

POTENTIAL OF CA FOR POSTHARVEST ARTHROPOD CONTROL IN FRESH HORTICULTURAL PERISHABLES: AN UPDATE OF SUMMARY TABLES COMPILED BY KE AND KADER, 1992a.

Elizabeth J. Mitcham, Tunya Lee A. Martin, Shijun Zhou, and Adel A. Kader  
 Department of Pomology, University of California, Davis, CA 95616

**Tolerance of some horticultural perishables to controlled atmospheres.**

Commodity	Temperature (°C)	CA composition		Tolerance (days) <sup>z</sup>	References
		O <sub>2</sub> %	CO <sub>2</sub> %		
Apple	0	0.02		12	Chen <i>et al.</i> (1985)
	0	0.25		23	Chu (1992)
	0	0.5		100	Couey and Olsen (1977)
	0	1	1-3	220	Dewey and Bourne (1982)
	0	2-3	1-3	300	Ke <i>et al.</i> (1991b)
	1 or 3	1.5-1.7	1.0-1.1	217-231	Lau (1983)
	5	0.02		9	Little <i>et al.</i> (1982)
	5	0.25		11	Morgan and Gaunce (1975)
	5	0.5		55	
	5	1	1-3	180	
	5	2-3	1-3	210	
	10	0.02		5	
	10	0.25		7	
	18			10-15	
22			90		
28		1-2		3	Chervin <i>et al.</i> (1998 & 1999)
(Gala)	20/40	>1.2/1.2	<1/1	6/14	Lay-Yee <i>et al.</i> (1997)
Apricot	0	0.3		12	Folchi <i>et al.</i> (1994, 1995)
	6	0.3		5	
	15	1		6	Botondi <i>et al.</i> (2000)
Asparagus	0 or 5	8	60	4	Corrigan and Carpenter (1993)
Avocado	20	0.25	80	3	Ke <i>et al.</i> (1995)
	20	0.1-0.4	50-75	1	Yahia and Carrillo-Lopez (1993)
Blueberry	5	0		14-21	Prange and Lidster (1992)
	5	5	10-20	42	Smittle and Miller (1988)
	21		54	2	
Broccoli	0	0.02		9	Cantwell <i>et al.</i> (1995, 1996)
	0	0.5		21	Zheng <i>et al.</i> (1993)
	5	0.02		4	
	5	0.5		21	
	0		30-50	2	
	5		30-50	2	
Carnation	0		30-50	6	Cantwell <i>et al.</i> (1995, 1996)
	5		30-50	6	Zheng <i>et al.</i> (1993)
	0		60	3	Irving and Honner (1994)
	0.5		60	1	Shelton <i>et al.</i> (1997)
	0.5	0.1/4	0/4	2/4	
	0.5	8.4/0.1/4	60/0/4	1/2/3	
Cherry	0	0.02		25	Chen <i>et al.</i> (1981)
	0	0.25		35-44	Folchi <i>et al.</i> (1994)
	0	1		56	Ke and Kader (1992b)
	5	0.02		21	Patterson (1982)
	5	0.25		38	Patterson and Melsted (1977)
	6	0.3		18	
	0		20-40	42	
	0		60	7	
	0		80-100	4-7	
	47	1	15	25 min	Shellie <i>et al.</i> (2000)
Chrysanthemum	0.5		60	1	Shelton <i>et al.</i> (1997)
	0.5	8.4/4	60/4	1/5 <sup>y</sup>	

