METHYL BROMIDE HEALTH MONITORING: FUMIGATED ORANGE IN SHIPPING CONTAINER TO COOLING STORAGE AND UNPACKED ROOM

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Introduction: Use of methyl bromide (MB) is being reduced in quarantine and pre-shipment (QPS) use because of its adverse effects on ozone. In Korea, MB alternatives such as ethyl formate (EF), phosphine (PH_3) gas and EF mixed with PH_3 have been developed and commercialized for use in some import and export fruits and vegetables, but not including imported orange, which is the 2nd most imported fruit in South Korea. Due to several acute and chronic inhalation accidents involving fumigators and related equipment, MB use is strongly restricted in South Korea. Safety protocols involve checking leakage during the fumigation and ventilation process, determining safe ventilation times for fumigator's safety, wearing of protective equipment, and the health and safety of related workers involved in transporting, unloading, cooling and unpacking in working place where fumigation takes place. There was no information to warn transporting companies and end-users that MB could be slowly released from fumigated commodities during transport, storage, packing and sale. The aim of this research was to determine ventilation times for imported oranges in the cooling chain. Modeling experiments were done on sorption and desorption of MB in a mini shipping container (MSC, 0.65m^3) and a cold storage room which emulated conditions of commercial cooling storage before unpacking and delivering to the end user.

Assessment of TLV of MB in common imported orange fumigation

MB fumigation of imported oranges and the post-fumigation process currently used in Korea is as follows:

1) Fumigation: Oranges filled with 25%(w/v) of filling ratio(f.r.) in the shipping container fumigated with 64g/m^3 of MB for 2hr at 5°C.
2) Post-Fumigation process until delivering end-user: 1-2hr ventilation with opened door using inside circulation fans → 18-24hr ventilation with small ventilation hole at rear of container in closed door conditions, in this case circulation fans are automatically on and off for adjusting temperature(5°C)→ Transporting container and loading oranges to cooling storage(2-5°C)→ Unpacking orange in work place(10-15°C)

All experiments were similarly designed by mini shipping container(Fig.1) except fumigation size. Concentration of MB during the fumigation and post-fumigation process (ventilation, transporting, storing and packing) was monitored with MB detector (miniRAE 3000, RAE systems).

Assessment of TLV of MB for improving worker safety following imported orange fumigation

For assessment of MB concentrations for worker safety post-fumigation in Korea, we evaluated to extend the ventilation times at two time conditions (5, 13°C) and estimated the filling ratio of oranges in cooling storage(2-5°C)

Results

Figure 2 represented the MB concentration inside MSC and storehouse during the fumigation and post fumigation process. During the 2hr fumigation, concentration of MB in MSC was decreased because MB was highly adsorbed to oranges. On the completion of fumigation, two types of ventilation were assessed. One was open door for 2hr and another was closed door but small ventilation hole for 24hr by rerouting the container circulation system. The concentration of MB rapidly decreased for 2hr ventilation, but significantly increased after open door ventilation because the MB released was desorbed from the fumigated oranges. This could be dangerous for workers involved in unloading oranges because the concentration of MB inside container is higher than short term exposure limit (STEL, 15ppm for MB) because unloading workers do not usually wear protective safety equipment. Workers involved with storage and packing were also exposed to more than the threshold limit values (TLV, the national standard for MB is 1ppm averaged over eight hours) of MB exposure. These results indicate that currently all post fumigation processes including ventilation, unloading, storing and packing expose workers to more than exposure standard of MB level. Currently, workers are ex posed to chronically toxic risk to health because of initially inadequate aeration of oranges.

To find the optimal ventilation method, we extended the ventilation time of MB-treated oranges at two temperature conditions. Figure 3 shows the relationships between ventilation time and concentration of desorbed MB gas under two temperature conditions (5, 13°C). When the ventilation time was extended, desorbed MB levels also decreased. We expected more than 60 and 55 hr of ventilation under TLV level of MB at 5°C and 13°C, respectively. This showed that ventilation at the higher temperature accelerated desorption of MB from oranges.

Excluding any negative effect in half life of oranges with variation of temperature, an alternative option for safe levels of MB was investigated that reduced the filling ratio(f.r. w/v) of oranges in cool storage also can help decrease MB levels. Figure 4 indicates that when filling ratio of oranges decreased to 5% or less, desorbed MB decreased to below the TLV level. In the case of 13% f.r. of oranges, it was estimated that more than 48 hr under TLV of MB level. In the case of decreasing it to less than 5% f.r. of oranges, it could reduce MB level under TLV in cold storage to within 24 hr.

Conclusions

We found that the currently used post-fumigation protocol in South Korea is unsafe for workers who are involved in unloading, storing and packing due. This is because of inadequacies in the aeration process. We strongly suggest that there should be more research done in designing better forced ventilation systems, extension of aeration times, reducing the amount of oranges kept in storage rooms, and equipping exhaust facilities in packing facilities. Newly developed EF fumigation could be an option to improve safety outcomes for workers involved in post-fumigation handling of oranges.

