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Effect of different preconditioning treatments for shelf-life extension of chilli (*Capsicum annuum* L.)

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Abstract

The effect of preconditioning treatment on the quality and shelf-life of chilli under low temperature storage was studied. Temperature conditioning treatments were employed on chilli prior to storage at 5 °C. The treatments comprised preconditioning at 15 °C for 1 day (T1), preconditioning at 15 °C for 2 days (T2), preconditioning at 15 °C for 1 day followed by 10 °C for 1 day (T3) and preconditioning at 15 °C for 2 days followed by 10 °C for 2 days (T4). Chilli without preconditioning treatment was used as control (T0). Quality characteristics evaluated during storage at 5 °C were texture, general appearance, weight loss, colour, pH, total titratable acidity (TTA), ascorbic acid and total soluble solids (TSS). The texture, general appearance, ascorbic acid, TSS content, respiration rate and ethylene production were not affected by preconditioning treatments. However, weight loss, colour, pH and TTA were significantly ($p < 0.05$) influenced by different preconditioning treatments. Preconditioning at 15 °C for 1 day (T1) resulted in better physical appearance of chilli as compared to other conditioning treatments.

Keywords: chilli, preconditioning, shelf-life, quality, low temperature storage

Introduction

Chilli is one of the groups of vegetables that has been identified for further research and development under the RMK9 based on the Balance of Trade (BOT) and the current issues associated with the industry. Longer storage period is required to maintain the freshness of chilli for local and export market. Chilli has the potential to be exported to other countries including Singapore, Brunei, Hong Kong, Japan and West Asia. Earlier studies had been focused on the infield practices (Zaulia et al. 2004), maturity, packing system and storage requirement of chilli.

At storage temperature of 5 – 8 °C, chilli can be stored for 3 – 6 weeks depending on the variety and stage of maturity at harvest (Abd. Shukor 1986). Storage at temperatures below the optimum will cause chilling injury and the symptoms include water-soaked appearance and fungi infection on the green stem and short storage life.

Preconditioning is a process whereby plants parts are exposed to temperature slightly above optimum for certain period before actual storage at lower temperatures to induce higher chilling tolerance. Preconditioning treatment has been reported to be a significant treatment that allows the healing process of bruises and cuts, resistance to chilling injury, reduce weight loss during storage and also the hazard of rot by preventing the entry of organisms (Abdullah et al. 2008; Moran et al. 2010).

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Temperature preconditioning was reported to reduce chilling injury in some produce including avocado, cucumbers, pineapple, loquat, tomatoes and zucchini (Wang 1996; Woolf et al. 2003; Lee et al. 2005; Cai et al. 2006; Abdullah et al. 2008; Liu et al. 2012). No study has been conducted to manipulate the potential of storing chilli below the optimum temperature for longer storage life than normally achieved. Therefore, the objective of this study was to evaluate the effect of preconditioning treatment on storage life of chilli.

Materials and methods

Chilli var Kulai at colour index 3 were purchased from Cameron Highlands, Pahang. Upon arrival, the fruits were washed, dried and sorted for uniformity of colour, shape, size and absence of defects. The chilli were packed in polyethylene bag 0.04 mm (average 200 g/bag). Approximately eight fruits representing per replicate and three replications were used at each sampling stage. All samples were subjected to the respected treatments:

T0 = Without preconditioning
T1 = Preconditioning at 15 °C for 1 day
T2 = Preconditioning at 15 °C for 2 days
T3 = Preconditioning at 15 °C for 1 day followed by 10 °C for 1 day
T4 = Preconditioning at 15 °C for 2 days followed by 10 °C for 2 days

The treated chilli were then stored at 5 ± 1 °C (RH 90 – 95%) for 7 weeks. Three replicates from each treatment were removed weekly to analyse the chemical and physical parameters, weight loss and gas (oxygen, carbon dioxide and ethylene) measurements.

Physical and chemical analyses

The percentage weight loss of chilli sample was obtained by measuring the difference in weight before and after storage. The samples were weighed using weighing machine, model Scaltec SBA51. The skin colour was determined by using the colour meter [Minolta Chromameter (CR300), Osaka, Japan] with the chromaticity planes defined by the dimension L*, a* and b* values. In this colour space, L* indicates lightness, while a* and b* are the chromaticity coordinates in which +a* is the red direction, –a* is the green direction, +b* is the yellow direction and –b* is the blue direction. The chroma (C*) which indicates the intensity of the colour was also calculated using the formula $C^* = \sqrt{(a^2 + b^2)}$. Colour of the fruit can be expressed as a hue angle, and can be calculated by using this formula: tan-1 (b/a).

