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Sanitation indicators as a tool to evaluate a food safety and sanitation training program for farmstead cheese processors

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ABSTRACT

This project evaluated the impact of a food safety and sanitation training program, developed for farmstead cheesemakers, by investigating its effects on the cleanliness of cheesemaking rooms of dairy farms in Pennsylvania. Participating farms (n = 16) were divided randomly into control (n = 6; no training) and two treatments, consisting of a food safety and sanitation training program without a video vignette (treatment 1; n = 5) and a training program supplemented with a video vignette (treatment 2; n = 5). Before the training and again 3–4 months after the training, environmental samplings were conducted on select surfaces in cheesemaking rooms. Surfaces were swabbed and evaluated for aerobic bacterial counts (AC), Enterobacteriaceae (EB), yeast and molds (YM), *Listeria* spp., and for levels of adenosine triphosphate (ATP). The results demonstrate that the training program, with or without the video vignette, significantly reduced ($p < 0.05$) populations ($\log_{10}$ CFU/100 cm^2) of AC (treatment 2 = 1.23), EB (treatment 1 = 1.18; treatment 2 = 0.89), and ATP (treatment 1 = 0.41; treatment 2 = 0.61) in samples taken from floors and drains. The results from this study may serve as a reference for future evaluations of food safety-related training programs that look beyond changes in employee knowledge, attitudes, skills, or behavior, and address or correlate to other potential indicators of sanitation, such as microbial counts and ATP levels.

1. Introduction

Foodborne diseases are a major health problem in the U.S., where an estimated total of 48 million illnesses, 128,000 hospitalizations, and 3000 deaths occur each year (Scallan, 2011). Ninety-seven outbreaks associated with cheese yielded 2112 illnesses, 221 hospitalizations and ten deaths between 1998 and 2012 (Anonymous, 2012). Nonetheless, cheese consumption is on the rise (Anonymous, 2016), especially artisanal ones, produced locally at small farms, and frequently made from raw milk (Waldman & Kerr, 2015).

Researchers have demonstrated that consumption of non-pasteurized dairy products can be 150 times riskier than for pasteurized products (Langer et al., 2012), given that pathogens are found more frequently in raw milk (Oliver, Boor, Murphy, & Murinda, 2009). Additionally, there appears to be an association between the person in charge having food safety training and being able to describe proper handwashing (Allwood, Jenkins, Paulus, Johnson, & Hedberg, 2004) and these small cheesemakers might lack proper food safety training, which could put consumers of such cheeses at risk. As such, handwashing and sanitation training are important aspects that must be employed to reduce the risk of a foodborne illness. Sanitation has been shown to reduce the load of pathogens, such as *Listeria monocytogenes*, from food-contact surfaces (Campdepadrós, Stchigel, Romeu, Quilez, & Solà, 2012). Risk assessment and prevention programs, such as hazard analysis and critical control point (HACCP), have been linked to better practices and lower microbial load (Carrascosa et al., 2016; Costa Dias et al., 2012; Cusato et al., 2013; Domenech, Amorós, & Escriche, 2013), thereby demonstrating that knowledge about the risks associated with food processing is important for foodborne illness risk reduction. Also, understanding the sources of contamination is an important component to ensure compliance. Non-food contact surfaces at food processing facilities may be a source of contamination and harbor pathogens like *L. monocytogenes* (Tompkin, 2002). Therefore, environmental contamination in food processing facilities, especially those located on small farms (Kersting,

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Medeiros, & LeJeune, 2010), is of concern.

Although there are numerous food safety programs and training recommendations, a barrier to effective training may be the generic, prescriptive content and the school-like delivery methods that are used (Chapman, MacLaurin, & Powell, 2011). Rather, the use of stories and verbal narratives when delivering a message may be more effective in conveying information than numerical statistics alone or informative messages (Morgan, Cole, Struttmann, & Piercy, 2002). Additionally, the use of fear, when incorporated into stories used in food safety training and with situations that fit into participant's lives, also was shown to increase the effectiveness of the training (Chapman et al., 2011; Morgan et al., 2002). A comprehensive literature review regarding the effectiveness of food safety training (Egan et al., 2007) found that there is limited evidence of such effectiveness. The main problems indicated by those authors were the lack of well-defined outcomes. However, another literature review (Medeiros, Cavalli, Salay, & Proença, 2011) reports that overall food safety training has a positive impact on knowledge, attitude, and behavior, especially when using interactive media and hands-on activities. These discrepancies illustrate how difficult it is to evaluate the efficacy of food safety training properly. Conversely, processors can easily assess contamination levels, the effectiveness of sanitation practices, and issues with good manufacturing practices (GMPs). They can achieve that by testing for sanitation indicators such as aerobic plate counts (APC, or AC), yeast and mold counts, Enterobacteriaceae, and adenosine triphosphate (ATP) on food-contact and non-food-contact surfaces (Tortorello, 2003).

