The Bioscan 10(1): 199-202, 2015
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

IMPACT OF CALCIUM CHLORIDE PRE-STORAGE TREATMENT ON JAMUN (*SYZYGIUM CUMINI* SKEELS) FRUITS UNDER COLD STORAGE

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KEYWORDS
Jamun
Calcium chloride
Physico-chemical
Shelf life

Received on :
30.01.2015

Accepted on :
17.03.2015

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ABSTRACT

Jamun fruits were subjected to pre-storage treatment with 1 and 2 per cent $CaCl_2$ for 5 min and same were compared with untreated fruits. Various physicochemical changes were recorded at 3 days interval up to 15 days storage in cold (13+1°C and 85 % RH). The results indicated that 1 per cent $CaCl_2$ treated jamun fruits maintained low physiological loss (11.61 %), retained more firmness (135g), low respiration rate (66.33ml CO_2/kg/h), soluble solids content (18.45) and titratable acidity (0.82%) and extended shelf life up to 14 days as compare to 9.50 days in control. The results of 1 and 2 per cent $CaCl_2$ treatment were statistically similar at $p<0.05$. In conclusion, pre-storage treatment of 1 per cent $CaCl_2$ for 5 min effectively delayed the physicochemical changes together with shelf-life extension under cold storage.

INTRODUCTION

Jamun is an important unexploited potential underutilized fruit. The fruit is highly perishable and deteriorates at very faster rate at ambient temperature. Moreover, the harvesting season of the fruit spans only mid April to May. Hence, there is a great deal of interest to prolong its useful life. Calcium has received considerable attention in recent years due to its desirable effects; particularly it can delay ripening and senescence, reduce respiration, extend shelf life and reduce the physiological disorders (Sharma *et al.,* 1996). The beneficial effects of exogenous application of calcium on different fruits are reported by many researchers in different fruit crops' *viz.,* custard apple (Swati and Bisen, 2012; Torres *et al.,* 2009; Lima, 2000), fig (Ifran *et al.,* 2013) passion fruit (Silva and Vieites, 2000), strawberry (Chen *et al.,* 2011) and apricot (Ali *et al.,* 2013). Further, $CaCl_2$ is naturally occurring, edible, and inexpensive and has been approved by the US Food and Drug Administration for postharvest use (Saftner *et al.,* 1998). Postharvest application of $CaCl_2$ at appropriate rates imparts no detrimental effect on consumer acceptance of treated fruit (Lester and Grusak, 2001). To best of our knowledge, reports on pre-storage $CaCl_2$ dip treatment in jamun fruits are not available. Hence, the study was under taken in jamun fruits to investigate the effect of $CaCl_2$ on physicochemical changes and shelf-life under cold storage.

MATERIALS AND METHODS

Fresh, uniform, free from defects and edible stage jamun fruits procured from fruit orchard located 100 km from the experiment station. Fruits were brought in plastic crates and pre-cooled for 12h in cold storage. Next day, they were washed and sorted to remove dust particles and damaged fruits. Jamun fruits were separated into 3 batches, each having 100 fruits per replicate (n=7). Fruits were dipped separately in calcium chloride solution at 1 (T_2) and 2 per cent (T_3) for 5 min and fruits dipped in distilled water served as control (T_1). Treated and air dried fruits were placed in corrugated card board boxes thereafter held under cold storage (13±1°C and 85% RH). Fruits were constantly drawn at 3 days interval up to 15 days for analysis. Weight loss was recorded as percentage loss in weight. Fruit firmness was measured using a handheld penetrometer (Lutron FG-5000A). Respiration rate was measured by closed static method using CO_2 gas analyser (PBI, DANSENSOR, CHECKMATE-2) as explained by Gong and Corey (1994).

Soluble solid content (°B) was determined using a hand held refractometer (Erma, Japan) and titratable acidity was estimated as out lined by Wills and Ku (2001).

