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Original article

The Effect of Sloping the Grinder Body of the Meat-Mincer Machines on the Reduction of Microorganism and Chemical Residuals after Cleaning-A Newly Design

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Abstract

Hygiene is critical for human health, particularly in locations where industrial meat products are produced. One of the most common causes of contamination in the meat sector is meat grinders, which are notoriously difficult to clean. As a result, eliminating the water that has accumulated in the body is critical for the meat grinders' hygiene. In the presented study the effect of tilting the neck region after grinder body washing on total bacterial growth, pH, and pathogens in a meat grinder functioning regularly in a workplace was investigated. The machine was cleaned, then set to the predetermined angle value and the sample was taken 5 minutes later. The machine was maintained at this angle value for 15 hours, then swab was taken before the morning began. swab samples were taken after cleaning and pre-production at 0, 10, 20, 30, and 40 degrees slopes. When the results were combined, it was discovered that about 30% decrease in the overall number of bacteria was observed with a 30-degree tilt. Since there is no antigen in the neck region after the cleaning, there is no salmonella and Listeria monocytogenes. The pH level approached that of the cleaning water, eliminating the cleaning chemicals' impact.

Keywords: Meat Hygiene, Meat Grinder, Cross-Contamination, Design, Bacteria, Pathogen.

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INTRODUCTION

Cross-contamination is the physical transfer or transmission of hazardous microbes from one person, thing, or area of unpolluted ones. Until the second part of the nineteenth century, minced meat was made with choppers and knives on hard logs. The earliest metal meat grinders, which are the forerunners of today's meat grinders, were produced in the second part of the nineteenth century using the Archimedes Screw Principle and operated by man-handling. One of the most common causes of contamination in the meat sector is meat grinders, which are notoriously difficult to clean. For example, if meat containing *Mycobacterium tuberculosis* is minced in a meat grinder without the proper cleaning, *Mycobacterium tuberculosis* may contaminate the meat during the following mincing process. Chemical contamination on the next product may occur if the chemicals used in the requisite washing process cannot be removed from the surface after cleaning. The meat grinders are one of the most significant key control points in a meat processing plant. They are used as the first step in the production of products with various microbiological and textural features and structures, such as minced meat, meatballs, sausage, and roasted meat. As a result, mincers are regarded as a critical control point in all industrial meat processing operations. Moller et al (2016) attempted to construct an equation to calculate the rate of germs infecting each other in pork and beef taken from the same meat grinder in his studies. Risk estimates, performed in their study revealed that grinding was influenced by sharpness of grinder knife and grinding temperature mainly. They explained that the risk of foodborne disease was reduced, when the grinding of meat was performed in a grinder made of stainless steel using a well-sharpened grinder knife and holding at room temperatures of 4°C or lower. Chung and Hellberg (2020) conducted research to identify the various species found in minced beef. Due to religious concerns, they also investigated the pig DNA that might be present in the ground beef after the pork was ground in the same meat grinder, as well as the impact of cleaning on it. Three different cleaning processes were used to examine the process of grinding two different meats in the same meat grinder.

Hygiene is critical for human health, particularly in locations where industrial meat products are produced. This has been the subject of many academic studies. In their study, Milios et al (2014) examined at carcass sampling methods for microbiological hygiene parameters. The carcasses sampled with indicator bacteria were examined to see if they had been exposed to cross-contamination during post-slaughter and processing or not. In the convenience food and meat-based food products industries, Henriques et al (2017) carried out studies on the monitoring of *Listeria monocytogenes* contamination and virulence (disease-causing activity) related aspects according to the level of hygiene. Alvseike et al (2018) conducted research in the meat sector with the goal of developing cellular manufacturing and a new hygiene concept. In the mentioned study different chilling cycles are used in distinct divisions, with the goal of reducing energy consumption in cellular production and ensuring healthy meat products. Gu et al (2019) took samples before and after sanitation to investigate the survival and multiplication of

foodborne pathogens unintentionally transferred in a fresh-cut produce processing facility. They investigated lot of bacterial species and explained that viable bacterial counts on various types of surfaces on the production floors were more consistently and significantly reduced after sanitation compared to the peripheral surfaces.

