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THE EFFECTS OF FRUIT MATURITY AT HARVEST ON DISEASE DEVELOPMENT IN LYCHEE DURING STORAGE

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โรคที่พบในช่วงเก็บรักษาผลลิ้นจี่จากผลที่เก็บเกี่ยวในระยะเวลาต่างๆ

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บทคัดย่อ : เก็บเกี่ยวผลลิ้นจี่ 3 ระยะ ได้แก่ระยะ M3 (ผิวเปลือกสีแดง 31-60%), M4 (ผิวเปลือกสีแดง 61-90%) และ M5 (ผิวเปลือกสีแดง 91-100%) หลังจากนั้นจุ่มผลลิ้นจี่ในสารละลาย benomyl (500 ppm ที่ 52°C นาน 2 นาที) ก่อนเก็บผลในถาดแล้วห่อด้วยพลาสติก PVC เก็บถาดทั้งหมดไว้ในตู้ควบคุมอุณหภูมิที่ 5°C นำผลลิ้นจี่มาตรวจสัปดาห์ละครั้งในช่วง 2-5 สัปดาห์ สำหรับ Control ไม่ได้จุ่มผลลิ้นจี่ใน benomyl ก่อนการเก็บรักษา.

การศึกษาครั้งนี้พบว่า ระยะเวลาที่เก็บรักษา 2 สัปดาห์ เปลือกของผลลิ้นจี่ M4 และ M5 ไม่เปลี่ยนเป็นสีน้ำตาล แต่ผลของระยะ M3 พื้นที่ผิวเปลือกเปลี่ยนเป็นสีน้ำตาลมากกว่า 50%และหลังจากการเก็บรักษา 3 สัปดาห์ ผลของระยะ M3 เปลี่ยนเป็นสีน้ำตาลทั้งหมด สำหรับเชื้อราที่ตรวจพบบนผลที่เก็บรักษาทั้ง 3 ระยะนั้น พบชนิดของเชื้อราคล้ายๆ กัน เชื้อราที่แยกได้มากที่สุดคือ *Cladosporium* sp. และ *Fusarium* sp. ส่วนผลที่จุ่มใน benomyl พบชนิดของเชื้อราน้อยกว่า จากผลการทดลองครั้งนี้พบว่า benomyl ช่วยลดการเกิดแผลด้านข้างผลได้มากกว่าแผลบริเวณขั้วผล.

ABSTRACT : At harvest, lychee fruit of three maturity levels : M3 (31-60% surface red), M4 (61-90% surface red) and M5 (91-100% surface red), were either treated with hot benomyl (500 ppm at 52 °C for 2 min) and air dried, or left untreated prior to PVC wrapping in punnets, and storage at 5 °C. The fruits were assessed weekly between 2 and 5 weeks after harvest.

Browning of the pericarp and disease development were absent from fruit of M4 and M5 maturity levels 2 weeks after harvest, while > 50% skin browning had developed on the M3 fruits. Browning had appeared on all fruits by 3 weeks after harvest. Similar levels and spectra of fungi were recorded from fruits of the three maturity levels, and were more prevalent in fruits that were not dipped in hot benomyl. *Cladosporium* sp. and *Fusarium* sp. were the most commonly detected fungi. Treatment in hot benomyl appeared to give greater control of side lesions than stem end lesions.

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INTRODUCTION

Lychee (*Litchi chinensis* Sonn.) is native to southern China. The fruit is round with a diameter of about 30 mm. The surface of the pericarp has an attractive red color. The inside is a single seed surrounded by film translucent white flesh. The pericarp turns brown and fruit deteriorate rapidly after harvest. In storage many kinds of organisms were found to grow on fruit. These organisms caused fruit decay and became unmarketable. Lately, some investigations were done with cold storage and fungicidal treatment of lychee fruit in order to expand the shelf life of the commodity after harvest. The objectives of this study were to 1) determine the stage of maturity at harvest in relation to fruit decay factors, 2) evaluate hot benomyl treatment and cold temperature storage for controlling contaminate fungi, and 3) determine the genera of contaminate fungi after interval of storage times.

