International Food Research Journal 28(6): 1179 - 1186 (December 2021)
Journal homepage: *http://www.ifrj.upm.edu.my*

Physicochemical parameters, organoleptic property, and *Escherichia coli* load of fresh turkey organs

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Article history

Received: 13 June 2020
Received in revised form: 18 March 2021
Accepted: 4 May 2021

Keywords

food contamination, indicator microorganism, digestive microflora, coliform bacteria

Abstract

Escherichia coli is a common microorganism of the digestive microflora of many warm-blooded animal species, including humans. The presence of *E. coli* in food is an indicator of faecal contamination and ultimately, possible contamination by pathogenic digestive microflora. The aim of the present work was to study the physicochemical parameters, organoleptic property, and *E. coli* load in turkey organs (thigh, upper thigh, breast, throat, liver, wing, and skin). A total of 224 samples were purchased from several markets, and subjected to different experiments. Results showed that the best overall scores for organoleptic property were recorded for breast (8.64 ± 0.43) and upper thigh (7.12 ± 0.72). The physicochemical parameter results varied across the studied organs. *E. coli* was isolated up to 100, 93.75, 90.62, 87.50, 62.5, 56.25, and 40.62% in the skin, wing, throat, liver, thigh, breast, and upper thigh samples, respectively. The highest *E. coli* loads were recorded in the skin, throat, and wing at 3.89, 3.52, and 3.27 $\log_{10}$ CFU/g, respectively. The present work highlighted the physicochemical parameters, organoleptic property, and E. coli load of turkey organs purchased from several districts of Kenitra city, and discussed a number of practices to improve turkey meat quality and protect consumer health from coliform contamination.

Introduction

Escherichia coli is a common microorganism among the digestive microflora of humans and other warm-blooded animals (Katouli, 2010). It is very often used with other thermotolerant coliforms as an indicator of faecal contamination in food and water. Although it is not a pathogen, it could signify possible food contamination by other pathogenic bacteria of digestive origin (Hulankova *et al.,* 2018). Certain pathogenic *E. coli* strains are also known to be responsible for childhood gastroenteritis (Wallace *et al.,* 2010) based on the generated clinical signs and pathogenicity factors (Greening and Cannon, 2016).

In Morocco, 7,118 foodborne illness cases have been reported, where more than 86% were of bacterial origin (Fassouane *et al.,* 2011). According to an investigation on foodborne illness outbreaks in Kenitra Provincial Hospital during the period of 2007 - 2009, 14 cases of foodborne illnesses were reported in the Gharb-Chrarda-Bni Hsein region. A total of 50% of the cases were reported in Kenitra city, and 14% were associated with poultry meat (Belomaria *et al.,* 2010). The constant surveillance of meat and meat products plays an important role in the prevention and controlling of foodborne illnesses. Depending on the type of food, the presence of *E. coli* can be interpreted differently in terms of risk to human health, particularly for meat samples (Zhao *et al.,* 2012). Generally, the absence of *E. coli* indicates compliance and good sanitary practices, and its presence may suggest poor hygienic conditions or the use of insufficient heat treatments. The presence of *E. coli* is also considered to be a sign of potential risk for human consumption (Stromberg *et al.,* 2017).

In a previous work, we have demonstrated the presence of four bacterial species — *E. coli, Klebsiella pneumonia, Pseudomonas* sp., and *Salmonella* — in turkey meat samples from different sale points; our results suggested a lack of strategies for the adequate quality control of turkey meat (Jaber *et al.,* 2017). In the present work, we focussed on the evaluation of the physicochemical parameters, organoleptic property, and determination of *E. coli*

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DOI: https://doi.org/10.47836/ifrj.28.6.09

occurrence in turkey organs in order to have a better understanding of the contamination status, and contribute to a better quality control of turkey meat.

Materials and methods

Samples

A total of 224 samples of different fresh turkey organs (breast, liver, thigh, upper thigh, throat, wing, and skin; 32 samples each) were purchased from random sale points within the districts of Kenitra city, Morocco. Upon purchase, the samples were placed in a stomacher bag, labelled, and then immediately transported to the laboratory in a cool box (4°C).