Hygiene Applications in Meat Grinders

After fresh meat grinding, nerve and adipose tissue attach to the machine grinder's body (neck region) and parts; the remaining connective tissue is manually separated from the machine parts (Figure 1.a and 1.b). The longer this connective tissue is in contact with the machine, the more the microorganism load. Equipment cleaning after processing is one of the most critical hygiene aspects in the food sector. CIP (cleaning in place) is a technique that has been utilized in a variety of industries in recent years (Michale et al. 2015, Narvaez et al. 2017, Lee et al. 2016). Chemicals are used to clean the detachable sections of the grinder's body, feed screw, crossing knife, hole plate and lock nut, which are then rinsed and stored in UV sterilizers to keep them sterile until the next time they are used. Because the meat grinder's body is monolithic with the machine, it is cleaned with chemicals and then rinsed. The major disadvantage is that the chemical residues that cannot be eliminated in dissolved form in the last rinse water remaining in the grinder body may build as a result of excessive chemical use. The reason for this is usually related to the meat grinders' design.

a) b)

Figure 1. a) Freshly ground meat grinder and b) machine parts

A traditional meat grinder features a rough body structure and is positioned parallel to the floor. Meat particles ground to this surface may stick. Following the cleaning process, these adherent particles can provide an environment in which bacteria can thrive in the presence of water (Figure 2) that cannot be totally dried after rinsing in the body. It's possible that the next product will be contaminated as a result of this. The most critical sterilizing step in meat processing facilities is to prevent bacteria from developing colonies by rapidly removing rinse water from the environment and machine equipment

surfaces after disinfectants and sterilizers have been used. The collection of rinse water in the main body is the most serious risk that continues after these procedures. Unfortunately, after the cleaning process is finished, the water remaining in the body and have an average temperature of 30℃. This temperature provides the ideal conditions for the growth of microbial flora in the ambient atmosphere. As a result, eliminating the water that has accumulated in the body is critical for the meat grinders' hygiene. Taking advantage of gravity would be the simplest method to accomplish this.

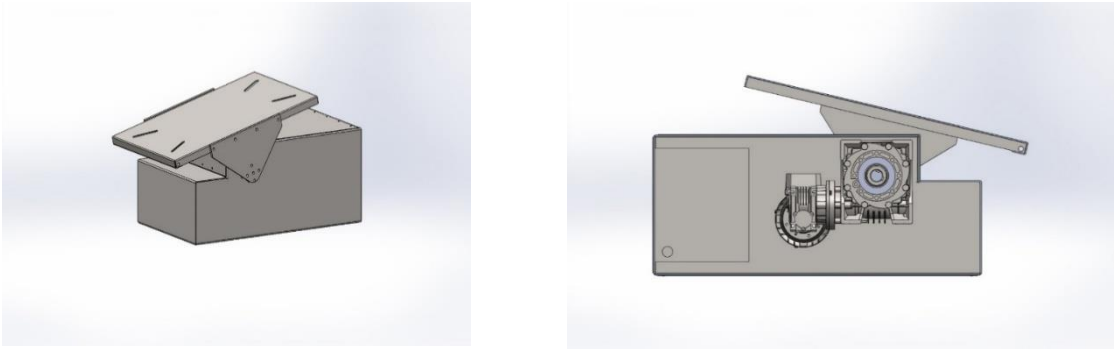
Figure 2. Remaining water in the meat grinder body after cleaning

Meat Grinder Tilt Machine Design

A problem-solution for the elimination of rinse water has not been found in the meat grinder design investigations. Rout and Bandyopadhyay (1999) focused on developing a single pitch, variable-length extruder and blade system, as well as identifying the best temperature and humidity for the process. Gokulakrishnan and Bandyopadhyay (1995) has created a design for meat grinders that reduces lumps. Isaksson et al (1996) carried out online experiments using infrared spectroscopy in mincers with various blade numbers and different hole sizes, emphasizing the importance of fat, water, and protein concentrations in minced meat in terms of nutrition and cleanliness. Irmscher et al (2016) has worked on the development of a high-speed beef pulping machine. Zhao and Sebranekb (1997) worked on the design of a knife to ensure that no bone pieces end up in the minced meat and create a no health risk to consumers. They used model meat to explore the mobility of hard particles in meat for this purpose.

The machine should be angled to clean the meat grinders more effectively and safely, according to the findings. However, in order to avoid damaging the parts, it is critical that the machine maintains stable while in operation. As a result, putting the machine on an inclined surface while it is working is unsafe. In this case, placing the meat grinder on an inclined and tiltable platform was considered. So, as a result, tilting experiments on the smallest and lightest 32 number meat grinders will suffice to determine the optimum slope, as it can be applied to other machine sizes.

