# Effect of Packing System, Calcium Chloride and Chlorine on the Storage Life of Strawberry Fruits *(Fragaria ananassa* cv. Kordistan)

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**Abstract**: Effect of packing system, calcium chlorite and chlorine was evaluated on storage life of strawberry fruits. Fruits were treated with commercial grade of chlorine (calcium hypochlorite at 0, 25, 50 and 100 ppm and sodium hypochlorite at 0, 25, 50 and 100 ppm with distilled water) for one minute and then treated with different grades of calcium chlorite 0, 0.5, 1 and 1.5 percentage for five minutes, then were divided to two groups; packed and non packed with plastic cover. Then fruits were evaluated for changes in quantity parameters; pH, TA (Titratable acidity), TSS (Total soluble solids), Dry and fresh weight ratio, water content, Anthocyanin, Ascorbic acid, $Ca^{2+}$, Sugar and pectin. The results showed that the packed fruits treated with calcium chloride (at 0.5 and 1 percentage) and chlorine (at 50 ppm) remained better when compared with non packed fruits. It was found that packing treatment had not a significant effect on pH. It can also deduce that packed treated fruits showed a lower TA, Anthocyanin, calcium, sugar and pectin while TSS, fresh to dry weight ratio, water content and ascorbic acid was higher in packed treated fruits.

**Keywords:** Strawberry, storage life**,** packing, post harvest, calcium chlorite, chlorine.

## INTRODUCTION

Modified atmosphere packaging can be used to extend the shelf life of many fruit and vegetables. This technology seems straightforward as it uses permeable films to change the concentration of carbon dioxide and oxygen around the product and the respiration rate of the product at a specific temperature. Though postharvest quality of a produce cannot be improved after harvest, it is possible to reduce the rate of loss quality. The rate of deterioration (physiological decay) of fruit is directly related to the respiration rate [1]. Surface treatments delay physiological decay in fruit tissues, stabilize the fruit surface and prevent degradation that affect the quality of the product. They also rinse the enzymes and substrates released from injured cells during cutting operations from the product surface. The strawberry is a delicate and perishable fruit, susceptible to mechanical injury, physiological deterioration, water loss and decay. Prompt cooling of strawberries to near $0^{O}C$ can slow undesirable quality and quantity changes and increase shelf-life [2, 3]. Many users underestimate the Complexity of this seemingly simple packaging system. However, $CO_2$ concentrations of 15–20% and $O_2$ levels of 5–10% have been reported to be optimum for different aspects of strawberry [4, 5]. Modified atmosphere (MA) packaging systems designed to produce optimum $O_2$ and $CO_2$ concentrations at suitable temperatures have been mathematically modeled [6-10]. Under usual storage, transport, and distribution, constant temperature of the fruit cannot be assured, so MA packaging designs could have complications from transient temperature changes. In studies on the suitability of plastic films for MA packaging for commodities with high respiration rates (such as strawberry) only combinations of polymeric and perforated films appear to have the potential to provide adequate fluxes of $O_2$ and $CO_2$ [1, 8, 11, 12]. Perforation-mediated MA packaging for strawberries seemed to be a feasible low-cost approach to preserve strawberry fruit quality. Calcium ($Ca^{2+}$) has been extensively reviewed as both an essential element and its potential role in maintaining postharvest quality of fruit and vegetable crops. A 1% solution of $CaCl_2$ delayed fruit ripening, improved resistance to fungal attack and maintained structural integrity of cell walls of strawberry during a 10 day storage period at 3°C [13]. It is also known that calcium play a significant role in maintaining quality in a number of different fruits. Pre- and postharvest application of calcium may delay senescence in fruits with no detrimental effect on consumer acceptance [14]. Exogenously applied calcium stabilizes the plant cell wall and protects it from cell wall degrading enzymes [15]. Studies have shown that the rate of senescence often depends on the calcium status of the tissue and by increasing calcium levels, various parameters of senescence such as respiration, protein, chlorophyll content and membrane fluidity are altered [16]. The pre and postharvest application of calcium salts has been used successfully in many fresh fruits to reduce loss of firmness and to slow down the ripening process [17]. The effectiveness of chlorine in decay prevention has been known for some time [18], although several limitations exist ((i.e., the rapid drop in fungi static activity of chlorine in the