MATERIALS AND METHODS

Lychee (*Litchi chinensis* Sonn.) fruit cv. Hong Huay were selected for the study of disease development during storage. At harvest, fruit of three maturity levels: M3 (31-60% surface red), M4 (61-90% surface red) and M5 (91-100% surface red) were considered as a treatment involved in the experiment. Another treatment was also proposed to prolong the shelf life or decay control of the fruit by dipping the fruit into the hot benomyl solution at the temperature of 52°C with the concentration of 500 ppm for a period of 2 minutes of time. After treated, 20 fruits of each treatment were kept in the foam punnets prior to wrapping with PVC film. Then the punnets were kept in the temperature and moisture controlled chamber at 5°C and relative humidity of 90-95% for 0, 2, 3, 4 and 5 weeks. All treatments were replicated two times. The study thus involved 60 punnets.

Fruits of each punnet were scored for quality. It was assumed, from the beginning of the study, that high-quality lychee especially those of M5 were fruits that retained the natural red color, showed no evidence of browning, and tasted like freshly harvested fruit. In M3 and M4, the red skin color of the pericarp was a little lighter than the M5 one. After the cold storage for 2, 3, 4

and 5 weeks, color of the pericarp was scored on a scale 0-10 : 0 = no browning; 10 = 100% of pericarp area was brown. Then ten fruit samples of each week were taken for the isolation of any fungal contaminants. Four 3 x 3 mm pieces of tissues from stem end, pericarp and fleshy part were transplanted and cultured on potato dextrose agar (PDA). The growth and species of fungi were observed and identified possibly to the genus.

RESULTS

After the punnets of lychee fruit were stored in the cold condition for two weeks, browning was observed on the skins of fruit of M3 in both of non dipped and dipped in hot benomyl treatments, whereas no sign of browning was developed on M4 and M5. Interestingly, in this second week, fungicide did not possess any efficacy to prolong the attractive color of fruit skin. In opposition, the fungicide was seemingly accelerated the pericarp to become browner than the one not treated (Table 1).

In the third, fourth and fifth weeks of all three maturity levels, the fruit of hot benomyl treatment also turned browner than the control treatments. Moreover, it was noted that in the last week of the observation, fruit of M3 were completely brown when compared with the rest (Table 1).

Table 1. Browning scores of the pericarp of lychee fruit harvested at three maturity levels and treated with hot benomyl and held in punnets covered with PVC film for 5 weeks at 5°C; 0 = red, 10 = very brown.

Treatment	Week/mean score			
	2	3	4	5
M3, no dip	1	4.5	7.5	9.5
M3, dipped in hot benomyl[1]	5	6.5	8.5	10.0
M4, no dip	0	4.5	7.0	7.5
M4, dipped in hot benomyl[1]	0	6.0	7.5	8.0
M5, no dip	0	6.5	7.5	7.5
M5, dipped in hot benomyl[1]	0	7.0	8.0	8.0

[1] 500 ppm, 52°C, 2 min.

Isolations of organisms were prepared from fruit samples after storage in cold condition for 0, 2, 3, 4, and 5 weeks. The following organisms were detected : *Botryodiplodia* sp., *Cladosporium* sp., *Fusarium* spp., *Penicillium* sp., *Pestalotia* sp., unknown with white and grey mycelium colony, bacteria and no growth. In M3 fruit, *Cladosporium* sp. and *Cladosporium* sp. growing together with *Fusarium* sp. were predominant among the fungi detected from the non-application of benomyl treatment (Table 2). However, when benomyl treated fruit were similarly examined, hot benomyl showed promise of being able to reduce the frequencies of fungi detected and more frequencies of no growth were obtained (Table 3). Resembling patterns of results of fungal organisms as ascertained in M3 fruit were also found in M4 and M5 fruit units (Table 4, 5, 6 and 7). Data of all contaminated organisms in 5 weeks between treated and non-treated with hot benomly were compared and presented in Table 8 and 9. Results emphasized that units treated with hot benomyl were generally in better condition in terms of less frequencies of contaminated fungi than those not treated. Besides, in non-treated treatments of M3 and M5 fruit, higher numbers of Cladosporium sp. were attained to grow on the fleshy part than those of pericarp and stem end (Table 8).

