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Hygienic measures of abattoir with reference to different disinfectants

Hanaa F. Salama[1*], Hoda M. Elzeftawy[1], Ghada A.K. Kirrella[2]

[1]*Food Hygiene Unit, Damanhur provisional Lab, Animal Health Research Institute (AHRI) Agriculture Research Center, Damanhur, Egypt.*
[2]*Department of Food control, Faculty of Veterinary Medicine, Kafrelsheikh University, Kafrelsheikh 33516, Egypt.*

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***Correspondence:**

Corresponding author: Hanaa F. Salama
E-mail address: hsalama689@gmail.com

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ABSTRACT

A crucial control point for good hygiene is the process of cleaning and disinfecting the slaughterhouse, the animals, the environment, and the hands of the workers. It is a crucial phase in the biosecurity process. By counting the aerobic bacteria, Coliform, *Staphylococcus aureus*, *Salmonella*, moulds, and yeasts, the current study was designed to assess the abattoir's contamination and its effects. A total of 120 samples were collected, including swabs from the floor, wall, workers' hands, animals' skin, and the outside of the carcass (20 samples/each). Results of aerobic plate count clarified that the highest mean value was recorded in the abattoirs' floors and walls ($1.48x10^6 \pm 2.29x10^5$, $9.54x10^5 \pm 1.44x10^5$ respectively), which were then followed by the skin, hands of workers and the outer surfaces of the carcass ($5.71x10^4 \pm 1.26x10^4$, $5.39x10^4 \pm 1.15x10^4$, $4.50x10^4 \pm 1.68x10^4$ respectively). After using disinfectants, chloroxylenol was the most effective disinfection across all tested samples, with the best reduction percentage. The highest mean value of staphylococcus count was recorded in the hands of workers ($1.95x10^5 \pm 1.03x10^5$) had the greatest staphylococcus count, followed by the outer surface of the carcass and the skin ($6.66x10^4 \pm 2.47x10^4$, $6.47x10^4 \pm 1.22x10^4$ respectively). The highest mean value of Coliform count was recorded on the outer surface of the carcasses 43.45 ± 10.61 MPN/cm^2, followed by the skin and the hands of the workers (33.90 ± 8.27, 28.90 ± 11.57 MPN/cm^2 respectively. Several spp of Coliform were detected such as *Citrobacter diversus*, *Escherichia coli*, *Enterobacter aerogenes* and Klebsiella pneumonia. Staph. aureus was reported depending on coagulase test, the incidence of infection was higher in Carcass than in hands and skin. Moreover, *Salmonella* incidence was higher in the hands followed by carcass. The abattoir's air samples had high mean value of mould 25.93 ± 2.83 compared to yeast 17.80 ± 3.58 (cfu/plate/minute). Regarding mould, H2O2 showed the best reduction rate followed by chlorine. While regarding yeast, chlorine was the best followed by chloroxylenol. Results of microbiological examination of the collected samples reflected a clear state of contamination in abattoirs environment and the effect of disinfectants.

Introduction

The rising human population across the world is frequently associated with the increased demand for foods of animal origin (Gutema *et al*., 2021). Animal proteins (APs), especially meat, are a crucial component of the worldwide human food culture. The nine necessary amino acids, especially tryptophan, threonine, and lysine, which are lacking in some plant proteins, are found in meat, making it a significant element of the human diet and nutrition (Leinonen *et al*., 2019). The Food and Agricultural Organization of the United Nations (FAO) advises a minimum per capita daily protein consumption of 0.60-0.75 g per kg body weight, with 60% of that amount assumed to be of animal origin, to highlight the significance of APs (FAO, 2022; Njoga *et al*., 2023).

Around the world, there is growing interest in and concern over food safety. Consumers may be in danger from public health hazards relating to food safety at any point in the food chain. Food safety in cattle production is therefore one of the World Organization of Animal Health's (WOAH) top priorities, according to Knight-Jones *et al*. (2010), Ahmed and Al-Mahmood (2023), and García-Díez *et al*. (2023). If the principles of food-borne hygiene practices are not put into practice, the abattoir is one of the food businesses that contributes to the issue of potential food-borne diseases and health risks associated with food (Abdullahi *et al*., 2016; Nyamakwere *et al*., 2017; Bersisa *et al*., 2019). The workers, the working environment, and the skins and gastrointestinal tract contents of the animals that were slaughtered were among the sources of meat contamination at abattoirs. Additionally, carcasses can get contaminated during the slaughter process if they come into touch with the animal's skin, blood, hair, limbs, bile, stomach, or gut contents, or if they do so while in facilities, equipment, water sources, air pollution, or workers' hands or clothes (Zailani *et al*., 2016; Diyantoro and Wardhana, 2019).

