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Effects of combining packaging and temperature preservation on cayenne pepper quality

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Abstract

Vegetables are an important source of nutrition in life. The post-harvest losses cause a lot of damage to farmers and consumers is mainly due to the reduction in weight, and sensory quality. Applied technology to control postharvest losses, both in quality and quantity is very essential. Cooling preservation and packaging maintains the color appearance and reduce cayenne pepper weight loss is more effective at normal room temperature. The cost of applying this technique is relatively low. This simple technique is easy to apply at the household and small-scale production in the rural area of Tra Vinh province (Vietnam), and steady improvement of living conditions of the local level.

Keywords: Post-harvest loss, cooling preservation, color appearance, weight loss, cayenne pepper

1. Introduction

Capsicum is a genus of flowering plants in the nightshade family Solanaceae. Its species are native to the Americas, where they have been cultivated for thousands of years. In modern times, it is cultivated worldwide, and has become a key element in many regional cuisines. In addition to use as spices and food vegetables, capsicum has also found use in medicines.

Some common chili pepper species in Vietnam are classified as following:

Capsicum chinense, the appearance and characteristics of the plants can vary greatly. Varieties such as the well-known habaneros grow to form a small, compact perennial bush approximately 0.5 meters in height. The flowers, as with most Capsicums, are small and white with five petals. When it forms, the fruit varies greatly in colour and shape with red, orange, and yellow being the most common final colours, but colours such as brown are also known. Another similarity with other chilli species would be shallow roots, which are very common in chillies.



Fig 1: *Capsicum chinense*

Capsicum frutescens is a species of chili pepper that is sometimes considered to be part of the species *Capsicum annuum*. Pepper cultivars in *Capsicum frutescens* can be annual or short-lived perennial plants. Flowers are white with a greenish white or greenish yellow corolla, and are either insect- or self-pollinated. The plants' berries typically grow erect; ellipsoid-conical to lanceoloid shaped. They are usually very small and pungent, growing 10–20 mm long and 3–7 mm in diameter. Fruit typically grows a pale yellow and matures to a bright red, but can also be other colors. *C. frutescens* has a smaller variety of shapes compared to other *Capsicum* species, likely because of the lack of human selection.

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More recently, however, *C. frutescens* has been bred to produce ornamental strains, because of its large quantities of erect peppers growing in colorful ripening patterns.



Capsicum annuum is a species of the plant genus *Capsicum* native to southern North America and northern South America. This species is the most common and extensively cultivated of the five domesticated capsicums. The species encompasses a wide variety of shapes and sizes of peppers, both mild and hot, ranging from bell peppers to chili peppers.



Fig 3: *Capsicum annuum*

The cayenne pepper—also known as the Guinea spice, cow-horn pepper, aleva, bird pepper, or, especially in its powdered form, red pepper—is a hot chili pepper used to flavor dishes. It remains green on the plant even when mature; once picked, it may or may not turn red. It is normally eaten red, but also eaten while still green. The fruits are generally dried and ground, or pulped and baked into cakes, which are then ground and sifted to make the powdered spice of the same name. Cayenne is used in cooking spicy dishes, as a powder or in its whole form.



Fig 4: Cayenne pepper

Cayenne pepper, by weight, is relatively high in vitamin A. It also contains vitamin B₆, vitamin E, vitamin C, riboflavin, potassium and manganese. However, given the very small amount of cayenne pepper typically consumed in a serving, it makes a negligible contribution to overall dietary intake of these nutrients.

The capsaicin compound found in the pepper has a variety in medicinal capabilities varying from pain-reliever, metabolism booster, cancer fighter, antibacterial agent, and an effective component in sports performance.

Cayenne pepper consumption dilates the blood vessels and

speeds the metabolism due to the high amounts of capsaicin. With the consumption of cayenne peppers, the amount of heat our body puts off is influenced. Capsaicin has the ability to boost your metabolism, which in turn causes weight loss. This increases circulation and blood flow to all major organs which facilitates oxygen and nutrient delivery. Some research suggests that cayenne pepper may support a healthy energy balance while suppressing appetite. Capsaicin, according to Diepvens *et al.* (2006), suggests that it has been shown to increase energy expenditure, therefore acts as a metabolism booster and beneficial in long-term weight loss [2]. Lejune *et al.* (2003) also found that there is a correlation between substrate oxidation and capsaicin. The results of this study implicate that capsaicin treatment sustained fat oxidation during weight maintenance, but not effect on weight regain after modest weight loss [8].