Organoleptic analysis

Samples were analysed by five chefs to assess their quality (tenderness, flavour, juiciness, and overall acceptance) after being boiled once. A 1 to 5 scale was used for scoring the test parameters, and the overall acceptance was scored on a 1 to 10 scale (Salifou *et al.,* 2013). The chefs had not eaten, drunk, or smoked for at least 30 min prior to the organoleptic analysis.

Physicochemical analysis

Physicochemical analysis contributes in protecting the consumer from all the parameters that do not result in visible changes in the product characteristics. This analysis is based on the determination of pH, humidity and organic content, mineral content, total volatile basic nitrogen (TVBN), and total acidity.

pH

The pH was measured using a mixture containing 2 g of homogenised flesh in 50 mL of distilled water. Measurements were carried out at room temperature using a pH meter (Jiang *et al.,* 2015). The pH values of duplicate readings were then averaged (Li *et al.,* 2012).

Humidity and organic content

The humidity and organic content were determined following AFNOR (1994). Briefly, after steaming a weighed mass of turkey meat at 105°C for 12 h, the humidity was calculated using Eq. (1), and the organic content using Eq. (2).

$$\text{Humidity Rate (HR)}(\%) = \frac{[\text{M2} - M\ ]}{[M\ - M\ ]} \times 100 \qquad \text{(Eq. 1)}$$

where, M0 = sample weight in g, M1 = capsule mass with the sample in g, and M2 = capsule mass with residue after burning in g.

$$\text{Organic content (OC)}(\%) = 100 - \text{HR} \qquad \text{(Eq. 2)}$$

Mineral content

The mineral content was determined following AFNOR (1994). Briefly, a grey residue was obtained using an oven at high temperature (550°C) for 4 h; and the percentage of total ash was calculated using Eq. (3).

$$\text{Mineral content (MC)}(\%) = \frac{\text{M (residue)}}{\text{M (sample weight)}} \times 100 \qquad \text{(Eq. 3)}$$

TVBN

The TVBN is one of the criteria used to assess products' alteration. Briefly, a meat filtrate was preheated in a water bath and cooled, and then three drops of 5% copper sulphate ($CuSO_4$) were added to the filtrate, and mixed. The resulting colour of the mixture indicates the freshness of the meat as follows: (i) if the colour remains sky blue, the sample is very fresh; and (ii) if the filtrate is transparent, the sample is not fresh.

Total *acidity*

The total acidity was determined by direct titration with NaOH (0.1 N) in the presence of phenolphthalein, and calculated according to the method of Park *et al.* (2013).

Bacteriological analysis

Preparation of samples

Microbiological analysis of turkey organ samples (25 g per organ) was carried out in a sterile environment by excision using a stomacher scalpel in a sterile stomacher bag containing 225 mL of peptone water (Biokar Diagnostics, France) for a few minutes with manual agitation. Decimal dilutions were performed using the same diluent.

Isolation of Escherichia coli

The isolation of *E. coli* was conducted using the MacConkey medium. A total of 1 mL of each dilution was spread on the surface of the agar using a glass rod, and inoculated plates were incubated at 37°C for 24 h. Following incubation, large brick-red colonies (> 0.5 mm in diameter) surrounded by an opaque halo were retained and counted (Chaiba *et al.,* 2007). The purification of *E. coli* strains was performed on EMB (Eosin Methylene Blue) medium after incubation at 37°C for 18 to 24 h. Colonies with metallic green or fluorescent sheen were confirmed later by biochemical identification (Barnes *et al.,* 2003).

Biochemical identification

Once *E. coli* colonies were selected and purified, they were subjected to Gram-staining, oxidase and and catalase tests, and Kligler test. Strains were confirmed using Enterobacteriaceae API® 20E (BioMérieux, USA). These biochemical tests are based on the ability of bacteria to hydrolyse hydrocarbons such as glucose, lactose, or mannitol (Singleton, 2004).

Statistical analysis

The bacterial enumeration was expressed in the logarithmic units of colony-forming unit per gram (log_{10} CFU/g), while the prevalence of contamination by *E. coli* strains, and compliance and non-compliance rates were expressed as percentages. The R software was used for the statistical analysis.