There are several microbiological indicators for the sanitary practices of the meat-processing and handling factories, including total bacterial count (TBC), *Enterobacteriaceae* count (EC), most probable number (MPN) of Coliform, *Staphylococcus aureus* count (TSC), mould count, and yeast count. These indications provide a clear picture of the sanitary practices and precautions used during carcass handling and processing, which ultimately has an impact on the creation of meat with good keeping quality (Kang *et al*., 2018; Camargo *et al*., 2019). Even with the use of effective cleaning techniques or powerful disinfectants, the slaughterhouse's sanitary measures were designed to prevent the transmission of microbes to and from animal corpses and the surrounding environment (Soliman *et al*., 2016). Disinfectant microbial resistance is a result of improper disinfectant usage, including decreased dosages, a lack of change, and other causes (Davies and Wales, 2019).

As a result, the goal of this study was to use various disinfectants to intervene and minimize the level of contamination as well as to examine how these disinfectants affected various microorganisms in order to attain the permitted limit of the allowable bacterial count in accordance with Egyptian standard specifications.

Materials and methods

Sampling

The Animal Health Research Institute, Damanhur's lab received samples twice a week, which were subsequently labeled and delivered there

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in an icebox. With a few adjustments, Pradhan *et al*. (2018) sampling and microbiological testing techniques were used.

Swabs collection and preparation

A total of 80 swabs were taken, including 20 samples each from worker's hands, animal skin, the floor and wall. The sample surface was demarcated with a sterile frame to designate a 25 cm^2 (5 cm X 5 cm) region. Samples were carefully labeled, and sterile cotton-tipped swabs were used to collect samples. The swabs were rubbed against the sampling sites for around 30 seconds before being transferred to a test tube with a screw lid containing 5 ml of sterile maintenance medium (0.85% NaCl and 0.1% peptone). To achieve even microbial distribution in the maintenance media, the tubes holding the swabs were vortexed for 30 seconds.

Water samples

From the indicated functional tanks and water taps, 20 water samples were taken. Five hundred milliliter sterile plastic screw-capped vials were used to collect the samples. With little delay, samples were labeled and brought in coolers to the lab. In order to create tenth-fold serial dilutions up to 10-6, the contents of the sample bottles were completely mixed by shaking before one ml was transferred with a sterile pipette to a sterile tube containing 9 ml of sterile peptone water (APHA, 1998).

Air samples

A 225-259 ml peptone water-filled impinger was used to collect 20 air samples. The pump's input was connected to the side arm of the trap, whilst the impinger's exit was connected to the trap's top inlet. The impinger intake was calibrated after being connected to the external calibrator. Following thorough mixing of the contents of the sample bottles, one ml was transferred using a sterile pipette to a sterile tube containing nine milliliters of sterile peptone water, from which tenth-fold serial dilutions up to 10-6 were made.

Microbiological examination

Determination of aerobic plate count (TAC)

The APHA (2001) technique was used to estimate the total aerobic plate count. In brief, one ml from each tube containing swab samples was pipetted into a sterile Petri plate. For each Petri dish, add 12–15 ml of Plate count agar (Difco Laboratories, Detroit, Michigan, USA) chilled to 45.0±1.0ºC, mixed well, then allowed to harden and incubated for 48 hours at 35.0±2.0ºC. In plates with 25–250 colonies per dish, note all colonies, even pinpoint-sized CFUs, as TAC.

Determination of total *Coliform* counts (TCC)

The most probable number (MPN) technique, as suggested by APHA (2001), was used via three tubes. Briefly stated, three test tubes containing MacConkey broth with inverted Durham's tubes were inoculated independently with one ml of each dilution. For 24-48 hours, the infected tubes were incubated at 37°C. Positive Durham's tubes with gas production and acid (yellow colour) production were noted. Using the suggested tables, the most probable number of Coliform was determined.

