An examination of room-to-room variation in sulfur dioxide concentrations resulting from fumigation in five different cold-storage facilities

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A report submitted to the California Table Grape Commission

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ABSTRACT

Sulfur dioxide concentrations were measured in two empty rooms in each of five cold-storage facilities during a 60-minute period following fumigation. In no case was the measured sulfur dioxide concentration as great as the predicted (calculated) concentration, and the measured concentration generally decreased during the 60 minutes of study. With the exception of one room in which an absorptive wall covering apparently contributed to a particularly rapid loss of sulfur dioxide from the room atmosphere, the two rooms within each facility reacted similarly with respect to the time course of loss of sulfur dioxide during the fumigation period.

This research was conducted in response to a request from the California Table Grape Commission for experimental data concerning differences that occur between different rooms in any given cold storage facilities in the atmospheric concentrations of sulfur dioxide following standard fumigation procedures with this chemical.

Five facilities were selected as being representative of the conditions that might be found in the table grape cold-storage industry. These facilities were: Elmco, Porterville (Table 1, Figure 1); Marko Zaninovich, McFarland (Table 2, Figure 2); V B Zaninovich, Ducor (Table 3, Figure 3); Pandol, Delano (Table 4, Figure 4); and Dulcich, Earlimart (Table 5, Figure 5). Two empty cold storage rooms were selected for study in each of the five facilities. These rooms were maintained at normal cold-storage temperatures, ranging from 30 to 34 degrees F.

Sulfur dioxide was provided in commercial cylinders by Snowden Enterprises, Fresno, CA. The amount of sulfur dioxide provided for each of the ten rooms in the study was based on a desired concentration of 0.25% and was determined by the usual calculation:

$$\frac{(0.0025)(\text{volume to be treated in cubic feet})}{5.5}$$

The cylinders were weighed before and after use, and all the rooms were remeasured at the time of the experimentation. The resulting exact record of the amount of sulfur dioxide used and the volumes of the treated rooms allowed a calculation of the actual percentage of sulfur dioxide that would have occurred in the rooms, assuming no losses on absorbing surfaces. These calculated figures are given in Tables 1-5 and Figures 1-5.

Actual atmospheric concentrations of sulfur dioxide were measured in the rooms at 0, 10, 20, 40, and 60 minutes following the emptying of the cylinders. Emptiness of the cylinders was determined by physically moving them and sensing that no liquid remained in them. Time required for emptying varied between 5 and 10 minutes and was related to the size of the cylinders. Atmospheric concentrations were determined by the use of Gastec Sulfur Dioxide Middle Range Detector Tubes No. 5M, which were filled with 100 ml samples of atmosphere, taken approximately four feet above the floor in the center of each room with the aid of a Gastec Multistroke Gas Sampling Pump. The tubes had been allowed to equilibrate to the ambient temperature in each room, and the resulting readings were corrected for a temperature of about 32 degrees F by being multiplied by 1.25, giving the measured sulfur dioxide concentration, with a stated accuracy tolerance of + or - 25%.

In all ten rooms, the actual measured sulfur dioxide concentration was less than the calculated (predicted) concentration. In addition, the measured concentration decreased during the hour of measurement, with the rate of decrease differing among the tested facilities but being similar for the two rooms within any given facility. For example, the two rooms selected for study in the Pandol facility (Table 4, Figure 4) were "precooling" rooms, and they had a greater rate of air turnover and a higher proportional area of refrigerating coil surface than rooms in any of the other tested facilities. Only 70% of the calculated concentration (0.22%) of sulfur dioxide was measured in the air at "0 minutes" after the emptying of the sulfur dioxide cylinders. This measured concentration decreased much more rapidly at the Pandol facility than it did in the larger storage rooms tested in the other facilities,

being reduced to only 14% of the original calculated concentration by the end of the hour.

