Academic Research Journal of Technical Vocational Schools

| artes@cumhuriyet.edu.tr | Founded: 2022 Available online, ISSN: 2822-5880 Publisher: Sivas Cumhuriyet Üniversitesi

Lactic Acid Decontamination in Carcass Meat

Erdinç Hastaoğlu[1,a] , Emre Hastaoğlu[2,3,b,*], Özlem Pelin Can[3,4,c]

[1]Yıldız Et Ltd. Şti, Sivas Türkiye
[2]Department of Gastronomy and Culinary Arts, Faculty of Tourism, SivasCumhuriyet University, Sivas, Türkiye
[3]Food Studies Application and Research Center, Sivas Cumhuriyet University, Sivas, Türkiye
[4]Department of Veterinary Food Hygiene and Technology, Faculty of Veterinary Medicine, Sivas Cumhuriyet University, Sivas, Türkiye
**Correspondingauthor*

ResearchArticle

History

Received: 05/07/2022
Accepted: 16/11/2022

ABSTRACT

Meat and meat products are very sensitive to bacterial spoilage and are exposed to many sources of bacterial contamination during production. Although many measures are being taken to ensure food safety, the use of new generation decontamination methods is limited. Decontamination with organic acids, on the other hand, has been stated by many authorities to be suitable for human health to be used in decontamination of foods. In this study, it is aimed to compile the decontamination studies of lactic acid on carcass meat. Studies show that the use of organic acids in different concentrations and/or use in carcass meats with different decontamination techniques is extremely effective in inhibiting pathogenic microorganisms. The level of inhibition on various microorganisms can be investigated by applying the decontamination technique with lactic acid at various concentrations on different tissues and different surfaces of the carcass. In addition, decontamination technique with various concentrations of lactic acid can be applied on different contact surfaces in carcass slaughter and shipping areas.

Keywords: Carcass, Decontamination, Lactic acid, Meat

[a] *hastaoglu_erdinc@hotmail.com* *https://orcid.org/0000-0002-3819-4045-*
[b] *ehastaoglu@cumhuriyet.edu.tr* *https://orcid.org/0000-0001-8802-6632*
[c] *opcan@cumhuriyet.edu.tr* *https://orcid.org/0000-0001-8769-4823*

How to Cite: Hastaoğlu E., Hastaoğlu E., Can ÖP., (2022) Lactic Acid Decontamination in Carcass Meat, Academic Research Journal of Technical Vocational Schools, 1(2): 36-40

Introduction

Food safety is important at every stage of the food supply chain. Especially unprocessed foods of animal origin are more sensitive than other processed foods. In order to ensure food safety in meat and meat products, necessary precautions should be taken at all steps from farm to fork. Fresh meat, which is a very favorable environment for the development of food-borne microorganisms, is pre-processed such as washing, cooling or freezing until the stage of processing and converting into product.

Hygiene is the most important step in all stages of meat production. The word “hygiene” means health in Latin and is defined as taking all protective measures to remove the risks that may occur at all stages of production in the production of healthy food suitable for human consumption. (FAO, 2003). Meat hygiene is defined as taking protective measures to remove all risks that may occur at all stages of meat production (raising, slaughter, shredding, preservation, transportation, etc.) (Heinz andHautzinger, 2007).

A large number of microorganisms found in beef are transmitted to meat in various ways depending on slaughter hygiene and the procedures applied. Normally, when healthy animals are slaughtered under hygienic conditions, the microorganism level is very low. However, due to the unhealthy condition of the slaughtered animals and the lack of attention to hygienic conditions during slaughter, meat is easily contaminated with many pathogens and microorganisms that cause spoilage (Heinz andHautzinger, 2007).

In studies conducted to determine the presence of microorganisms in beef that can cause food-borne illness, it is known that beef is contaminated with different pathogenic bacteria, especially *Escherichia coli* O157:H7, *Listeria monocytogenes, Staphylococcus aureus,* *Salmonella* and *Clostridium perfringens*, and that meat also mediates the transport of these microorganisms. (Fantelliand Stephan, 2001; Montseratand Yuste, 2009; Amani et al., 2017; Lathaet al., 2017).

