Effect of hot water treatment and irradiation on chemical composition of graded mango fruits (*Mangifera indica*) cv Alphonso under ambient and cold storage conditions

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ABSTRACT

This study involved hot water treatment of mango fruits at 55°C carried out at Agricultural Produce Market Committee (APMC), Nachane, Ratnagiri, Maharashtra followed by irradiation at 400 gray at Krushak (Krushi Utpadan Sanrakshan Kendra), Lasalgaon, Nashik, Maharashtra. Irradiated fruits were carried to Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra. Fruits were kept for ripening under ambient and cold storage conditions. Chemical parameters viz pH (4.27), reducing sugar (2.54%), total sugar (11.05%) and ascorbic acid (35.46 mg/100 g) were found maximum in hot water treated and irradiated fruits.

Keywords: Grading; hot water treatment; irradiation; cold storage; corrugated fiber board boxes

INTRODUCTION

India is famous for its exotic mango hotspots, promising delightful flavors and aroma. Import of Indian mangoes in USA and Japan has not been permitted citing presence of fruit flies and stone weevil since 2006. Japan and USA have lifted ban provided mangoes were given vapour heat treatment for Japan and irradiation for USA. For shipment of mangoes to USA it is mandatory to get the consignment irradiated. Currently Krushak (Krushi Utpadan Sanrakshan Kendra), Lasalgaon, Nashik, MS is the only approved agency for the purpose. The facilities for vapour heat treatment exist at Maharashtra State Agricultural Marketing Board, Vashi; AP State Agro-industries Development Corporation, Tirupathi and Nuzvid; Uttar Pradesh Mandi Parishad, Saharanpur, UP; Galla Foods Limited, Chittor, AP and Nikko Namdhari Foods Ltd, Nashik, Maharashtra (Anon 2009).

MATERIAL and METHODS

The mature fruits were harvested and graded as per maturity into three groups 75, 85, and 100 per cent of specific gravity by float and sink method (Amarakoon et al 1999) at Nachane, Ratnagiri. Fruits were washed in water as per grades, dried, packed in corrugated fiber board (CFB) boxes, given a hot water treatment for 5 minutes for which they were separately passed through hot water unit fitted with thermostat control sensors to maintain desired temperature of 55°C and dried with blow of air. Fruits were packed in labeled CFB boxes provided with ventilators covered with insect proof screen of 30 mesh (Mandatory for USA and Japan). The packaging material was of food grade quality. Packed boxes were given irradiation at 400 gray at Lasalgoan, Nashik. As per grades CFB boxes were loaded in pallets and conveyed towards irradiation chamber. Fruits of control treatment were carried in van but not irradiated. After irradiation fruits were returned to Dapoli and kept for ripening at ambient temperature (28.6 to 31.8°C, 76% relative humidity) and at cold storage (12 ± 2°C, 90% relative humidity). After ripening fruits were analyzed for chemical properties viz pH, sugar and ascorbic acid. The experiment was conducted by using factorial completely randomized block design using treatments viz T_1 (75% mature fruits, control), T_2 (75% mature, hot water-

treated and irradiated fruits), T_3 (85% mature fruits, control), T_4 (85% mature, hot water-treated and irradiated fruits), T_5 (100% mature fruits, control) and T_6 (100% mature, hot water-treated and irradiated fruits) and sub-treatments AT (Storage at ambient temperature, 28.6 to 31.8°C, 76% RH) and CS (Storage at cold temperature,12 ± 2°C, 90% RH). The experiment was replicated six times with 20 fruits per treatment.

RESULTS and DISCUSSION

The changes in pH, reducing sugar, total sugar and ascorbic acid of graded fruits given hot water treatment and irradiation and stored under ambient temperature and cold storage are presented in Tables 1 to 4.

pH

pH increased at ripened stage irrespective of the treatments and storage conditions (Table 1). As per pooled data the highest pH (4.27) was observed in T_6 (100% mature, hot water-treated and irradiated fruits) being significantly superior over the rest. Higher pH was recorded in cold storage fruits (4.06) as compared to ambient temperature fruits (4.01). The pH increased in all treatments during storage period which could be attributed to corresponding degradation of organic acids during ripening. Janave and Sharma (2005) noticed 5.15 pH in control and 5.13, 5.14, 5.17, and 4.91 pH in 50, 100, 150 and 200 gray irradiated fruits respectively after 15 days at 30-32°C.

