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Sustainable Approaches to Prolonging Shelf Life in Green Mature Tomato Fruit

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ABSTRACT

Green mature tomato fruits demonstrate better transportability compared to fully matured ones. This approach has the potential to play a significant role in diminishing postharvest losses and enhancing the accessibility of nutritionally rich fruit in developing countries. The instability of electricity and insufficient cold storage facilities is recognized for fading the shelf life of various fruits and vegetables. However, post-harvest interventions, including tomatoes, can extend perishable products' shelf life. Firstly, tomato fruits were harvested at the green mature stage and stored at 33°C for 0, 10, 20, and 30 days, followed by a shift to 25°C. Subsequently, ten fruits were subjected to various treatments: A - control (25°C), B - 33°C with 30-40% RH, C - 33°C with 50-60% RH, and D - 33°C with 80-90% RH. Different relative humidity (RH) levels were achieved using saturated salts, specifically $MgCl2.6H_2O$, Mg $(NO_3)2.6H_2O$, and $KCl+KNO_3$ for treatments B, C, and D, respectively. The evaluation encompassed parameters such as ethylene production, CO_2 release, fruit firmness, weight loss, and color development. A higher temperature, such as 33°C, may be considered advantageous for the storage of green mature tomato fruit. Evidently, tomatoes were successfully stored for over 55 days at this temperature. Across all relative humidity (RH) conditions, there was more noticeable color development in fruits stored at 25°C compared to those stored at 33°C. Among the various RH conditions, fruits stored at 33°C with 80-90% RH experienced the least weight loss, although fruit firmness gradually declined over time. Storing green mature tomato fruit at 33°C with 30-40% RH resulted in the lowest ethylene production compared to 25°C and other RH conditions. Consequently, certain practical benefits of green mature tomato fruit under elevated temperatures and diverse relative humidity (RH) conditions are suggested. However, further detailed research may be necessary to explore potential metabolic changes.

Keywords: High Temperature, Relative Humidity, Shelf Life, Green Mature Tomato

INTRODUCTION

Agriculture serves as a scientific discipline aimed at sustaining the global population, which is projected to reach 8.5 billion by 2030, 9.7 billion by 2050, and 10.4 billion by 2100 (UN, 2023). This crucial practice addresses the challenge of feeding an ever-expanding population. Moreover, an excess of one billion individuals, equivalent to approximately 15% of the global population, suffer from conditions of extreme poverty. These people rely on producing food for their family sustenance (Matthew and Paul, 2014).

Tomato (Sola*num lycopersicum* L.) possesses remarkable nutritional attributes that can considerably contribute to human health (Stommel, 2007). It is recognized for its potential chemo-preventive activities, offering protection against various chronic diseases due to its rich content of lycopene and other bioactive compounds (Giovannucci 1999a, 2002b). Given the high water content inherent in tomatoes, implementing post-harvest interventions becomes imperative to enhance these horticultural perishables' storage and marketable lifespan, as observed in studies such as *et al*. 2015). Insufficient electricity supply and the absence of suitable cold storage facilities have been recognized as constraints limiting product shelf life in developing countries. Opting for the harvesting of green mature tomatoes presents a promising alternative, aiming to reduce fruit damage during transportation within retail channels (Wang *et al*., 2008).

Exposing green mature tomato fruit to 38°C for two days was found to facilitate normal ripening without inducing chilling injury symptoms, as observed after two weeks of storage at 20°C (McDonald *et al.,* 1998). Prior to storage at 2°C, subjecting green mature tomato fruit to 38°C effectively prevented chilling injury development for up to 30 days without causing heat injury (Lurie and Sabehat, 1997). Ogura (1976) suggested a brief storage period of 2-3 days at 40°C to extend shelf life, emphasizing the need for further studies to establish practical techniques. Conversely, while green mature tomato fruit can endure storage for up to 14 days at 18-20°C with 90-95% relative humidity (RH), fully ripe tomatoes exhibit a more limited storage life of 4-7 days at 13-15°C with 90-95% RH. The transportation and storage of fresh produce typically necessitate low temperatures and high RH conditions (Getinet *et al.,* 2008).

The maturity stage of tomato fruit at harvest is a critical factor influencing both storage life and final fruit quality, as (Alam *et al.,* 2006) emphasized. In many developing countries, farmers commonly harvest tomatoes at the ripe stage, despite the understanding that ripe fruit is more susceptible to damage and has a shorter shelf life (Toivonen, 2007). Given the high water content of tomatoes, amounting to 93.5% (Gastélum *et al.,* 2011), there is a tendency for significant post-harvest losses.