The normal time that sulfur dioxide is allowed to remain in a fumigated room before it is removed by scrubbing or venting is 30 to 60 minutes. Summary calculations presented in Tables 1-5 show the mean concentration of sulfur dioxide measured in each room over both a 30- and a 60-minute period. The 30-minute mean was calculated as the average of the 0, 10, 20, and 30-minute measurements, and the 60-minute mean was calculated as the average of the the 0, 10, 20, 30, 40, 50, and 60-minute measurements. Measurements were not actually made at 30 or 50 minutes, and these values were estimated as the means of the observations immediately preceding and following those times. A summary of the sulfur dioxide concentrations found to occur in the rooms over the 30- and 60-minute periods following fumigation is as follows:

	30 Minutes		60 Minutes	
Facility	Rm 1	Rm 2	Rm 1	Rm 2
Elmco	0.13	0.20	0.11	0.19
M. Zanin.	0.17	0.18	0.16	0.17
V. B. Z.	0.18	0.20	0.17	0.18
Pandol	0.11	0.12	0.08	0.09
Dulcich	0.15	0.12	0.14	0.13

The only exception to the trend for rooms within a facility to respond similarly in sulfur dioxide concentrations following fumigation was in the Elmco facility (Table 1, Figure 1). In that facility, one of the rooms exhibited a more rapid decrease in concentration than the other, arriving at a final concentration of 0.07% (vs. 0.16% in the room that did not show the rapid decrease) at the end of the hour. Upon examining differences between the two rooms, it was noted that more than 50% of the wall surface in the room showing the rapid decrease was covered with a porous foam material used in fire protection, whereas all of the walls in the other room were covered with smoothly painted (nonporous) plywood. In fact, walls in the eight rooms in the four other facilities were all coated with a smooth surface of paint.

These observations are supported by those of Marois et al.*, who measured atmospheric concentrations of sulfur dioxide following low level (0.02%) fumigations and concluded that cooling systems and walls are major factors in removing this chemical from the air in fumigated cold storage rooms.

*Marois, J. J., A. M. Bledsoe, W. D. Gubler, and D. A. Luvisi. 1986. Control of Botrytis cinerea on grape berries during postharvest storage with reduced levels of sulfur dioxide. Plant Disease 70: 1050-1052.

Table 1. Sulfur dioxide atmospheric concentrations resulting from fumigating two cold storage rooms in the Elmco facility, Porterville, CA on March 15, 1988.

Dimensions, cubic feet		127,285	215,430
Pounds sulfur dioxide used		57.5	97.0
Calculated sulfur dioxide concentration (%)		0.25	0.25
Temperature, degrees F		31.5	30.0
	Minutes		
Measured SO2 conc. (%)	0	0.14	0.21
	10	0.15	0.21
	20	0.12	0.20
	40	0.09	0.19
	60	0.07	0.16
Mean SO2 conc. (%) for 1 hour		0.11	0.19
for first 30 min.		0.13	0.20