Reducing sugar

Highest reducing sugar (2.54%) was observed in treatment T_6 (100% mature, hot water-treated and irradiated fruits) which was at par with T_4 (85% mature, hot water-treated and irradiated fruits), T_5 (100% mature fruits, control) and T_2 (75% mature, hot water-treated and irradiated fruits) with 2.50, 2.50 and 2.46 per cent reducing sugar respectively (Table 2). Cold storage fruits had higher (2.60%) reducing sugar content as compared to ambient temperature fruits. It increased in all the treatments after storage. This could be due to conversion of starch into sugars. Janave and Sharma (2005) observed 3.33, 0.89 and 1.39 per cent RS in control, 100 and 300 gray irradiated fruits respectively after 17 days of storage. Jabbar et al (2011) reported 2.18 per cent reducing sugar in cv Samar Bahisht Chausa fruits treated with hot water.

Total sugar

Total sugar (Table 3) was maximum (11.05%) in T_6 (100% mature, hot water-treated and irradiated fruits) and at par with T_4 (85% mature, hot water-treated and irradiated fruits) and T_2 (75% mature, hot water-treated and irradiated fruits) with values 11.01 and 10.94 per cent respectively. There was significant

Table 1. Effect of hot water treatment and irradiation of mango fruits on pH under ambient and cold storage conditions

Treatment (T)	pH										
	2008				2009				Pooled		
	Initial value	AT	CS	Mean	Initial value	AT	CS	Mean	AT	CS	Mean
T_1	2.64	3.81	3.84	3.83	2.65	3.82	3.85	3.83	3.81	3.84	3.83
T_2		3.96	3.99	3.97		3.99	4.00	4.00	3.97	3.99	3.98
T_3	2.58	3.85	3.90	3.88	2.55	3.86	3.91	3.88	3.85	3.90	3.89
T_4		4.07	4.15	4.11		4.08	4.16	4.12	4.07	4.15	4.13
T_5	2.51	4.14	4.15	4.14	2.49	4.15	4.16	4.15	4.14	4.15	4.14
T_6		4.26	4.33	4.29		4.16	4.33	4.24	4.21	4.33	4.27
Mean		4.01	4.06			4.01	4.06		4.01	4.06	

T_1= 75% mature fruits (control), T_2= 75% mature, hot water treated and irradiated fruits, T_3= 85% mature fruits (control), T_4= 85% mature, hot water treated and irradiated fruits, C_5= 100% mature fruits (control), T_6= 100% mature, hot water treated and irradiated fruits, AT= Ambient temperature, CS= Cold storage

	Treatment			Sub-treatment			Interaction		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
SE	0.015	0.012	0.009	0.009	0.007	0.005	0.022	0.017	0.013
$CD_{0.01}$	0.058	0.046	0.040	0.0033	0.027	0.021	NS	NS	NS

Table 2. Effect of hot water treatment and irradiation of mango fruits on reducing sugar under ambient and cold storage conditions

Treatment	Reducing sugar (%)										
	2008				2009				Pooled		
	Initial value	AT	CS	Mean	Initial value	AT	CS	Mean	AT	CS	Mean
T_1	1.34	2.20	2.50	2.35	1.32	2.28	2.57	2.42	2.24	2.54	2.39
T_2		2.30	2.53	2.42		2.37	2.61	2.49	2.34	2.57	2.46
T_3	1.38	2.24	2.55	2.40	1.36	2.33	2.63	2.48	2.29	2.59	2.44
T_4		2.34	2.57	2.46		2.42	2.66	2.54	2.38	2.62	2.50
T_5	1.40	2.28	2.60	2.44	1.39	2.42	2.68	2.55	2.35	2.64	2.50
T_6		2.38	2.62	2.50		2.45	2.70	2.57	2.42	2.66	2.54
Mean		2.29	2.56			2.38	2.64		2.34	2.60	

T_1= 75% mature fruits (control), T_2= 75% mature, hot water treated and irradiated fruits, T_3= 85% mature fruits (control), T_4= 85% mature, hot water treated and irradiated fruits, C_5= 100% mature fruits (control), T_6= 100% mature, hot water treated and irradiated fruits, AT= Ambient temperature, CS= Cold storage

	Treatment			Sub-treatment			Interaction		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
SE	0.124	0.011	0.021	0.007	0.006	0.005	0.017	0.015	0.014
$CD_{0.01}$	0.046	0.041	0.080	0.0027	0.024	0.017	NS	NS	NS

increase in total sugar under all treatments. This could be due to increased maturity of fruits and low temperature. The rise in total sugar during ripening could be attributed to the conversion of starch into sugars. Janave and Sharma (2005) noticed increase in TS (12.73, 13.56 and 13.46%) in control, 100 and 300 gamma-ray irradiated mangoes respectively stored at ambient temperature. Jabbar et al (2011) reported 13.82 per cent total sugar in cv Samar Bahisht Chausa mango fruits treated with hot water.