The contamination of beef with microorganisms generally occurs due to 3 different reasons. One of these ways of transmission is the direct transmission of microorganisms found in the blood or internal organs (liver, kidney, spleen, lymph nodes, etc.) to the carcasses, especially during slaughter, since the slaughtered animals are not healthy. For this reason, it is very important to make the necessary health checks of animals before slaughter. Another way of transmission is the form of contamination that occurs during slaughter. This type of contamination generally occurs due to the use of faulty slaughter techniques (contamination of the carcass with intestinal contents, etc.) and the dirty tools and equipment used during slaughter. The third factor that is important in the contamination of meat with microorganisms is the contamination that occurs after slaughter. The sources of this contamination are primarily related to the hygienic conditions of the cooling rooms, the hygienic conditions of the employees and the tools used during the shredding (Graceyet al., 1999).

Decontamination

Compliance with hygienic rules in the process in order to obtain safe products is not sufficient on its own, as a constant flow of bacteria and cross-contamination are inevitable in enterprises. The positive effect of bacterial reduction during the conversion of muscle to meat on product safety and quality is always important to the meat processing industry. In this way, bacterial contamination levels can be reduced in the slaughter process, but it is difficult or even impossible to completely eliminate. Healthy production practices (SMP-Sanitary Manufacturing Practices) during slaughtering and processing are effective in reducing bacterial contamination; but sufficient reduction is not achieved. Therefore, in recent years, carcass decontamination technology has attracted attention and has been successfully applied to increase the shelf life of meat products and to meet consumers' demands for safe food. Microorganisms present on the surface of the carcass in the first stage after slaughter then penetrate into the deep parts of the meat. By using decontamination methods, this initial surface contamination is reduced and microbial growth is prevented or limited. In other words, with carcass decontamination techniques, it is aimed to eliminate or reduce the factors that can cause meat spoilage and that can be pathogenic for humans. Especially in the USA, decontamination of raw meat is widely used to prevent epidemics caused by the consumption of meat and meat products originating from *E. coli* O157:H7 (Beyaz, 2007).

United States Department of Agriculture, The Food Safety and Inspection Service (USDA/FSIS) has authorized the use of certain chemicals as decontaminants for the inhibition of pathogenic microorganisms in carcasses. Among these chemicals, the most widely used are organic acids (lactic acid, lactates, acetic acid, acetates, sodium propionate) and hot water and steam applications. In the European Union countries, the use of lactic acid for decontamination in cattle carcasses was authorized in 2013 (EU Regulations, 2013), and in Turkey, a draft communiqué on the use of lactic acid in cattle carcasses was published by the Ministry of Agriculture and Forestry in 2016 (Ministry of Agriculture and Forestry, 2016).There are different types of physical and chemical decontamination applications (Table 1) in order to reduce the bacteria that cause spoilage, especially pathogenic microorganisms in carcasses (Bolder, 1997;Sofosand Smith, 1998).

Table 1. Decontamination Applications (Loretz et al., 2010)

Chemical Applications	Physical Applications
OrganicAcids	Water (hot water, steam)
InorganicPhosphates	Ultra High Pressure
Chloride	Irradiation
Bacteriosins	ElectromagneticWave
Oxidizers (Ozone, Hydrogenperoxide)	UltrasonicEnergy
OrganicPreservatives	UV Rays

Organic acids commonly used in decontamination processes are weak acids that do not ionize and contain carboxyl groups (COOH). Organic acids are in large number and lactic acid, malic acid, formic acid, citric acid, sorbic acid, propionic acid and salts are some of them. Application of organic acids should be part of the hygiene program along with other decontaminants (Bolder, 1997). In the United States, organic acids are agents authorized by the Ministry of Agriculture as surface decontaminants. The natural amount of lactic acid in the meat is about 10g/kg and contributes to the flavor of the meat. In addition, the lactic acid in the meat reduces the pH value of the meat and provides microbial safety. Different organic acids are applied to the carcasses by spraying or dipping, and organic acids create a bactericidal or bacteriostatic effect on the surface of the carcasses. At the same time, they prevent Gram-negative bacteria from adhering to the surface, which causes deterioration in carcasses (Sofosand Smith, 1998).

The decontamination method to be used should reduce the incidence of pathogens of fecal origin, should not change the color-appearance or taste-odor of the products, should not leave residues, should not have toxic effects on consumers and other health-threatening effects, should not have unacceptable risks on the product and the environment, and it should also be easy to apply and it should be cheap. The effectiveness of the methods used in decontamination; It depends on the pressure and temperature of the water used, if it is used with chemicals, their densities, application time and application method. Various decontamination methods are used in order to inhibit microbial growth in carcasses, extend the shelf life by increasing the durability of meats offered for consumption, and prevent infections and intoxications caused by raw materials. Chemical and physical decontamination methods or their combinations are legally and widely applied in many countries of the European Union, especially the United States of America, in the form of spraying, dipping, washing or steaming the carcasses before the evisceration and/or cooling stages. Decontamination methods in general can cause a decrease in all bacteria levels, mainly total aerobic bacteria and coliform bacteria (Beyaz, 2007).