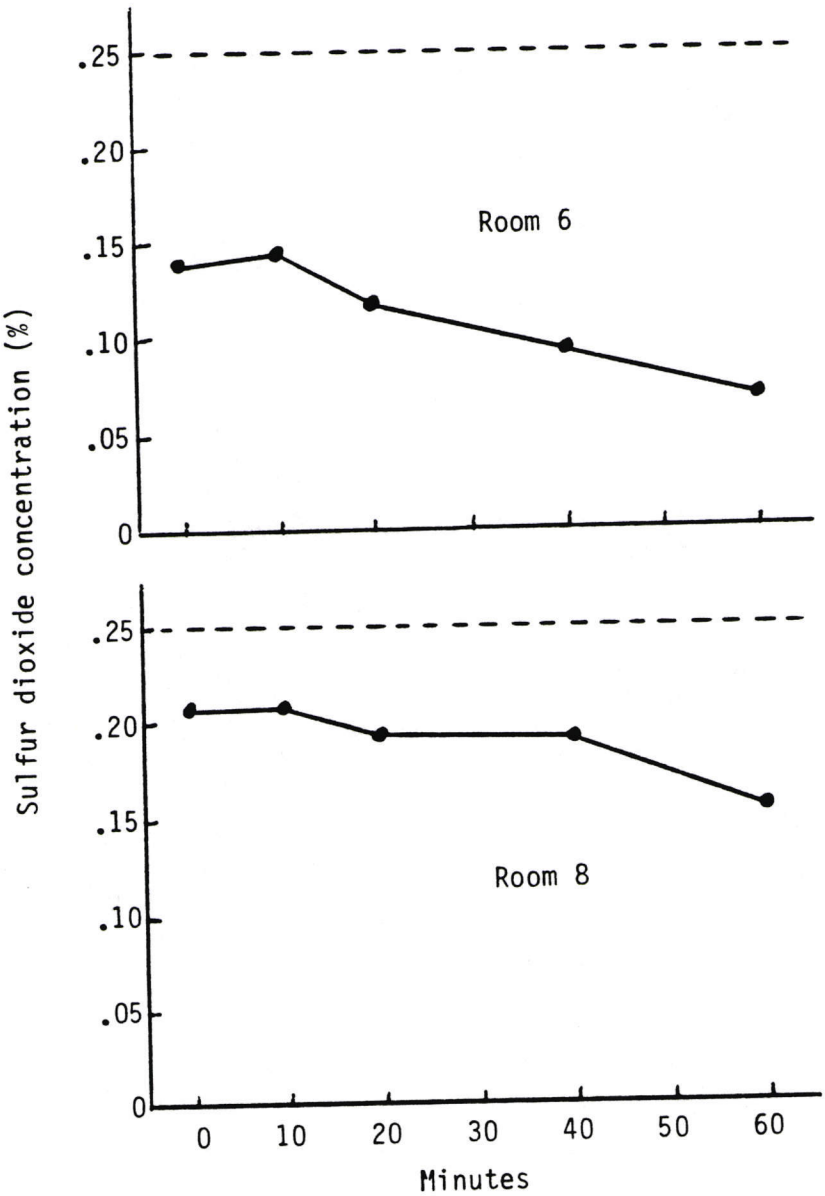


Figure 1. Sulfur dioxide concentrations measured during the first 60 minutes after fumigation of two rooms at the Elmco Cold-Storage Facility.

Table 2. Sulfur dioxide atmospheric concentrations resulting from fumigating two cold storage rooms in the Marko Zaninovich facility, McFarland, CA on March 15, 1988.

Dimensions, cubic feet		289,536	289,536
Pounds sulfur dioxide used		126.3	125.5
Calculated sulfur dioxide concentration (%)		0.24	0.24
Temperature, degrees F		33.5	33.5
	Minutes		
Measured SO2 conc. (%)	0	0.16	0.17
	10	0.17	0.20
	20	0.18	0.18
	40	0.15	0.16
	60	0.15	0.14
Mean SO2 conc. (%) for 1 hour		0.16	0.17
for first 30 min.		0.17	0.18

