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ORGANOLEPTIC QUALITY AND STORABILITY OF MATURITY GRADED GUAVA FRUITS (CV. SARDAR) AS INFLUENCED BY CALCIUM TREATMENTS DURING COLD STORAGE

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ABSTRACT
An investigation on organoleptic quality and storability of maturity graded guava fruits (mature green and colour turning) treated with $CaCl_2$ (1.0 and 2.0%) and $Ca(NO_3)_2$ (1.0 and 2.0%) during cold storage ($10 \pm 1^{\circ}C$ and $90 \pm 5\%$ RH) was determined during Dec-Jan (2009-10 and 2010-11). The fruits were evaluated for various parameters initially at harvest before storage and on 5, 10, 15 and 20 days of storage. During investigation period, organoleptic quality changed according to the stage of maturity at harvest as evidenced by TSS, reducing and total sugar contents which increased gradually and reached their peaks on days coinciding with ripe stage followed by a gradual decline towards the end of storage, while acidity decreased consistently with the advancement of storage. Organoleptic parameters such as, fruit appearance and colour, flavour, taste and overall acceptance gradually increased till ripe stage, while fruit texture declined continuously. All the Calcium treatments significantly improved shelf life without hampering organoleptic quality compared to control during cold storage. However, MG stage in combination with 2.0 % $Ca(NO_3)_2$ recorded a potential shelf life of 23.83 and 23.67 days with moderately acceptable organoleptic quality (6.37 and 6.34) for both the years of investigation.

INTRODUCTION

Guava (*Psidium guajava* L.) is one of the most well known edible tree fruits grown widely in more than sixty countries throughout the tropical and sub-tropical regions in the world. In India it occupies an area of 0.26 million hectares with annual production of 3.66 million tonnes (Saxena and Gandhi, 2014). The fruits are delicious, rich in vitamin 'C', pectin and minerals like Calcium, Phosphorous and Iron. Guava fruits are normally consumed as fresh or processed into several products like jam, jelly, cheese, nectar, paste *etc*. (Boora, 2012). There is a great demand of guava fruits in both domestic and international markets for fresh and processing purposes. The share of guava in fresh fruit export from India is mere 0.65 per cent which can be further boosted, if fruit is properly handled after harvest to earn more foreign exchange (Mitra *et al*., 2008). Guava is a perishable fruit and highly prone to bruising and mechanical injuries. Due to such perishability, control of fruit ripening is fundamental and this generates the necessity to search for new technologies to increase shelf life, reach distant markets and thus improve the marketing process (Mitra *et al*., 2012).

Skin colour is the best maturity index in guava as it could be monitored non-destructively during fruit ripening and storage (Mercado-Silva *et al*., 1998 and Asrey *et al*., 2008). Fruits attaining maturity show signs of changing colour from pale green to yellowish green. If the fruit is to be shipped to distant markets it should be mature, full sized and of firm texture, but without an obvious colour-break on the surface. Fruits for local market can be harvested in a more advanced stage of maturity (Singh, 2007). However, harvesting fruits at appropriate stage of maturity is critical in maintaining the post harvest quality of guava fruits (Azzolini *et al*., 2004 and Patel *et al*., 2015). Post harvest applications of Calcium compounds extend the shelf life of fruits by maintaining firmness and minimizing the rate of respiration, protein breakdown and disease incidence (Singh *et al*., 1981). Calcium salts such as lactate, chloride and nitrate (0.5-3.5%) have been shown promise in shelf life extension and quality retention in guava (Hiwale and Singh, 2003; Selvan and Bal, 2005b; Mahajan *et al*, 2011 and Barche *et al*., 2015). Storage of fruits at low temperatures for a definite period is a common practice in developed countries (Mahajan *et al*., 2009). Low temperature may delay or retard ripening and may reduce spoilage due to its effects on reducing respiration rate, transpiration, ethylene production, ripening, senescence and disease incidence. On the other hand, enzymatic reactions occur slowly at low temperatures, extending shelf life of perishables (Bron *et al*., 2005). The effect of low temperature (0-3°C) on storage life of guava fruits had been examined and a storage life of 2-3 weeks

has been reported (Selvan and Bal, 2005a). Such low temperature storage causes fruit to lose consumer appeal and economic value. In spite of the previous findings, there is a dearth of information on the storability and quality of maturity graded guava fruits treated with Calcium salts during cold storage. Therefore this study was initiated to investigate at such conditions.

MATERIALS AND METHODS

The present investigation was carried out at Quality Control Laboratory, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad, during Dec-Jan (2009-10 and 2010-11). Lucknow-49 popularly known as Sardar guava, a selection from Allahabad safeda is possibly the most cultivated variety of guava in India characterized by medium to large sized fruits, thick flesh, cream white colour, few seeds, acid sweet, high in pectin and good for jelly making (Mitra *et al*., 2008 and Gaur *et al*., 2014).