Results and discussion

Organoleptic analysis of different organs of turkey

The results of the organoleptic analysis of different organs of turkey are shown in Table 1. The values of the first organoleptic criterion (flavour) were low for throat, wing, thigh, liver, and upper thigh, while the best score was found in breast (4.26 ± 0.54). Low flavour scores can be explained by the poor storage of poultry samples and the feed diet used during breeding period.

For juiciness, the highest values were recorded in liver (4.68 ± 0.71) and upper thigh (4.52 ± 0.53), followed in decreasing order by thigh (3.35 ± 0.62), wing (2.63 ± 0.85), breast (2.54 ± 0.63), and throat (1.53 ± 0.12). The decrease in the juiciness rating depends mainly on the nature of the organ analysed. Low juiciness values can be explained by the loss of juice during maturation, method of cooking, and intramuscular fat content (Hughes *et al.,* 2014).

For tenderness, liver scored the highest (4.96 ± 0.96), followed by upper thigh (4.85 ± 0.93). These two organs were very tender as compared to the other organs which scored poorly.

For overall acceptance, the chefs scored average values of 8.64 ± 0.43 and 7.12 ± 0.72 for breast and upper thigh, respectively. Other organs were either moderately or poorly scored / accepted. Tenderness and flavour are important criteria of meat quality and are closely linked to the quantity and quality of lipids present in the muscles. According to Hocquette *et al.* (2010), it takes a minimum of 3 to 4% lipids to give the meat a flavour and juiciness that will be appreciated by consumers.

Physicochemical analysis of different organs of turkey

The results of the physicochemical analysis of the raw turkey organ samples are shown in Table 1. The pH values of the various organs were greater than 5. The highest pH was recorded at 6.12 ± 0.83

Table 1. Organoleptic property and physicochemical parameters of different organs of turkey.

Organ	Thigh	Upper thigh	Liver	Breast	Wing	Throat
Organoleptic property						
Flavour	2.21 ± 0.21	3.65 ± 0.75	2.64 ± 0.83	4.26 ± 0.54	2.13 ± 0.46	1.62 ± 0.52
Juiciness	3.35 ± 0.62	4.52 ± 0.53	4.68 ± 0.71	2.54 ± 0.63	2.63 ± 0.85	1.53 ± 0.12
Tenderness	3.95 ± 0.45	4.85 ± 0.93	4.96 ± 0.96	3.25 ± 0.35	2.93 ± 0.64	1.12 ± 0.36
Overall score	4.05 ± 0.95	7.12 ± 0.72	5.26 ± 0.53	8.64 ± 0.43	2.85 ± 0.63	1.64 ± 0.63
Physicochemical parameter						
pH	5.5 ± 0.63	5.75 ± 0.83	6.12 ± 0.83	5.49 ± 0.94	5.28 ± 0.81	5.32 ± 0.63
HR	73.35 ± 0.84	76.52 ± 1.34	82.65 ± 0.75	71.52 ± 0.41	41.25 ± 1.54	38.54 ± 1.83
OC	26,7 ± 0.84	23.48 ± 0.64	17.35 ± 0.84	28.48 ± 1.64	58.75 ± 1.84	61.46 ± 0.94
MC	1.65 ± 0.52	1.26 ± 0.31	1.1 ± 0.42	1.46 ± 0.64	1.65 ± 0.85	1.95 ± 0.52
AI	3.94 ± 0.4	3.65 ± 0.44	4.52 ± 0.85	2.56 ± 0.75	3.96 ± 0.52	3.85 ± 0.71
TVBN	F	F	UF	F	UF	UF

HR: humidity rate, OC: organic content, MC: mineral content, AI: acidity index, TVBN: total volatile basic nitrogen, UF: unfresh, and F: fresh.

for liver, followed by 5.7 ± 0.83, 5.5 ± 0.63, 5.49 ± 0.94, 5.32 ± 0.63, and 5.28 ± 0.81 for upper thigh, thigh, breast, throat, and wing, respectively. The average pH of meat is around 6 (Kadim *et al.,* 2009). During maturation, glycogen is transformed into lactic acid, the pH of meat then decreases, thus allowing for the activation of the enzymes necessary for the fragmentation of proteins (Farouk *et al.,* 2014) which affects the characteristics and quality of meat (Li *et al.,* 2014).