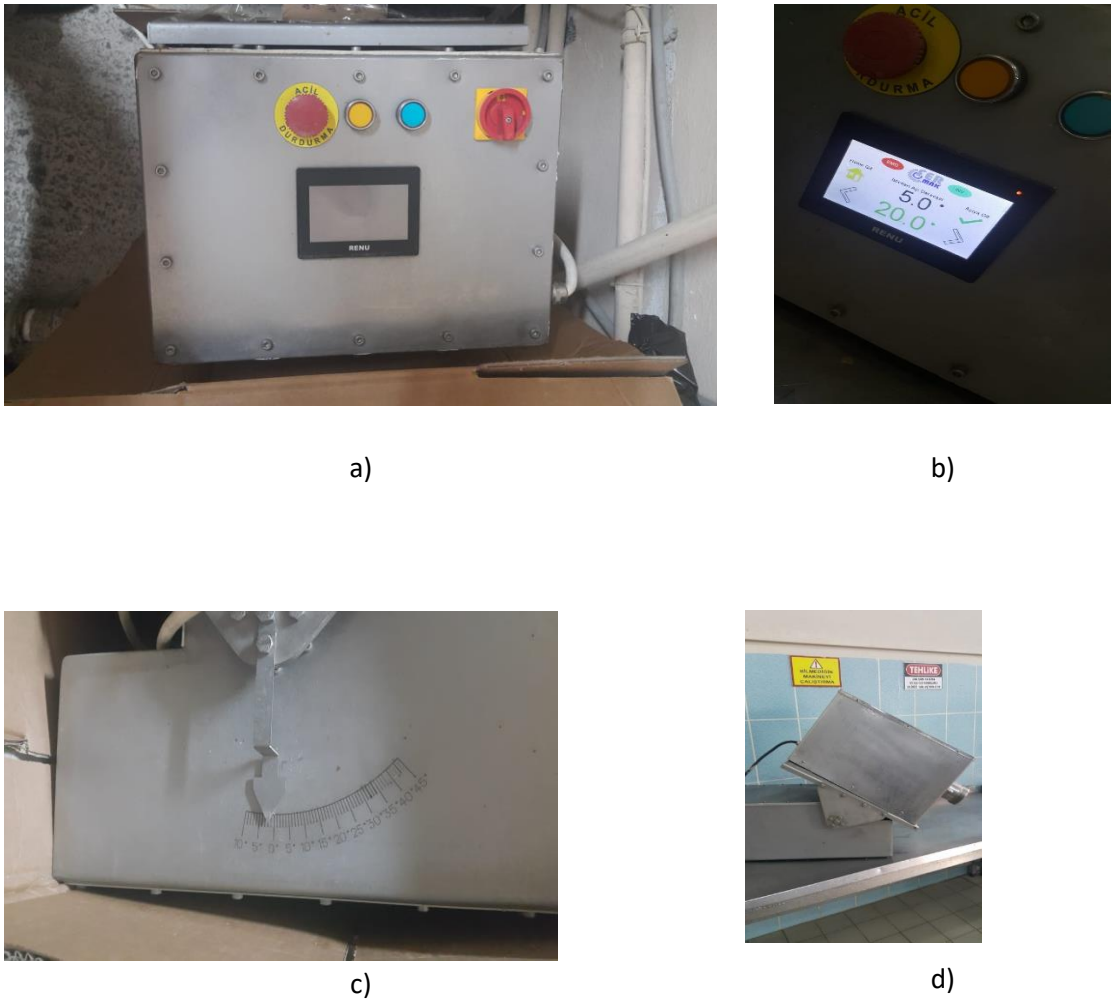
First and foremost, the tilting machine to be designed should be able to take a slope of up to 45 degrees and be made in such a way that it does not endanger the employees while doing so. As a result, it is expected that the tilting machine will be installed to the bottom of the meat grinder with its bolts. The slope of the tilting machine should not move while cleaning, and it should be able to be locked at that angle. The tilting machine, as illustrated in Figure 3.a, was conceived and sketched in light of these assumptions. The main chassis, an electric motor, the reducer illustrated in Figure 3.b, the tilt sensor, and software make up the machine in its most basic form. Furthermore, different models and brands of meat grinders will be fixed to the table from their feet using the fixing holes, which are decided to be set on the machine table.



a) b)

Figure 3. a) Schematic representation of tilting machine b) Positions of Motor Shaft and Gearbox in Machine Design

The TUBAP (Trakya University Scientific Research Projects Unit) project supplied the necessary funding for the purchase and assembly of the necessary pieces of the planned machine. Figure 4.a shows a tilting machine that has been manufactured. For electronic identification of the machine's slope, a digital display panel as the one shown in Figure 4.b is installed. Depending on the device's sensitivity, the tilt value of the machine can be set to +-1. A miter was also drawn on the machine, as shown in Figure 4.c, to confirm that the bevel was correctly read from the electronic display. Figure 4.d also shows the machine's view and the location at its maximum angle.



a) b)

c) d)

Figure 4. a) Manufactured tilting machine b) Digital display panel c) Analog miter d) Tilting machine at 45^0