Total *Staphylococcus aureus* count (TSC)

The samples were then subjected to conventional microbiological processing to isolate Staph. aureus using Baird Parker agar (Difco Laboratories, Detroit, Michigan, USA) (APHA, 2001). On blood agar plates (Difco Laboratories, Detroit, Michigan, USA), suspected colonies (black, glossy convex colonies, 1-1.5 mm in diameter, and surrounded by a clear halo zone) were sub-cultured and incubated for 24 hours at 37°C. According to Quinn *et al*. (2002), Gram stain, catalase, mannitol fermentation, and coagulase tests were carried out on suspicious colonies to identify Staph. aureus. The formula for calculating the total Staph. aureus count was Total Staph. aureus count = Positive colonies x reciprocal dilution factor. Colonies reported as log_{10} cfu/ cm^2 (counted colonies).

Determination of molds and yeasts count

Dichloran rose Bengal chloramphenicol agar (oxoid CM0727) triplicate plates were sterilized, and 0.2 ml of the initial dilution (2:1) was equally placed over each plate's dry surface. The control plate and the inoculation plate were both incubated for 7 days in the "upright position" at 25°C. Each mold count and yeast count/cm^2 of the tested surfaces were then computed and recorded (ISO 21527-1, 2008). Following the incubation time, the average of each mold and yeast colony was counted over the triplicate plates.

Statistical Analysis

All measurements were repeated, and all data are reported as means ±SD. Base 10 logarithms of colony-forming units per cm^2 (log_{10} cfu/cm^2) were used to convert bacterial counts. The Duncan test was used to assess statistical significance, with $P < 0.05$ being considered significant.

Results

Microbial counts

Enumeration of aerobic bacteria in the abattoir before and after using different disinfectants and their Reduction percentages

Table 1 shows the levels of aerobic bacteria in the slaughterhouse before and after disinfection. Prior to the use of disinfectants, the highest TAC count was found in the abattoirs' floors and walls ($1.48x106±2.29x10^5$, $9.54x10^5±1.44x10^5$ respectively), which were then followed by the skin, hands of workers and the outer surfaces of the carcass ($5.71x10^4±1.26x10^4$, $5.39x10^4±1.15x10^4$, $4.50x10^4±1.68x10^4$ respectively). The reduction percentage in the overall aerobic bacterial count. This outcome demonstrates that chloroxylenol was the most effective disinfection across all tested samples, with the best reduction percentage. Chlorine, on the other hand, has a lower level of disinfection effectiveness.

Enumeration of the total Staphylococcus in the abattoir before and after using different disinfectants and their Reduction percentages

Table 2 displays the overall Staphylococcus concentrations in the abattoir before and after disinfection. Prior to the use of disinfectants, the hands of workers ($1.95x10^5±1.03x10^5$) had the greatest Staphylococcus count, followed by the outer surface of the carcass and the skin ($6.66x10^4 ±2.47x10^4$, $6.47x10^4±1.22x10^4$ respectively). The reduction percentage in the staphylococcus count. This outcome demonstrates that chloroxylenol had the highest reduction percentage in all tested samples, making it the best disinfectant. Chlorine, on the other hand, performed disinfection less effectively.

Enumeration of the total *Coliform* counts in the abattoir

The data in Table 3 showed that water, hands of workers, skin, and the outside of carcasses all contained the most probable number (MPN) of Coliform. The data revealed that the outer surface of the carcasses had the highest MPN of Coliform with a mean value 43.45±10.61, followed by

the skin and the hands of the workers (33.90±8.27, 28.90±11.57 MPN/cm^2 respectively. Water, on the other hand, had the lowest quantities of Coliform (5.60±1.70 MPN/cm^2).

The main representative of the group of fecal Coliform was *Citrobacter diversus* in both carcass and hands, while *Escherichia coli* was the main infection in the skin followed by carcass, hands and water. On the

Table 1. The total aerobic bacterial count of floors, walls, skin, the outer surface of carcass, hands of workers (cfu/cm^2), water (cfu/ml), and air (cfu/plate/minutes), (cfu/cm^2) before and after using disinfectants & their Reduction percentage.