Material

Uniform medium sized guava fruits apparently free from diseases and bruises were harvested from a nearby farmer's orchard and graded for two stages of maturity. Mature green stage (MG) is when maximum growth of fruits had been attained and their skin colour changes from dark green to light green; colour turning stage (CT) is when the skin colour turns slightly yellow from light green. They were divided into requisite lots for further handling.

Postharvest treatments, packing and storage

The study consisted of three replications and 10 treatment combinations. For each replication, thirty fruits (approx. 5Kg) each for MG and CT stages were selected and subjected to treatment with Calcium salts. The fruits were dipped in aqueous solutions of Calcium chloride (1 and 2 %) and Calcium nitrate (1 and 2 %) separately each for 15-20 minutes. The control fruits were dipped in tap water and kept for comparison. The surface of the fruit was air dried and thereafter packed in newspaper lined Corrugated Fibre Board (CFB) boxes of 400/300/140 mm size, 3 ply thickness, 4.5Kg capacity with 5 percent ventilation. The fruits were stored in walk-in cold chamber (Quality Control Laboratory, ANGRAU, Rajendranagar, Hyderabad) maintained at $10 \pm 1^{o}C$ temperature and $90 \pm 5\%$ relative humidity.

Analytical methods

Observations on organoleptic parameters of guava fruits were recorded initially before cold storage (Table 1) and at 5 days interval during both the years of investigation. The total soluble solids (TSS) were determined by using a hand refractometer, 0-32 scale (Erma, Japan) corrected at 20°C and expressed in ^{0}Brix (Ranganna, 1986). Acidity, reducing and total sugars were estimated by volumetric method as per the procedure outlined by Ranganna (1986). The organoleptic rating for guava fruits was done by a panel of five semi-trained judges on the basis of nine-point hedonic scale (9 = Like Extremely; 8 = Like Very Much; 7 = Like Moderately; 6 = Like Slightly; 5 = Neither Like Nor Dislike; 4 = Dislike Slightly; 3 = Dislike Moderately; 2 = Dislike Very Much; 1 = Dislike Extremely) for fruit appearance and colour, flavour, texture and taste. The average of all the above characters was calculated and expressed as overall acceptance or palatability rating. A score of 5.5 and above is considered acceptable for consumer appeal of guava fruits (Amerine *et al*., 1965). The shelf life was assessed by recording the number of days the fruits remained in good condition without spoilage in each replication during storage. When the spoilage (over-ripening, skin browning and rotting) of fruits under different treatments exceeded 50 percent, it was considered as the end of storage period which was judged by visual scoring (Jayachandran, 2000).

Statistical analysis

There were three replications for each treatment and each replicate was comprised of 30 fruits. The experiment was laid out in Completely Randomized Design (CRD) with factorial concept and the data was subjected to analysis as per the procedure outlined by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

TSS (^{0}Brix)

Independent of maturity stages at which guava fruits were harvested and Calcium treatments, total soluble solids did not differ significantly during cold storage (Table 2). However the TSS content of guava fruits increased initially, was found maximum on 10th day and 15th day of storage respectively with CT (12.14 and 12.15) and MG (12.02 and 12.02) stages and declined later towards the end of storage. Hydrolysis of starch or conversion of acids to sugars could be the reason for increased TSS with advancement of storage period. At later stages, these sugars along with other organic acids were utilized for respiration at a much faster rate (Wills *et al*., 1981). This similar incline in TSS until ripe stage followed a decline during storage was also reported in the findings of Soares *et al*. (2007) and Ajang *et al*. (2016) in guava. Significant differences were obtained for TSS with respect to Calcium treatments and control. The maximum reduction in TSS from 10th day to 20th day of storage was found in control (11.13 and 11.11) while the minimum reduction was with 2.0% $Ca(NO_3)_2$ (11.69 and 11.67) for both the years of study. Preserving effect on TSS with Calcium salts (nitrate and chloride) was achieved due to retardation of ripening and reduced metabolic activity (Singh

Table 1: Initial readings on organoleptic parameters of guava fruits before cold storage

Parameters	2009-10		2010-11	
	MG stage	CT stage	MG stage	CT stage
TSS	10.40	10.80	10.40	11.00
Acidity	0.72	0.65	0.70	0.68
Reducing sugars	3.88	4.22	3.92	4.18
Total sugars	5.86	6.18	5.91	6.25
Organoleptic score (Overall acceptance)	3.75	5.00	3.25	5.00