The texture of fresh fruit was measured using a texture analyser (TA.xt.Plus, Stable Micro Systems), fitted with a needle stainless steel cylindrical probe (P2N), and travelled 10 mm of the depth of the cut surface of the sample with penetration speed of 5 mm/sec. Values were expressed as Newton (N). The tissue firmness was determined at three different places on the fruits. Three readings on each fruit were taken and the tissue firmness was expressed as kg pressure.

Samples for the chemical analysis were blended using a kitchen blender. The pH value was measured using an Origon digital pH meter (model SA 520) and total titratable acidity was measured by titrating the known volume of homogenates solution with 0.1 N NaOH to an end point of pH 8.1 using digital burette. The total soluble solids (TSS) were determined by a digital refractometer (ATAGO RX-5000, ATAGO, Japan). Ascorbic acid content was determined by titration with 2,6 dichlorophenolindophenol until a faint pink colour persists. All experiments were performed in triplicates.

Respiration rate and ethylene production

To determine the respiration rate and ethylene production, three fruits which formed one replicate, were taken for every treatment and all treatments had three replicates. All samples were placed in each container. The gases in the container were measured weekly.

Respiration rate was measured by the rate of CO_2 given off by the fruit. The gas samples (O_2, CO_2 and ethylene) were drawn by a syringe through a septum in the container. CO_2 was detected using a different detector (thermal conductivity detector; TCD) with a stainless steel column packed with Porapak R of 80/100-mesh size. For ethylene measurement, 1 ml of the gas sample was injected into a Perkin Elmer Auto System XL gas chromatography fitted with flame ionisation detector (FID) and a stainless steel column packed with Porapak T of 100/120-mesh size. The flow rate of the purified helium gas was 30 ml/min and the column oven was operated at 50 °C and 100 °C for CO_2 and ethylene respectively. Thus, the same amount of O_2 gas sample was detected using a TCD gas chromatography (Varian 1420) fitted with a 1,500 mm x 3 mm stainless steel column packed with Porapak R of 80/100-mesh size. Helium was also used as a carrier gas at the same flow rate and the injector temperature was 35 °C.

Statistical analysis

The SAS (Statistical Analysis System Inst. 1985) program was used for data analyses of this completely randomised design (CRD) experiment, with five treatments and three replicates. The values obtained were subjected to analysis of variance (ANOVA) and correlation between parameters and tested using Least Significant Difference (LSD) at $p < 0.05$ level.

Results and discussion

Physical characteristics

Colour is the major quality attribute considered to have the most impact on consumer selection of the produce. Chilli treated with preconditioning treatment exhibited better red colour retention as compared to untreated chilli until 3 weeks of storage. After 4 weeks, redness 'a' was high in chilli with preconditioning treatment and significantly lower in untreated chilli. However, no significant ($p > 0.05$) colour changes were observed between the preconditioning treatments *(Figure 1)*. This can be assumed that all preconditioning treatments showed the same redness. Skin redness 'a' was high at 1, 6 and 7 weeks of storage as shown by the higher values of 'a' as compared to other weeks.

Skin lightness 'l' were increased after 5 weeks of storage and the highest 'l' value was +36.39 at week 6. Hue angle values for skin colour of chilli were significantly different among storage duration. Fresh chilli which was in week 0 had the highest hue angle value compared to other weeks. The decrease of hue angle value, which was indicated with the increase in red colour in chilli, probably due to the colour development that occurred more obviously as the maturity increased and with longer storage period. There was a significant difference ($p < 0.05$) between treated and

