

CONTROLLED ATMOSPHERES FOR STORAGE  
AND TRANSPORT OF PERISHABLE  
AGRICULTURAL COMMODITIES

Papers Presented at the  
Fourth National Controlled  
Atmosphere Research Conference

July 23-26, 1985

Raleigh, North Carolina

Edited by

Sylvia M. Blankenship, Assistant Professor  
Department of Horticultural Science  
North Carolina State University

Sponsored by

Department of Horticultural Science  
North Carolina State University  
Horticultural Report #126

## PREFACE

The manuscripts contained in this proceedings were all presented at the Fourth National Controlled Atmosphere Research Conference, held July 23-26, 1985, at the Raleigh Hilton Hotel, Raleigh, North Carolina. The conference was sponsored by the Department of Horticultural Science, North Carolina State University. Thanks to the cooperation of the authors, little editing of the manuscripts was necessary and they appear much as they were submitted. Summaries of CA conditions for various commodities and a list of CA equipment suppliers are included at the end of the proceedings. The summaries were compiled to indicate the range of CA conditions that have been used and are not to be taken as recommendations.

The support of the conference sponsors was greatly appreciated. A list of the sponsors appears in the following pages. I hope everyone who reads this proceeding will take a moment to look at the list of sponsors. Without their support it would have been difficult to have had this conference.

Thanks should go to the Program Committee and the Local Arrangements Committee. The Program Committee, who planned the conference agenda, was composed of Adel Kader (Chairman), G. David Blanpied, David R. Dilley, Werner J. Lipton, Daryl G. Richardson, William R. Romig, and Larry K. Hammett. The Local Arrangements Committee, who handled details of registration and meeting facilities, was composed of Walter E. Ballinger (Chairman), Sylvia M. Blankenship, Larry K. Hammett, and L. George Wilson. A special thanks should go to Mrs. Margaret Pittman for handling much of the paperwork and registration for the conference, and Mrs. Jean Wilkinson who did the secretarial work necessary to put the proceeding together and helped tremendously in organizing the manuscripts.

I would like to thank the Visual Communications Division of North Carolina State University, particularly Mr. Jimmy Tart and Dr. David Jenkins for their assistance in preparing this proceedings.

Sylvia M. Blankenship  
Dept. of Horticultural Science  
North Carolina State University  
Raleigh, North Carolina

Sponsors

Austin Foods Company  
One Quality Lane  
Cary, NC 27511  
(919) 467-0164

Campbell Soup Company  
Buck Carter  
Route 2, Box 98  
Maxton, NC 28364  
(919) 844-3318

Catalytic Generators, Inc.  
1185 Pineridge Road  
Norfolk, VA 23502  
(804) 855-0191

Eagle Snacks  
Anheuser-Busch Companies  
David Dickerson  
1101 Wyoming Street  
St. Louis, MO 63118-2627  
(314) 577-4831

General Food Corporation  
250 North Street  
White Plains, NY 10625  
(914) 335-2500

National Fruit Company  
Clyde Brown  
P.O. Box 916  
Lincolnton, NC 28093  
(704) 735-2531

Neogen Food Tech. Corp.  
4245 Okemos Road  
Okemos, MI 48864  
(517) 349-9162

Pepsi-Cola Bottling Company  
of Raleigh, NC, Inc.  
Bobby R. Moon, Sales Manager  
2838 Wake Forest Road  
Raleigh, NC 27609  
(919) 828-0391

Perishables Research Organization  
P.O. Box 2227  
Novato, CA 94948  
(415) 898-2001

R.J.R. Technical Company  
110 Reynolds Blvd.  
Winston-Salem, NC 27102  
(919) 773-4637

U.S. Department of Agriculture  
Cooperative State Research Service  
Office of the Administrator  
Washington, DC 20250  
(202) 447-4201

Wise Foods/Borden, Inc.  
Jim Watts  
228 Raseley Street  
Berwick, PA 18603  
(717) 759-4160