Examined samples	No	Positive samples		Counts		
		No	%	Min.	Max.	Mean± SEM
Before disinfectants						
Floors of abattoir	20	20	100	$5.36x10^5$	$2.80x10^6$	$1.48x10^6$±$2.29x10^5$
Walls of abattoirs	20	20	100	$3.77x10^5$	$1.72x10^6$	$9.54x10^5$ ±$1.44x10^5$
Water	20	20	100	$2.75x10^2$	$1.17x10^4$	$4.64x10^3$±$9.35x10^2$
Air	20	20	100	32	$2.48x10^2$	$1.09x10^2$±18.14
Skin	20	20	100	$6.45x10^3$	$1.29x10^5$	$5.71x10^4$±$1.26x10^4$
The outer surface of the carcass	20	20	100	$5.40x10^3$	$1.42x10^5$	$4.50x10^4$ ±$1.68x10^4$
Hands of workers	20	20	100	$9.86x10^3$	$1.16x10^5$	$5.39x10^4$±$1.15x10^4$
After using chloroxylenol as a disinfectant						
Floors of abattoir	20	20	100	$5.35x10^4$	$1.63x10^6$	$4.50x10^5$±$1.40x10^5$
Reduction percentage		69.65				
Walls of abattoirs	20	20	100	$1.07x10^5$	$5.25x10^5$	$2.67x10^5$ ±$4.06x10^4$
Reduction percentage		72.05				
Air	20	20	100	26	$2.30x10^2$	94.13±13.25
Reduction percentage		23.42				
Skin	20	20	100	$5.69x10^3$	$2.43x10^4$	$1.30x10^4$±$1.98x10^3$
Reduction percentage		77.24				
The outer surface of the carcass	20	20	100	$1.60x10^3$	$2.03x10^4$	$8.63x10^3$ ±$2.06x10^3$
Reduction percentage		80.85				
Hands of workers	20	20	100	$2.58x10^3$	$2.33x10^4$	$1.13x10^4$±$2.26x10^3$
Reduction percentage		78.97				
After using H_2O_2 as a disinfectant						
Floors of abattoir	20	20	100	$2.09x10^5$	$1.64x10^6$	$6.57x10^5$±$1.29x10^5$
Reduction percentage		55.63				
Walls of abattoirs	20	20	100	$1.60x10^5$	$6.27x10^5$	$3.50x10^5$ ±$4.98x10^4$
Reduction percentage		63.25				
Air	20	20	100	35	$2.21x10^2$	93.07±12.32
Reduction percentage		4.74				
Skin	20	20	100	$2.16x10^3$	$4.80x10^4$	$1.85x10^4$±$4.37x10^3$
Reduction percentage		67.60				
The outer surface of the carcass	20	20	100	$5.15x10^3$	$4.05x10^4$	$1.47x10^4$ ±$4.60x10^3$
Reduction percentage		67.22				
Hands of workers	20	20	100	$3.62x10^3$	3.80	$1.76x10^4$±$3.61x10^3$
Reduction percentage		67.32				
After using chlorine as a disinfectant						
Floors of abattoir	20	20	100	$3.69x10^5$	$1.35x10^6$	$8.83x10^5$±$1.20x10^5$
Reduction percentage		40.43				
Walls of abattoirs	20	20	100	$2.15x10^5$	$9.88x10^5$	$5.95x10^5$ ±$8.88x10^4$
Reduction percentage		37.71				
Air	20	20	100	43	$2.56x10^2$	$1.30x10^2$±14.70
Reduction percentage		2.31				
Skin	20	20	100	$4.24x10^3$	$4.66x10^4$	$2.66x10^4$±$4.68x10^3$
Reduction percentage		53.40				
The outer surface of the carcass	20	20	100	$3.72x10^3$	$8.33x10^4$	$2.74x10^4$ ±$9.92x10^3$
Reduction percentage		39.21				
Hands of workers	20	20	100	$5.70x10^3$	$6.83x10^4$	$2.89x10^4$±$6.31x10^3$
Reduction percentage		46.30				

other hand, *Enterobacter aerogenes* was the main infection in water followed by Klebsiella pneumonia (Table 4). Staph. aureus was reported depending on coagulase test, the incidence of infection was higher in Carcass than in hands and skin. Moreover, *Salmonella* was detected by both colonial characters and biochemical tests. *Salmonella* incidence was higher in the hands followed by carcass (Table 4).

Enumeration of the total molds and yeasts count in the abattoir before and after using different disinfectants

The abattoir's air samples were analyzed for total molds count (TMC) and total yeasts count (TYC) (cfu/plate/minute). The results are shown in Table 5, TMC was more prevalent in air samples than TYC, with a mean value of 25.93±2.83compared to TYC's mean value of 17.80±3.58 (cfu/plate/minute). Regarding mold, H_2O_2 showed the best reduction rate followed by chlorine. While regarding yeast, chlorine was the best followed by chloroxylenol.