As a pain-reliever, capsaicin has the ability to interrupt the transmission of pain messaging to the brain, causing our bodies to be less likely to acknowledge the pain. Lorna *et al.* (2004) discusses the process in which the chemical compound found in cayenne peppers has the ability to bind to nociceptors. The excitation of the neurons causes a period of enhanced sensitivity, which is then followed by a refractory period that will eventually cause desensitization. For individuals who suffer from musculoskeletal or neuropathic pain, capsaicin creams may help in the reduction of pain, especially if they seem to feel no relief from other treatments [9].

Apoptosis or cell death has also been shown to be correlated with consumption of cayenne peppers, especially in prostate cancer cell lines. The capsaicin in the peppers has the capability to be linked with both the treatment and prevention of prostate cancer. Mori *et al.* (2006) suggests capsaicin has an antiproliferative effect on prostate cancer cells due to the apoptosis of androgen receptors. There is a possibility of the management of prostate cancer by measuring apoptosis and exposing PC-3 cells to increasing doses of capsaicin, which is making headway in finding cancer cures [11].

Cayenne pepper is also claimed to be an aphrodisiac because it contains capsaicin. It has also been shown to aid in the oxidation of adipose tissue regulate high blood pressure, promote healthy liver function and tissue production, help regulate the digestive system, promote healthy mucus production in the membranes that line internal organs [16].

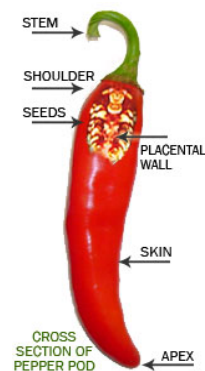


Fig 5: Cross section of cayenne pepper

There are many provinces cultivate cayenne pepper in Vietnam such as Quynh Phu (Thai Binh) 1200 ha, Dai Loc (Quang Nam), Phu My (Binh Dinh), Phu Cat (Binh Dinh), Bo Trach (Quang Binh), Chau Doc (An Giang) and other provinces. People process chilli pepper into various forms, for example: frozen, dried, fermented, powdered, sauced, smoked etc.

Several researches mentioned to pepper species preservation as follow:

V. Rodov *et al.* (1995) showed modified-humidity packaging reduces decay of harvested red bell pepper fruit. Lowering the in-package relative humidity (RH) by adding hygroscopic material reduced decay of bell pepper (*Capsicum annuum* L.) fruit sealed in low-density polyethylene and stored 2 or 3 weeks at 8 °C. Without hygroscopic material, the in-package RH was prevented or significantly reduced. Humidity level varied from 88% with 15 g NaCl to 97% with 5 g NaCl for a package containing 0.5 to 0.6 kg of fruit. Adding hygroscopic material increased the vapor pressure deficit in the packages and the weight loss of the fruit. However, peppers packaged with NaCl still had lower weight loss and better quality than the non-sealed fruit. The water regime formed in four-fruit packages in the presence of 10 g NaCl enabled optimal balance between reduced fruit desiccation and inhibited pathogen development, thus extending the postharvest life of bell pepper [17].

G.A. Gonzalez-Aguilar *et al.* (1999) improved the storage quality of bell peppers pretreated with hot water and polyethylene packaging. Treatments of bell peppers (*Capsicum annuum* L.) with hot water at 45 °C for 15 min or 53 °C for 4 min prior to storage at 8 °C markedly reduced the incidence of fungal infections. However, the hot water treatment induced shrivelling during storage. When hot water treated pepper fruits were subsequently placed in low density polyethylene bags, storage quality of these peppers improved tremendously including retention of firmness, reduction of water loss, retardation of color change, and alleviation of chilling injury. Total soluble solid, titratable acidity and pH values in the pepper fruit were generally not affected by these treatments. A 4 min dip at 53 °C followed by packaging with 0.065 mm low density polyethylene film was very effective in maintaining pepper quality. This treatment inhibited respiration rate, reduced decay, retained turgidity and green color, and maintained excellent overall quality after 28 days of storage at 8 °C. Hot water treatment combined with polyethylene film packaging is a promising technique for improving the storage quality of bell peppers [5].