This study addresses the scarcity of research on integrating high temperature and relative humidity to prolong tomatoes' storage in developing countries, focusing on Afghanistan. The primary objective is to investigate challenges related to preserving fruits and vegetables, particularly addressing issues restricting electricity scarcity and the absence of proper cold storage facilities.

MATERIALS AND METHODS

The research was conducted at the Tokyo University of Agriculture, focusing on green mature tomato fruit of the RED HOPE variety from the Kaneko Seed Company. The tomatoes were harvested in the morning in Saitama prefecture of Japan and promptly transported to the laboratory for the experiments. Firstly, tomato fruit at the green mature stage was harvested and stored at 33℃ for 0, 10, 20, and 30 days, followed by a shift to 25℃. Then, ten fruits underwent various treatments: A (control at 25℃), B (33℃ with 30-40% RH), C (33℃ with 50-60% RH), and D (33℃ with 80-90% RH). Different levels of RH were achieved using saturated salts, specifically $MgCl_2.6H_2O$, Mg $(NO_3)_2.6H_2O$, and $KCl+KNO_3$ for treatments B, C, and D, respectively. The evaluation encompassed ethylene production, CO_2 release, fruit firmness, weight loss, and color development.

Fruit color was measured using Handy Colorimeter NR-3000. Weight loss was calculated and evaluated as a percentage against initial weight by a simple scale HF-4000. Fruit firmness was evaluated by Multilateral Tester model 2519-104 of INSTRON Company, and the data were indicated as N when a 1.0 cm diameter plunger presses tomato fruit at 1 mm/sec speed. Ethylene production was measured by GC-FID (Gas Chromatography-Flame Ionization Detector). CO_2 was measured by GC-TCD (Gas Chromatography-Thermal Conductivity Detector). In this study, given the time-series nature of data, we opted for the utilization of line graphs for the data analysis, as they provide a clear and effective representation of the data trends and patterns.

RESULTS AND DISCUSSION

Among the various high temperatures tested in this experiment, 33℃ appears to be a favorable temperature for the storage of green mature tomato fruit. Notably, tomatoes stored at 33℃ demonstrated a remarkable shelf life, exceeding 55 days. The storage conditions at 33℃ also led to the inhibition of ethylene production, suggesting the potential suppression of ethylene-producing enzymes such as 1-aminocyclopropane-1-carboxylate (ACC) synthase or ACC oxidase at higher temperatures. The fruit's observed weight loss correlated with storage temperature and treatment duration. Specifically, the lowest weight loss occurred at 25℃ stored for 0 day, followed by those stored for 10 days at 33℃, with other temperatures exhibiting higher rates. Higher temperature storage and longer durations significantly suppressed pigmentation, accelerated fruit softening, and resulted in a harder fruit peel after some water loss, as illustrated in Figure 1.

