



# **Impact of Chemicals and Storage Conditions on Post-harvest Quality of Litchi (*Litchi chinensis* Sonn.) cv. China**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## **ABSTRACT**

The efficacy of chemical dips and different storage condition, alone and in combination were imposed in freshly harvested litchi fruit to investigate the changes of bio-chemical composition of fruits at regular interval for a certain period of storage. The pre-cooled litchi fruits after disinfectant were dipped for 60 seconds in lecithin (0.5% & 1%), Hot water, HCl (3%) with hot water, CaCl<sub>2</sub> (1% & 2%), CaSO<sub>4</sub> (1% & 2%), wax emulsion (5% & 10%), CaNO<sub>3</sub> (0.5% & 1%), Chitosan (1% & 2%) and Kaolin (1% & 2%). The treated fruits were stored at room temperature as well as at 4°C & 90% R.H and the quality attributes were assessed at 2, 4, 6 and 8 days interval. Calcium nitrate @ 1% under refrigerated conditions recorded maximum ascorbic acid (54.50 mg/100g pulp), fruit firmness (1.75 kg cm<sup>-2</sup>) and the lowest acidity (0.42%). Total soluble solids (18.17°B), total sugar (11.27%) and polymeric colour retention with high anthocyanin content (48.94 mg/100g pulp) in peel was found in treated fruits with calcium chloride @1% at 4°C & 90% R.H even after 8 days of storage.

*Keywords: Litchi; chemicals; temperature; storage; quality.*

## **1. INTRODUCTION**

Litchi (*Litchi chinensis* Sonn.) is an important sub-tropical evergreen fruit crop belonging to

family sapindaceae, and believed to have originated in China, where it has been grown in Southern Guangdong state for thousands of years. China, India, South Africa, Israel,

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Madagascar, Mauritius, USA, Indonesia, Philippines, Taiwan, Thailand, Australia, Brazil and Vietnam are the litchi growing countries in the world [1,2,3]. It is highly specific to climatic requirements and probably due to this reason its cultivation is restricted to few countries in the world. India is the second largest producer of litchi in the world after China. In India 711,000 metric tonnes of litchi is produced annually from 93,000 hectares' area [4]. In India, litchi ranks 7<sup>th</sup> in area and 9<sup>th</sup> in production among fruit crops but in value terms, it ranks six. The edible portion or fruit is the aril with distinctive flavour mostly consumed as fresh. Besides, several value added products like excellent canned fruits, highly flavoured squash, pickles, preserves and wine are made from litchi. Dried litchi commonly called litchi-nut is very popular among the Chinese. Fresh litchi fruit deteriorates very fast just after harvest. Freshness as well as maintenance of harvest quality of litchi has been one of the biggest challenges in litchi supply chain [5]. Post harvest challenges like micro-cracking in skin, pericarp browning, weight and flavour loss, fruit rot and decay during storage and transportation are the common hindrance [6,7]. Consumers want the produce to be fresh, typified by quality harvest. Freshly harvested litchi fruits during handling and marketing are severely impaired by pericarp browning and affect the sensory quality and consumer's preference [8]. Disinfestations by irradiation and heat treatments for expanding export market have been found to be alternatives to treatment with insecticides. But post harvest sulphur fumigation, acid treatments of fruits [9], pericarp coating with anti-transpiring agents and some other chemicals like benomyl, kaolin etc are very common to reduce the decay and some are adversely affecting the eating quality as well as health hazards. Simultaneously, there is increasing consumer and regulatory resistance to the use of this chemical. Recent researches have focused on reducing the major post harvest problems in order to produce light-coloured, chemical-free fruit without disease or insect infestation. A steady process of moisture loss and desiccation of fruits [10] and degradation of anthocyanin by PPO and peroxidase enzyme [11] is the most important reason for postharvest pericarp browning which renders the fruit unmarketable. Peroxidase activity coupled with ascorbic acid oxidation enhances anthocyanin degradation. Aril breakdown or softening of the aril involves a loss of turgidity and translucency where fruits become blunt in taste. The disorder starts near the pericarp and is prevalent at the

end of the stem. Techniques to reduce browning and maintain the red colour and prolonged storage life includes chemical treatments, packaging in perforated plastic bags and storage under cold conditions [12]. Although India is the second largest producer of litchi, a commercially viable technique is not available here for its shelf life extension. Fruit rotting due to fungal infection, loss of fruit weight, pigmentation, residue levels of fungicides and losses of bio active compound of fruits are still very common in cold storage condition. Non-availability of proper techniques is the biggest barrier for ambitious vendors involved in trade of fruits. The development of techniques can offer a practical solution to the difficulties associated with harvested litchi fruits. Keeping in view and to deal with such problems, an integrated approach was initiated by dipping the fruits in different level of chemicals and stored under modified atmospheric conditions to improve the post harvest quality and extension of the shelf life of litchi fruits.