Discussion

Despite the increased focus on food hygiene and food safety by public authorities and, as a result, by food operators, the consumption of foods contaminated with pathogenic microorganisms or their toxins still ranks among the top causes of disease, hospitalization, and financial loss (CDC, 2023). Six hundred million cases of foodborne diseases and 420,000 fatalities worldwide arise from tainted food each year. There are currently 7.8 billion individuals on the planet, and 56 million of them pass away every year. A food-borne disease affects 7.69% of people annually, and it is responsible for 7.5% of world mortality (or 56 million fatalities) (Lee and Yoon, 2021). In order to ensure food safety in the slaughterhouse, additional measures must be used in addition to the standard meat inspection to mitigate the risks posed by latent zoonoses. To properly follow slaughterhouse hygiene best practices is one significant strategy to prevent contamination in daily operations. This study emphasizes the importance of effective in-process cleaning and disinfection of the floor, wall, water, air, worker's hands, animal skin, and other surfaces.

One of the microbiological indices of the quality of food is the total plate count of aerobic bacteria observed in abattoirs. According to Cavalheiro *et al*. (2022), the presence of aerobic organisms indicates that there are favorable circumstances for the growth of microorganisms. According to the data in Table 1, results of aerobic plate count (TAC) of the exam-

Table 2. The total staphylococcus counts of skin, the outer surface of carcass and hands of workers (cfu /cm2) before and after using disinfectants & their Reduction percentage.

Examined samples	No	Positive samples		Counts		
		No	%	Min.	Max.	Mean± SEM
Before disinfectants						
Skin	20	20	100	$1.53x10^4$	$1.28x10^5$	$6.47x10^4±1.22x10^4$
The outer surface of the carcass	20	20	100	$5.05x10^3$	$2.14x10^4$	$6.66x10^4±2.47x10^4$
Hands of workers	20	20	100	$5.15x10^3$	$1.03x10^6$	$1.95x10^5±1.03x10^5$
After using chloroxylenol as a disinfectant						
Skin	20	20	100	$5.15x10^3$	$3.55x10^4$	$1.54x10^4±3.37x10^3$
Reduction percentage			76.28			
The outer surface of the carcass	20	20	100	50	$1.53x10^4$	$7.68x10^3±1.27x10^3$
Reduction percentage			88.47			
Hands of workers	20	20	100	$2.55x10^4$	$1.22x10^5$	$6.26x10^4±1.07x10^4$
Reduction percentage			64.68			
After using H2O2 as a disinfectant						
Skin	20	20	100	50	$4.57x10^4$	$2.51x10^4±5.07x10^3$
Reduction percentage			64.70			
The outer surface of the carcass	20	20	100	50	$2.03x10^4$	$1.02x10^4±2.13x10^3$
Reduction percentage			84.67			
Hands of workers	20	20	100	$2.04x10^4$	$1.16x10^5$	$6.10x10^4±1.06x10^4$
Reduction percentage			65.54			
After using chlorine as a disinfectant						
Skin	20	20	100	$5.30x10^3$	$4.58x10^4$	$2.62x10^4±4.26x10^3$
Reduction percentage			64.17			
The outer surface of the carcass	20	20	100	$1.07x10^4$	$6.12x10^4$	$3.23x10^4±5.22x10^3$
Reduction percentage			51.46			
Hands of workers	20	20	100	$3.05x10^4$	$1.27x10^5$	$7.31x10^4±1.08x10^4$
Reduction percentage			58.73			

Table 3. Total *Coliform* count of the examined samples (MPN /cm^2 or ml).

Samples	No.	Positive samples		Counts		
		No	%	Min.	Max.	Mean± SEM
Skin	20	12	60	4	150	33.90±8.27
The outer surface of the carcass	20	10	50	3	210	43.45±10.61
Hands of workers	20	15	75	4	240	28.90±11.57
Water	20	5	25	3	35	5.60±1.70

ined samples during the current study clarified that the highest mean value was recorded in the abattoirs' floors and walls ($1.48x10^6±2.29x10^5$, $9.54x10^5±1.44x10^5$ respectively), followed by skin, hand swabs of workers and the outer surfaces of the carcass ($5.71x10^4±1.26x10^4$, $5.39x10^4±1.15x10^4$, $4.50x10^4±1.68x10^4$ respectively), then water samples ($4.64x10^3±9.35x10^2$) and lastly air samples ($1.09x10^2±18.14$). According to the CFS (2014), the permissible level of bacteria should be fewer than 103, and a range of 103 to 105 is regarded as the borderline limit; nevertheless, a count of more than 105 is deemed inappropriate.