Ascorbic acid

Maximum ascorbic acid content was also found in T_6 (35.46 mg/100 g) which was at par with 34.61 mg/100 g in T_4 (Table 4). Interaction effects were significant. Higher ascorbic acid was recorded under ambient temperature in T_6 (36.71 mg/100 g) which was at par with T_4 (35.71 mg/100 g) and T_2 (33.90 mg/100 g). However in all cases its content decreased during storage which could be attributed to its degradation during ripening process. Janave and Sharma (2005) reported increase in ascorbic acid (95.3 mg/100 g) with irradiation dose of 100 gray whereas the ascorbic acid was found to decrease (71.2 mg/ 100 g) with a dose of 300 gray and in control. Broisler et al (2007) observed a small increase in ascorbic acid content on the first day after irradiation. Mansour et al (2006) reported 37.4, 37.6 and 33.0 mg per 100 g ascorbic acid in hot air- treated (40°C) fruits of cvs Keitt, Kent and Tommy Atkins respectively stored at 12°C for a period of four weeks.

CONCLUSION

The highest pH (4.27), maximum reducing sugar (2.54%), highest total sugars (11.05%) and maximum ascorbic acid (35.46 mg/100 g) were found in hot water-treated, irradiated and 100 per cent mature mango fruits as compared to other treatments. All these parameters were higher in cold storage fruits than the fruits stored at ambient temperature.

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Table 3. Effect of hot water treatment and irradiation of mango fruits on total sugar under ambient and cold storage

Treatment	Total sugar (%)										
	2008				2009				Pooled		
	Initial value	AT	CS	Mean	Initial value	AT	CS	Mean	AT	CS	Mean
T_1	2.58	9.15	10.54	9.84	2.57	9.22	10.15	9.68	9.18	10.34	9.76
T_2		11.05	10.81	10.93		11.06	10.87	10.96	11.10	10.84	10.94
T_3	2.62	9.22	10.70	9.96	2.60	9.29	10.61	10.28	9.25	10.65	10.12
T_4		11.16	10.90	11.03		11.11	10.95	10.99	11.13	10.92	11.01
T_5	2.65	9.28	10.72	10.00	2.66	9.35	10.76	10.38	9.31	10.74	10.19
T_6		11.26	10.98	11.12		11.22	11.03	11.07	11.24	11.00	11.05
Mean		10.18	10.77			10.22	10.72		10.20	10.74	

T_1= 75% mature fruits (control), T_2= 75% mature, hot water treated and irradiated fruits, T_3= 85% mature fruits (control), T_4= 85% mature, hot water treated and irradiated fruits, C_5= 100% mature fruits (control), T_6= 100% mature, hot water treated and irradiated fruits, AT= Ambient temperature, CS= Cold storage

	Treatment			Sub-treatment			Interaction		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
SE	0.041	0.033	0.030	0.024	0.019	0.017	0.058	0.047	0.046
$CD_{0.01}$	0.156	0.126	0.115	0.090	0.072	0.064	0.221	0.178	0.184

Table 4. Effect of hot water treatment and irradiation of mango fruits on ascorbic acid under ambient and cold storage conditions

Treatment	Ascorbic acid (mg/100 g)										
	2008				2009				Pooled		
	Initial value	AT	CS	Mean	Initial value	AT	CS	Mean	AT	CS	Mean
T_1	75.09	17.74	27.62	22.68	74.15	20.97	31.02	25.99	19.36	29.32	24.34
T_2		32.54	30.69	31.61		35.26	33.99	34.62	33.90	32.34	33.12
T_3	73.36	19.82	29.68	24.75	73.41	22.76	33.06	27.91	21.29	31.37	26.33
T_4		34.72	31.91	33.32		36.70	35.13	35.91	35.71	33.52	34.61
T_5	72.92	20.40	31.85	26.12	71.80	23.28	35.01	29.15	21.84	33.43	27.64
T_6		35.35	32.70	34.02		38.07	35.47	36.77	36.71	34.21	35.46
Mean		26.76	30.78			29.51	33.94		28.14	32.36	

T_1= 75% mature fruits (control), T_2= 75% mature, hot water treated and irradiated fruits, T_3= 85% mature fruits (control), T_4= 85% mature, hot water treated and irradiated fruits, C_5= 100% mature fruits (control), T_6= 100% mature, hot water treated and irradiated fruits, AT= Ambient temperature, CS= Cold storage

	Treatment			Sub-treatment			Interaction		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
SE	0.494	0.853	0.610	0.285	0.492	0.372	0.699	1.207	0.932
$CD_{0.01}$	1.861	3.211	2.336	1.074	1.854	1.480	2.632	4.541	3.728

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