

Study on the Effect of Irradiation on Storage Quality of Preserved Tomato Crush

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Abstract: Tomatoes were processed into tomato crush using standard methods and they were packed in 150 gauge polythene bags. Each product was subjected to following treatments T1- in which chemical preservatives were added (0.4g of potassium metabisulphite+0.2g of sodium benzoate per kg, glacial acetic acid 5ml/kg) which was taken as control and T2, T3, T4 were prepared without added preservatives and are subjected to irradiation at 0.50kGy, 1.00kGy and 2.00kGy. The storage studies were carried out up to 60 days at ambient temperature. Samples were analyzed for physico – chemical and microbial parameters on the day of preparation (0 day), 30th day and 60th day. No change was observed in TSS content and pH of crush samples during storage period. Moisture content decreased on storage at 5% significant level in the products. 2.00kGy irradiation treatment showed highest retention of moisture. There was drastic decrease seen in vitamin C content and lycopene content during entire storage period. 1.00kGy irradiation treatment showed highest retention of vitamin C content and lycopene content. TBARS (%), MDA and reducing sugars increased with the increase in doses of irradiation. As the irradiation dose and storage period increased antioxidant activity decreased. Total bacterial count increased on storage but, as the irradiation dosage increased there was decrease in bacterial count. No mould growth was noticed in crush samples throughout the period of storage.

Keywords: Irradiation, Tomato crush, Physico chemical parameters, Total Antioxidant activity, Microbial analysis

1. Introduction

Tomato (*Solanum Lycopersicom* Mill.) is one of the most widely cultivated vegetable crops in Mediterranean countries. It is one of the most important vegetable crops in India, accounting for about 8.23 per cent of the total vegetable production in the country. Tremendous progress has been made in tomato production during the past four and half decades. The production has increased by almost 15-times, from a mere 0.54 Mt in 1961 to about 8.2 Mt in 2005 [1]. At present, India is the fourth largest producer of tomato, accounting for 6.6 per cent of the world production. Tomatoes also contain a large variety of other important nutrients such as β -carotene, polyphenols, and vitamin C, which are thought to be potent antioxidants.

They also contain folate, which could contribute to their beneficial effects [2] [3]. Tomato has limited shelf life under ambient conditions and is highly perishable. It creates glut during peak season of production and becomes scanty during off-season. Short shelf life coupled with inadequate processing facilities results in heavy revenue loss to the country.

The demand for tomato processing is increasing rapidly both at domestic and international market with major portion of it being used in preparation of convenience food. Thus, there exists a need to develop a suitable technology for processing and preservation of this valuable produce in a way that will not only check losses but also generate additional revenue.

Food irradiation is a processing technology aimed at the improvement of food safety, which has gained interest of researchers in the fields of food science and consumer research worldwide during the past few decades. This technology is already recognized as a technically feasible method for reducing postharvest food losses, ensuring the hygienic quality of food, longer storage of food, therefore

facilitating wider food trade [4]. Radiation can safely and effectively eliminate the pathogenic bacteria from food, disinfest the fruits and vegetables, extend the shelf life of many products through delayed ripening process, inhibit the sprouting of bulbs and tubers, and reduce or totally eliminate the microorganism load. Irradiation (cold pasteurisation) of food is achieved by exposing the product to a source of ionizing energy. It is a physical means of food processing that involves exposing pre-packaged or bulk foodstuffs to gamma rays (Cobalt-60), X-rays, or electrons [5]. The effect depends on the dose, measured in kilograys (equal to 1000 grays). Low doses of irradiation (less than 1 kGy) only disrupt cellular activity enough to prevent reproduction (as with Mediterranean fruit flies on guava) or sprouting (on potatoes). Medium doses (between 1 kGy and 10 kGy) reduce microbial loads on food, as with *Trichnella* on pork [6]. High doses (between 10 kGy and 25 kGy) kill a comprehensive spectrum of fungi and bacteria pests (as with spice imports) and extend the shelf life of perishable foods (such as strawberries). Very high doses (greater than 25 kGy) were used to sterilize medical equipment, hospital food and pet food.

