



**ASSESSMENT OF BACTERIAL CONTAMINATION IN BEEF FROM THE  
SLAUGHTER SLAB, ABATTOIR AND BUTCHERIES OF AMURIA TOWN  
COUNCIL, AMURIA DISTRICT.**

**BY**

EYOU PETER

[BU/UP/2021/0149]

[www.peter2eyou@gmail.com](mailto:www.peter2eyou@gmail.com)

July-August 2024

**Supervisor:** Prof. OLILA DEO

**A RESEARCH DISSERTATION REPORT SUBMITTED TO THE FACULTY OF  
AGRICULTURE AND ANIMAL SCIENCES IN FULFILMENT OF THE  
REQUIREMENTS FOR AWARD OF A BACHELOR IN ANIMAL PRODUCTION  
AND MANAGEMENT OF BUSITEMA UNIVERSITY**


## ABSTRACT

Assessment of bacterial contamination in beef from the abattoir, slaughter slab and butcheries of Amuria town council was conducted with objectives of finding out the dominant contaminating bacteria in beef and to find out the hygienic practices that could be contributing to beef contamination. This research study employed both qualitative and quantitative approaches where a cross-sectional design was used to randomly collect a total of 60 samples from the abattoir, slaughter slab and butcheries for microbial lab analysis. An observation checklist was used during the study to document the hygiene status of this beef supply chain. The results of this study were analysed using B-SOP 1 procedure and it was found out that *E. coli* was the dominant (66.7%) contaminant in all the three locations i.e. abattoir, slaughter slab and butcheries. *E. coli* contamination in beef was found more co-existent with *Salmonella* (20%) than *Shigella* (13.3%). However, the percentage of *E. coli* was the highest in the butcheries (80%) and lowest in the slaughter slab (50%). *E. coli* & *Salmonella* contamination was higher in the slaughter slab (30%) but had similar contamination level in the abattoir and butcheries (15%) respectively. *E. coli* & *shigella* contamination was the highest in the slaughter slab (20%) and lowest in the butcheries (5%). The results of this study based on the chi-square analysis at 5% level of significance indicated that there was no significant difference in contamination across the abattoir, slaughter slab and butcheries for *E. coli*, *salmonella* and *shigella* as all the chi-square values were below the critical value of  $\chi^2 = 3.841$ . This suggest that the poor handling and hygiene practices observed in this study may be widespread across the entire beef supply chain. Basing on these findings, its recommended that regular microbial examination be conducted in the high risky places of the supply chain such as butcheries, slaughter slab and that there should be implementation of strict hygiene and beef handling protocols through the entire beef production and supply chain.

**DECLARATION**

I Eyou Peter declare that the work in this report is from my personal output and has never been submitted for any academic award in any institution of higher learning.

Name: EYOU PETER

Signature.....  ..... Date..... 01 / 11 / 2024.....

## APPROVAL

This research report was written under my supervision and I have reviewed its adherence to the required academic and research guidelines of Busitema University.

Name: Prof. OLILA DEO

Signature.....

Date.....

4/11/24

## **DEDICATION**

I dedicate this research report to God my heavenly provider whose greatest love and kindness enabled me reach up to this date.

## **ACKNOWLEDGEMENTS**

I would like to express my deepest gratitude to my dear parents, Mr. Odeng Bosco and Mrs. Akiror Mary for their financial support and encouragement throughout the three years of my academic journey. I would like to great fully appreciate my supervisor Prof. Olila Deo and the team of senior lecturers from the Animal Department of Arapai campuss for their invaluable and dedicated guidance in ensuring that this research dissertation report reaches this level. I congratulate the team of specialized scientists from NADDEC Entebbe who offered me technical advice and guidance during the laboratory research analysis. Lastly, I would like to thank the management of Amuria Town Council for accepting me to successfully conduct this research study to its completion. May God bless all of you abundantly.