G.A. Gonzalez-Aguilar *et al.* (2000) studied the polyamines induced by hot water treatments reduce chilling injury and decay in pepper fruit. Treatment of peppers with hot water (53 °C) for 4 min was found to be effective in alleviating chilling injury and reducing decay after 14 and 28 days of storage at 8 °C. Treatment at 45 °C for 15 min was less effective in maintaining pepper quality during storage. Packaging with low density polyethylene film significantly reduced weight loss and chilling injury during low temperature storage. Lower O₂ and higher CO₂ levels were found in internal and in-package atmospheres of heated fruit than controls. Ethylene was not detected in the in-package atmosphere of treated fruit, but was present in the control. Polyamine levels increased immediately after hot water treatments. Putrescine levels increased during storage at 8 °C particularly in heat-treated fruit and in packaged fruit. A significant increase in putrescine was noted in packaged fruit treated at 53 °C for 4 min after 14 days of storage. Spermine levels decreased in control fruit during storage. However, heat treatment in combination with film packaging maintained higher levels of spermine in peppers during storage than controls. These results indicated that hot water treatment in conjunction with film packaging may delay chilling injury and decay of bell peppers through a mechanism that involved elevation of polyamine levels [6].

Julien Mercier *et al.* (2001) used shortwave ultraviolet irradiation for control of decay caused by botrytis cinerea in

bell pepper: induced resistance and germicidal effects. Shortwave ultraviolet radiation (UV-C) was tested for controlling natural infections and inducing resistance to fungal decay caused by *Botrytis cinerea* Pers.: Fr. (gray mold rot) in bell pepper fruit. All UV-C doses tested (0.22, 0.44, 0.88, or 2.20 kJ·m⁻²) caused a reduction in the number of natural infections occurring during storage at 13 °C. A UV-C dose of 0.88 kJ·m⁻² controlled most effectively natural infections in peppers stored at both 13 and 20 °C. Although UV-C was found to be highly germicidal to *B. cinerea* conidia exposed on agar or on fruit wounds, it did not prevent infection of fruit inoculated with the pathogen 24 hours before exposure to UV-C. However, fruit which were exposed to UV-C 24 hours before inoculation with *B. cinerea* had a lower percentage of infections. For this reason, UV-C appears to act mainly as an inducer of disease resistance in this crop rather than a sanitizing agent. UV-C was effective in inducing resistance to *B. cinerea* in fruit at various stages of maturity, from green to red. Disease resistance was also induced in fruit which had been stored for 7 days before UV-C treatment. The effect of UV-C doses was found to be additive as two successive exposures at 0.44 kJ·m⁻² had an equivalent effect as one exposure to the optimal dose of 0.88 kJ·m⁻². However, two successive exposures to 0.88 kJ·m⁻² were less effective than one exposure to this dose [7].

Elazar Fallik *et al.* (2009) showed the prevention of chilling injury in sweet bell pepper stored at 1.5 °C by heat treatments and individual shrink packaging. This research has revealed that individual shrink packaging following prestorage-HWRB treatment, significantly reduced chilling injuries and chilling severity, as shown by very low percentage of CI and a very low CI index, while maintaining a good overall quality (less decay incidence and weight loss) after 21 d at 1.5 °C plus 3 d at 20 °C [3].

Mustafa Sakalda and Kenan Kayna (2010) clarified the biochemical and quality parameters changes of green sweet bell peppers as affected by different postharvest treatments. In this research, the effects of different postharvest treatments on quality and biochemical properties of "Maxibell F1" California Wonder type peppers at green mature stage were determined. In this content, ultraviolet C (UV-C) at 254 nm treatments for 2.5, 5, 10 min and hot water dipping (HWD) treatments for 2 min at 40, 50, 60 °C were done respectively. Besides, low density polyethylene (LDPE) and polyvinylchloride (PVC) based modified atmosphere packaging (MAP) applications were materialized. Some quality and biochemical parameters such as flexibility, soluble solids content, weight loss, decay incidence, ascorbic acid content, total chlorophyll content and membrane leakage were assessed after each storage period on peppers. Furthermore, the gas concentrations inside modified atmosphere packages were daily measured. Treated peppers were stored at 6–7 °C and 90 - 95% RH conditions for 15, 30 and 45 days with two days shelf life at 18 – 20 °C respectively. According to the results, storage period affected the quality and biochemical properties. Thus, quality and biochemical properties reduced with prolonged storage period. Furthermore LDPE based MAP, PVC based MAP and HWD at 40 °C were found successful in terms of keeping the parameters as mentioned, respectively. The differences between treatments became evident especially after 30 and 45 days storage [12].