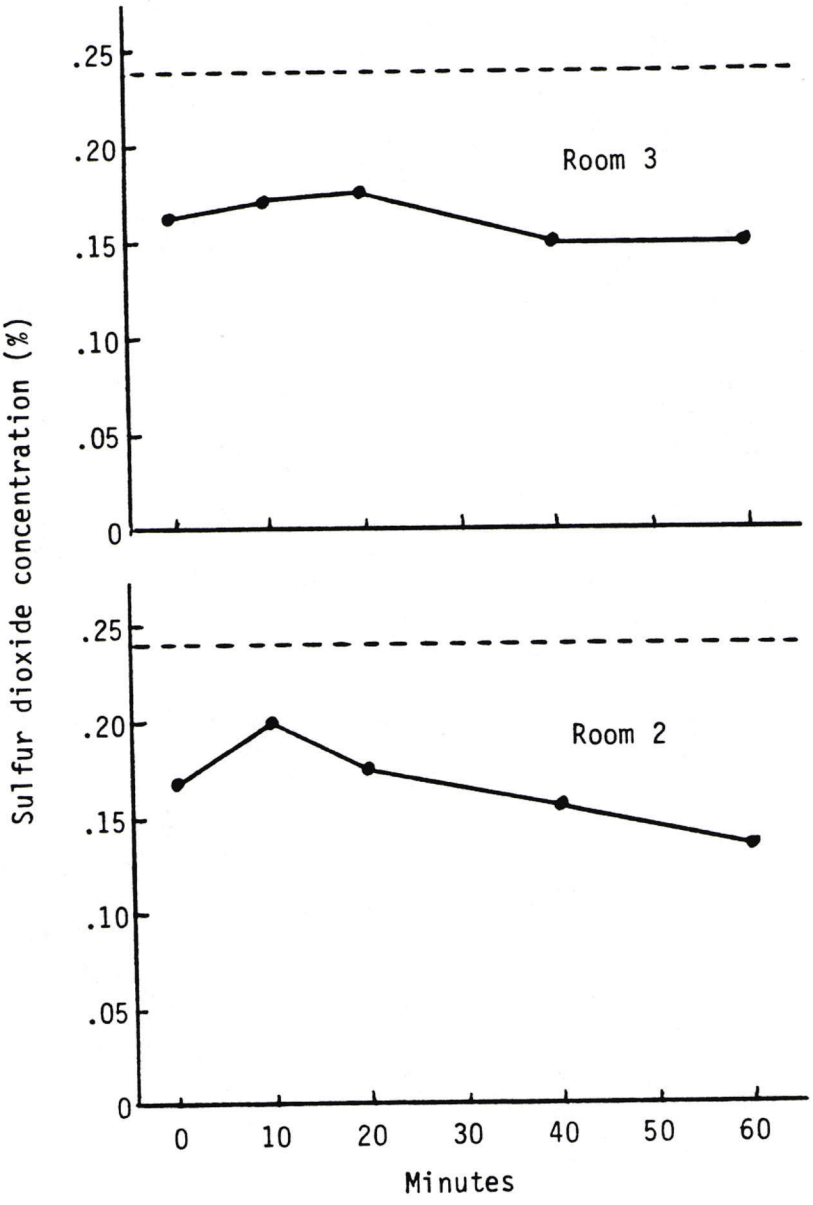


Figure 2. Sulfur dioxide concentrations measured during the first 60 minutes after fumigation of two rooms at the Marko Zaninovich Cold-Storage Facility.

Table 3. Sulfur dioxide atmospheric concentrations resulting from fumigating two cold storage rooms in the V B Zaninovich facility, Ducor, CA on March 17, 1988.

Dimensions, cubic feet		63,296	63,296
Pounds sulfur dioxide used		30.3	30.8
Calculated sulfur dioxide concentration (%)		0.26	0.26
Temperature, degrees F		34.0	34.0
	Minutes		
Measured SO2 conc. (%)	0	0.21	0.22
	10	0.18	0.21
	20	0.18	0.18
	40	0.15	0.16
	60	0.13	0.15
Mean SO2 conc. (%) for 1 hour		0.17	0.18
for first 30 min.		0.18	0.20