## 2. MATERIALS AND METHODS

The present study was conducted in a laboratory, Department of Horticulture, Nagaland University, SASRD, Medziphema Campus during 2016-2017 and 2017-2018. Fully matured fruits were randomly harvested during early morning hours attached to the pedicel to maintain the keeping quality. Immediately after harvest, the fruits were pre-cooled in ice water and fan dried. The chemical solutions of different concentrations were prepared and the fruits were dipped for 60 seconds. For hot water treatment, the fruits were dipped for 30 seconds at 98<sup>o</sup> C. The treatment combinations were designed under **Factor-I:** Lecithin @ 0.5% (C<sub>1</sub>), Lecithin @ 1% (C<sub>2</sub>), Hot Water (C<sub>3</sub>), Hot Water + HCl @ 3% (C<sub>4</sub>), Calcium Chloride @ 1% (C<sub>5</sub>), Calcium Chloride @ 2% (C<sub>6</sub>), Calcium Sulphate @ 1% (C<sub>7</sub>), Calcium Sulphate @ 2% (C<sub>8</sub>), Wax Emulsion @ 5% (C<sub>9</sub>), Wax Emulsion @ 10% (C<sub>10</sub>), Calcium Nitrate @ 0.5% (C<sub>11</sub>), Calcium Nitrate @ 1% (C<sub>12</sub>), Chitosan @ 1% (C<sub>13</sub>), Chitosan @ 2% (C<sub>14</sub>), Kaolin @ 1% (C<sub>15</sub>), Kaolin @ 2% (C<sub>16</sub>), without any chemical i.e. Control (C<sub>17</sub>) and **Factor-II:** different storage condition: under room temperature (T<sub>1</sub>) and refrigerated condition i.e. 4°C & 90% Relative Humidity (T<sub>2</sub>). The experiment was laid out in a two factor Completely Randomized Design (CRD) and all the treatments were represented by three replicates. Observations were recorded in different interval like 0, 2, 4, 6 and 8 days after harvest (DAH) with TSS, total sugar, Vitamin C,

titratable acidity, anthocyanin and firmness. The TSS of fruit was determined with the help of EMRA hand refractometer (0-32 °Brix) calibrated at 20 °C and the results were expressed in Brix (°B). Total sugar content of the fruit was estimated by titrating the fruit juice against Fehling 'A' and Fehling 'B' reagents using methylene blue as indicator and presented in percent (%). Titratable acidity was estimated by titrating the diluted fruit juice against 0.1N NaOH solution using phenolphthalein as an indicator and expressed in term of percentage fresh weight of fruit [13]. Ascorbic acid (Vitamin-C) content was estimated by visual titration method of 2, 6 Dichlorophenol Indophenols dye [14]. The result obtained was expressed in mg/100g of juice. Anthocyanin content of peel was estimated by standard procedure [13] and expressed as mg/100g of peel. The fruit firmness was measured by using penetrometer and expressed in kg cm<sup>-2</sup>. The pooled data obtained in respect to various parameters were statistically analyzed by the method of analysis of variance [15].

### 3. RESULTS AND DISCUSSIONS

#### 3.1 Total Soluble Solids (TSS)

Data depicted in Table 1 indicated that there was a significant influence in TSS content of fruits among the different treatment from 2 DAH to 8 DAH both in chemicals and different storage condition except on 0 DAH. A general increasing trend in TSS content (14.87 °B at 0 DAH to 16.73 °B at 8 DAH) was noticed irrespective of the various chemicals and storage condition. Chemical treatments were found to have significant influence on TSS. Calcium chloride @ 1% (C<sub>5</sub>) showed the highest TSS (18.17 °B) followed by C<sub>12</sub> (1% calcium nitrate) and C<sub>11</sub> (0.5% calcium nitrate) with 17.40 °B and 17.38 °B respectively and the lowest was obtained from C<sub>14</sub> (2% Chitosan) with 16.01 °B at 8 DAH. It was noted that the fruit stored under 4°C+ 90% R.H (T<sub>2</sub>) had higher TSS content with 16.89 °B while the lowest TSS under room temperature (T<sub>1</sub>) with 16.57 °B at 8 DAH. The results indicated that chemical treatments and storage conditions have marked influence ( $P=4.3828E-11$ ) on the TSS content of the fruit at end of storage. Hydrolysis of starch or conversion of acids to sugars could be the reason for the increase in TSS with advancement of storage period [16,17]. Higher TSS level was retained by 1% calcium chloride treated fruits during storage. This may be due to the role calcium salts in maintaining the lowest metabolic activity during storage of fruits. Similar

results were found in on papaya using 3% calcium chloride [18] and on Earli Grande peach trees using 100 mg/l calcium chloride [19].