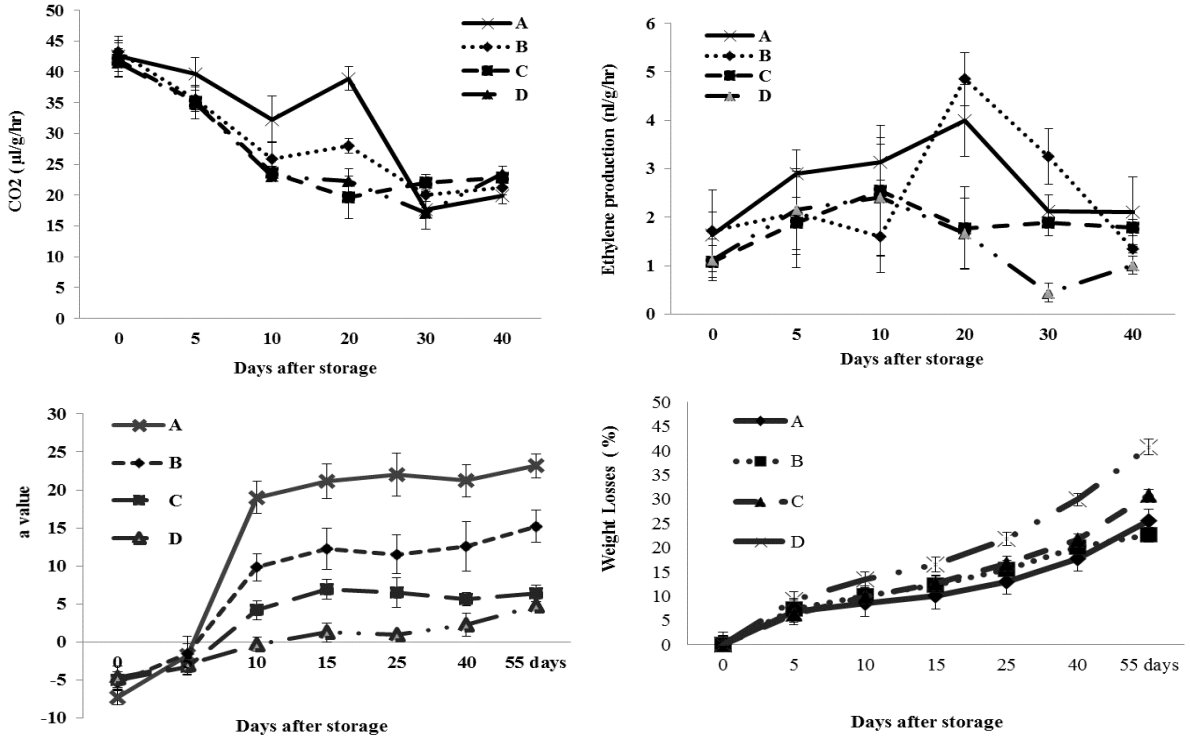

Figure 1. *Effect of 33℃ temperature storage on CO_2, ethylene production, color (redness), and weight loss of green mature tomato fruit. Tomato fruit was harvested at the green mature stage, stored at 33℃ for 0(initial), 10, 20, and 30 days, and shifted to 25℃. Data are indicated in the means of 3 replications with SE.*

The inhibition of color development was evident at elevated temperatures. Storage at 25°C induced the most pronounced color formation compared to 33°C under all RH conditions. Notably, the treatment with 80-90% RH, followed by 50-60% RH, effectively prevented color formation compared to 30-40% RH and control treatments, aligning with findings reported by Lurie and Klein (1997), as shown in Figure 2A. The lowest fruit weight loss was observed in the 33°C with 80-90% RH treatment, followed by 25°C, and other treatments (Figure 2B). Fruit firmness exhibited a gradual decrease, with fruits in the 33°C with 80-90% RH treatment being the hardest, followed by the control. Additionally, fruits stored at 33°C with 30-40% RH were harder than those at 33°C with 50-60% RH (Figure 2C). Ethylene production was notably inhibited by storage at 33°C with 30-40% RH compared to 25°C and other RH conditions. Substantial differences were observed between 25°C and the other treatments at 33°C with all RH, particularly after 20 days of storage (Figure 2D). Tomato fruit exhibited a gradual decrease in the respiration rate across all treatments until 30 days of storage, followed by an increase. The respiration rate was consistently suppressed under all RH conditions in the 33°C treatments.

