NEW CA STORAGE RESEARCH FACILITIES AT THE HORTICULTURAL RESEARCH INSTITUTE OF ONTARIO

C. L. Chu, R. B. Smith and E. M. Lauro
Horticultural Research Institute of Ontario
Vineland Station, Ontario, Canada LOR 2E0

With the support of the Board of Industrial Leadership and Development (BILD) program introduced by the Provincial Government, Ontario's fruit and vegetable industry has begun to avail itself of the benefits of new technology to extend storage life and maintain crop quality in order to compete with other producing areas of the world. Many commercial fruit and vegetable storage facilities have been built in Ontario with encouragement from Provincial and Federal storage assistance programs. The BILD program and the Ontario Ministry of Agriculture and Food have also funded a total of $1.6 million toward the capital investment of a major storage research facility for fruit and vegetable storage at the Horticultural Research Institute situated at Vineland Station. The building construction was started in November 1981 and was officially opened in November 1984.

This new storage research facility is in a one-floor brick building which sits on a total area of approximately 930 m^2 (Fig. 1). It consists of 6 medium size CA storage rooms, 17 small size CA storage rooms, 3 fumigation rooms, 30 portable CA storage chambers in 3 walk-in coolers, 2 temperature controlled respiration rooms, a CA monitoring/control room, a cold-temperature laboratory, a gas chromatography laboratory, a post-harvest physiology laboratory, a filacell forced-air cooling room, a hydrocooling room, a large receiving and crop-handling area and a mechanical room.

Air Ventilation in the Building

Since fruits and vegetables will be stored in the same building, a provision in the design was made to prevent C_2H_4 from seeping into the ethylene-sensitive storage sections. Building partitions are constructed of 20-cm thick cement blocks and sealed at the floor, ceiling and wall corners. Prefabricated rooms were then erected within each of the partitioned areas. Thus there is no direct cross-wall mixing of atmospheres between ethylene-producing and ethylene-sensitive areas.

The ventilation system introduces 100% fresh air into the building. The capacity of the exhaust fan is 240 m^3/min (8474 cfm). The use of 100% fresh air, while not ideal from the point of view of energy efficiency, is the most effective way of achieving a non-ethylene environment at the present time.

The issue of energy conservation was addressed during the design of the building and was achieved through the addition of insulation in the walls and implementation of an energy recovery system. The waste heat from the condensing unit is used to preheat the fresh air in the winter and to reheat the dehumidified air in the summer. The air conditioning system can provide 15-19^{o}C air in the winter and 18-22^{o}C air in the summer. Peripheral heaters supply additional heat to office and laboratory space in winter.

Refrigeration System

The system that supplies refrigeration to coolers is contained in the mechanical room. Two separate 54 KW chiller units are used to supply a secondary coolant (20% glycol) to heat exchangers located in each refrigerated room. The temperature of the glycol is -3.3^{o}C. Waste heat from the condensing unit is used in the building heating system. Each cooler is supplied with a secondary circulation pump and a three-way mixing valve to allow coolant flow into the room coil as required. An electric heater is incorporated in the secondary loop to provide an automatic defrost for the cooling coil. The controls for this defrost system are located inside a control panel on the outside wall of the cooler. Temperature controllers and alarm indicators are also provided in this control panel (2).

Heat exchange through the cooling coils in each walk-in cooler is accomplished using a high capacity squirrel-caged fan. The volume of air passing through the coil is adjustable to provide a wide range of air flow. Each room is equipped with a silicon controlled rectifier (SCR) control fan speed and/or manual dampers and by-pass ducting. During loading and initial cooling of the produce, the SCR controls, dampers and by-passes are set to allow a high volume of air to pass through the stacks for fast room cooling. After the produce temperature is lowered, the air flow controllers can be adjusted to allow a fraction of full air flow. The adjustable range of air volume for a small size CA storage room (2 m x 2 m) is between 42 m^3/min (1500 cfm) and 1.7 m^3/min (60 cfm).

CA Monitoring/Control Room

An automatic gas sampling and distribution system has been designed and developed for all CA storage rooms and chambers (1). The system is set up to control O_2 and CO_2 levels and to monitor C_2H_4 in all CA rooms and chambers. An interface panel is used to activate solenoid valves and pumps by means of a computer controlled data acquisition system. An atmospheric sample from each CA room or chamber is drawn into the gas control room through copper tubes and pumped into O_2 and CO_2 analyzers. If the O_2 level is higher than the set value, then N_2 is automatically injected into the appropriate room under the computer control. If the O_2 level is low, then air is automatically injected into the appropriate room. Similarily, the CO_2 level in a CA room can be adjusted by adding CO_2 or N_2 into the room. The system also has the ability to monitor and display C_2H_4 levels in each CA room or CA chamber and record the temperature of each refrigerated room.

Special Coating Treatment for CA Rooms

All CA rooms were pressure tested for air tightness. The requirements were a loss in pressure of not more than 125 Pa over 30 minutes when the initial pressure was 250 Pa (2). This was achieved by sealing the panel joints with nylon tape and by coating all inside panels of the room with 3 layers of Steridex paint (3). A special gasket designed for airplane manufacture was used to seal the inner door.

