Microbiological and Physicochemical Parameters of Beef and Lamb Meat Produced in Abattoirs in Northern Greece. Preliminary Results

Anestis Tsitsos[1], Vangelis Economou[2], Eirini Chouliara[3], Theodoros Kalitsis[4], Aggeliki Argyriadou[5], Georgios Arsenos[6], Ioannis Ambrosiadis[7]

[1]Laboratory of Hygiene of Food of Animal Origin – Veterinary Public Health, School of Veterinary Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki, Greece; e-mail: tsitanes@vet.auth.gr
[2]Laboratory of Hygiene of Food of Animal Origin – Veterinary Public Health, School of Veterinary Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki. Greece; e-mail: boikonom@vet.auth.gr
[3]Laboratory of Technology of Food of Animal Origin, School of Veterinary Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki, Greece; e-mail: echoulia@vet.auth.gr
[4]Laboratory of Animal Husbandry, School of Veterinary Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki, Greece; e-mail: tgkallitsis@vet.auth.gr
[5]Laboratory of Animal Husbandry, School of Veterinary Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki, Greece; e-mail: argyrian@vet.auth.gr
[6]Laboratory of Animal Husbandry, School of Veterinary Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki, Greece; e-mail: arsenosg@vet.auth.gr
[7]Laboratory of Technology of Food of Animal Origin, School of Veterinary Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki, Greece; e-mail: ambros@vet.auth.gr

Abstract. Meat quality and hygiene are perquisites for the marketing of meat and meat products. In this research paper the results of the monitoring of meat quality from abattoirs of Northern Greece are reported. Samples of lamb meat and beef were collected in order to examine the physicochemical parameters (pH, moisture, total fat and total proteins) and microbiological quality indicators (total mesophilic count, total psychrophilic counts and coliform count) of meat produced in these plants. Concerning beef, the most contaminated area was the hindquarter, followed by the forequarter and the abdomen. Differences were observed in the microbiological quality of the lamb carcasses prepared at different abattoirs, pointing the importance of personalized hygiene measures. Small deviation was observed in the physicochemical parameters examined, with lamb meat having a pH of 6.17 (SD=0.24), humidity of 63.2% (SD=4.5%), total fat 5.4% (SD=4.1%), and total proteins 20.8% (SD=4.5%).

Keywords: meat quality; meat hygiene; lamb meat; mutton; goat; Greece.

Proceedings of the 9th International Conference on Information and Communication Technologies in Agriculture, Food & Environment (HAICTA 2020), Thessaloniki, Greece, September 24-27, 2020.

1 Introduction

Meat is an essential part of the human diet. As in most foods, its suitability for human consumption is determined by its safety and quality. The term "safety" is easily defined; still, it is not so for the term "quality" which is a rather generic term, prone to social and time variations. With hygiene a perquisite, it is acceptable that quality is formed by the consumer preferences, namely its organoleptic characteristics, nutritional value, and the technological properties of meat (Elmasry *et al*., 2012). Still, in order to compare quality of different meat, certain physicochemical parameters have been introduced as quality markers that are objective still not usually perceived by the consumer. In Greece, the characterization of meat quality relies mostly in empirical characteristics, with scarce scientific information concerning objective quality characteristics (Krystallis *et al*., 2007). The scope of this research was to assess the hygiene and quality of beef and sheep meat produced in abattoirs of Northern Greece by certain hygiene and quality markers.

2 Materials and Methods

The abattoirs under examination are situated in the Prefectures of Thessaly and Central Macedonia. They are licensed by the European Union for the slaughter of ruminants and pigs. The abattoirs were visited from October 2019 to June 2020. Approximately 1 hr after slaughter, the surface of the carcasses was sampled following the non-destructive swab method. In brief, a sterile swab was soaked in 5 ml of Minimum Recovery Diluent (MRD, Oxoid) and was used to wipe a 100 cm^2 carcass surface area. The swab was added to the tube containing 5 ml MRD and transported to the Laboratory of Food Hygiene – Veterinary Public Health in an insulated container under refrigeration. Within 24 hr, decimal dilutions were performed in MRD containing tubes. From each dilution, 0.1 ml of the diluent was surface inoculated in the appropriate media. For the microbiological parameters examined the plates inoculated were Plate Count agar (Biolab) for Total Mesophilic Viable Count (TMVC) and Total Psychrophilic Plate Count, and Violet Red Bile agar (Biolab) for coliform count. The examination of samples for TMVC and coliform count was performed according to ISO 4833/2005 and ISO 21528-2/2017 with modifications, as proposed by the Commission Regulation (EC) No. 2073/2005 on microbiological criteria for foodstuffs. Incubation was performed at 30°C for 72h for TMVC, 10°C for 7 days for TPVC and 37°C for 24h for coliforms. After incubation, the characteristic colonies were counted, and the results were recorded. A total of 88 and 166 swab samples were examined for surface contamination of beef and sheep carcasses respectively.

