Effect of low temperature conditioning (LTC)

As compared to non-LTC treatments stored at 2°C, LTC improved bract appearance and skin lightness for both LTC treatments (10 - 2 and 6 - 2) after 4 weeks of storage and shelf life 1 day (Table 3). After 3 days shelf life, a slight reduction in the translucency chilling symptom compared to non-LTC fruit (stored directly at 2°C) was recorded, but there was no significant difference between the 10 - 2 LTC (0.7) and 6 - 2 (0.8). Overall, the best treatment for improving quality at 2°C was the 10°C LTC treatment. These results are similar to observations on avocado (Woolf *et al.*, 2002) and papaya (Chen & Paull, 1986).

CONCLUSION

For 'LD1' red dragon fruit, the best storage temperature is 6°C with a limit of ≈ 4 weeks, no chilling injury was observed. However, a lower temperature (2°C) results in reducing quality (wilting and desiccation bracts), and a distinct chilling injury symptom - translucence of the outer layer of the flesh. Low temperature conditioning could reduce some of these chilling disorders to some extent.

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EFFECT OF STORAGE TEMPERATURES ON POSTHARVEST DISEASES OF DRAGON FRUIT (*Hylocereus undatus* Haw.) CULTIVATED IN THE MEKONG DELTA REGION, VIETNAM

Nguyen Khanh Ngoc[1], Nguyen Van Phong*[1], A.B. Woolf[2], R.A. Fullerton[2]

Abstract

This study was aimed to determine the effects of different storage temperatures and storage durations on postharvest diseases of dragon fruit planted in the Mekong delta region. Dragon fruit of uniform maturity and without defects were collected from two growers in Long An and Tien Giang provinces and stored at 0°C, 5°C and 10°C for 21 and 26 days before kept in 20°C stores for 3 days to simulate shelf life in the market. Other fruit were harvested and held at 20°C for 7 and 12 days considered as a non-stored control. The proportion of fruit with rots and changes in bract

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appearance were recorded and analysed. Results conducted from the experiment showed that fruits stored at 0°C and 10°C (for both 21- 26 days), and fruit kept at 20°C (control) for seven and 12 days sustained the most damage. The most common disorders were rots and wilting and colour change (yellowing) of the bracts. Fruits stored at 6°C for 21 and 26 days remained fresh in appearance and had significantly fewer rots. The pathogenicity of fungi isolated from the rots was confirmed by re-inoculation of healthy fruit and the pathogens identified by conventional and molecular methods. The main fungi associated with spoiled fruit were: *Alternaria alternata*, *Aspergillus* sp., *Bipolaris cactivora*, *Cladosporium* sp., *Colletotrichum gloeosporioides*, *Colletotrichum truncatum*, *Fusarium andiyazi, Fusarium dimerum*, *Fusarium equiseti, Geotrichum candidum, Mucor* sp., *Neoscytalidium dimidiatum, Phomopsis longicolla*, *Rhizopus stolonifer*.

Keywords: Pathogenic fungi, postharvest rots, quality, storage, temperature

INTRODUCTION

Dragon fruit (*Hylocereus undatus* (Haw.), Britton and Rose) is a member of the Cactaceae family which has a climbing vine habit supported by adventitious roots. It was originated from South America (Crane and Balerdi, 2005) and introduced to Vietnam over 100 years ago by the French. In recent years, dragon fruit has become one of Vietnam's major fruit crops and production is continuously increased. The crop has been mainly cultivated in 15 provinces with a total area of approximately 30.000 ha (2013), primarily in the three southern provinces of Binh Thuan, Tien Giang and Long An (Hoang Viet, 2013).