Table 2: Effect of maturity stages and Calcium treatments on Total Soluble Solids (^{0}Brix) of guava fruits cv. Lucknow-49 during cold storage

Maturity Stages	Storage period (Days)									
	2009-10					2010-11				
	5	10	15	20	Mean	5	10	15	20	Mean
Mature Green stage (S1)	11.19	11.98	12.02	10.74	11.48	11.22	12.00	12.02	10.73	11.49
Colour Turning stage (S2)	11.96	12.14	11.38	10.07	11.39	11.95	12.15	11.45	10.07	11.40
Calcium Treatments										
Calcium chloride - 1% (T1)	11.35	11.98	11.70	10.35	11.34^{cd}	11.38	11.99	11.78	10.40	11.39^{bcd}
Calcium chloride - 2% (T2)	11.52	12.06	11.82	10.47	11.47^{bc}	11.49	12.06	11.93	10.48	11.49^{abc}
Calcium nitrate - 1% (T3)	11.46	12.15	11.99	10.66	11.56^{ab}	11.53	12.15	11.99	10.67	11.58^{ab}
Calcium nitrate - 2% (T4)	11.60	12.20	12.08	10.88	11.69^{a}	11.62	12.20	12.07	10.78	11.67^{a}
Control (T5)	11.94	12.02	10.88	9.69	11.13^{e}	11.90	12.02	10.86	9.68	11.11^{e}
Mean	11.57^{bc}	12.08^{a}	11.69^{b}	10.41^{d}		11.58^{bc}	12.09^{a}	11.72^{b}	10.40^{d}	

	2009-10		2010-11	
	S.Em ±	C.D (0.05)	S.Em ±	C.D (0.05)
Maturity Stages (MS)	0.046	NS	0.048	NS
Calcium Treatments (CT)	0.073	0.206	0.076	0.215
Storage Period (SP)	0.065	0.184	0.068	0.192
MS × CT	0.103	NS	0.108	NS
MS × SP	0.092	0.260	0.097	0.272
CT × SP	0.146	0.411	0.153	0.430
MS × CT × SP	0.207	NS	0.216	NS

Table 3: Effect of maturity stages and Calcium treatments on acidity (%) of guava fruits cv. Lucknow-49 during cold storage

Maturity Stages	Storage period (Days)									
	2009-10					2010-11				
	5	10	15	20	Mean	5	10	15	20	Mean
Mature Green stage (S1)	0.67	0.63	0.58	0.50	0.59^{b}	0.67	0.63	0.57	0.51	0.60^{b}
Colour Turning stage (S2)	0.61	0.57	0.51	0.46	0.54^{a}	0.61	0.57	0.53	0.46	0.54^{a}
Calcium Treatments										
Calcium chloride - 1% (T1)	0.62	0.59	0.55	0.49	0.56^{b}	0.63	0.59	0.55	0.49	0.56^{b}
Calcium chloride - 2% (T2)	0.64	0.60	0.54	0.50	0.57^{bc}	0.63	0.61	0.55	0.49	0.57^{bc}
Calcium nitrate - 1% (T3)	0.65	0.61	0.57	0.50	0.58^{cd}	0.64	0.61	0.58	0.51	0.58^{bcd}
Calcium nitrate - 2% (T4)	0.66	0.63	0.58	0.51	0.60^{e}	0.66	0.62	0.58	0.53	0.60^{de}
Control (T5)	0.63	0.57	0.48	0.40	0.52^{a}	0.63	0.57	0.50	0.41	0.52^{a}
Mean	0.64^{d}	0.60^{c}	0.54^{b}	0.48^{a}		0.64^{d}	0.60^{c}	0.55^{b}	0.49^{a}	

	2009-10		2010-11	
	S.Em ±	C.D (0.05)	S.Em ±	C.D (0.05)
Maturity Stages (MS)	0.002	0.007	0.003	0.007
Calcium Treatments (CT)	0.004	0.011	0.004	0.011
Storage Period (SP)	0.003	0.010	0.004	0.010
MS × CT	0.005	NS	0.006	NS
MS × SP	0.005	0.014	0.005	NS
CT × SP	0.008	0.021	0.008	0.022
MS × CT × SP	0.011	NS	0.011	NS

et al., 1987), while the rate of reduction in TSS was much higher under control. The results are in accordance with the findings of Mahajan *et al*. (2011) and Goutam *et al*. (2010) in guava and Gupta *et al*. (2011) in peach.

