IJFANS
International Journal of Food And Nutritional Sciences

Volume 3, Issue 6, Oct-Dec 2014, www.ijfans.com e-ISSN: 2320-7876

INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

IMPACT FACTOR ~ 1.021

Official Journal of IIFANS

e-ISSN 2320 –7876 *www.ijfans.com*
Vol.3, Iss.6, Oct-Dec 2014

Research Paper *Open Access*

DEVELOPMENT OF SHELF STABLE INTERMEDIATE MOISTURE *TOMATO (LYCOPERSICON ESCULENTUM)* SLICES USING RADIATION AS HURDLE TECHNOLOGY

Anurag Chaturvedi*[1], Sujatha V*[1] Ramesh Chander[2] and Dilip babu. J[3]
[1]Department of Foods & Nutrition, Acharya N.G.Ranga Agricultural University, Hyderabad, India. [2]Meat & Meat Products Section, Food Technology Division, Bhabha Atomic Research center, [3] Vegetable Research Institute, Andhra Pradesh Horticulture University, Hyderabad, India

*Corresponding Author: sujathaankem@gmail.com

Received on: 15th October, 2014 **Accepted on: 2nd December, 2014**

ABSTRACT

Tomato (Lycopersicon esculentum) is highly perishable and difficult to preserve fresh for long periods at ambient temperature and humidity. Shelf-stable intermediate moisture (IM) tomato slices were developed based on 'hurdle technology'[HT] which included the combination of the factors like drying by two methods - Infrared drying (IR) or Tray drying (TD) to reduce water activity [a_w] to 0.6,pre-treatments and packaging. The product was stored in 400 gauge polyethene and treated with low doses of gamma radiation 2.5 kGy as a major hurdle technology and observed for shelf life stability at ambient conditions (30^{o}C and 65% RH). Infra red dried tomato slices treated with gamma radiation (IRR) were found to be stable up to 6 months without substantial loss of flavor, taste, color and texture than the other treatments. IRR yielded IM Tomato slices with improved rehydration potential, appearance and with the nutrient retention up to 51.9 % of β-carotene, 51.3% of total carotenoids 58% lycopene and 32.89% of vitamin C more than the tray dried IM Tomato slices. The product was microbiologically safe throughout the study. Infrared drying using radiation as hurdle technology could be suggested as a potential method for obtaining high quality IM products with optimum sensory, microbial and nutritional quality

Keywords: Shelf stable, intermediate moisture, hurdle technology, infrared drying, tray drying, gamma radiation

INTRODUCTION

Tomato 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. Tomato production has increased by almost 15 times, from a mere 0.54 Mt in 1961 to about 8.2 Mt in 2005 (FAO). Sometimes, the surplus production of tomato causes glut in the market, causing distress sale and low profit to the growers. One of the probable solutions to the problem of this glut is processing.

Conventional preservation technologies which offer the only means of preserving the surplus produce have many drawbacks specific to fruits and vegetables, the former yields products with rigid structures which need rehydration for prolonged periods and generally have texture and flavor inferior to the fresh materials, it is unsuitable due to shrinkage to toughness caused by slow prolonged drying (Jayaraman, 1988). Canned products on the other hand, suffer from the disadvantages of bulk, weight, overcooked texture and flavor, high cost and dependence for safety or wholesomeness on the integrity of the container. In order to extend the shelf life of these products they are usually processed thermally using methods such as hot water immersion, however these treatments can cause a reduction in antioxidant capacity (Dewanto et.al., 2002).

Consumers are demanding high quality and convenient products with natural flavour and taste, and greatly appreciate the fresh appearance of minimally processed food (Oey et.al., 2008). With the increased demand for fresh-like quality, processors have turned toward Intermediate-moisture products that are more stable than fresh products and use mild preservation techniques.

This study examines innovative hurdle techniques to obtain shelf stable product with fresh-like characteristics. The concept of wholesomeness has been used for food irradiation. It is a specifically defined term and it includes concepts of microbiological and toxicological safety and nutritional adequacy (Skala et.al., 1987). Radiation technology can be very promising and effective alternatives for ensuring microbial quality and safety of minimally processed fruits and vegetables and is also recommended for processed fruits. More than 100 years of research has accepted the use of irradiation in food industry as a food safety method (Scott, 2004). However, very few reports exist on the use of radiation processing for enhancing shelf life of processed fruits and vegetables.