Dragon fruit is susceptible to a wide range of postharvest rots resulting in serious losses during storage and subsequent distribution in the market. A large number of fungi have been reported to be associated with postharvest rots of dragon fruit outside of Vietnam including *Alternaria* sp., *Ascochyta* sp., *Aspergillus* sp., *Bipolaris* sp., *Capnodium* sp., *Colletotrichum gloeosporioides, Colletotrichum truncatum*, *Dothiorella* sp., *Fusarium* sp., *Gloeosporium agaves, Marssonina agaves, Phytophthora* sp. *and Sphaceloma* sp. (Wang and Lin, 2005; Le Bellec *et al.*, 2006; Taba *et al.*, 2007; Palmateer *et al.*, 2007; Paull, 2007; Sijam *et al.*, 2008; Li We Guo *et al.*, 2013). A wider variety of fungal species have been found to be associated with rots of dragon fruit planted in Binh Thuan Province. They include: *Alternaria alternata, A. cheiranthi, Aspergillus avenaceus, Aspergillus sp., Bipolaris cactivora, Cladosporium herbarum*, *Cladosporium oxysporum, Colletotrichum gloeosporioides*, *Corynespora abelavata, Curvularia lunata, Diplodia* sp., *Fusarium semitectum, Fusarium sp., Gleosporium* sp., *Glomerella* sp., *Haplariopsis fagicola, Mucor hiermalis, Penicillium* sp., *Phoma* sp., *Phomopsis* sp., *Rhizopus* sp., (Le Van To *et al.*, 2000a; Tran Viet Ha, 2004; FAO, 2004; He PF *et al.*, 2012).

Postharvest rots are a major cause of loss of shelf life of dragon fruit. Various studies have been made on the effect of storage temperature to shelf life of dragon fruit. Le Van To (2000b) showed that dragon fruit stored at a flesh temperature of 28°C under 70% humidity had a shelf life of only seven days. When stored at a flesh temperature of 5°C a shelf life of 30 days was recorded but, when stored at a lower temperature the fruit sustained chilling injury, a result obtained from a study conducted by Do Minh Hien and Nguyen Thanh Tung (2003). Lau *et al.* (2007) found that when fruit were held at 10°C under 90% humidity, no disease observed after 6 days, but started to appear after 15 days. Dragon fruit has only recently become a major crop in the Mekong Delta region, particularly the Long An and Tien Giang provinces, and production areas have been increasing rapidly. This study was aimed to determine the effect of a range of different storage temperatures on fruit quality and to identify the principal pathogens associated with postharvest rots on dragon fruit from the Long An and Tien Giang provinces in particular.

MATERIALS AND METHODS

The experiment was carried out in the microbiology laboratory of the Division of Postharvest Technology, Southern Horticulture Research Institute (SOFRI), Vietnam in August 2013 to September 2014 (rainy season) period.

Materials

White flesh dragon fruit was harvested from orchards in the Tien Giang (Cho Gao district) and Long An provinces.

Methods

The calyx cavities were cleaned by brush and the fruit washed under running water and left to dry. Fruit were then placed individually in perforated plastic bags, wrapped (but unsealed) and placed in boxes (10 fruits per box). Two boxes of fruit from each province were placed in controlled temperature cabinets set at 0°C, 5°C and 10°C for each of two storage periods, 21 and 26 days. Because the controllers on the storage cabinets allowed temperatures to fluctuate above the set point the actual storage temperatures ranged from 0 - 1°C, 5 - 6°C and 10 - 12°C. To simplify the process of data collection, the values of the set temperatures were used throughout the paper. A second set of fruit was harvested from the same orchards, cleaned as above mentioned way, and four boxes of 10 fruits from each orchard kept at 20°C for 7 and 12 days (non-stored). After 21 and 26 days, the fruit that had been stored at 0°C, 5°C, 10°C were moved from cool store and held at 20°C for three days to prolong shelf life. The experiment was laid out in completely random design of 16 treatments and conducted with two replicate boxes of fruit per treatment (10 fruits for each replication).

After the designated storage periods fruits were examined and assessed for incidence and severity of disease and the situation of bracts as well.