#### 3.2 Total Sugar

The total sugar of the fruit as cited in Table 1 showed that different postharvest treatments and their interaction have significant effect on the total sugar content of fruits. A general increasing trend in total sugar content (8.84% at 0 DAH to 10.56% at 8 DAH) of fruits was noticed irrespective of the various chemicals and temperature. The highest total sugar (11.27%) was recorded from C<sub>5</sub> (1% calcium chloride) which was statistically at par with C<sub>12</sub> (1% calcium nitrate) with 11.19% followed by C<sub>10</sub> (10% wax emulsion) with 11.12% and the lowest sugar content (9.88%) was in C<sub>13</sub> (1% chitosan) followed by C<sub>14</sub> (2% chitosan) with 9.96% at 8 DAH. The postharvest storage conditions showed significant effect on the total sugar content except 0 DAH which were insignificant. The fruits treated with 4°C + 90% R.H (T<sub>2</sub>) recorded the highest level of total sugar (11.18%) whereas storage at room temperature (T<sub>1</sub>) recorded the lowest sugar of 9.98% at 8 DAH. Significant increase ( $P=5.5456E-13$ , 0 DAH & 8 DAH) in total sugar during storage might be due to breakdown of polysaccharides into monosaccharides and disaccharides or due to conversion of starch into sugars. Higher sugar level was retained by 1% calcium chloride treated fruits during storage. It is suspected due to the role of calcium chloride to delay senescence. These results were in close conformity with the findings of [20] using calcium chloride and calcium nitrate in guava fruits.

#### 3.3 Ascorbic Acid

Vitamin-C content of the fruits was significantly affected by chemical treatments and temperature as well as their interaction in Table 2. A general decreasing trend in Vitamin-C (from 61.41 mg to 50.27 mg) was observed across the storage period. The fruits treated with 1% calcium nitrate (C<sub>12</sub>) showed the highest vitamin C content (54.50 mg/100 g pulp) in fruits followed by 1% calcium chloride (C<sub>5</sub>) with 50.00 mg/100 g pulp and the lowest (46.83 mg/100 g pulp) was in 1% Chitosan (C<sub>13</sub>) at 8 DAH. The decreasing trends of Vitamin-C content significantly influence from beginning to end of storage ( $P=4.0786E-12$ ). It was also noted that the fruit stored in 4°C+ 90% R.H (T<sub>2</sub>) showed higher vitamin-C content with 54.58 mg/100 g of pulp, while the lowest vitamin

C content at room temperature ( $T_1$ ) with 45.96 mg/100 g pulp at 8 DAH. The ascorbic content decreased gradually with the advancement of storage period [21,22,23]. During storage, oxidizing enzymes like ascorbic acid oxidase, peroxidase, catalase and polyphenol oxidase might be causing a decrease in the ascorbic content of the fruits [24]. Activities of oxidizing enzymes might be reduced in 1% calcium nitrate treated fruits which results in higher ascorbic acid content during the storage of fruits. This finding is in agreement with those of [25] and [26] in mango using 1% calcium nitrate.

### 3.4 Titratable Acidity

The results obtained in Table 2 showed that chemical treatments, storage conditions and their interaction had significant effect on acid content of fruit. A general declining trend in acidity of fruit was noticed irrespective of various chemical treatments and different storage condition. The initial value at 0 DAH was 0.66% which declines to 0.54% at 8DAH significantly ( $P=1.0576E-09$ ). The lowest acid content in fruits was noticed in  $C_{12}$  (1% calcium nitrate) with 0.42% and the second lowest was followed in 1% calcium chloride, 2% calcium chloride and 0.5% calcium nitrate with 0.49% at 8 DAH. The higher acidity content (0.61%) in fruits was recorded in 1% chitosan ( $C_{13}$ ) which was statistically at par with hot water + 3% HCl ( $C_4$ ) with 0.60% and hot water ( $C_3$ ) with 0.59%. The highest acidity was recorded at room temperature ( $T_1$ ) with 0.56% and the lowest from 4°C+ 90% R.H ( $T_2$ ) with 0.52% at 8 DAH. The data indicated the linear decrease in acidity under all the treatments during storage and this gradual decline might be due to utilization of acid in metabolism. Similar trend was also noticed by [27] in litchi cv. 'Huaizhi' treated with chitosan stored for 6 days at -1°C. This gradual decrease in acidity with the increase in storage could be attributed to use of rapid utilization of organic acids in the respiratory [16]. The lower acidity in fruits treated with calcium might be due to decreased hydrolysis of organic acids and subsequent accumulation of these acids which are oxidized at a slower rate because of decreased respiration [28].