MATERIALS AND METHODS

The study was taken up to develop shelf stable intermediate moisture vegetables using radiation processing as a hurdle after standardization of pre-treatments and drying conditions, packaging material and radiation doses to be used. The protocols followed for processing of IM tomato is presented in Table 1.

Table 1: Standardized protocols for preparation of IM TOMATO

Pretreatment	Per cent moisture	Optimum radiation dose(kGy)	Packaging material	Mode of drying			
Blanching	26.7%	2.50	400 gauge polyethene bags	Infra red		Tray drying	
				Temp ^{0}C	*Time (hr:min)*	*Temp* ^{0}C	*Time (hr:min)*
				60	3.30	80^{0}C	6.30

EXPERIMENTAL DESIGN AND TREATMENT FOR SHELF LIFE STUDIES

The standardized protocols were used for preparation of IM tomatoes Table 1.The following treatments were designed to ascertain the effect of shelf stability with optimal organoleptic quality.

Treatment 1 Tray dried (TD)
Treatment 2 Tray dried and radiated (TDR)
Treatment 3 Infra red dried (IR)
Treatment 4 Infra red dried and radiated (IRR)

Standardized IM tomatoes were analyzed for nutritional, microbiological and acceptability changes at an interval of 0, 30, 60, 90, 120, 150 and 180 days of storage period. Parameters assessed were as follows

PHYSICAL PROPERTIES

Physiological loss of weight (PLW) was estimated by recording initial and subsequent weights during regular intervals during storage and per cent of loss in weight was calculated, Rehydration ratio was recorded as ratio of the weight of dehydrated sample to the weight of rehydrated sample (McGuire, 1992).

COLOUR ESTIMATION

Hunter lab Color spectrometer was used for color estimation.The most common technique to assess the color is by colorimetry. There are several color scales in which the surface color can be represented. The 3-dimensional scale L^*, a^* and b^* is used where L^* is the lightness coefficient, ranging from 0 (black) to 100 (white) on a vertical axis. The a^* is purple-red (positive a^*value) and blue-green (negative a^* value) on a horizontal axis. A second horizontal axis is b^*, that represents yellow (positive b^* value) or blue (negative b^* value) color (Ranganna, 1986).

ORGANOLEPTIC PROPERTIES

The organoleptic scoring was done by a panel of 10 judges in the sensory evaluation laboratory using a score card developed for the purpose. A five point hedonic scale was used to evaluate (Periaym et.al., 1957). The results were expressed as mean scores by taking average of all the replicates.

CHEMICAL PROPERTIES

Moisture was estimated by (AOAC, 1990) Total and βcarotenes-by Spectro photo meter method (Zakaria et.al., 1979), vitamin C and acidity by titration method (McGuire, 1992).

MICROBIAL PROPERTIES

For estimating viable bacterial, yeast and mold count dilution plate method was followed. For bacterial estimation, plate count agar was used and for yeast and mold potato dextrose agar was used (Krishnakumar et.al., 2006).

STATISTICAL ANALYSIS

All the experiments were repeated three times and data obtained was statistically analyzed using Analysis of Variance ANOVA (Snecdor et.al., 1983) two factor with replications to assess the significant difference at 0.05 % and 0.01% level using AGRES software to compare between, within the treatments and the effect of treatments. Once the product was spoilt that treatment was eliminated from analysis and only other three treatments were considered for two factor analysis.

RESULTS AND DISCUSSION

Effect of radiation as hurdle technology on shelf life, physical and organoleptic quality of IM tomato stored at ambient temperature is presented in Table 2.

PHYSICAL PROPERTIES

SHELF LIFE

The shelf life of the IM tomato increased from 2 to 6 months at ambient temperature, when dried using infrared drier and radiated with 2.5 kGy dose. The samples processed in tray drier have shown lower shelf life. Infrared drying in combination with radiation technology showed high product quality and improved shelf stability at 25.87% moisture level when packed in 400 gauge polyethylene covers at ambient temperature (30°C and 65% RH).