**Tolerance of some horticultural perishables to controlled atmospheres (continued).**

Commodity	Temperature (°C)	CA composition		Tolerance (days)	References		
		O <sub>2</sub> %	CO <sub>2</sub> %				
Chrysanthemum cont.	0.5	8.4/0.1/4	60/0/4	1/2/3 <sup>y</sup>	Shelton et al. (1997)		
	0.5	0.1		2			
Cut flowers	2	0.1		4	Shelton <i>et al.</i> (1996)		
	Date	22-28	4-7	60-85		4.5 mo.	
Grape	5	0.5	35-45	6	Ahumada <i>et al.</i> (1996)		
Grapefruit	10	0.05	0	21	Shellie et al. (1997a)		
	10	16.8	20	21	Shellie <i>et al.</i> (1997b)		
	46	1	20	0.13			
Kiwifruit	40	0.4	20	0.3	Lay-Yee and Whiting (1996)		
Lettuce	0	0.02		13	Cantwell <i>et al.</i> (1995, 1996) Zheng <i>et al.</i> (1993)		
	0	0.5		21			
	5	0.02		11			
	5	0.5		21			
	0		30-50	5			
	5		30-50	3-4			
Mango	20	0.2-0.3	50	5	Yahia (1993, 1994) Yahia <i>et al.</i> (1989) Yahia and Hernandez (1993) Yahia and Vazquez-Moreno (1993) Yahia and Ortega (1999) Yahia et al. (1997)		
	20	2	70-80	5			
	20	0.5		4			
	40, 42, 43	0	50	160 min			
	48	0.8	67	160 min			
	(mature green)	12 or 15	3			14-21	
	12	1	30-50	3	Bender et al. (2000) Leon et al. (1997)		
Nectarine	0	0.02		14	Folchi <i>et al.</i> (1994) Ke and Kader (1992b) Ke <i>et al.</i> (1994) Kerbel <i>et al.</i> (1990) Mitchell <i>et al.</i> (1984) Smilanick and Fouse (1989) Soderstrom <i>et al.</i> (1987)		
	0	0.24		28			
	5	0.5		3-6			
	5	2	20	8			
	6	0.3		30			
	10	0.02		10			
	10	0.25		13			
	15	0.5		2-3			
	20	0.25		3-5			
	25	0.50		2-3			
	0	4.2	80	10			
	0	1	99	6			
	Orange	5	0.02			16	Ke and Kader (1989, 1990)
		5	0.25			23	
10		0.02		15			
10		0.25		20			
5		8.4	60	5			
Orchid	0.5	8.4/4	60/4	1/5	Shelton <i>et al.</i> (1997)		
	0.5	8.4/0.1	60/0	1/2			
	0.5	0.1		2			
	0.5	0.1/4	0/4	2/4			
Papaya	20	0.2-0.4		2-3	Yahia <i>et al.</i> (1989, 1992), Yahia (1995)		
Peach	0	0.02		40	Carpenter <i>et al.</i> (1992) Ke <i>et al.</i> (1991c) Ke et al. (1994) Mitchell <i>et al.</i> (1984)		
	0	0.25		>40			
	5	0.02		14			
	5	0.25	60	14			
	0	8	80	7			
	0	4.2	99	6			

**Tolerance of some horticultural perishables to controlled atmospheres (continued).**

Commodity	Temperature (°C)	CA composition		Tolerance (days) <sup>z</sup>	References	
		O <sub>2</sub> %	CO <sub>2</sub> %			
Peach, cont.	0	1		3	Mitchell <i>et al.</i> (1984)	
	0	0.21	99	19		
	0	0.21		5		
	20	0.25	99	3-5		
	20	0.21		4		
Pear, Asian	0	0.02		14	Ke <i>et al.</i> (1991b) Zagory <i>et al.</i> (1989)	
	0	0.25		14		
	2	1-3		60-120		
	5	0.02		11		
	5	0.25		13		
Pear, European	0	0.02		>10	Chen and Mellenthin (1982) Ke <i>et al.</i> (1990, 1994) Mellenthin <i>et al.</i> (1980) Yoshida <i>et al.</i> (1986)	
	0	0.25		40		
	0	0.5		60		
	0	1	1-3	90		
	5	0.25		18		
	5	1		25		
	10	0.25		10		
	10	1		>10		
	25	0.25		3-5		
	0-10	10-16	20-50	6		
	5-10	4.2	80	4		
	20	0.25	80	2-3		
	28	1		3 h		Chervin <i>et al.</i> (1998,1999)
Persimmon	20	0.5	5	7-10	Dentener <i>et al.</i> (1990) Gazit and Adato (1972) Mitcham <i>et al.</i> (1997a) Pesis and Ben-Arie (1986) Pesis <i>et al.</i> (1986)	
	20	3	33	10		
	20	0-4	80-100	2-5		
	20	0.25	40	7		
Plum	0	8	60	7	Carpenter <i>et al.</i> (1992) Folchi <i>et al.</i> (1994) Ke <i>et al.</i> (1991b) Mitchell <i>et al.</i> (1984)	
	5	0.02		32		
	5	0.25		41		
	6	0.3		15		
	10	0.02		9		
	10	0.25		14		
	0	1	99	5		
5	4.2	80	6			
Rose	0	0.02		15-20	Cantwell <i>et al.</i> (1995, 1996) Zheng <i>et al.</i> (1993)	
	0	0.5		>21		
	5	0.02		7-14		
	5	0.5		>21		
	0		30-50	2-4		
	5		30-50	1-2		
	0.5		60	1		Shelton <i>et al.</i> (1997)
	0.5	8.4/4	60/4	1/5 <sup>y</sup>		
Strawberry	0	0.02		6	Ke <i>et al.</i> (1991a)	
	0	0.25		10		
	5	0.25		8		
	5	1		>10		
	0-5		20	10-15		
	0-5	4.2-10	50-80	8		
Sweet Potato	25	2	40	7-10	Delate and Brecht (1989)	