MATERIAL and METHOD

First and foremost, the machine was set up on a flat surface that is parallel to the ground. The sanitation operation was carried out at the end of the day after the machine had been worked at its typical intensity during the day. Its purpose is to detect a rise in microorganisms during the hours when the equipment is not in use. The initial reference microorganism load was calculated using samples collected 5 minutes after the cleaning operation was completed. The following swab was taken shortly before the start of the next day's office hours. Between two measurements, there is a 15-hour gap. Each angle value at which the machine was kept tilted was measured using swab on different days (17 p.m. – 8 a.m.). The machine was cleaned, then set to the predetermined angle value and the sample was taken 5 minutes later. The machine was maintained at this angle value for 15 hours, then swab was taken before the morning began, and the machine's angle value was reset to 0 and it began working again for the day. In the meantime, the facility's ambient temperature is set at 24°C to 28°C. Analysis procedures were carried

out in the Trakya University Technology Research Development Application and Research Center (TUTAGEM) Laboratory and the Meat and Meat Products Processing Facility Laboratory of the Edirne Open Penitentiary Institution (EDAC) in order to make the analysis results more reliable and to make comparisons. Figures 5.a and 5.b demonstrate taking swab at 0 degrees and 20 degrees inclination, respectively, to demonstrate how the samples are taken.

a) b)

Figure 5. Taking swab a) at 0^0 b) at 20^0

Within 30 minutes, the samples were transferred to the TUTAGEM laboratory and the EDAC Meat Processing Facility laboratory. On the samples taken in both laboratories, the total number of aerobic bacteria was obtained by TS EN ISO 4833-2 standard.

Swab samples were taken after cleaning and pre-production at 0, 10, 20, 30, and 40 degrees slopes and subjected to further examination with the "Biomérieux" minividas device to see if the slope offered to the machine makes a difference in terms of harmful bacteria. The presence-absence tests for *E. coli O157 H7*, *Listeria monocytogenes*, and *Salmonella* were done in this context. In order to detect chemical residues, pH measurements were also performed. A 25 cm^2 section of the neck was used for sampling. The results of the analyses are expressed in cfu/cm^2.

RESULTS AND DISCUSSION

Total Bacteria Growth

The first sample was taken in the place where the machine stood without tipping over under normal conditions. It was discovered that the water did not drain from the neck after 5 minutes of cleaning. TUTAGEM laboratory measured 30000 cfu/cm^2 and EDAC laboratory measured 26000

cfu/cm^2 for two different samples collected 5 minutes after cleaning at 0-degree inclination, as shown in Figure 6. The next morning's examination revealed that the water has not entirely drained. As a result, the number of bacteria has risen by around 5.5 times, with an average of 155000 cfu/cm^2. It is obvious that this circumstance, which occurs every day under normal processing conditions, will result in significant contamination in the initial minced meat the next day. The water that was unable to be removed resulted in the significant growth of microorganisms.

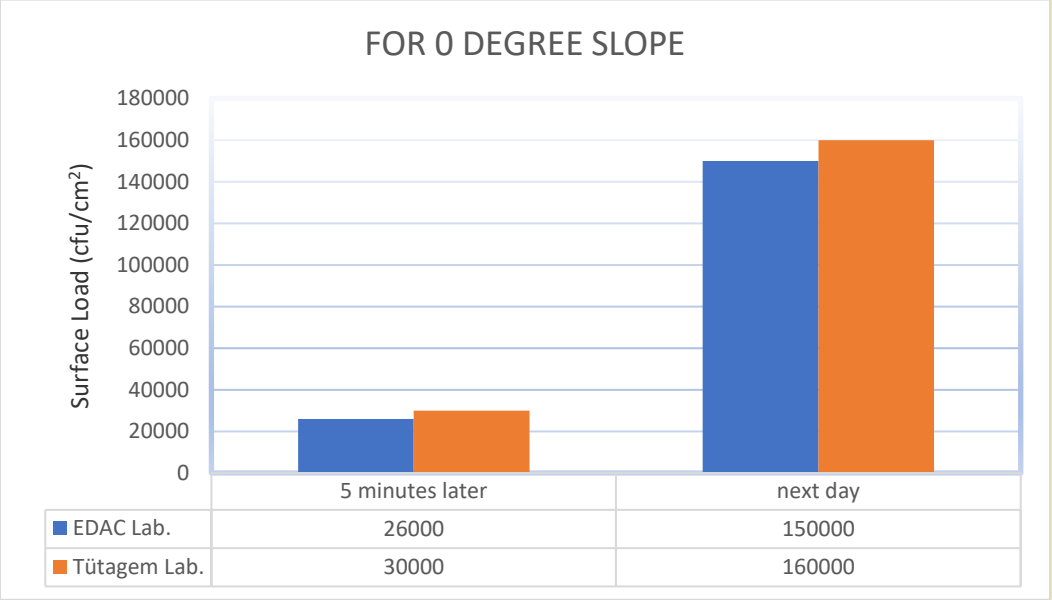


Figure 6. Total bacteria growth for a 0 degree slope

The meat grinder's tilting mechanism was first put to test when it was tilted at a 10-degree angle. After the usual cleaning operation was completed at the end of the day, the machine was tilted to a 10-degree angle and swab was taken after waiting 5 minutes. Prior to swab, visual checks showed that the water in the meat grinder's body stayed in the form of droplets. As shown in Figure 7, the swab counted 11000 cfu/cm^2 bacteria in the TUTAGEM lab and 10000 cfu/cm^2 in the EDAC lab. The meat grinder was observed to be drier the next day than it had been the day before. As seen in Figure 7, bacterial counts ranged between 80000 and 88000. The rise in microorganisms was found to be 8 times in this case. The 10-degree slope was insufficient for rapid water removal and did not prevent microorganism growth.