CONFERENCE PARTICIPANTS

- Abeles, Dr. Fred B., Appalachian Fruit Research Station, Kearneysville,  
West Virginia 25430 USA (304)725-3451
- Adams, Mr. Glenn, C.T.S., 42 Henderson Rd., Clayton, North 3168, Victoria,  
Australia (408)424-2911 - c/o TransFRESH Corp., USA
- Aharoni, Dr. Nehemia, Plant Hormone Lab., USDA,ARS, BARC-west, Beltsville,  
Maryland 20705 USA (301)399-3629 - Permanent Address: Dept. of Fruit  
and Vegetable Storage, Agric. Res. Organization, The Volcanic Center,  
Bet Dagan 50250, Israel
- Akins, Mr. Gene, Catalytic Generators, Inc., Norfolk, Virginia 23502 USA  
(804)855-0191
- Armstrong, Dr. Glenn S., General Mills, Inc., 9000 Plymouth Ave., N.  
Minneapolis, Minnesota 55427 USA (612)540-7273
- Autio, Dr. Wesley R., University of Massachusetts, French Hall, Amherst,  
Massachusetts 01003 USA (413)545-2249
- Baker, Mr. Daniel A., Shield Brite Corp., P.O. Box 558, Kirkland,  
Washington 98003 USA (206)827-8711
- Ballinger, Dr. Walter E., Horticultural Science Dept., Box 7609, N. C. State  
University, Raleigh, North Carolina 27695 USA (919)737-3189
- Baumgardner, Dr. R.A., Horticultural Science Dept., Clemson University,  
Clemson, South Carolina 29635 USA (803)656-3011
- Baxter, Mr. Lawford, 320 Alderman Hall, University of Minnesota, St. Paul,  
Minnesota 55108 USA (612)373-1163
- Beaton, Mrs. Nancy, Catalytic Generators, 1185 Pineridge Road, Norfolk,  
Virginia 23502 USA (804)855-0191
- Bedrosian, Dr. Karakian, Natural Pak Systems, Sherwood Ct., Alpine, New  
Jersey 07620 USA (201)767-0249
- Berard, Miss Luce S., Agriculture Canada, C.P. 457, St-Jean-sur-Richelieu,  
Quebec, Canada J3B 6Z8 (514)346-4494
- Binkley, Dr. C. Robert, Knouse Foods Cooperative, Inc., Main Street.,  
Peach Glen, Pennsylvania 17306 USA (717)677-8181
- Blankenship, Dr. Sylvia M. Horticultural Science Dept., Box 7609, N. C.  
State University, Raleigh, North Carolina 27695 USA (919)737-3166
- Blanpied, Dr. G. David, Pomology Dept., Cornell University, Ithaca, New  
York 14850 USA (607)256-5438
- Blonski, Mr. Mieczslaw, PZ Comindex, Ul. 17 Stycznia 32, Warsaw, Poland  
PL-02148 467 081 ext. 260
- Bramlage, Dr. William J., Dept. of Plant & Soil Sciences, University of  
Massachusetts, French Hall, Amherst, Massachusetts 01003 USA  
(413)545-2244
- Buescher, Dr. Ron W., Food Science Dept., University of Arkansas, RR11.  
Fayetteville, Arkansas 72701 USA (501)575-4605
- Cain, Mr. Jack, Catalytic Generators, Inc., 1185 Pineridge Rd., Norfolk,  
Virginia 23502 USA (804)855-0191
- Calbo, Dr. Adonai G., KM 09 Rod. Brasilia/Anapolis, CP 11.1316, CEP 70.333,  
Brasilia, DF. Brazil
- Chen, Dr. Paul M., Mid-Columbia Expt. Sta., Oregon State Univ., 3005 Expt.  
Sta. Dr., Hood River, Oregon 97031 USA (503)386-2030
- Chestnutt, Mr. James L., R.J.R. Archer, Reynolds Blvd., BGTC, Winston-  
Salem, North Carolina 27102 USA (919)773-5986

Chu, Dr. Chun-Lung (George), Horticultural Research Institute of Ontario,  
Vineland Station, Ontario, Canada LOR 2E0 (416)562-4141

Cottle, Dr. Wendell E., Hercules Incorporated, Research & Development Dept.,  
Research Center, Wilmington, Delaware 19894 USA (302)995-3179

Crowder, Mr. Emry L., Crowder Refrigeration, Inc., P.O. Box 1188,  
Okanogan, Washington 98840 USA (509)422-3395

