A Precision Controlled Atmosphere Storage[1]

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Abstract. An inexpensive, versatile, and simple recirculating controlled atmosphere storage system was designed, constructed and tested. It is demonstrated that this controlled atmosphere storage system has minimal variation in O_2 and CO_2 composition. In addition, the system allows controlled atmosphere research to be conducted in conventional storages that are otherwise unsuited for this type of research.

To expand post-harvest physiology and processing research of pomological crops, 2 small cold rooms were converted into controlled atmosphere (CA) storages which would be suitable for experimental work. This paper describes the CA storage systems, their operation, and presents data on their performance.

The cold rooms were supplied with precision thermostats capable of controlling the temperature within ± 1F. Small metal chambers were utilized within the rooms to permit adequate flexibility in the research program, since the volume and number of different atmospheres could be varied. Nine U. S. Steel Products drums[3] (18 gauge, 33 gal.) were placed in each cold room. The lid of each drum was fitted with a 10 x 10 inch plexiglass window to permit visual observation of the fruit and a mercury thermometer in each drum. Anderson (2) employed similar drums, but replaced the metal lids with 3/8 inch plate glass and gaskets which may be preferable since only one gasket was used. Two wooden boxes with a total capacity of about 150 apples were used in each drum. Three air pumps (Neptune Dyna-Pump Model No. 2) and 3 lime containers (2.5 liter acid jugs) were used to provide circulation and to control the composition of the atmospheres.

The system was operated as a conventional CA storage since fruit respiration was used to lower the O_2 and raise the CO_2 concentration except as noted. The O_2 concentration was kept from going below the desired level by metering air into the vacuum side of the air pumps. The concentration of CO_2 was prevented from going above the desired level by passing part of the circulating atmosphere through small, drylime ($Ca(OH)_2$) scrubbers. Other methods of CO_2 removal could have been used (9, 10). A Beckman model 956 process oxygen analyzer and model IR315 infrared analyzer for CO_2 were used to analyze the atmospheres. The O_2 and CO_2 standards contained 2.97% O_2 and 18.1% CO_2 respectively. The O_2 and CO_2 were each measured to the nearest 0.1%.

Three controlled atmospheres were utilized to test the system during the 1967-68 storage season. Each CA treatment was maintained in three drums in each cold room. Shown schematically is one treatment in Fig. 1. After daily atmospheric analysis the O_2 and CO_2 valves were adjusted as necessary.

Shown in Fig. 2 are the O_2 and CO_2 concentrations of treatments 1, 2, and 3 from January 6 to March 17, 1968. Difficulties with the O_2 analyzer precluded accurate measurement of O_2 prior to January 12.

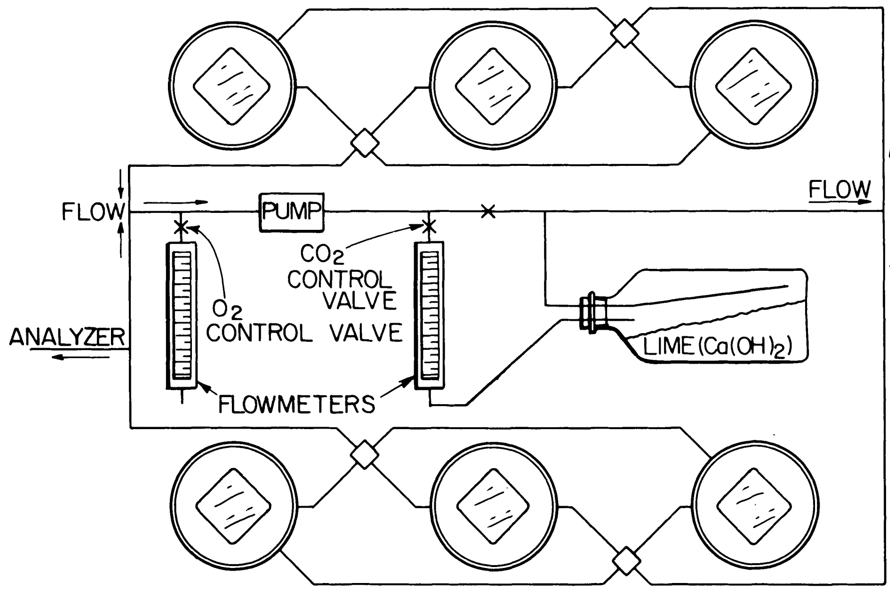

Fig. 1. Schematic diagram of equipment assembled for one CA treatment.

Table 1. Desired, high, mean and low levels, and standard deviations of the O_2 and CO_2 percentages for treatments 1, 2 and 3 during the period January 28 to March 17, 1968.

Treatment	Gas	Level in % Desired	High	Mean	Low	SD
1-"Std.CA"	O_2	3.0	3.3	2.98	2.7	0.13
	CO_2	2.0	2.2	2.00	1.8	0.09
2-"High CO_2"	O_2	3.0	3.4	2.99	2.7	0.14
	CO_2	3.0	3.3	3.03	2.6	0.14
3-"Low O_2"	O_2	2.0	2.5	2.04	1.7	0.19
	CO_2	2.0	2.4	2.00	1.6	0.17

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[3]Manufacturers' names are given only for identification purposes and do not constitute endorsement over other suitable equipment.