## TABLE OF CONTENTS

<b>ABSTRACT</b> .....	i
<b>DECLARATION</b> .....	ii
<b>APPROVAL</b> .....	iii
<b>DEDICATION</b> .....	iv
<b>ACKNOWLEDGEMENTS</b> .....	v
<b>TABLE OF CONTENTS</b> .....	vi
<b>LIST OF FIGURES</b> .....	ix
<b>LIST OF TABLES</b> .....	x
<b>ABBREVIATIONS</b> .....	xi
<b>CHAPTER ONE</b> .....	1
1.0 <b>Introduction</b> .....	1
1.1 <b>Background to the study</b> .....	1
1.2 <b>Problem statement</b> .....	2
1.3 <b>Main objective</b> .....	2
1.4 <b>Specific objectives</b> .....	2
1.5 <b>Research questions</b> .....	2
1.6 <b>Significance of the research</b> .....	3
1.7 <b>Justification</b> .....	3
1.8 <b>Scope</b> .....	3
<b>CHAPTER TWO</b> .....	4
<b>LITERATURE REVIEW</b> .....	4
2.0 <b>Background</b> .....	4
2.1 <b>Beef contamination</b> .....	6
2.2 <b>Factors that contribute to beef contamination</b> .....	6
2.3 <b>Beef microbial spoilage</b> .....	7

2.4 Aerobic bacteria that cause beef contamination .....	7
2.5 Facultative bacteria that cause beef contamination .....	7
2.6 Anaerobic bacteria that cause beef contamination .....	8
2.7 Salmonella.....	8
2.7.1 Shigella.....	9
2.8 Escherichia coli.....	9
2.9 Sources of beef contamination .....	10
2.9.1 On farm factors.....	10
2.9.2 During slaughter and processing of carcasses.....	10
2.9.3 Transportation of carcasses.....	11
2.9.4 Retail and consumer handling .....	11
<b>CHAPTER THREE</b> .....	<b>12</b>
<b>3.0 MATERIALS AND METHODS</b> .....	<b>12</b>
3.1 Research design .....	12
3.2 Research approaches .....	12
3.3 Description of the geographical area of the study .....	12
3.4 Sampling strategies .....	12
3.4.1 Materials .....	12
3.4.2 Serial dilution of the beef samples .....	13
3.5 Culture procedure.....	13
3.5.1 Indole production test.....	14
3.5.2 Motility test.....	14
3.5.3 Hydrogen sulphide production test .....	14
3.5.4 Summary for interpretation of the bacterial tests.....	15
3.6 Data collection methods.....	15
3.7 Data quality control .....	15
3.8 Measurements.....	15



<b>3.9 Data analysis</b> .....	15
<b>CHAPTER FOUR</b> .....	16
<b>4.0 RESULTS AND DISCUSSIONS</b> .....	16
<b>4.1 RESULTS</b> .....	16
<b>4.1.2 Dominant bacteria in the beef samples.</b> .....	16
<b>4.1.3 RAW DATA ANALYSIS</b> .....	18
<b>4.1.4 Hygienic practices that contributed to beef contamination.</b> .....	25
<b>4.2 DISCUSSIONS</b> .....	28
<b>5.0 CONCLUSIONS AND RECOMMENDATIONS</b> .....	34
<b>5.1 CONCLUSIONS</b> .....	34
<b>5.2 RECOMMENDATIONS</b> .....	34
<b>REFERENCE LIST AND APPENDICES</b> .....	35
<b>REFERENCE LIST</b> .....	35
<b>APPENDICES</b> .....	42
<b>Appendix i</b> .....	42
<b>OBSERVATION CHECKLIST</b> .....	42
<b>Appendix ii</b> .....	44
<b>WORK PLAN</b> .....	44
<b>PICTURES</b> .....	45

## LIST OF FIGURES

<i>Figure 1. Bar chart showing relative distribution of bacteria in the abattoir.....</i>	<i>17</i>
<i>Figure 2. Bar chart showing relative distribution of the bacteria in the slaughter slab.....</i>	<i>17</i>
<i>Figure 3. Bar chart showing relative distribution of the bacteria in the butcheries.....</i>	<i>18</i>
<i>Figure 4. Beef handling in the butcheries Figure 3. Bar chart showing relative distribution of the bacteria in the butcheries.....</i>	<i>44</i>
<i>Figure 5. Means of beef transport to the butcheries.....</i>	<i>44</i>
<i>Figure 6. Handling of beef in the abattoir.....</i>	<i>44</i>
<i>Figure 7. Water source at the slaughter slab.....</i>	<i>45</i>
<i>Figure 8. Ruminant waste management at the slaughter slab.....</i>	<i>45</i>

