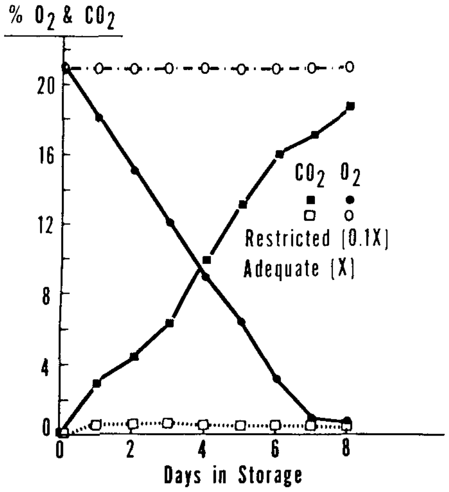
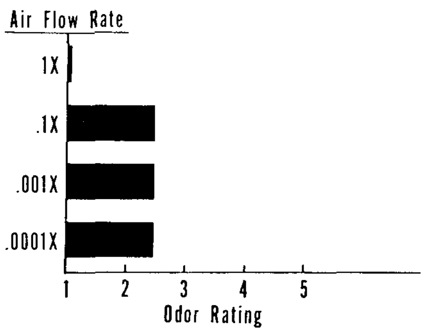
GRAPH 1. EFFECT OF AIR CIRCULATION ON O_2 AND CO_2 IN COMMERCIAL CONTAINERS OF BROCCOLI 8 DAYS SIMULATED TRANSIT 36.5°F

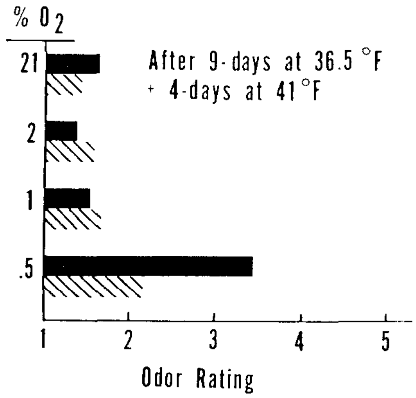


GRAPH 2. EFFECT OF AIR-FLOW RATE ON BROCCOLI ODOR AFTER 8-DAYS STORAGE AT 36.5°F

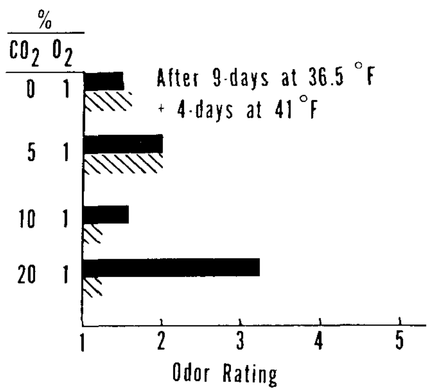


1 = normal
3 = different and objectionable,
5 = severely objectionable
1X = 1.5-2 litres of air/hr/Kg of broccoli

GRAPH 3. EFFECT OF O_2 LEVEL ON BROCCOLI ODOR AFTER STORAGE



GRAPH 4. EFFECT OF CO_2 LEVEL ON BROCCOLI ODOR AFTER STORAGE



BROCCOLI SHIPPING ODORS

caused by poor air circulation and low oxygen levels

R. F. KASMIRE · A. A. KADER · J. KLAUSTERMEYER

BECAUSE OF INADEQUATE air exchange in the storage environment, broccoli (*Brassica oleracea* var. Italica cv Gem) developed a strong, offensive odor after 8 to 10 days at 2.5°C (36.5°F). The restricted air circulation through containers of broccoli caused rapid oxygen depletion and carbon dioxide accumulation (graph 1) in storage tests conducted in the L. K. Mann Laboratory at the University of California, Davis.

The odor noted in the Davis studies was comparable with that observed in rail shipments of broccoli unloaded at Eastern markets, especially during late fall through early spring. Most of these problem shipments were shipped under heavy top-icing, with little or no air circulation through the loads during transit. The UC studies were designed to evaluate the effects of air circulation rates and the levels of oxygen and carbon dioxide in the storage environments as factors in the formation of offensive odors by broccoli curds.

Respiration

Broccoli's respiration rate was used to calculate a normal aeration rate such that CO_2 would not accumulate above .5%. Reducing the air flow rate through broccoli storage chambers to .1 of the normal air flow rate for broccoli during 8 days of storage at 36.5°F (simulated transit conditions) caused an offensive odor. However, the odor disappeared after holding the product for an additional 2 to 4 days in air at 41°F. Lower air flow rates did not cause stronger, nor more persistent odors (graph 2). The offensive odor was more noticeable after holding at 0°C (32°F) than at 2.5°C (36.5°F) or 5°C (41°F) for 10 days, and increased with duration of storage at 0° or 2.5°C. Increased carbon dioxide levels (up to 20%) in storage atmospheres delayed senescence (yellowing and deterioration) and did not cause offensive odors if the oxygen level was normal (21%). A low oxygen level (1% or lower) or reduced air flow rate (.1% normal) caused a highly offensive, nauseating odor (graph 3). Low oxygen (1%) in combination with high carbon dioxide levels (10–20%) also caused an offensive odor in stored broccoli (graph 4).

Air flow

Treatment variations of air-flow rate and percentage of oxygen and carbon dioxide in the storage atmosphere did not affect the other broccoli market-quality factors evaluated, including overall appearance, head color, and compactness.

Bacterial soft rot, *Erwinia carotovora*, also causes a pungent, but noticeably different off-odor than that caused by low O_2 levels. However, the odor caused by bacterial soft rot is also intensified by low O_2 levels.

The results of this study confirm that the cause of offensive odors in commercial shipments is lack of air circulation through the loads. This results in oxygen depletion and carbon dioxide accumulation in affected loads. The problem could be alleviated by using less top-ice over loads in rail cars, and by only shipping cars with the air circulating fans operating.

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