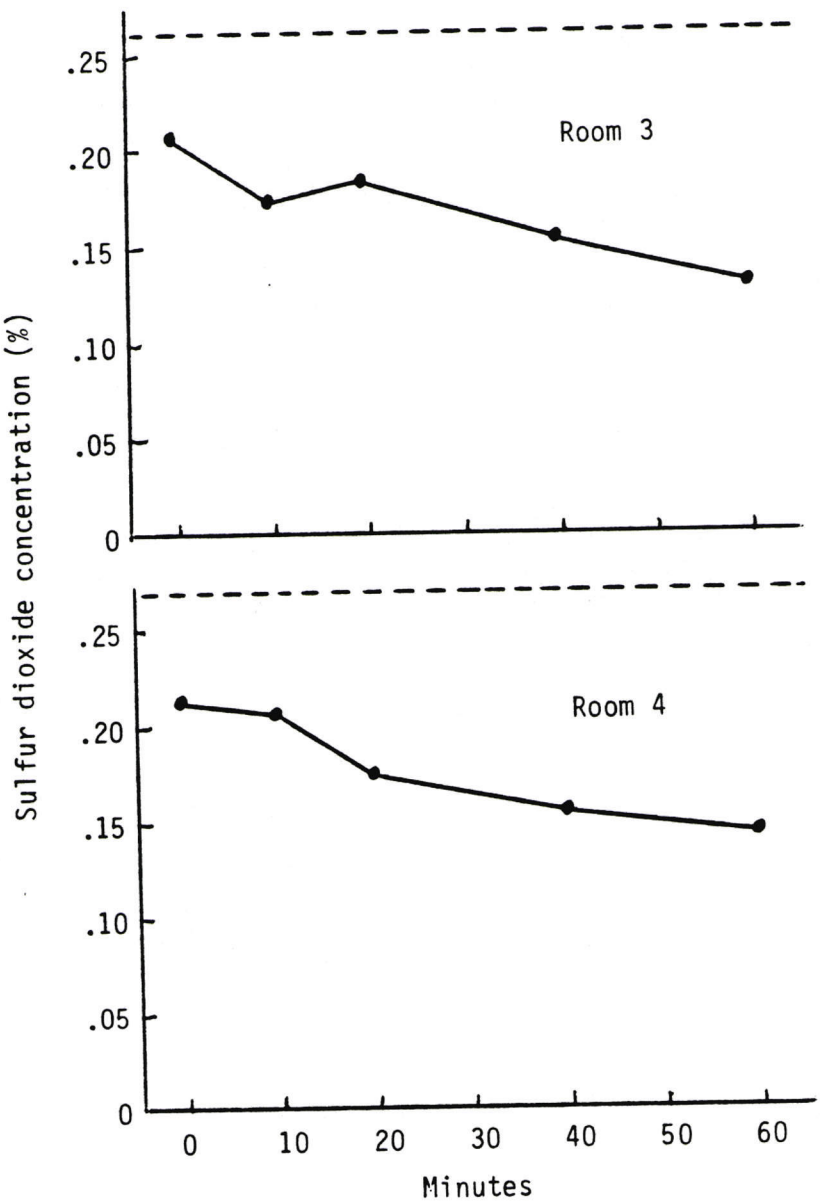


Figure 3. Sulfur dioxide concentrations measured during the first 60 minutes after fumigation of two rooms at the VBZ Cold-Storage Facility.

Table 4. Sulfur dioxide atmospheric concentrations resulting from fumigating two cold storage rooms in the Pandol facility, Delano, CA on March 17, 1988.

Dimensions, cubic feet		24,768	24,768
Pounds sulfur dioxide used		10.0	9.8
Calculated sulfur dioxide concentration (%)		0.22	0.22
Temperature, degrees F		34.0	32.5
	Minutes		
Measured SO2 conc. (%)	0	0.15	0.16
	10	0.12	0.13
	20	0.09	0.10
	40	0.06	0.06
	60	0.03	0.03
Mean SO2 conc. (%) for 1 hour		0.08	0.09
for first 30 min.		0.11	0.12

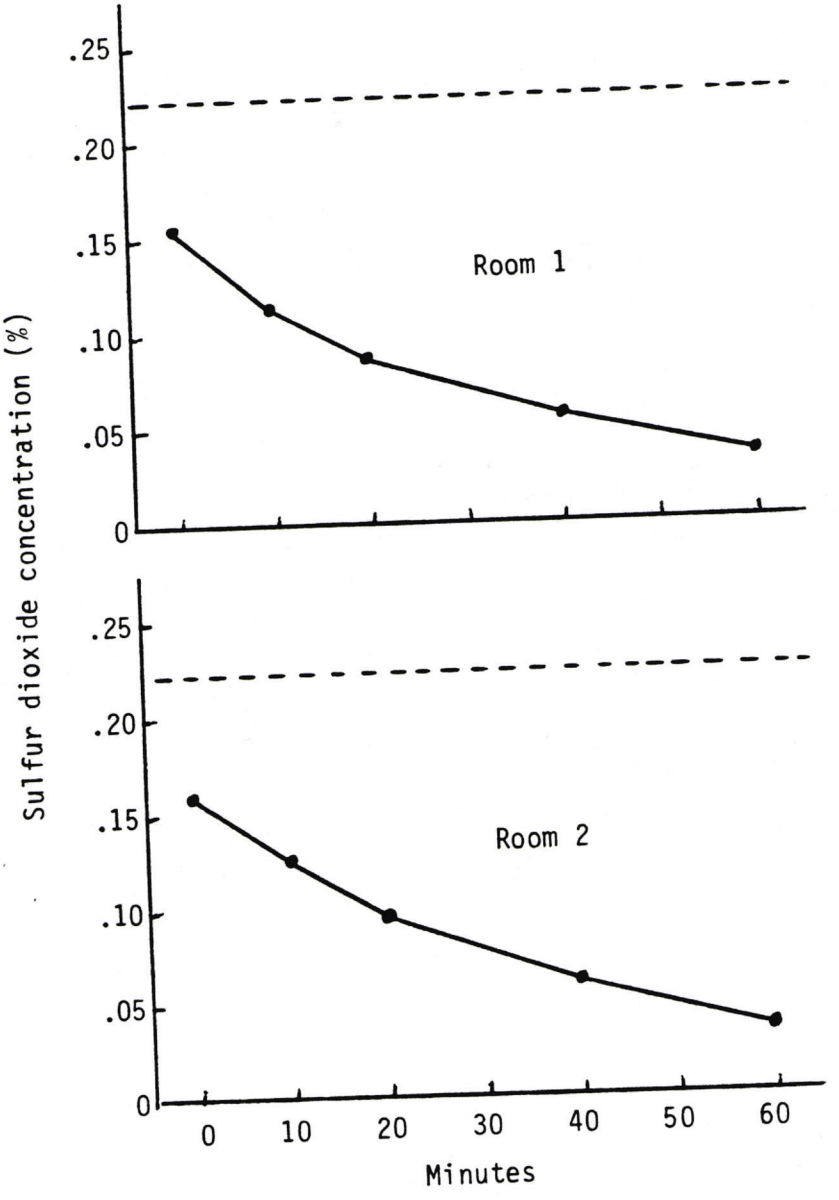


Figure 4. Sulfur dioxide concentrations measured during the first 60 minutes after fumigation of two rooms at the Pandol Cold-Storage Facility.

