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Effect of three storage methods on fruit decay and brown rot of apple

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Summary: The aim of our two-year study was to evaluate fruit decay and Monilinia fruit rot in three controlled atmospheres (CA), ultra-low oxygen (ULO) and traditional storage methods on apples for a duration of several months storage period. Four phytopathological treatments were studied under each storage condition: 1) 48 healthy fruit per unit, 2) 48 injured fruit per unit, 3) 47 healthy fruit and 1 brown rotted fruit per unit, and 4) 47 injured fruit and 1 brown rotted fruit per unit. Our results clearly demonstrated that fruit loss during storage is highly influenced by storage conditions and health status of the stored fruits. In the 2005 experiment, the lowest and largest fruit decay occurred under the ULO and traditional storage conditions, respectively (Table 1). The fruit decay was significantly different for the different storage methods. Fruit decay was fully suppressed in ULO storage except in the tretments of injured and injured + 1 brown rotted apple. Under CA and traditional storage conditions, when healthy fruit was stored, fruit decay was significantly lower compared with injured fruit including 1 brown rotted fruits. However, half of the fruit decay was caused by *M. fructigena* in CA store irrespective to phytopathogenic treatments. In 2006, results were not so consistent on cv. Idared but were not essentially different from the 2005 experiments.

Key words: fruit rot, *Monilinia fructigena*, ULO, CA, apple, storage

Introduction

Several fruit rot pathogens cause losses in apple during storage, including *Alternaria* spp., *Cylindrocarpon heteronema*, *Gloeosporium* spp., *Phomopsis mali*, *Venturia inaequalis*, *Botrytis cinerea*, *Penicillium expansum*, *Phytophthora cactorum*, *Sphaeropsis malorum*, *Trichotecium roseum*, *Rhizophus stolonifer*, and *Monilinia fructigena* (*Glits*, 2000; *Holb*, 2004; *Kállay & Rozsnyai*, 2005).

Controlled atmospheres (CA) have been demonstrated to reduce fungal growth on fruits (*De Vries-Paterson* et al., 1991; *Sitton & Patterson*, 1992; *Ahmadi* et al., 1999). *Tian* et al. (2001) found that growth of *Monilinia fructicola* (G. Wint.) Honey, both in potato dextrose agar (PDA) and in sweet cherry fruit, declined significantly with increased CO_2 concentrations.

Storage under atmospheres containing <1 kPa O_2, referred to as ultra-low O_2 (ULO), have been shown to suppress development of pathogenic fungi (Barkai-Golan, 1990) and kill insect pests (*Ke & Kader*, 1991). *Sommer* (1985) and *Barkai-Golan* (1990) suggested that refrigerated ULO storage reduced decay by directly suppressing pathogen growth and by indirectly maintaining resistance of the host to infection. They both highlighted the importance of low temperature in combination with ULO for optimum suppression. Results of *Shellie* (2002) showed that inoculated fruit stored under ULO at 18 °C developed larger lesion diameters than fruit stored under ULO at 14 °C.

In our study, we aimed to evaluate fruit decay and Monilinia fruit rot in three CA and ULO and traditional storage methods on apples for a duration of several months storage period.

Materials and methods

The study was conducted in two years (2005 and 2006) in a controlled atmosphere and ultra low oxygen storage room of Balker-Coop BV, Ömböly, Hungary as well as a traditional storage room in Ömböly, Hungary. Cultivar Florina was used for the study in 2005 and cv. Idared in 2006. Fruit unit was stored on 20 November in both years.

Three storage methods were used: traditional, controlled atmosphere (CA) and ultra low oxygen (ULO). Four phytopathological treatments were studied under each storage condition: 1) 48 healthy fruit per unit, 2) 48 injured fruit per unit, 3) 47 healthy fruit and 1 brown rotted fruit per unit, and 4) 47 injured fruit and 1 brown rotted fruit per unit. Fruits were placed in storage boxes and treatments were replicated four times in each storage method. In treatments 3 and 4, each brown rotted fruit was placed in the middle of boxes.

Incidence of fruit rot decay and brown rot was assessed on a monthly basis (20 December, 20 January, 20 February and 20 March) and best conditions were evaluated in the treatments. In this study, we present only the results of final assessment dates of each year.