MOISTURE CONTENT

During storage, decrease in moisture content was maximum in IRR (26.98%) and minimum in TD (13%). Though all the treatments showed significant change in PLW throughout the storage period, IRR treatment showed better shelf life at ambient temperature

Rehydration Ratio (RR) Rehydration ratio was significantly affected by the combined effect of TD and radiation Maximum rehydration ratio was observed in IRR.This behaviour might be due the fact that more heating coagulates the protoplasmic protein and destroys the osmotic properties of cell membrane, resulting less swelling of dehydrated material (Vega et.al., 2008).

ORGANOLEPTIC PROPERTIES

Among the four treatments studied, infrared drying with 0.75 kGy radiation dose were found to be the best in terms of taste, flavour, texture, color and overall acceptability at ambient temperature.

CHEMICAL PROPERTIES

Effect of radiation as hurdle technology on chemical properties of IM tomato stored at ambient temperature is presented in Table 3.

Table 2- Effect radiation as a hurdle on shelf life, physical parameters, organoleptic properties and colour values on IM tomato stored at ambient temperature

S.no	Parameters	TD		TD R		IR		IRR	
	Shelf life	**0day**	**After 2 months**	**0day**	**after 5 months**	**0day**	**after 3 months**	**0day**	**after 6 months**
A	**Shelf life**	**2 months**		**5 months**		**3 months**		**6 months**	
1	Moisture	27.8	24.16	27.8	21.81	25.87	21.42	25.87	18.89
	(%) change		13.00%		21.50%		17.20%		26.98%
3	RR	7.4	6.79	7.4	5.22	7.8	6.9	7.8	6.23
	(%) change		91.76%		75.81%		88.46%		79.87%
B	**Sensory Scores**								
I	Taste	4.9	3.4	4.9	3	4.9	3	4.9	2.9
ii	Flavor	4.9	3.3	4.9	2.5	4.9	2.7	4.9	2.5
iii	Texture	4.1	2.9	4.1	2.3	4.7	2.5	4.7	2.5
iv	Color	4.8	2.9	4.8	2.5	4.6	2.2	4.6	2.3
v	OA	4.9	2.9	4.9	2.4	4.4	2	4.4	2.1
C	**Color values**								
I	L*	41.38	37.69	41.38	32.8	41.38	36.76	41.38	30.31
ii	a*	6.29	6.12	6.29	5.32	6.29	5.23	6.29	4.62
iii	b*	10.48	8.65	10.48	5.34	10.48	7.87	10.48	6.56
iv	DE	5.77	7.12	5.77	6.36	5.77	6.87	5.77	7.96
v	Hue	59.02	54.7	59.02	45.08	59.02	56.38	59.02	54.82
vii	Color intensity (dC)	7.63	11.92	7.63	17.53	7.63	14.22	7.63	20.95

NOTE: *TD - Tray dried *TDR - Tray dried and radiated *IR - Infra red dried *IRR - Infra red dried and radiated AA- Ascorbic Acid,TC- Total Carotenoids, βC – beta carotenoids, RS – Reducing Sugars, TS- Total Sugars, TBC- Total Bacteria Count, TMC Total Mold Count, RR – Rehydration Ratio, OA- Overall acceptability

Table 3. Effect of radiation as a hurdle on nutritional and microbial quality in IM Tomato stored at ambient temperature

S.no	Parameters	TD		TDR		IR		IRR	
	Shelf life	**0day**	**After 2 months**	**0day**	**after 5 months**		**Shelf life**	**0day**	**After 2 months**
C	**Acidity**	1.02	1.41	1.02	1.4	1.1	0.32	1.1	0.31
D	**AA (mg/100g)**	65.00	30.10	65.00	12	76.00	37.8	76.00	25.00
	(%)		46.31%		18.46%		49.74%		32.89%
E	**TC (µg/100g)**	4562.33	2346.00	4562.33	1693.22	4562.33	2845.50	4562.33	2341.8
	(%)		51.42%		46.80%		62.30%		51.30%
F	**βC (µg/100g)**	482.67	280.91	482.67	163.75	482.67	290.54	482.67	174.61
	(%)		69.99%		55%		69.10%		51.90%
G	**RS mg/100g**	8.05	9.01	8.05	13.20	8.05	10.75	8.05	13.80
H	**TS (mg/100g)**	14.05	20.80	14.05	20.12	14.05	18.15	14.05	12.30

