COMMERCIAL SCALE APPLICATION OF ETHYL FORMATE WITH NITROGEN FOR QUARANTINE TREATMENT

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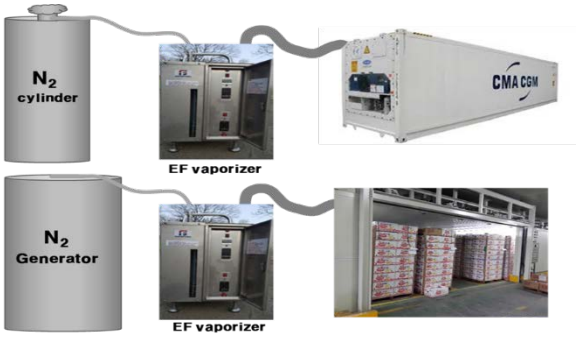
Introduction

Methyl bromide (MeBr) had being planned phasing out and recommended to reduce it usage by the International Plant Protection Convention (IPPC). This is because it was listed as ozone depleting substance (ODS) as well as recent worker safety issues resulted from post-fumigated fruits, such as fumigated oranges and pineapple caused chronic inhalation toxicity. Therefore, from point view of protecting ozone policy and worker safe applications, MeBr need to be urgently replaced. Ethyl formate (EF) offers great potential to replace MeBr for fresh fruit fumigation. However, the cylinderized EF formulated with carbon dioxide is too expensive to adapt commercial practices, and worker safety with handing comprised and heavy cylinders as well as restrict emission of CO_2 are issues to use for large scale commercial fumigation.

Recently, the cost-effective and practically safe use of liquid EF (Fumate registered name) with nitrogen gas has been developed by cooperative research between Murdoch University in Australia and Animal and Plant Quarantine Agency (QIA) in Republic of Korea. The new application technology for application of liquid EF is 100 times safer than MeBr in terms of threshold limit values (EF, TLV=100ppm). EF is known as food additive and naturally occurred substances. Herein, we are commercially demonstrated that new liquid EF application technology on different types of commodities such as oranges, lemons, grapefruits and bananas in different type fumigation facilities and sizes in practices. All commercial trials was successful in terms of efficacy to target quarantine pest based on quarantine guideline and satisfactions to maintain the quality of the commodities. This technology could provide the clean environments (no ozone depletions and CO_2 emissions), safe to fumigators and related workers and practically cost-effective to industries.

Liquid Ethyl formate (EF) application Technology

EF vaporizer (trade name, SFM-1) was used for application of liquid EF. The liquid EF was vaporized and purged with N_2 gas (Inert carrier gas to eliminate explosive risk) formed nonflammable EF+N_2 formulation and directly inject into the fumigation chambers (Figure 1).



Liquid EF is vaporized with heated N_2 gas through the nitrogen heater, which fitted in vaporizer and discharged through the fumigation chamber.

Figure 1. EF vaporizer (SFM-1) application system

Results of the commercial scale trials (Table 1)

Table 1. Accumulative CTP (g h/m^3)

Imported Commodity	Applied Dose (g/m^3)	Fumi. Time (hr)	Temp (°C)	l.r (w/v)	Fumi. Size (m^3)	Application facility	Accoumlative CTP(gh/m3) (Inside banana box)
banana	35	4	13±1	15.0	150	PVC-Tarp	(22.0)
banana	35	4	13±1	18.0	121	Metal chamber	(26.6)
Orange	70	4	5±1	27.5	67.3	40ft reefer	122.4
Orange	70	4	6±1	27.4	67.5	40ft reefer	133.7
Orange	70	4	6±1	27.4	67.3	40ft reefer	125.4
banana	35	4	13±1	19.0	423	Fumi. room	(26.1)
Lemon	70	4	6±1	34.6	67.9	40ft reefer	112.9
Grapefruit	70	4	6±1	31.9	67.6	40ft reefer	122.7
banana	35	4	14±1	19.0	222	PVC-Tarp	(29.0)
Lemon	70	4	6±1	36.7	67.5	40ft reefer	116.9
banana	35	4	13±1	19.0	37.5	PVC-Tarp	(36.3)
banana	35	4	13±1	19.0	60	PVC-Tarp	77.2
Lemon	70	4	7±1	34.9	67.4	40ft reefer	112.2
banana	35	4	14±1	19.0	140.4	PVC-Tarp	71.9
banana	35	4	14±1	19.0	268	PVC-Tarp	(31.7)

The technology differences between cylinderized EF +CO_2 and liquid EF with N_2 technology

Technology	Cylinderized EF	Liquid EF with N_2 Technology
A.I.	- Ethyl formate 16.6 %	- Ethyl formate 99 %
Commercialized	- Cylinderized liquidized gas	- Liquid
Application in fumigation site	- General vaporizer	- Special designed EF Vap. with N_2 (to eliminate flammable risk)
Comments	- CO_2 emissions - Worker safety issue (handing heavy metal cyl.)	- Non-CO_2 emissions - Cost-effective (saving cyl. charging, trade *etc*)

Conclusions

The benefits with liquid EF fumigation by EF vaporizer + N_2 on imported fruits in Korea

- Replaced current unacceptable MeBr fumigation: Consumer and worker safety issues
- Replaced cost-ineffective cylinderized EF with CO_2 application
- Reduced greenhouse gas (CO_2) from cylinderized EF with CO_2 application
- Easy & safe technology to fumigators

References

Agarwal, M., Ren, Y.L., Newman, J., Learmonth, S., 2015. Ethyl formate: A potential disinfestation treatment of Eucalyptus weevil (*Gonipterus platensis*) (Coleoptera: Curculionidae) in apples. *J. Econ. Entomol.* 108(6), 2566-2571.

Kim H.M., Park Y.J., Park M.G. Ren Y.L., Kim H.G., Lee B.H., Yang J.O. 2017. Cost-effectiveness liquid ethyl formate with nitrogen application for disinfestation of imported bananas. The 2017 Korean Society of Applied Entomology (KSAE) spring meeting and international symposium. Apr. 26-28, Kyeongju. Korea. P-194.

Yang J.O., Park M.G., Jeong Y.C., Lee B.H., 2016. Application of ethyl formate with nitrogen for controlling fruit and vegetable insect pests in perishable commodities. Proceedings 10th Int. Conf. on CAF in Stored Products. 6-11. Nov. 2016. New Delhi, India. 4P-4. Pp. 241-243.

Yang J.O., Park Y.R., Park M.G., Ren Y.L., Kim H.G., Lee B.H. 2017. New available quarantine technology for application of ethyl formate. International symposium and annual meeting of the Korean Society of Pesticide Science(KSPS). Apr. 06-07, Yeosu. Korea. P-104.

Yang J.O., Kim H.M., Park Y.J., Park M.G., Ren Y.L., Lee B.H. 2017. New quarantine trials for using liquid ethyl formate with nitrogen application on imported citrus fruits_Cost-effectiveness and worker safety. International symposium and annual meeting of the Korean Society of Pesticide Science (KSPS). Apr. 06-07, Yeosu. Korea. P-105.