

Comparative Assessment of Quality Parameters in Relative Humidity Controlled Storage Condition for Selected Vegetables in Sri Lanka

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ABSTRACT

World facing a major global challenge to ensure the food security for world escalating population. Expected population to be reach 10.5 billion in the year 2050 and to ensure the food security need to reduce the post-harvest losses in fruits and vegetables. Sri Lanka losses 30 - 40% of post-harvest losses annually. Sri Lankan farmers face problems while they store vegetables in a short period of time. Most storage methods are expensive and hard to use. Under this research, evaluate the storage conditions with the quality parameters of vegetables. Potato (*Solanumtuberosum*), Beetroot (*Beta vulgaris L.*), Knol kohl (*Brassica oleracea var. gongylodes*), Carrot (*Daucuscarota L.*), Tomato (*Solanumlycopersicum*), Lime (*Citrus aurantifolia,C.latifolia*), Cauliflower (*Brassica oleracea variety botrytis*) and Okra (*Abelmoschusesculentus*) used for this experiment to represent all Sri Lankan climates. The storage room temperature was maintained at 21 - 22 °C by using an air conditioner and Relative Humidity (RH) level of 65% was maintained by using an air compressor. Firmness, Brix, pH, Lightness, Hue angle and Chroma values were used to evaluate vegetables in initial and after storage. Beet root ambient and the RH samples showed significantly same firmness values of 169.05 ± 4.06 N and 175.63 ± 9.14 N. Okra, Carrot and Lime didn't show any significant different pH values for initial, ambient and RH conditions. Beetroot and Cauliflower resulted significantly less deviated Brix values compared to initial values of 6.70 ± 0.17 and 4.33 ± 0.35. Beetroot, Lime, Carrot, Cauliflower, Okra and Knol Khol didn't show any significant difference in lightness values. Tomato, Lime, Okra and Potato showed significantly best quality in three parameters out of all six quality parameters.

1. Introduction

One of the major global challenge is how to ensure the food security for world escalating population. The current population is expected to reach 10.5 billion in the year 2050 and to ensure the food security, food supplies need to be increased by 60% (Aulakh and Regmi, 2013). Increasing urban population, shift of diet pattern, decline fresh water and biodiversity, loss of fertile land are the reasons that reduce the world food production (Kiaya, 2014). However fruit and vegetables are the most important sources of vital micronutrients, phytochemicals and fiber for humans. New investigations prove that vegetables and fruits help to prevent chronic and non- communicable diseases(Jany et al. 2008).

When considering postharvest losses, according to the type of country, developing country show 20-50 % postharvest losses, but in developed countries have 10-20 % of postharvest losses (Lee et al., 1995). Reduction of post-harvest losses is an approach to increase food availability in the world. FAO (Food and Agriculture Organization of U.N) predicts 1.3 billion tons of food are wasted annually (Aulakh and Regmi, 2013). African, South Asian and Caribbean countries have 40-50% of food wastage due to tropical weather and poorly developed infrastructures (Kiaya, 2014). Sri Lanka losses 30-40% of fruit and vegetables annually through post-harvest chain. Annually 270,000 tonnes of vegetables and fruits are lost and 20 billion LKR of financial loss occurred in Sri Lanka (Abeygunasekara, 2015). According to the surveys, nearly 10% of post-harvest losses have been occurring at storage levels in less developed countries (Kitinoja and Kader, 2015). When considering the food type Perishable vegetables and fruits facilitate the easy

attack of the micro-organism due to high water activity and spoiled quickly (Singh et al., 2014). However cereals like other foods we can facilitate but for fresh vegetables need to have a proper storage to maintain fresh vegetables. Farmers can produce tons of fresh vegetable and fruits, but if they don't have proper, fast and equitability market channel to reach the consumer, losses will be extensive (Kader, 2004).

