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HYGIENE MONITORING OF TEXTILES USED IN THE FOOD INDUSTRY

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ABSTRACT

Protective clothing is required in the food-processing industry, to protect workers from contamination by bacteria, fungi, viruses, prions etc. contained in the secretions and raw meat of slaughtered animals, and to protect the meat from being contaminated by microorganisms carried by the workers. It is well-understood that textiles are a control point (CP), and must be appropriately cleaned and disinfected in order to prevent biocontamination. Although the laundering procedure itself is important for achieving disinfection, it is also essential to maintain an appropriate hygiene level in the laundry, in order to prevent recontamination of textiles by environmental viable microorganisms. In this study, a sanitary-microbiological analysis was carried out in selected CPs in two laundries. Chemo-thermal washing efficiency was determined by evaluating the anti-bacterial effect against *Enterococcus faecium* and *Staphylococcus aureus*. The hygienic state of the laundries was determined by evaluating the number and type of microorganisms at selected CPs throughout the whole laundering procedure. The results indicated that the sanitary condition of both laundries did not reach the required levels and that several microbes were resistant to cleaning and disinfecting agents. It is obvious from the results that achievement of an appropriate hygiene level during laundering textiles from the food processing industry requires the implementation of appropriate corrective monitoring measures.

Key words: laundry hygiene, textiles, food-processing industry, occupational health

INTRODUCTION

The protective clothing of workers in slaughter houses is required both for protection of meat against contamination with microorganisms and for protection of the workers from microorganisms contained in carcasses, faeces, bone dust, blood clots etc. (4).

Most people assume that the laundry returned to them is in fact clean and, therefore, safe. However, the dirt may certainly have been removed, but it is far from sterile. Experience encourages all infection control teams to take laundering very seriously during outbreaks that seem to have no apparent cause (2,3,5,10,17,21).

On the 14th of July 1993, the European Committee accepted a new directive: EG Richtlinie 93/43/EWG for Hygiene in the Food Industry that is based on the HACCP (Hazard Analysis and Critical Control Points) system. The HACCP system is a quality system which enables a company to formulate food safety policies and is based on establishing, documenting and maintaining a system of ensuring that all known potential hazards are identified, and that all relevant hazards are controlled in such a manner that a company's products do not harm the consumer. A critical control point (CCP) is a point, procedure or stage in the food chain at which control can be applied, and is essential to prevent any food safety hazard or reduce it to an acceptable level (1,7). It was accepted that textiles used in the food Industry (i.e. working clothes, towels etc.) are classified as a CCP.

On the 23rd of September 2002, the European Committee for Standardization (CEN) approved a standard based on RABC (Risk Analysis and Biocontamination Control) principles, for

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laundry processed textiles. This document provides a management system that uses the principles of a risk analysis and biocontamination control system based on preventive measures. This enables laundries to continuously assure the microbiological quality of laundered textiles, especially for textiles used in specific sectors, such as pharmaceuticals, medical instruments, food, healthcare and cosmetics (8). A control point (CP) is any point or step in a process at which control is applied, in order to contain, eliminate or reduce biocontamination risk.

Due to the trend of economizing on laundering costs by reducing time, energy, detergents and disinfecting agents as well as water, the risk has grown of microorganisms surviving the laundry procedure, and thus, adapting to yet another habitat (16). Laundry procedures, especially in continuous batch washers with a capacity of 50 kg dry laundry/compartment and 9 to 14 compartments, cannot be economical if water at 90ºC is used; the optimum temperature is therefore around 60ºC. Preliminary studies (10) hare shown that the disinfection effect of the laundry procedure has in addition to achieving an appropriate hygiene level in the laundry, a very important role in reducing bacterial contamination of the cleaned and disinfected textiles. According to the regulations of the Robert-Koch Institute in Germany (15) the disinfection effect of a laundering procedure can be thermal, chemical or chemo-thermal (6,18).

In 1998, directions for the laundering quality and hygiene (RAL-GZ 992/3) for textiles from the food-processing industry were issued by RAL, the German Institute for Quality Assurance and Certification (18). These directions are valid as important recommendations for laundries in the European Union. The Hohenstein Research Institute, Germany, is authorized by RAL to issue Certificates of laundering quality and hygiene of textiles from the food-processing industry, on RABC and HACCP principles. Retaining the Certificate depends on unannounced annual inspections of the laundering and disinfecting quality and the hygiene levels in the laundries, according to standard methods and in comparison with chosen limited values.