2. Materials and Methods

Fully riped tomatoes varieties were purchased from local farmers. 5x 6 150 gauge polythene covers were purchased from the local market. All chemicals used in the investigation were of Analytical Grade. Gamma Chamber 5000 was used for giving radiation treatments. It is compact shelf shielded Cobalt 60 gamma irradiator providing an irradiation volume of approximately 5000cc. Radiation field is provided by a set of stationary Cobalt 60 source placed in a cylindrical cage. The source is doubly encapsulated in corrosion resistant stainless steel pencils and is tested in accordance with international standards. Two access holes of 8 mm diameter are provided service sleeves for gases, thermocouple etc. Mechanism for rotating/ stirring samples

during irradiation is also incorporated. The lead shield provided around the source is adequate to keep the external radiation field well within permissible limits. Tomato crush was prepared using standard method by Anand and Vijay, 1977 [7] cut pieces of tomatoes were concentrated to a brix of 15 by boiling to which glacial acetic acid (5ml/kg) was added in the final stage of preparation. In the control product preservatives (0.4g of potassium metabisulphite+0.2g of sodium benzoate per kg) were added in the final stage of preparation and no preservatives were added to T1, T2, T3. After cooling they were packed in polythene bags.

2.1 Experimental Design

T1 : Control made using chemicals
 T2 : 0.50 kilo Gray with duration of 11mins and 12seconds.
 T3 : 1.00 kilo Gray with duration Of 22mins and 35 seconds.
 T4: 2.00 kilo Gray with duration Of 45mins and 7 seconds.

2.2 Interval of Analysis

Physico chemical and microbial parameters were analyzed on 0 day, 30th day and 60th day.

2.3 Physico Chemical Parameters

Acidity was calculated by titrating against 0.1 N NaOH. Digital pH meter was used to measure the pH content of the samples. pH, Lycopene content [8], Moisturte content and Vitamin C were determined as per the method [9]. TSS by approved AOAC method [10]. Reducing sugars were determined by the method of Lane and Eynon [11], The antioxidant activity was estimated by TBARS (Thiobarbituric Acid Reducing substance) and MDA method [12].

3. Microbial Analysis

3.1 Total Bacterial Count

Dilution plate method was followed for estimating the microbial load in which one gram of sample is mixed in 9ml of the saline (sterile) water to a suspension. One ml from this suspension is transferred in to other tube containing 9ml of sterile saline water. This dilution is 10⁻², in similar way serial dilutions were made. 1 ml from each serial dilutions were placed in a sterile petridish and cooled. Plate Agar Medium was added to the petridish and contents are mixed thoroughly by moving the petridishes. These plates were incubated at 28± 2oc for 48hours. Individual colonies were counted by using colony counter and multiplied with the dilution factor to get the microbial population in one gm of the sample [13].

3.2 Total Mould Count

Dilution plate method was followed for estimating the microbial load by [13]. Samples were diluted before plating in the same way as in the bacterial count. Potato Dextrose Agar was used as medium for estimating the fungal population.

3.3 Statistical Analysis

Statistical analysis was carried out at the end of the study. The data was subjected by two-way analysis of variance (ANOVA), [14] and means were tested for significance by critical difference.