In vegetable and food markets, consumer always consider about the quality of the fresh item. In the case of term quality can be described as the degree of excellence of a product or its appropriateness for a particular use. Quality of produce includes sensory properties texture, taste, appearance and aroma, chemical ingredients, nutritive values, mechanical properties and functional properties (Abbott, 1999). Developers and researchers always need to consider about the quality and quantity of fresh vegetables when introducing new storage facilities. In Sri Lanka, small scale farmers and middlemen store their vegetable and fruit production until they get sufficient price. In food storage main factor is the internal temperature. Low temperatures infestation of insect, growing mold can be prevented while it helps with extended storage (Mekhilef et al., 2013). Previous findings revealed that vegetables can be stored without losing their quality at lower temperature of 0-10 °C and high relative humidity value of 80-95%. High initial cost, complexity, power consumptions are the problems that discourage the farmers to move into an advance storage facility in Sri Lanka. Their requirement is simple, short term storage facilities to reduce their post harvest losses. In this research developed the low relative humidity with higher temperature

storage condition for five day storage and evaluate how this storage condition effect on the quality of fresh vegetables.

2. Material and Methods

Eight different vegetables were selected for the experiment Potato (*Solanum tuberosum*), Beetroot (*Beta vulgaris* L.), Knol kohl (*Brassica oleraceavar. gongyloides*), Carrot (*Daucus carota* L.), Tomato (*Solanum lycopersicum*), Lime (*Citrus aurantifolia, C. latifolia*), Cauliflower (*Brassica oleracea variety botrytis*) and Okra (*Abelmoschus esculentus*) were selected for the study. Above vegetable represent the upcountry and low country vegetables in Sri Lanka. All the vegetables were collected at fully mature stage and storage with minimum physical injuries. Storage facility was established in Dambulla (Low country Dry zone-DL1) Sri Lanka with fully covered storage rooms with dimension of 14ftx7ftx8ft were used for the experiment. The storage room temperature was maintained at 21 - 22 degrees of Celsius by using an air conditioner and relative humidity (RH) level of 65% was maintained by using an F75 sprayer with 1.5mm nozzle which was connected with an air compressor. All vegetable samples were placed in the same sized plastic crates. Five days of storage time were maintained. All vegetables were evaluated at the initial stage (prior to storage), after five days in relative humidity controlled storage and ambient condition. Ambient condition served as a control sample. RH and the temperature were measured by using an ISO LAB thermohygrometer device. Vegetable quality was evaluated by using following parameters. Firmness of the vegetables was measured by using fruit firmness tester 53205. pH value was measured by using a glass probe pH meter. The

Brix value of vegetables was measured by using ATAGO Refractometer PAL-1 as a percentage of total soluble solid (TSS). Surface colour of the vegetable measured as a parameter of appearance. $L^*a^*b^*$ colour coordinates of vegetable,s surface were measured by using Chroma meter model CR-400. L^* value indicated the lightness, a^* (-red to + green) and b^* (-blue to +yellow). Recorded $L^*a^*b^*$ values were used to calculate the Hue angle and Chroma value by using following equations 2 and 3.

$$\text{Chroma}(C) = (a^{*2} + b^{*2})^{\frac{1}{2}} \quad (\text{Rahman et al., 2014}). \quad (2)$$

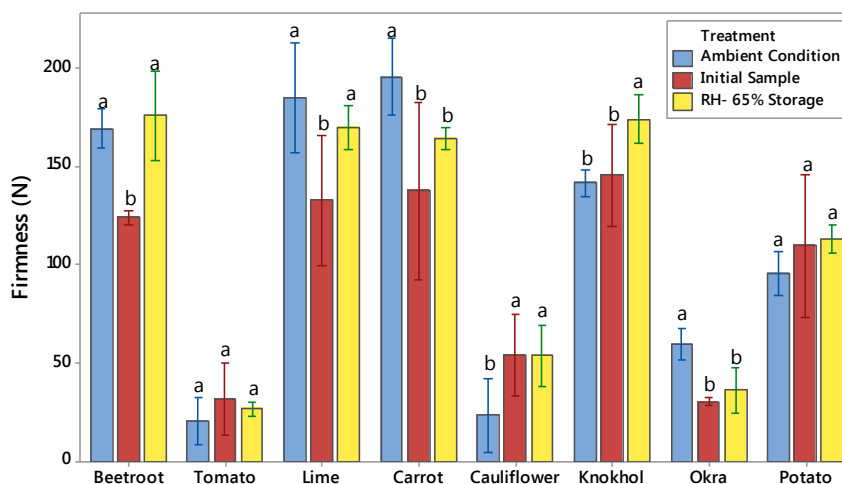
$$\text{HueAngle}(h) = \tan^{-1}\left(\frac{b^*}{a^*}\right) \quad (\text{Rahman et al., 2014}). \quad (3)$$

Three replicates for each vegetable were used with complete randomized block design (CRD). Data was analyzed by using Minitab 17 (product of 2013 Minitab Inc.) and SAS Edition 2.59 (product of 2012-2016, SAS Institute Inc. Cary, NC, USA). Means were separated by using Duncan's Multiple Range Test (DMRT) with significant level of 0.05.