Three different disinfectants were utilized in this investigation; Table 1 shows that the chloroxylenol disinfectant had the best decrease percentage of the total aerobic count across all samples. Chloroxylenol indicated a reduction of TAC of 80% on the exterior surface of the carcasses, followed by worker hands, animal skin, and slaughterhouse wall (78.97%, 77.24%, and 72.05%) respectively, the floor of the abattoir, and finally, air samples. Between the three disinfectants, there were statistically negligible variations in the decrease percentage (P value = 0.0795). The results of this study were consistent with those of other investigations using Noro cleanse® and Dettol®, a substance related to chloroxylenol. One of the halophenol groups, chloroxylenol, which makes up 4.8% of the ingredient in Dettol®, operates by denaturing proteins. altering cell wall permeability, and causing cell leakage (Njagi *et al*., 2005; Acsa *et al*., 2021). Both Gram-positive and Gram-negative bacteria respond well to it as a disinfectant, however, Gram-positive bacteria are affected more strongly (Poger and Mark, 2019). Since it is powerful against bacteria, viruses, fungi, and spores, hydrogen peroxide is one of the most crucial peroxygenases in disinfectants (Lineback *et al*., 2018; McSharry *et al*., 2021). Both are employed in industrial operations such as the disinfection and sterilization of medical devices as well as the decontamination of food plants and equipment (Leggett *et al*., 2016). H_2O_2 was used as a disinfectant in this investigation following chloroxylenol, which had the highest TAC reduction percentage. Finally, it was shown that utilizing chlorine as a disinfectant resulted in the lowest degree of TAC decrease percentage.

Results of swabs showed that the highest counts of staphylococcus were obtained from the hands of workers ($1.95x10^5±1.03x10^5$), followed by the outer surface of the carcass and the skin ($6.66x10^4$ $±2.47x10^4$, $6.47x10^4±1.22x10^4$ respectively). Several diseases in humans as well as animals are brought on by *Staphylococcus aureus*. The dirties and fecal matter that are present on the wool may be the cause of the increased mean values of staph. aureus count in the studied carcass samples (Ebied *et al*., 2023).

The greater prevalence of Staph. aureus infection in this study's animal carcasses may be a result of unsanitary procedures, poor handling during slaughter, dirty surrounding surfaces, and undertrained staff. The Staphylococci can be found on environmental surfaces such as air, dust, sewage, food, and food preparation tools. The main reservoirs are people and animals. About 50% of healthy people have staphylococci in their nasal passages, throat, hair, and skin. Although equipment and surrounding surfaces can potentially be sources of *S. aureus* contamination, food handlers are typically the primary source of food contamination in outbreaks of food poisoning (FDA, 2007). In Table 2, the disinfectant chloroxylenol demonstrated the greatest decrease in the percentage of *S. aureus* count across all investigated samples. Chloroxylenol demonstrated an 88.47% decrease of *S. aureus* on the exterior of the corpse, followed by reductions of 76.28% and 64.68% on the skin of the animals and the hands of the workers, respectively. Between the three disinfectants, there were statistically significant variations in the decrease % (P value = 0.008). This outcome was comparable to that reported by Acsa *et al*. (2021), who described Dettol's effectiveness as a disinfectant against *S. aureus*.

Results of swabs showed that the highest bacteria and Coliform were obtained from the outer surface of the carcass (43.45±10.61), followed by the skin and hands of workers (33.90±8.27, 28.90±11.57 MPN/cm^2) respectively. This finding is in line with that of Stoica *et al*. (2014), who claimed that the presence of microbiological hazards in animal carcasses is unavoidable due to the presence of microorganisms in the environ-

Table 4. Incidence of identified coli forms, *Staphylococcus aureus*, and *Salmonella* isolated from the examined sample.

	Examined samples							
	Skin		Carcass		Hands		Water	
	No	%	No	%	No	%	No	%
Coliform spp.								
Citrobacter diversus	11	31.43	13	52	18	47.37	3	20
Escherichia coli	16	45.71	7	28	10	26.32	4	26.67
Enterobacter aerogenes	4	11.43	3	12	8	21.05	6	40
Klebsiella pneumoniae	4	11.43	2	8	2	5.26	2	13.33
Total	35	100	25	100	38	100	15	100
Staphylococcus aureus								
Suspected *S. aureus* positive samples	8	20	16	40	12	30	--	--
Coagulase-positive *S. aureus* samples	5	12.5	20	50	16	16	--	--
Salmonella								
Positive samples according to colonial characters	3	15	5	2	8	40	0	0
Positive samples according to biochemical tests	1	5	25	10	4	20	0	0

Table 5. Total molds and yeasts count (cfu /plate/minute) of examined air samples in the abattoir.