I	**Lycopene (µg/100g)**	9361.8	7285.4	9361.80	4485.0	9361.8	7344.0	9361.80	5433.2
	(%)		77.80		47.9		78.4		58.0
J	**TBC**(log cfu/gm)	0.95	2.85	0.95	2.59	0.95	1.90	0.95	1.90
K	**TMC**(log cfu/gm)	0.85	2.83	0.85	2.35	0.85	1.85	0.85	1.82

Note: *TD - Tray dried *TDR - Tray dried and radiated *IR - Infra red dried *IRR - Infra red dried and radiated
AA-Ascorbic Acid,TC- Total Carotenoids, βC – beta carotenoids, RS – Reducing Sugars, TS- Total Sugars, TBC- Total Bacteria Count, TMC Total Mold Count, RR – Rehydration Ratio, OA- Overall acceptability.

ACIDITY

There was significant change in acidity among different treatments on storage with tray dried samples showing higher acidity (1.41 %) and Infrared-irradiated samples showing lower acidity (0.31 %) at the end of the storage period.

ASCORBIC ACID

Vitamin C is a reactive compound and it is particularity vulnerable to storage conditions (Davey et.al., 2000). Ascorbic acid decreased with increase in storage time in both the driers as ascorbic acid is sensitive to heat and light. During storage maximum retention of ascorbic acid was observed in IR 49.74% followed by and IRR. Degradation of ascorbic acid was more in TDR samples. Vitamin C is heat sensitive and prolonged exposure at higher temperature destroys it. Optimum temperature formaximum vitamin C retention was observed to be 60 °C. Kaur and Singh (1981) also reported the similar findings Browning of IM tomato samples was minimum when the samples were dehydrated in IR and maximum browning was observed in TD

TOTAL AND BETA CAROTENES

Total carotenoid content can be referred to as one of the measures of quality index. Initially there were minimal changes in carotenoids retention but by the end of storage period the retention levels decreased in both the treatments. Maximum retention of total carotenoids, of β-carotene was observed in IR 62.30 percent and 69.10 percent respectively.

LYCOPENE

Lycopene content in tomato-based food products can be considered as quality index. Lycopene retention was 58% in IRR samples after 6months of storage where as only 47.9% was retained in TDR after 5 months of storage period. Llycopene in tomato is relatively resistant to degradation [17, 18] whereas other antioxidants (ascorbic acid, tocopherol, and b-carotene) decrease as a function of thermal processing [18] The effect of thermal treatments on lycopene in tomato products has attracted much attention With increasing interest and awareness of its health benefits, the stability of lycopene during food processing and storage has been reported by many [19 20, 21,22,23,24,25,]. The data in the literature are in agreement that lycopene remains relatively stable during typical food processing procedures, except at extreme conditions (for example, very high temperature or very long heating times) Heating and exposure to light are the major factors to affect food quality in processing and material handling procedure. Most of the studies indicated that lycopene losses were lowered when tomatoes were processed as pieces than in paste . Drying tomato halves at 110^0C for approximately 4 hours caused a lycopene loss of 12% [26]. Also, semi-drying of fruit quarters at 42^0C for 18 hours resulted in 10.5–20.5% loss of lycopene in three different tomato cultivars [27]. The results were in agreement with their findings.

REDUCING SUGARS AND TOTAL SUGARS

During storage reducing sugars and total sugars increased. Maximum increase was observed in TD samples Total sugars decreased in IRR.

