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# Sanitation's impact on the effectiveness of the pest management programs of food processing facilities

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ABSTRACT

Pest management in food processing facilities strives to prevent product loss due to insect consumption or infestation of raw or processed product. Facility managers may use a combination of different control methods to prevent or eliminate insect outbreaks. Prior research has suggested that sanitation, a preventative measure, may improve the effectiveness and reliability of other control methods, which may also reduce the cost of pest management for food processors when using these methods. Two food processing facilities in the Midwest were evaluated on their levels of sanitation and then monitored for insect pests following fumigation with Profume™. Facility managers were interviewed regarding their facility's pest control and sanitation programs, as well as their own attitudes and opinions regarding pest control. Bioassay results suggested an equal level of effectiveness of fumigation for both facilities, but monitoring data suggested that the cleaner facility (Facility A) had slower pest population rebound rates than the less-clean facility (Facility B). Comparison of pest control costs in each facility revealed that Facility A spent less than Facility B on pest control as predicted, but also spent less on sanitation. This suggests that greater investment in sanitation is not required for improved facility cleanliness and pest management effectiveness. Knowledge and involvement on the part of management and the employees in the facility's pest management program, may serve as a better indicator of sanitation's impact on facility pest management. These findings appear to correlate with the early results of an online survey that seeks a broader perspective of industry trends.



## 1. Introduction

An estimated $8.5 billion is spent on chemical pesticides annually in agricultural and food processing production to prevent losses due to insect damage (Phillips et al., 2000). With so much investment directed toward controlling pest species, facility operators should ensure that effective control methods are used. Past studies have shown that environmental factors can directly impact stored product insects (SPIs) and the effectiveness of the chemical agents designed to control them (Semeao et al., 2012; Arthur, 2000). Additionally, some products, like methyl bromide, are being removed from the market (United Nations, 2012), while others have lost effectiveness due to resistance traits developing in insect populations (Zettler and Cuperus, 1990; Zettler and Beeman, 1995; Bridgeman et al., 2000; Bell, 2000; Benhalima et al., 2004; Daglish, 2004; Athie and Mills, 2005; Pimentel et al., 2007; Adams et al., 2010; Opit et al., 2012). These realities, therefore, require a change in focus of pest control to improve effectiveness and reduce costs.

Sanitation has been emphasized as the first step in stored product pest management (Phillips and Thorne, 2009; Campbell et al., 2004). It limits food resources that stored product pests can exploit, increases the likelihood of pest insects encountering monitoring traps, and ensures that residual pesticides remain effective for extended periods of time (Arthur, 2000). However, the direct impact of sanitation on pest management in food processing facilities is less understood, especially how the investment in sanitation may impact the overall cost and effectiveness of a facility's pest management program. Better-understanding the link between sanitation and pest management may help pest control professionals in making recommendations to their clients and encourage facility operators to adopt a sanitation-oriented program.

Observations were made in two food processing facilities to form a baseline regarding the relationship between sanitation and

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pest management. Both facilities were assessed on their level of sanitation and the perceived effectiveness of their pest management programs, while interviews with facility managers were incorporated to determine the financial dynamics between sanitation and pest management. An online survey was also developed to determine if the patterns observed in the case-study extended to the food processing industry as a whole.

## 2. Materials and methods

### 2.1. Case study

Two commercial food processing facilities located in the Midwestern United States were observed for 4–5 months starting in July 2011. They were examined for 1) their apparent sanitation level based on a standardized set of criteria, 2) the effectiveness and reliability of their pest management programs using fumigation bioassays and monitoring trap capture data to compare the facilities, and 3) the financial relationship between sanitation and pest management in each facility. The facilities were of similar size, annual production level, and follow an annual calendar schedule for fumigation treatments (Table 1). Despite similarities between facilities, some differences did exist: Facility A was a newer building made of a combination concrete-sheet metal construction and situated in a rural area, while Facility B was an older building made mostly of concrete and located in a populated urban center.