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presence of organic substances that modify the pH of the solution). Our study was conducted to evaluate the effects of chlorine (sodium and calcium hypo chloride), calcium chlorite, and plastic packing system on storage life of strawberry produced in southwestern Iran (Kurdistan province).

## MATERIALS AND METHODS

### Plant Harvesting and Treatments

Strawberry fruits grown at strawberry field in Su village, Kurdistan province, Iran, were harvested at a commercially mature stage, sorted to eliminate damaged, shriveled, and unripe fruit, and selected for uniform size and color.

Fruits transferred to the laboratory and they were kept at refrigerator at 4 $^0$C. Strawberry fruits were treated with commercial grade of chlorine (calcium hypochlorite made up as 0, 25, 50 and 100 ppm or sodium hypochlorite made up as 0, 25, 50 and 100 ppm with distilled water) for one minute as a short time treatment and then treated with commercial grade of calcium chlorite made up as 0, 0.5, 1 and 1.5 percentage with distilled water for five minutes as a long time treatment (immersion). After treatments, fruit were divided into two groups; one group being packed with plastic cover and the other, not packed fruit were held in cold storage at 4 $^0$C and evaluated.

### Fruits Analysis

- **pH, TA and TSS**: The pH of juice was determined using a pH meter which had been previously standardized. Titratable acidity (TA) was determined by titration with 0.1 *N* NaOH and result were calculated as percent critic acid and expressed as percentage. Total soluble solids (TSS) of the fruits were determined using a refractometer.

- **Fresh and dry weight ratio and water content:** The fruits were weighted after harvesting and then were air dried at air dried temperature to reduce possible water and finally the water content was calculated as bellow:

$$\text{Water content} = \frac{\text{Fresh weight - dry weight}}{\text{dry weight}}$$

- **Anthocyanin quantification and Ascorbic acid measurement:strawberry fruits(** 0.1 g) was homogenized with acidic methanol then were kept at refrigerator for 24 h. Absorbance was measured in a Spectrometer at 530 and 657nm.

- A=A530 - (1/4 A657)

- Ascorbic acid was measured by the di-chlorophenol endophenol and titration method then amount of ascorbic acid was determined as bellow equation:

$V_A \cdot V_D \times F \times 100 \times 100 \div W\ 10 \times 10$

While that:

$V_A$ = sample volume

$V_D$ = check volume

$W_{10}$ = sample weight

Vcc = standard volume and f= 2/ Vcc

- **$Ca^{2+}$, Sugar and Pectin Measurements:** Strawberry fruits were collected, washed in distilled water to remove any external material and 1 g of any sample was placed at 80 $^0$**C** oven for 24 h. Dried samples were ground and placed in 550 $^o$C electric furnace for 6 h, and 2 N HCl were added, then $Ca^{2+}$ was measured using an Atomic absorption for total sugar analyzing fruit juice was prepared and then A and B Fehling solutions (prepared from cupper sulphat and double sodium and- potassium tartarat respectively) were added to the juice and boiled for 10-15 seconds then sugar was determined by titration with methylen blue. For pectin measurement 40 g of strawberry fruits were homogenized with water and boiling, filtered and made final volume with .01 M NaOH then added citric acid 1 M and $CaCl_2$ 2 N. final material is calcium pectat and total amount of pectin was calculated by equation.

### Statistical Analysis

The experimental design was randomized completely block design (RCBD) with three replicates. Analysis of variance (ANOVA) was used to detect treatment effect. The data were analyzed using MSTAT-C (Michigan State Univ. microcomputer program) and mean separation were performed by using Duncan's Multiple Range Test.