<sup>z</sup>Tolerance in days, unless otherwise noted

<sup>y</sup> Sequential controlled atmosphere treatment

## REFERENCES

- Ahumada, M.H., E.J. Mitcham, and D.G. Moore. 1996. Postharvest quality of 'Thompson Seedless' grapes after insecticidal controlled-atmosphere treatments. *HortScience* 31:833-836.
- Bender, R. J., J. K. Brecht, S. A. Sargent, and D. J. Huber. 2000. Mango tolerance to reduced oxygen levels in controlled atmosphere storage. *J. Amer. Soc. Hort. Sci.* 125(6):707-713.
- Botondi, R., A. Crisà, R. Massantini, and F. Mencarelli. 2000. Effects of low oxygen short-term exposure at 15°C on postharvest physiology and quality of apricots harvested at two ripening stages. *J. Hort. Science Biotech.* 75(2):202-208.
- Cantwell, M. X. Nie, M. Reid, A. Carpenter, and R.J. Zong. 1996. High carbon dioxide treatments for insect disinfestation of cut flowers and green leafy vegetables. pp. 410-415. In: *International Symposium on Postharvest Science and Technology of Horticultural Crops*. June 27-July 1, 1995. Beijing, China.
- Cantwell, M.K., M.S. Reid, A.Carpenter, and X. Nie. 1995. Short-term and long-term high carbon dioxide treatments for insect disinfestation of flowers and leafy vegetables, pp. 287-292. In: L. Kushwaha, R. Serwatowski, and R. Brook (eds): *Harvest and postharvest technologies for fresh fruits and vegetables*. Guanajuata, Mexico:ASAE.
- Carpenter, A., A. Stocker, and G. Van Der Mespel. 1992. Impact of CO<sub>2</sub> levels on New Zealand flower thrips and on stone fruit quality. *New Zealand J. Crop Hort. Sci.* 20:256.
- Chen, P. M., W.M. Mellenthin. (1982) Storage behaviour of 'd'Anjou' pears in low oxygen and air. In: Richardson, D.G.; Meheriuk, M. (eds) *Controlled Atmospheres for Storage and Transport of Perishable Agricultural Commodities*. Beaverton, Oregon, USA; Timber Press. pp. 139-148.
- Chen, P. M., W.M. Mellenthin, S.B. Kelly, and T.J. Facticeau. 1981. Effects of low oxygen and temperature on quality retention of 'Bing' cherries during prolonged storage. *J. Amer. Soc. Hort. Sci.* 106:533-535.
- Chen, P. M.; Olsen, K. L.; Meheriuk, M. (1985) Effects of low-oxygen atmosphere on storage scale and quality preservation of 'Delicious' apples. *J. Amer. Soc. Hort. Sci.* 110:16-20.
- Chervin, C., S.L. Kreidl, A.J. Hamilton, P.R. Franz, S.R. Whitmore, T. Thomann, J. Vitou, P.R. Merriman, and R. Walker. 1999. Evaluation of a non-chemical disinfestation treatment on the quality of pome fruit and mortality of lepidopterous pests. *Australian J. Exp. Agric.* 39:335-344.
- Chervin, C., A. Jessup, A. Hamilton, S. Kreidle, S. Kulkarni, and P. Franz. 1998. Non-chemical disinfestation: combining the combinations – additive effects of combination of three postharvest treatments on insect mortality and pome fruit quality. *Acta Hort.* 464:273-278.
- Chu, C.L. 1992. Postharvest control of San Jose scale on apples by controlled atmosphere storage. *Postharvest Biol. Technol.* 1:361-369.
- Corrigan, V.K. and A. Carpenter. 1993. Effects of treatment with elevated carbon dioxide levels on the sensory quality of asparagus. *New Zealand J. Crop Hort. Sci.* 21:349-357
