UPDATE ON PROFUME® GAS FUMIGANT AS A GLOBAL, POST-HARVEST FUMIGANT

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ProFume® gas fumigant (99.8% sulfuryl fluoride [SF], Dow AgroSciences, Indianapolis, IN, USA) received its first registration in Switzerland for flour mill fumigation in 2003. Since then, ProFume has been registered in 18 countries, including the U. S., Canada, Mexico, Australia, and numerous countries in the E. U. ProFume has been developed for use in food handling establishments, stationary transportation vehicles (railcars, shipping containers, trucks, etc.), temporary and permanent fumigation chambers and storage structure. A wide range of commodities are fumigated with ProFume, including cereal grains, dried fruits, herbs, spices, legumes, tree nuts, seeds, and wood products. The types of structures and commodities fumigated with ProFume vary depending upon country registration. Edible commodities fumigated with ProFume are accepted for international trade due in part to MRLs for SF established by the CODEX Alimentarius Commission in 2006.

Cocoa in the United States (Thoms et al. 2008) and the Netherlands (Quast 2012; Duvier 2012) are fumigated with ProFume. After methyl bromide was no longer available for commodity fumigation in the E.U., others methods including freezing and low oxygen combined with heat proved uneconomical and ineffective compared to ProFume for insect control in stored cocoa (Quast 2012; Duvier 2012). Dow AgroSciences worked with cocoa merchants and processors, fumigators, and researchers in the U.S. (Thoms et al. 2008) and Europe (Noppe et al. 2012) to develop efficacious methods for fumigating cocoa beans using ProFume.

Dow AgroSciences continues to work with new stakeholders to adopt ProFume for registered commodities, such as peanuts. In 2013, a high peanut crop harvest resulted in large volumes of peanuts exported from the U.S. ProFume fulfills an industry need for short fumigant exposure times prior to international shipment to meet tight time schedules. Dow AgroSciences conducted demonstrative fluoride (F-) residue testing for a key peanut processor on their shelled and in-shell runner peanuts after fumigation at the maximum dosage rate (1500 g-h/m^3) of ProFume. (Note: this testing was in additional to previous GLP testing conducted to obtain registration and establish MRLs for peanuts in the U.S.) Fluoride analysis was conducted by the Dried Fruit and Nut Association (DFA) laboratory in Fresno, CA. Results showed the negligible increase in F- residue (maximum 0.14 ppm) after fumigation was less than the background F- concentration (1.03 – 1.05 ppm). There was no effect of the condition of the peanuts (shelled or in-shell) on the F- residue after fumigation. The total F- residues of 1.17 ppm or less detected in peanuts after

fumigation were below the maximum F- tolerance of 15 ppm permitted in the United States, 2 ppm used in Europe as a surrogate background level, and F- tolerances accepted by other countries where fumigated peanuts were exported.

Fumigators using ProFume® are required to adhere to stewardship policy which includes initial and recurrent training and allowing a Dow AgroSciences representative to observe their first fumigation using ProFume. Dow AgroSciences validated the following practices as part of on-site training in January 2013 during fumigation of nine cargo containers filled to about 65% capacity with peanuts in bulk tote bags. ProFume was introduced into the head space of each cargo container using 30.5 m of 0.64 cm ID hose connected to 7.6 m of 0.32 cm ID hose. Cardboard lined the containers and covered the tote tops to prevent mechanical damage to the totes during shipment. The hose and headspace configurations enabled introduction of ProFume without use of a fan. No condensation or discoloration of the tote bags and peanuts were observed after the fumigation. The rear of the cargo container was sealed with 4 mil polyethylene sheeting inside the cargo doors to enhance SF confinement. SF concentrations inside each container were withdrawn periodically throughout the 26 h exposure period and were measured using an SF-ReportIR (Spectros Instruments, Inc.). The mean SF half loss time (HLT) was 13.8 hours (range: 9.4 - 23.5 hours). The required target dosage of 1255 g-h/m^3, based on temperature (23^{o}F) and target pests including *Tribolium confusum*, *T. castaneum* and *Plodia interpunctella*, was obtained in all cargo containers. Required dosage, HLT and dosage accumulation were calculated using the ProFume Fumiguide® (Dow AgroSciences). Ducting connected to a J-fan was used to efficiently vent the containers during aeration. An SF-ExplorIR (Spectros Instruments, Inc.) was used to test for clearance of SF and to ensure workers were not exposed to concentrations of SF exceeding 1 ppm. ProFume has been used during 2013 to fumigate peanuts using the above procedures with no reported lack of efficacy or adverse effects on peanuts.

Periodically, food processing facility managers have requested documentation that deposition of F- residues on food processing surfaces does not occur during fumigation with ProFume. The chemical properties of SF would indicate fluoride deposition on these inert surfaces would not occur. Dow AgroSciences in collaboration with the DFA evaluated F- residues on glass, stainless steel and ceramic surfaces before and after exposure to ProFume. Samples were fumigated for 24 h at 35^{o}C at the maximum dosage rate of (1500 g-h/m^3) for ProFume. The fumigation treatment was replicated three times, with two samples of each surface type in each replicate. SF concentrations in chambers were verified after introduction and before aeration using a Varian Model 3800 gas chromatograph using thermal conductivity detection. After fumigation, a 10x10cm area delineated by a template was wiped twice on each treated and control sample using two GhostWipes moistened with deionized water. F- residues for each surface replicate were measured with a Denver Instrument Model 225 pH/mV/ion meter with a F-Combination Electrode using a procedure validated by DFA. No significant differences (P=0.4335) in F- levels of different surfaces in fumigated samples could

be detected, so residue values were combined for all fumigated samples. No significant difference (P=0.1025) could be detected between untreated control and fumigated samples. Based on these results, F- residues recovered from glass, stainless steel and ceramic surfaces following fumigation with ProFume are from exposure to naturally occurring fluoride in the environment and not from exposure to SF.

Dow AgroSciences will continue to provide technical support for application of ProFume® for the post-harvest industry. This support is provided to ensure regulatory requirements are met during efficacious use of the fumigant.

ACKNOWLEDGMENTS

Marty Morgan of Dow AgroSciences conducted the peanut fumigations for F-testing. Mr. Eric Hobelmann of Dow AgroSciences documented procedures during fumigation of peanuts in bulk totes in cargo containers.

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