There are several CPs in laundries (Table 1) that need to be controled in order to reduce bacterial contamination:

CP 1: Washing procedure

The chemo-thermal disinfection efficiency of the laundering procedure is the most important CP in the laundry. It is also the most difficult to achieve, since it is necessary to optimize the laundering quality, which demands minimal usage of disinfecting and bleaching agents in order to achieve minimal damage to the laundered textiles, with a disinfecting effect that is greater when larger amounts of disinfecting agents are used (11). The disinfecting efficiency of each new procedure should be evaluated by determining the bactericidal effect of standard bio indicators. If the anti-microbic washing effect is confirmed, the washing procedure should be monitored daily. The parameters checked are: disinfecting time and temperature, bath-ratio, detergent and disinfectant dosage and the pH-value of the technical water. The parameter's limits are given by the detergent producer together with tolerance values. If the values are exceeded, the corrective action is to repeat the washing procedure. External control includes inserting bio indicators in a random laundering procedure, thus evaluating the disinfection effect. All external controls of the disinfection effect should prove that no bio indicators survive any chosen laundering procedure.

CP 2: Textiles

Cleaned, ironed and folded textiles are an important CP, because these are used in further processes of the food-processing industry. External control consists of taking 10 random samples using plate count agar plates, of folded and ironed textiles. The recommended values (18) after an incubation period of 24 h at 36ºC are noted in Table 1. Damp textiles should also be assessed in order to evaluate the general hygienic state of the tumblers, sorting and conveyer belts etc.

CP 3: Water

Water is also an important CP because a large amount of water is returned to the laundering procedure in an effort to economize. If the laundering procedures don't have an efficient disinfection effect, the washing can become burdened with large amounts of microorganisms that multiply excessively under appropriate conditions for growth in washing machines, such as: warm atmosphere, adequate moisture and plenty of nourishment in the form of human excrements, soils etc. from the dirty textiles. The ion exchangers for water softening consist of organic polymers, on which microorganisms adhere to surfaces and a gel layer called biofilm inevitably forms. When the biofilm reaches a critical point, the microorganisms rinse into the softened water - biofouling (9,12,13). Therefore, it is necessary to disinfect the ion exchanger at regular intervals. Monitoring consists of checking the disinfection times and dosages of those disinfection agents given by the softening plant manufacturer. When the values' limits are breached, the disinfection should be repeated. External control is carried out by taking water samples from different CPs, as noted in Table 1.

CP 4: Technical equipment and CP 5: Storage shelves/transport

The regular cleaning and disinfecting of technical equipment, storage shelves, and transport vehicles in contact with laundered textiles is very important in preventing bacterial contamination. The most important CP is the water press extractor, which is difficult to clean due to the danger of injuries. Important CPs are also lifting and conveyer belts on which a large amount of microorganisms deposit, which can contaminate clean textiles as well as all surfaces, in contact with clean textiles. External control consisted of taking random samples using plate count agar plates, at different CPs, as noted in Table 1.

Table 1. Recommended values of critical control points for laundries involved in cleaning textiles from the food processing industry.

CP	Criterion
Washing procedure	No growth of bio indicators
Ironed and folded textiles*	9 out of 10 samples should not contain more than 50 CFU/dm^{2†}
Damp textiles	< 100 CFU/dm^2
Tap washing water, softened water, wringing water	< 100 CFU/mL‡
Technical equipment (washing machines, sorting and conveyer belts)	< 100 CFU/dm^2
Storage shelves/transport (flatwork ironer shelves, folded laundry shelves, side wall in transport vehicles)	< 100 CFU/dm^2
Hand hygiene (Before and after cleaning and disinfecting)	< 100 CFU/dm^2

* The RODAC-agar plates used for surface sampling of ironed and folded textiles should not contain pathogenic and potentially pathogenic microorganisms such as: *Escherichia coli*, *Enterobacter cloaque* etc.; † CFU/dm^2 (colony forming units) = number of colonies (bacteria, fungi) formed on RODAC-agar plates after being incubated for (48±4) hours at 37ºC calculated to an area of 1 dm^2; ‡ CFU/mL = number of colonies (bacteria, fungi) formed in 1 mL water samples after being incubated for (24±4) hours at 37ºC or in 1 mL water samples after being incubated for (72±4) hours at 22ºC.