- Couey, M. and K. Olsen. 1977. Commercial use of prestorage carbon dioxide treatment to retain quality in Golden Delicious apples. In: Dewey, D. H. (ed) *Controlled Atmospheres for Storage and Transport of Perishable Agricultural Commodities Horticultural Report No. 28*. East Lansing, Michigan, USA; Michigan State University pp. 165-169.
- Delate, K. M. and J.K. Brecht. 1989. Quality of tropical sweet potatoes exposed to controlled-atmosphere treatments for postharvest insect control. *J. Amer. Soc. Hort. Sci.* 114:963-968.
- Dentener, P.R., E.A. MacRae and P.J. Jackson. 1990. Insect disinfestation of New Zealand persimmons. In: *Abstracts of Contributed Papers, 23<sup>rd</sup> International Horticultural Congress, Firenze, Italy 27 August- 1 September 1990*. Abstract No.2163, p. 518.
- Dewey, D. H. and M.L. Bourne. 1982. Low oxygen CA storage of McIntosh apples. In: Richardson, D.G.; Meheriuk, M. (eds) *Controlled Atmospheres for Storage and Transport of Perishable Agricultural Commodities*. Beaverton, Oregon, USA; Timber Press. pp. 101-107.
- Folchi, A., G.C. Pratella, P. Bertolini, and P.P. Cazzola. 1994. Effects of oxygen stress on stone fruits. pp. 107-119. In: P.E. Zerbini *et al* (ed.): *Proc. Workshop Controlled Atmosphere Storage of Fruit and Vegetables*, April 22-23, 1993. Milan, Italy.
- Folchi, A., G.C. Pratella, S.P. Tian, and P. Bertolini. 1995. Effect of low oxygen stress in apricot at different temperatures. *Ital. J. Food Sci.* 7:245-254.
- Gaunce, A. P., C.V.G. Morgan, and M. Meheriuk. 1982. Control of tree fruit insects with modified atmospheres. In: Richardson, D.G.; Meheriuk, M. (eds) *Controlled Atmospheres for Storage and Transport of Perishable Agricultural Commodities*. Beaverton, Oregon, USA; Timber Press. pp. 383-390.
- Gazit, S. and I. Adato. 1972. Effect of carbon dioxide atmosphere on the course of astringency disappearance of persimmon (*Diospyros khaki* Linn.) fruits. *J. Food Sci.* 37:815 - 817.
- Hallman, G.J. 1994. Controlled atmospheres. pp. 121-136. In: R.E. Paull and J.W. Armstrong (eds): *Insect pests and fresh horticultural products: treatments and responses*. Wallingford, UK: CAB International.
- Irving, D.E. and L. Honnor. 1994. Carnations: effects of high concentrations of carbon dioxide on flower physiology and longevity. *Postharvest Biol. Technol.* 4:281-287.
- Kader, A.A. and D. Ke. 1994. Controlled atmospheres. pp. 223-236. In: R.E. Paull and J.W. Armstrong (eds): *Insect pests and fresh horticultural products: treatments and responses*. Wallingford, UK: CAB International.
- Ke, D. and A.A. Kader. 1989. Tolerance and responses of fresh fruits to oxygen levels at or below 1%, p. 209-216. In: *Proc. 5th Intl. Controlled Atmosphere Res. Conf., Wenatchee, Wash., 14-16 June 1989*, vol. 2.
- Ke, D. and A.A. Kader. 1990. Tolerance of 'Valencia' oranges to controlled atmospheres as determined by physiological responses and quality attributes. *J. Amer. Soc. Hort. Sci.* 115:779-783.