4. Results and Discussion

4.1 Physico – Chemical Parameters

4.1.1 Titrable Acidity

Acidity in fruits is an important factor in determining maturity. Titrable acidity gives the total or potential acidity, rather than indicating the number of free protons in any particular sample. It is a measure of all aggregate acids and sum of all volatile and fixed acids. Acidity in tomato crush increased from 0 day (1.14 %) significantly ($p < 0.05$) to 30th day (1.19%) and 60th day (1.22 %). Significant changes ($p < 0.05$) were noticed among the treatments. Highest acidity value was recorded in T1 (1.21%) followed by T2 (1.19 %) and lowest acidity in T4 (1.16 %) which was almost same with T3 (1.17 %). Significant interaction effects ($p < 0.05$) were observed between the treatments and storage periods. During different storage periods, the change in acidity lowered with increase in the irradiation dosage. Significant increase in acidity was observed in all treatments during the entire period of storage and this increase may be due to loss of moisture in the product leading to concentration of the products by the end of storage. In a similar study by [15] showed that the increase in the acidity in mango pulp was attributed to increase in the concentration of weakly ionized acid and their salts during storage of mango pulp. [16], [17] reported in their study the reason for the increase in acidity could be oxidation of reducing sugars (sucrose), formation of acids by break down of polysaccharides and by degradation of pectic compounds and uronic acid.

4.1.2 pH

The results indicated that there was no significant change observed in pH during different storage periods and between the treatments. The pH of the damples did not change throughout the storage period (4.29 %). Among the treatments lowest pH was recorded in T1 (4.26%) whereas other treatments recorded the same pH (4.30%). There was no significant interaction effects observed between the treatments and periods.

4.1.3 TSS

TSS of tomato crush recorded significant changes ($p < 0.05$) during the storage period. There was a significant increase in TSS from 0 day (15.00%) to 60th day (15.06%). Among the treatments significant changes were recorded between T4 (15.01%) and T3 (15.03%) where T4 had lower TSS followed by T3. TSS of T2 (15.05%) recorded almost same value as that of T1 (15.06%) which was higher. There were significant interaction effects ($p < 0.05$) between the treatments and periods on storage. TSS increased as irradiation dosage decreased in all treatments. [18] observed that there was a significant increase in TSS content within storage period and this incline in TSS was due to the

development of pectin (water soluble) from insoluble protopectin.

4.1.4 Moisture Content

There were significant changes ($p < 0.05$) in moisture content of tomato crush on storage. The moisture content decreased from 0 day (82.75%) to 60th day (80.29%) and reduced drastically from 30th day (82.35%) to 60th day (80.29%). Significant changes ($p < 0.05$) were observed among treatments in which T3 (82.17%) recorded higher moisture content followed by T4 (82.04%) and lowest was recorded in T1 (80.29%). The interaction effect between treatments and periods were not significant ($p > 0.05$). Moisture content decreased in all treatments during the storage period. Decrease in the moisture content of the product may be due to high temperature and low humidity in the ambient conditions. Other reason for decrease can also be attributed to low moisture barrier property of 150 gauge polythene bags, which were used for packing the products.

4.1.5 Lycopene content

There was a significant decrease ($p < 0.05$) in the lycopene content of tomato crush from 0 day (11,906.95 $\mu\text{g} \%$) to 60th day (2909.96 $\mu\text{g} \%$). [19] also reported that lycopene was highly susceptible to oxidative and thermal degradation. Significant changes ($p < 0.05$) were noticed among the treatments in which T4 (6113.77 $\mu\text{g} \%$) contained the lowest lycopene content followed by T3 (6556.61 $\mu\text{g} \%$) and T1 recorded highest (7497.23 $\mu\text{g} \%$). The interaction effects between treatments and periods were found to be significant ($p < 0.05$). Lycopene content decreased drastically as the irradiation dosage and storage period increased. Lycopene content in concentrated tomato products was generally lower than expected, because of losses during processing as reported by [20].

4.1.6 Vitamin C

There was a significant decrease ($p < 0.05$) in vitamin C content of tomato crush as the storage period increased. On the 0 day tomato crush had high vitamin C content (43.91mg %), which significantly decreased to a greater extent by the 30th day (11.02mg %) and decreased more by 60th day (6.07%). [21] also observed drastic reductions of ascorbic acid in irradiated tomato juice and black and red currants. Among all the treatments significant changes ($p < 0.05$) were observed where T1 recorded highest vitamin C (22.62mg %) followed by T2 (21.31mg %) and lowest vitamin C content was observed in T4 (17.64mg %). During processing, vitamin C is destroyed mainly due to oxidation reactions and the heat applied in the presence of air [22]. The interaction effects between the treatments and periods were significant ($p < 0.05$). Vitamin C decreased in all the treatments during the storage. As the irradiation dosage increased Vitamin C content decreased drastically. According to [23] also reported that the destruction of vitamin C was 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.