Rot severity was assessed according to the calibration proposed by Woolf et al. (2006) where: 0 = no rots on the skin / body of the fruit; 0.5 = trace (rots on <5% of the area of the fruit surface; 1 = slight (rots on >5 - 10% of the area of the fruit surface, or shrivelled flesh at the basal end of the fruit); 1.5 = slight–moderate (rots on >10 - 15% of the area of the fruit surface (just acceptable)); 2 = moderate (rots on >15 - 25% of the area of the fruit surface (unacceptable)); 2.5 = moderate–severe (rots on >25 - 50% of the area of the fruit surface); 3 = severe (rots on >50% of the area of the fruit surface).

Bract situation was assessed according the scale suggested by Allan Woolf *et al.* (2006) where: 0=bright green, yellow and red colours, no browning/ blackening, firm, straight or slightly curved, well away from side of fruit, no shrivel; 1=Green colour fading, moderate yellow, slight browning of margins, medium firmness, moderate in-curling of bracts, slight shrivel; 2=green tips, most bract is yellow, moderate browning, very soft, slight drying, severe in-curling of bracts, slight-moderate shrivel; 3=no green, severe yellowing and/or browning, and some blackening of margins, moderate drying, severe in-curling, lower bracts lay flat on fruit, moderate-severe shrivel; 4=no green, complete yellowing or browning or blackening, red colour remaining only at base, severe drying, completely curled to base, severe shrivel (but not to base of bract); 5=black, completely dry, completely shrivelled.

Fruit rots on the majority of fruit from all treatments were examined and categorized according to symptom type. Individual symptoms were described and photographed. Fruit rot fungi were isolated and identified by procedures of Koch's postulates (Koch, 1890). Symptoms expressed by each of the pathogens were photographed and described. Pure cultures of each of the pathogens were photographed to capture colony characteristics and images made of fruiting structures and spores. The cultures were grouped on the basis of colony morphology, and type of fruiting bodies and spores (if present) and tentative identifications were implemented on many isolates. In case that identifications could not be made with confidence to the species level, colonies were sent to a private biotechnology company (Nam Khoa Biotek, Ho Chi Minh City) for sequencing of the internal transcribed spacer (ITS) region of ribosomal RNA gene and the sequences compared with sequences previously lodged in Genbank. Representative samples of each species were stored at SOFRI in sterile water at 5°C for the future studies.

Data Analysis

Data were subjected to analysis for significant differences by Analysis of Variance (ANOVA) and comparisons of treatment means were performed by using the Least Significant Difference (LSD) at 5% significance level with SAS software, version 8.1.

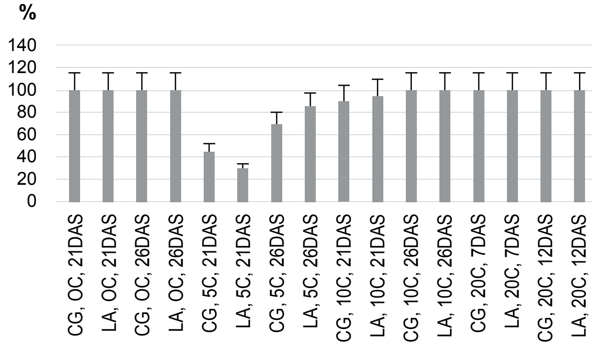
RESULTS AND DISCUSSION

Results

Disease Incidence and Severity

The percentage of disease incidence and average rot severity on fruit from all treatments were shown in Figures 1 and 2, respectively. Fruit that was harvested and kept at 20°C for 7 and 12 days were all severely rotted with a disease incidence of 100%. Fruit kept at that temperature for 7 days had an average severity score of 2.0 and maximum grade of 3.0 was observed after 12 days. The incidence and severity of disease in fruits stored in cool rooms at different temperatures and times differed from treatment to treatment. Fruits stored at 0°C for 21 and 26 d had a disease incidence of 100% but quite low severity score of (<1.5) except fruits planted in Long An which had an average severity score of 1.5 at 26 days. When stored at 5°C fruits from both Cho Gao and Long An had the lowest disease incidences (45% and 30%, respectively) after 21 days of storage, increasing to 70% and 85%, respectively after 26 days storage. At that temperature, disease severities in fruits planted in Cho Gao and Long An were also low (0.5 and 0.4 average rot severity, respectively). When stored for an additional five days there was an increase in both incidence (70% and 85%, respectively) and severity (0.6 and 0.7, respectively) for fruit from both districts.