## RESULTS AND DISCUSSION

Analysis of variance and significant difference of pH for packing treatment is presented in Table **1**. Packing

**Table 1: Effect of Packing System on Some Triats in Strawberry Fruits**

| pH | | TA | | TSS | | Fresh to dry weight ratio | | Water content | | Anthocyanin | | Ascorbic acid | | $Ca^{2+}$ | | Sugar | | pectin | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| 3.5 | 3.5 | 0.8 | 0.7 | 1.3 | 1.4 | 7.6 | 8.3 | 7.2 | 6.4 | 1.5 | 1.3 | 53.6 | 53.2 | 0.81 | 0.77 | 9.7 | 9.4 | 0.71 | 0.69 |
| a | a | a | b | b | a | b | a | b | a | a | b | a | b | a | b | a | b | a | b |

1 and 2 are packing and non packing treatments respectively.
Means with the same letter did not differ significantly within a column at $p< 0.05$.

treatment had not significant effect on pH. It was found that the application of calcium chloride had a significant effect on pH and decreased the amount of pH in concentrations of 0.5% and 1% while that the concentration of 1.5% had not a significant effect on pH reduction when compared with control (Table **2**). The application of sodium hypochloride had not a significant difference on pH, but the application of calcium hypochlorite in concentration of 50ppm increased the pH when compared whit control (Table **3**). Other levels of calcium hypochlorite had not a significant effect on pH (Table **3**). The interaction effects of packing × $CaCl_2$, packing × chlorine and packing × $CaCl_2$ × chlorine had not a significant effect on pH while that the interaction of $CaCl_2$ × chlorine had a significant effect on pH (Table **4**). In the present study, the value of pH observed between 3.5 and 3.64.

It had observed that strawberry fruits packed with plastic cover was reduced the titratable acidity (TA), and this reduction is significant (Table **1**). Calcium chloride had a significant effect on TA and the 1.5% concentrations was the most effective in increasing the TA (Table **2**). in concentration of 50 ppm, chlorine treatment was reduced the TA but calcium hypochloride was the most effective in reducing the amount of TA and reduced it from 0.83 ppm to 0.15 ppm (Table **3**). The interaction effect of packing × $CaCl_2$ had a significant effect on TA but other interaction effects were not significant (Table **4**). Titrable acidity is directly related to concentration of organic acids present in the fruit, which are an important parameter in maintaining the quality of fruits. [19]. Manganaris et al. has reported the post harvest calcium chlorite dips did not affect TA in peaches during storage. While Shirzadeh et al. demonstrated that postharvest calcium chloride dips did an effect of TA in apple during storage [20].

Souza et al. stated that the reduction of TTA (Total Titratable Acidity) in strawberries beginning at the $14^{th}$ day of its storage must have been a result of acid oxidation during the Krebs cycle, once that this constitutes an excellent energy reserve for the fruit [21].

The changes of increasing TSS of strawberry fruits during the package period and application of calcium chloride were shown in Tables **1** and **2**. Packing system and calcium chlorite had a significant effect on TSS when compared with control (Wich one is Control). Chlorine treatment had not a significant effect on TSS and no any significant difference had seen between control and other levels. the interaction effects of packing × $CaCl_2$, packing × chlorine and packing × $CaCl_2$ × chlorine had not a significant effect on TSS too (Table **4**). Shirzadeh et al. reported that TSS was not influenced by the postharvest calcium dips in apple fruits [20]. Akhtar et al. has reported maximum TSS in loquat (Eriobotrya japonica Lindl.) was observed in 3% Cacl2 and lowest TSS was record in control [22]. They suggest that Highest TSS in 3% CaCl2 might be due to