4.1.7 Reducing sugars

The reducing sugars of tomato crush changed significantly ($p < 0.05$) during storage. The reducing sugars increased

significantly from 0 day (4.36%) to 60th day (9.85%). Among the treatments significant changes ($p < 0.05$) were observed with T2 having higher reducing sugars (7.13%) followed by T1 (7.06%) which was the same as that recorded in T4 (7.06%) and lower value was noticed in T3 (7.04%). The interaction effects between treatments and periods of storage were noticed to be significant ($p < 0.05$). Reducing sugars increased in all treatments as the storage periods increased. [24] also reported similar trend in mango products like pulp, juice and nectar.

4.2 Total Antioxidant Activity: (TBARS and MDA)

In tomato crush significant changes ($p < 0.05$) were observed during storage. The per cent TBARS increased significantly from 0 day (278.03%) to 60th day (452.65%). Significant changes ($p < 0.05$) were observed among the treatments in which T4 recorded the highest value (424.24%) followed by T3 (384.85%). T1 recorded the lowest value of per cent TBARS (319.70%). Significant interaction effects ($p < 0.05$) between treatment and periods were observed. Per cent TBARS increased in all the treatments during the storage periods as the irradiation dose increased. The antioxidant capacity of tomato products often changes when more invasive processing steps are used [25]

The MDA values during storage of tomato crush showed significant increase ($p < 0.05$) in MDA from 0 day (394.62 nm/gfw) to 60th day (642.47 nm/gfw). Malondialdehyde was higher in T4 (602.15 nm/gfw), followed by T3 (546.24 nm/gfw). T1 had significantly low MDA value (453.76 nm/gfw) when compared to other treatments. The interaction effect of treatments and periods were significant ($p < 0.05$). MDA values increased with increase in the irradiation dosage and storage period. Similar results were found by [26] on storage of tomato and amaranth processed products.

Both per cent TBARS and MDA are inversely proportional to antioxidant activity i.e., with increase of TBARS and MDA content antioxidant activity decreases. In this study as the storage period and irradiation dosage increased there was increase in TBARS and MDA in both puree and crush which indicates that as the irradiation dose and storage period increased antioxidant activity of the preserved tomato products decreased. It was suggested that the initial reduction in the overall antioxidant activity could be attributed not only to the thermal degradation of naturally occurring antioxidants but also to the formation of early maillard reaction products with prooxidant properties [27]. A higher antioxidant activity was obtained through thermal treatments such as steaming, microwaving, frying, and drying of the tomato fruits [28] [29].

4.3 Microbial Analysis: (TBC-Total Bacterial Count and TMC- Total Mould Count):

The results obtained for TBC in tomato crush. On 0 day no bacterial count was recorded in T3, T4 and T2 but T1 recorded (0.10 cfu g/ml). On 30th day bacterial count was more than double noticed on 0 day Highest was recorded in T1 (0.40 cfu g/ml) and in T4 was without any bacterial count. Higher bacterial count was observed in T1 (0.73 cfu g/ml), followed by T2 (0.46 cfu g/ml) and least was recorded

in T4 (0.10 cfu g/ml) on 60th day. Similar results were reported by [30] that all the bacterial contents of test pathogens into the samples were reduced to below the limit of detection by 3kGy irradiation dosage or less in ready to use vegetables.

No mould growth was noticed in crush samples in the entire period of storage study of 60 days. Similar results was

reported [31] in prepacked soup-green stored at 10 OC. Reduction in microflora in commercial prepacked fresh cut lettuce was observed by treating it with a radiation dose of 0.19 kGy.