3. Results and Discussion

Ambient temperature and RH of five days storage were 28.71 ± 0.9229 °C and 78.12 ± 5.9843 %, respectively.

Figure 01- Firmness Value of vegetables in before storage (Initial), after storage of RH 65% and ambient (RH 78.12 ± 5.9843 %). Values in each Bar followed by the same letter (s) are not significantly different at 5% level according to Duncan Multiple Range Test (DMRT).



Source: Prepared by the author using Minitab 17.

Beet root resulted significantly higher firmness value compared to initial firmness value. Both ambient and the RH controlled samples showed same firmness values of 169.05 ± 4.06 N and 175.63 ± 9.14 N. The same results were observed in Lime (Figure 01). Water removed from the vegetable surface resulted weight loss in fresh vegetables. Turgidity and firmness decreased when weight loss reduced by 4 – 5 % (Nascimento, 2009). Potato and Tomato didn't show significantly different firmness value compare to initial, RH 65 % and ambient condition with respective p values of 0.105 and 0.098. Okra and carrot resulted significantly higher firmness values of 59.63 ± 3.19 N and in ambient condition. Initial and the RH control

samples didn't show any significantly different firmness values for carrot and okra. Knol Khol observed highest firmness value of 173.72 ± 4.97 N in RH control sample and cauliflower showed the lowest firmness value of 23.55 ± 7.51 N in the ambient condition sample. After five day storage Beetroot, Knol Khol and Potato resulted higher firmness value in RH storage condition. Because above mention vegetables starting to sprout within five days under RH 65% storage condition (Figure 02).

Figure 02 – Sprouting in Beetroot after five days of storage in RH 65% condition.

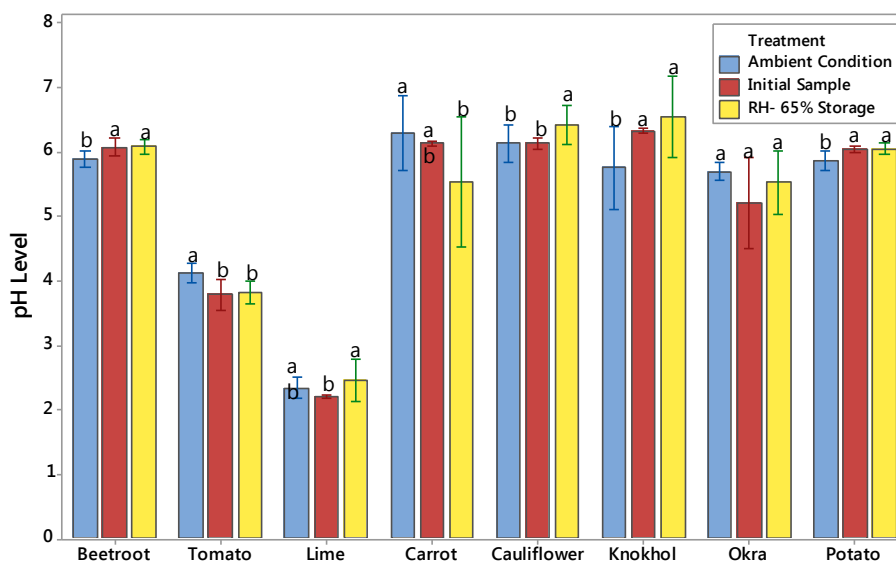


Source: Picture taken by the author

and RH conditions. But Carrot gave the lowest pH value of 5.84 in RH storage and supported by the past finding of 5.88-6.40 (Jonathan and Ann, 1962). Potato, Knol-Khol and Beetroot resulted significantly low pH values in ambient condition. Potato, Knol-Khol and Beetroot showed pH values of 6.05 ± 0.04 , 6.560 ± 0.254 and 6.09 ± 0.05 respectively in RH 65% condition. All resulted pH values for Potato and Beetroot are acceptable compared to standard values of 5.40-5.90 and 5.30-6.60 respectively (Jonathan and Ann, 1962). After five day storage above mention vegetables resulted significantly same pH values that were observed in the initial samples (Figure 03)

Figure 03- pH Value of vegetables in before storage (Initial), after storage of RH 65% and ambient (RH 78.12 ± 5.9843 %). Values in each Bar followed by the same letter (s) are not significantly different at 5% level according to Duncan Multiple Range Test (DMRT).