Examined samples	No	Positive samples		Counts		
Before disinfectants		No	%	Min.	Max.	Mean± SEM
Mold	20	20	100	10	49	25.93±2.83
Yeast	20	20	100	3	48	17.80±3.58
After using chloroxylenol as a disinfectant						
Mold	20	20	100	8	35	21.53±2.28
Yeast	20	20	100	5	32	15.80±2.26
After using H_2O_2 as a disinfectant						
Mold	20	20	100	9	34	18.67±1.77
Yeast	20	20	100	8	33	18.20±1.80
After using chlorine as a disinfectant						
Mold	20	20	100	11	44	20.87±2.15
Yeast	20	20	100	7	35	15.53±2.06

ment, on the animal, and on contact surfaces with the carcass that are susceptible to harboring a variety of microorganisms. *Coliform* contamination levels over the threshold are signs of fecal pollution at slaughterhouses, which starts with skinning and direct worker contact. Additionally, contamination during evisceration and washing may arise from intestinal fluids as well as water used for rinsing and washing. *Escherichia coli*, which is prevalent in the feces, intestines, and hide of healthy cattle from where it may possibly infect meat during the slaughtering process, has been linked to several food poisoning incidences caused by undercooked meat products (Darwish *et al*., 2015). The presented data in Table 4 showed that the main representative of the group of fecal Coliform was *Citrobacter diversus* in both carcass and hands (52%, 47.37%) respectively, while *Escherichia coli* was the main infection in the skin (45.71%), followed by carcass, water and hands (28%, 26.67%, 26.32%) respectively. *Enterobacter aerogenes* was the main infection in water followed by Klebsiella pneumonia. Staph. aureus was reported depending on coagulase test, the incidence of infection was higher in Carcass than in hands and skin. According to studies (Argudín *et al*., 2010; Lim *et al*., 2023), significant quantities of coagulase-positive Staph. aureus must infect the meal in order to create enough enterotoxin to induce food poisoning. Furthermore, colonial characteristics and biochemical tests both revealed the presence of *Salmonella*. Hands (20%) had the highest prevalence of *Salmonella*, followed by carcasses (10%). This outcome was better than that of Geresu and Desta (2021), who noted that there were 8.57% of *Salmonella* isolates found in the hand swabs of slaughterhouse workers. Since most workers in the current research setting handled rumen content and gastrointestinal tracts without washing their hands, the personal cleanliness differential of the food handlers may contribute to explain this discrepancy.

An indicator of good sanitation and a high-quality product is the total number of mold spores. Molds may contribute to the putrefactive processes or, less frequently, they may cause meals to taste and smell moldy. Furthermore, because mold can flourish in a huge temperature range, it may be found on practically any food at almost any temperature that it is stored. Additionally, mold may contribute to putrefactive processes and generate mycotoxins, which are poisonous compounds that are detrimental to both humans and animals (Algabry *et al*., 2010). The presented data in Table 5 showed that TMC was more prevalent in air samples than TYC, with a mean value of 25.93±2.83 compared to TYC's mean value of 17.80±3.58 (cfu/plate/minute). H_2O_2 and chlorine both had the best reduction rates for mold. Chlorine was the most effective against yeast, followed by chloroxylenol. Finally, both yeast and mold may be cleaned using chlorine.

Even with the use of effective cleaning techniques or powerful disinfectants, the slaughterhouse's sanitary measures were designed to prevent the transmission of microbes to and from animal corpses and the surrounding environment Soliman *et al*. (2016). Disinfectant-resistant microorganisms are a result of the overuse of disinfectants, which includes using lower quantities, remaining the same, and other causes (Davies and Wales, 2019).

Conclusion

The study's findings indicated that the samples used for collection included a range of microbial burdens. In order to prevent contamination and ensure the manufacture of safe meat products, hygienic procedures such as appropriate cleaning and disinfection should be used in the environment and abattoirs.

Conflict of interest

The authors declare that they have no conflict of interest.

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