CP 6: Hand hygiene

The contact of clean textiles with personnel cannot be avoided due to the many manual tasks required, such as: sorting, ironing with press ironers, folding, insertion in flatwork ironers, folding textiles from flatwork ironers, transporting folded textiles to storage shelves, and transport vehicles etc. Monitoring involves regular education organised by the laundry management, regarding proper hand hygiene. Corrective actions consist of advising the personnel to adhere to instructions. External control is conducted by taking random samples using plate count agar plates, of the hands of personnel at different CPs, as noted in Table 1.

This study reports results of an external evaluation of the hygienic conditions of selected CPs throughout a complete laundering procedure.

MATERIALS AND METHODS

Laundering procedures

The laundering procedure A was conducted in an industrial drum washing machine. The disinfection procedure had a thermal disinfection effect, as indicated by the duration of 36 min at 90ºC, thus exceeding the minimal duration of 10 min at 90ºC as demanded by the Robert-Koch Institute (6). A stain remover against blood stains was added to the pre-wash bath. An industrial commercial detergent was used for the main laundering procedure. (Commercial names have been omitted to protect the participant laundries and the impartiality of the research). The laundry procedure B was conducted in a continuous batch washer. The disinfection time was 3.33 min at a temperature of 90ºC with a commercial disinfection agent containing 30% hydrogen peroxide, added at a concentration of 6.5 mL/kg water together with a commercial detergent.

Assessment of the disinfection effect of the laundering procedure

Enterococcus faecium and *Staphylococcus aureus* (6) were used as bioindicators and inoculated into defibrinated sheep blood in order to determine the efficiency of chemo-thermal or thermal (14) disinfection during the investigated laundering procedures. *Enterococcus faecium* and *Staphylococcus aureus* are standard bioindicators used in European tests for determining basic bactericidal disinfectant efficiency with the aim of achieving a reduction of 100,000 CFU/mL according to RKI (Robert Koch Institute) regulations (14). This method of bioindicator preparation has been described previously (10,11,15). The bioindicators were incorporated into the laundering procedure (washing, rinsing and wringing phases), then taken out and brought to the lab. They were put into 40 mL of tryptic soy broth (TSB) for 4 days at 36ºC (Incubator, Wtb Binder) after which 1 mL of the homogenized suspension was spread onto the following agars: bile esculin azide agar for *Enterococcus faecium* and Baird-Parker agar for *Staphylococcus aureus*, incubated for 24 hours at 36ºC. The presence of *Enterococcus faecium* was confirmed by olive green to black colonies. Black, shiny colonies with a halo (20) confirmed the presence of *Staphylococcus aureus.* Chemo-thermal disinfection was successful when no growth of colonies in any agars was detected, thus achieving the necessary reduction of 100,000 CFU/mL for bacteria.

Assessment of water samples

Two hundred micro-litres of each water sample were placed on trypcase soy agar. Two samples were prepared for each main sample - one for incubation at 22ºC for 72 h, the other for incubation at 37ºC for 24 h. CFU was determined, then identification by general microbiological methods, as noted below.

Assessment of plate counting agar samples

The count agar plates containing RODAC agar were incubated at 37°C for 48 h. After the incubation period, the CFU was determined and identification of the formed colonies was conducted by general microbiological methods, as noted below.

General microbiological methods for identification

All formed colonies were analyzed using the following general and specific microbiological methods (10). Any presence of isolates from the family of *Enterobacteriaceae* was confirmed by Gram's stain, catalase activity, oxidase activity and growth on Endo agar, VRB-agar and VRBD-agar. Confirmation of *Pseudomonas aeruginosa* was characterized by Gram's stain, catalase activity, oxidase activity and growth on cetrimid agar. Any presence of *Stapylococcus* sp. water isolates was confirmed by Gram's stain, catalase activity, oxidase activity, coagulase activity, as well as growth on Baird-Parker agar and Columbia blood agar. *Enterococcus* sp. isolates were characterized by Gram's stain, catalase activity, oxidase activity, pyrase activity and growth on bile esculin azide agar and Columbia blood agar. Confirmation of *Micrococcus* sp. isolates was achieved by Gram's stain, catalase activity, oxidase activity and absence of growth on OF-medium under anaerobic conditions. *Corynebacterium* sp. isolates were characterized by Gram's stain, catalase activity, oxidase activity and microscopy. Gram positive aerobic spore forming bacilli were confirmed by Gram's stain, catalase activity and growth on TSA-agar after thermal treatment of samples (10 min, 75ºC). Presence of yeasts and fungi were characterized by visual observation of hypheae or the presence of yeast cells.