Curry, Dr. Eric A., USDA,ARS, 1104 Western, Wenatchee, Washington 98801  
USA (509)662-4317

D'Amico, Mr. Joseph S., Nitrotec Engineering Co., 7310 Ritchie Hwy.,  
Glen Burnie, Maryland 21061 USA (301)766-6595

DeMent, Dr. Jack D., Castle & Cooke Foods, P.O. Box 3080, Boca Raton,  
Florida 33421 USA (305)368-1671

Dewey, Dr. Donald H. (Retired) Michigan State University/1423 Lakeside Dr.,  
East Lansing, Michigan 48823 USA (517)337-8018

Diedering, Ms. Deborah E., Chemical Engineer, Dow Chemical Ci., 1891 N.  
Swede Rd., Midland, Michigan 48640 USA (515)636-0235

Dilley, Ms. Catherine L., Neogen Food Tech. Corp., 241 East Saginaw Suite  
517, East Lansing, Michigan 48823 USA (517)332-8700

Dilley, Dr. David R., Michigan State University, Horticulture Dept.,  
East Lansing, Michigan 48824 USA (517)355-3286

Douglas, Mr. James B., Zeigler Mechanical Contractors, P.O. Box 3095,  
Winchester, Virginia 22601 USA (703)667-4757

Dover, Mr. Colin J., East Malling Research Station, East Malling, Maidstone,  
Kent, United Kingdom 0732 843 833

D'Souza, Mr. Mervyn C., Division of Plant & Soil Sciences, West Virginia  
University, P.O. Box 6108, Morgantown, West Virginia 26506 USA

Eisenberg, Dr. Barry A., University of Illinois, Horticulture Dept., 407 W.  
Dorner Dr., Urbana, Illinois 61801 USA (217)333-7980

Eksteen, Dr. Gabriel J., Fruit Tech. Res. Institute, P. Bag X-5013,  
Stellenbosch 7600, Republic of South Africa 27 2231 2001 Est. 138

El-Kazzaz, Dr. Mohamed K., Plant Pathology Dept., Faculty of Agriculture,  
Tanta University, Kafr El-Sheikh, Egypt

El-Khoreiby, Dr. Ali M., Dept. Horticulture, Faculty of Agriculture,  
Suez Canal University, Ismailia, Egypt

Elson, Dr. Clive M., NovaChem Ltd., P.O. Box 1030, Armdale, Halifax, Nova  
Scotia, Canada B3L 4K9 (902)429-9780, loc. 2268

Escrache, Dr. Angel J., Centro de Edafologia Y Biologia Aplicada del  
Segura, Consejo Superior Investigaciones Cietificas, P.O. 195,  
Murcia, Spain 217662

Feng, Mrs. Shuang Ging, Horticulture Science Dept., University of Guelph,  
Guelph, Ontario, Canada N1G 2W1 (519)824-4120, Ext. 2233

Fica, Mr. Joachim, Horticulture Dept., Michigan State Univ., East Lansing,  
Michigan 48824 USA (517)355-7483

Findlay, Mr. John S., Farmer & C.A. Store Operator, Graymead Farm, P.O.  
Elgin, South Africa 7180 (S.A.) 0225-4820

Frenkel, Dr. Chaim, Rutgers - The State University, Dept. of Horticulture,  
Box 231, New Brunswick, New Jersey 08903 USA (201)932-9471

Gruber, Mr. Jack, University of Illinois, Horticulture Dept., 407 W. Dorner  
Dr., Urbana, Illinois 61801 USA (217)333-7980

Guanshu, Mrs. Wang, Design Institute Ministry of Commerce, 11 Fucheng  
Road, Beijing, China 892-329

Hammett, Dr. Larry K., USDA,ARS, Dept. of Horticultural Science, N. C. State University, Raleigh, North Carolina 27695 USA (919)737-3166

Henneman, Mr. John W., Clifton Precision Instruments & Life Support Div., 2734 Hickory Grove Rd., P.O. Box 4508, Davenport, Iowa 52808 USA (319)383-6425

Hentschke, Mr. Roque, Dept. of Horticulture, Santa Catarina State Extn. Service (ACARESC), C.P. 502 - Florianopolis 88 000 - Santa Catarina, Brazil