## LIST OF TABLES

<i>Table 1. Materials and their laboratory use during the research.....</i>	<i>13</i>
<i>Table 2. Interpretation of the bacterial tests.....</i>	<i>16</i>
<i>Table 3. Data obtained from laboratory analysis of the samples.....</i>	<i>16</i>
<i>Table 4. Chi-square analysis for abattoir and slaughter slab for E. coli.....</i>	<i>19</i>
<i>Table 5. Chi square analysis for abattoir and butcheries for E. coli.....</i>	<i>20</i>
<i>Table 6. Chi-square analysis for the abattoir and slaughter slab for E. coli and Salmonella.....</i>	<i>21</i>
<i>Table 7. Chi-square analysis for the abattoir and butcheries for E. coli and Salmonella.....</i>	<i>22</i>
<i>Table 8. Chi-square analysis for abattoir and slaughter slab for E. coli and shigella.....</i>	<i>23</i>
<i>Table 9. Chi-square analysis for the abattoir and butcheries for E. coli and shigella.....</i>	<i>23</i>
<i>Table 10. Summary of the chi square analysis in the beef supply chain of Amuria town council.....</i>	<i>24</i>

## **ABBREVIATIONS**

FAO – Food and Agriculture Organisation

WHO- World Health Organisation

e.g – for example

etc – and so on

i.e – that is to say

CDC – Centre for Diseases Control and Prevention

FSA – Food Science Agency

DVO – District Veterinary Officer

JFP – Journal of Food Protection

URN- Uganda Radio Network

## CHAPTER ONE

### 1.0 Introduction

#### 1.1 Background to the study

The population in Africa is predicted to triple by 2050 and it's believed that there will be increased purchasing power by consumers of animal products. In Uganda for example, the population is projected to increase to more than 100 million by 2050 and consumption of all types of meat will almost triple (FAO, 2018).

Beef is an important source of proteins and essential nutrients consumed worldwide. However, the meat industry faces significant challenges in ensuring the safety of meat products whereby contamination is a major risk problem. Bacteria such as *Escherichia coli*, *Salmonella* and *Listeria monocytogenes* are beef pathogens and can cause serious harm to consumers if not properly controlled (Havelaar et al., 2015).

According to the World Health Organisation, foodborne illnesses are a major public health problem caused by food contamination globally with an estimated 600 million cases and 420,000 deaths due to foodborne illnesses each year. These figures demonstrate that there is need for urgent implementation of effective measures to prevent and control contamination in food products such as beef (WHO, 2015).

In Africa, meat contamination poses a serious significant health problem where food safety infrastructure and resources may be limited. Research has shown that the main cause of illness in meat products in African have been attributed to inadequate slaughter houses and lack of refrigeration houses for meat. The impact of these challenges is significant because they can cause foodborne illnesses and impact public health. (Nychas et al., 2008).

In Uganda with the population that heavily relies in beef as a primary protein source, the issue of bacterial contamination in beef is a critical concern. Research shows that beef products sold in supermarkets and shops have varying levels of contamination raising concerns about the efficiency of current measures to protect consumers from food contamination.

The presence of pathogens in beef not only affects the health of consumers but also creates uncertainty about the reputation of the Uganda's meat industry affecting trade and

## REFERENCE LIST AND APPENDICES

### REFERENCE LIST

- Addis, M. (2015). Major Causes of Meat Spoilage and Preservation Techniques: A Review. 41. [Www.iiste.org](http://www.iiste.org).
- Alegbeleye, O. O. (2018). How Functional Is Moringa oleifera? A Review of Its Nutritive, Medicinal, and Socioeconomic Potential. In Food and Nutrition Bulletin (Vol. 39, Issue 1, Pp. 149–170). SAGE Publications Inc. <https://doi.org/10.1177/0379572117749814>
- Almeida, m. C. S., Brito, p. A., Dantas, v. V., Prazeres, a. R., Silva, e. V. C., & Silva, j. B. (2022). Monitoring the temperature of refrigeration Counters and beef sold in butcher shops in the city of Cametá in The state of Pará, Brazil. *Ars Veterinaria*, 38(3), 98. <https://doi.org/10.15361/2175-0106.2022v38n3p98-103>
- Antonio, A., & Quijada, R. (2023). Molasses as an alternative energy source for diets used in beef production systems.
- Arthur, T. M., Brichta Harhay, D. M., Bosilevac, J. M., Kalchayanand, N., Shackelford, S. D., Wheeler, T. L., & Koohmaraie, M. (2010). Super shedding of *Escherichia coli* O157:H7 by cattle and the impact on beef carcass contamination. In *Meat Science* (Vol. 86, Issue 1, Pp. 32–37). <https://doi.org/10.1016/j.meatsci.2010.04.019>.
- Aslam, M., Nattress, F., Greer, G., Yost, C., Gill, C., & McMullen, L. (2003). Origin of Contamination and genetic diversity of *Escherichia coli* in beef cattle. *Applied and Environmental Microbiology*, 69(5), 2794–2799. <https://doi.org/10.1128/AEM.69.5.2794-2799.2003>
- Bosilevac, J. M., Guerini, M. N., Kalchayanand, N., & Koohmaraie, M. (2009). Prevalence and Characterization of salmonellae in commercial ground beef in the United States. *Applied And Environmental Microbiology*, 75(7), 1892–1900. <https://doi.org/10.1128/AEM.02530-08>
- Byaruhanga, J., Odua, F., Ssebunya, Y., Aketch, O., Tayebwa, D. S., Rwego, I. B., & Vudriko,