When stored at 10°C for 21 days, fruit from both Cho Gao and Long An had a much higher disease incidence (90% and 95%, respectively) compared to fruits stored at 5°C. When stored for 26 days, 100% of fruits with disease incidence was recorded in both districts. Despite the higher incidence of disease after the 21 days storage, the average severity scores remained low (0.9 and 1.6 for Cho Gao and Long An fruit, respectively). However, the additional five days storage resulted in higher severity scores of 1.8 and 1.6 for fruit from each district, respectively.



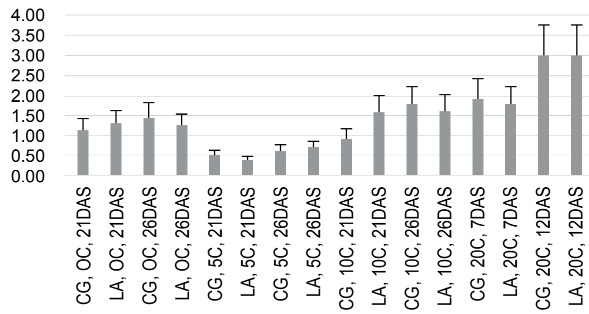


Figure 1 and 2 (respectively)**.** Percent disease incidence; and Average rot severity (rating scale 0-3) of dragon fruit from Cho Gao (CG-Tien Giang Province) and Long An Province (LA) following storage at different temperatures and times. C= °C; DAS= after placing in storage.

Bract appearance

For each storage temperature, there was a consistent pattern of greater bract deterioration after 26 days storage than after 21 days (Figure 3). Least deterioration occurred on fruit taken from Cho Gao district and stored at 5°C for 21 d. Bract deterioration on fruit from Long An was greater than that of Cho Gao fruit. Although bract deterioration was greater on fruit from both provinces when stored for 26 d at 5°C, the difference in response of the fruit from the two districts was still evident. The fruit for this trial were sampled from commercial orchards and the pre-harvest spray programmes were not known. Gibberellic acid (GA_3) is routinely applied during fruit development to kept bract colour unchangeable after harvest. It is possible that the consistent difference in bract structure of fruits harvested from the two orchards under the same storage conditions is related to differences in the pre-harvest treatment with GA_3 in those orchards. On fruit that had been stored at 20°C for 7 and 12 d there was severe discoloration and shrivelling, reaching the maximum grade scale of 5 by 12 days. Overall, only fruit that had been stored at 5°C for 21 days had bracts of market acceptability.

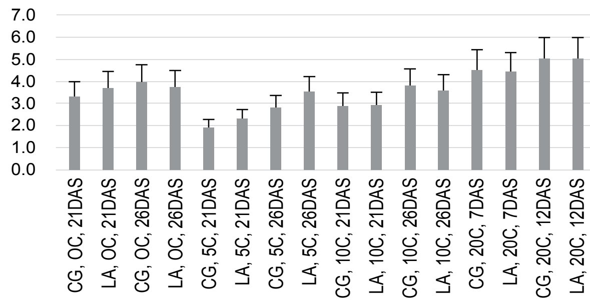


Figure 3. Bract appearance (rating scale 0-5) of dragon fruit from Cho Gao (CG-Tien Giang Province) and Long An Province (LA) following storage at different temperatures and times. C= °C; DAS= after placing in storage.

Pathogens associated with rots

Utilization of pathogenicity tests and re-isolation to pure culture, identifications were made by conventional methods based on reproductive morphology and by ITS sequencing. Species of confirmed pathogenicity and identity isolated from rots in this trial were (ITS Genbank sequence match in brackets): *Alternaria alternata* (99%), *Aspergillus* sp., *Bipolaris cactivora* (99%), *Cladosporium* sp., *Colletotrichum gloeosporioides*

(99%), *Colletotrichum truncatum* (99%), *Fusarium dimerum* (99%), *Fusarium equiseti* (99%), *Fusarium andiyaz (99%), Phomopsis longicolla (99%), Neoscytalidium dimidiatum, Rhizopus stolonifer*, *Mucor* sp., *Geotrichum candidum.*

Images of symptoms, colony characteristics and reproductive structures were assembled into a single file to be used for future identification of rots occurred in stored fruits. Images of commonly occurring diseases on the fruit are provided in Figure 4.