- Ke, D. and A.A. Kader. 1992a. Potential of controlled atmospheres for postharvest insect disinfestation of fruits and vegetables. *Postharvest News Infor.* 3:31N-37N.
- Ke, D. and A.A. Kader. 1992b. External and internal factors influence fruit tolerance to low oxygen atmospheres. *J. Amer. Soc. Hort. Sci.* 117:913-918.
- Ke, D., F. El-Wazir, F., B. Cole, M. Mateos, and A.A. Kader. 1994. Tolerance of peach and nectarine fruits to insecticidal controlled atmospheres as influenced by cultivar, maturity, and size. *Postharvest Biol. Technol.* 4:135-146.
- Ke, D., L. Goldstein, M. O'Mahony, and A. A. Kader. 1991a. Effects of short term exposure to low O<sub>2</sub> and high CO<sub>2</sub> atmospheres on quality attributes of strawberries. *J. Food Sci.* 56:50-54.
- Ke, D., L. Rodriguez-Sinobas, and A.A. Kader. 1991b. Physiology and prediction of fruit tolerance to low oxygen atmospheres. *J. Amer. Soc. Hort. Sci.* 116:253-260.
- Ke, D., L. Rodriguez-Sinobas, and A.A. Kader. 1991c. Physiological responses and quality attributes of peaches kept in low oxygen atmospheres. *Scientia Horticulturae* 47:295-303.
- Ke, D., H. van Gorsel, and A.A. Kader. 1990. Physiological and quality responses of 'Bartlett' pears to reduced-O<sub>2</sub> and enhanced-CO<sub>2</sub> atmospheres and storage temperature. *J. Amer. Soc. Hort. Sci.* 115:435-439.
- Ke, D., E.M. Yahia, B. Hess, L. Zhou, and A.A. Kader. 1995. Regulation of fermentative metabolism in avocado fruit under oxygen and carbon dioxide stresses. *J. Amer. Soc. Hort. Sci.* 120:481-490.
- Ke, D., E.M. Yahia, M. Mateos, and A.A. Kader. 1994. Ethanol fermentation of 'Bartlett' pears as influenced by ripening stage and atmospheric composition. *J. Amer. Soc. Hort. Sci.* 119:976-982.
- Kerbel, E., D. Ke., and A.A. Kader. 1990. Tolerance of 'Fantasia' nectarine to low O<sub>2</sub> and high CO<sub>2</sub> atmospheres. In: *Proc. Int'l Conf. on Technol. Innov. in Freezing and Refrig. of Fruits and Vegetables*, IIR, Paris, France, pp. 325-331.
- Kosittrakun, M. 1989. Effects of near anaerobic storage conditions on physiology and flavour of various fruit types and on apple maggot (*Rhagoletis pomonella*). Ph.D. Dissertation, Oregon State University, Corvallis, Oregon, USA.
- Lau, O. L. 1983. Effects of storage procedures and low oxygen and high carbon dioxide atmospheres on storage quality of 'Spartan' apples. *J. Amer. Soc. Hort. Sci.* 108: 953-957.
- Lay-Yee, M, D.C. Whiting, and K.J. Rose. 1997. Response of 'Royal Gala' and 'Granny Smith' apples to high-temperature controlled atmosphere treatments for control of *Epiphyas postvittana* and *Nyctelia huttoni*. *Postharvest Biol. Technol.* 12:127-136.
- Lay-Yee, M. and D.C. Whiting. 1996. Response of 'Hayward' kiwifruit to high-temperature/low oxygen controlled atmosphere treatments for control of two-spotted spider mite (*Tetranychus urticae*). *Postharvest Biol. Technol.* 7:73-81.
- Leon, D.M., J. de la Cruz, K.L. Parkin, and H.S. Garcia. 1997. Effect of controlled atmospheres containing low O<sub>2</sub> and high CO<sub>2</sub> on chilling susceptibility of Manila mangoes. *Acta Hort.* 455:635-642.