L.V. Raymond *et al.* (2012) examined the effect of chitosan coating on physical and microbial characteristics of fresh-cut green peppers (*Capsicum annuum* L.). Green pepper slices were subjected to chitosan coating treatment achieved by dipping, afterwards stored at 5 °C for a period of 15 days. The effect of various chitosan concentrations (0%, 0.5%, 1.0% and

2% (w/v) chitosan) on some physico-chemical and microbial characteristics of the slices was subsequently analyzed during storage. The data indicated that the performance of chitosan treatments was better than that of control. The decrease of surface lightness was delayed by chitosan treatments; and the surface green colour was kept under marginal changes compared to control. On the other hand, a greater reduction of fungal incidence, carbon dioxide concentration and electrolyte leakage of the chitosan treated samples was observed with increased chitosan concentration treatment. Microbiological evaluation revealed that total viable cells count decreased with increasing chitosan concentration. This correlated well with the external changes which were affected to a lesser extent in the 2% chitosan compared to the control; in addition, delaying of changes was significantly chitosan concentration dependent [10].

Emilio Ochoa-Reyes *et al.* (2013) demonstrated the improvement of shelf life quality of green bell peppers using edible coating formulations. Three different biopolymers (pectin, Arabic, and xanthan gums) were evaluated in mixtures with candelilla wax as hydrophobic phase, jojoba oil as plasticizer and a crude extract of polyphenols as source of bioactive compounds. Green bell peppers were immersion-treated and then stored at room temperature. Response variables were: weight loss, color, appearance, pH, total soluble solids and firmness changes which were kinetically determined. All peppers treated with edible-coating showed a significant difference (Tukey, $p \leq 0.05$) in weight loss compared to control treatment (without edible coating), while a lower level of deterioration was observed in fruits treated with edible coating formulated with arabic gum, but appearance remained similar among fruits treated with different edible coatings. Use of mixtures of biopolymers, candelilla wax, jojoba oil and polyphenols to develop edible and functionalized coatings significantly extended shelf life of green bell pepper [4].

Dargie Tsegay *et al.* (2013) showed the effects of harvesting stage and storage duration on postharvest quality and shelf life of sweet bell pepper (*Capsicum annuum* L.) varieties under passive refrigeration system. A laboratory experiment was carried out to determine the effects of harvesting stages (0, 25, 50, 75 and 100% fruit colourations) and storage durations (0, 1, 2, 3 and 4 weeks) on physicochemical quality and shelf life of sweet pepper varieties (Telmo-Red and Velez-Yellow) under passive refrigeration system (PRS). The aim of the study was to identify the optimum stage of maturity at harvest and storage period under PRS that can ensure better quality and longer shelf life of two greenhouse sweet pepper varieties. The experiment was arranged in 2 x 5 x 5 factorial combinations in complete randomized design (CRD) with three replications. Thirty (30) fruits of sweet pepper were packed in card-board boxes for each treatment and stored under PRS optimum storage conditions. Fruits were assessed for weight loss percentage, fruit firmness, total soluble solids, titratable acidity, postharvest decay percentage and shelf life. Total soluble solids were increased; whereas fruit firmness decreased with increasing harvesting stages. Weight loss percentage, postharvest decay percentage and shelf life increased; while fruit firmness decreased with increasing storage periods. Telmo variety showed significantly better postharvest quality and storability potential than Velez variety [1].

R. Renu and Chidanand. D. V (2013) showed the effect of modified atmosphere storage conditions on biochemical parameters of bell peppers. Fruits were packed in corrugated fiber board boxes in diffusion channel system with different lengths (10 cm, 17.5 cm and 25 cm) and same diameter of

5mm at 33, 20 and 8 °C. Optimum storage conditions for maximum shelf life extension were found to be, 25cm diffusion channel length, 8 °C temperature and 95% RH. Highest percentage retention of ascorbic acid was found for Bell Peppers (20 kg) stored in CFB boxes with diffusion channel length of 25 cm. As diffusion channel length increased acid value also decreased, silicon membrane window area also had a proportional effect on pH value. TSS increases as the storage time increases in all the treatments [15].

