ONTARIO EXPERIENCES WITH 1-MCP (SMARTFRESH™) ON APPLES

Dr. Jennifer R. DeEll
Ontario Ministry of Agriculture, Food, and Rural Affairs
Simcoe, Ontario, Canada
Jennifer.DeEll@omaf.gov.on.ca

Dr. Dennis P. Murr
Department of Plant Agriculture
University of Guelph, Ontario, Canada

1-MCP EFFECTS ON APPLE QUALITY

Postharvest treatment with 1-methylcyclopropene (1-MCP, SmartFresh™) can improve many quality characteristics of apples during storage. For example, 1-MCP treated apples have shown 1 to 5 lb greater firmness than similar non-treated fruit, depending on cultivar, maturity at harvest, storage conditions, and the delay between harvest and 1-MCP application (DeEll and Murr, 2002; MacLean et al., 2001). Reduced ethylene production and respiration have also been found in apples treated with 1-MCP (DeEll et al., 2005a; DeEll et al., 2005b). Superficial scald incidence in 'Cortland' stored at 0 to 1 ºC in ambient air for 120 days was reduced to <10% with 1-MCP treatment, compared to 100% in non-treated fruit (DeEll et al., 2002). Similarly, 'Delicious' apples not treated with 1-MCP and held in standard controlled atmosphere (CA) storage (2.5% O_2 + 2.5% CO_2) at 0 ºC for 240 days had 93% incidence of superficial scald, while similar fruit treated with 1-MCP had 4% incidence (DeEll et al., 2005c). The incidence of senescent breakdown in 'Cripsin' stored at 0 to 1°C in ambient air for 180 days was zero with 1-MCP treatment, compared to >80% in non-treated fruit (DeEll and Murr, unpublished data). 1-MCP has also substantially reduced the development of peel greasiness in 'Jonagold' apples (DeEll and Murr, unpublished data) and maintained higher antioxidant levels in 'McIntosh' and 'Delicious' fruit during storage (MacLean et al., 2003).

Unfortunately, 1-MCP treatment tends to increase the susceptibility of apples to external CO_2 injury (DeEll et al., 2003; DeEll et al., 2005a). 'McIntosh' treated with 1-MCP had 26 to 39% incidence of CO_2 injury (Figure 1) in standard CA storage (3% O_2 + 2.5% CO_2 for the first 30 days followed by 3% O_2 + 4.5% CO_2 thereafter) at 3 ºC, compared to zero incidence in the non-treated fruit. Likewise, 'Empire' apples treated with 1-MCP also exhibited a higher incidence of CO_2 injury in CA (2.5% O_2 + 2% CO_2) at 2 ºC, compared to similar non-treated fruit. In these same studies, the application of aminoethoxyvinylglycine (ReTain™) further promoted external CO_2 injury in 'Empire' apples (DeEll et al., 2003).

Postharvest drenching with the antioxidant diphenylamine (DPA) is a common commercial practice to control superficial scald in apples. DPA treatment of 'Empire' fruit also reduces susceptibility to external CO_2 injury (Burmeister and Dilley, 1995; Watkins et al., 1997). During commercial SmartFresh™ trials in Ontario, 'Empire' apples from a packinghouse that did not drench with DPA developed symptoms of CO_2 injury, while 'Empire' from another packinghouse that drenched with DPA exhibited no CO_2 injury (DeEll et al., 2005a).

Figure 1: 'McIntosh' apples with external CO_2 injury.

In the same commercial trials, some internal browning was observed in 'Empire' apples after 9 months of standard CA storage. 1-MCP treatment did not affect the development of internal browning, but the incidence varied greatly from one CA room to another at the same packinghouse (DeEll et al., 2005a). In another study, 1-MCP treated 'Empire' showed significantly higher incidence of core browning in various CA regimes, compared to non-treated fruit (DeEll et al., 2005c).

Aroma volatile development can also be affected by 1-MCP treatment. Post-storage volatile production of 'Gala' apples was reduced by 1-MCP and the effect was greater at temperatures below 3 ºC and at low O_2 concentrations (Singh et al., 2004). Further studies found that activity of one of the major enzymes in aroma ester biosynthesis (alcohol o-acyltransferase, which is responsible for conversion of alcohols to esters) was reduced in 'Gala' by 1-MCP, as well as storage in CA and at low (<3 ºC) temperatures (Singh et al., 2005).

1-MCP APPLICATION AFTER STORAGE

When 'Empire' apples were put into storage at the proper maturity, they also responded to post-storage applications of 1-MCP (DeEll and Murr, unpublished data). Response to 1-MCP was better in fruit from low oxygen CA (1.2% O_2 + 1% CO_2) than in those from standard CA (2.5% O_2 + 2% CO_2) at 2 ºC; however, the beneficial effects decreased with increased time between removal from CA and 1-MCP treatment (Table 1).

In addition to improved firmness retention (Table 1), reductions in ethylene production and respiration were observed after post-storage applications of 1-MCP (data not presented). These benefits were also noted in 'Empire' apples after 240 days of CA storage (data not presented).

Other data showed that there was little effect of 1-MCP on 'Delicious' and 'Empire' apple quality when treatment followed a period of air storage (DeEll and Murr, unpublished data). This was probably due to the fact that plenty of ethylene was already being produced by the air-stored fruit, in which case 1-MCP would not be effective at blocking the ethylene receptor sites.

Table 1: Firmness (kg-force) of 'Empire' apples held for 120 days in standard (2.5% O_2 + 2% CO_2) and low O_2 (1.2% O_2 + 1% CO_2) CA for 120 days at 2 ºC and then treated with 1-MCP (1 ppm for 24 hours) after 0, 4, 7, 10, or 14 days in air storage at 0 ºC.