Organic acid solutions applied by dipping or spraying are the most commonly used chemical decontaminants; It produces a broadly superficial bactericidal and bacteriostatic effect. It is legally permitted by the US Department of Agriculture to immerse carcasses in an organic acid (usually lactic acid) solution prior to evisceration. In the European Union countries, there is no consensus in this direction. While Belgium and Germany allow the use of organic acids, it is still illegal in some countries such as France, the Netherlands and Luxembourg. In the meat hygiene regulations of these countries, it is not allowed to use any other decontamination method other than washing with potable quality water. This is due to their reluctance to use this technology because of the risk of being perceived as a method of balancing or concealing inadequate hygienic practices in slaughterhouses. With the application of organic acids, the contamination on the carcass surface is significantly reduced, its antimicrobial effect continues after the application, it extends the shelf life of the carcass and improves the sensory and microbiological quality of the meat. Smulders and Greer (1998) reported a 1.5 log reduction in surface contamination of carcasses by using diluted solutions of organic acids. It has been reported that organic acids are more effective when applied while the carcass is still warm, especially after skinning and before evisceration.

The bactericidal and bacteriostatic effects of undissociated acids are 10-600 times stronger than those that dissociate. Since organic acids are in undissociated form when dissolved in water, they have a stronger antibacterial effect than inorganic acids that completely dissociate in water, such as hydrochloric acid. However, even under the same pH and decomposition conditions, there are differences between organic acids in terms of antimicrobial effect. This is called the specific acid effect and it is known that lactic acid (Figure 1) is the strongest acid in this respect.

The effectiveness of organic acids depends on the pH value in addition to the degree of dissociation of the acid. The antibacterial effect is also related to the type of acid used, the sensitivity of the target microorganism to acid, the density of the acid, the method and duration of application, and the temperature of the solution. This effect can be increased by increasing the application time and temperature or by applying chemicals such as salt/sugar before application. Increasing the application time of acid to meat affects the survival time of bacteria. In this respect, it is reported that a time interval of 15 to 300 seconds should be used in order to observe the expected positive effect from the application. Studies show that the addition of organic acid is an effective way to reduce the microbial population and increase the shelf life, and the combination of two or more acids is more effective than a single acid application. (Ariyapitipun et al., 1999; Beyaz, 2007).

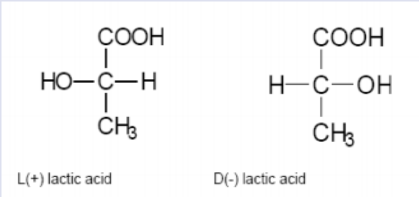

Figure 1. D and L forms of Lactic Acid (Anderson and Marschall, 1990)

In reports of USDA (United States Department of Agriculture) – FSIS (Food Safety and Inspection Service), it is recommended to use organic acids such as acetic and lactic acid at concentrations of 1.5-2.5%. It is recommended to apply lactic acid for decontamination while the carcasses are still warm, after removal of the internal organs, before cooling. It is stated that 2% solution of lactic acid is quite ineffective when applied to refrigerated carcasses, but a large reduction in microbial numbers is observed with the use of 4% concentration. Lactic acid can be used by adding to cold, warm or hot water. The density of the lactic acid used can vary from 0.2% to 2.5%. The most commonly used ratio for beef carcass is 2% density. (USDA-FSIS, 1996).

Studies on Chemical Decontamination in Meat

Researchers reported that the reducing effect of lactic acid on bacteria is related to the concentration of lactic acid used, the temperature of the lactic acid solution, the application method, the processing time and the pH-value (Anderson and Marshall, 1990).

Depending on the use of lactic acid solutions in 1-2% concentrations, the number of microorganisms is reduced after slaughter and during storage. It is known that lactic acid, which is generally used in 1-2% concentration, does not cause a significant change on the sensory qualities and color of the meat (Bolder, 1997; Sofosand Smith, 1998).