Results

Fruit decay and brown rot in 2005–2006

In the 2005 experiment, the lowest and largest fruit decay occurred under the ULO and traditional storage conditions, respectively, after four months storage (*Table 1*). The fruit decay was significantly different for the different storage methods (*statistical analyses are not shown*). Fruit decay was fully suppressed in ULO storage except in the treatments of injured and injured + 1 brown rotted apple. In the CA storage room, average fruit loss was between 20 and 35%. Under CA storage condition, when healthy fruit were stored, fruit decay was significantly lower compared with injured fruit including 1 brown rotted fruit. However, half of the fruit decay was caused by *M. fructigena* under CA storage conditions irrespective to phytopathogenic treatments. In the traditional store room, average fruit loss was between 31 and 52% after a four-month storage period. Again, when healthy fruit were stored, fruit decay was significantly lower compared with injured fruit including 1 brown rotted fruits. In addition, similarly to CA storage conditions, half of the fruit decay was caused by *M. fructigena* in the traditional store room, irrespective to phytopathogenic treatments.

Table 1. Fruit decay and Monilinia fruit rot after a four-month storage period in four phytopathological treatments under CA and ULO and traditional storage methods on cv. Florina (20 March, 2006)

Storage method	Incidence of fruit decay	Incidence of brown rot within fruit rot decay
CA		
Healthy	20.8	50.1
Healthy + 1 brown rotted apple	25.1	41.7
Injured	31.2	40.9
Injured + 1 brown rotted apple	35.4	47.1
$LSD_{0.05}$	5.8	3.7
ULO		
Healthy	0.0	0.0
Healthy + 1 brown rotted apple	0.0	0.0
Injured	4.1	50.4
Injured + 1 brown rotted apple	4.2	0.0
$LSD_{0.05}$	2.8	10.5
Traditional		
Healthy	31.2	46.6
Healthy + 1 brown rotted apple	35.4	47.1
Injured	45.8	45.4
Injured + 1 brown rotted apple	52.1	48.0
$LSD_{0.05}$	8.2	5.5

Fruit decay and brown rot in 2006–2007

In 2006, results were not so consistent on cv. Idared but were not essentially different from the 2005 experiments. Similarly to 2005 experiments, the lowest and largest fruit decay occurred under the ULO and traditional storage conditions, respectively, in the 2006 experiments (*Table 2*). The fruit decay was significantly different for the different storage methods (*statistical analyses are not shown*). Fruit decay was fully suppressed in ULO storage except in the treatments of injured and injured + 1 brown rotted apple. In the CA storage room, average fruit loss was lower than in the 2005 treatments (from 4.5 to 14.4%). Under CA storage conditions, when healthy fruit were stored fruit decay was significantly lower compared with injured fruit including 1 brown rotted fruits. Fruit decay caused by *M. fructigena* ranged between 33 and 50% under CA storage conditions irrespective to phytopathogenic treatments. In the traditional storage room, average fruit loss was again lower (from 14 to 48%) after a four-month storage period compared with data of the 2005 experiments. Healthy fruit remained more healthy compared with injured fruit after four months of storage. However, fruit decay in the 2006 treatments caused by *M. fructigena* was variable and it did not correspond clearly with phytopathogenic treatments.

Table 2. Fruit decay and Monilinia fruit rot after a four-month storage period in four phytopathological treatments under CA and ULO and traditional storage methods on cv. Florina (20 March, 2007)

Storage method	Incidence of fruit decay	Incidence of brown rot within fruit rot decay
CA		
Healthy	4.5	50.8
Healthy + 1 brown rotted apple	6.3	33.3
Injured	16.8	50.2
Injured + 1 brown rotted apple	14.4	42.8
$LSD_{0.05}$	4.7	10.9
ULO		
Healthy	0.0	0.0
Healthy + 1 brown rotted apple	0.0	0.0
Injured	2.0	0.0
Injured + 1 brown rotted apple	2.1	0.0
$LSD_{0.05}$	1.5	–
Traditional		
Healthy	14.6	42.7
Healthy + 1 brown rotted apple	18.4	33.3
Injured	22.8	45.3
Injured + 1 brown rotted apple	47.8	82.6
$LSD_{0.05}$	8.3	23.2

Conclusions

Our results clearly demonstrated that fruit loss during storage is highly influenced by storage conditions and health status of the stored fruits. For long term storage, ULO storage conditions provided the best option regarding to storage loss caused by fruit pathogenic microorganisms. Storage of healthy fruit is especially important under traditional storage conditions, where storage loss can be severe due to transported decayed fruits into the store room. Either injured or decayed fruit can severely increase storage loss under traditional and CA storage conditions.

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