Table 2. Frequency of isolation of fungi obtained from stem end (S), pericarp (P) and fleshy part (F) of M3 maturity level of lychee fruit without fungicidal treatment and stored at 5°C for 5 weeks.

Fungus	Storage time														
	0 Week			2 Weeks			3 Weeks			4 Weeks			5 Weeks		
	S	P	F	S	P	F	S	P	F	S	P	F	S	P	F
1. *Botryodiplodia* sp.	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
2. *Cladosporium* sp.	-	3	6	2	2	4	3	3	4	1	5	5	3	5	4
3. *Fusarium* sp.	-	4	2	-	-	-	-	4	1	-	-	-	-	-	-
4. *Penicillium* sp.	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
5. *Pestalotia* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
6. *Cladosporium* sp. + *Fusarium* sp.	10	-	-	8	8	-	7	-	-	8	3	1	7	2	-
7. *Fusarium* sp. + *Penicillium* sp.	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
8. Unknown (white and grey colony)	-	-	-	-	-	4	-	-	4	-	-	-	-	-	-
9. No growth	-	-	1	-	-	2	-	-	1	-	-	2	-	-	4
10. Bacteria	-	3	1	-	-	-	-	3	-	-	-	-	-	-	2
Total	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Table 3. Frequency of isolation of fungi obtained from stem end (S), pericarp (P) and fleshy part (F) of M3 maturity level of lychee fruit dipped in hot benomyl at 500 ppm, 52°C, 2 min. and then stored at 5°C for 5 weeks.

Fungus	Storage time														
	0 Week			2 Weeks			3 Weeks			4 Weeks			5 Weeks		
	S	P	F	S	P	F	S	P	F	S	P	F	S	P	F
1. *Botryodiplodia* sp.	-	-	-	-	-	-	3	-	-	-	-	-	-	-	4
2. *Cladosporium* sp.	3	-	-	-	-	-	-	-	-	6	-	-	1	9	-
3. *Fusarium* sp. (1)	3	-	-	3	1	-	4	-	-	-	-	-	-	-	-
4. *Fusarium* sp. (2)	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
5. *Pestalotia* sp.	2	1	-	5	-	-	2	1	-	-	-	-	-	1	-
6. *Cladosporium* sp. + *Fusarium* sp. (1)	2	-	-	-	-	-	-	4	-	1	-	-	9	-	-
7. Unknown (white and grey colony)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8. No growth	-	5	10	2	9	10	-	5	10	3	10	10	-	-	6
9. Bacteria	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Table 4. Frequency of isolation of fungi obtained from stem end (S), pericarp (P) and fleshy part (F) of M4 maturity level of lychee fruit without fungicidal treatment and stored at 5°C for 5 weeks.

Fungus	Storage time														
	0 Week			2 Weeks			3 Weeks			4 Weeks			5 Weeks		
	S	P	F	S	P	F	S	P	F	S	P	F	S	P	F
1. *Cladosporium* sp.	1	6	3	-	1	6	3	2	5	2	5	7	4	8	-
2. *Fusarium* sp.	7	2	-	-	-	-	-	-	-	1	2	2	-	-	-
3. *Cladosporium* sp. + *Fusarium* sp.	2	2	7	10	8	-	7	8	-	7	3	-	6	2	-
4. Unknown (white and grey colony)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
5. No growth	-	-	-	-	1	4	-	-	5	-	-	1	-	-	1
Total	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Table 5. Frequency of isolation of fungi obtained from stem end (S), pericarp (P) and fleshy part (F) of M4 maturity level of lychee fruit dipped in hot benomyl at 500 ppm, 52°C, 2 min. and then stored at 5°C for 5 weeks.