R. Hameed *et al.* (2013) evaluated the effect of different storage conditions on quality of green chillies (*Capsicum annuum* L.). They investigated the effect of different storage conditions viz., 0 °C (R.H. 80-90 %), 5 °C (R.H. 80-90 %), 10 °C (R.H. 80-90 %) and 15 °C (R.H. 85-95 %) on the shelf life and quality attributes of green chillies. Each of the cold and humid storage conditions were applied to chilli for three weeks. After removal from storage, chillies were divided into two lots where one lot was kept at 15 °C (R.H. 85-95 %) and other at ambient conditions (22 °C ± 1 °C) with a R.H. 65-70 % for one week shelf study. Changes in quality, weight, respiration, decay, softness, total chlorophyll content, marketability, acidity, and ascorbic acid content were recorded. After the three week storage, the fruits subjected to 10 °C exhibited a comparatively less weight loss, decay, softness, ethylene production and respiration rate but more firmness, compared to all other storage conditions. Retention of chlorophyll was higher at the lower temperatures (0 °C), However, chilling injury was observed on the fruit stored at 5 °C and 0 °C, especially when taken out of storage and subjected to shelf life studies, where the fruits were found to be unmarketable after two days. The minimal quality loss occurred at shelf temperature of 15 °C compared to the ambient temperature [14].

Ranjeet Singh *et al.* (2014) examined shelf-life enhancement of green bell pepper (*Capsicum annuum* L.) under active modified atmosphere storage. The effect of modified atmosphere packaging (MAP) along with moisture absorbing was assessed for maintaining quality attributes and extending shelf life of green bell pepper (*Capsicum annuum* L.) in bulk packages. Under active packaging the quality of capsicum were based on MAP using permeable polymeric films and sachets of silica gel crystals as moisture absorbents. Pre-designed polypropylene film (38 µm) packages were used for storage study under MAP at 8 ± 1 °C temperature. The in-pack O₂ and CO₂ composition and respiration rate in the package headspace was monitored during storage in all the treatments. A modified atmosphere of 4.5% O₂, 7.8% CO₂ and 4.7% O₂, 7.5% CO₂ were achieved in the MA packages with and without moisture absorbent, respectively. The active packaging significantly reduced the respiration rate of fruit in the package. These packaged fruits were compared with non-packaged samples, which served as control stored at both ambient conditions (CS) and control at refrigerated temperature (CR). The quality of capsicums was assessed by physiological weight loss, color (L^* , h^* and C^*) values, firmness, ascorbic acid, decay and marketability. The shelf life of bell pepper was extended to 49 days in active packages, 42 days with MA packages, as compared to 21 days with CR packages and 7 days with CS. Above all, by placing silica crystals sachets in the head space with moisture absorbing ability, could further extend the shelf life of capsicum 7 days in addition to modified atmosphere packaging alone with 97% fruit marketability [13].

In this paper, we mention to a simple technique applicable in household model to save cost which is executed on cayenne pepper.

2. Material and Method

2.1 Material

Raw material is cayenne pepper harvested in Tra Vinh province. PE bag is also used to pack cayenne pepper during experiments.

2.2 Method

Separate cayenne peppers into two portions having the same weight, pack in PE bag with 6 holes (diameter $d = 0.2-0.3$ cm). Then store in two different conditions: sample (1) kept in cooling (9.4 °C) and sample (2) kept in normal temperature. Monitor color change and weight loss in each two days.

Table 1: Raw cayenne pepper ready for experiment


Weight		Number of fruit as color		
		Green	Yellow green, light red	Red
Sample 1: Cooling (9.4 °C)	100g	3	7	
Sample 2: Normal room temperature	100g	4	6	

3. Result & Discussion

After 9 days, cayenne peppers change their appearance as follow:

* At normal room temperature:

Table 2: Color change of cayenne pepper under normal room temperature

Date	Color change			Weight (g)	Note
	Green	Yellow green, light red	Red		
21/9/2012	3 (30%)	7 (70%)	0	100	
23/9/2012	0	3 (30%)	7 (9%)	95.4	
25/9/2012	0	1 (10%)	7 (70%)	94.7	
27/9/2012	0	0	0	86.3	

* At cooling condition:

