2.80±0.20 ^g
6	3.47±0.416 ^{f,g}	3.67±0.306 ^f	3.33±0.231 ^{f,g}	3.00±0.20 ^g	5.20±0.40 ^{c,d}	3.20±0.20 ^{f,g}	3.67±0.306 ^f	3.40±0.20 ^f
9	5.33±0.833 ^b	3.93±0.231 ^d	3.87±0.115 ^{e,f}	3.33±0.115 ^f	5.73±0.693 ^a	3.67±0.115 ^f	4.60±0.20 ^e	4.33±0.306 ^e
12	5.87±0.40 ^{f,g}	4.20±0.577 ^{c,d}	4.00±0.40 ^e	3.67±0.20 ^{e,f}	6.20±0.40 ^{c,d}	4.47±0.416 ^e	5.00±0.20 ^{d,e}	4.87±0.306 ^{d,e}
15	-	4.40±0.346 ^{b,c}	4.20±0.231 ^d	3.87±0.306 ^d	-	5.73±0.306 ^c	5.80±0.20 ^c	5.73±0.306 ^c
18	-	5.27±0.115 ^a	4.40±0.60 ^a	4.20±0.346 ^a	-	6.60±0.60 ^a	6.73±0.416 ^a	6.40±0.346 ^a
21	-	5.33±0.808 ^c	5.27±0.306 ^{b,c}	4.40±0.40 ^e	-	7.27±0.924 ^{b,c}	7.40±0.40 ^b	7.13±0.231 ^{b,c}
24	-	6.20±0.115 ^f	5.33±0.20 ^{e,f}	5.27±0.306 ^{e,f}	-	7.67±0.306 ^f	7.45±0.20 ^e	7.20±0.20 ^e

*: Any two mean values having similar superscript letter in all rows and columns are insignificantly ($p \leq 0.05$) different; **: At 15±1°C (RH of 90-85%)

Table 8: Acceptability of salad slices prepared from Amani tomato cultivar treated with gamma rays and stored for 21 and 24 days

Treatment (KGy)	Tomato fruits stored for 21 days				
	Color	Texture	Taste	Flavor	Over all acceptability
0.25	18 ^a	19 ^a	17 ^a	14 ^a	18 ^a
0.50	25 ^a	22 ^a	21 ^a	27 ^a	27 ^a
1.00	15 ^a	13 ^a	14 ^a	18 ^a	15 ^a
Tomato fruits stored for 24 days					
0.25	13 ^a	14 ^a	10 ^b	16 ^a	14 ^a
0.50	20 ^a	25 ^a	22 ^a	26 ^a	27 ^a
1.00	24 ^a	17 ^a	15 ^a	19 ^a	19 ^a

Acceptability test according to the ranking procedure of Ihekononye and Ngoddy (1985); 8 reps, 4 treatment rank total (13-27)

through their amount present, but also through their ratio. Tomato fruits high in both sugars and acids have excellent flavor, (Saltveit, 2005).

Acceptability of fresh tomato slices and tomato paste: Table 8 and 9 Show the acceptability of fresh

tomato slices prepared from Amani and tomato paste processed from Beto 86 tomato treated with gamma rays and stored for 21 and 24 days. After ripening, no significant ($p \leq 0.05$) differences were observed in all quality attributes of fruits treated. The treatment with gamma radiation of three doses did not affect the color,

Table 9: Acceptability of paste prepared from Beto86 tomato cultivar treated with gamma rays and stored for 21 and 24 days

Treatment (KGy)	Tomato fruits stored for 21 days				
	Color	Texture	Taste	Flavor	Over all acceptability
0.25	21 ^a	26 ^a	22 ^a	20 ^a	24 ^a
0.50	16 ^a	22 ^a	17 ^a	18 ^a	18 ^a
1.00	13 ^a	16 ^a	14 ^a	15 ^a	14 ^a
Tomato fruits stored for 24 days					
0.25	22 ^a	24 ^a	23 ^a	17 ^a	21 ^a
0.50	19 ^a	21 ^a	20 ^a	20 ^a	19 ^a
1.00	15 ^a	14 ^a	17 ^a	13 ^a	16 ^a

Acceptability test according to the ranking procedure of Ihekononye and Ngoddy (1985) 8 reps, 4 treatment rank total (13-27)

texture, flavor and taste of slices prepared from Amani or the paste processed from Beto 86 tomato cultivars. 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.

CONCLUSION

Gamma irradiation treatments were found suitable for delay of ripening and extension of shelf life of tomato fruits. Slices from Amani and paste prepared from Beto 86 tomato fruits treated with three doses of gamma rays (0.25-0.50 and 1.00 kGy) were found acceptable in color, texture, taste and flavor.

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