Table 1: Effect of Irradiation on Titrable Acidity, Ph And Tss

Treatments	Titrable Acidity				pH				TSS			
	0day	30 th day	60 th day	Mean	0day	30 th day	60 th day	Mean	0day	30 th day	60 th day	Mean
T1	1.15	1.21	1.26	1.21	4.26	4.26	4.26	4.26	15.00	15.09	15.10	15.06
T2	1.15	1.19	1.23	1.19	4.30	4.30	4.30	4.3	15.00	15.07	15.08	15.05
T3	1.13	1.17	1.21	1.17	4.30	4.30	4.30	4.3	15.00	15.04	15.04	15.03
T4	1.13	1.17	1.19	1.16	4.30	4.30	4.30	4.3	15.00	15.02	15.02	15.01
Mean	1.14	1.19	1.22		4.29	4.29	4.29		15.00	15.05	15.06	
	SEd	CD			SEd	CD			SEd	CD		
For treatments	0.024	0.050*			0.011	NS			0.001	0.003*		
For periods	0.021	0.044*			0.009	NS			0.002	0.002*		
T*P	0.042	0.088*			0.019	NS			0.003	0.006*		

Table 2: Effect of Irradiation on Moisture Content, Lycopene And Vitamin C

Treatments	Moisture content				Lycopene				Vitamin C			
	0day	30 th day	60 th day	Mean	0day	30 th day	60 th day	Mean	0day	30 th day	60 th day	Mean
T1	81.97	81.50	79.87	81.11	13163.72	6181.38	3146.60	7497.23	46.79	13.47	7.60	22.62
T2	82.03	82.14	80.35	82.17	12258.75	5734.09	2824.14	6938.99	45.81	12.00	6.13	21.31
T3	80.56	82.56	79.93	85.04	11465.27	5214.00	2990.57	6556.61	42.87	10.53	5.88	19.76
T4	81.99	83.18	81.02	81.01	10740.06	4922.74	2678.51	6113.77	40.18	8.08	4.66	17.64
Mean	81.24	82.35	80.29		11906.95	5513.50	2909.96		43.91	11.02	6.07	
	SEd	CD			SEd	CD			SEd	CD		
For treatments	0.441	0.911*			103.438	213.543*			0.380	0.784*		
For periods	0.382	0.789*			89.580	184.933*			0.329	0.679*		
T*P	1.765	NS			179.160	369.867*			0.658	1.358*		

Table 3: Effect of Irradiation on Reducing Sugars and Total Antioxidant Activity

Treatments	Reducing sugars				TBARS				MDA			
	0day	30 th day	60 th day	Mean	0day	30 th day	60 th day	Mean	0day	30 th day	60 th day	Mean
T1	4.33	7.02	9.84	7.06	230.30	343.94	384.85	319.70	326.88	488.17	546.24	453.76
T2	4.37	7.09	9.92	7.13	260.61	357.58	448.48	355.56	369.89	507.53	636.56	504.66
T3	4.37	7.00	9.82	7.06	289.39	390.91	474.24	384.85	410.75	554.84	673.12	546.24
T4	4.37	6.96	9.80	7.04	331.82	437.88	503.03	424.24	470.97	621.51	713.98	602.15
Mean	4.36	7.02	9.85		278.03	382.58	452.65		394.62	543.01	642.47	
	SEd	CD			SEd	CD			SEd	CD		
For treatments	0.007	0.055*			5.15	10.630*			7.311	15.090*		
For periods	0.008	0.047*			4.460	9.205*			6.331	13.068*		
T*P	0.015	0.095*			8.920	10411*			12.663	26.137*		

Titrable acidity (1.00kGy) and moisture content (2.00kGy) showed less variation during the storage period, whereas pH is not varied and TSS content of 2.00kGy irradiated sample had no variation till the end of storage period. Lycopene content and Vitamin C content drastically decreased over the period of study, 2.00kGy irradiated sample showed highest retention of lycopene content and 1.00kGy sample showed highest retention of Vitamin C content. There was an increase of reducing sugars content in which 1.00kGy sample exhibited minimum increase. TBARS (%) and MDA increased as irradiation dosage increased. No bacterial and mould count was seen in 2.00kGy irradiated sample in entire period of study.