Figure 7. Total bacteria growth for a 10 degree slope

After the cleaning procedure, the meat grinder was set to a 20-degree angled position for the next analysis and observed that the water remains in the body in the form of droplets after 5 minutes. The TUTAGEM laboratory discovered 60000 bacteria per square centimeter, while the EDAC laboratory detected 55000 bacteria per square centimeter in the initial swab examination. As a result, it was observed that the microorganism loads of the meat ground on the sample day were larger than those of the prior meats. Our goal, however, is to ensure that the bacteria have decreased after 15 hours. The meat grinder's body was found to be dry the next day when it was visually examined. TUTAGEM and EDAC laboratories, respectively, counted 80000 and 88000 bacteria per cm^2 from the sample. When these statistics, which are also shown in the graph in Figure 8, were reviewed, it was discovered that the pace of increase in bacteria fell significantly, despite the fact that the number of germs did not decrease 15 hours after the cleaning procedure. Residual water was observed to be removed relatively efficiently. The bacteria increase coefficient dropped from 8 to 1.33 as evaluated together with Figure 7. The continued increase in the number of microorganisms, on the other hand, shows that the water removal time is insufficient, allowing bacteria to cling to the surface and multiply.

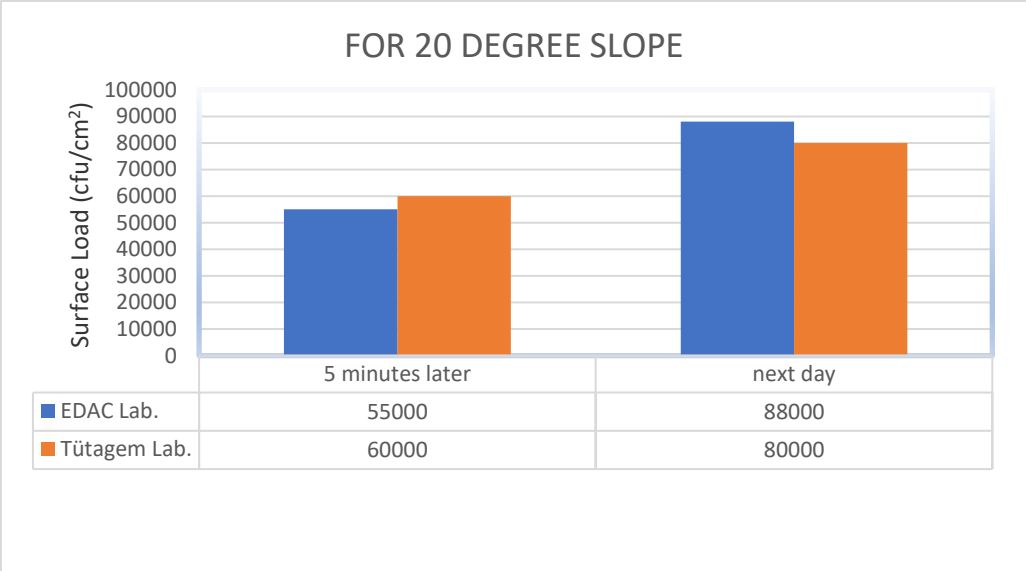


Figure 8. Total bacteria growth for a 20 degree slope

The machine was brought to a slope value of 30 degrees after cleaning for the fourth group analysis, and swab was collected after 5 minutes. According to the visual and manual examinations performed before swab the meat grinder's body was moist and there were no droplets. Figure 9 shows that the TUTAGEM laboratory discovered 26000 cfu/cm^2 while the EDAC laboratory detected 33000 cfu/cm^2. The next day, the meat grinder's body was observed dry, and the number of microorganisms in both swab samples had fallen by about 1.5 times. The fast removal of the water caused the bacteria in the water to be unable to hold in the meat grinder's body, and for the first time, a drop in the number of bacteria was recorded.