When consider about the pH values, Okra, Carrot and Lime didn't show any significant different pH values for initial, ambient



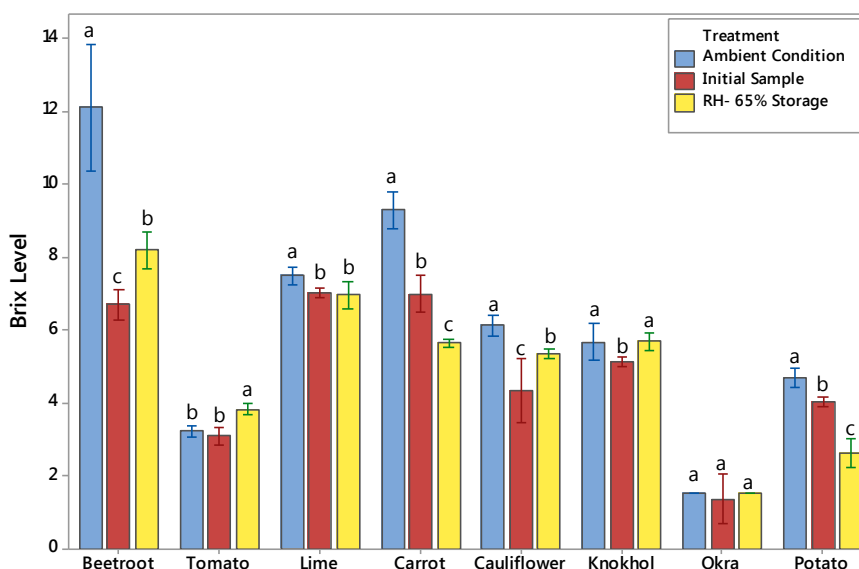
Source: Prepared by the author using Minitab 17.

Tomato showed significantly higher pH value, in ambient condition. It resulted more acidic tomatoes compared to other samples. In Cauliflower ambient condition showed significantly same pH value when compared to initial sample after five day storage. In RH controlled storage sample showed higher pH value of 6.42 ± 0.121 . If the pH remains same within the storage time period, it indicate vegetable has good buffering capacity. If have the low buffering capacity, vegetable will change pH quickly in response to acidic or alkaline compounds produced by microorganisms (Valero et al., 2012).

When increase Glucose and fructose content by 60% to 40% respectively but sucrose and maltose remain same throughout the ripening process of result higher Brix value at the end (Nascimento, 2009). Except Carrot and Potato all other vegetables increased their Brix values after five days at ambient and RH control conditions. After harvest accumulated starch will hydrolyzed into soluble sugar in all vegetables. Due to that phenomenon increasing of a Brix value after harvesting with the

time. But in carrot and potato showed significantly lower value of 5.65 ± 0.05 and 2.63 ± 0.15 in RH storage when compared to initial sample. After five day storage okra showed significantly same Brix value compared to initial one. Beetroot and Cauliflower resulted significantly lest deviated values compared to initial values of 6.70 ± 0.17 and 4.33 ± 0.35 . After 5 days Beetroot and Cauliflower showed Brix values of 8.20 ± 0.2 and 5.37 ± 0.05 in RH storage. According to the (Harrill, 1998) 8 and 6 were the average Brix levels for Beetroot and Cauliflower. Lime in initial and RH storage, Knol Khol in ambient and RH storage, tomato in initial and ambient conditions showed significantly same Brix values with respective p values of 0.002, 0.004 and 0.001 (Figure 04).

Figure 04- Brix Value of vegetables in before storage (Initial), after storage of RH 65% and ambient (RH 78.12 ± 5.9843 %). Values in each Bar followed by the same letter (s) are not significantly different at 5% level according to Duncan Multiple Range Test (DMRT).

