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Analysis of the effectiveness of sanitizers for a low moisture footwear sanitization unit

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***Abstract*— *Footwear sanitization is critically considered in food industries as control of the cross contamination of pathogens for the safety and quality of the production. Since poor maintenance of footbaths type of footwear sanitization systems can further enhance cross contaminations, importance of low moisture systems in footwear sanitization is acclaimed. This study examines the efficacy of the decontamination of E. coli, with IPA/ethanol, QAC/ethanol, IPA/QAC/ethanol, IPA/QAC/water chemical treatments for boots and slippers. Cleaned footwears were treated with E. coli sample and sanitizer was treated by spraying. Swab tests were done before and after applying treatments. Using dilution series, CFU was counted after incubating the selected diluent on the petri plates. Log value of the reduction of E. coli was graphically represented, and further statistical analysis was done by Tukey's test with a post hoc test. Results revealed that IPA/QAC/water treatment was the best as it significantly contribute (Tukey's test, $P \leq 0.05$) in log reduction/CFUs of microorganism. Overall study depicts IPA/QAC/water combination is efficient and effective as sanitizer combination for a low moisture footwear sanitization system.*

Keywords*—*E. coli, Footwear sanitization, IPA, Low moisture systems, QAC.

I. INTRODUCTION

Safety of food is a vital issue in most of the food manufacturing industries to prevent the ingress and spread of the pathogens. It is often considered into Good manufacturing Practices (GMPs) in food processing environments. Frequently, Cross contamination from external sources as footwear has considered as a decisive factor in hygienic control. Even in HACCP[1] footwear sanitization has considered as a critical point (CP) to manage.

Foot baths are commonly used to decontaminate footwear soles to enhance the hygienic environment, which required high capital investment, chemicals and human resource for maintenance. Some studies depicts that footbaths are responsible for the enhancing of environmental microbial load, if not maintained properly [1] [2]. Even such systems can lead to microbial spread and boost the safety risk by introducing water and increasing humidity of the thoroughly dry areas of a plant [3]. Increased humidity level can severely affect the quality of low moisture food products and enhances the safety issues mostly related with foodborne pathogens.

Foodborne diseases are common, as millions of cases were reported worldwide for a year [4]. Among number of pathogens, *Listeria monocytogenes*, *Campylobacter spp*., *Staphylococcus aureus* and *Escherichia coli* (*E. coli*) are frequently causing food borne illnesses and food spoilage. Specially, *E. coli* is extremely associated with the food safety factor as it's a facultative anaerobic microorganism which found in warm blooded animals intestine [5].

Since low moisture systems for footwear sanitization is an imperative, this study proposes the use of sanitizers in different combinations for a footwear sanitization unit on the affectivity in decontamination of *E. coli* for two different footwears as boots and slippers.

Despite of footbaths, vaporizable proper sanitizer combination can be used for a low moisture footwear sanitization system. Sanitizers are the chemicals those were not effect to the quality of the product and even the safety but used for reducing microorganisms which considered as critical to human health [6]. Hypochlorite, Quaternary ammonium compounds (QACs), Chlorine dioxides, Iodophors, Peroxyacetyl acids (PAAs), Isopropyl alcohols (IPAs) and *etc.* are examples for sanitizing agents. Therefore, overall study was based on the effectiveness of QAC and IPA chemical combinations on the decontamination of *E. coli* on footwears; boots and slippers.

II. MATERIALS AND METHODS

2.1 Footwear

Two different types of footwear were used in the study as work boots and slippers. Comparatively boots were having wide treads than slippers which are having narrow treads more shallow with closer together (Fig. 1). Six identical unused pairs of footwears (Slippers and boots separately) were used in the study.

[1] HACCP - Hazard Analysis Critical Control Point

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In each trial, footwear was cleaned and disinfected thoroughly on, before used and after used. Cleaning and disinfection was carried out by; rinsing with 600ppm chlorinated water for 5 minutes and dried with clean paper tissues. Then, 98% ethanol was sprayed and allowed to dry. The effectiveness of the disinfection procedure was analyzed by a Swab test before processing the trials.

Fig.1: (A) work boots, (B) tread pattern of work boot, (C) work slippers, (D) tread pattern of slippers

2.2 Preparation of *E. coli* sample
A 200mL previously prepared *E.Coli* sample was taken for the study. 25mL of the sample was absorbed into a sponge (30cm*30cm*3cm) before each trial.