Discussion

Results conducted from our study on the effects of low storage temperature and duration on incidence and severity of rots and bract discoloration are in agreement with results reported by Le Van To (2000b); Do Minh Hien and Nguyen Thanh Tung (2003). The latter authors showed that fruit stored below 5°C were affected by chilling injury. In this trial a similar effect was noted at 5-6°C storage. It is likely that the higher incidence and severity of postharvest rots at lower temperatures was related to physiological damage caused by chilling and consequently lower resistance to pathogenic fungi. At above 5°C temperature, the increase in incidence and severity of rots is most likely related to the development of numerous the pathogens at temperatures of 10°C and above.

The pathogenic species confirmed in this study were *Alternaria alternata*, *Aspergillus* sp., *Bipolaris cactivora*, *Cladosporium* sp., *Colletotrichum gloeosporioides*, *Colletotrichum truncatum, Fusarium andiyazi, Fusarium dimerum*, *Fusarium equiseti, Geotrichum candidum, Mucor* sp., *Neoscytalidium dimidiatum, Phomopsis longicolla*, *Rhizopus stolonifer*. The results in terms of the effects of storage temperatures and the range of pathogens detected, are consistent with those reported by Le Van To (2000a), Tran Viet Ha (2004) and He PF *et al*. (2012).

CONCLUSION

The pathogenicity on dragon fruit of 14 species of fungi belonging to 11 different genera was confirmed. For white-flesh dragon fruit cultivated in Long An and Tien Giang provinces, storage temperature of 5°C is considered appropriate for preserving fruit bract appearance and minimizing storage rots. As well as optimum storage temperature, other methods should also be accordingly applied to prevent fungal infection of fruit both before and after harvest. Future studies are planned on the sources of infection of dragon fruit, the temperature activity profiles for the different species in relation to infection and pathogenesis under different storage conditions, and the evaluation of a range of options, including heat and sanitizers to minimize postharvest rots of dragon fruit.

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ADAPTABILITY OF KOREAN CHINESE CABBAGE VARIETIES IN THE RED RIVER DELTA OF VIETNAM

Pham Thi Thu Huong*[1], Cho Won Dae[2] Lee Dong Jin[2]

Abstract

The objectives of the study were to test adaptability and identify the best performance varieties of Korean Chinese cabbage in the Red River Delta, Vietnam. Adaptability of 12 Korean varieties was tested in winter - spring 2012 -2013 and winter - spring 2013 -2014 at the Field Crops Research Institute, (20° 54' N, 106° 17' E), in Hai Duong province... The crop was transplanted at the distance of 60 cm x 40 cm. Fertilizer application was 170 N - 100 P_2O_5 - 150 K_2O and 10 ton of manure per ha. Most of the tested varieties were well adapted to the Red River Delta conditions. Asia yellow Mini and Jeongsang varieties with high yield (number) and high quality product were the most promising varieties, which can be grown in winter-spring season in the Red River Delta of Vietnam.

Key words: Adaptability Chinese cabbage, Korean varieties, Red River Delta

INTRODUCTION

In Vietnam, agricultural potential and market access affect the economic development of rural areas. The poverty rate in remote areas is closely associated with low agricultural development potential and lack of access to markets (Minot *et al.*, 2006). Crop production contributes 77% of the profit from agricultural production (1990-2008) (General Statistic Office (GSO), 2009) and plays an important role in the economy of rural areas in Vietnam.

Vegetables are important crops in the Red River Delta (RRD) in Northern part of Vietnam (Huong *et al.*, 2013). In 2012, the rural population of the RRD was 14 million, constituting 70% of the total population of this region and earning a living mainly from agricultural production (General Statistic

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