Acidity (%)

It is evident from Table 3 that acidity decreased significantly from 5th day to 20th day during cold storage irrespective of maturity stages and Calcium treatments studied and this decrease might be due to rapid utilization of organic acids in the respiratory process (Wills *et al*., 1981). Among the maturity stages, MG stage (0.59 and 0.60) retained higher levels of acidity compared to CT stage (0.54 and 0.54) throughout storage. Similar reports on higher acidity were noticed in mature green guava fruits (Mercado-Silva *et al*., 1998) and mature green mango fruits (Lalel *et al*., 2003). Among the Calcium treatments studied, 2.0% $Ca(NO_3)_2$ retained maximum acidity (0.60 and 0.60) followed by 1.0% $Ca(NO_3)_2$ (0.58 and 0.58) compared to control (0.52 and 0.52) during storage. Reasonable levels of acidity were maintained upto 10th day of storage in untreated fruits. However the loss in acidity was much higher in the latter half of storage, wherein the fruits tend to be insipid in taste. The higher acidity in Calcium treated fruits might be due to decreased hydrolysis of organic acids and subsequent accumulation of these acids which were

Table 4: Effect of maturity stages and Calcium treatments on Reducing Sugars (%) of guava fruits cv. Lucknow-49 during cold storage

Maturity Stages	Storage period (Days)									
	2009-10					2010-11				
	5	10	15	20	Mean	5	10	15	20	Mean
Mature Green stage (S1)	3.96	4.22	4.27	3.73	4.05[a]	3.96	4.25	4.32	3.83	4.09[a]
Colour Turning stage (S2)	4.27	4.31	3.85	3.50	3.98[b]	4.21	4.38	3.89	3.53	4.00[b]
Calcium Treatments										
Calcium chloride - 1% (T1)	3.97	4.10	3.93	3.51	3.88[d]	3.95	4.20	4.03	3.58	3.94[d]
Calcium chloride - 2% (T2)	4.01	4.16	4.04	3.60	3.95[c]	4.03	4.29	4.14	3.76	4.05[c]
Calcium nitrate - 1% (T3)	4.14	4.40	4.25	3.86	4.16[ab]	4.09	4.39	4.26	3.85	4.15[ab]
Calcium nitrate - 2% (T4)	4.22	4.44	4.33	3.94	4.23[a]	4.13	4.44	4.31	3.91	4.20[a]
Control (T5)	4.24	4.23	3.77	3.17	3.85[de]	4.24	4.26	3.78	3.30	3.89[de]
Mean	4.12[b]	4.26[a]	4.06[bc]	3.62[d]		4.09[bc]	4.31[a]	4.10[b]	3.68[d]	

	2009-10		2010-11	
	S.Em ±	C.D (0.05)	S.Em ±	C.D (0.05)
Maturity Stages (MS)	0.016	0.045	0.018	0.051
Calcium Treatments (CT)	0.025	0.072	0.029	0.081
Storage Period (SP)	0.023	0.064	0.026	0.072
MS × CT	0.036	0.101	0.041	0.114
MS × SP	0.032	0.091	0.036	0.102
CT × SP	0.051	0.143	0.058	0.162
MS × CT × SP	0.072	NS	0.081	NS

Table 5: Effect of maturity stages and Calcium treatments on Total Sugars (%) of guava fruits cv. Lucknow-49 during cold storage

Maturity Stages	Storage period (Days)									
	2009-10					2010-11				
	5	10	15	20	Mean	5	10	15	20	Mean
Mature Green stage (S1)	6.47	6.99	7.03	6.15	6.66[a]	6.49	7.05	7.03	6.30	6.72[a]
Colour Turning stage (S2)	6.97	7.07	6.50	5.73	6.57[b]	6.99	7.07	6.53	5.85	6.61[b]
Calcium Treatments										
Calcium chloride - 1% (T1)	6.48	6.86	6.79	5.76	6.48[d]	6.56	6.96	6.81	6.12	6.61[cd]
Calcium chloride - 2% (T2)	6.65	7.06	6.93	6.06	6.67[bc]	6.68	7.07	6.91	6.22	6.72[bc]
Calcium nitrate - 1% (T3)	6.68	7.07	6.99	6.28	6.75[ab]	6.70	7.14	7.00	6.37	6.80[ab]
Calcium nitrate - 2% (T4)	6.82	7.21	7.06	6.39	6.87[a]	6.80	7.21	7.06	6.45	6.88[a]
Control (T5)	7.00	6.95	6.06	5.23	6.31[e]	6.98	6.92	6.11	5.22	6.31[e]
Mean	6.72[bc]	7.03[a]	6.77[b]	5.94[c]		6.74[bc]	7.06[a]	6.78[b]	6.07[d]	

	2009-10		2010-11	
	S.Em ±	C.D (0.05)	S.Em ±	C.D (0.05)
Maturity Stages (MS)	0.027	0.075	0.030	0.084
Calcium Treatments (CT)	0.042	0.119	0.047	0.133
Storage Period (SP)	0.038	0.106	0.042	0.119
MS × CT	0.060	NS	0.067	0.189
MS × SP	0.053	0.150	0.060	0.169
CT × SP	0.084	0.238	0.095	0.267
MS × CT × SP	0.119	NS	0.134	0.377

oxidized at a slower rate because of decreased respiration (Singh *et al*., 1981). In general, fruits with higher acidity obtained maximum shelf life in guava (Mahajan *et al*., 2011) and peach (Gupta *et al*., 2011) during cold storage.