5. Future Scope of Study

As this technic is non thermal many nutrients can be retained without adding preservatives. Many varieties of raw /

processed foods can be irradiated using different dosages. Shelf life studies can be extended from several months to years.

References

- [1] FAO .2007. Food and Agriculture Organization. (FAOSTAT@ faostat.org).
- [2] Martínez-Valverde, I., Periago, M. J., Provan, G., & Chesson, A. 2002. Phenolic compounds, lycopene and antioxidant activity in commercial varieties of tomato (*Lycopersicon esculentum*). *Journal of Agricultural and Food Chemistry*. 82: 323–330.
- [3] Periago, M. J., García-Alonso, F. J., Jacob, K., Olivares, A. B., Bernal, M. J., Iniesta, M. D. 2008. Bioactive compounds, folates and antioxidant properties of tomatoes (*Lycopersicon esculentum*) during vine

- ripening. *International Journal of Food Science and Nutrition*. 12; 1–15.
- [4] Jyoti, P. M., Sukalyan, C., Sandeep, K., Subrata, P., Jiin-Shuh, J., Alok, C. S., Anindita, C. and Subhas, C. S. 2009. Effects of gamma irradiation on edible seed protein, amino acids and genomic DNA during sterilization. *Food Chemistry*. 114: 1237–1244.
- [5] Mahapatra, A.K., Muthukumarappan, K., and Julson, J. L. (2005). Applications of ozone, bacteriocins and irradiation in food processing: a review. *Critical Reviews in Food Science and Nutrition*. 45(6): 447-461.
- [6] Niemira, B.A and Fan, X.2006. Low-dose irradiation of fresh and fresh-cut produce. safety, sensory, and shelf-life. In: Sommers, C.H., Fan, X. (Eds.). *Food Irradiation Research and Technology*.32(5): 45-52.
- [7] Anand J C and sethi vijay 1977. Whole tomato concentrate. *Indian Horticulture*. 22(2) :14.
- [8] Ranganna S 2001 Handbook of Analysis and quality control for fruit and vegetable products II Edition Tata McGraw Hill.
- [9] Ranganna, S. 1986. Hand book of Analysis and Quality control for fruit and vegetable products. Tata McGraw Hill., New Delhi. 7-12.
- [10] AOAC.1990. Official methods of analysis for moisture. *Association of Official Analytical Chemists*, 14th Ed. Washington, DC. Vol.2.
- [11] AOAC. 1965 Official Methods of Analysis, *Association of Official Analytical Chemists*, Washington, D C 12th Edition 31.054, 22 :109.
- [12] Nickos A Bostoglou, Dimitrios J Fletouris, Georgios E, Papageorgiou, Vassilios N Vassilopoulos, Antonios J Mantis and Antonios G Trakatellis 1994. Rapid, sensitive and specific thiobarbituric acid method for measuring Lipid peroxidation in Animal Tissue, food, and Feedstuff samples. *Journal of Agricultural Food Chemistry*. 42: 1931-1937.
- [13] Cruickshank, R., Duguid, J P., Marmion, B P and Surain, R H A. 1975. Medical Microbiology. The practice of medical microbiology. Churchill Livingstone, Edinbargh, London and Newyork p. 306.
- [14] Snedecor, G.W and Cochran, W.G.1983.Statistical Methods Oxford and IBH publishing company New Delhi.
- [15] Hummel, M. and Okey, R. 1950. Relation of canned tomato products to storage losses of ascorbic acid. *Food Research*. 15: 405-414.
- [16] Iqbal, S.A., S.Yasmin, Wadud and W.H. Shah. 2001. Production storage packing and quality evaluation of Gouva Nectar. *Pakistan Journal of Food Science*. 11: 33-36.