Table 5. Sulfur dioxide atmospheric concentrations resulting from fumigating two cold storage rooms in the Dulcich facility, Earlimart, CA on March 18, 1988.

Dimensions, cubic feet		160,886	121,836
Pounds sulfur dioxide used		76.5	59.0
Calculated sulfur dioxide concentration (%)		0.26	0.27
Temperature, degrees F		33.0	33.0
	Minutes		
Measured SO2 conc. (%)	0	0.12	0.06
	10	0.16	0.12
	20	0.16	0.16
	40	0.14	0.14
	60	0.13	0.13
Mean SO2 conc. (%) for 1 hour		0.14	0.13
for first 30 min.		0.15	0.12

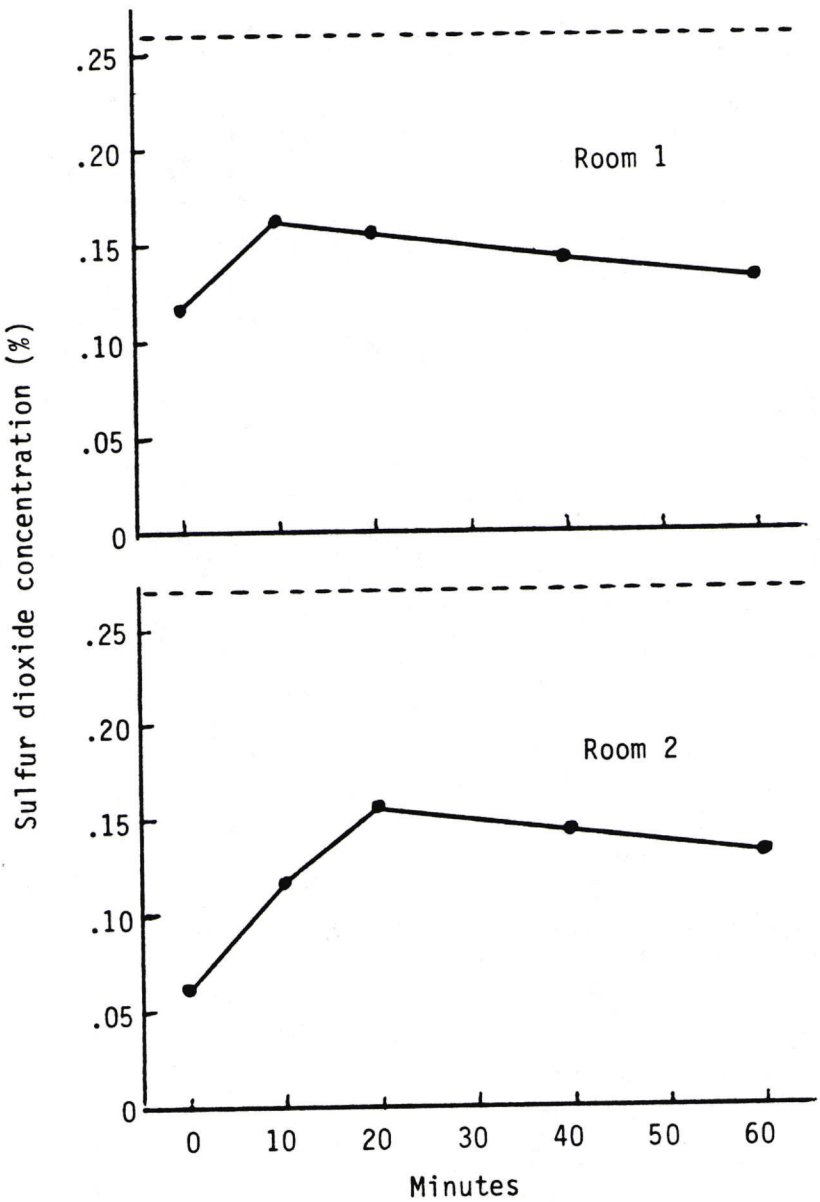


Figure 5. Sulfur dioxide concentrations measured during the first 60 minutes after fumigation of two rooms at the Dulcich Cold-Storage Facility.