Reducing and total sugars (%)

The present study revealed that reducing and total sugars of guava fruits differed significantly with maturity stages and Calcium treatments during both the years of study (Tables 4 and 5). The sugar contents increased upto 10th day of storage coinciding the ripe stage followed by a decline later on. Patel *et al*. (2015) reported that reducing and total sugars increased during guava fruit ripening and then decreased during senescence. The increase in sugars might perhaps be due to conversion of pectin and hemicellulose into reducing sugars and the subsequent decrease may be due to utilization of these sugars along with acids for respiration as suggested by Wills *et al*. (1981). Guava fruits picked at MG retained higher amounts of reducing (4.05 and 4.09) and total sugars (6.66 and 6.72) compared to CT stage. However, sugar contents were found maximum with CT stage on 10th day, while the loss was more on 15th and 20th days of storage. It appears that fruits harvested at later stage received more nutrients and metabolites which get accumulated while there is disruption

Table 6a: Effect of maturity stages and Calcium treatments on Organoleptic rating (Appearance and colour) of guava fruits cv. Lucknow-49 during cold storage

Maturity Stages	Storage period (Days)									
	2009-10					2010-11				
	5	10	15	20	Mean	5	10	15	20	Mean
Mature Green stage (S1)	4.53	6.36	7.81	5.87	6.14[a]	4.35	6.27	7.67	5.96	6.06[a]
Colour Turning stage (S2)	6.07	7.68	6.04	4.09	5.97[b]	5.83	7.64	6.19	4.17	5.96[b]
Calcium Treatments										
Calcium chloride - 1% (T1)	4.87	6.93	7.10	5.13	6.01[cd]	4.60	6.87	7.13	5.30	5.98[cd]
Calcium chloride - 2% (T2)	4.93	6.97	7.27	5.27	6.11[bc]	4.70	6.93	7.30	5.33	6.07[bc]
Calcium nitrate - 1% (T3)	5.07	7.07	7.33	5.37	6.21[ab]	4.77	6.97	7.37	5.47	6.14[ab]
Calcium nitrate - 2% (T4)	5.17	7.13	7.43	5.43	6.29[a]	4.90	7.07	7.40	5.50	6.22[a]
Control (T5)	6.47	7.00	5.50	3.70	5.67[e]	6.47	6.93	5.43	3.73	5.64[e]
Mean	5.30[c]	7.02[a]	6.93[ab]	4.98[d]		5.09[c]	6.95[a]	6.93[ab]	5.07[cd]	

	2009-10		2010-11	
	S.Em ±	C.D (0.05)	S.Em ±	C.D (0.05)
Maturity Stages (MS)	0.036	0.102	0.031	0.087
Calcium Treatments (CT)	0.058	0.162	0.049	0.138
Storage Period (SP)	0.052	0.145	0.044	0.123
MS × CT	0.081	NS	0.069	0.195
MS × SP	0.073	0.205	0.062	0.174
CT × SP	0.115	0.324	0.098	0.276
MS × CT × SP	0.163	0.458	0.139	0.390

Table 6b: Effect of maturity stages and Calcium treatments on Organoleptic rating (Flavour) of guava fruits cv. Lucknow-49 during cold storage

Maturity Stages	Storage period (Days)									
	2009-10					2010-11				
	5	10	15	20	Mean	5	10	15	20	Mean
Mature Green stage (S1)	4.44	6.61	7.88	5.95	6.22[a]	4.57	6.59	7.83	6.03	6.25[a]
Colour Turning stage (S2)	5.90	7.88	6.49	4.12	6.10[b]	5.89	8.07	6.24	4.32	6.13[b]
Calcium Treatments										
Calcium chloride - 1% (T1)	4.77	7.17	7.33	5.13	6.10[cd]	4.73	7.23	7.13	5.30	6.10[d]
Calcium chloride - 2% (T2)	4.80	7.20	7.50	5.30	6.20[bc]	4.87	7.30	7.33	5.50	6.25[bc]
Calcium nitrate - 1% (T3)	4.83	7.30	7.67	5.47	6.32[ab]	4.97	7.27	7.60	5.50	6.33[ab]
Calcium nitrate - 2% (T4)	4.93	7.37	7.73	5.50	6.38[a]	4.97	7.50	7.53	5.77	6.44[a]
Control (T5)	6.52	7.20	5.70	3.77	5.80[e]	6.63	7.33	5.57	3.80	5.83[e]
Mean	5.17[c]	7.25[a]	7.19[ab]	5.03[d]		5.23[c]	7.33[a]	7.03[b]	5.17[cd]	