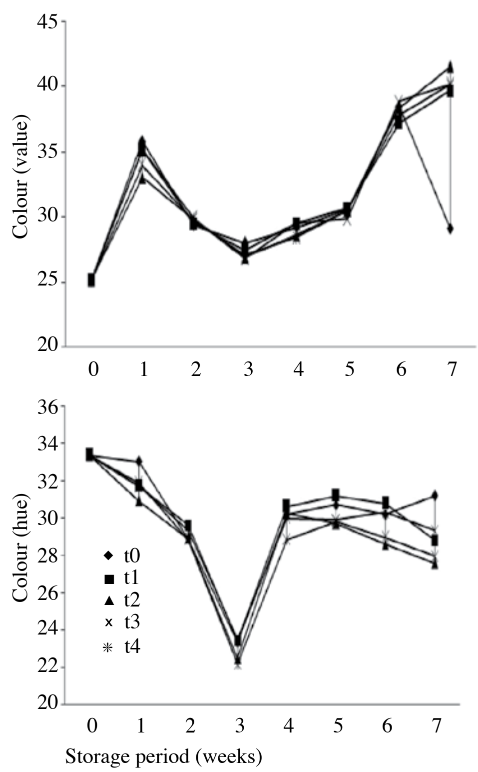

Figure 1. Changes in colour of chilli with different preconditioning treatments during storage at 5 °C

untreated chilli whereby untreated chilli had higher hue angle values compared to treated chilli at 7 weeks of storage.

The percentage weight loss showed an increasing trend with the duration of storage *(Figure 2)*. The lowest percentage weight loss was at week 1 (0.15%) and the highest at week 7 (0.94 – 1.66%). This increasing trend was in line with Abdullah et al. (1996) on pineapple storage and Razali et al. (2004) on minimally processed long bean storage. There was a significant difference (*p* <0.05) in percentage weight loss of chilli with different treatments of preconditioning. The percentage weight loss of chilli with preconditioning treatment at 15 ºC for 2 days was highest (1.66%) while preconditioning treatment at 15 ºC for 1 day only was the lowest (0.19%).

The weight loss in chilli during storage can affect the fruit quality significantly. The excessive weight loss can lead to reduce

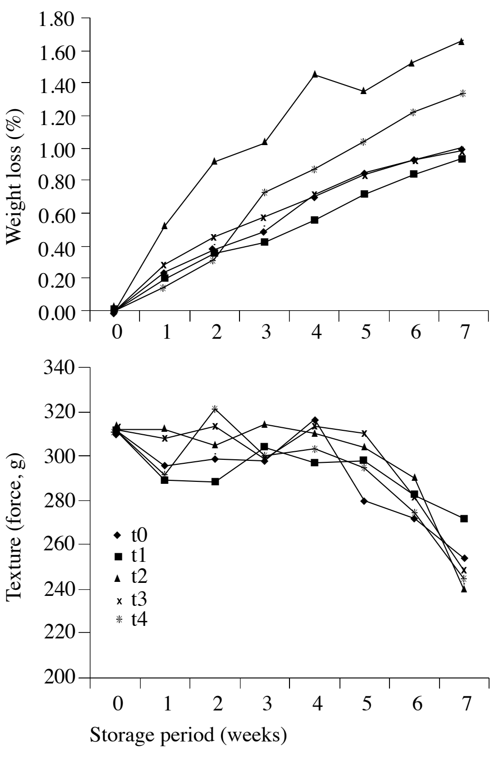

Figure 2. Effects of different preconditioning treatments on weight loss and texture on chilli during storage at 5 °C

texture quality due to water loss. The weight loss can be reduced by applying a moisture barrier on the fruit surface. Fruit coating has been reported to maintain freshness and reduce weight loss during storage in fruits such as apple (Drake and Nelson 1990) and guava (Abdullah et al. 1992).

The texture of chilli also changed during ripening. There was a significant difference (*p* <0.05) in firmness for chilli that stored from week 0 – 5 compared with week 6 and 7 *(Figure 2)*. Texture was maintained as in control (W0) from week 1 to week 5 and became softer in week 6 followed by week 7. Softening is indicated by the lower force required to puncture the fruit. Softening occurred because of the breakdown of polymeric carbohydrates especially pectic substances and hemicelullose that weaken the cell walls and the cohesive forces binding the cells together (Wills et al. 1989). Water loss in chilli might be a major factor affecting the firmness of chilli and this was supported by increasing trend in percentage of weight loss throughout the storage period.

The storage life of chilli can be prolonged for 4 weeks and the general appearance starting to decline at week 5. Chilli maintained fresh for 2 weeks of storage period and still acceptable until week 4 then became worse at week 5 to week 7. There was a slight difference among treatments. Untreated chilli had better appearance than treated chilli while the longest preconditioning time which was 4 days had the worst chilli appearance.