Overall acceptability of fruits was evaluated by panel of six semi-trained judges on 10 point structured line scale, 1 being highly unacceptable and 10 being highly acceptable. Shelf life of fruits was determined by counting number of days up to which the 50 per cent of fruits remained marketable. Statistical analysis (ANOVA) was performed using Web Agri Stat Package (WASP) Version 2.0 (Jangam and Thali, 2011). Significant differences among means at $p = 0.05$ were determined by post hoc tests using Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

Weight loss (%)

Weight loss in 1 per cent $CaCl_2$ treated fruits recorded minimum value (11.60 %) which was on par with 2 per cent $CaCl_2$ dip treatment (Table 1). Untreated fruits showed maximum weight loss (13.33%) on 15th day storage. The lower weight loss in calcium treated jamun fruits is attributed to membrane functionality and integrity maintenance with lower losses of phospholipids and proteins and reduced ion leakage which could be responsible for lower weight loss. Similar results were observed in custard apple (Swati and Bisen, 2012); apricot (Ali, *et al.*, 2013); apple (Shirzadeh *et al.*, 2011); strawberry (Chen *et al.*, 2011); sugar apples (Lima, 2000).

Firmness (g)

Firmness values decreased in all the treatments during the storage (Table 1). Calcium chloride treatment at 1 per cent significantly delayed the firmness loss in jamun fruits. Lionetti *et al.* (2010) reported possible effects of Ca^{2+} is due to bridging of anti-parallel pectic polysaccharide homogalacturonan (HG) that plays a vital role in maintaining cell wall integrity and cell-wall cohesion, with negatively charges carboxyl groups to form egg-box like structures. Calcium enhances fruit firmness by cross-linking the pectic polysaccharide chains by virtue of its divalent ionic character. Calcium binding cell wall components may also reduce accessibility of cell wall degrading enzymes to their substrates (Vicente *et al.*, 2009). Fruit firmness may be due to the calcium binding to free carboxyl groups of polygalacturonate polymer, stabilizing and strengthening the cell walls (Conway and Sams, 1983). The de-esterified pectin chains may crosslink with either endogenous calcium or added (exogenous) calcium to form a tighter, firmer structure (Grant *et al.*, 1973). Similar results of Ca maintaining firmness is reported in papaya (Madani *et al.*, 2014); apricot (Ali *et al.*, 2013); strawberries (Chen *et al.*, 2011); apple (Shirzadeh *et al.*, 2011); and sugar apples (Lima, 2000).

Respiration rate (mL CO_2/Kg/h)

Dip treatment of fruits with 2 per cent $CaCl_2$ recorded minimum

Table 1: Influence of calcium chloride dip treatments on physiological loss in weight, firmness and respiration rate of jamun fruits under cold storage (13 ± 1 °C and 85 per cent RH). Similar alphabets within the column represents non-significant differences at (p = 0.05) probability level according into Duncan's multiple range test

	Number of days in storage					
	Initial	3	6	9	12	15
Weight loss (%)						
Control	0.00	10.58 ± 0.51^a	11.42 ± 0.55^a	11.94 ± 0.92^a	12.53 ± 0.50^a	13.33 ± 0.57^a
$CaCl_2$ at 1%		7.96 ± 0.14^c	9.12 ± 1.36^b	9.51 ± 0.50^b	10.1 ± 0.57^b	11.61 ± 0.65^b
$CaCl_2$ at 2%		8.86 ± 0.27^b	9.21 ± 0.70^b	9.56 ± 0.24^b	10.1 ± 0.62^b	11.71 ± 0.62^b
Mean		9.13	9.92	10.34	10.91	12.22
Firmess (g)						
Control	156.00	150.00 ± 1.73^b	147.00 ± 1.00^b	142.33 ± 1.19^b	137.00 ± 1.00^b	130.00 ± 1.00
$CaCl_2$ at 1%		153.33 ± 0.88^a	151.00 ± 0.69^a	147.00 ± 1.00^a	142.33 ± 1.19^a	135.00 ± 1.00
$CaCl_2$ at 2%		153.67 ± 0.59^a	149.67 ± 1.00^a	147.00 ± 1.00^a	143.33 ± 1.19^a	140.00 ± 1.00
Mean		152.33	149.22	145.44	140.88	135.00
Respiration rate (ml CO_2/Kg/h)						
Control	33.45	55.73 ± 0.81^a	66.04 ± 0.55^a	67.67 ± 0.59^a	74.60 ± 0.52^a	82.95 ± 0.96^a
$CaCl_2$ at 1%		42.08 ± 1.12^b	50.32 ± 0.51^b	56.00 ± 1.00^b	63.32 ± 0.30^b	66.33 ± 0.88^b
$CaCl_2$ at 2%		39.96 ± 0.06^c	46.99 ± 0.74^c	50.33 ± 1.33^c	58.16 ± 0.54^c	63.33 ± 1.33^b
Mean		45.92	54.45	58.00	58.16	70.87