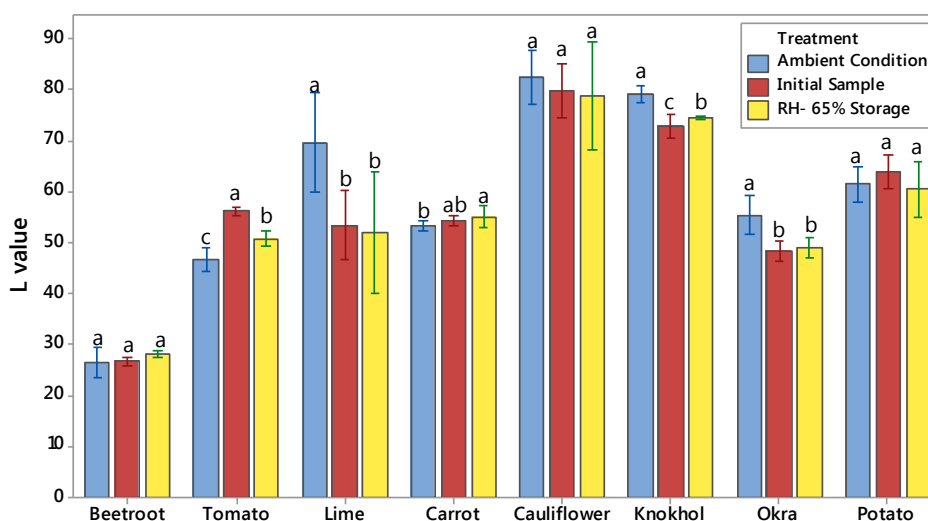


Source: Prepared by the author using Minitab 17.

When considering about L value Beetroot, Cauliflower, Potato and Carrot didn't show any significant difference among two storage condition compared to initial sample. Lightness value in RH 65% condition in Potato was comparatively low according to the findings of 61.20 by Abbas et al., (2017). According to the findings of Augspole and Rakcejeva, (2013) Carrot reported L* value of 56.81. Lime and okra in RH storage showed significantly same lightness value compared to initial sample. Tomato resulted highest lightness value in initial sample second most one in RH 65% and lowest one ambient

condition. In case of knokhol resulted significantly highest lightness value in ambient then RH and finally in the initial sample (Figure 05).

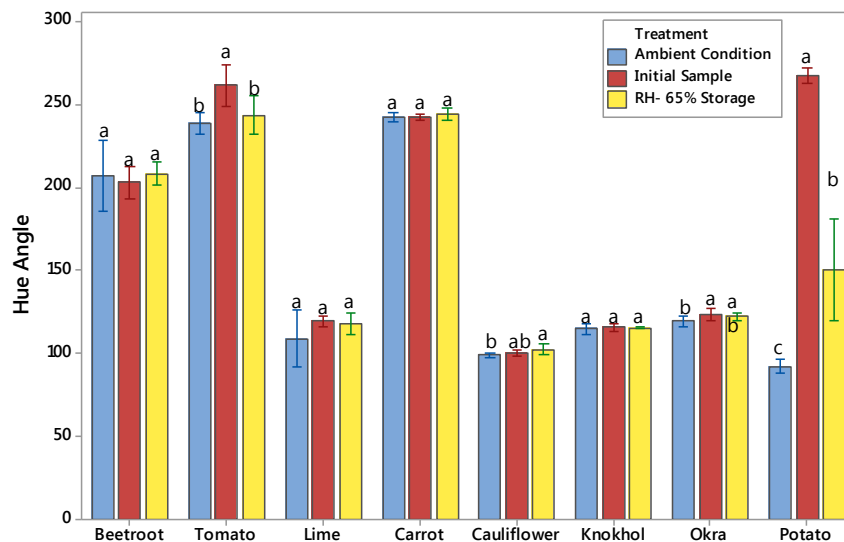
Figure 05- Lightness (L) Value of vegetables in before storage (Initial), after storage of RH 65% and ambient (RH 78.12 ± 5.9843 %). Values in each Bar followed by the same letter (s) are not significantly different at 5% level according to Duncan Multiple Range Test (DMRT).



Source: Prepared by the author using Minitab 17.

Beetroot, Lime, Carrot, Cauliflower, Okra and Knol Khol didn't show any significant difference among ambient and RH storage compared to initial sample (Figure 06). In Tomato ambient and RH sample resulted significantly lower value of 238.56 ± 2.47 and 243.72 ± 4.57 for hue angle. Within five day storage Potato changed its colour significantly with each storage.