Chemical analysis

The pH of chilli showed a decreasing trend during 3 weeks of storage and fluctuated until the end of the storage period *(Figure 3)*. Fresh chilli at week 0 had the highest pH (5.45) and lowest pH (5.0) at week 3. The pH value did not change extensively during storage. There was no significant difference among treatments, however, chilli with preconditioning treatment at 15 °C for 1 day had high pH

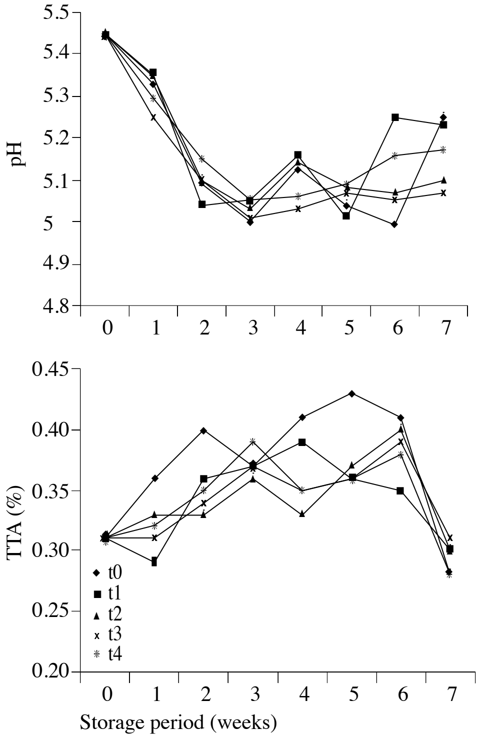

Figure 3. Effects of different preconditioning treatments on pH and total titratable acidity (TTA) on chilli during storage at 5 °C

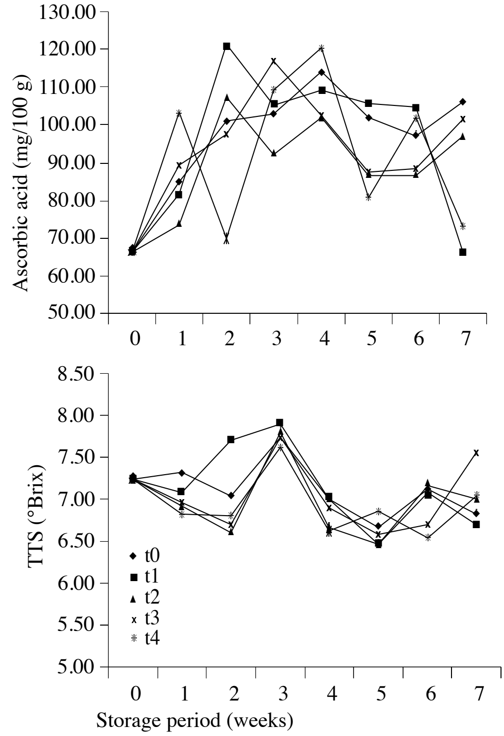

Figure 4. Effects of different preconditioning treatments on ascorbic acid content and total soluble solids (TSS) on chilli during storage at 5 °C

and chillli with preconditioning treatment at 15 °C for 1 day then 10 °C for 1 day had low pH.

These results were in line with TTA where the values were higher when the pH decreased *(Figure 3)*. The results showed that the TTA gradually increased until week 3 and fluctuated until the end of the storage period. The results also showed significant difference (p <0.05) between untreated chilli and preconditioning chilli where untreated chilli gave high TTA result. There were no significant difference (p >0.05) among various preconditioning treatments in chilli.

There was no significant difference (p >0.05) among treatments on ascorbic acid content in chilli during storage *(Figure 4)*. Thus, ascorbic acid content of chilli was not affected by the different preconditioning treatments and was the same as chilli without preconditioning treatment. The concentration of ascorbic acid during storage increased until week 4 and declined thereafter. The highest concentration of ascorbic acid was 120.48 mg/100 g and the lowest was 66.15 mg/100 g. A reduction in ascorbic acid content after week 4 indicated the quality reduction of chilli after the periods. These results were in line with general appearance results where the stored chilli was still acceptable until week 4. Reduction in ascorbic acid content is always associated with the increase of surface browning (Wong et al. 1994) and degradation of fruit quality.

There were no significant difference (p >0.05) in TSS content among the preconditioning treatments *(Figure 4)*. This showed that the TSS content was not affected by the preconditioning treatments and was the same as in untreated chilli. The TSS content was significantly higher at week 3 (7.90 °Brix) and slightly lower in all weeks of storage. The reduction in the TSS content is probably due to it being used as a respiratory substrate during the metabolic process (Kays 1991). These results indicate that the TSS content did not change extensively during storage.