### 3.5 Anthocyanin Content of Peel

Anthocyanin content of the peel was significantly affected by chemical treatments, temperature as well as their interaction effect as depicted in Table 3. There was a general decreasing trends of mean value of anthocyanin (51.41 mg at 0

DAH to 48.14 mg 8 DAH) in peel with progress of storage period irrespective of various postharvest treatments. The highest retention of anthocyanin with 48.94 mg/100g of peel was found in 1% calcium chloride( $C_5$ ) followed by 1% calcium nitrate( $C_{12}$ ) with 48.92 mg/100g of peel at 8 DAH. It was observed that the anthocyanin content of stored litchi fruits significantly decreased with storage period. The anthocyanin content of the peel was quite high in 4°C+ 90% R.H ( $T_2$ ) with 49.28 mg/100g of peel as compared to fruits stored in room temperature ( $T_1$ ) with 47.00 mg/100g of peel. Retention of anthocyanin content was better in 1% calcium chloride at low temperature. The discolouration of anthocyanin with increase in storage period was also confirmed by [12] and may be due to enzymatic activity (PPO and peroxidase) and decrease in antioxidants levels which resulted in the hydrolysis of anthocyanins into sugar [11]. The anthocyanins are hydrolysed by anthocyanase and PPO and/or POD oxidises to anthocyanidins [9,29].

### 3.6 Firmness

The data depicted in Table 3 showed that chemicals, temperature and their interaction effect had significant effect ( $P=1.6243E-13$ ) on firmness of the fruit. Fruit firmness gradually declined with progress of storage period. The mean initial firmness was 2.07 kg/cm<sup>2</sup> and at end of storage it was 1.55 kg/cm<sup>2</sup>. Different chemicals significantly affected the firmness of the fruits. Retention of maximum firmness (1.75 kg/cm<sup>2</sup>) was noticed with calcium nitrate @ 1% ( $C_{12}$ ) while, the minimum was found in chitosan @1% (1.36 kg/cm<sup>2</sup>) and chitosan @ 2% 1.37 kg/cm<sup>2</sup> at 8DAH. Different storage conditions also showed significant influence in firmness where, maximum firmness (1.67 kg/cm<sup>2</sup>) was obtained from the fruits stored at 4 °C & 90% R.H ( $T_2$ ) whereas the lowest (1.42 kg/cm<sup>2</sup>) was recorded in room temperature ( $T_1$ ) at 8 DAH. Softening of fruits is associated with dissolution of the middle lamellae, structure and linkages between polysaccharides by hydrolytic enzymes such as polygalacturonase and pectin methyl esterase [30,31,32]. Calcium nitrate has been found to be effective in increasing the firmness of fruits by delaying senescence, preserving cellular organization and retarding respiration rate. These results are in similar with the findings of [33] in guava using 2% calcium nitrate under cold storage and using 1% calcium nitrate in guava [34] and in plum [35].

Table 1. Influence of chemicals and temperature on total soluble solids (°B) and total sugar (%) in Litchi cv. China