Figure 06- Hue Angle value of vegetables in before storage (Initial), after storage of RH 65% and ambient (RH 78.12 ± 5.9843 %). Values in each Bar followed by the same letter (s) are not significantly different at 5% level according to Duncan Multiple Range Test (DMRT).

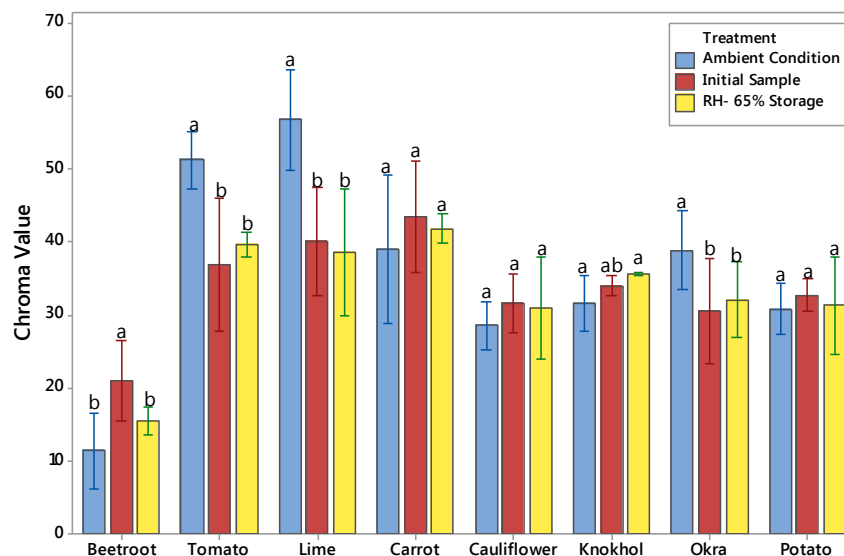


Source: Prepared by the author using Minitab 17.

Chroma value indicates the colour intensity of the surface (Ayala-Silva et al., 2005). In tomato ambient condition resulted highest Chroma value that means the ambient condition sample observed higher red in colour. This was supported by the findings of (Nascimento, 2009). Okra and Lime also resulted same pattern as tomato (Figure 07). Cauliflower, Carrot, Knol Khol and Potato didn't show any significant difference in colour intensity among initial, ambient or RH storage condition.

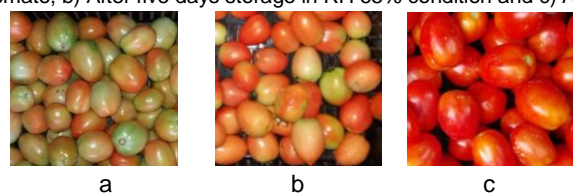
Beetroot resulted highest colour intensity in initial sample compared to ambient and RH storage.

Figure 07- Chroma value of vegetables in before storage (Initial), after storage of RH 65% and ambient (RH 78.12 ± 5.9843 %). Values in each Bar followed by the same letter (s) are not significantly different at 5% level according to Duncan Multiple Range Test (DMRT).



Source: Prepared by the author using Minitab 17.

Figure 08- a) Initial sample of tomato, b) After five days storage in RH 65% condition and c) Ambient condition (control sample)



4. Conclusion

When considering about final conclusion vegetable showed different conditions were best for different parameters. Beetroot can be storage, five days in RH 65% without losing pH and Brix

value, however firmness and the colour appearance resulted same values with ambient sample. In case of Tomato pH, Chroma and Lightness observed same value in RH storage compared to initial sample. Lime showed same conclusion like

in tomato, but RH and ambient condition resulted lower firmness value compared to initial sample. Carrot and Cauliflower didn't show any significant difference in lightness, chroma and hue angle among storage conditions. That concluded without using RH storage they can keep their appearance same as initial sample. Lightness, pH in Knol Khol and firmness, lightness and chroma value in Okra showed best keeping quality in RH 65% storage compared to the other two conditions. In the case of Potato, pH, Brix and hue angle showed better quality in RH 65% storage condition and other parameters didn't show any significant difference out of three

different conditions. Finally concluded that Tomato, Lime, Okra and Potato showed significantly better quality in three parameters out of all six quality parameters. However Beetroot, Carrot, Cauliflower and Knol Khol showed significantly best quality in two parameters out of all six quality parameters

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