Table 2: Influence of calcium chloride dip treatments on Soluble solids Content and titratable acidity of jamun fruits under cold storage (13 ± 1 °C and 85 per cent RH). Similar alphabets within the column represents non-significant differences at (p < 0.05) probability level according into Duncan's multiple range test

	Number of days in storage					
	Initial	3	6	9	12	15
Soluble solids Content (°B)						
Control	17.21	18.04 ± 0.26	18.25 ± 0.57	18.50 ± 0.51	18.72 ± 0.36	19.74 ± 0.58^a
$CaCl_2$ at 1%		17.83 ± 0.82	18.01 ± 0.51	18.17 ± 0.16	18.34 ± 0.19	18.45 ± 0.41^b
$CaCl_2$ at 2%		17.75 ± 0.23	18.04 ± 0.26	18.94 ± 1.15	19.22 ± 0.68	19.09 ± 0.27^{ab}
Mean		17.87	18.10	18.53	18.76	19.09
Titratable acidity (%)						
Control	1.23	1.02 ± 0.03	0.98 ± 0.01^b	0.96 ± 0.01	0.92 ± 0.06^a	0.88 ± 0.02^a
$CaCl_2$ at 1%		1.21 ± 0.10	1.13 ± 0.04^a	1.03 ± 0.05	0.94 ± 0.13^a	0.82 ± 0.01^b
$CaCl_2$ at 2%		1.20 ± 0.10	1.11 ± 0.10^a	1.02 ± 0.03	0.65 ± 0.01^b	0.88 ± 0.02^a
Mean						

Table 3: Influence of calcium chloride dip treatments on overall acceptability scores (out of 10) of jamun fruits under cold storage (13 ± 1 °C and 85 per cent RH). Similar alphabets within the column represents non-significant differences at (p < 0.05) probability level according into Duncan's multiple range test

	Overall acceptability scores Number of days in storage 3	6	9	12	15
Control	6.50 ± 0.10[b]	6.32 ± 0.21[b]	6.08 ± 0.16[b]	5.83 ± 0.15[b]	5.53 ± 0.28[b]
$CaCl_2$ at 1%	8.33 ± 0.45[a]	8.10 ± 0.13[a]	7.76 ± 0.21[a]	7.57 ± 0.14[a]	7.27 ± 0.15[a]
$CaCl_2$ at 2%	8.27 ± 0.26[a]	8.03 ± 0.70[a]	7.80 ± 010[a]	7.49 ± 0.15[a]	7.36 ± 0.13[a]
Mean	7.7	7.48	7.21	6.96	6.72

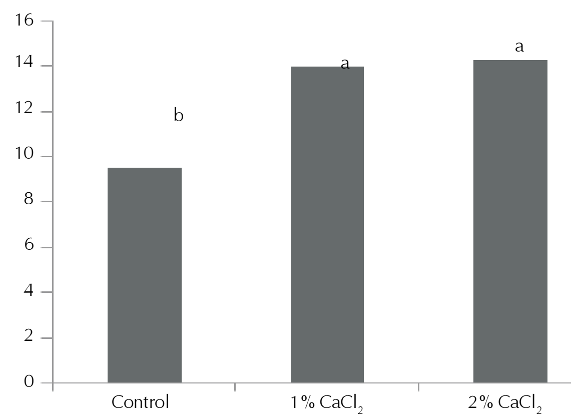

Figure 1: Influence of calcium chloride dip treatments on shelf life (days) of jamun fruits under cold storage (13 + 1p C and 85 per cent RH). Similar alphabets represents non-significant differences at (p < 0.05) probability level according into Duncan's multiple range test