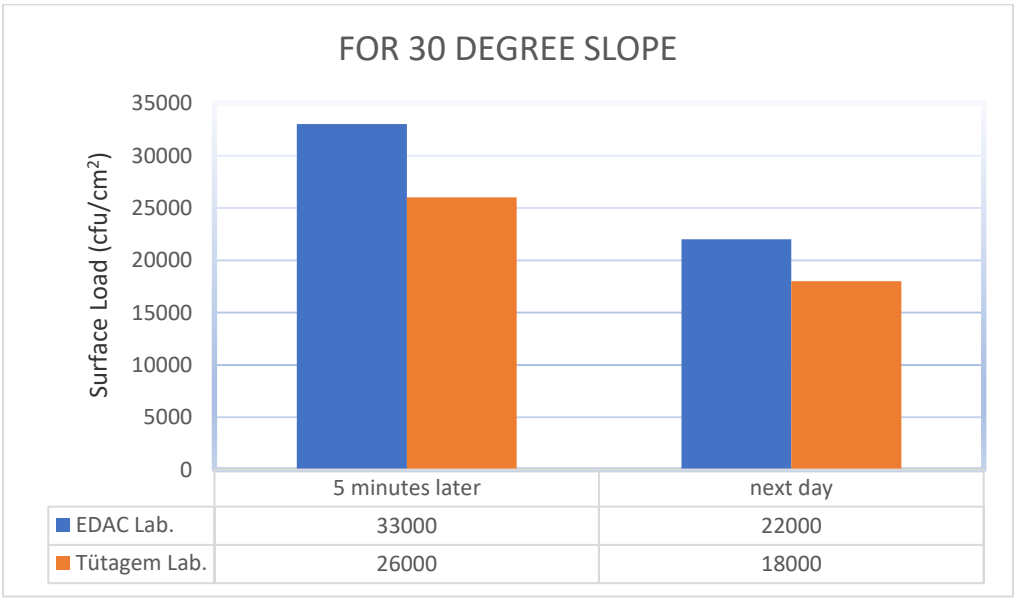


Figure 9. Total bacteria growth for a 30 degree slope

The machine was moved to an inclined position of 40 degrees following the cleaning procedure for the last group analysis, and the sample was obtained 5 minutes later. The grinder's body was moist but there were no droplets detected during the visual examination. Figure 10 shows that the TUTAGEM laboratory discovered 80000 bacteria per cm^2, while the EDAC laboratory found 84000 bacteria per cm^2. The meat grinder's body was found to be dry the next day. The overall quantity of bacteria has decreased dramatically. According to the data from the TUTAGEM laboratory, bacterial counts have decreased by 3.2 times, and according to the EDAC laboratory, bacterial numbers have decreased by 3.65 times. Because the bacteria in the water were unable to hold on to the meat grinder's body due to the quick removal of water, the bacteria's reproductive activity was adversely affected as anticipated.

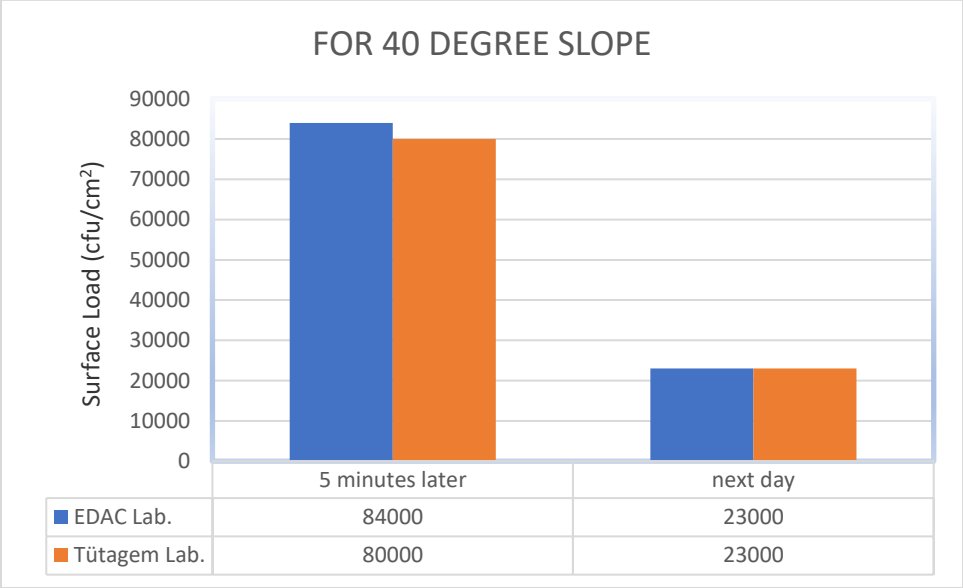


Figure 10. Total bacteria growth for a 40 degree slope

pH Measurements

The quantity of pH in the water, as is well known, delivers excellent information about the chemical residue. The chemical residue ratio rises as the pH rises. Cleaning meat fat requires a high pH and highly concentrated chemicals. These chemicals, on the other hand, should be thoroughly washed and removed from the environment without leaving any residue. In this regard, the goal is also to investigate the role of the developed tilting mechanism in the removal of sanitation chemicals from the body. Apart from the bacteria count studies, samples for chemical counting were also collected every day after each cleaning by tilting the machine 5 degrees.