To date, no current training program exists to address the specific and unique food safety needs of farmstead cheesemakers or addressed the relationship of a food safety training program and the impact on sanitation indicators (ex. microbial counts and ATP levels) in these establishments. Therefore, the purpose of this study is to evaluate the effect of a food safety training program and a video vignette, developed specifically for farmstead cheesemakers, on the microbial quality of surfaces found in cheesemaking rooms of farmstead dairy farms in Pennsylvania. It is hypothesized that increased food safety knowledge will positively affect employee attitude and behavior, thereby reducing sanitation indicators (microbial load and ATP levels) in the cheesemaking environment. These changes have the potential to improve the quality and safety of farmstead cheese.

2. Material and methods

The population for this study comprises small dairy farms in the state of Pennsylvania that produce cheese on site. Our target clientele were farms where the dairy business was the main source of income, which made cheese with milk from the farm herd or bought locally, and that usually had one person responsible for the cheesemaking. This study used an adaptation of a pre-test/post-test experimental control group design (Campbell & Stanley, 1963). There was no random sampling of participants since all 55 possible participants were contacted. We randomly assigned the 16 ($n = 16$) farms that agreed to participate to either a control ($n = 6$), treatment 1 (without video vignette; $n = 5$), or treatment 2 (with video vignette; $n = 5$) group (Fig. 1). Randomization was carried with the help of an online tool (Anonymous, 2015), in a true experimental design. The training had two modules; the first covered basic food safety and sanitation applied to small cheese producers and included a step-by-step demonstration of how to clean cheese vats. The second module covered personal hygiene and included a step-by-step demonstration of how to perform proper handwashing. The training was delivered to both treatment groups using a counter-top flip-chart format (Nieto-Montenegro, Brown, & LaBorde, 2008; Richard et al., 2013).

A video vignette was shown to participants in treatment group 2 using a laptop computer before the delivery of the training. The video vignette consisted of a mock news excerpt depicting a foodborne listeria outbreak involving cheese. The script for the video vignette was based on a real outbreak case involving a cheese company in Kenton, DE (Anonymous, 2014). In the video vignette, actors depicted a news reporter who interviews a physician about listeriosis, and a real food safety specialist discusses the causes of the outbreak and what could be done to avoid it. The vignette contained no structured food safety or sanitation educational aspects. The main goal of the vignette was to incorporate a story-telling primer before the training in an attempt to yield better training results (Chapman et al., 2011; Morgan et al., 2002).

Environmental samples were obtained before and after the training for the treatment groups and at two time-points for the control group. The interval between samplings was 3–4 months for both control and treatment groups with pre-samples collected May to June and post-samples collected September to October 2015.

Ten different areas were sampled in each cheesemaking room of the 16 plants, including five food-contact surfaces and five non-food-contact surfaces (Table 1). Sampling sites 1 to 5 were chosen, based on a previous needs assessment where the floor, drain, and multiple handles were the nonfood contact surfaces with the highest microbial counts (Machado, 2016). Sampling sites 6 to 10 were chosen based on the most common food contact surfaces found in the cheesemaking rooms.

Sampling sites were divided into four groups (A, B, C, and D) according to their similar characteristics and overall microbial load, as assessed previously (Machado, 2016). Group A sample sites included floors and drains, which were non-food contact sites with the highest microbial load; group B samples included doors and hose handles which had high counts; group C encompassed the cleanest sites from the food contact surfaces and had a low microbial load. Group D had samples from tables that were used as a food contact surface, but could also be used for other activities. Since tables were usually used for other activities after cheesemaking, and sampling was done up to 24 h after a cheesemaking session, the microbial load was not as low as the other food contact surfaces, so they were put in a separate group (Machado, 2016).

For microbial analyses, flat surfaces were sampled in duplicate with 3M® swab samplers (3M, St. Paul, MN), containing 10 mL of neutralizing buffer, and a 10 × 10 cm sterile plastic template (3M, St. Paul, MN). The designated area was sampled with the swab using two perpendicular sequences of "S" strokes, followed by a third diagonal streak, always with rotation of the swab to ensure contact of all parts of the swab surface. The same sampling technique was used for ATP (adenosine triphosphate) testing. For non-flat surfaces, an equivalent area of 100 cm^2 was sampled when possible. For small, uneven surfaces (e.g. door handles), approximately half of the area was sampled for microbiological testing (one-quarter for each duplicate), while the remaining area was sampled for ATP testing. Samples for microbiological testing were collected in duplicate, while ATP testing had a single area tested. Environmental microbiological swabs were transported to the laboratory in a portable cooler with reusable ice packs, stored under refrigeration, and analyzed within 24 h. For ATP testing, a Clean-Trace™ luminometer and Clean-Trace™ surface ATP swabs (3M, St. Paul, MN) were used. ATP results were measured in relative light units (RLUs) and recorded on site.

Tubes from microbiological samples with 10 mL of neutralizing buffer were vortexed for 30 s and used for the inoculum. After aliquots had been taken for plates and dilutions for counts of total aerobic counts (AC), Enterobacteriaceae (EB), and yeast and mold (YM), the leftover volume of neutralizing buffer was used for