Respiration rate and ethylene production

The O_2 consumption of chilli showed an increasing trend which was 598.52 ml/kg/h at week 6 and was the highest consumption *(Figure 5)*. The consumption of O_2 in chilli treated with preconditioning treatment at 15 °C for 2 days and chilli treated with preconditioning treatment at 15 °C for 2 days followed by 10 °C for 2 days were the same as consumption of O_2 in untreated chilli. Hence, preconditioning treatments did not affect the O_2 consumption. On the other hand, the consumption of O_2 in chilli treated with preconditioning treatment at 15 °C

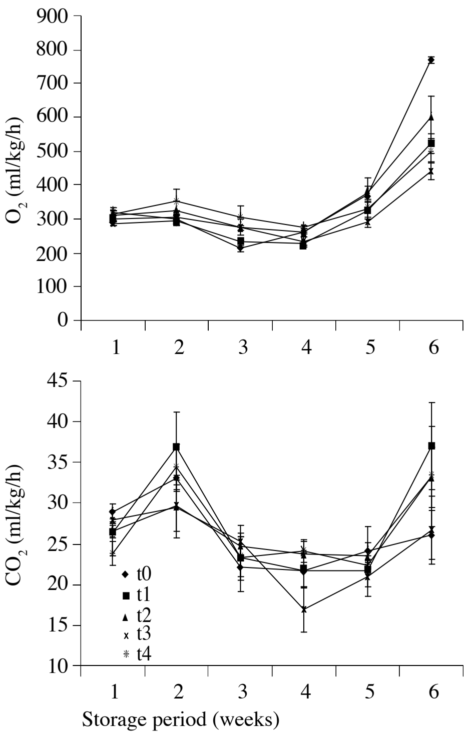

Figure 5. Effects of different preconditioning treatments on O_2 consumption and CO_2 production on chilli during storage at 5 °C

for 1 day and at 15 °C for 1 day followed by 10 °C for 1 day were seen significantly lower than untreated chilli.

Production of CO_2 was not significantly different (p >0.05) among treatments in chilli. This indicate that CO_2 production was not affected by preconditioning treatment. However, there was significant difference (p <0.05) in production of CO_2 during storage. Production of CO_2 at week 2 and week 6 were higher compared to the other weeks *(Figure 5)*. It was increased until week 2 and decreased along the storage period until week 5 and increased again at the end of storage period (week 6). The increment of CO_2 production after week 5 might be due to the mechanical damage after long storage period. Emerging of fungus would also be the factor contributing to high production of CO_2. From the results, it was observed that all CO_2 production levels were reported as high. A high CO_2 concentration level (>10%) can cause CO_2 injury on chilli (Kader 1986). Increased CO_2 level in chilli resulted in internal browning and spoilage as reported on bell pepper (Kays 1991). A produce that cannot tolerate a high CO_2 atmosphere may result in breakdown of pectic substance and affect the firmness.

There was no significant difference (p >0.05) on ethylene rate of preconditioned chilli and untreated chilli throughout the storage period. The production of ethylene was observed at week 1 until week 5 and only in certain treatments. There was also no production of ethylene at the end of storage period (week 6).

Conclusion

Maintaining the quality by preconditioning treatment before exposing to the actual storage temperature is considered a new technique to extend the shelf-life of chilli. Chilli that preconditioned at 15 °C for 1 day maintained low percentage weight loss and stable in pH and TTA value without affecting the quality and respiration rate of chilli. However, more study need to be done to optimise the application of preconditioning treatments in chilli to get more profound findings.

References

Abd. Shukor, A.R. (1986). Handling and storage of chilli. Maklumat Teknol. Makanan, MARDI Bil. 14A, MARDI, Serdang

Abdullah, H., Rohaya, M.A. and Abd Aziz, I. (1996). Quality changes in pineapple (*Ananas comosus* cv. N36) stored at low temperature. *MARDI Res. J.* 24(1): 39 – 47

Abdullah, H., Rohaya, M.A. and Engku Hasmah, E.A. (2008). Increasing pineapple fruit resistance to chilling injury during storage by temperature preconditioning. *Actae Horticulturae* 768: 217 – 224

Abdullah, H., Rohaya, M.A. and Salbiah, H. (1992). Effects of perforated polyethylene bags and waxing on quality of guava (*Psidium guajava* L. cv. Taiwan) during storage. *MARDI Res. J.* 20: 73 – 78