RESULTS AND DISCUSSION

The microbiological evaluation results of the CPs are noted in Table 2, for both laundries.

CP 1: Washing procedure: Disinfection effect

It was obvious from the results that the investigated laundering procedure A had a sufficient thermal disinfection effect; on the other hand, the laundering procedure B did not, due to the survival of both *Enterococcus faecium* and *Staphylococcus aureus*. The duration of laundering procedure B was too short to have a thermal effect and at the same time the reaction time of the disinfection agent (hydrogen peroxide) was too short to have a chemical washing-effect.

CP 2: Textiles

All the results of the textile surface sampling show that the overall hygiene in both laundries was insufficient, due to excessive growth of resistant microbes. Although the washing procedure in laundry A had an appropriate disinfection washing effect, it was obvious that further textile handling was unprofessional and the textiles were contaminated with typical skin bacteria such as: coagulase negative *Staphylococcus* sp., *Micrococcus* sp. and *Corynebacterium* sp. *Enterococcus* sp., an indicator of faecal contamination was also found on textiles from laundry B. The origin of enteroccoci on the ironed and folded textiles could have been from the unprofessional movement of workers from the unclean area containing dirty and contaminated textiles to the clean area, without changing their protective clothing, and conducting proper hand hygiene. Moulds were also found on the ironed and folded textiles thus indicating that the working area was also contaminated with fungi, due to insufficient cleaning and disinfection measures on all working areas, surfaces, technical equipment, storage shelves, transport vehicles etc.

From the results of textiles' surface sampling of the textiles from laundry B, unprofessional handling of textiles by the workers was also evident, due to the presence of typical skin bacteria as well as insufficient cleaning and disinfection measures at all working areas etc leading to the presence of *Bacillus* sp. (first indicator of insufficient cleaning and disinfecting measures), saprophytic Gram negative rods and non-fermentative Gram negative rods.

CP 3: Water

The microbiological assessment of technical water was appropriate in both laundries, indicating sufficient initial conditions for laundering. The wringing water from laundering procedure A was within the recommended value, confirming an appropriate washing procedure. The results for the wringing water from laundering procedure B exceeded the recommended value and confirmed the presence of *Pseudomonas aeruginosa*, an autochthonic water microorganism, thus confirming an overall insufficient disinfection effect for laundering procedure B.

CP 4: Technical equipment and CP 5: Storage shelves

Surface sampling of technical equipment, storage shelves, and transport vehicles also confirmed insufficient cleaning and disinfection measures at all working areas etc, as the above mentioned microorganisms were found on these surfaces.

CP 6: Hand hygiene

The microbiological assessment of hand-hygiene was most alarming. The assessment before hand washing and disinfection showed that the hygiene level of the workers was most inappropriate. On the other hand, the assessment of hand-hygiene after cleaning and disinfection showed that the workers had not been instructed in the proper procedure for cleaning and disinfecting their hands.

Comparison of both laundering procedures showed that optimising the detergents, bleaching and disinfection agents in order to achieve washing quality and, at the same time, a creating a chemo-thermal disinfecting effect were much more complicated

Table 2. Evaluation of control points.