Hicks, Dr. James R., Vegetable Crops Dept., Cornell University, Ithaca, New York 14853 USA (607)256-4593

Hillstrom, Mr. Robert S., Inotek International Co., P.O. Box 358, Painesville, Ohio 44077 USA

Houston, Mr. William, Controlled Atmosphere Instrumentation, Inc., Rt. 2, Box 106, Tyee, Okanogan, Washington 98840 USA (509)422-6381

Huang, Mr. Chao-Chia, Pomology Dept., Cornell University, Ithaca, New York 14853 USA (607)256-5438

Hudson, Dr. Donald E., USDA,ARS, Hort Crops Qual. Res. Bldg., 6021, P.O. Box 231, Rutgers Univ., Cook College, New Brunswick, New Jersey 08903 USA

Ingle, Dr. Morris, Div. of Plant & Soil Sciences, West Virginia Univ., P.O. Box 6108, Morgantown, West Virginia 26506 USA (304)293-6023

Johnson, Mr. David S., East Malling Research Station, East Malling, Maidstone, Kent, United Kingdom ME19 6BJ (0732-843833)

Joyce, Mr. Daryl C., University of California, Dept. of Environ. Hort. Davis, California 95616 USA (916)752-7060

Kader, Dr. Adel A., Univ. of California, Dept. of Pomology, Davis, California 95616 USA (916)752-0909

Kanellis, Mr. Angelos K., Graduate Student, Univ. of Maryland, Dept. of Horticulture, College Park, Maryland 20742 USA (301)454-6704

Karper, Mr. Cyrus A., Knouse Foods Cooperative, Inc., Main Street, Peach Glen, Pennsylvania 17306 USA

Klag, Mr. Nancy G., USDA, Plant Protection & Quarantine, 209 River St., Hoboken, New Jersey 07030 USA (201)659-9099

Kramer, Mr. Leon W., Duckwall-Pooley Fruit Co., P.O. Box 150, Odell, Oregon 97044 USA (503)386-3171

Krueger, Mr. Edward R., C.A. Equipment, 104 11th St., NE, E. Wenatchee, Washington 98801 USA (509)884-1549

Kupferman, Dr. Eugene M., Washington State Univ., TFRC, 1100 N. Western Wenatchee, Washington 98801 USA (509)663-8181

Lacasse, Mr. Stephen T., Shoreham Cooperative Apple Producers Assoc., P.O. Box 175, Shoreham, Vermont 05770 USA (802)898-7400

Lange, Dr. Edward, Research Institute of Pomology, Skierniewice, Poland

Lau, Dr. Oi-Lim (Sam), Okanagan Federated Shippers Assoc., c/o Agriculture Canada Res. Sta., Summerland, BC, Canada VOH 1Z0 (604)494-7711

Leake, Dr. Luther, The Pillsbury Co., 311 Second St., SE, Minneapolis, Minnesota 55414 USA

Leavens, Mr. Roland B., Design Coordination-Food Plant Engineering, Inc., P.O. Box 9906, Yakima, Washington 98909 USA (509)248-5530

Lee, Dr. Julian J., Michigan State Univ., School of Packaging, East Lansing, Michigan 48824 USA (517)355-9117

Lehman, Ms. Laura J., Graduate Student, Horticultural Science Dept., N. C. State University, Raleigh, North Carolina 27695 USA (919)737-3178

Leshuk, Mr. Jeff, University of Illinois, Dept. of Horticulture, 407 W. Dorner Dr., Urbana, Illinois 61801 USA (217)333-7980

Lidster, Dr. Perry D., Agriculture Canada, Kentville, Nova Scotia, Canada B4N 1J5 (902)678-2171

Lipton, Dr. Werner J., USDA,ARS, 2021 S. Peach Ave., Fresno, California 93727 USA (209)487-5334

Little, Mr. Colin R., Horticulture Research Institute, Knoxfield, P.O. Box 174, Ferntree Gully, Victoria, Australia 3156 61.3. 2212233

Liu, Dr. Frank W., Dept. of Pomology, Cornell University, Ithaca, New York 14853 USA (607)256-5438