Medium Size CA Storage Rooms

Six air-tight prefabricated walk-in coolers (3 m x 3 m) are installed in two areas. Three rooms in the first area are assigned to the storage of ethylene-sensitive crops. The other three rooms in the second area are assigned to the storage of ethylene-producing crops. Each CA room is equipped with an individual temperature-control unit, a low differential pressure release switch/valve, 'a plastic U-shaped pipe filled with water, an air-tight plywood inner door (195 cm x 145 cm), an access port (50 cm x 50 cm) covered with plexiglas on the inner door, a protective and insulated outer door, an RTD temperature sensor, and one set of two copper tubes for atmosphere sampling and return. The RTD sensor and copper tubes are connected from each CA room to the CA montoring/control room for recording temperature and controlling atmosphere. Each of these CA rooms has a storage space of 16 m^3 and holding capacity of 12 bulk bins. This type of room is designed to conduct semi-commercial trials.

Small CA Storage Rooms

Seventeen air-tight prefabricated walk-in coolers (2 m x 2 m) are installed in two areas. Seven CA rooms in the first area are assigned to the storage of ethylene-sensitive crops. Ten CA rooms in the second area are assigned to the storage of ethylene-producing crops. Each CA room is equipped with an individual temperature-control unit, a low differential pressure release switch/valve, a plastic U-shaped pipe filled with water, an air-tight plywood inner door (195 cm x 85 cm), an access port (50 cm x 50 cm) covered with plexiglas on the inner door, a protective and insulated outer door, a RTD temperature sensor, and a set of two copper tubes for atmosphere sampling and return. The RTD sensor and copper tubes are connected from each CA room to the CA montoring/control room for recording temperature and controlling atmosphere. Each of these CA rooms has a storage space of 8 m^3 and holding capacity of 100 bushels. This type of room is designed to conduct factorially arranged trials. Factors related to storage environment such as O_2 concentration, CO_2 concentration, C_2H_4 concentration, and temperature, as well as other factors related to cultivar, pre-harvest spray, post-harvest treatment, orchard management and proper replication of an experiment may be considered.

CA Storage Chambers

Thirty disposable polyethylene bags of 6 ml in thickness and 137 cm x 244 cm in size are used in 3 walk-in coolers (3 m x 5 m). Each cooler has 10 sets of two copper tubes mounted on the side wall. One bag can be connected to the openings of a set of two tubes for the circulation and sampling of atmosphere. The atmosphere combination in each bag can be controlled from the CA monitoring/control room. Each bag can hold 8 bushels of crop. This type chamber is designed to accommodate preliminary small scale CA storage trials.

Fumigation Rooms

Three prefabricated walk-in coolers are used for storing crops such as dessert grapes which require fumigation with SO_2. At the end of each fumigation, the atmosphere in each of these rooms can be exhausted to outside the building through a venting system. These rooms are located in the ethylene sensitive area of the building.

Respiration Rooms and Gas Chromatography Laboratory

Two prefabricated walk-in coolers (3m x 4m) are installed in a gas chromatography laboratory. Each cooler is equipped with an individual temperature-control unit and 40 respiration chambers. Rates of CO_2 and C_2H_4 productions of various crops can be measured and recorded by gas chromatography.

Cold-Temperature Laboratory

One prefabricated walk-in cooler (2 m x 3 m) has been installed to provide a low-temperature work environment. It is equipped with a lab bench, air and vacuum supplies, cold and hot water, a double sink and a centrifuge. This room is designed to conduct sample preparation and studies in enzymatic activity.

Post-Harvest Physiology Laboratory

This air-conditioned laboratory (12 m x 5.5 m) has an island and two wall laboratory benches with a total of 21 m^2 of bench-top area. This laboratory is equipped with two penetrometers, an automatic titrimeter, a microprocessor pH meter, a balance, an electronic balance, an analytical balance, a microscope, a glass still, a digital refractometer, a spectrophotometer, a fume hood, and a micro-computer. Also located in this area for use throughout the complex are a portable air velocity meter, a psychrometer and a $CO_2/SO_2/O_2$ analyzer.

Pre-storage Produce Cooling Facilities

The pre-storage produce cooling capability include room cooling, forced-air cooling, and hydrocooling. Room cooling can be accomplished in any one of several cold rooms. The forced-air cooling room (3 m x 7 m) is equipped with a HumiFresh filacell unit designed to precool produce. The hydrocooler is located in a prefabricated walk-in cooler room (3 m x 4 m) and is designed to handle 6 to 9 containers containing 20 to 25 kg of produce. Water is cooled using chipped ice. The system can be drained, washed and recharged with water and secondary treatments can be added in approximately 10 minutes.