- [17] Hussain, P. R., Dar, M. A., Meena R. S.,Mir M. A., Shafi Fand Wani A. M. 2008. Changes in quality of apple (*Malus domestica*) cultivars due to gamma irradiation and storage conditions. *Journal of food science technology*. 45(1): 44-49.
- [18] Khalil, M., Ramzan, M., Ali, A and Riaz, R.A., 1979. Studies on the preparation and storage stability of comminuted lime squash. *Pakistan Journal Science Ind. Res.* 22 (5): 267-272.
- [19] Henry, L. K., Catignani, G. L. and Schwartz, S. J. 1998. Oxidative degradation kinetics of lycopene, lutein and 9 cis and all trans beta carotene. *Journal of the American Oil Chemists Society*. 75(7): 823-829.
- [20] Tavares C. A and Rodriguez-Amaya D. B .1994. Carotenoid composition of Brazillian tomatoes and tomato products. *Lebensm-Wiss U. Technology- Food Science and Technology*. 27:219-224.
- [21] Wilska-Jeszka, J and Skorupinska, A. 1975. Evaluation of radiated and pasteurized fruit juices during 12 months of storage. *Brazillian Archies of Biology and Technology*. 23: 243-259.
- [22] Leoni, C. 2002. Improving the nutritional quality of processed fruits and vegetables: the case of tomatoes, in *Fruit and Vegetable Processing: Improving Quality*. Jongen, W., Ed., Woodhead Publishing Ltd and CRC Press, LLC., Cambridge. pp. 83–122.
- [23] Snauwart, F. 1973. Influence of gamma irradiation on the provitamin A (b-carotene) in solution. *Radiation Preservation of Food*. IAEA, Vienna, 29.
- [24] Gunjal B. B and Waghmare N. J. 1987. Flow characteristics of pulp, juice and nectar of baneshan and neelam mangoes. *Journal of Food Sciences and Technology*. 24 :20-23.
- [25] Powell, A.L.T and Bennett, A.B. 2002. Tomato, in *Fruit and Vegetable Biotechnology*. Valpuesta, V., Ed., Woodhead Publishing Ltd., New York. pp. 185–221.
- [26] Amina Sadiya 2003. Antioxidant acitivity : effect of storage and processing in tomato and amaranth. *Ph.D Thesis* submitted to Acharya N G Ranga Agricultural University, Rajendranagar, Hyderabad.
- [27] Anese M Manzocco L, Nicolli M C and Lericci C R.1999. Antioxidant properties of tomato juice as affected by heating. *Journal of Science and Food Agriculture*. 34: 314-318.
- [28] Chen, R.Y., Wu, J.J. Tsai, M.J., and Liu, M.S. 2000. Effect of storage and thermal treatment on the antioxidant activityof tomato fruits. *Journal of the Chinese Agricultural Chemical Society (Taiwan)*. 38: 353–360.
- [29] Chang, C.H., Lin, H.Y., Chang, C.Y., and Liu, Y.C. 2006. Comparisons on the antioxidant properties of fresh, freeze-dried and hot-air-dried tomatoes. *Journal of Food Engineering*. 77(3): 478–485.
- [30] Na Young Leea,, Cheorun Job, Dong Hwa Shina, Wang Geun Kimc and Myung Woo Byunb. 2006. Effect of g-irradiation on pathogens inoculated into ready-to-use vegetables. *Food Microbiology*. 23: 649–656.
- [31] Langerak, D. I and Damen, G. A. 1978. Influence of irradiation on the keeping quality of prepacked soup-greens stored at 10 0C. In: food preservation of irradiation. Vol 1 Proc. Series International Atomic Energy Agency. Vienna, Austria pp: 221: 275- 282.

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