MICROBIAL PROPERTIES

TBC &TMC

Compared to control, total bacterial count was less (Table3) in all the radiated samples No Coli forms were observed in any sample fresh or processed. IRR recorded least count and low rate of growth throughout the storage period. Non irradiated samples showed a significant increase in yeast and mold during storage when compared to radiated samples. The lower count of bacteria, yeast and mold in radiated samples may be due to DNA damage of bacteria on exposure to radiations leading to cell death [29]. Khattak *et al* [30] reported that with minimal dose 0.19kGy and 0.17 kGy of irradiation eliminated Escherichia coli and 0.25 and 0.29 kGy Salmonella paratyphi in cucumber and cabbage, respectively.

TDN was highly populated than IRN may be due to microbial inactivation as infrared heating source produces more energy. Hamanaka *et al.* [31] and Sawai *et al.* [32] reported that shorter treatment time was enough to inactivate pathogens *E. Coli* population, bacteria with minimal changes in food quality. No Coli forms were observed in any sample throughout the storage period, indicating that the product was stable with respect to bacteria, yeast and mold growth. This may be due to a combination of different hurdles of Irradiation, Infrared heating and packing which more effectively inhibited or inactivated microorganisms and food poisoning leaving desired fermentation process unaffected. The application has proven as very successful, as an appropriate combination of hurdles providing microbial stability, safety and also stable sensory and nutritive properties.

CONCLUSION

In the present study, it has been found that a reduction in a_w by hurdle technology of radiation processing, Infra red drier, 400 gauge polythene bags could keep intermediate moisture product safe, acceptable and effective in retention of nutrients up to a period of six months at ambient temperature. The different combinations of hurdles used were more effective than use of a single preservative in large amounts which may not provide the same effect.

ACKNOWLEDGMENT

The authors thank Board of **Research in Nuclear Sciences (BRNS) Department of Atomic Energy (DAE)** for funding this project entitled 'Development of shelf stable intermediate moisture fruit and vegetable products using radiation processes as a hurdle technology".

REFERENCES

- Food and Agriculture Organization (FAOSTAT@ faostat.org)
- Jayaraman K.S. (1988). Development of intermediate moisture tropical fruit and vegetableproducts-technological problems and prospects, Food preservation by moisture controlby C.C. Seow. pp: 175-197
- Dewanto, V., Wu, X., Adom, K., & Liu, R. (2002). Thermal processing enhances the nutritional value of tomatoes by increasing the total antioxidant activity. Journal of Agricultural and Food Chemistry, 50(10), 3010–3014.
- Oey, I., Van der Plancken, I., Van Loey, A., & Hendrickx, M. (2008). Does high pressure processing influence nutritional aspects of plant based food systems? Trends in Food Science and Technology, 19, 300–308.
- Skala JH, McGown EL, Waring PP. 1987. Wholesomeness of irradiated foods. Journal of Food Protection 50:150–160.
- Scott Smith J, Suresh P (2004). Irradiation and Food Safety. Food Technology, Irradiation and Food Safety. 58(11): 48-55.
- Ranganna, S.1986. Handbook of Analysis and Quality Control for Fruits and Vegetable Products. Tata McGraw Hill, New Delhi.
- McGuire, R.G.1992. Reporting of Objective Color Measurements. Hortscience 27(12): 254-1255.
- Periaym, D.R. and Pilgrim, J.F. 1957. Hedonic scale method of measuring food preferences. Food Technology 11(9): 9–14.
- AOAC, Official methods of analysis of the association of official analytical chemists, 15th Rd., 1990, Vol.2.
- Zakaria,M., Simpson,K., Brown, P. R. and Kostulvic, A. 1979. Use of reversed phase HPLC analysis for the determination of pro – vitamin A carotenes in tomatoes. Journal of Chromatography 176: 109 – 117.
- Krishnakumar,T. and Devadas,C.T. 2006. Microbiological changes during storage of sugarcane juice in different packaging materials. Beverage and Food World 33(10): 82-83.
- Snecdor, G.W. and Cohran, W.G. 1983. Statistical methods, 217–235. New Delhi: Oxford and IBH publishing company.
- Vega-Galvez A, Lemus-Mondaca R, Bilbao-Sa´inz C, Fito P, Andre´sA (2008) Effect of air drying temperature on the quality of rehydrated dried red bell pepper (var. Lamuyo). J Food Eng 85:42–50
- Davey, M. W., Van Montagu, M., Inze´, D., Sanmartin, M., Kanellis, A., Smirnoff, N., et al. (2000). Plant L-ascorbic acid: chemistry,function, metabolism, bioavailability and effects of processing. Journal of the Science of Food and Agriculture, 80, 825–860
- Kaur B, Singh S (1981) Effect of dehydration on storage of cauliflower on the physical characteristics. Indian Food Packer 35(1):23–26
- Abushita, AA, Daood, HG and Biacs, PA. (2000) Change in carotenoids and antioxidant vitamins in tomato as a function of varietal and technological factors. Journal of Agricultural and Food Chemistry 48, 2075-2081.
- Nguyen, M. L., & Schwartz, S. J. (1998). Lycopene stability during food processing. Proceedings of the Society for Experimental Biology and Medicine, 218, 101–105.
- Sharma, SK and Le Maguer, M. (1996) Kinetics of lycopene degradation in tomato pulp solids under different processing and storage conditions. Food Research International, 29, 309-315.
- Shi, J and Le Maguer, M. (2000) Lycopene in Tomatoes: Chemical and Physical Properties Affected by Food Processing. Critical Reviews in Biotechnology 20, 4, 293-334
- Takeoka, G R, Dao, L, Flessa, S, Gillespie, DM, Jewell, WT, Huebner, B, Bertow, D and Ebeler, SE, (2001) Processing effects on lycopene content and antioxidant activity of tomatoes. Journal of Agricultural and Food Chemistry 49, (8), 3713-3717.
- Graziani, G., Pernice, R., Lanzuise, S., Vitaglione, P., Anese, M., and Fogliano, V. (2003). Effect of peeling and heating on carotenoid content and antioxidant activity of tomato and tomato–virgin