- Little, C. R., J.D. Fragher, and H.J. Taylor. 1982. Effects of initial oxygen stress treatments in low oxygen modified atmosphere storage of 'Granny Smith' apples. *J. Amer. Soc. Hort. Sci.* 107:320-323.
- Mellenthin, W. M., P.M. Chen, and S.B. Kelly. 1980. Low oxygen effects on dessert quality, scale prevention, and nitrogen metabolism of 'd'Anjou' pear fruit during long-term storage. *J. Amer. Soc. Hort. Sci.* 105:522-527.
- Mitcham, E.J., M.M. Attia, and W. Biasi. 1997a. Tolerance of 'Fuyu' persimmons to low oxygen and high carbon dioxide atmospheres for insect disinfestation. *Postharvest Biol. Technol.* 10:155-160.
- Mitchell, F. G., A.A. Kader, G. Crisosto, and G. Mayer. 1984. The tolerance of stone fruits to elevated CO<sub>2</sub> and low O<sub>2</sub> levels. Report to the California Tree Fruit Agreement, Sacramento, California, USA. 11 pp.
- Morgan, C. V. G. and A.P. Gaunce. 1975. Carbon dioxide as a fumigant against the San Jose scale (Homoptera:Diaspididae) on harvested apples. *Canadian Entomol.* 107:935-936.
- Navarro, S., E. Donahaye, M. Rindner, and A. Azieli. 1998. Storage of dried fruits under controlled atmosphere for preservation and control of nitidulid beetles. *Acta Hort.* 480:221-226.
- Patterson, M. E. 1982. CA storage of cherries. In: Richardson, D.G.; Meheriuk, M. (eds) *Controlled Atmospheres for Storage and Transport of Perishable Agricultural Commodities*. Beaverton, Oregon, USA; Timber Press. pp. 149-154.
- Patterson, M. E. and J.L. Melsted. 1977. Sweet cherry handling and storage alternatives. In: Dewey, D. H. (ed) *Controlled Atmospheres for Storage and Transport of Perishable Agricultural Commodities*. Horticultural Report No. 28. East Lansing, Michigan, USA; Michigan State University pp. 55-59.
- Pesis, E. and R. Ben-Arie. 1986. Carbon dioxide assimilation during postharvest removal of astringency from persimmon fruit. *Physiol. Plant.* 67:644-648.
- Pesis, E., A. Levi, and R. Ben-Arie. 1986. Deastringency of persimmon fruits by creating a modified atmosphere in polyethylene bags. *J. Food Sci.* 51:1014-1016, 1041.
- Prange, R. K. and Lidster, P. D. 1992. Controlled-atmosphere effects on blueberry maggot and lowbush blueberry fruit. *HortScience* 27:1094-1096.
- Shellie, K.C., J. Cumaragunta, and R.L. Mangan. 1997a. Hypoxic and hypercarbic cold storage for disinfesting grapefruit of Mexican fruit fly. *CA'97 Proceedings Volume 1, Postharvest Horticulture Series No. 15*. Davis, CA: Univ. Calif. Postharvest Outreach Program, pp. 98-104.
- Shellie, K.C., R.L. Mangan, and S.J. Ingle. 1997b. Tolerance of grapefruit and Mexican fruit fly larvae to heated controlled atmospheres. *Postharvest Biol. Technol.* 10:179-186.
- Shellie, K. C., L. Neven, and S. Drake. 2000. Controlled atmosphere temperature treatments for disinfestations of 'Bing' sweet cherry. *HortScience* 35(3):412.
- Shelton, M., A. Carpenter, and C.W. Van Epenhuijsen. 1997. Sequential CA: effects on aphids, spider mites and cut flower vase life. *CA'97 Proceedings Volume 1, Postharvest Horticulture Series No. 15*. Davis, CA: Univ. Calif. Postharvest Outreach Program,