The percentages of organic content in each organ were as follows: 61.46 ± 0.94, 58.75 ± 1.84, 28.48 ± 1.64, 26.7 ± 0.84, 23.48 ± 0.64, and 17.35 ± 0.84% for throat, wing, breast, thigh, upper thigh, and liver, respectively. This reduction in mineral content was strongly correlated with the humidity rate, which yielded the average rates of 38.54 ± 1.83 and 41.25 ± 1.54% for throat and wing, respectively, and were out of the 60 - 85% range given by Seoparno (2005). On the other hand, the values found for breast, thigh, upper thigh, and liver were within the range of 60 - 85% (Favier *et al.,* 1995). The average acidity index of the analysed organs varied between 2.56 ± 0.75 for breast, which was the lowest rate, and 4.52 ± 0.85 for liver, which was the highest. The TVBN of thigh, upper thigh, and breast indicated freshness, while the other organs were deemed unfresh. According to Ouaked and Morakeb (2016), during the storage of meats throughout the cold chain, these organs are likely to be the target of physical modifications and biochemical reactions. The length of time at which poultry carcasses are stored at -18°C also seems to play a role in the importance of losses by exudation during defrosting, which can cause losses of great magnitudes.

Biochemical identification

The biochemical identification results are presented in Table 2. The colonies were Gram-negative *bacilli*, oxidase negative, and catalase positive. The Kligler test yielded positive for glucose and lactose fermentation as well as for gas production, and negative for H_2S production. The mannitol/motility test showed that the strains were motile and able to ferment mannitol. The confirmation test performed by the API 20E gallery revealed negative results for the production of acetoin (Voges-Proskauer, VP), tryptophan deaminase (TDA), and urease (URE), and positive results for indole and *ortho*-nitrophenyl-β-D-galactopyranoside (ONPG). All these results matched those of *E. coli*.

Table 2. Biochemical identifications of *Escherichia coli* isolated from different organs of turkey.

Test		Result
Gram staining		*Bacillus* / Gram negative
Oxidase test		Negative
Catalase test		Positive
Kligler test	Glucose fermentation	Positive
	Lactose fermentation	Positive
	H_2S production	Negative
	Gas production	Positive
Mannitol / mobility test	Mannitol fermentation	Positive
	Mobility	Positive
API 20E gallery test	Citrate	Negative
	VP	Negative
	TDA	Negative
	Urease	Negative
	Indole	Positive
	ONPG	Positive

H_2S: hydrogen sulphide, VP: Voges-Proskauer, TDA: tryptophan deaminase, and ONPG: *ortho*-nitrophenyl-β-D-galactopyranoside.

Prevalence of E. coli in different organs of turkey

Figure 1 shows that *E. coli* was present in all the tested organs with varying prevalence; 100, 93.75, 90.62, 87.50, 62.5, 56.25, and 40.62% for skin, wing, throat, liver, thigh, breast, and upper thigh, respectively. The high prevalence of *E coli* on the skin could be explained by its higher degree of exposure caused by direct contact with handling equipment and hands during evisceration.

E. coli load in different organs of turkey

The average *E. coli* load of the different organs of turkey (Figure 2) ranged from 3.89 (skin) to 2.09 $\log_{10}$ CFU/g (liver). *E. coli* load on the skin, wing, and throat were high because they are particularly exposed to the risk of microbiological contamination during, possible contamination by the rupture of the gastric reservoirs or oesophagus, and handling during evisceration (Grashorn, 2010).