Fungus	Storage time														
	0 Week			2 Weeks			3 Weeks			4 Weeks			5 Weeks		
	S	P	F	S	P	F	S	P	F	S	P	F	S	P	F
1. *Cladosporium* sp.	-	-	-	1	3	1	-	3	-	2	4	2	2	8	6
2. *Fusarium* sp.	5	-	-	3	-	-	5	1	-	8	4	2	2	-	-
3. *Pestalotia* sp.	2	2	-	-	-	-	4	-	-	-	-	-	-	-	-
4. *Cladosporium* sp. + *Fusarium* sp.	-	-	-	3	1	-	-	-	-	-	-	4	-	-	-
5. *Cladosporium* sp. + *Pestalotia* sp.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Unknown (white and grey colony)	-	-	-	-	-	-	-	-	-	-	-	-	5	2	3
7. No growth	2	6	10	3	6	9	1	6	10	-	2	2	1	-	1
8. Bacteria	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Table 6. Frequency of isolation of fungi obtained from stem end (S), pericarp (P) and fleshy part (F) of M5 maturity level of lychee fruit without fungicidal treatment and stored at 5°C for 5 weeks.

Fungus	Storage time														
	0 Week			2 Weeks			3 Weeks			4 Weeks			5 Weeks		
	S	P	F	S	P	F	S	P	F	S	P	F	S	P	F
1. *Botryodiplodia* sp.	-	-	8	-	-	-	-	1	1	-	-	-	-	-	2
2. *Cladosporium* sp.	2	2	-	3	1	7	2	2	3	-	2	9	1	1	3
3. *Fusarium* sp.	6	1	-	-	-	-	-	-	4	-	-	1	9	2	1
4. *Cladosporium* sp. + *Fusarium* sp.	2	7	-	7	9	-	8	7	-	10	7	-	-	4	-
5. *Pestalotia* sp.	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1
6. Unknown (white and grey colony)	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
7. No growth	-	-	2	-	-	3	-	-	2	-	-	-	-	-	-
Total	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Table 7. Frequency of isolation of fungi obtained from stem end (S), pericarp (P) and fleshy part (F) of M5 maturity level of lychee fruit dipped in hot benomyl at 500 ppm, 52°C, 2 min. and then stored at 5°C for 5 weeks.

Fungus	Storage time														
	0 Week			2 Weeks			3 Weeks			4 Weeks			5 Weeks		
	S	P	F	S	P	F	S	P	F	S	P	F	S	P	F
1. *Botryodiplodia* sp.	-	-	-	-	-	-	4	4	-	-	4	-	-	-	-
2. *Cladosporium* sp.	2	-	-	3	3	1	-	-	1	2	-	2	5	5	2
3. *Curvularia* sp.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	4
4. *Fusarium* sp.	-	2	-	5	2	-	6	-	-	4	-	-	-	-	-
5. *Pestalotia* sp.	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-
6. *Cladosporium* sp. + *Fusarium* sp. (1)	4	-	-	-	3	-	-	-	-	-	4	4	-	5	-
7. Unknown (white and grey colony)	-	-	-	-	-	-	-	-	-	-	-	4	4	-	3
8. No growth	3	8	10	2	2	9	-	6	8	3	2	-	1	-	1
Total	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Table 8. Frequency of isolation of fungi obtained from stem end (S), pericarp (P) and fleshy part (F) of M3, M4 and M5 maturity levels of lychee fruit without fungicidal treatment and stored at 5°C for 5 weeks. Isolations were done on weeks : 0, 2, 3, 4 and 5.