Treatments (Chemicals)	TSS (°B)					Total sugar (%)				
	0 DAH	2 DAH	4 DAH	6 DAH	8 DAH	0 DAH	2 DAH	4 DAH	6 DAH	8 DAH
C <sub>1</sub> : Lecithin @ 0.5%	14.96	15.45	15.69	16.19	16.43	8.77	9.51	9.93	10.18	10.30
C <sub>2</sub> :Lecithin @ 1%	14.85	15.90	16.33	16.66	16.90	8.79	9.62	9.97	10.22	10.34
C <sub>3</sub> :Hot water	14.93	15.15	15.26	15.79	16.03	8.77	9.45	9.78	10.03	10.15
C <sub>4</sub> :Hot water + HCl @ 3%	14.80	15.14	15.45	15.79	16.03	8.79	9.41	9.71	9.96	10.08
C <sub>5</sub> :CaCl <sub>2</sub> @ 1%	14.97	16.70	17.35	17.93	18.17	8.91	10.45	10.86	11.10	11.27
C <sub>6</sub> : CaCl <sub>2</sub> @ 2%	14.86	16.41	16.68	17.10	17.34	8.92	10.00	10.42	10.67	10.79
C <sub>7</sub> :CaSO <sub>4</sub> @ 1%	14.98	15.79	16.15	16.43	16.67	8.86	10.08	10.47	10.72	10.84
C <sub>8</sub> :CaSO <sub>4</sub> @ 2%	14.96	15.61	15.92	16.30	16.54	8.79	9.79	10.45	10.70	10.82
C <sub>9</sub> :Wax emulsion @ 5%	14.84	16.22	16.47	16.98	17.22	8.91	10.26	10.58	10.83	10.95
C <sub>10</sub> :Wax emulsion @10%	14.80	16.36	16.70	17.02	17.26	8.99	10.33	10.80	11.00	11.12
C <sub>11</sub> :Ca(NO <sub>2</sub> ) <sub>3</sub> @ 0.5%	14.81	16.07	16.55	17.14	17.38	8.81	9.96	10.40	10.65	10.77
C <sub>12</sub> :Ca(NO <sub>2</sub> ) <sub>3</sub> @ 1%	14.96	16.42	16.79	17.16	17.40	8.80	10.36	10.81	11.07	11.19
C <sub>13</sub> :Chitosan @ 1%	14.75	15.23	15.45	15.79	16.03	8.79	9.41	9.51	9.76	9.88
C <sub>14</sub> :Chitosan @ 2%	14.76	15.21	15.56	15.77	16.01	8.77	9.36	9.59	9.84	9.96
C <sub>15</sub> :Kaolin @ 1%	14.89	15.36	15.69	15.99	16.23	8.79	9.66	10.14	10.39	10.51
C <sub>16</sub> :Kaolin @ 2%	14.74	15.44	15.81	15.98	16.22	8.84	9.67	10.15	10.40	10.52
C <sub>17</sub> : Control	14.88	15.40	15.73	16.31	16.55	8.94	9.62	10.00	10.25	10.37
S.Em (±)	0.19	0.22	0.20	0.30	0.30	0.18	0.17	0.20	0.21	0.20
CD (P=0.05)	NS	0.61	0.56	0.83	0.83	NS	0.48	0.57	0.57	0.57
<b>Storage condition</b>										
T <sub>1</sub> : Room temperature	14.83	15.61	15.92	16.33	16.57	8.83	9.43	9.61	9.86	9.98
T <sub>2</sub> : 4°C & 90% RH	14.91	15.91	16.26	16.65	16.89	8.85	10.21	10.81	11.06	11.18
S.Em (±)	0.07	0.07	0.07	0.10	0.10	0.06	0.06	0.07	0.07	0.07
CD (P=0.05)	NS	0.21	0.19	0.29	0.29	NS	0.16	0.20	0.20	0.20
Mean±(s)	14.87±0.08	15.75±0.49	16.09±0.56	16.49±0.60	16.73±0.61	8.84±0.07	9.82±0.37	10.21±0.46	10.56±0.45	10.58±0.80

\*DAH: Days After Harvest

Table 2. Influence of chemicals and temperature on ascorbic acid (mg/ 100g pulp) and titratable acidity (%) in Litchi cv. China