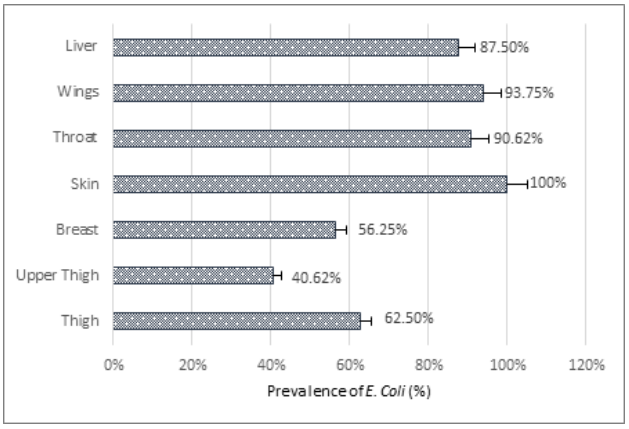

Figure 1. Prevalence of *E. coli* in different parts of the turkey organs

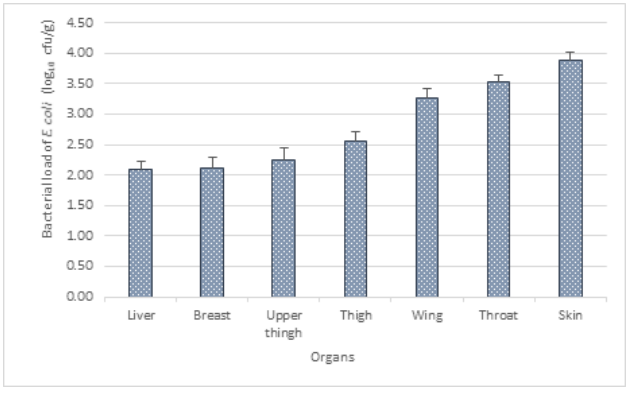

Figure 2. The average bacterial load of *E. coli* in different parts of the turkey body

When compared to that of the European Commission, *E. coli* load in most of the analysed organs in the present work exceeded the limit prescribed for foods of animal origin. The acceptable limit for *E. coli* in cuts and preparations of raw poultry meat is 5×10^2 CFU/g (2.69 $\log_{10}$ CFU/g) (AFSSA, 2003). The compliance/non-compliance results of the organs are illustrated in Figure 3. The non-compliance rates ranged from 21.42 to 100%, while the compliance rates did not exceed 78.57%. Similar results were published by other authors. Cohen *et al.* (2007) recorded average contamination loads ranging between 1.6 and 2.9 $\log_{10}$ CFU/g, with a prevalence of 48.40% and a non-compliance rate of 22.4%. Abdellah *et al.* (2013) reported an average contamination load of 3.43 $\log_{10}$ CFU/g with a 100% higher prevalence than the result obtained in the present work; however, the reported non-compliance rate was 83.3%. In Vietnam, Chu and Nguyen (2009) obtained average contamination loads ranging from 1.56 to 2.18 $\log_{10}$ CFU/g with a non-compliance rate of 59.3% and a prevalence of 100%. Tran and Luu (2004) reported a non-compliance rate of 68.75%. In America, Zhao *et al.* (2001) reported a prevalence of *E. coli* in poultry meat ranging from 38.7 and 11.9% for chicken and turkey meat, respectively.

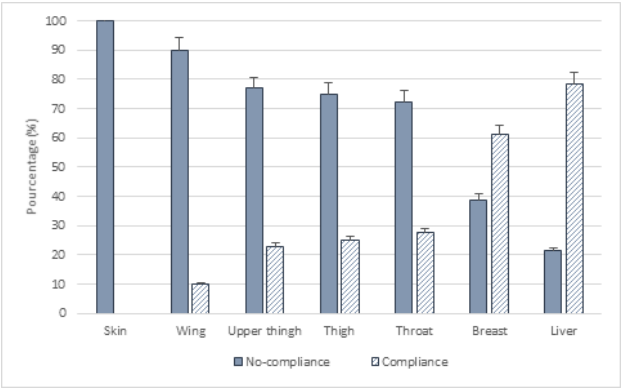

Figure 3. Compliance and non-compliance rates of different turkey organs.