pp. 127-131.

- Shelton, M.D., V.R. Walter, D.G. Brandl, and V. Mendez. 1996. The effects of refrigerated, controlled-atmosphere storage during marine shipment on insect mortality and cut-flower vase life. *HortTechnology* 6:247-250.
- Smilanick, K. L. and D.C. Fouse. 1989. Quality of nectarines stored in insecticidal low-O<sub>2</sub> atmospheres at 5° and 15°C. *J. Amer. Soc. Hort. Sci.* 114:431-436.
- Smittle, D. A. and W.R. Miller. 1988. Rabbit-eye blueberry storage life and fruit quality in controlled atmospheres and air storage. *J. Amer. Soc. Hort. Sci.* 113:723-728.
- Soderstrom, E. L. and D.G. Brandl. 1989. Codling moth response to controlled atmospheres. In: Fellman, J. K. (ed) Proceedings of the 5th International Controlled Atmosphere Research Conference, Wenatchee, Washington, USA, 14-16 June, 1989, vol. 1, pp. 215-219.
- Soderstrom, E. L., D.G. Brandl, and B. MacKey. 1990. Responses of codling moth (Lepidoptera: Tortricidae) life stages to high carbon dioxide or low oxygen atmospheres. *J. Econ. Entomol.* 83:472-475.
- Soderstrom, E. L., D.G. Brandl, and B. Mackey. 1991. Response of *Cydia pomonella* (L.) (Lepidoptera: Tortricidae) adults and eggs to oxygen deficient or carbon dioxide enriched atmospheres. *J. Stored Prod. Res.* 27:95-101.
- Soderstrom, E. L., D.G. Brandl, and J.L. Smilanick. 1987. Controlled atmospheres for postharvest control of codling moth on fresh tree fruits. Report to California Tree Fruit Agreement, Sacramento, California, USA.
- Yahia, E.M. 1995. Insecticidal atmospheres for tropical fruits. pp. 282-286. In: L. Kushwaha, R. Serwatowski, and R. Brook (eds): Harvest and Postharvest Technologies for Fresh Fruits and Vegetables. Guanajuato, Mexico.
- Yahia, E.M. 1994. The potential use of insecticidal atmospheres for mango, avocado, and papaya fruits. pp. 373-374. In: B.R. Champ, E. Highley, and G.I. Johnson (eds): Postharvest handling of tropical fruits. Canberra, Australia: Australian Centre for Agric. Res.
- Yahia, E.M. 1993. Responses of some tropical fruits to insecticidal atmospheres. *Acta Horticulturae* 343:371-376.
- Yahia, E. M. and A. Carrillo-Lopez. 1993. Responses of avocado fruit to insecticidal O<sub>2</sub> and CO<sub>2</sub> atmospheres. *Food Sci. & Technol. (Lebensmittel-Wissenschaft und Technologie)* 26:307-311.
- Yahia, E. M. and M.T. Hernandez. 1993. Tolerance and responses of harvested mango to insecticidal low-oxygen atmospheres. *HortScience* 28:1031-1033.
- Yahia, E. M. and D. Ortega. 1999. Effects of insecticidal controlled atmospheres at high temperature on the quality of mango fruit. *HortScience* 34(3):512.
- Yahia, E. M. and L. Vazquez-Moreno. 1993. Responses of mango to insecticidal oxygen and carbon dioxide atmospheres. *Food Sci. & Technol. (Lebensmittel-Wissenschaft und Technologie)* 26:42-48.
- Yahia, E.M., D. Ortega, P. Santiago, and L. Lagunez. 1997. Responses of mango and mortality of *Anastrepha ludens* and *A. obliqua* to modified atmospheres at high temperatures. CA'97 Proceedings Volume 1, Postharvest Horticulture Series No. 15. Davis, CA: Univ. Calif. Postharvest Outreach Program, pp. 105-112.
- Yahia, E. M., M. Rivera and O. Hernandez. 1992. Responses of papaya to short-term insecticidal oxygen atmospheres. *J. Amer. Soc. Hort. Sci.* 117:96-99.
- Yahia, E. M., F. Medina, and M. Rivera. 1989. The tolerance of mango and papaya to atmospheres containing very high levels of CO<sub>2</sub> and/or very low levels of O<sub>2</sub> as a possible insect control treatment. In: Fellman, J. K. (ed) Proceedings of the 5th International Controlled Atmosphere Research Conference, Wenatchee, Washington USA, 14-26 June, 1989. Vol. 2. pp. 77-89.
- Yoshida, T., D.M. Borgic, P.M. Chen, and E.A. Mielke. 1986. Changes in ethylene, acids, and brown-core development of 'Bartlett' pears in low oxygen storage. *HortScience* 21:472-474.
- Zagory, D., D. Ke, D., and A.A. Kader. 1989. Long term storage of 'Early Gold' and 'Shinko' Asian pears in low oxygen atmospheres. In: Fellman, J. K. (ed) Proceedings of the 5th International Controlled Atmosphere Research Conference, Wenatchee, Washington USA, 14-26 June, 1989. Vol. 1. pp. 353-358.
- Zheng, J., M.S. Reid, D. Ke, and M. Cantwell. 1993. Atmosphere modification for postharvest control of thrips and aphids on flowers and green leafy vegetables. Proceedings of the 6th International Controlled Atmosphere Research Conference, Ithaca, New York, USA, June 1993, pp. 394-401.
- Zhou, S., R. S. Criddle, and E. J. Mitcham. 2000. Metabolic response of *Platynota stultana* pupae to controlled atmospheres and its relation to insect mortality response. *J. Insect Physiol.* 46:1375-1385.
- Zhou, S. and E. J. Mitcham. 1998. Sequential controlled atmosphere treatments for quarantine control of pacific spider mites (Acari: Tetranychidae). *J. Econ. Entomol.* 91(6):1427-1432.