Samples were also collected by the destructive method from cold carcasses. In brief a piece weighting approximately 100 g was excised from the thigh region (*quadriceps fermoris*) or elsewhere and transported to the laboratory within the same day. The samples were examined for their pH, water activity, humidity, total fats and total proteins. Prior to examination the samples were comminuted with a Warring laboratory blender. For pH examination, 10 g of muscle were dispersed in 40 ml of distilled water and let to settle. Ph examination was performed with a Hannah Ph211 pH meter. Water activity was measured with a HygroPalm HP23-AW-A water Activity Analyzer (Rotronic AG) according to the manufacturer's instructions. Humidity was examined with a moisture analyser (Ohaus MB27) according to the manufacturer's instructions. Total fat was determined according to the reference analysis Weibull-Stoldt method, with hydrolysis as the first step and extraction in the Soxtherm, according to the AOAC method 991.36. Total protein was determined according to the AOAC Official Method 928.08. A total of 110 beef samples and 37 sheep samples were examined for their physicochemical properties, with 10 and 25 of them respectively examined for total fat and total proteins.

3 Results and Discussion

An effort was made to monitor the hygiene and quality of lamb and beef produced in the abattoirs of Northern Greece. For this purpose, a total of 88 and 166 surface samples were collected from bovine and sheep carcasses, and 110 beef samples and 37 sheep meat samples examined for their physicochemical properties. The physicochemical analyses results are reported in Table 1 and Table 2. In brief the cold carcass hindquarter pH was in average 5.69, the diaphragm pH was in average 6.2, the forequarter pH was in average 5.77 and the liver pH was in average 6.43. The deviation was small, implying the repeatability of the slaughtering procedure and the uniform conditions in all animals slaughtered, not permitting different conditions of chilling.

Table 1. PH of the beef muscle from the sites sampled (average in bold, standard deviation in parentheses and italics).

Carcass part		
Hindquarter	**5.69**	*(0.10)*
Diaphragm	**6.2**	*(0.15)*
Forequarter	**5.77**	*(0.24)*
Liver	**6.43**	*(0.04)*

Concerning the physicochemical analyses of the hindquarter samples from sheep cold carcasses, the average value of pH was 6.26, humidity was 63.2%, total fat was 5.4%, and total proteins 20.8 %. Little difference was observed between samples from different abattoirs concerning the pH of the cold carcass and the humidity. Still there were differences in the total fat and total proteins of the samples examined that were not statistically significant as shown by the deviation of the abattoir 2 samples. This can be attributed to the number of samples examined and the examination of some older animal carcasses from abattoir 2 since meat from older animals is generally richer in fat.

Table 2. Physicochemical analyses of lamb meat (average in bold, standard deviation in parentheses and italics).

	pH		Humidity		Total fat		Total proteins	
Abattoir 1	**6.26**	*(0.14)*	**63.8%**	*(3.0%)*	**4.0%**	*(1.2%)*	**19.8%**	*(4.4%)*
Abattoir 2	**6.07**	*(0.29)*	**61.4%**	*(7.7%)*	**9.9%**	*(6.4%)*	**24.3%**	*(2.8%)*
Total	**6.17**	*(0.24)*	**63.2%**	*(4.5%)*	**5.4%**	*(4.1%)*	**20.8%**	*(4.5%)*

Concerning the surface contamination of bovine carcasses, the results are shown in Table 3 and in Graphs 1 and 2. In hindquarters, the average value of TMVC was 4.83 log_{10} CFU/cm^2, TPVC 2.13 log_{10} CFU/cm^2 and coliform count was 0.86 log_{10} CFU/cm^2. The abdomen examination results were 1.76 log_{10} CFU/cm^2 for TMVC, 0.83 log_{10} CFU/cm^2 for TPVC, and 0.56 log_{10} CFU/cm^2 coliform count. In forequarter samples TMVC was 2.48 log_{10} CFU/cm^2, TPVC 1.35 log_{10} CFU/cm^2 and coliform count was 0.68 log_{10} CFU/cm^2 in average. The hindquarter surface was more contaminated than the forequarter and abdomen surfaces, with the abdomen surfaces being the least contaminated.