P. (2020). Comparison of Tick Control and Antibiotic Use Practices at Farm Level in Regions of High and Low Acaricide Resistance in Uganda. *Veterinary Medicine International*, 2020. <https://doi.org/10.1155/2020/4606059>

Chanachai, K., Pittayawonganon, C., Areechokchai, D., Suchatsoonthorn, C., Pokawattana, L., 19 & Jiraphongsa, C. (2008). A food borne outbreak of gastroenteritis due to shigella and possibly salmonella in a school (Vol. 39, Issue 2).

Coll Cárdenas, F., Andrés, S., Giannuzzi, L., & Zaritzky, N. (2011). Antimicrobial action and Effects on beef quality attributes of a gaseous ozone treatment at refrigeration Temperatures. *Food Control*, 22(8), 1442–1447. <https://doi.org/10.1016/j.foodcont.2011.03.006>

Collinson, M. (n.d.). *A History of Farming Systems Research* (Cabi Publishing). Davies, P. (n.d.). REVIEW Food safety and its impact on domestic and export markets. In *Swine Health and Production* (Vol. 5, Issue 1).

Durmuşoğlu, H., İncili, G. K., Demir, P., & İlhak, O. İ. (2020). Effects of workers' hand Washing and knife disinfection practices on microbiological quality of small animal Carcasses in slaughterhouse environment. *Journal of Food Processing and Preservation*, 44(12). <https://doi.org/10.1111/jfpp.14918>

Dyal, J. W., Grant, M. P., Broadwater, K., Bjork, A., Waltenburg, M. A., Gibbins, J. D., Hale, C., Silver, M., Fischer, M., Steinberg, J., Basler, C. A., Jacobs, J. R., Kennedy, E. D., Tomasi, S., Trout, D., Hornsby-Myers, J., Oussayef, N. L., Delaney, L. J., Patel, K., Honein, M. A. (2020). COVID-19 Among Workers in Meat and Poultry Processing Facilities — 19 States, April 2020. *MMWR. Morbidity and Mortality Weekly Report*, 69(18). <https://doi.org/10.15585/mmwr.mm6918e3>

Grace, D., Dipeolu, M., & Alonso, S. (2019). Improving food safety in the informal sector: nine Years later. *Infection Ecology and Epidemiology*, 9(1). <https://doi.org/10.1080/20008686.2019.1579613>

Greer, G. G., & Jeremiah, L. E. (1980). Influence of Retail Display Temperature on Psychrotrophic Bacterial Growth and Beef Case-Life (Vol. 43, Issue 7).

Hentges, D. J., Maier, B. R., Burton, G. C., Flynn, M. A., & Tsutakawa, R. K. (1977). Effect of A High-Beef Diet on the Fecal Bacterial Flora of Humans<sup>1</sup>. In *CANCER RESEARCH* (Vol.37).

Hussain, M., & Bashir, U. (n.d.). Dynamics of Trade Balance and the J -Curve Phenomenon:

Evidence from Pakistan. In *The Journal of Commerce* (Vol. 5, Issue 2). Innes, G.

K., Nachman, K. E., Abraham, A. G., Casey, J. A., Patton, A. N., Price, L. B., Tartof, S.

Y., & Davis, M. F. (2021). Contamination of retail meat samples with multi drug resistant

Organisms in relation to organic and conventional production and processing: A Cross-

sectional analysis of data from the United States national antimicrobial resistance

Monitoring system, 2012–2017. *Environmental Health Perspectives*, 129(5).