**Table 2: Effect of Calcium Chloride on Some Triats in Strawberry Fruits**

| Treatments (%) | pH | TA | TSS | Fresh to dry weight ratio | Water content | Anthocyanin | Ascorbic acid | $Ca^{2+}$ | Sugar | pectin |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 3.63 a | 0.75 c | 1.30 b | 7.80 a | 6.80 b | 1.20 c | 53.18 b | 0.81 a | 9.60 ab | 0.60 d |
| 0.5 | 3.60 b | 0.75 c | 1.34 a | 7.90 a | 6.90 b | 1.40 b | 53.18 b | 0.77 a | 9.20 a | 0.65 c |
| 1 | 3.60 b | 0.77 b | 1.34 a | 8.00 a | 7.10 a | 1.60 a | 53.62 b | 0.75 a | 10.00 a | 0.70 b |
| 1.5 | 3.63 a | 0.80 a | 1.34 a | 7.90 a | 6.85 b | 1.20 c | 55.50 a | 0.14 b | 9.50 ab | 0.80 a |

Means with the same letter did not differ significantly within a column at $p< 0.05$

**Table 3: Effect of Chlorine on Some Triats in Strawberry Fruits**

| Treatments(ppm) | pH | TA | TSS | Fresh to dry weight ratio | Water content | Anthocyanin | Ascorbic acid | $Ca^{2+}$ | Sugar | pectin |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 SHC* | 3.62 ab | 0.77 b | 1.34 a | 7.90 b | 6.90 b | 1.40 bc | 53.00 a | 0.88 a | 9.50 ab | 0.68 b |
| 25 SHC | 3.60 ab | 0.77 b | 1.34 a | 7.80 bc | 6.80 bc | 1.40 bc | 53.50 a | 0.75 a | 8.50 b | 0.73 ab |
| 50 SHC | 3.64 a | 0.14 d | 1.34 a | 7.90 b | 7.10 ab | 0.90 e | 53.00 a | 0.78 a | 9.50 ab | 0.68 b |
| 100 SHC | 3.62 ab | 0.71 c | 1.34 a | 7.40 cd | 6.40 cd | 1.50 b | 53.00 a | 0.70 a | 10.30 a | 0.69 b |
| 0 CHC** | 3.57 b | 0.83 a | 1.34 a | 7.30 d | 6.30 d | 1.70 a | 54.00 a | 0.77 a | 8.50 b | 0.70 b |
| 25 CHC | 3.60 ab | 0.72 c | 1.34 a | 9.10 a | 8.10 a | 1.30 d | 53.50 a | 0.70 a | 8.60 b | 0.75 a |
| 50 CHC | 3.64 a | 0.15 d | 1.34 a | 8.40 b | 8.40 a | 0.90 e | 53.00 a | 0.78 a | 9.50 ab | 0.71 ab |
| 100 CHC | 3.62 ab | 0.77 b | 1.34 a | 8.30 b | 8.30 b | 1.40 bc | 53.50 a | 0.70 a | 10.00 a | 0.68 b |

Means followed by the same letter(s) for each trait in each column are not significant at p< 0.01.
*,** are sodium hypochlorite and calcium hypochlorite respectively.

**Table 4: Analysis of Variance (ANOVA) for the Traits Investigated**

| S.O.V | D.f | PH | TA | TSS | Fresh to dry weight ratio | Water content | Anthocyanin | Ascorbic acid | $Ca^{2+}$ | Sugar | pectin |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Packing | 1 | ns | * | * | * | * | * | * | * | * | * |
| $CaCl_2$ | 3 | * | * | * | ns | * | * | * | * | * | * |
| Chlorine | 7 | * | * | ns | * | * | * | ns | ns | * | * |
| Packing× $CaCl_2$ | 3 | ns | ** | ns | * | * | ns | ns | ns | ns | ns |
| Packing ×Chlorine | 7 | ns | ns | ns | * | ** | ns | ns | ns | ns | ns |
| $CaCl_2$ × Chlorine | 21 | ** | ns | ns | ns | ns | ** | ** | ns | ** | ns |
| Packing× $CaCl_2$× Chlorine | 21 | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns |
| Error | 110 | - | - | - | - | - | - | - | - | - | - |

nsNon- significant.
* Significantly at p < 0.05.
** Significantly at p < 0.01.

the fact that more concentration of CaCl2 (3%) formed a thin layer on the surface of fruit which delayed degradation process. The TSS ratio which is generally related to sugar-acid metabolism and mineral content shows different changes depending on the storage temperature, atmosphere combination, and maturity stage of the fruit [23].