respiration rate (63.33 ml CO_2/kg/h) as compared to control (82.95 ml CO_2/kg/h) during the storage (Table 2). The effects of calcium in reducing the respiration rate might be due to its role in fruit ripening through physical and biochemical mechanisms (Burns and Pressey, 1987; Conway, 1987) and its universally accepted role in reducing the rate of plant senescence and ripening (Ferguson, 1984). The effect of Ca^{2+} in reducing the respiration rate is also attributed to the fact that Ca regulates the various metabolic processes (Tuteja and Mahajan, 2007). Concurrent results of delay in respiration in postharvest Ca treated fruits were also reported for both climacteric and non-climacteric fruits by Wang *et al.* (2014) in sweet cherry fruit; Madani *et al.* (2014) in papaya and; Shirzadeh *et al.* (2011) in apple.

Soluble solids Content (°B)

Soluble solids content of jamun fruits did not showed significant difference ($p<0.05$) during the storage up to 12 days of storage (Table 2). However, at 15th day, 1 per cent $CaCl_2$ treated fruits showed lower value (18.45 ± 0.41) and the highest value for SSC was noticed in control fruits (19.74 ± 0.58). The lower SSC in $CaCl_2$ treated fruits may be attributed to delay in progression of several aspects of fruit ripening by calcium by inhibition of starch hydrolysis. Chen *et al.* (2011) reported 1 per cent $CaCl_2$ significantly reduced SSC in strawberry fruits due to the effects of $CaCl_2$ on reducing respiration and metabolic activity (Mahmud *et al.*, 2008).

Titratable acidity (%)

The titratable acidity of $CaCl_2$ fruits recorded lowest value (0.82 ± 0.01) at 15th day in cold storage (Table 2). Significantly maximum titratable acidity resulting from slower degradation of organic acid was recorded in the calcium chloride treatments. This could be due to retarding of ripening by calcium chloride treatments as a result of inhibited ethylene activity that could delay in the utilization of organic acids in the enzymatic reactions of respiration. The results of maintenance of highest level of titratable acidity by calcium chloride treatments are in conformity with the findings of Elham *et al.* (2011) in apple fruits.

Overall acceptability (Scores out of 10)

Jamun fruits dipped with 2 per cent $CaCl_2$ recorded highest scores (7.36 ± 0.13) for overall acceptability which was on par with treatment with 1 per cent $CaCl_2$ (7.27 ± 0.15) at 15 days storage (Table 3). Untreated jamun fruits showed minimum scores of overall acceptability (5.53 ± 0.28) at the end of 15days of cold storage. Overall acceptability of the fruits may be due to effects of calcium in reducing decay and maintaining firmness and overall quality.

Shelf life (Days)

Shelf life of jamun fruits affected by the $CaCl_2$ treatments (Fig. 1). Significantly maximum shelf life of 14.33 ± 0.77 days was recorded in 2 per cent treatment while, the minimum shelf life was recorded in control (9.50 ± 0.09 days). Calcium is a key element affecting fruit quality. Cell wall calcium plays a fundamental role in maintaining cell wall stabilization and integrity by interacting with the uronic acid carboxyl functions in pectic polysaccharide chains to create the pectin 'egg-box' (Vicente *et al.*, 2007). Calcium in harvested fruits was utilized in maintaining qualities, preventing softening and prolonging shelf life by reducing rotting or microbial spoilage (Verdini *et al.*, 2008). Concurrent results were also reported Monica *et al.* (2013) in litchi; Verdini *et al.* (2008) in strawberries; Liu *et al.* (2009) in apricots.

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