The high level of *E. coli* contamination in the various organs of turkey could be explained by the oesophageal reflux of the gastrointestinal contents during evisceration, which is known as an important source of carcass contamination (Salifou *et al.,* 2010). This contamination is probably due to the poor hygienic practices during animal slaughter and carcass cutting/processing (Ghafir *et al.,* 2008). The presence of *E. coli* is an indication of faecal contamination and a sign of the potential presence of pathogens (*Salmonella* sp., *E. coli* 0157 or VTEC non-O157, *Yersinia* sp., and *Campylobacter* sp.) as they share the same ecological characteristics (Baba-Moussa *et al.,* 2010). Filth and hair from the outer surface of the hide will be transferred to the underlying meat, as well as faeces or bacteria from handling during slaughter and meat processing

operations (Rani *et al.,* 2017). The main factors causing the contamination of minced meat by pathogens and saprophytic bacteria are the lack of hygiene and poor sanitary conditions observed at the point of sale (Kandhai *et al.,* 2004). Furthermore, cross-contamination may occur from processing tools, equipment, structural components of the facility, human contact, and carcass-to-carcass contact (de Freitas Costa *et al.,* 2017). The high loads of these microorganisms in ready-to-eat meat represent a potential risk of toxic infection to the consumers. These foodborne infections have become widespread worldwide (Majid *et al.,* 2008). Majority of these diseases are due to the ingestion of contaminated meat and meat products (Dibi *et al.,* 2017). According to WHO (2006), 25% of diarrhoeal cases due to foodborne diseases are caused by food infected with *E. coli*. Infections are most often caused by the consumption of contaminated and undercooked meat, but can also be caused by the consumption of water, raw milk, fruits, and vegetables; swimming; and contact between people (Feng, 2001).

Conclusion

The present work assessed the physicochemical parameters and organoleptic property of turkey organ samples purchased from different markets in Kenitra, Morocco. Different results obtained could be due to the storage duration, thawing condition, contamination rate, and biochemical reaction involved. Different turkey organs were in fact contaminated with *E. coli*, and the prevalence was alarming which ranged from 40.62 to 100%, with an average load of between 2.12 and 3.89 $\log_{10}$ CFU/g. Therefore, turkey meat sold at these markets represents a potential risk of pathogenic infection to the consumers. To ensure consumer safety, hygienic practices such as adequate and proper cooking of turkey meat should be carried out, and handlers should be encouraged to comply with hygienic regulations. Additionally, the cleanliness of the knives used in bleeding and evisceration, which have an effect on the nature and number of microorganisms present in the carcass, should be considered to reduce the contamination of the meat and protect the consumer from pathogenic infections.

Acknowledgement

The authors gratefully acknowledge the support received from the National Hygiene Institute of Rabat City, Morocco, for the completion of the present work.

References

Abdellah, E., Rhazi, F. F. and Oumokhtar, B. 2013. Prevalence and antibiogram study of *Escherichia coli* and *Staphylococcus aureus* in turkey meat in Morocco. Pharmaceutica Analytica Acta 4(9): article no. 270.

Baba-Moussa, L., Ahissou, H., Azokpata, P., Assogba, B., Atindéhou, M., Anagonou, S., ... and Prévost, G. 2010. Toxins and adhesion factors associated with *Staphylococcus aureus* strains isolated from diarrheal patients in Benin. African Journal of Biotechnological 9: 604-611.

Barnes, H. J., Vaillancourt, J. P. and Gross, W. B. 2003. Colibaccilosis. In Saif Y. M., Barnes, H. J., Glisson, J. R., Fadly, A. M., McDougald, L. R. and Swayne, D. E. (eds). Diseases of Poultry (11th ed), p. 631-656. United States: Iowa State Press.

Belomaria, M., Aboussaleh, Y., Ahami, A. O. T., Bouazza, O., Mahly, M. and Khayati, Y. 2010. Collective food toxin infection patterns in Gharb-Chrarda-Bni Hsein region in northwest of Morocco. Antropo 21: 79-84.

Chaiba, A., Rhazi Filali, F., Chahlaoui, A., Soulaymani Bencheikh, R. and Zerhouni, M. 2007. Microbiological quality of poultry meat on the Meknès market (Morocco). Internet Journal of Food Safety 9: 67-71.