	2009-10		2010-11	
	S.Em ±	C.D (0.05)	S.Em ±	C.D (0.05)
Maturity Stages (MS)	0.034	0.095	0.027	0.077
Calcium Treatments (CT)	0.053	0.150	0.043	0.122
Storage Period (SP)	0.048	0.134	0.039	0.109
MS × CT	0.075	NS	0.061	NS
MS × SP	0.067	0.190	0.055	0.155
CT × SP	0.107	0.300	0.087	0.245
MS × CT × SP	0.151	0.424	0.123	0.346

in the flow of nutrients and other metabolites in the fruits picked at earlier stage (Bashir and Abu-Goukh (2003). In all the Calcium treated fruits, reasonably higher levels of sugars were retained during storage than control and this may be attributed due to slow hydrolysis of starch to sugars and gradual build up of sugars during the latter half of storage (Singh *et al*., 1987). However, it was observed that Calcium nitrate (2%) obtained maximum reducing (4.05 and 4.09) and total sugars (6.66 and 6.72) compared to Calcium chloride treatments during storage which might be due to the differential absorption of Calcium by the fruit from different sources (Jayachandran *et al*., 2005). These results are in line to those reported by Bisen *et al*., 2014; Selvan and Bal (2005b) in guava, Bharathi and Srihari (2004) in sapota.

Organoleptic quality (9 point scale)

Organoleptic quality (fruit appearance and colour, flavour, texture, taste and overall acceptance) obtained significant differences with maturity stages, Calcium treatments, storage and their interaction during cold storage for both the years of study (Tables 6a, 6b, 6c, 6d and 6e). All the organoleptic

Table 6c: Effect of maturity stages and Calcium treatments on Organoleptic rating (Texture) of guava fruits cv. Lucknow-49 during cold storage

Maturity Stages	Storage period (Days)									
	2009-10					2010-11				
	5	10	15	20	Mean	5	10	15	20	Mean
Mature Green stage (S1)	8.04	6.83	5.49	4.12	6.12[a]	7.99	6.80	5.68	4.03	6.12[a]
Colour Turning stage (S2)	7.85	6.56	5.27	4.20	5.97[b]	7.84	6.56	5.16	4.12	5.92[b]
Calcium Treatments										
Calcium chloride - 1% (T1)	8.00	6.77	5.33	4.13	6.06[cd]	7.90	6.63	5.43	4.10	6.02[d]
Calcium chloride - 2% (T2)	8.07	6.73	5.43	4.20	6.11[bc]	8.07	6.87	5.60	4.20	6.18[ab]
Calcium nitrate - 1% (T3)	8.10	6.87	5.57	4.30	6.21[ab]	8.03	6.87	5.53	4.17	6.15[abc]
Calcium nitrate - 2% (T4)	8.13	6.93	5.63	4.37	6.27[a]	8.10	6.93	5.57	4.20	6.20[a]
Control (T5)	7.43	6.17	4.93	3.80	5.58[e]	7.47	6.10	4.97	3.70	5.56[e]
Mean	7.95[a]	6.69[b]	5.38[c]	4.16[d]		7.91[a]	6.68[b]	5.42[c]	4.07[d]	

	2009-10		2010-11	
	S.Em ±	C.D (0.05)	S.Em ±	C.D (0.05)
Maturity Stages (MS)	0.029	0.081	0.027	0.075
Calcium Treatments (CT)	0.046	0.128	0.042	0.119
Storage Period (SP)	0.041	0.115	0.038	0.106
MS × CT	0.065	NS	0.060	NS
MS × SP	0.058	0.162	0.053	0.150
CT × SP	0.091	NS	0.084	NS
MS × CT × SP	0.129	NS	0.119	NS

Table 6d: Effect of maturity stages and Calcium treatments on Organoleptic rating (Taste) of guava fruits cv. Lucknow-49 during cold storage