Treatments (Chemicals)	Ascorbic Acid (mg/ 100g pulp)					Titratable Acidity (%)				
	0 DAH	2 DAH	4 DAH	6 DAH	8 DAH	0 DAH	2 DAH	4 DAH	6 DAH	8 DAH
C <sub>1</sub> : Lecithin @ 0.5%	63.12	53.67	53.17	51.83	48.33	0.63	0.65	0.63	0.59	0.57
C <sub>2</sub> :Lecithin @ 1%	61.30	54.00	53.50	52.33	48.67	0.66	0.61	0.59	0.56	0.54
C <sub>3</sub> :Hot water	62.07	53.33	52.83	51.00	47.00	0.64	0.66	0.66	0.62	0.59
C <sub>4</sub> :Hot water + HCl @ 3%	59.33	53.00	52.50	50.33	47.67	0.67	0.67	0.63	0.62	0.60
C <sub>5</sub> :CaCl <sub>2</sub> @ 1%	61.08	57.50	57.00	55.67	54.00	0.64	0.58	0.55	0.53	0.49
C <sub>6</sub> : CaCl <sub>2</sub> @ 2%	62.07	56.17	55.67	54.33	52.00	0.65	0.58	0.56	0.53	0.49
C <sub>7</sub> :CaSO <sub>4</sub> @ 1%	60.81	57.00	56.00	54.83	52.67	0.63	0.62	0.59	0.58	0.53
C <sub>8</sub> :CaSO <sub>4</sub> @ 2%	62.05	55.58	54.83	53.50	50.58	0.64	0.63	0.61	0.59	0.56
C <sub>9</sub> :Wax emulsion @ 5%	59.33	56.67	56.33	55.17	53.17	0.66	0.59	0.57	0.54	0.51
C <sub>10</sub> :Wax emulsion @ 10%	60.77	57.25	56.67	55.50	53.50	0.67	0.58	0.56	0.54	0.51
C <sub>11</sub> :Ca(NO <sub>2</sub> ) <sub>3</sub> @ 0.5%	63.39	55.67	55.33	54.25	51.17	0.68	0.60	0.56	0.53	0.49
C <sub>12</sub> :Ca(NO <sub>2</sub> ) <sub>3</sub> @ 1%	62.72	58.00	57.33	56.17	54.50	0.63	0.56	0.51	0.47	0.42
C <sub>13</sub> :Chitosan @ 1%	60.72	52.17	51.83	49.50	46.83	0.68	0.66	0.64	0.62	0.61
C <sub>14</sub> :Chitosan @ 2%	60.58	52.50	52.00	50.83	47.17	0.68	0.66	0.63	0.62	0.58
C <sub>15</sub> :Kaolin @ 1%	63.39	54.67	54.17	52.83	49.83	0.66	0.65	0.63	0.59	0.56
C <sub>16</sub> :Kaolin @ 2%	60.52	55.17	54.50	53.17	48.33	0.67	0.64	0.62	0.61	0.56
C <sub>17</sub> : Control	60.77	54.17	53.50	52.50	49.17	0.65	0.64	0.62	0.59	0.56
S.Em (±)	0.98	0.43	0.61	0.66	0.58	0.03	0.02	0.01	0.02	0.02
CD (P=0.05)	NS	1.22	1.69	1.83	1.61	NS	0.04	0.04	0.06	0.07
<b>Storage condition</b>										
T <sub>1</sub> : Room temperature	61.42	52.70	52.12	49.99	45.96	0.65	0.63	0.61	0.58	0.56
T <sub>2</sub> : 4°C & 90% RH	61.41	57.48	56.96	56.33	54.58	0.67	0.61	0.58	0.56	0.52
S.Em (±)	0.34	0.15	0.21	0.22	0.20	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	NS	0.42	0.58	0.63	0.55	NS	0.02	0.02	0.03	0.03
Mean±(s)	61.41±1.20	55.10±1.90	54.54±1.86	53.16±2.17	50.27±2.87	0.66±0.02	0.62±0.03	0.60±0.04	0.57±0.04	0.54±0.05

Table 3. Influence of chemicals and temperature on anthocyanin content (mg/ 100g peel) and firmness kg cm<sup>-2</sup> in Litchi cv. China

Treatments (Chemicals)	Anthocyanin (mg/ 100g peel)					Firmness (kg cm <sup>-2</sup> )				
	0 DAH	2 DAH	4 DAH	6 DAH	8 DAH	0 DAH	2 DAH	4 DAH	6 DAH	8 DAH
C <sub>1</sub> : Lecithin @ 0.5%	50.82	48.58	48.41	47.88	47.78	2.03	1.63	1.60	1.55	1.49
C <sub>2</sub> :Lecithin @ 1%	51.02	48.76	48.52	48.02	47.83	2.07	1.65	1.63	1.58	1.52
C <sub>3</sub> :Hot water	52.33	48.13	48.23	47.69	47.61	2.08	1.61	1.58	1.52	1.43
C <sub>4</sub> :Hot water + HCl @ 3%	50.82	50.90	50.06	48.35	47.30	2.04	1.57	1.54	1.48	1.40
C <sub>5</sub> :CaCl <sub>2</sub> @ 1%	52.13	50.05	49.69	49.28	48.94	2.11	1.88	1.83	1.78	1.64
C <sub>6</sub> : CaCl <sub>2</sub> @ 2%	51.02	49.55	49.15	48.80	48.56	2.07	1.75	1.73	1.65	1.62
C <sub>7</sub> :CaSO <sub>4</sub> @ 1%	52.13	49.69	49.26	48.95	48.59	2.08	1.78	1.75	1.69	1.64
C <sub>8</sub> :CaSO <sub>4</sub> @ 2%	51.94	49.28	49.00	48.58	48.31	2.08	1.73	1.68	1.62	1.57
C <sub>9</sub> :Wax emulsion @ 5%	50.68	49.82	49.32	49.00	48.68	2.10	1.83	1.78	1.73	1.67
C <sub>10</sub> :Wax emulsion @ 10%	51.95	49.87	49.46	49.13	48.76	2.09	1.86	1.81	1.74	1.68
C <sub>11</sub> :Ca(NO <sub>2</sub> ) <sub>3</sub> @ 0.5%	51.75	49.42	49.07	48.67	48.12	2.03	1.73	1.70	1.63	1.59
C <sub>12</sub> :Ca(NO <sub>2</sub> ) <sub>3</sub> @ 1%	51.35	49.95	49.56	49.25	48.92	2.08	1.90	1.85	1.80	1.75
C <sub>13</sub> :Chitosan @ 1%	51.19	48.27	47.74	47.22	47.09	2.11	1.53	1.49	1.48	1.36
C <sub>14</sub> :Chitosan @ 2%	51.2	48.37	47.90	47.49	47.30	2.07	1.55	1.52	1.49	1.37
C <sub>15</sub> :Kaolin @ 1%	51.19	48.97	48.83	48.35	48.39	2.03	1.69	1.66	1.58	1.54
C <sub>16</sub> :Kaolin @ 2%	51.02	49.15	48.91	48.44	48.17	2.05	1.71	1.67	1.52	1.56
C <sub>17</sub> : Control	51.38	48.88	48.64	48.23	48.01	2.09	1.68	1.62	1.25	1.43
S.Em (±)	0.62	0.12	0.15	0.17	0.19	0.04	0.05	0.05	0.20	0.06
CD (P=0.05)	NS	0.34	0.42	0.48	0.54	NS	0.15	0.15	1.54	0.16
<b>Storage condition</b>										
T <sub>1</sub> : Room temperature	51.44	48.42	47.97	47.30	47.00	2.08	1.59	1.55	1.50	1.42
T <sub>2</sub> : 4°C & 90% RH	51.37	50.12	49.88	49.56	49.28	2.06	1.83	1.79	1.72	1.67
S.Em (±)	0.21	0.04	0.05	0.06	0.07	0.01	0.02	0.02	0.02	0.02
CD (P=0.05)	NS	0.12	0.14	0.17	0.19	NS	0.05	0.05	0.05	0.05
Mean±(s)	51.41±0.49	49.27±0.75	48.93±0.67	48.43±0.69	48.14±0.67	2.07±0.03	1.71±0.11	1.67±0.11	1.61±0.13	1.55±0.12