Chu, T. T. H., Nguyen, T. H. D. and Nguyen, T. T. H. 2009. Contamination of some bacteria isolated from chicken meat in retail markets in Hanoi and examination of the antibiotic resistance ability of *Salmonella* and *E. coli* strains isolated. Journal of Science and Development 7: 181-186.

Cohen, N., Ennaji, H., Bouchrif, B., Hassar, M. and Karib, H. 2007. Comparative study of microbiological quality of raw poultry meat at various seasons and for different slaughtering processes in Casablanca (Morocco). Journal of Applied Poultry Research 16: 502-508.

de Freitas Costa, E., Corbellini, L. G., da Silva, A. P. S. P. and Nauta, M. 2017. A stochastic model to assess the effect of meat inspection practices on the contamination of the pig carcasses. Risk Analysis 37(10): 1849-1864.

Dibi, E. A. D. B., N'Goran-Aw, Z. E. B., Akmel, D. C., Kablan, T. and Assidjo, E. N. 2017. Microbial hazards linked to the consumption of braised beef meat in Côte d'Ivoire. International Journal of Innovation and Applied Studies 19(3): 496-507.

Farouk, M. M., Wiklund, E. and Young, O. A. 2014. Small heat shock proteins and their role in meat

tenderness: a review. Meat Science 96(1): 26-40.

Fassouane, S. B., Filliol, I., Hassar, M. and Cohen, N. 2011. Detection of Shiga toxin-producing *Escherichia coli* in meat marketed in Casablanca (Morocco). Cellular and Molecular Biology 57(suppl): OL1476-OL1479.

Favier, J. C., Ireland-Ripert, J., Toque, C. and Feinberg, M. 1995. General food directory - composition table. Paris: Institut National de la Recherche Agronomique (INRA).

Feng, P. 2001. *Escherichia coli*. In Labbé, R. G. and García, S. (eds). Guide to Foodborne Pathogens. United States: John Wiley and Sons.

French Food Safety Agency (AFSSA). 2003. Assessment of knowledge relating to *Escherichia coli* producing Shiga-toxins. France: AFFSA.

French Standardization Association (AFNOR). 1994. Soil quality: collection of French standards 1994. France: AFNOR.

Ghafir, Y., China, B., Dierick, K., Zutter, L. D. E. and Daube, G. 2008. Hygiene indicator microorganisms for selected pathogens on beef, pork, and poultry meats in Belgium. Journal of Food Protection 71: 35-45.

Grashorn, M. A. 2010. Research into poultry meat quality. British Poultry Science 51: 60-67.

Greening, G. E. and Cannon, J. L. 2016. Human and animal viruses in food (including taxonomy of enteric viruses). In Goyal, S. and Cannon, J. (eds). Viruses in Foods, p. 5-57. United States: Springer.

Hocquette, J. F., Gondret, F., Baéza, E., Médale, F., Jurie, C. and Pethick, D. W. 2010. Intramuscular fat content in meat-producing animals: development, genetic and nutritional control, identification of putative markers. Animal 4: 303-319.

Hughes, J. M., Oiseth, S. K., Purslow, P. P. and Warner, R. D. 2014. A structural approach to understanding the interactions between colour, water-holding capacity and tenderness. Meat Science 98(3): 520-532.

Hulankova, R., Borilova, G., Abdullah F. A. A. and Buchtova, H. 2018. Microbiological quality of organic chicken meat during refrigerated storage in air and modified atmospheres. British Poultry Science 59: 506-513.

Jaber, H., Ijoub, R., Zaher, A., Chakit, M., Rhaiem, N., Bourkhiss, B. and Ouhssine, M. 2017. Microbiological study of turkey meat marketed in Kenitra (north-oust of Morocco). Journal of Nutrition and Food Sciences 7(4): article no. 620.

Jiang, N. N., Xing, T., Wang, P., Xie, C. and Xu, X. L. 2015. Effects of water-misting sprays with forced ventilation after transport during summer on meat quality, stress parameters, glycolytic potential and microstructures of muscle in broilers. Asian-Australasian Journal of Animal Sciences 28: 1767-1773.