Table 3: Color change of cayenne pepper under cooling temperature


Date	Color change			Weight (g)	Note
	Green	Yellow green, light red	Red		
21/9/2012	4 (40%)	6 (60%)	0	100	
23/9/2012	4 (40%)	6 (60%)	0	91.2	
25/9/2012	4 (40%)	6 (60%)	0	88.3	
27/9/2012	4 (40%)	0	6 (60%)	86.3	
29/09/2012	4 (40%)	0	6 (60%)	84.4	



Fig 6: Appearance of cayenne pepper under different temperature

At normal room temperature, cayenne peppers become decay over 20% so they should be stopped preserving. Keep monitor the cooling experiment and see some noticeable appearances:

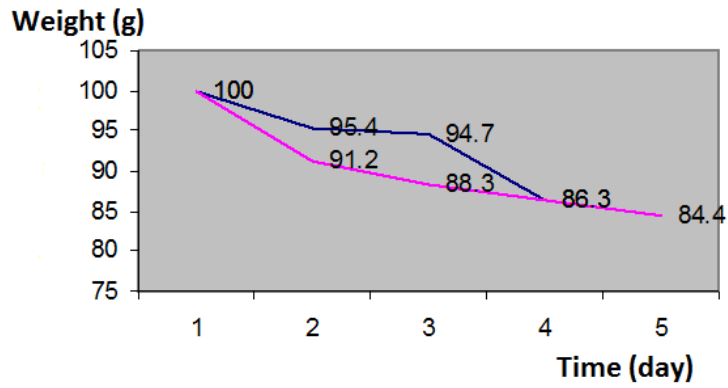


Fig 7: Weight loss of cayenne pepper by time

Room temperature: —
Cooling temperature: —

On color change, this phenomenon appears quickly at normal room temperature, while cooling condition is very minor.

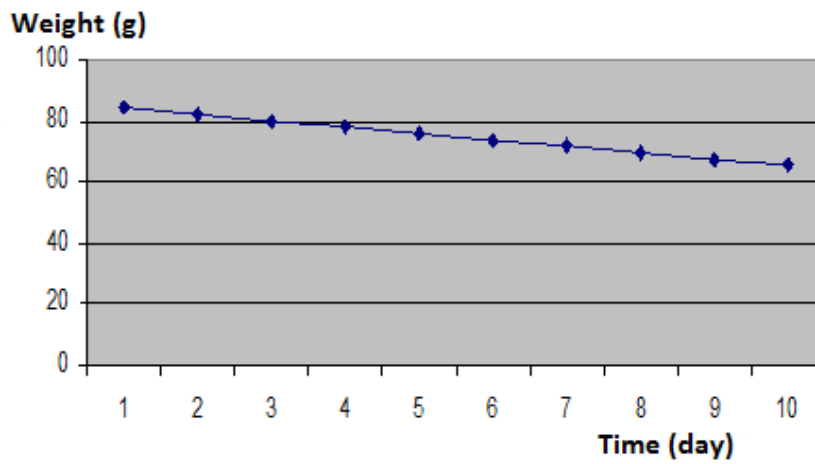




Fig 8: Weight loss of cayenne pepper under cooling condition

Date	Color change			Weight (g)	Note
	Green	Yellow green, light red	Red		
1/10/2012	3 (30%)	1 (10%)	6 (60%)	82.2	 First day
3/10/2012	3 (30%)	1 (10%)	6 (60%)	80	 Second day

5/10/2012	2 (20%)	2 (20%)	6 (60%)	78.1	 Third day
8/10/2012	2 (20 %)	2 (20%)	6 (60 %)	75.4	 Fourth day
10/10/2012	2(20 %)	1 (10%)	7 (70 %)	73.5	 Fifth day
12/10/2012	2(20%)	1 (10%)	7 (70%)	71.7	 Sixth day
15/10/2012	2 (20%)	1 (10%)	7 (70 %)	69.5	 Seventh day
17/10/2012	2 (20%)	1 (10%)	7 (70 %)	67.5	 Eighth day
19/10/2012				65.6	 Nineth day 2 decay

4. Conclusion

We recognize that cooling preservation can preserve color change and reduce weight loss of cayenne pepper significantly. It should be studied with other methods combined chemical, packing and cooling to maintain quality of cayenne pepper and other vegetables.

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