Fresh to dry weight ratio was affected by packing treatment and it was increased when compared with control (Table **1**). On the other hand calcium chloride had not a significant effect on Fresh to dry weight ratio (Table **2**), while that chlorine had a significant effect on it (Table **3**), but the interaction effects of packing × $CaCl_2$, packing × chlorine were increased the Fresh to dry weight ratio of strawberry fruits (Table **4**).

Packing treatment was increased the amount of water content (Table **1**). In additional 1% concentration of calcium chloride treatment was increased the water content of strawberry fruits while that no significant difference had seen between control and other levels of calcium chloride (Table **2**). Fruits which were treated with 25 and 50 ppm of chlorine concentrations and interaction effect of packing × chlorine were increased the water content. Other interaction effects had not a significant effect on water fruits (Tables **3** and **4**).

Packing treatment was increased the amount of Anthocyanin, Ascorbic acid, $Ca^{2+}$**,** Sugar and pectin (Table **1**). Using 1% of calcium chlorite treatment was the most effective in increasing the Anthocyanin. Application of 1.5% of calcium chloride treatment was increased the Ascorbic acid and pectin and decreased the $Ca^{2+}$. No significant difference had seen between control and other levels of calcium chlorite for these trials. Calcium chlorite also had not a significant effect on sugar (Table **2**). Ke *et al*. reported a reduction in

strawberry redness during storage at $CO_2$ 20%, or very low $O_2$ levels (0.25%) [24]. Sanz *et al*. suggested that although strawberries from packages with 1.57 $mm^2$ perforation surfaces reached a $CO_2$ content >20%, no decrease in redness was observed for these fruits compared to packages with different perforation degrees that were <20% $CO_2$. Previous findings [25] Pérez *et al*. showed that strawberries may continue ripening after harvest quite in the same way as fruits still attached to the plant. [26, 27]. This would include a decrease in sucrose concomitant with an increase in glucose and fructose during storage and shelf-life. Nutritional value of strawberries has been mainly evaluated as the content of ascorbic acid. This acid is quite unstable and thus it is also an indication of fruit freshness [25]. These results show that $CaCl_2$ treatments had a significant effect on retaining ascorbic acid content in strawberry fruit. This might be because higher concentrations of $CaCl_2$ delayed the rapid oxidation of ascorbic acid. ( Ruoyi *et al*. also stated that Ascorbic acid content of peaches was maintained in fifty days storage with a postharvest application of 0.5% $CaCl_2$ [28]. With respect to pectic substances, it is already well established that the soluble and total pectin contents increase and decrease, respectively during ripening [29]. Ben-Arie and Lavee, In the major part of the fruits, the decrease in the total pectin content was resulted from the nonsterilization caused by the enzyme pectinametilestarase, followed by a depolymerization induced by the activity of polygalacturonase [30], which caused an increment in the soluble pectin.

Using chlorine in 50 ppm (for both sodium hypochlorite and calcium hypochlorite) was the most effective in decreasing the anthocyanin, while that this treatment had not a significant effect on Ascorbic acid and $Ca^{2+}$. 100 ppm treatment of sodium hypochlorite and calcium hypochlorite was increased the sugar, while that the highest amount of pectin had seen in application of 25 ppm of calcium hypochlorite (Table **3**).

Interaction effect of $CaCl_2$ × chlorine had a significant effect on anthocyanin, ascorbic acid and sugar content and these traits were increased. Other interaction effects were not significant (Table **4**).

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