Fungus	Maturity level								
	M3			M4			M5		
	S	P	F	S	P	F	S	P	F
1. *Botryodiplodia* sp.	-	2	-	-	-	-	-	1	11
2. *Cladosporium* sp.	9	18	23	10	22	21	8	8	22
3. *Fusarium* sp.	-	8	3	8	4	2	15	3	6
4. *Penicillium* sp.	-	-	2	-	-	-	-	-	-
5. *Pestalotia*sp.	-	3	-	-	-	-	-	2	1
6. *Cladosporium* sp. + *Fusarium* sp.	40	13	1	32	23	7	27	34	-
7. *Fusarium* sp. + *Penicillium* sp.	1	-	-	-	-	-	-	-	-
8. Unknown (white and grey colony)	-	-	8	-	-	9	-	2	3
9. No growth	-	-	10	-	1	11	-	-	7
10. Bacteria	-	6	3	-	-	-	-	-	-
Total	50	50	50	50	50	50	50	50	50

Table 9. Frequency of isolation of fungi obtained from stem end (S), pericarp (P) and fleshy part (F) of M3, M4 and M5 maturity levels of lychee fruit dipped in hot benomyl at 500 ppm, 52°C, 2 min and then stored at 5°C for 5 weeks.

Fungus	Maturity level								
	M3			M4			M5		
	S	P	F	S	P	F	S	P	F
1. *Botryodiplodia* sp.	3	-	4	-	-	-	4	8	-
2. *Cladosporium* sp.	10	9	-	5	18	9	12	8	6
3. *Fusarium* sp.	10	1	-	23	5	2	15	4	-
4. *Curvularia* sp.	-	-	-	-	-	-	-	-	5
5. *Pestalotia* sp.	9	3	-	6	2	-	2	-	-
6. *Cladosporium* sp. + *Fusarium* sp.	12	4	-	3	1	4	4	12	4
7. *Cladosporium* sp. + *Pestalotia* sp.	-	-	-	1	-				
8. Unknown (white and grey colony)	-	-	-	5	2	3	4	-	7
9. No growth	6	29	46	7	20	32	9	18	28
10. Bacteria	-	4	-	-	2	-	-	-	-
Total	50	50	50	50	50	50	50	50	50

DISCUSSION

Stage of maturity of lychee fruit at harvest did appear to be related to the browning of the pericarp when fruits were kept in cold condition at 5°C. In this study, it was obviously indicated that the pericarp of early harvested fruit turned brown sooner than the late harvested one. Hot benomyl treatment did produce some damage to the pericarp of fruit of all stages of maturity. Our result in the investigation agreed with the work of Scott and his colleagues, (1982), in which they mentioned that when fruit were exposed to water or benomyl at 56°C for 4 min, serious damage of the skin occurred and pigment

was leached from the fruit. However, in different treatment, they obtained a contrary result and concluded that after eight days of storage, a benomyl dip (0.05% at 52°C for 2 min) followed by packing the fruit in punnets and over-wrapping with PVC film is suggested for controlling rotting, browning and loss in weight at temperatures of 20-30°C. Recently, (1990), Snowdon wrote that in storage of lychee fruit at 5°C for a month, chilling injury may occur. She also said that the red color may be retained best at 7° to 10°C. In our case, the use of cold temperature enabled to keep a good skin color of M4 and M5 fruit with and without dipping in hot benomyl for at least up to 14 days. Actually, lychee deteriorate rapidly after harvest. Scott et al. (1982) reviewed that at ambient temperatures of 20-30°C, browning of the pericarp can occur within 24 hours of harvest. Therefore, in the finding of this experiment,if the fleshy quality and flavor did not lessen, the temperature at 5°C would do better in keeping the freshness of lychee for more than two weeks.

Fungal cultures of *Cladosporium* sp., *Fusarium* sp. and *Cladosporium* sp. growing together with *Fusarium* sp. were predominate among the fungi obtained on fruit after stored for up to 5 weeks. The finding of this test assured that the use of hot benomyl treatment could reduce the number of frequencies of contaminate fungi on the fruit after storing for a period of time. As in Australia, Scott, *et al.* (1982) made a conclusive remark that bunches of fruit could be separated into single fruits, dipped in hot benomyl (0.05% at 52°C for 2 min), then packed in punnets and over-wrapped with a suitable plastic film. With these treatments, fruit should be better able to withstand shipment by surface transport to more distant markets.

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