In the meat processing facility where this study was done, concentrated bleach with a pH value of 11.4 was used for cleaning purposes in all meat grinders. Afterwards, while the machine was horizontal, the grinder's body was washed with rinse water with a pH of 7.92. The machine was cleaned

for the last time with rinse water after the specified slope value was given to it. Swab was taken from the body of the meat grinder in an oblique position the next morning (15 hours later) before production. These samples were measured with a pH meter after being held in a 100 mL distilled water solution for 1 hour, and the results are shown in the graph in Figure 11.

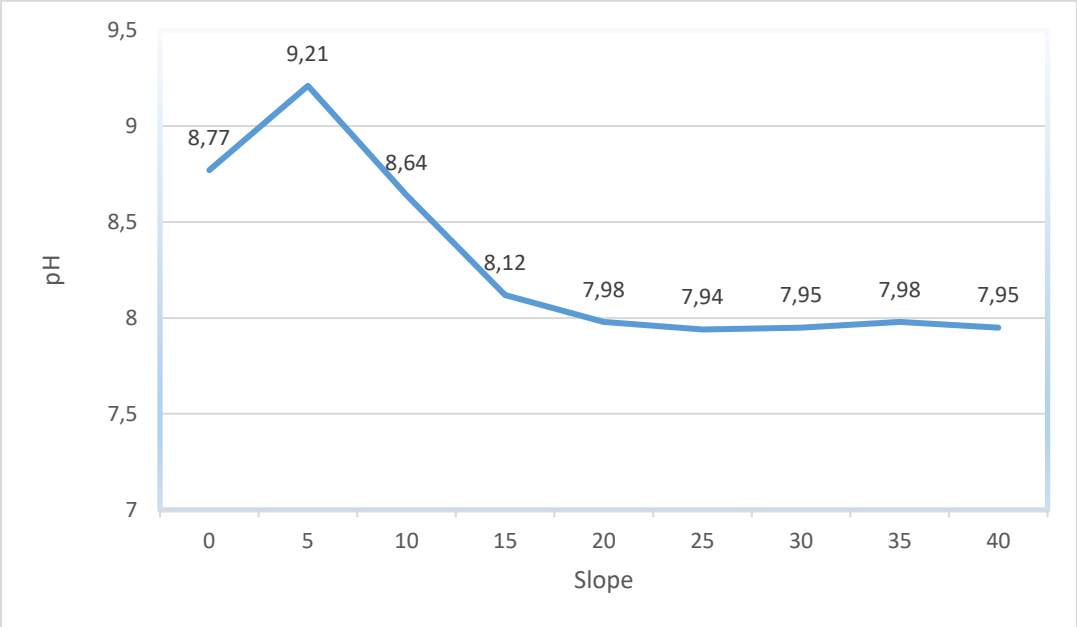


Figure 11. Detection of chemical residuals

When looking at the graph, it can be observed that after a 20-degree slope, the quantity of chemical residue in the body is nearly nil. There is a possibility of chemical residue in the first batch of ground beef taken the next day on slopes less than 20 degrees. The body is affected by this residue, which is carcinogenic. It can cause cancer if exposed for a long time and continuously. As a result, this study has proved the need to incline the body in order to eliminate the chemicals used for sanitation in the cleaning of meat grinders from the grinders' body with rinse water.

Pathogen Analysis

Swab samples were taken after cleaning and pre-production at 0, 5, 10, 20, 30, and 40 degrees slopes and examined using the minividas device to see if the slope supplied to the machine makes a difference in terms of harmful bacteria. The minividas device uses fluorescence rays to identify antigen in a sample. As known, antigens are the structures in the body that cause antibodies to develop. The results of the analyses for *L. monocytogenes*, *E. coli O157 H7*, and *Salmonella* in the codex are shown in Tables 1 and 2. In Table 1, "+" sign indicates that there is pathogen on the swab taken from neck region, whereas "-" sign indicates no pathogen.

Table 1. Pathogen detection in samples taken 5 minutes after cleaning

Slope	***Salmonella***	***E. coli***	***L. monocytogenes***
0	+	-	+
10	+	-	+
20	+	-	+
30	+	-	+
40	+	-	+

Table 2. Pathogen detection in samples taken the next day (15 hours later)

Slope	*Salmonella*	*E. coli*	*L. monocytogenes*
0	+	-	+
10	+	-	+
20	-	-	+
30	-	-	-
40	-	-	-

Pathogens found in raw meat cannot be found in heat-treated products, according to the Turkish food codex. The temperatures and durations at which pathogens will be inactivated are taken into account while performing heat treatments. Cross-contamination increases the quantity of pathogens, which lowers the quality of the final product. Furthermore, their presence in the environment has the potential to contaminate the final product. The pathogens were unaffected by increasing the slope to 10 degrees. While a 20-degree inclination was adequate for *Salmonella* to lack antigen in the girnders' body region, it was insufficient for *L. monocytogenes*. When the slope was raised to 30 degrees, no antigen residue for both pathogens was observed the next day. The necessity of fast removing water from the body with the slope supplied to the machine in terms of pathogens has been proved once again, much like the number of bacteria and pH value.