Lougheed, E.C., Horticulture Science Dept., Univ. of Guelph, Guelph, Ontario, Canada N1G 2W1 (159)824-4120 - Ext. 3032 or 2233

Lovegrove, Mr. John, Shipping Corp. of New Zealand, P.O. Box 3420, Auckland, New Zealand (c/o TransFRESH Corp.), USA - (408)424-2911

Massey, Jr., Dr. Louis M., New York State Agric. Expt. Sta., Cornell Univ., Geneva, New York 14456 USA (319)787-2284

Masters, Ms. Jacqueline F., Vegetable Crops Dept., Cornell University, 158 Plant Science Bldg., Ithaca, New York 14853 USA (607)256-4417

Matthaeus, Mr. Michael V., High Transport Ltd., (International Agritech), P.O. Box 11368, Santa Rosa, California 95406 USA (707)578-5511

Mattus, Dr. George E., Virginia Technical Institute, 706 Airport Rd., Blacksburg, Virginia 24060 USA (703)552-4520

Meheriuk, Dr. Michael, Agriculture Canada, RR2, Summerland, British Columbia, Canada V0H 1Z0

Meriwether, Dr. Lewis S., American Cyanamid Co., 1937 W. Main St., P.O. Box 60, Stamford, Connecticut 06904 USA (203)348-7331 Ext. 2389

McConnell, Mr. Danny R., McConnell Farms, Rt. 1, Box 387, Hendersonville, North Carolina 28738 USA (704)692-8125

Muñoz, Mr. Antonia, Incomex, P.O. Box 90, Murcia, Murcia, Spain 34/68/831600

Muñoz, Mr. Francisco L., Incomex, P.O. Box 90, Murcia, Murcia, Spain 34/68/831600

Navarro, Mr. Jesus, Incomex, P.O. 90, Murcia, Murcia, Spain 34/68/831600

Olsen, Dr. Kenneth L., USDA,ARS, Tree Fruit Research Lab., 1104 N. Western Ave., Wenatchee, Washington 98801 USA (509)662-4317

Patten, Dr. Kim D., Texas A&M University, Drawer F, Overton, Texas 75484 USA (214)834-6191

Patterson, Dr. Max E., Dept. of Horticulture/Landscape, Washington State University, Pullman, Washington 99164-6414 USA (509)335-3454

Peary, Mr. James S., Dept. of Horticulture, The Ohio State University, 2001 Fyffe Ct., Columbus, Ohio 43210 USA (614)422-5030

Perrin, Dr. Peter W., Agriculture Canada Res. Sta., Box 1000, Agassiz, British Columbia, Canada V0M 1A0 (604)796-221

Phan, Dr. Ton C., Dept. Biological Sciences, Universite' de Montreal, C.P. 6128, Station "A", Montreal, Quebec Canada H3C 3J7 (514)343-7239

Prince, Dr. Tim A., Dept. of Horticulture, Ohio State University, 2001 Fyffe Ct., Columbus, Ohio 43210 USA (614)422-8200

Purvis, Dr. Albert C., Horticulture Dept., Louisiana State University, 137 Julian Miller Hall, Baton Rouge, Louisiana 70803 USA (504)388-2052

Qi, Mr. Shou-chun, Dept. of Pomology, 136 Plant Science Bldg., Cornell University, Ithaca, New York 14853 USA (607)256-5438

Reis, Mr. Sinval, Paraná State Storage Co. (COPASA), Rua Monsenhor Celso, 154, Curitiba, 80 000, Paraná, Brazil

Reyes, Dr. Andres A., Agriculture Canada, Vineland Station, Ontario,  
Canada LOR 2E0 (416)562-4113

Rice, Mr. David R., Rice Fruit Co., Box 361, Biglerville, Pennsylvania  
17307 USA (717)677-8131

Rice, Mr. Mark L., Rice Fruit Co., Box 361, Biglerville, Pennsylvania  
17307 USA (717)677-8131

Richardson, Dr. Daryl G., Horticulture Dept., Oregon State University,  
Corvallis, Oregon 97331 USA (503)754-3695

Rij, Mr. Roger E., USDA,ARS, 2021 S. Peach St., Fresno, California  
92727 USA

Rodde, Mr. Ken, TransFRESH Corp., P.O. Box 1788, Salinas, California  
93902 USA (408)424-2911