Cai, C., Xu, C.J., Shan, L.L., Li, X., Zhou, C.H., Zhang, W.S., Ferguson, I. and Chan, K.S. (2006). Low temperature conditioning reduced postharvest chilling injury in loquat fruit. *Postharvest Biology and Technology* 41: 252 – 259

Drake, S.R. and Nelson, J.W. (1990). Storage quality of waxed and nonwaxed Delicious and Golden apples. *J. Food Quality* 13(5): 331 – 341

Kader, A.A. (1986). Biochemical and physiological basis for effects of controlled and modified atmospheres on fruits and vegetables. *Food Technol*. 40(5): 99

Kays, S.J. (1991). *Postharvest physiology of perishable plant products*, 532 p. New York: AVI Publishing Co.

Lee, S.H., Chung, G.C. and Steudle, E. (2005). Gating of aquaporins by low temperature in roots of chilling-sensitive cucumber and chilling-tolerant fig leaf gourd. *J Exp Bot*. 56(413): 985 – 995

Liu, C., Jahangir, M.M. and Ying T. (2012). Alleviation of chilling injury in postharvest tomato fruit by preconditioning with ultraviolet irradiation. *J Sci Food Agric*. 92(15): 3016 – 3022

Moran, E.R., Deell, R.J. and Murr, P.D. (2010) Effects of preconditioning and fruit maturity on the occurrence of soft scald and soggy breakdown in 'Honeycrisp' apples. *Hortscience* 45(11): 1719 – 1722

Razali, M., Habsah, M. and Che Omar, D. (2004). Effect of different forms of cutting on quality of minimally processed long bean (*Vigna sesquipedalis* L.) during storage. *J. Trop. Agric. and Fd. Sc.* 32(1): 45 – 56

Wang, C.K. (1996). Temperature preconditioning affects ascorbate antioxidant system in chilled zucchini squash. *Postharvest Biology and Technology* 8: 29 – 36

Wills, R.B.H., McGlasson, W.B., Graham, D., Lee, T.H. and Hall, E.G. (1989). *An introduction to the physiology and handling of fruits and vegetable,* p. 17 – 38. Oxford: BSP Professional Books

Wong, D.W.S., Camirand, W.M. and Pavlath, A.E. (1994). Edible coatings for fresh fruits and vegetables, past, present and future. In: *Edible coating and films to improve food quality,* (Krochta, J., Baldwin, E.A. and Nisperos-Carriedo M.O., eds.), p. 25 – 64. Lancester: Technomic Publishing Co.

Woolf, A.B., Cox, K.A., Anne White and Ferguson I.B. (2003). Low temperature conditioning treatments reduce external chilling injury of 'Hass' avocados. *Postharvest Biology and Technology* 28: 113 – 122

Zaulia, O., Illias, M.K., Che Omar, D., Habsah, M. and Zaipun, M.Z. (2004). Effect of different planting on postharvest quality of chilli grown under the rain shelter. HRC Technical Report, MARDI, Serdang

Abstrak
Kesan rawatan prakondisi yang berbeza ke atas kualiti dan jangka hayat cili yang disimpan pada suhu rendah dikaji. Rawatan prakondisi suhu dijalankan ke atas cili sebelum disimpan pada suhu 5 °C. Rawatan terdiri daripada prakondisi pada 15 °C selama 1 hari (T1), prakondisi pada 15 °C selama 2 hari (T2), prakondisi pada 15 °C selama 1 hari, diikuti dengan 10 °C selama 1 hari (T3) dan prakondisi pada 15 °C selama 2 hari diikuti dengan 10 °C selama 2 hari (T4). Cili tanpa rawatan prakondisi digunakan sebagai kawalan (T0). Parameter kualiti yang dinilai semasa simpanan pada suhu 5 °C ialah tekstur, keadaan umum, kehilangan berat, warna, pH, jumlah keasidan boleh titrat (TTA), vitamin C dan jumlah pepejal larut (TSS). Tekstur, keadaan umum, asid askorbik, TTS, kadar respirasi dan penghasilan gas etilena tidak dipengaruhi oleh rawatan prakondisi. Walau bagaimanapun, kehilangan berat, warna, pH dan TTA dipengaruhi oleh rawatan prakondisi. Prakondisi pada suhu 15 °C selama 1 hari (T1) dapat memberi keadaan fizikal yang lebih baik kepada cili berbanding dengan rawatan prakondisi yang lain.