	No 1-MCP Days at ~22°C			**+ 1-MCP** Days at ~22°C		
	1	7	14	1	7	14
Standard CA						
1-MCP						
At harvest[1]	7.1	6.6	6.1	7.0	7.2	7.0
Post-storage						
0 days	7.3	6.7	5.8	6.9	7.0	6.6
4 days	7.1	6.6	5.9	7.2	7.2	6.5
7 days	7.1	6.2	5.8	7.1	6.6	6.1
10 days	7.1	6.2	5.7	7.2	6.8	6.1
14 days	7.3	6.6	6.0	7.3	6.9	6.4
Low O_2 CA						
1-MCP						
At harvest	7.1	7.0	6.3	7.1	7.1	7.2
Post-storage						
0 days	7.0	7.0	6.1	7.2	7.1	6.8
4 days	7.1	6.8	6.3	7.1	7.2	6.8
7 days	7.1	6.8	6.2	7.2	7.1	6.4
10 days	7.3	6.7	6.1	7.2	7.2	6.5
14 days	7.2	6.7	6.0	7.3	7.0	6.4

[1] 1-MCP applied at harvest, before CA storage

SMARTFRESH™ REGISTRATION IN CANADA

In 2003, a research permit (66-RP-03) was granted by the Pest Management Regulatory Agency (PMRA) to allow SmartFresh (1-MCP) treatment at five commercial apple storages in Canada. Treatment was limited to a maximum of 20 rooms for all sites, and a maximum total of 6500 tonnes of apples could be treated under the permit. All treated apples had to be exported. The research permit was specifically granted to establish a Maximum Residue Limit (MRL) for the use of 1-MCP in Canada, but this study also demonstrated the efficacy of commercial applications of SmartFresh on 'Empire' apples in Canada.

In 2004, SmartFresh received temporary registration for use on apples in Canada until December 2005. At this time additional efficacy data was required by the PMRA. Research required to generate the necessary data began in the 2004 harvest season and continued until November 2005. The following data was requested, representing two main objectives: 1) to compare the effectiveness of SmartFresh concentrations 1 ppm (registered in U.S.) and 0.625 ppm (registered

in U.K.) throughout the commercial harvest window, with delays prior to treatment, and during 12 months of storage, and 2) to evaluate the effectiveness of SmartFresh on early, mid, and late-season apple cultivars during 6 months of commercial air storage and 12 months of commercial CA storage. The results of these trials will be available at the end of 2005.

LITERATURE CITED

Burmeister, D.M., Dilley, D.R. 1995. A 'scald-like' controlled atmosphere storage disorder of Empire apples – a chilling injury induced by CO_2. Postharvest Biol. Technol. 6:1-7.

DeEll, J.R., and D.P. Murr. 2002. 1-Methylcyclopropene (1-MCP) to control ripening and reduce ethylene effects in apples. Interim Industry Report for Year 2 of Project #00-6025, Agriculture and Agri-Food Canada, 38 pp.

DeEll, J.R., D.P. Murr, M.D. Porteous, and H.P.V. Rupasinghe. 2002. Influence of temperature and duration of 1-methylcyclopropene (1-MCP) treatment on apple quality. Postharvest Biol. Technol. 24:349-353.

DeEll, J.R., D.P. Murr, L. Wiley, and M.D. Porteous. 2003. 1-Methylcyclopropene (1-MCP) increases CO_2 injury in apples. Acta Hort. 600:277-280.

DeEll, J., J. Ayres, and D. Murr. 2005a. Commercial application of 1-methylcyclopropene affects storability and disorders of 'Empire' apples. In: CA 2005, 9th Intl. Controlled Atmosphere Res. Conf., Program & Abstracts, p. 46 (abstract #44). Full article – Acta Hort. (in press).

DeEll, J.R., D.P. Murr, R. Mueller, L. Wiley, and M.D. Porteous. 2005b. Influence of 1-methylcyclopropene (1-MCP), diphenylamine (DPA), and CO_2 concentration during storage on 'Empire' apple quality. Postharvest Biol. Technol. 38:1-8.

DeEll, J.R., D.P. Murr, L. Wiley, and R. Mueller. 2005c. Interactions of 1-MCP and low oxygen CA storage on apple quality. Acta Hort. 682:941-948.

MacLean, D.D., D.P. Murr and J.R. DeEll. 2001. Effect of apple maturity and treatment temperature on the efficacy of 1-MCP. HortScience 36:490-491 (abstract).

MacLean, D.D., D.P. Murr, and J.R. DeEll. 2003. A modified total oxyradical scavenging capacity assay for antioxidants in plant tissues. Postharvest Biol. Technol. 29:183-194.

Singh, H.P., D. Murr, G. Paliyath, and J. DeEll. 2004. Impact of 1-methylcyclopropene and controlled atmosphere storage on volatile production in 'Gala' apples. HortScience 39:817 (abstract).

Singh, H.P., D.P. Murr, G. Paliyath, and J.R. DeEll. 2005. Aroma volatile biosynthesis in 'Gala' apples stored in controlled atmosphere. In: CA 2005, 9th Intl. Controlled Atmosphere Res. Conf., Program & Abstracts, p. 7 (abstract #15).

Watkins, C.B., Silsby, K.J., Goffinet, M.C. 1997. Controlled atmosphere and antioxidant effects on external CO_2 injury of 'Empire' apples. HortScience 32:1242-1246.