#### 4. CONCLUSION

The above studies demonstrated that the fruits dipped in calcium chloride (1%) solution and stored at 4 °C with 90% R.H remained in good condition and changed in biochemical composition of fruits like TSS, total sugar and anthocyanin. Simultaneously calcium nitrate (1%) showed more skin tensile strength (firmness) and decline acidity under refrigerated condition at 4 °C with 90% R. H. Chemically treated fruits with controlled atmosphere maintained the post harvest freshness without economic loss even at 8 days after harvest.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

- Menzel CM. The physiology of growth and cropping in Lychee. South African Litchi Grower Association's Yearbook; 2001.
- Lemmer D. Report on Chinese litchi. South African Litchi Grower Association Year Book; 2002.
- Huang X, Subhadrabandhu, Mitra S, Ben-Arie R, Stern R. Origin, history, production and processing. C.M. Menzel, G.K. Waite (Eds.), Litchi and Longan Botany, Production and Uses, CABI, Oxfordshire, UK; 2005.
- Anonymous. Indian Horticulture Database 2018-2019. National Horticulture Board, Ministry of Agriculture, Government of India, Gurgaon. 2019. Accessed on 21<sup>st</sup> March, 2021.
- Available: [www.nhb.gov.in](http://www.nhb.gov.in).
- Singh G, Nath V, Purbey SK, Singh SK, Pal RK. Post harvest handling and vaporization of litchi fruits. FAO Bulletin, published by NRC-Litchi, Muzaffarpur, Bihar. 2012;1-30.
- Tian SP, Li BQ, Xu Y. Effect of O<sub>2</sub> and CO<sub>2</sub> concentrations on physiology and quality of litchi fruit in storage. Food Chemistry. 2005; 659-663.
- Sivakumar D, Zeeman K, Korsten L. Effect of biocontrol agent (*Bacillus subtilis*) and modified atmosphere packaging on postharvest decay control and quality retention of litchi during storage. Phytoparasitica. 2007; 35(5):507-518.
- Mangaraj S, Goswami TK. Modeling of Respiration Rate of Litchi Fruit under Aerobic Conditions. Food and Bioprocess Technology. 2011;4:272-281.
- Jiang Y, Li Y, Li J. Browning control, shelf life extension and quality maintenance of frozen litchi fruit by hydrochloric acid. Journal of Food Engineering. 2003;63:147-151.
- Lin HT. Post harvest pericarp browning mechanism and postharvest handling of longan fruit. Ph.D dissertation, Zhejiang University, Hangzhou, China. 2002
- Sun D, Liang G, Xie J, Lei X, Mo Y. Improved preservation effects of litchi fruit by combining chitosan coating with ascorbic acid treatment during postharvest storage. African Journal of Biotechnology. 2010;9:3272-3279
- Neog M, Saikia L. Control of post-harvest pericarp browning of litchi (*Litchi chinensis* sonn.). Journal of Food Science and Technology. 2010;47(1):100-104.
- Ranganna S. Handbook of analysis and quality control for fruits and vegetables products, Tata Mcgraw Hill Publishing Co. Ltd. New Delhi, India; 2001.
- AOAC. Official methods of analysis. Association of official analytical Chemist 15<sup>th</sup> Edn, Washington; 1984.
- Panse VG, Sukhatme PV. Statistical method for Agriculture workers, ICAR, New Delhi. 1995;119-210.
- Wills RBH, Lee D, Graham WB, Mc Glasson, Hall FG. In: Postharvest: An introduction to the physiology and handling of fruits and vegetables. CBS Publishers & Distributors. Edition: 1<sup>st</sup>; 1996.
- Aklimuzzaman M, Goswami C, Howlader J, Kader HD, Hasan KM. Postharvest storage behaviour of litchi. Journal of Horticultural Science and Biotechnology. 2011;15(3):1-8.
- Srinu B, Manohar RA, Veena JK, Narender RS, Sharma HK. Effect of different post-harvest treatments on quality and shelf life of papaya. Journal of Pharmacognosy and Phytochemistry. 2017;6(5):1788-1792.