General discussion

Many features in this storage facility had taken several months of effort to make them operational. Some facilities meet preliminary test requirements but are not yet fully tested. The next few years will be very crucial to debug any possible problems and to start the launch of highly technical storage research program for the Ontario fruit and vegetable industry. In the mean time, new storage techniques such as low O_2 storage for 'McIntosh' apples and filacell storage for cabbages are being adopted rapidly in Ontario. These new storage techniques will have long term benefits for both producer and consumer.

Literature Cited

1. Chu, C.L. and E.M. Lauro 1985. Monitoring of controlled atmosphere storage by micro-computer. Proc. of Postharvest 1984 Conf., Univ. of Montreal, Quebec, Canada. p. 41-44.

2. Lauro, E.M., C.L. Chu and R.B. Smith. 1985. Research facilities for improved storage of fruit and vegetable crops. Proc. Canadian Soc. of Agr. Eng., Charlottetown, Prince Edward Island, Canada. (submitted for publication, paper No. 85-414)

3. Lovelidge, B. 1975. An elastic plastic film of great value as a fruit store membrane. Grower 83(3):138,140.

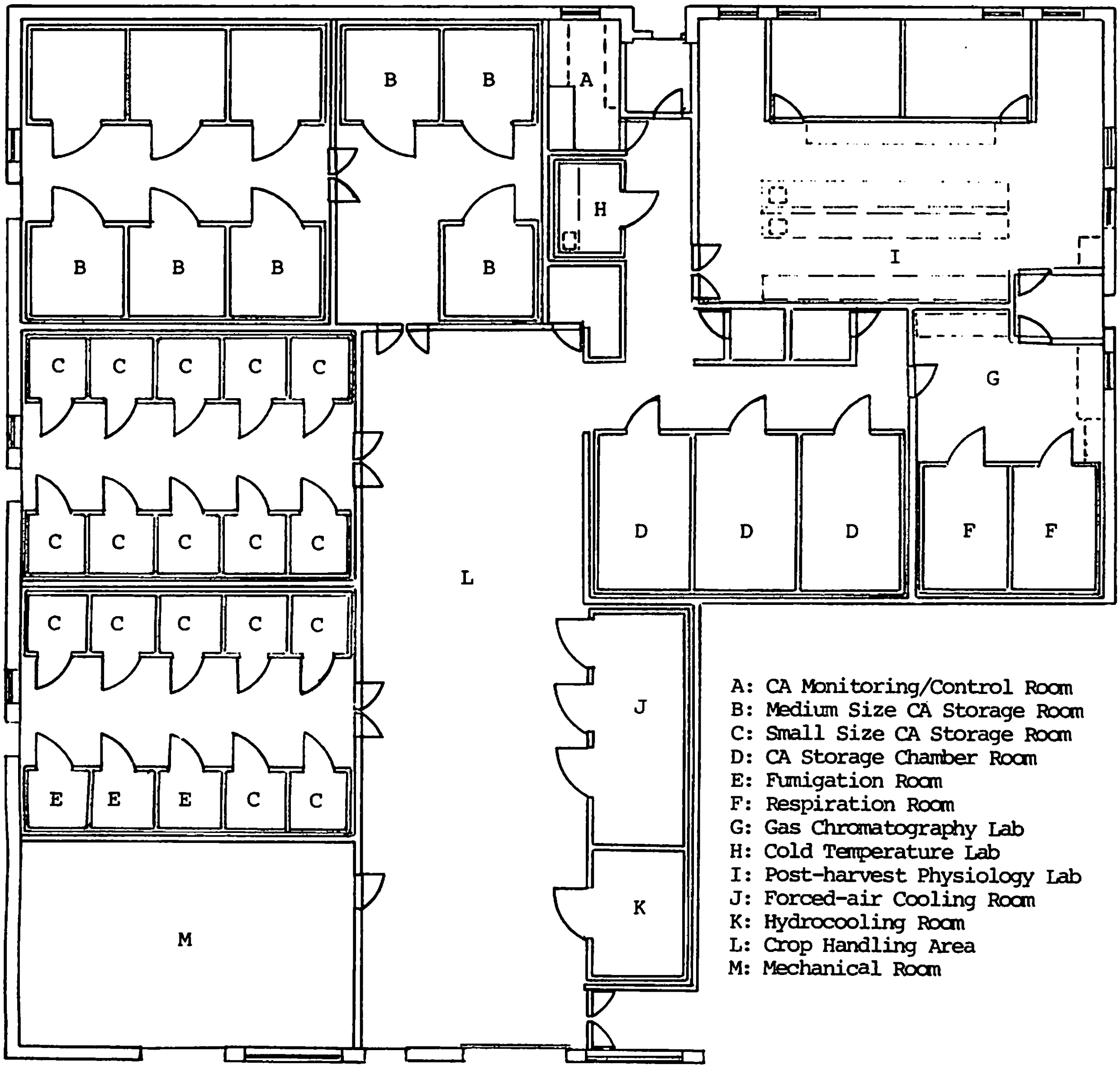

Fig. 1. Plan of Storage Research Building at the Horticultural Research Institute of Ontario.