Tambyl and Conner, (1997) found in their study that bacterial reduction in chicken breast skins inoculated with *S. typhimurium* varied depending on the concentration of lactic acid and the temperature of the solution, while lactic acid at 4% concentration caused an average of 2 log bacterial reduction.

Sakhar et al., (1999) found that there was a significant decrease in the number of *S. aureus* in the samples after decontamination with lactic acid (0.25% lactic acid solution, 60 seconds immersion) in poultry meat production compared to the control group. Castillo et al., (2001) stated that the decrease in the number of aerobic bacteria as a result of the application of 4% concentration of lactic acid, with a solution temperature of 55°C, to the cooled cattle carcass surfaces in the form of a spray is at the level of 3.0-3.3 log.

Coşansu and Ayhan, (2012) reported that dipping chicken thighs and breast meats in 1 and 3% concentrations of lactic acid for 10 minutes resulted in 0.75, 1.21 and 0.97, 1.72 log reductions in the number of *Salmonella enteritidis*, respectively. According to Chaine et al., (2013) stated that there was a decrease of approximately 1.4 log in Salmonella bacteria in chicken skins dipped in lactic acid solution at a concentration of 5-16% for 1 minute.

The type of organic acid used in decontamination, the fatness of the carcass surface and the type of bacteria are important factors in efficiency. The activity of lactic acid is lower on fatty carcass surfaces. With the use of buffered lactic acid, discoloration caused by normal lactic acid can be prevented. Due to the undissociated acid molecules in buffered lactic acid, the antimicrobial effect is more visible, as the pH-value of the environment is lower. For these reasons, organic acids and especially lactic acid have decontaminant properties suitable for carcass and meat surfaces (Bolder, 1997; Sofosand Smith, 1998; Loretzet al., 2010).

Ozdemir et al., (2006) in beef samples where they immersed lactic acid in 1 and 2% concentrations and hot water at 82°C for 15 seconds, the numbers of L. monocytogenes in samples treated with lactic acid at 1 and 2% concentrations were 0.69 and 1.09, respectively, on the 0th day of the storage period. They found that it decreased at the log level. Ikeda et al., (2003) from the decontamination processes performed by immersing in hot water (75°C, 30 seconds immersion) and 2% lactic acid solution (55°C) for 30 seconds in beef samples contaminated with acid-adapted and unadapted *L. monocytogenes* they stated that the numbers of *L.monocytogenes* in the samples decreased at the level of 1.4-2.0 and 1.8-2.6 log, respectively. According to Anang et al., (2007) investigated the effects of lactic acid and lauricidin on experimentally contaminated *L. monocytogenes, S. Enteritidis,* and *E. coli* O157:H7 in poultry breast skins. They were immersed for 20 and 30 minutes. Researchers reported that the most effective treatment on bacteria occurred in samples treated with 2% lactic acid concentration for 30 minutes, and the decrease was found at 1.97, 1.71 and 2.59 log levels on *L. monocytogenes, S. Enteritits* and *E. coli* O157:H7, respectively.

Mohammed and Abdel-Naeem, (2018) stated in their study that the antibacterial effect of lactic acid increased due to the use of sodium dodecyl sulphate, and this was due to the direct interaction of lactic acid with microorganisms due to the opening of the follicles of sodium dodecyl sulphate in poultry skins. One of the studies investigating the effects of organic acids on pathogenic bacteria in meat belonging to different animal species, on beef samples contaminated with a mixed mixture of 4 different serotypes of *L. monocytogenes*, 2% in hot water (75°C, 30 seconds immersion) and a solution temperature of about 55°C (Koutsoumanis et al., 2004). They found that there was a decrease in the number of *L. monocytogenes* by 0.82 and 1.43 log, respectively, immediately after the treatment, in their study by dipping them separately in lactic acid solution for 30 seconds. In the same study, researchers reported that when the samples were immersed in hot water and lactic acid together, the reduction detected immediately after the treatment reached 2.73 log level.

In a study, the numbers of *L. monocytogenes* and *S. aureus* in experimentally contaminated meat decreased significantly in the applications of 1, 2 and 3 % lactic acid and water vapor and 2% lactic acid + water vapor applications. Among these applications, 2% lactic acid + water vapor and 3% lactic acid + water vapor were found to be the most effective applications (Yusufu, 2019).