19. El-Alakmy HA. Effect of calcium application and wrapping treatments on fruit quality of Earli Grande peach trees (*Prunus persica* L.). Journal of Applied Sciences Research. 2012;8(7):3845-3849.
20. Bhooriya MS, Bisen BP, Pandey SK. Effect of post-harvest treatments on shelf life and quality of Guava (*Psidium guajava*) fruits. International Journal of Chemical Studies. 2018;6(4):2559-2564.
21. Kaushik N, Kaur BP, Rao PS. Application of high pressure processing for shelf life extension of litchi fruits (*Litchi chinensis* cv. Bombai) during refrigeration. Food Science and Technology. 2014; 20:527-541.
22. Shah NS, Nath N. Changes in the qualities of minimally-processed litchis: effect of anti-browning agents, osmo-vacuum drying and moderate vacuum packaging. Food Science and Technology. 2008;41:660-668.
23. Piga A, Caro AD, Pinna I, Agabbio M. Changes in ascorbic acid, polyphenol content and antioxidant activity in minimally processed cactus pear fruits. Food Science and Technology. 2003; 36:257-262.
24. Singh S, Singh AK, Joshi HK. Prolong storability of Indian gooseberry under semi-arid ecosystem of Gujarat. Indian Journal of Agricultural Sciences. 2005;75:647-650.
25. Ray PK, Ruby R, Singh SK. Effect of sulphur dioxide fumigation and low temperature on post-harvest browning and quality of litchi fruits. Food Science and Technology. 2005;42:226-230.
26. Jain SK, Mukherjee S. Enhancing keeping quality of fruits in mango cv. Langra. Indian Journal of Horticulture. 2011;68(1):142-144.
27. Dong H, Cheng L, Tan J, Zheng K, Jiang Y. Effect of chitosan on quality and shelf life of peeled litchi fruit. Journal of Food Engineering. 2004;64(3):355-358.
28. Gupta NS, Jawandha K, Gill SP. Effect of calcium on cold storage and post cold storage quality of peach. Journal of Food Science and Technology. 2011;48(2):225-229.
29. Ducamp Collin M, Lebrun M, Ramarson H, Self G. Anthocyanin and anthocyanin degradation enzymes in Kwai May and Wai Chee cultivars of litchi grown in Reunion Island and Spain. Fruits. 2007;62:353-359.
30. Vicente AR, Saladié M, Rose JKC, Labavitch JM. The linkage between cell wall metabolism and fruit softening: looking to the future. Journal of the Science of Food and Agriculture. 2007;87:1435-1448.
31. Tanada-Palmu PS, Grosso CRF. Effect of edible wheat glut coatings on refrigerated strawberry (*Fragaria ananassa*) quality. Postharvest Biol. Technol. 2005;36(2): 199-208.
32. White PJ, Broadley MR. Annals of Botany. 2003;9:487.
33. Nasima, N., Swaminathan, V., Rajangam, J. and Venkatesan, K. Response of post-harvest dipping on shelf life and quality of guava (*Psidium guajava* L.) fruits under cold storage. International Journal of Chemical Studies. 2019;7(3):1901-1905.
34. Goutam M, Dhaliwal HS, Mahajan BVC. Effect of pre-harvest calcium sprays on post-harvest life of winter guava (*Psidium guajava* L.). Journal of Food Science and Technology. 2010;47(5):501-506.
35. Mahajan BVC, Randhaha JS, Kaur H, Dhatt, AS. Effect of post harvest application of calcium nitrate and gibberellic acid on storage life of plum. Indian Journal of Horticulture. 2008;65(1): 94-96.

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