Romig, Dr. William R., General Foods Corp., 555 S. Broadway, Tarrytown,  
New York 10591 USA

Saltveit, Jr., Dr. Mikal E., Dept. of Vegetable Crops, University of  
California, Davis, California 95616 USA (916)752-1815

Shiflett, Mr. Richard H., Controlled Atmosphere Equipment, 104 11th St.,  
NE, East Wenatchee, Washington 98801 USA (509)884-1549

Sive, Mr. Arye, Cold Storage Research Lab., Israel Fruit Growers Assoc.,  
Kirya Shemona 10200 Israel (067) 40208

Skrzynski, Mr. Jan, Michigan State University, Horticulture Dept., East  
Lansing, Michigan 48823 USA (517)233-7483; Permanent address:  
Hort. Dept., Academy of Agriculture, 29 Listopada, 48, 31-425  
Krakow, Poland

Soderstrom, Dr. Edwin L., USDA,ARS, Horticultural Crops Res. Lab.,  
2020 S. Peach, Fresno, California 93727 USA (209)487-5310

Solomos, Dr. Theo, Dept of Horticulture, University of Maryland, College  
Park, Maryland 20742 USA (301)454-6504

Sorensen, Mr. Eduardo, B.SC. Engineer, President, SASA SAC, P.O. Box 423,  
Santiago, Chile (2) 2318003

Staby, Dr. George L., Perishables Research Organization, P.O. Box 2227,  
Novato, California 94948 USA (415)898-2001

Stone, Dr. Edward, Campbell Soup Co., Campbell Place, Camden, New Jersey  
08101 USA (609)342-6035

Tompkins, Dr. Daniel R., USDA, Rm. 6440 South, Coop. State Research  
Service, Washington, DC 20250 USA (202)447-4201

Valenti, Dr. Peter C., R.J.R. Technical Co., 1100 Reynolds Blvd., Winston-  
Salem, North Carolina 27102 USA (919)773-4637

Walter, Jr., Dr. William M., USDA, Dept. of Food Science, North Carolina  
State University, Raleigh, North Carolina 27695 USA (919)737-2979

Wang, Dr. Chien Y., USDA, Bldg. 002, BARC-west, Beltsville, Maryland  
20705 USA (301)344-3128

Waters, Jr., Dr. Luther, Department of Horticulture, University of  
Minnesota, 1970 Folwell Ave., St. Paul, Minnesota 55108 USA  
(612)373-1102

Watkins, Mr. Chris, Div. of Horticulture & Processing, DSIR Private Bag,  
Auckland, New Zealand (201) 932-9471 (in USA Rutgers Univ.)

Werner, Mr. Reni, Dept. of Horticulture, Santa Catarina State Extension  
Service (ACARESC), C.P. 502, Florianopolis, 88 000, Santa Catarina,  
Brazil

Weck, Mr. Fred H., Purafil Inc., 981, Route 22, Suite 2000, Bridgewater,  
New Jersey 08807 USA (201)725-3761

- Williams, Dr. Kathy M., Horticultural Science Dept., Box 7609, N. C.  
State University, Raleigh, North Carolina 27695 USA (919)737-3283
- Wilson, Dr. L. George, Horticultural Science Dept., Box 7609, N. C.  
State University, Raleigh, North Carolina 27695 USA (919)737-3283
- Winkler, Mr. Gary A., Oscar Meyer, 910 Meyer Ave., Madison, Wisconsin  
53704 USA (608)241-3311
- Wojciechowski, Dr. Jerzy, Institute of Catalysis and Surface Chemistry,  
Ul. Niezapominajek 1, Cracow, Poland PL-30239 (Cracow) 225900
- Wolfe, Dr. Steve, Fresh Western Marketing, Inc., P.O. Box 5275, Salinas,  
California 93915 USA (408)758-1390
- Worthington-Smith, Mr. Peter S., Worthington-Smith & Brouwer, 601 Tulbagh  
Centre, Hans Strijdom Ave., Foreshore Cape Town, Republic of South  
Africa (021) 216216
- Xiangrong, Mr. You, Design Institute, Ministry of Commerce, 11 Fucheng  
Road, Beijing, China 892329
- Yahia, Mr. Elhadi, Dept. of Pomology, Cornell University, Ithaca, New  
York 14853 USA (607)256-5438
- Yuncheng, Mr. Dai, Design Institute, Ministry of Commerce, 11 Fucheng  
Road, Beijing, China 892329