2.3 Preparation of sanitizers
Study was carried out by using two chemical sanitizers in different composition while ethanol or water using as base solvent as shown in the table 1.

Table.1: Sanitizer combination

Chemical	Ratio	Contact time
IPA/Ethanol	10:1	1 min
QAC/Ethanol	10:1	1 min
IPA/QAC/Ethanol	10:10:1	1 min
IPA/QAC/Water	10:10:1	1 min

Prepared sanitizers were transferred into a sprayer (capacity 100mL) which can spray approximately 0.20 mL per stroke as measured at the beginning of the study.

2.4 Task and Procedure
Clean footwear was pressed on the *E.Coli* treated sponge for 1 minute. Three locations of each footwear from the top to bottom was sprayed using one stroke, holding nozzle of it 5±1 cm away from the footwear. Footwear was held its downside up for the easiness of further tests. All the tests were conducted as triplicates for slippers and boots discretely.

2.5 Microbiological sampling and analysis
To enumerate the initial *E. coli* content a swab test was performed before applying the sanitizers. After 1 min of a contact time, again a Swab test was done for each footwear. The suspension in each swab test bottle was serially diluted and plated on petri plates. Plates were incubated at 35^0C for 48 hours.

2.6 Statistical analysis
Colony forming units (CFU) were counted for both types of footwear and recorded after converted them into log values. And also mean value for CFU in triplicate of each treatment and controls were calculated. The difference of the defined log value of the initial and the post treatment for separate footwears were noted as the log reduction value. A Tukey comparison test was conducted using Minitab 17 by means of analyzing the variance. Finally, one way ANOVA was conducted as a post hoc test for the tukey's test, to determine the significantly different treatment.

III. RESULTS AND DISCUSSION

CFU in terms of average log value for each treatment are depicting in fig. 2. According to the results, slippers type

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footwear having high *E. coli* load than in work boots. This might be due to the tread line pattern of the foot wears (fig. 1). Slippers are having narrow and shallower as well as closely aligned treads which provide a big surface for microorganisms than the wide tread pattern in a boot. According to previous studies; it confirms that wide tread patterns on footwear combines with less count of pathogens compared with narrow tread pattern [3].