Liu et al. (2016), found a 1.5 log decrease in *S. Typhmurium* numbers after the application of 1.5% concentration lactic acid at a solution temperature of 50°C for 15 seconds in the form of a spray. Yeh et al., (2018) stated that ultraviolet and bacteriophages were more effective on *Salmonella* numbers than lactic acid in beef. Van Netten et al. (1997) in a study they conducted, reported that lactic acid at concentrations of 1-5% for 30-90 seconds killed Gram-negative bacteria as a result of application to pig carcasses. It has been stated that *Y.enterocolitica*, one of the pathogens, is susceptible to organic acids, while E.coli O157:H7 is resistant.

Lactic acid is reported as an effective solution used to inhibit the growth of *Listeria monocytogenes*. Solutions of lactic and acetic acid, prepared in concentrations of 1-3%, among organic acids applied to reduce the number of bacteria from the carcass, are the most widely used in the poultry and red meat industry, either alone or in combination.

Result and Recommendations

Meat and its products chemical structure, processing, storage, depending on packaging and transport conditions may be contaminated. Meat and products of decontamination;

- Product protection,
- Consumerensuring the health and safety,
- The businessof great importance in terms of preventing losses to the economycarries.

In order to ensure food safety in carcass meat, decontamination can be applied at various ratesand with various preservation techniques. Studies show that it is possible to reduce manypathogenic microorganisms thanks to carcass decontamination with lactic acid. The level of inhibition on various microorganisms can be investigated by applying the decontamination technique with lactic acid at various concentrations on different tissues and different surfaces of the carcass. In addition, decontamination technique with various concentrations of lactic acid can be applied on different contact surfaces in carcass slaughter and shipping areas.

In the future, different decontamination applications combinations are tried, the healthiest and most appropriate decontamination conditions should be investigated for different meats and products. Positive and negative effects of applications on meat quality and aroma effects should also be evaluated in studies.

References

Amani MS, Zakaria EM, Raheem Abd El KA. 2017. EnvironmentalContamination with Methicillin Resistant Staphylococci in Food animalcarcasses, Benha Veterinary Medical Journal, 32(1), 170-176.

Anang DM, Rusul G, Bakar J, Ling FH. 2007. Effects of lactic acid andlauricidin on the survival of Listeria monocytogenes, Salmonella Enteritidis and Escherichia coli 0157:H7 in chicken breast stored at 4ºC, Food Control,18, 961-969.

Anderson ME, Marschall RT. 1990. Reducing microbial population on beeftissues: Concentration and temperature of lactic acid, Journal Food Safety, 10,181-190.

Ariyapitipun T, Mustapha A, Clarke AD. 1999. Microbial shelf life determination of vacuum-packaged fresh beef treated with polylactic acid, lactic acid, and nisin solutions, Journal of Food Protection, 62 (8): 913–20.

Beyaz D. 2007. Koyun Karkaslarının Mikrobiyal Kalitesi Üzerine Laktik Asit Sprey Uygulamasının Etkisi, Doktora Tezi, Uludağ Üniversitesi Sağlık Bilimleri Enstitüsü Besin Hijyeni ve Teknolojisi Anabilim Dalı, Bursa.

Bolder NM. 1997. Decontamination of meat and poultry carcasses, Trends in Food Science & Technology, 8: 221-227, 1997.

Castillo A, Lucia LM, Mercado I, Acuff GR. 2001. In-Plant evaluation of a lactic acid treatment for reduction of bacteria on chilled beef carcasses, JournalFood Protection, 64, (5), 738-740.

Chaine A, Arnaud E, Kondjoyan A, CollignanA, Sarter S. 2013. Effects ofsteam and lactic acid treatments on the survival of Salmonella Enteritidis andCampylobacter jejuniinoculated on chicken skin, International Journal FoodMicrobiology, 162, 276-282.

Coşansu S, Ayhan K. 2012. Effects of lactic and acetic acid on survival ofSalmonella enteritidisduring refrigerated and frozen storage of chicken meats, Food and Bioprocess Technology, 5(1), 372-377.

Eurpean Union Commission Regulation (EU) No 101/2013 of 4 February 2013.Concerning the use of lactic acid to reduce microbiological surfacecontamination on bovine carcases.

Fantelli K, Stephan R. 2001. Prevalence and characteristics of shigatoxinproducing Escherichia coli and Listeria monocytogenes strains isolated from minced meat in Switzerland, International Journal Food Microbiology, 22, (1-2), 63-69.

FAO, 2003. Recommended International Code of Practice: General Principles of Food Hygiene', in Codex Alimentarius Commission Food Hygiene BasicTexts: 3rd edition.