<https://doi.org/10.1289/EHP7327>

Jaja, I. F., & Wang-Ungeviwa, P. (2022). A 6-year retrospective report of livestock parasitic

Diseases in the Eastern Cape Province, South Africa. *Open Veterinary Journal*, 12(2), 204–

211. <https://doi.org/10.5455/OVJ.2022.v12.i2.8>

Jay, J. M. . (2006). *Modern food microbiology*. Aspen Publishers. Juneja, V. K., Novak, J.

S., Marks, H. M., & Gombas, D. E. (n.d.). Growth of *Clostridium Perfringens* from spore

inocula in cooked cured beef: development of a predictive model. Kamihiro, S., Stergiadis,

S., Leifert, C., Eyre, M. D., & Butler, G. (2015). Meat quality and Health implications of

organic and conventional beef production. *Meat Science*, 100, 306– 20 318.

<https://doi.org/10.1016/j.meatsci.2014.10.015>

Kibooga, C., Nakiyemba, C., & Asiimwe, R. (2024). Antibiotic use in Uganda's livestockkeeping

Households: prevalence, patterns, and determinants. *Pastoralism: Research,*

*Policy and Practice*, 14. <https://doi.org/10.3389/past.2024.13017>



Koutsoumanis, K., Allende, A., Alvarez-Ordóñez, A., Bover-Cid, S., Chemaly, M., De Cesare,

A., Herman, L., Hilbert, F., Lindqvist, R., Nauta, M., Peixe, L., Ru, G., Simmons, M., Skandamis, P., Suffredini, E., Blagojevic, B., Van Damme, I., Hempen, M., Messens, W., & Bolton, D. (2023). Microbiological safety of aged meat. *EFSA Journal*, 21(1).

<https://doi.org/10.2903/j.efsa.2023.7745>

Lanza, E. (n.d.). Determination of Moisture, Protein, Fat, and Calories in Raw Pork and Beef

By Near Infrared Spectroscopy.

Levantesi, C., Bonadonna, L., Briancesco, R., Grohmann, E., Toze, S., & Tandoi, V. (2012). Salmonella in surface and drinking water: Occurrence and water-mediated transmission. In *Food Research International* (Vol. 45, Issue 2, pp. 587–602).

<https://doi.org/10.1016/j.foodres.2011.06.037>

Maass, B. L., Midega, C. A. O., Mutimura, M., Rahetlah, V. B., Salgado, P., Kabirizi, J. M., Khan, Z. R., Ghimire, S. R., & Rao, I. M. (2015). Homecoming of Brachiaria : Improved Hybrids Prove Useful for African Animal Agriculture. *East African Agricultural and Forestry Journal*, 81(1), 71–78. <https://doi.org/10.1080/00128325.2015.1041263>

Makenzie Grayce Flach, by, Mindy Brashears, A. M., Miller, M. F., Sanchez-Plata, M. X., &

Sheridan, M. (2023). Development of Pre-Harvest Monitoring Sentinel for Strategic Decision-Making in Beef Processing Chair of the Committee. Marie, J., & Hodgen, J.

(2006). Factors influencing off-flavor in beef.

<https://digitalcommons.unl.edu/animalscidiss/1>

Midelet, G., & Carpentier, B. (2002). Transfer of microorganisms, including *Listeria Monocytogenes*, from various materials to beef. *Applied and Environmental Microbiology*, 68(8), 4015–4024. <https://doi.org/10.1128/AEM.68.8.4015-4024.2002>.

Mollel, M. H., Mujuru, M., Mjimba, V., Darangwa, N., & Nyanzi, R. (2021). Moringa oleifera

Noise: Science or quackery and the way forward. *African Journal of Science, Technology*,

Innovation and Development, 13(3),273–282. <https://doi.org/10.1080/20421338.2020.1732078>

Nychas, G. J. E., Skandamis, P. N., Tassou, C. C., & Koutsoumanis, K. P. (2008). Meat spoilage During distribution. *Meat Science*, 78(1–2), 77–89.

<https://doi.org/10.1016/j.meatsci.2007.06.020>

Olaimat, A. N., Al-Holy, M. A., Shahbaz, H. M., Al-Nabulsi, A. A., Abu Ghoush, M. H., Osaili, T. M., Ayyash, M. M., & Holley, R. A. (2018). Emergence of Antibiotic Resistance in

*Listeria monocytogenes* Isolated from Food Products: A Comprehensive Review. In *Comprehensive Reviews in Food Science and Food Safety* (Vol. 17, Issue 5, pp. 1277–1292). Blackwell Publishing Inc. <https://doi.org/10.1111/1541-4337.12387>

Onyeka, L. O., Adesiyun, A. A., Keddy, K. H., Manqele, A., Madoroba, E., & Thompson, P.