The microbial counts are in average below the limits posed by the he Commission Regulation (EC) No. 2073/2005 on microbiological criteria for foodstuffs. More specifically, no batch of carcasses exceeded the average limit posed of 3.5 log_{10} CFU/cm^2. In three cases the surface count was larger than 3.5 log_{10} CFU/cm^2 but below the upper limit of 5.0 log_{10} CFU/cm^2 of individual samples. According to Paszkiewicz & Pyz-Łukasik (2012) the total aerobic bacteria count on calf carcasses slaughtered in Polish abattoirs ranged from $3.5*10^3$ CFU/cm^2 up to $7.0*10^3$ CFU/cm^2. These results are larger than the ones reported in our study for abdomen and forequarter areas, but smaller than the counts observed for hindquarter samples. This can be justified by the unified analysis of the different carcass surface sampling points. Also, the coliform counts reported (1.7*10 cfu/cm^2) are larger than the ones reported in this paper, possibly due to better evisceration techniques. Zweifel *et al.* (2008) have examined the surface contamination of pigs and cattle slaughtered in small scale Swiss abattoirs. They report that the mean TMVCs of cattle carcasses ranged from 2.7 to 3.8 $log_{10}CFU*cm^{-2}$, a value that is smaller than the ones observed in this study. Camargo *et al.* (2018) report that the contamination rates in four Brazilian abattoirs were in average 2.93 ± 0.06 $log_{10}CFU*cm^{-2}$ for TMVC and 1.81 ± 0.07 $log_{10}CFU*cm^{-2}$ for total coliforms, which are comparable to the ones observed in the present study. Still, it should be noted that comparison of microbial contamination of the carcasses should not be done with data from countries outside the European Union since in other areas and more specifically in North America, they are hampered by the application of decontamination procedures (Koohmaraie *et al.*, 2005). In contrast, Petruzzelli *et al.* (2016) report quite lower TMVC counts (1.96 log cfu/cm^2) in bovine carcasses from three small-scale Italian abattoirs.

Table 3. Microbial counts of different beef carcass areas (average in bold, standard deviation in parentheses and italics).

	Hindquarter		Abdomen		Forequarter		Average	
TMVC	**4.83**	*(1.79)*	**1.76**	*(0.70)*	**2.48**	*(1.21)*	**3.02**	*(1.85)*
TPVC	**2.13**	*(2.07)*	**0.83**	*(0.49)*	**1.35**	*(1.23)*	**1.44**	*(1.50)*
Coliforms	**0.86**	*(0.78)*	**0.56**	*(0.16)*	**0.68**	*(0.31)*	**0.66**	*(0.39)*

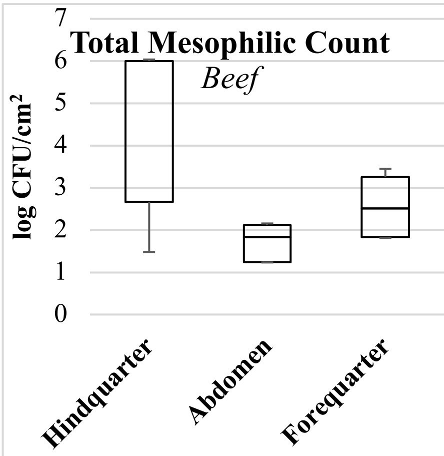

Fig. 1. Total mesophilic counts of beef carcass areas (n= 36).

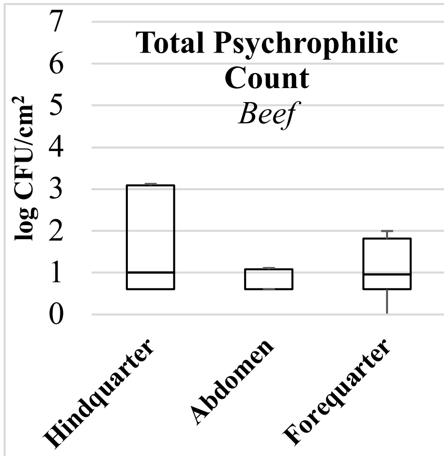

Fig. 2. Total psychrophilic count of beef carcass areas (n= 36).