olive oil systems. *European Food Research and Technology* 216: 116–121.

- Sahlin, E., Savage, G.P., and Lister, C.E. (2004). Investigation of the antioxidant properties of tomatoes after processing. *Journal of Food Composition and Analysis* 17: 635–647.
- Goula, A.M., and Adamopoulos, K.G. (2005). Stability of lycopene during spray drying of tomato pulp. *LWT-Food Science and Technology* 38: 479–487.
- Goula, A.M., Adamopoulos, K.G., Chatzitakis, P.C., and Nikas, V.A. (2006). Prediction of lycopene degradation during a drying process of tomato pulp. *Journal of Food Engineering 74*(1): 37–46.
- Zanoni, B, Peri, C, Nani, N and Lavelli, V. (1999) Oxidative heat damage of tomato halves as affected by drying. Food Research International 31, 5, 395-401.
- Toor, R.K., Savage, G.P., and Lister, C.E. (2006). Seasonal variations in the antioxidant composition of greenhouse grown tomatoes. *Journal of Food Composition and Analysis*, 19: 1–10.
- D’souza C., Mervyn C., Suman singha, and Morris Ingle (1992) ‘Lycopene concentration of tomato fruit can be estimated from chromaticity values” HortScience 27 (5): 465-466.
- Brennan, J.G., 2006. Food processing handbook. In S.Alistair, Grandison (Eds.) Online ISBN: 978-3-527-32468-2
- Khattak *et al.* (2005) Khattak, A.B., N. Bibi, M.A. Chaudry, M. Khan, M. Khan and M.J. Qureshi, 2005. Shelf life extension of minimally processed cabbage and cucumber through gamma irradiation. Journal of Food Protection, 68(1): 105-110.
- Hamanaka, D., S. Dokan, E. Yasunaga, S. Kuroki, T. Uchino and K. Akimoto, 2000. The sterilization effects on infrared ray of the agricultural products spoilage microorganisms (Part 1). An ASAE Meeting Presentation, Milwaukee, WI, July 9–12, No. 00 6090.
- Sawai, J., K. Sagara, A. Hashimoto, H. Igarashi and M. Shimizu, 2003. Inactivation characteristics shown by enzymes and bacteria treated with far-infrared radiative heating. International Journal of Food Science Technology, 38: 661–667.