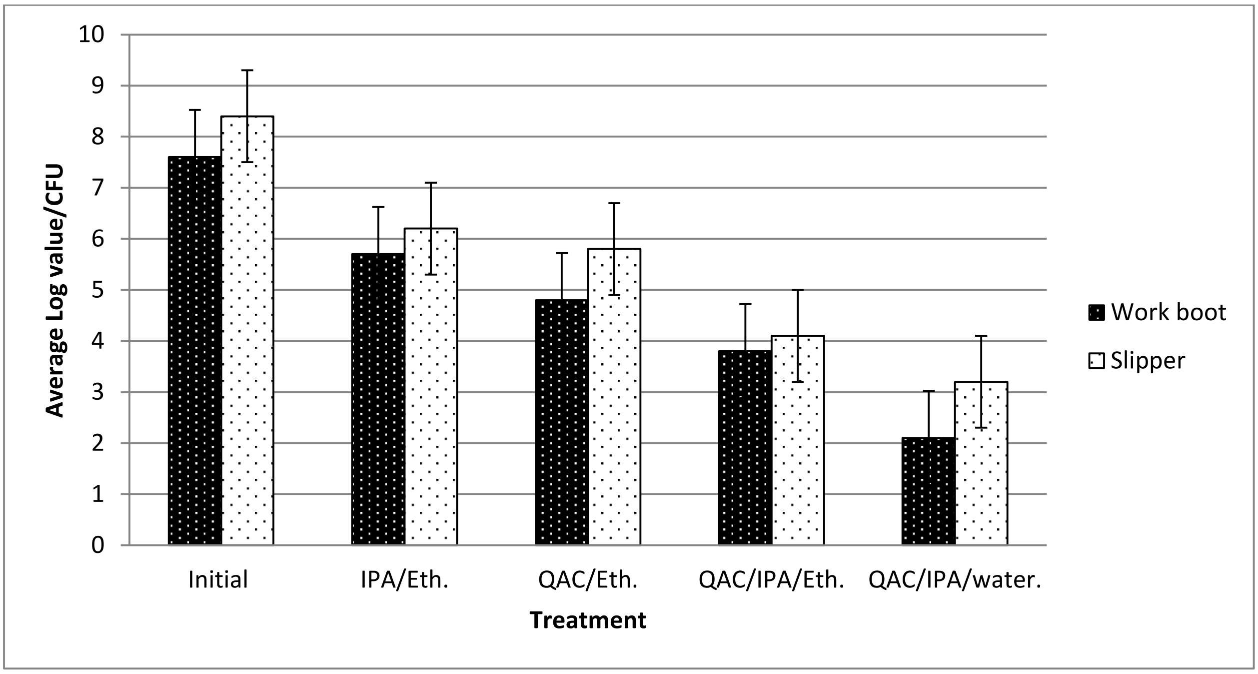

Fig.2: Average log values of CFU of E. coli after sanitization

According to the fig. 2, reduction of log CFU for QAC/ethanol was higher than for the IPA/ethanol. QAC is mostly active than IPA, since IPA is a secondary alcohol, but; QAC is a complex chemical which is having a positively charged cation that can easily bind with phospholipids of the microbial cell wall. This supports to destroy the microbial load to an extent [7]. Gram negative, E.coli like microorganisms effected by QAC most.

Results impart, combination of QAC/IPA/ethanol indicates higher log reduction than for QAC/ethanol and IPA/ethanol. This resulted by the total action of QAC and IPA together towards the E.coli. According to previous studies, QAC and IPA are most effective towards pathogens in decontamination of footwear soles [3].

But QAC/IPA/water shows an uppermost log reduction compared to all other treatments. And also it depicts a difference with the treatment of QAC/IPA/ethanol. Therefore, the variation was caused by the base “water” because it has enhanced the sanitization power of QAC/IPA. Thus dry QAC is not active towards pathogens since it needed at least some moisture to activate against the target microorganism [3].

Overall study found that there was a less difference in sanitization between slipper and work boots except in the initial microorganism load. Both footwears revealed similar variation pattern of sanitization within the study. The degree of decontamination is depends on the type of the footwear, microorganism load in the footwear sole and the type of the sanitizer. Similar variation pattern for sanitization of two footwear, boot and slipper can be occurred due to the similarity of the treatments.

Study extends to the efficacy of the sanitization on the basis of log reduction, and it was analyzed according to tukey’s test, using Minitab 17 statistical software. Results pertaining to the log reduction in *E. coli* populations on the work boot and slipper footwears with respect to the four treatments were significantly different (Tukey’s test, $P \leq 0.05$) to each other. Post hoc analysis for the Tukey’s test, one way ANOVA was also found that, all four treatments are significantly different from each other.

This finding tends the variation between each treatment on footwears; boot and slipper. Figure 2 describes such a variation as per QAC/IPA/water shows the highest log/CFU reduction for *E. coli* decontamination while QAC and IPA alone show a lower log reduction. A research conducted on the *Salmonella* population has shown similar results for the combination of QAC and IPA as >3.9 log reduction, but for aqueous QAC 1.3 log reduction [8]. Therefore, a remarkable biocidal activity is presented in the combination of the sanitizers QAC/IPA.

On facts, the study found that all four chemical treatments for boots and slippers were capable in reducing *E. coli* content to an extent, but the uppermost 99.99% *E. coli* reduction was examined in work boots and slippers for QAC/IPA/water. But in practical conditions this depends on the bactericidal activity of the microorganism as the longer contact times can enhance it [9], except other factors such as maintenance practices.

IV. CONCLUSION

Inclusive study suggested IPA/QAC/water, the best sanitizer combination in reducing *E. coli* population on footwear. Thus, IPA/QAC/water is most suitable for low moisture footwear sanitization system as QAC/IPA/water combination was the best for log reduction of *E. coli* population (99.99%) since water activated function of QAC towards pathogens.

The effect of water (<5%) in the QAC/IPA/water having minimum influence compared to water based footbaths containing aqueous QAC, since IPA and QAC are readily vaporizable [3]. This supports to reduce the risks of cross contaminations and suitable for dry environments where humidity of the plant is a critical factor (i.e. biscuits manufacturing).

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