The microbial counts of the sheep carcasses surface samples from the two abattoirs under investigation are reported in Table 4. In brief, TMVC was 4.02 $\log_{10}$ CFU/cm^2 and 1.91 $\log_{10}$ CFU/cm^2, TPVC was 3.47 $\log_{10}$ CFU/cm^2 and 2.56 $\log_{10}$ CFU/cm^2, and coliform count was 4.02 $\log_{10}$ CFU/cm^2 and 1.91 $\log_{10}$ CFU/cm^2 in abattoir 1 samples and abattoir 2 samples respectively. In Graphs 3, 4 and 5, boxplot graphs of the microbial counts under investigation have been constructed in order to compare the contamination of the surfaces in the carcasses produced in these two abattoirs. The TPVC and coliform counts were comparable, showing no actual differences. Still, the TMVC variation was larger in abattoir 1 than in abattoir 2, with the median being larger in abattoir 2 than in abattoir 1; therefore, the production process is judged as inconsistent in abattoir 1, although in general the efficiency of its procedures could end up in a less contaminated sheep carcass.

Table 4. Microbial counts of lamb hindquarters (log10 CFU/cm2) between the two abattoirs sampled (average in bold, standard deviation in parentheses and italics).

	Abattoir 1 (n=44)	**Abattoir 2** (n=122)
Total Mesophilic Count	**4.02** *(1.67)*	**1.91** *(1.30)*
Total Psychrophilic Count	**3.47** *(0.57)*	**2.56** *(0.74)*
Coliforms	**1.26** *(0.98)*	**1.26** *(1.13)*

Sierra *et al*. (1997) have reported larger microbial counts after the washing step of a sheep abattoir in Ireland. In brief the average microbial counts in four plans investigated ranged from 4.63 to 4.88 $\log_{10}$ CFU/cm^2. The larger counts can be attributed to the different carcass areas sampled which were the abdomen. This is in accordance with the observation that the evisceration stage was considered the most implicated in carcass contamination by Enterobacteriaceae, although no correlation between the total counts and the Enterobacteriaceae was observed. Milios *et al*. (2011) have reported, among other, that TMVC and Enterobacteriaceae counts in a Greek lamb abattoir were 5.89 and 3.74 $\log_{10}$ CFU/cm^2. They have also proposed that steam decontamination could greatly benefit the overall microbial quality of the sheep carcass. Røssvol *et al*. (2018) compared the effects of two evisceration methods on the hygiene of sheep carcasses, stating that no difference exists between the methods examined. Petruzzelli *et al*. (2016) report quite smaller TMVC counts (2.27 log cfu/cm^2) in bovine carcasses from three small-scale Italian abattoirs.

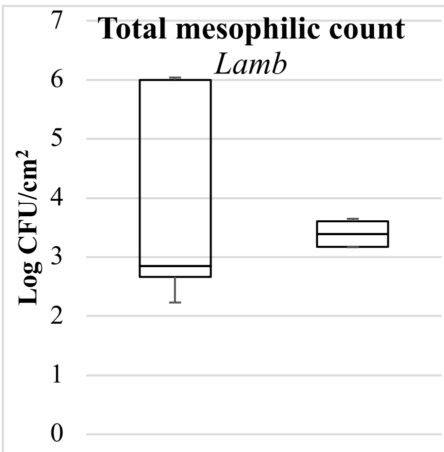

Fig. 3. Comparison of total mesophilic counts of lamb hindquarters from abattoir 1 and 2.

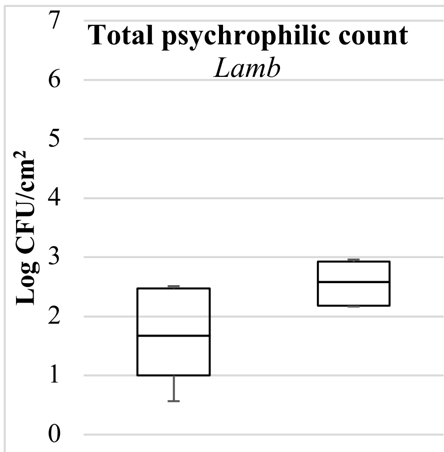

Fig. 4. Comparison of total psychrophilic counts of lamb hindquarters from abattoir 1 and 2.