Gracey JF, Collins DS, Huey RJ. 1999. Meat Hygiene. Tenth Edition. W. B. Saunders Company Ltd, 758, London.

Heinz G, Hautzinger P. 2017. Meat ProcessingTechnologyfor Small toMediumscaleProducers. FAO Regional Office For Asia and The Pacific, 456, Bangkok.

Ikeda JS, Samelis J, Kendall PA, Smith GC, Sofos JN. 2003. Acid adaptationdoes not promote survival or growth of Listeria monocytogenes on fresh beeffollowing acid and nonacid decontamination treatments, Journal FoodProtection, 66(6), 985-992.

Koutsoumanis KP, Ashton LV, GeornarasI, Belk KE, Scanga JA, KendallPA, Smith GC, Sofos JN. 2004. Effect of single or sequential hot waterand lactic acid decontamination treatments on the survival and growth ofListeria monocytogenes and spoilage microflora during aerobic storage of freshbeef at 4, 10 and 25 C, Journal Food Protection, 67, (12), 2703-2711.

Latha C, Any CJ, Ajaykumar VJ, Sunil B. 2017. Prevalence of Listeriamonocytogenes, Yersinia enterocolitica, Staphylococcus aureus, and Salmonella enterica in meat and meat products using polimerazechain reaction, Veterinary World, 10, 8: 927-931.

Liu A, Peng Z, Zou L, Zhou K, Ao X, He L, Chen S. 2016. The effects oflactic acid-based spray washing on bacterial profile and quality of chickencarcasses, Food Control, 60, 615-620.

Loretz M, Stephan R, Zweifel C. 2010. Antimicrobial activity ofdecontamination teratments for poultry carcasses: A literatüre survey, Food Control, 21, 791-804.

Ministry of Agriculture and Forestry of Turkish Republic. 2016. Regulation on the use of lactic acid to reduce microbiological superficial contamination in beef carcasses.

Mohammed HMH, Abdel-Naeem HHS. 2018. Enhancing the bactericidalefficacy of lactic acid against Salmonella Typhimurium attached to chicken skin by sodiumdodecylsulphate addition, LWT-Food Science andTechnology,87, 464-469.

Montserat MM, Yuste J. 2009. Emerging bacterial pathogens in meat and poultry: an overview, Food and Bioprocess Technology, 3, 24-35.

Özdemir H, Yıldırım Y, Küplülü Ö, Koluman A, Göncüoğlu M, İnat G.2006. Effects of lactic acid and hot water treatments on SalmonellaTyphimurium and Listeria monocytogenes, Food Control, 17, 299-303.

Sakhare PZ, Sachindra NM, Yashoda KP, Rao Narasimha D. 1999. Efficacyof intermittent decontamination treatments during processing in reducing themicrobial load on broiler chicken carcass, Food Control, 10, 189-194.

Smulders FJM, Greer GG. 1998. Integrating microbial decontamination withorganic acids in HACCP programmes for muscle foods: prospects andcontroversies, International Journal of Food Microbiology, 44: 149–169.

Sofos JN, Smith GC. 1998. Nonacid meat decontamination Technologies: Model studies and commercial applications. International Journal Food Microbiology,44, 171-188.

Tamblyn KC, Conner DE. 1997. Bactericidal activity of organic acids againstSalmonella Typhimurium attached to broiler chicken skin, Journal FoodProtection, 60(6), 629-633.

USDA–FSIS. Notice of policy change; achieving the zero tolerance performancestandard for beef carcasses by knife trimming and vacuuming with hot water orsteam; use of acceptable carcass interventions for reducing carcass contaminationwithout prior agency approval. United States Department of Agriculture, FoodSafety and Inspection Service. Fed. Reg., 61: 15024–15027, 1996.

Van Netten P, Mossel DAA, Huis İ. 1997. Microbial changes on freshly slaughtered pork carcasses due to hot lactic acid decontamination, Journal of Food Science, 17 (2): 89–111.

Yeh Y, De Moura FH, Van den Broek K, De Mello AS. 2018. Effect ofultraviolet light, organic acids, and bacteriophage on Salmonella populations inground beef. Meat Science, 139, 44-48.

Yusufu G. 2019. Investigation of the Effect of Lactic Acid and Hot Steam Applications on Microorganism Numbers in Beef Inoculated with Listeria monocytogenes and Staphylococcus aureus, MSc, Ankara University, Ankara