N. (n.d.). Prevalence, Risk Factors and Molecular Characteristics of Shiga toxin producing *Escherichia coli* in Beef Abattoirs in Gauteng, South Africa.

Parmley, E. J., Pintar, K., Majowicz, S., Avery, B., Cook, A., Jokinen, C., Gannon, V., Lapen,

D. R., Topp, E., Edge, T. A., Gilmour, M., Pollari, F., Reid-Smith, R., & Irwin, R. (2013).

21. A Canadian application of one health: Integration of salmonella data from various Canadian Surveillance programs (2005-2010). In *Foodborne Pathogens and Disease* (Vol. 10, Issue 9, pp. 747–756). <https://doi.org/10.1089/fpd.2012.1438>

Prendergast, D. M., Daly, D. J., Sheridan, J. J., McDowell, D. A., & Blair, I. S. (2004). The Effect of abattoir design on aerial contamination levels and the relationship between aerial And carcass contamination levels in two Irish beef abattoirs. *Food Microbiology*, 21(5), 589–596. <https://doi.org/10.1016/j.fm.2003.11.002>

Scallan, E., Hoekstra, R. M., Angulo, F. J., Tauxe, R. V., Widdowson, M. A., Roy, S. L., Jones, J. L., & Griffin, P. M. (2011). Foodborne illness acquired in the United States-Major Pathogens. *Emerging Infectious Diseases*, 17(1), 15. <https://doi.org/10.3201/eid1701.P11101>

Schilling, M. W., Yoon, Y., Tokarsky, O., Pham, A. J., Williams, R. C., & Marshall, D. L.

(2009). Effects of ionizing irradiation and hydrostatic pressure on Escherichia coli O157:H7 inactivation, chemical composition, and sensory acceptability of ground beef Patties. *Meat Science*, 81(4), 705–710. <https://doi.org/10.1016/j.meatsci.2008.10.023>

Sheridan, J. J. (1998). Sources of contamination during slaughter and measures for control. *Journal of Food Safety*, 18(4), 321–339. <https://doi.org/10.1111/j.1745-4565.1998.tb00223.x>

Sumner, J., Petrenas, E., Dean, P., Dowsett, P., West, G., Wiering, R., & Raven, G. (n.d.). Microbial contamination on beef and sheep carcasses in South Australia. [www.elsevier.com/locate/ijfoodmicro](http://www.elsevier.com/locate/ijfoodmicro)

Syahputri, B. E., & Sucipto, S. (2021). Monitoring of beef cold chain to ensure quality, safety, and halal using RFID: A review. *IOP Conference Series: Earth and Environmental Science*, 924(1). <https://doi.org/10.1088/1755-1315/924/1/012001>

Vachon, M. S., Hedberg, C., Tarr, G. A. M., Bender, J., Smith, K., & Peterson, H. H. (n.d.). Preventing the Zoonotic Transmission of Shiga toxin-producing Escherichia coli and Subsequent Development of Post-diarrheal Hemolytic Uremic Syndrome at Animal Contact Venues using a One Health Approach.

Wall, P. G., & Chen, J. (2018). Moving from risk communication to food information communication and consumer engagement. *Npj Science of Food*, 2(1). <https://doi.org/10.1038/s41538-018-0031-7>

Yang, X., Wang, H., Hrycauk, S., Klassen, M. D., & Yang, C. X. (2021). Effects of Peroxyacetic Acid Spray and Storage Temperature on the Microbiota and Sensory Properties of Vacuum-Packed Subprimal Cuts of Meat. *FOOD MICROBIOLOGY*. <https://doi.org/10.1128/AEM>

Zulkifli, I., Goh, Y. M., Norbaiyah, B., Sazili, A. Q., Lotfi, M., Soleimani, A. F., & Small, A.

H. (2014). Changes in blood parameters and electroencephalogram of cattle as affected by

Different stunning and slaughter methods in cattle. *Animal Production Science*, 54(2), 187–193. <https://doi.org/10.1071/AN12128> (<https://www.antibioticresearch.org.uk>)