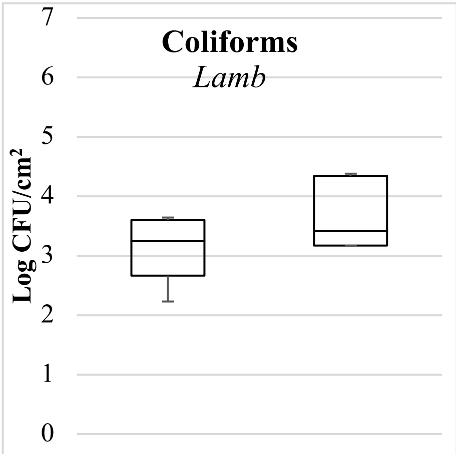

Figure 5. Comparison of coliform counts of lamb hindquarters between abattoir 1 and 2.

Acknowledgments. This research has been co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE (project code: T1EDK-05479).

References

1. Camargo AC, Cossi MVC, Silva WPD, et al. (2019). Microbiological Testing for the Proper Assessment of the Hygiene Status of Beef Carcasses. Microorganisms. 2019;7(3):86. https://doi.org/10.3390/microorganisms7030086.
2. Commission Regulation (EC) No. 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. OJ L 338, 22.12.2005, pp. 1-26.
3. Elmasry G, Barbin DF, Sun DW, Allen P (2012). Meat quality evaluation by hyperspectral imaging technique: an overview. Critical Reviews in Food Science and Nutrition 52(8):689-711. https://doi.org/10.1080/10408398.2010.507908
4. ISO 21528-2:2005 Microbiology of food and animal feeding stuffs - Horizontal method for the detection and enumeration of Enterobacteriaceae - Part 2: Colony-count method.
5. ISO 4833:2004 Microbiology of food and animal feeding stuffs - Horizontal method for the enumeration of microorganisms – Colony-count technique at 30°C.
6. Koohmaraie M, Arthur TM, Bosilevac JM, Guerini M, Shackelford SD, Wheeler TL (2005). Post-harvest interventions to reduce/eliminate pathogens in beef. Meat Science 71(1):79-91. https://doi.org/10.1016/j.meatsci.2005.03.012

7. Krystallis A, Chryssochoidis G, Scholderer J (2007). Consumer-perceived quality in 'traditional' food chains: the case of the Greek meat supply chain. Appetite 48(1):54-68. https://doi.org/10.1016/j.appet.2006.06.003
8. Milios K, Mataragas M, Pantouvakis A, Drosinos EH, Zoiopoulos PE (2011). Evaluation of control over the microbiological contamination of carcasses in a lamb carcass dressing process operated with or without pasteurizing treatment. International Journal of Food Microbiology 146(2): 170-175. https://doi.org/10.1016/j.ijfoodmicro.2011. 02.023
9. Paszkiewicz, W., & Pyz-Łukasik, R. (2012). Bacterial Contamination of Calf Carcasses During Production Cycle, Bulletin of the Veterinary Institute in Pulawy, 56(1), 47-49. https://doi.org/10.2478/v10213-012-0009-1
10. Petruzzelli A, Osimani A, Pasquini M, et al. (2016). Trends in the microbial contamination of bovine, ovine and swine carcasses in three small-scale abattoirs in central Italy: A four-year monitoring. Meat Science 111:53-59. https://doi.org/10.1016/j.meatsci.2015.08.016.
11. Røssvoll E, Røtterud OJ, Hauge SJ, Alvseike O (2018). A comparison of two evisceration methods on hygienic quality in the pelvic area of sheep carcasses. Meat Science 137:134-138. https://doi.org/10.1016/j.meatsci.2017.11.025
12. Sierra ML, Sheridan JJ, McGuire L. Microbial quality of lamb carcasses during processing and the acridine orange direct count technique (a modified DEFT) for rapid enumeration of total viable counts. International Journal of Food Microbiology 1997;36(1):61-67. https://doi.org/10.1016/s0168-1605(96)01247-0
13. Zweifel C, Fischer R, Stephan R (2008). Microbiological contamination of pig and cattle carcasses in different small-scale Swiss abattoirs. Meat Science 78(3):225-231. https://doi.org/10.1016/j.meatsci.2007.06.025