TABLE OF CONTENTS

|   | Page |
|---|------|
| An overview of the physiological and biochemical basis of CA effects on fresh horticultural crops.<br><i>Adel A. Kader</i> .....  | 1    |
| Interactions between O <sub>2</sub> levels, rate of respiration and gas diffusion in five apple varieties.<br><i>Theophanes Solomos</i> .....   | 10   |
| The effect of low oxygen on the activities of pectin-methylesterase and acid phosphatase during the course of ripening of bananas.<br><i>Angelos Kanellis and Theophanes Solomos</i> .....  | 20   |
| An unknown organic acid that accumulates during CA storage.<br><i>C.T. Phan and F. Cormier</i> .....  | 27   |
| A new method for the determination of ACC.<br><i>C.T. Phan and D. Lanneluc-Sanson</i> .....   | 30   |
| Are substituted benzothiadiazoles specific inhibitors of ethylene action.<br><i>Fred B. Abeles</i> .....  | 33   |
| Storage responses of four apple cultivars to low O <sub>2</sub> atmospheres.<br><i>O.L. (Sam) Lau</i> .....   | 43   |
| Factors affecting the progressive development of low-oxygen injury in apples.<br><i>Perry D. Lidster, G.D. Blanpied, and E.C. Lougheed</i> .....  | 57   |
| Odor-active volatiles in McIntosh apples stored in stimulated low-ethylene controlled atmospheres.<br><i>El Hadi Yahia, F.W. Liu, Terry E. Acree, and Robert Butts</i> .....                | 70   |
| The effect of delayed cooling and delayed application of CA storage of McIntosh apples under low and high ethylene levels.<br><i>Joachim Fica, Jan Skrzynski, and David R. Dilley</i> ..... | 82   |
| Low ethylene CA storage for Empire apples.<br><i>G.D. Blanpied</i> .....  | 95   |
| Processing quality of three eastern-grown apple cultivars following CA storage.<br><i>L.M. Massey, Jr. and M.R. McLellan</i> .....  | 103  |
| The effect of ethylene removal during controlled atmosphere storage of Red Delicious, Empire, Idared, and Law Rome apples.<br><i>Jan Skrzynski, Joachim Fica, and David R. Dilley</i> ..... | 115  |
| Conditions for low ethylene CA storage of apples:<br>A review. <i>F.W. Liu</i> .....  | 127  |

|  |     |
|--|-----|
| Effect of CO <sub>2</sub> concentration on ethylene production, organic acid retention, and internal disorders of pear fruit in low O <sub>2</sub> storage.<br><i>Paul M. Chen, Takashi Yoshida, and Diane M. Borgie</i> ..... | 135 |
| Effect of low O <sub>2</sub> atmospheres on postharvest quality of Chinese cabbage, cucumbers, and eggplants.<br><i>Chien Yi Wang</i> .....  | 142 |
| Effect of CA on several storage disorders of winter cabbage. <i>Luce S. Bérard</i> .....   | 150 |
| The effects of CA on deterioration of broccoli.<br><i>Donald E. Hudson and Paul A. Lachance</i> .....  | 160 |
| Modified atmospheres to delay senescence and decay of broccoli.<br><i>Nehemia Aharoni, Sonia Philosoph-Hadas, and Rivka Barkai-Golan</i> .....   | 169 |
| Protecting pickling cucumbers from deterioration by controlled atmospheres.<br><i>Ronald W. Buescher</i> .....   | 178 |
| X Effect of pathogen-suppressing modified atmospheres on stored cut flowers.<br><i>Daryl C. Joyce and Michael S. Reid</i> .....  | 185 |
| Use of CA for quarantine control of insects on fresh fruits and vegetables.<br><i>Narcy G. Klag</i> .....  | 199 |
| Controlled atmospheres to reduce postharvest insect damage to horticultural crops.<br><i>Edwin L. Soderstrom and David G. Brandl</i> .....   | 207 |
| Sources of variation and variability in measuring and adjusting controlled atmospheres.<br><i>E.C. Loughheed, David J. Bishop, and G.D. Blanpied</i> .....   | 213 |
| New CA storage research facilities at the Horticultural Research Institute of Ontario.<br><i>C.L. Chu, R.B. Smith, and E.M. Lauro</i> .....  | 229 |
| Small scale simulated commercial CA storage rooms.<br><i>E.C. Loughheed, L.S. Wiley, and J.T.A. Proctor</i> .....  | 235 |
| Development of the differentially permeable fruit coating "Nutri-Save <sup>R</sup> " for the modified atmosphere storage of fruit.<br><i>Clive M. Elson, Ernie R. Hayes, and Perry D. Lidster</i> .....                        | 248 |
| X MA Packaging of tulip bulbs: Physiological implications, disease control, and package performance under temperature fluctuation.<br><i>Timothy A. Prince and Robert C. Hermer</i> .....                                      | 263 |
| Effect of two polymeric coatings on fruit quality in d'Anjou and Bartlett pears.<br><i>M. Meheriuk and O.L. Lau</i> .....  | 270 |