CONCLUSION

The effect of tilting the whole machine after washing on total bacterial growth, pH, and pathogens in a meat grinder functioning regularly in a workplace was investigated in this study. When the results were combined, it was discovered that inclining the meat grinders' body up to 20 degrees after the cleaning process had no significant effect on all three parameters. At 20 degrees inclination, only *Salmonella* pathogenicity was not identified. The measurement findings on slopes over this number, on the other hand, are quite promising. A decrease in the overall number of bacteria was observed with a 30-degree tilt. The pH level approached that of the cleaning water, eliminating the cleaning chemicals' impact. It was observed that *salmonella* and *Listeria monocytogenes* have no antigen. The overall number of bacteria decreases by much more than 30 degrees on a 40-degree slope. In light of all of this

information, if the meat grinders' body components are manufactured with 30 and 40-degree slopes, cross-contamination and chemical contamination caused by the meat grinders' will be avoided in the business.

REFERENCES

Alvseike, O., Prieto, M., Torkveen, K., Ruud, C. & Nesbakken, T. (2018). Meat inspection and hygiene in a meat factory cell-An alternative concept. *Food Control*, 90, 32-39.

Chung, S. & Hellberg, R. (2020). Effects of poor sanitation procedures on cross-contamination of animal species in ground meat products. *Food Control*, 109, 1-6.

Gokulakrishnan, P. & Bandyopadhyay, S. (1995). Formulation and characterization of some pelleted feeds for Penaeus monodon. *Fish. Technol.*, 32(1), 19-24.

Gu, G., Ottesen, A., Bolten, S., Wang, L., Luo, Y., rideout, S., Lyu, S. & Nou, X. (2019). Impact of routine sanitation on the microbiomes in a fresh procedure processing facility. *International Journal of Food Microbiology*, 294, 31-41.

Henriques, A.R., Gama, L.T. & Fraqueza, M.J. (2017). Tracking Listeria monocytogenes contamination and virulence-associated characteristics in the ready-to-eat meat-based food products industry according to the hygiene level. *International Journal of Food Microbiology*, 242, 101-106.

Irmscher, S. B., Gibis, M., Herrmann, K., Kohlus, R., & Weiss, J. (2016). Development of a novel homogenizer using the vane pump-grinder technology for the production of meat batter. *Journal of Food Engineering*, 169, 10-17.

Isaksson, T., Nilsen, B.N., Togersen, G., Hammond, R.P. & Hildrum, K.I. (1996). On-line, proximate analysis of ground beef directly at a meat grinder outlet. *Meat Science*, 43(3-4), 245-253.

Lee, E.J., Kim, Y.H., Lee, C.H., Kim, H.S. & Kim, H.S. (2016). Effect of different physical conditions on fouling control in in-situ chemical cleaning in place (CIP) for flat sheet membranes fouled by secondary effluents. *Chemical Engineering Journal*, 302, 128–136.

Michael, I., Michael, C., Duan, X., He, X., Dionysiou, D.D., Mills, M.A. & Fatta-Kassinos, D. (2015). Dissolved effluent organic matter: characteristics and potential implications in wastewater treatment and reuse applications. *Water Res.*, 77, 213-248.

Milios, K.T., Drosinos, E.H. & Zoiopoulos, P.E. (2014). Food safety management system validation and verification in meat industry: carcass sampling methods for microbiological hygiene criteria-A review. *Food Control*, 43, 74-81.

Moller, C.O., San'ana A.S., Hansen, S:K.H., Nauta, M.J., Silva, L.P., Alvarenga, V.O., Maffei, D., Pacheco, F., Lopes, J., Franco, B.D.G.M., Aabo, S. & Hansen, T.B. (2016). Robustness of of a cross contamination model describing transfer of pathogens during grinding of meat. *Procedia Food Science*, 7, 97-100.

Rodriguez-Narvaez, O.M., Peralta-Hernandez, J.M., Goonetilleke, A. & Bandala, E.R. (2017). Treatment technologies for emerging contaminants in water: a review. *Chemical Engineering Journal*, 323, 361–380.

Rout, R.K. & Bandyopadhyay, S. (1999). A comparative study of shrimp feed pellets processed through cooking extruder and meat mincer. *Aquacultural Engineering*, 19, 71-79.

Zhao, Y. & Sebranek, J.G. (1997). Technology for meat-grinding systems to improve removal of hard particles from ground meat. *Meat Science*, 45(3), 389-403.