Special note should be made of the final 10 days for treatment 2 (Fig. 2). During this period the valve settings for the control of O_2 and CO_2 were not changed. Therefore the system was in equilibrium and a steady-state condition had been reached. Table 1 contains the desired, high, mean and low levels, and standard deviations of the O_2 and CO_2 percentages of treatments 1, 2, and 3 during the period from January 28 to March 17. This allowed a 16-day period (1/12-1/27) during which the operator became familiar with the system. The data in Table 1 indicate the capabilities of this system and show the precision with which the O_2 and CO_2 percentages can be maintained.

In Fig. 2 it can be seen that the O_2 concentration of treatment 3 tended to increase above the 2% level and a periodic N_2 flush was required to lower the O_2 level. The N_2 -adding system had not been perfected, as is evident in Fig. 2 and from the large standard deviations for the % O_2 and CO_2 (Table 1).

An attempt was made to compare the precision of this system with that reported in the literature. Several papers (3,4,7) reported only the desired composition and gave no data concerning the variability while others listed the mean O_2 and CO_2 percentages (8,11). A third group of papers (1,2,5,6) mentioned the amount of variation obtained in their storages.

Although a strict comparison with these four studies is not possible, it appears that the CA storage reported herein has minimal variation in O_2 and CO_2 composition and that the storage does meet the requirements for a precision CA storage.

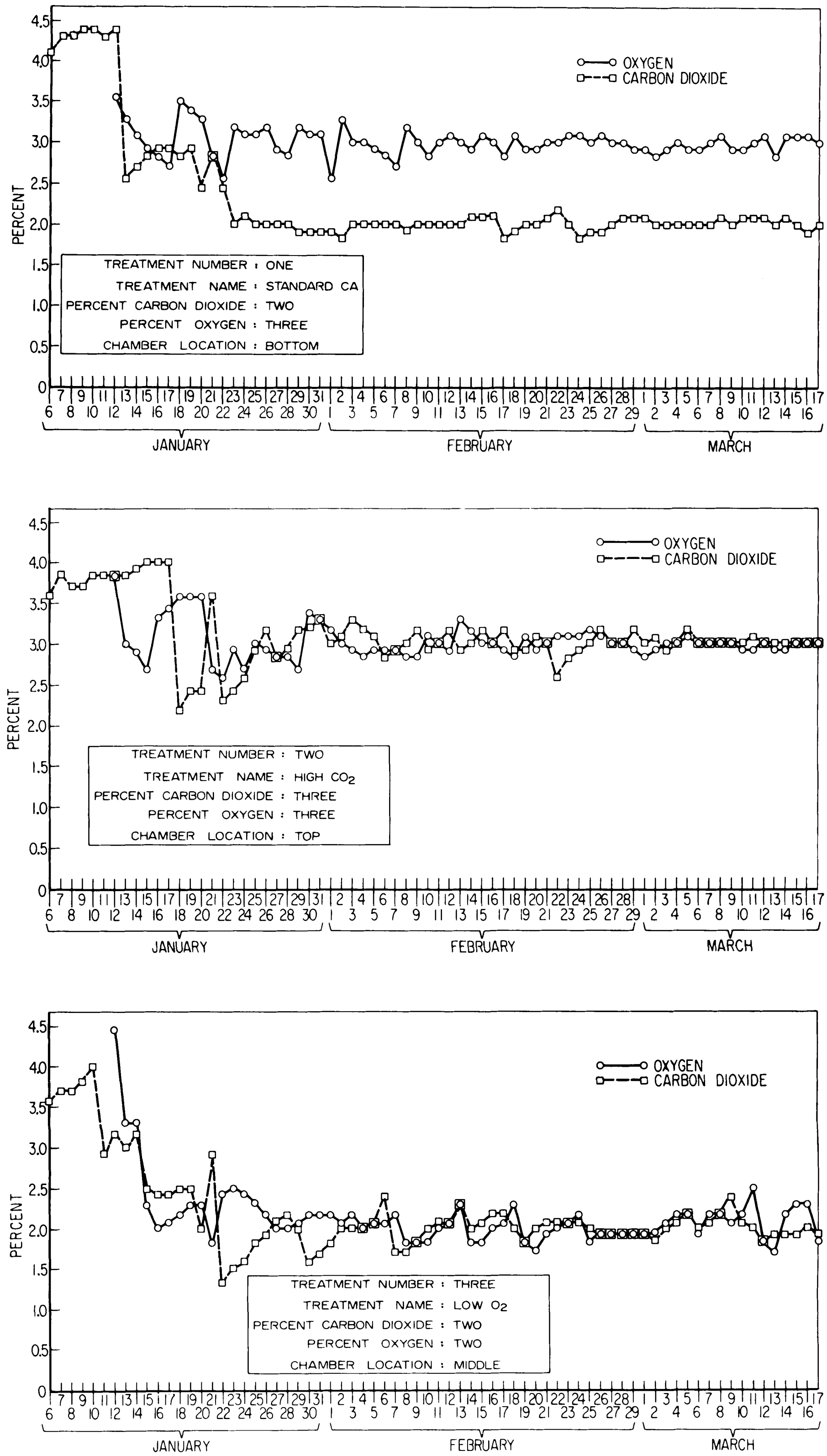

Fig. 2. Oxygen and carbon dioxide concentrations of treatments 1, 2, and 3 from January 6 to March 17, 1968.

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