Maturity Stages	Storage period (Days)									
	2009-10					2010-11				
	5	10	15	20	Mean	5	10	15	20	Mean
Mature Green stage (S1)	4.55	6.65	8.16	6.03	6.35[a]	4.53	6.65	8.09	6.04	6.33[a]
Colour Turning stage (S2)	6.04	8.08	6.45	4.12	6.17[b]	5.99	8.05	6.45	4.19	6.17[b]
Calcium Treatments										
Calcium chloride - 1% (T1)	4.77	7.17	7.57	5.17	6.17[cd]	4.73	7.30	7.47	5.30	6.20[cd]
Calcium chloride - 2% (T2)	4.87	7.30	7.63	5.33	6.28[c]	4.87	7.30	7.57	5.47	6.30[bc]
Calcium nitrate - 1% (T3)	5.03	7.47	7.80	5.50	6.45[ab]	4.97	7.40	7.77	5.50	6.41[ab]
Calcium nitrate - 2% (T4)	5.10	7.53	7.87	5.63	6.53[a]	5.10	7.40	7.93	5.57	6.50[a]
Control (T5)	6.70	7.37	5.67	3.73	5.87[e]	6.63	7.37	5.63	3.73	5.84[e]
Mean	5.29[c]	7.37[a]	7.31[ab]	5.07[d]		5.26[c]	7.35[a]	7.27[ab]	5.11[d]	

	2009-10		2010-11	
	S.Em ±	C.D (0.05)	S.Em ±	C.D (0.05)
Maturity Stages (MS)	0.027	0.077	0.028	0.079
Calcium Treatments (CT)	0.043	0.121	0.044	0.124
Storage Period (SP)	0.039	0.109	0.040	0.111
MS × CT	0.061	NS	0.063	NS
MS × SP	0.055	0.153	0.056	0.157
CT × SP	0.086	0.243	0.089	0.249
MS × CT × SP	0.122	0.343	0.125	0.352

parameters except fruit texture increased upto 10th and 15th days respectively with CT and MG stages on days coinciding with ripe stage and were rated 'like moderately' to 'like very much', while texture decreased from 5th to 20th day of storage. Visual appearance or look of the fruit is important from the view point of acceptance by the consumer. MG fruits (6.14 and 6.06) retained maximum scores for fruit appearances and colour than CT fruits (5.97 and 5.96) throughout storage. The textural quality of a fruit is influenced by skin toughness and flesh firmness. MG fruits (6.22 and 6.25) were more firm in texture than CT fruits (6.10 and 6.13) throughout storage. Brito and Narain (2002) also reported similar decrease in sapota fruit texture during maturation and ripening. Taste and flavour in guava are mainly determined by proper brix-acid blend. Retention of TSS, sugars, acidity and ascorbic acid content of fruits during storage is desirable for the preservation of fruit quality. They were predominantly higher in fruits at CT stage during the initial days of storage (5th and 10th) and were rated 'like moderately' to 'like very much', but rapid loss in quality was noticed thereafter. A rapid decline in these attributes with CT stage after 10 days of cold storage could probably be due to over-ripening and rapid senescence. Similar trends were also noticed with overall acceptance with MG stage fruits (6.21 and 6.19) being more firm and appealing than CT stage (6.05

Table 6e: Effect of maturity stages and Calcium treatments on Organoleptic rating (Overall acceptance) of guava fruits cv. Lucknow-49 during cold storage

Maturity Stages	Storage period (Days)									
	2009-10					2010-11				
	5	10	15	20	Mean	5	10	15	20	Mean
Mature Green stage (S1)	5.39	6.61	7.34	5.49	6.21[a]	5.36	6.58	7.32	5.51	6.19[a]
Colour Turning stage (S2)	6.47	7.55	6.06	4.13	6.05[b]	6.39	7.58	6.01	4.20	6.04[b]
Calcium Treatments										
Calcium chloride - 1% (T1)	5.60	7.01	6.83	4.89	6.08[d]	5.49	7.01	6.79	5.00	6.07[d]
Calcium chloride - 2% (T2)	5.67	7.05	6.96	5.03	6.18[c]	5.63	7.10	6.95	5.13	6.20[bc]
Calcium nitrate - 1% (T3)	5.76	7.18	7.09	5.16	6.30[ab]	5.68	7.13	7.07	5.16	6.26[b]
Calcium nitrate - 2% (T4)	5.83	7.24	7.17	5.23	6.37[a]	5.77	7.23	7.11	5.26	6.34[a]
Control (T5)	6.78	6.93	5.45	3.75	5.73[e]	6.80	6.93	5.40	3.74	5.72[e]
Mean	5.93[c]	7.08[a]	6.70[b]	4.81[d]		5.87[c]	7.08[a]	6.66[b]	4.86[d]	