|  |     |
|--|-----|
| Current status and recent trends in CA storage<br>in Washington. <i>Kenneth L. Olsen</i> .....   | 276 |
| Storage construction for effective ultra low oxygen<br>storage in Australia.<br><i>C.R. Little and B.L. Tugwell</i> .....  | 281 |
| Summary of CA storage in China.<br><i>Wang Guangshu</i> .....  | 290 |
| Recent advances in low O <sub>2</sub> and low ethylene<br>storage of apples in Poland.<br><i>Edward Lange</i> .....  | 295 |
| Dynamic control of storage atmospheres.<br><i>A.S. Wollin, C.R. Little, and J.S. Packer</i> .....  | 308 |
| Most efficient and dependable CA control of fruits<br>and vegetables utilizing pressure swing<br>adsorption with carbon molecular sieve.<br><i>Joseph S. D'Amico</i> ..... | 316 |
| *Commercialization of controlled atmospheres<br>during transportation.<br><i>George L. Staby</i> .....   | 323 |
| Generon* air separation system.<br><i>D.E. Diederling and K.B. McReynolds</i> .....  | 325 |
| Economic analysis of systems used to establish<br>CA atmospheres.<br><i>J.A. Bartsch, Alison M. Wolanyk, and G.D. Blanpied</i> .....                                       | 336 |
| Ethylene effects on postharvest fruit diseases.<br><i>M.K. El-Kazzaz, N.F. Sommer, and A.A. Kader</i> .....  | 348 |
| Production of ethylene gas inside the ripening room<br><i>Eugene Akins</i> .....   | 352 |
| New technology for analyzing ethylene and determining<br>the onset of the ethylene climacteric of apples.<br><i>Catherine L. Dilley and David R. Dilley</i> .....          | 353 |
| A comparison of ethylene removal by means of catalytic<br>combustion and chemical absorption.<br><i>Jerzy Wojciechowski, G.D. Blanpied, and J.A. Bartsch</i> .....         | 363 |
| Effects of ethylene removal during storage of Bramley's<br>seedling. <i>C.J. Dover</i> .....   | 374 |

| <u>Summaries</u>   | Page |
|--|------|
| Controlled atmosphere storage conditions for some of the more commonly grown apple cultivars.<br><i>M. Meheriuk</i> .....  | 395  |
| CA recommendations for pears (including Asian pears).<br><i>Daryl G. Richardson</i> .....  | 422  |
| A summary of CA requirements and recommendations for fruits other than pome fruits.<br><i>Adel A. Kader</i> .....  | 445  |
| A summary of CA requirements and recommendations for vegetables. <i>Mikal E. Saltveit</i> .....  | 471  |
| A summary of CA requirements, limitations, and recommendations for ornamentals.<br><i>Barry A. Eisenberg</i> .....   | 493  |
| List of suppliers of equipment, materials, and services related to controlled and modified atmosphere packaging, transport, and storage of perishable commodities.<br><i>Adel A. Kader</i> ..... | 506  |