Figure 1. Designed mini shipping container(0.5 x 0.5 x 2.3m, stainless steel)

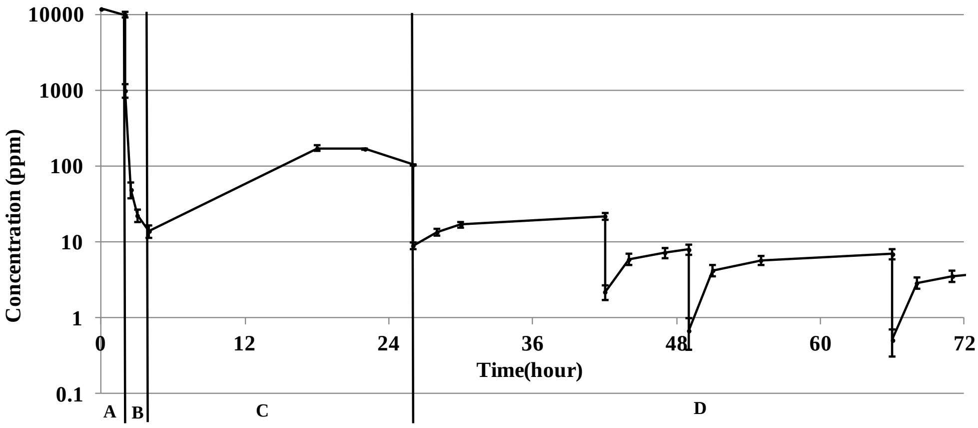

Figure 2. MB concentration inside a mini shipping container and cool storage
A=Fumigation process, B-D=Post fumigation process
B: Ventilation with door open
C: After ventilation, re-seal the door
D: Transported to the cooling storage and stored at 2-5°C

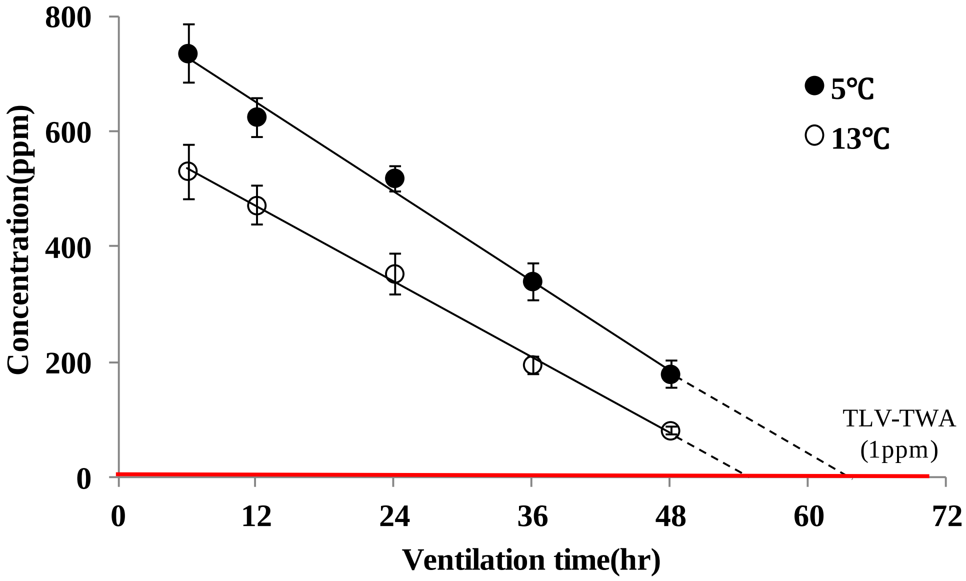

Figure 3. Relationship between ventilation times and concentration of desorbed MB gas by two temperature conditions. As ventilation time increases, concentration of desorbed MB gas decreases. Desorption of MB was accelerated when storage was at higher temperatures.

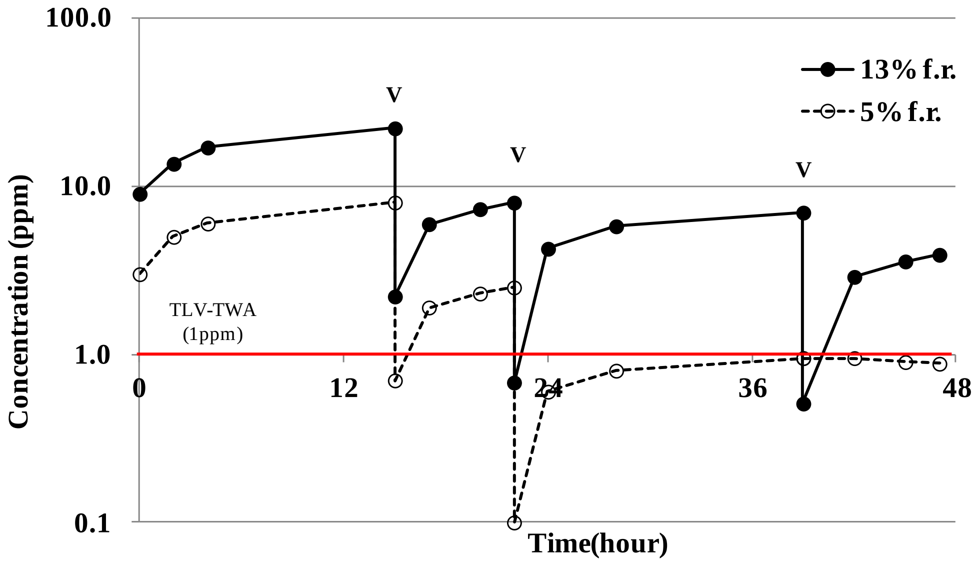

Figure 4. MB concentration at post fumigation process inside cooling storage by filling ratio of MB treated orange box
("V" indicates the ventilation of cooling storage)