	2009-10		2010-11	
	S.Em ±	C.D (0.05)	S.Em ±	C.D (0.05)
Maturity Stages (MS)	0.017	0.047	0.014	0.039
Calcium Treatments (CT)	0.026	0.074	0.022	0.061
Storage Period (SP)	0.024	0.067	0.020	0.055
MS × CT	0.037	0.105	0.031	0.087
MS × SP	0.033	0.094	0.028	0.078
CT × SP	0.053	0.149	0.044	0.123
MS × CT × SP	0.075	0.211	0.062	0.174

Table 7: Effect of maturity stages and Calcium treatments on Shelf life (days) of guava fruits cv. Lucknow-49 during cold storage

Calcium Treatments	Maturity Stages					
	2009-10			2010-11		
	Mature Green stage	Colour Turning stage	Mean	Mature Green stage	Colour Turning stage	Mean
Calcium chloride - 1% (T1)	22.67	21.67	22.17[cd]	22.67	21.33	22.00[cd]
Calcium chloride - 2% (T2)	23.00	22.00	22.50[c]	23.33	21.67	22.50[bc]
Calcium nitrate - 1% (T3)	24.00	22.67	23.33[b]	23.67	22.00	22.83[b]
Calcium nitrate - 2% (T4)	24.67	23.00	23.83[a]	24.33	23.00	23.67[a]
Control (T5)	21.00	20.00	20.50[e]	20.67	19.67	20.17[e]
Mean	23.07[a]	21.87[b]		22.93[a]	21.53[b]	

	2009-10		2010-11	
	S.Em ±	C.D (0.05)	S.Em ±	C.D (0.05)
Maturity Stages (MS)	0.094	0.278	0.133	0.393
Calcium Treatments (CT)	0.149	0.440	0.211	0.622
MS × CT	0.211	0.622	0.298	0.880

and 6.04) throughout storage. Lalel *et al*. (2003) and Gonge *et al*. (2014) suggested that the extended shelf life and delay in the climacteric peak of early harvested fruits might be the reason for obtaining highest organoleptic scores during the end of storage.

Similarly, the organoleptic quality with respect to appearance and colour, flavour, texture, taste and overall acceptance were found maximum with all the Calcium treatments compared to control. However, guava fruits treated with 2.0% $Ca(NO_3)_2$ retained maximum scores for all the organoleptic parameters and were rated as 'like moderately' to 'like very much', while the fruits under control were dull in appearance, poor in flavour with symptoms of chilling injury and rated as 'Neither Like Nor Dislike' throughout storage. Calcium nitrate treated fruits were superior in organoleptic quality than Calcium chloride, due to the fact that they obtained higher TSS and sugars, as evidenced by the results. The observed difference between the two Calcium salts as a result of high relative humidity in cold storage, wherein the Ca' concentration might be diluted from the fruit surface in $CaCl_2$ treated fruits due to the hygroscopic nature of $CaCl_2$ (Singh *et al*., 1987). Previous reports of Singh *et al*. (2007) and Goutam *et al*. (2010) also found that $Ca(NO_3)_2$ treated guava fruits scored highest for organoleptic parameters during storage.

Shelf life (Days)

It was evident from Table 7 that significant differences in shelf life were observed with maturity stages and Calcium treatments during cold storage. Among the stages, MG stage fruits obtained maximum shelf life (23.07 and 22.93) without spoilage compared to CT stage (21.87 and 21.53) for both the years of study. The maximum shelf life with MG stage fruits might be due to a shift in climacteric peak because of delayed

physiological and biochemical changes during ripening and the delay in these changes being more prominent in cold storage (Paull and Chen, 2002). The fruits picked at the later stage of maturity were spoiled due to over-ripening and rotting with poor palatability during the end of storage. This trend of increased spoilage with increased ripeness is similar to those reported by Kamil *et al*. (2008) in guava, Narayana and Mustaffa (2007) and Gonge *et al*. (2014) in banana. Among the Calcium salts studied, post harvest application of Calcium nitrate at both the concentrations was found to be superior over Calcium chloride in extending the shelf life of guava fruits. The observed difference between the two Calcium salts might be due to differential absorption of calcium by the fruit from different sources (Jayachandran, 2000). Guava fruits with all the Calcium treatments remained fit for consumption nearly 23 days as against control (20.50 and 20.17) during cold storage and this could possibly be due to the role of Calcium in delaying the ripening related changes and early onset of senescence. However, 2.0% $Ca(NO_3)_2$ reported a maximum shelf life of 23.83 and 23.67 days followed by 1.0% $Ca(NO_3)_2$ (23.33 and 22.83) for both the years of study. Calcium treatment has been reported to extend shelf life of guava (Mahajan *et al*., 2011) and peach (Gupta *et al*., 2011) fruits during cold storage also lend support for the present findings.

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