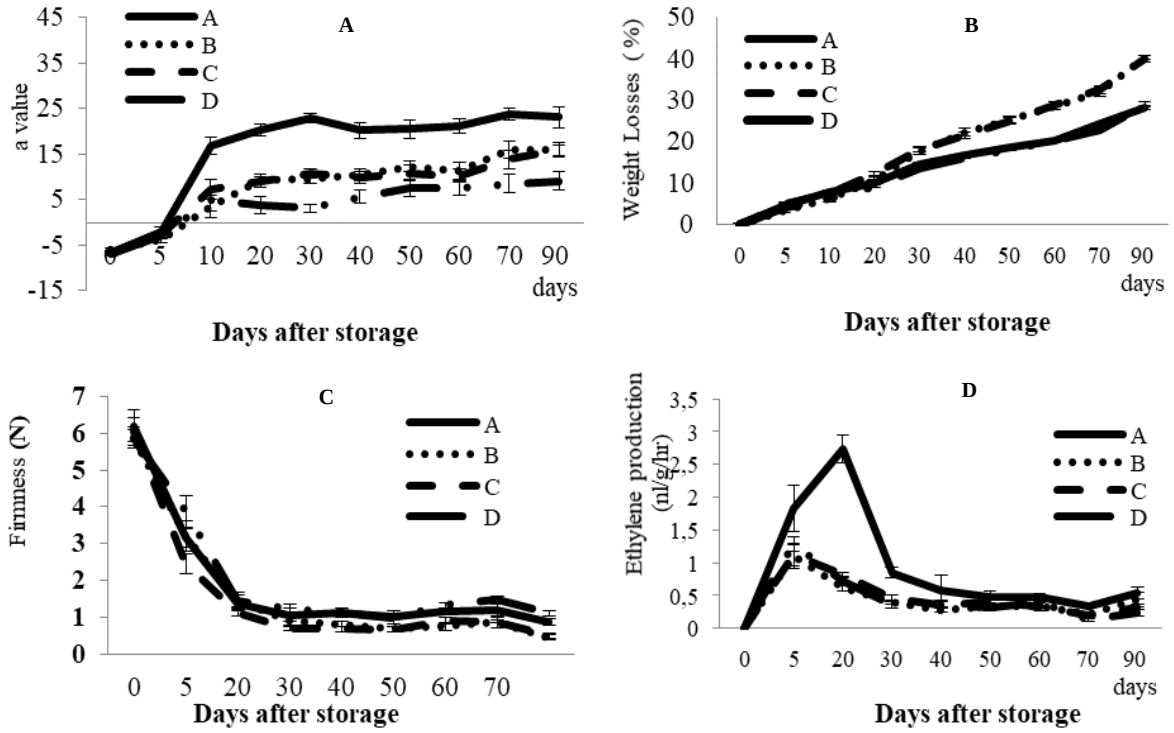

Figure 2. The effect of RH at high-temperature storage on pigmentation (A), weight loss (B), firmness (C), and ethylene production (D), of green mature tomato fruit. Tomato fruit were harvested at green mature stage and stored at 250C (control), or treatments (33°C with 30-40% RH: B, 33°C with 50-60% RH: C, 33°C with 80-90% RH: D). Data are indicated in the means of 10 replications with SE.

CONCLUSION

In addressing the electricity scarcity and inadequate cold storage in developing countries, we propose harvesting tomato fruit at the mature green stage for extended transportation. While farmers commonly harvest at the ripe stage, acknowledged for shorter shelf life, fully ripe harvesting may be preferable for local markets. Alternatively, exposing tomatoes to high temperatures with varied relative humidity levels using saturated salts shows promise for shelf-life extension. Our findings suggest that this approach is practical for preserving green mature tomato freshness in tropical regions, indicating some practical advantages, though detailed research is needed to investigate potential metabolic changes.

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REFERENCES

Alam, M., M. Rahman, M. Mamun, I. Ahmad, and K. Islam. (2006). Enzyme activities in relation to sugar accumulation in tomato. In: Proceeding of Pakistan Academic Sci. **43**: 241-248.

Getinet, H., T. Seyoum, and K. Woldetsadik (2008). The effect of cultivar, maturity stage, and storage environment on quality of tomatoes. J. Food Eng. **87**:467-478.

Giovannucci, E. (1999) Tomatoes, tomato-based products, lycopene, and cancer: review of the epidemiologic literature. J. of the National Cancer Institute. **91**: 317-331.

Giovannucci, E. (2002). A review of epidemiologic studies of tomatoes, lycopene, and prostate cancer. Experimental Biology and Medicine. **227**: 852-859.

Lurie, S., and A. Sabehat. (1997). Pre-storage temperature manipulations to reduce chilling injury in tomatoes. Postharvest Biol. Technol. **11**: 57-62.

Matthew A. Jenks and Paul M. Hasegawa. (2014). Plant Abiotic Stress. Second Edition, Blackwell, john Wiley and Sons, Inc.

McDonald, R. E., T. G. McCollum, and E. A. Baldwin. (1998). Heat treatment of mature green tomatoes: differential effects of ethylene and partial ripening. J. Am. Soc. Hort. Sci. **123**: 457-462.

Ogura, N., Hayashi, T. Ogishima, Y. Abe, H. Nakegawa, H. Takehana (1976). Ethylene pro- duction by tomato fruits at various temperatures and effect of ethylene treatment on fruits. J. Agric. Chem. Soc. Japan. **50**: 519-523 (In Japanese).

Stommel, J. R. (2007). Genetic enhancement of tomato fruit nutritive values. In: Razdan, M. K. and Mattoo, A. K. (eds) Genetic Improvement of Solanaceous Crops. Volume 2: Tomato. Science Publishers, Enfield, New Hampshire. 193-238 pp.

Toivonen, P. M. A. (2007). Fruit maturation and ripening and their relationship to quality. Stewart Post- harvest Rev. **3**: 1-5.

UN. (2023). Population. United Nations. https://w.w.w.un.org/en/global-issues/ Population (accessed 2023/12/07).

Wang, Y., W. Baogang, and L. Li. (2008). Keeping quality of tomato fruit by high electro-static field pretreatment during storage. J. Sci. Food Agric. **88**:464-470.