Observations began at each facility's yearly fumigation application with ProFume™ (sulfuryl fluoride) gas. Fumigations were conducted as part of annual treatments performed by professional, commercial fumigators. Treatments were considered to have met the standards of the professionals conducting them and so trapping observations were interpreted through this lens of successful application. Treatments occurred in July (Facility A) and August 2011 (Facility B) in the first year and in early August 2012 for Facility B in the second year. Less than 24 h before treatment, vials containing adult and egg *Tribolium castaneum* (Herbst) were set out in each facility (Facility A: 181 adult vials, 63 egg vials; Facility B: 90 adult vials, 90 egg vials). Each vial contained five individuals of each life stage. Mortality after exposure was used as a measure of treatment effectiveness, with adult mortality measured by the number of dead following exposure and egg mortality measured by the number of individuals that failed to reach maturity after 42 d post-fumigation. Following treatment, Storgard™ Dome monitoring traps targeting *T. castaneum* were set out on each floor of the facility with a total of 50 traps setup in Facility A (~12.5 traps/floor) and a total of 100 traps placed in Facility B (~10 traps/floor). Adult beetle trap capture was recorded monthly for a period of 5 months in Facility A and 4 months in Facility B. Due to the working environment of both facilities, some traps were occasionally disturbed or removed from the environment by facility employees. To limit the effect of these disturbances, trap capture averages only used undisturbed traps and trap capture rates were standardized as "Number of beetles per trap per day."

We evaluated each facility on its level of sanitation, based on a standardized set of criteria developed by Tsai (2010). Facility managers were also interviewed regarding the costs associated with sanitation and other pest control methods, as well as their knowledge or attitudes toward both. Cost of pest control was estimated from the sum total of investments for all classes of pest control used in the facility (fumigation, residual sprays, etc.) and cost of sanitation was estimated from average employee wage multiplied by the number of man-hours devoted to cleaning (Zagurramurdi et al., 2007). When an exact value was not available (i.e. if the information was the responsibility of another department), managers were asked to provide a reasonable estimate, based on prior experience.

**Table 1**
Facility manager responses to questions about basic information regarding the size, output, and pest control in two food processing facilities.

| Facility data | Facility A | Facility B |
|---|---|---|
| Grain processed | Corn | Corn, Wheat, Oat, Soybean |
| Location | Rural | Urban |
| Est. Floor size of treated area (sq. ft) | 64,000 | 61,000 |
| Number of full-time employees | 190 | 70 |
| Number of grain-milling units | 3 | 4 |
| Number of grain meal sifting units | 3 | 2 |
| Annual revenue (est. millions of dollars) | 72 | 76.52 |
| Pest control within facility or outside provider? | Within facility | Outside provider |
| Number of fumigations/year? | 1 | 1 |
| Cost of Pest Control ($/yr) | 33,000 | 56,000 |
| Sanitation Costs ($/yr) | 31,000 | 44,000 |

### 2.2. Online survey

An online survey was developed using Qualtrics™. A request for participants was advertised in two milling journals, with a link directing the readers to the online survey. Respondents were asked a series of 31 questions relating to their facility, its pest management and sanitation programs, and their perceptions and knowledge of both. All responses were collected anonymously to protect respondents and their employers' identities.

## 3. Results

### 3.1. Sanitation scores

Based on Tsai's (2010) criteria, Facility A scored higher than Facility B in terms of the overall level of sanitation present in each facility. Facility A was classified as having "Superior" sanitation, while Facility B was classified as having "Good" sanitation. Facility A generally observed good operational practices in almost every area of the facility, while Facility B was found lacking in several areas. Among them, 1) Facility B had large piles of raw or processed material left out for extended periods of time, 2) doors were left open to the outside environment for indeterminate periods of time, and 3) facility conditions allowed for the build-up of moisture and dust. In general, Facility A did a better job addressing these aspects of facility sanitation.

### 3.2. Fumigation bioassay results

The results of bioassay data indicate that an effective dose of Sulfuryl fluoride permeated all areas of each facility (Fig. 1). Facility A had 100% mortality of adult beetles in vials (Avg. = 0 ± 0 beetles alive; Control Avg. = 5 ± 0 beetles alive) and 100% mortality of beetle eggs (Avg. = 0 ± 0 beetles alive; Control Avg. = 3.8 ± 0.29 beetles alive). Facility B had 99.1% mortality of adult beetles (Avg. = 0.044 ± 0.042 beetles alive; Control Avg. = 5 ± 0 beetles alive) and 94% mortality for beetle eggs (Avg. = 0.3 ± 0.077 beetles alive; Control Avg. = 3.8 ± 0.39 beetles alive). The apparent lower effectiveness of Facility B's fumigation is due to some of the adult and egg vials being placed in an area of the facility that was fogged with an aerosol, but not fumigated. The vials therefore physically shielded the specimens from the aerosol. When un-fumigated vials were removed from the mortality average, both adult and egg mortality increased (Adult avg. = 0 ± 0 beetles alive; Egg avg. = 0.18 ± 0.061 beetles alive). Overall, the results of both