CP	Laundry A		Laundry B	
	Growth of microorganisms	Evaluation	Growth of microorganisms	Evaluation
Washing process (Bio indicators)	No growth	Thermal washing effect	Growth of *E. faecium* and *Staphylococcus aureus*	No chemo-thermal washing effect
Surface sampling of ironed and folded textiles (Working cloths)	*Micrococcus* sp., CNS†, *Enterococcus* sp., mould, *Corynebacterium* sp.	> 100 CFU/dm² in 3 out of 10 samples	*Corynebacterium* sp., *Bacillus* sp., saprophytic Gram neg. rods	> 100 CFU/dm² in 2 out of 10 samples
Damp textiles (Working cloths)	CNS	> 100 CFU/dm² in 1 out of 2 samples	*Corynebacterium* sp., GNR‡	> 100 CFU/dm² in 1 out of 2 samples
Tap water	Meso-phylic, autochthonic microorganisms	< 100 CFU/mL at both temperatures	Meso-phylic, autochthonic microorganisms	< 100 CFU/mL at both temperatures
Softened water	-	-	Meso-phylic, autochthonic microorganisms	< 100 CFU/mL at both temperatures
Wringing water	*Bacillus* sp.	< 100 CFU/mL at both temperatures	Meso-phylic, autochthonic microorganisms, *Pseudomonas aeruginosa*	> 100 CFU/mL at both temperatures
Technical equipment	*Corynebacterium* sp., CNS	< 100 CFU/dm² in all 5 samples	*Pseudomonas aeruginosa*, GNR, *Bacillus* sp., *Corynebacterium* sp.	> 100 CFU/dm² in 4 out of 5 samples
Storage shelves/ transport	CNS, *Bacillus* sp., *Corynebacterium* sp., *Staphylococcus aureus*	> 100 CFU/dm² in 2 out of 3 samples	CNS	> 100 CFU/dm² in 3 out of 4 samples
Hand hygiene (before and after cleaning and disinfecting)	CNS	> 100 CFU/dm² in all 6 samples	CNS, *Micrococcus* sp.	> 100 CFU/dm² in all 6 samples

* *Staphylococcus aureus*, ATCC 6538 and *Enterococcus faecium*, ATCC 6057; † CNS – Coagulase negative Staphylococci; ‡ GNR – non fermentative Gram negative rods.

than simply achieving a thermal disinfection effect. It also showed that laundering procedures do not always have a disinfecting effect, even though the textiles look clean, and thus laundering should be taken seriously by infection control teams. Assessment of the hygienic state of all working areas, surfaces, technical equipment, storage shelves, transport vehicles etc. indicated that overall regular cleaning and disinfection measures were necessary to maintain an appropriate hygiene level for the washed textiles and that, despite the appropriate disinfection effect of the laundering procedure, recontamination of laundered textiles is inevitable if further handling (sorting, ironing, folding etc.) is not conducted under professional conditions. The assessment also showed that the usual cleaning and disinfection agents used for surfaces in laundries did not successfully inhibit resistant microbes, such as: *Enterococcus* sp., *Staphylococcus aureus*, *Corynebacterium* sp., *Bacillus* sp. which were found in different CPs in the clean areas. Regular training and education of the workers is the most important element for implementing monitoring systems, such as HACCP, RABC or RAL-GZ 992/3, which provide, not only the technical skills required for implementing appropriate control measures in order to control biocontamination risks, but also help to change the attitudes of people (19). In order for the control measures to succeed in improving food safety in a laundry, a high level of commitment and full functional involvement is required, by the management, but especially by the workers.

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RESUMO

Monitoramento da higiene de têxteis usados na indústria de alimentos

Na indústria de alimentos é necessário o uso de roupas de proteção, para proteger os trabalhadores da contaminação por bactérias, fungos, virus, prions, etc, encontrados nas secreções e carne dos animais abatidos, assim como proteger a carne da contaminação com microrganismos carreados pelos trabalhadores. Os têxteis são um Ponto de Controle (PC), e devem ser limpos e desinfetados de forma adequada para prevenir a biocontaminação. Embora o processo de lavagem seja importante para obter a desinfecção, é também essencial manter um nível apropriado de higiene dentro da lavanderia para prevenir recontaminação dos têxteis com microrganismos do ambiente. Nesse trabalho, realizou-se uma análise microbiológica de Pontos Críticos de duas lavanderias. A eficiência da lavagem termoquímica foi determinada através da análise do efeito antibacteriano contra *Enterococcus faecium* e *Staphylococcus aureus*. A higiene nas lavanderias foi avaliada através da determinação do número e tipos de microrganismos presentes em PCs selecionados no processo de lavagem. Os resultados indicaram que as condições de higiene nas duas lavanderias não atingiram os níveis necessários, e que vários microrganismos apresentaram resistência aos agentes sanificantes e de limpeza, indicando a necessidade de implementação de medidas corretivas apropriadas.

Palavras-chave: higiene, têxteis, indústria de alimentos, saúde ocupacional

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