Kadim, I. T., Mahgoub, O., Al-Marzooqi, W., Khalaf, S. K., Mansour, M. H., Al-Sinawi, S. S. H. and Al-Amri, I. S. 2009. Effect of electrical stimulation on histochemical muscle fiber staining, quality and composition of camel and cattle *Longissimus thoracis* muscles. Journal of Food Science 74: S44-S52.

Kandhai, W. C., Reij, M. W., Gorris, L. G., Guillaume-Gentil, O. and Van-Schothorst, M. 2004. Occurrence of *Enterobacter sakazakii* in food production environments and households. Lancet 363: 39-40.

Katouli M. 2010. Population structure of gut *Escherichia coli* and its role in development of extra-intestinal infections. Iranian Journal of Microbiology 2(2): 59-72.

Li, C., Liu, D., Zhou, G., Xu, X., Qi, J., Shi, P. and Xia, T. 2012. Meat quality and cooking attributes of thawed pork with different low field NMR T_{21}. Meat Science 92(2): 79-83.

Li, P., Wang, T., Mao, Y., Zhang, Y., Niu, L., Liang, R., ... and Luo, X. 2014. Effect of ultimate pH on postmortem myofibrillar protein degradation and meat quality characteristics of Chinese yellow crossbreed cattle. The Scientific World Journal 2014: article ID 174253.

Majid, E., Male, K. B. and Luong, J. H. T. 2008. Boron doped diamond biosensor for detection of *Escherichia coli*. Journal of Agricultural and Food Chemistry 56(17): 7691-7695 .

Ouaked, L. and Morakeb, F. 2016. Study of the nutritional and microbiological quality of poultry pâté. Trial of making a vegetable pâté. Algeria: Université Mouloud Mammeri, PhD thesis.

Park, H. R., Kim, Y. A., Jung, S. W., Kim, H. C. and Lee, S. J. 2013. Response of microbial time temperature indicator to quality indices of chicken breast meat during storage. Food Science and Biotechnology 22(4): 1145-1152.

Rani, Z. T., Hugo, A., Hugo, C. J., Vimiso, P. and Muchenje, V. 2017. Effect of post-slaughter handling during distribution on microbiological quality and safety of meat in the formal and informal sectors of South Africa: a review. South African Journal of Animal Science 47(3): 255-267.

Salifou, C. F. A., Dahouda, M., Boko, K. C., Kassa, S. K., Houaga, I., Farougou, S., ... and Youssa, O. 2013. Assessment of the technological and

organoleptic quality of the meat of cattle of the Borgou, Lagoon and Zebu Peulh breeds, reared on natural pastures. Journal of Applied Biosciences 63: 4736-4753.

Salifou, C. F. A., Salifou, S., Tougan, P. U., Ahounou, G. S. and Youssao, A. K. I. 2010. Evaluation of the hygiene of the slaughtering process at Cotonou Porto-Novo slaughterhouses using bacteriological surface examination. In 13th Muscle Sciences and Meat Technology Days. France: Clermont Ferrand.

Seoparno, 2005. Meat science and technology. 4th ed. Indonesia: Gadjah Mada University Press.

Singleton, P. 2004. Identification of bacteria. In Singleton, P. (ed). Bacteria in Biology, Biotechnology and Medicine. United Kingdom: John Wiley and Sons.

Stromberg, Z. R., Johnson, J. R., Fairbrother, J. M., Kilbourne, J., Van Goor, A., Curtiss, R. and Mellata, M. 2017. Evaluation of *Escherichia coli* isolates from healthy chickens to determine their potential risk to poultry and human health. PLoS One 12(7): article ID e0180599.

Tran, T. H. and Luu, Q. H. 2004. The situation of *E. coli* and *Salmonella* contamination in animal products in Hanoi and the results of microbial identification. In Animal Husbandry and Veterinary Conference. Vietnam: Ministry of Agriculture and Rural Development.

Wallace R. J., Oleszek, W., Franz, C., Hahn, I., Baser, K. H. C., Mathe, A. and Teichmann, K. 2010. Dietary plant bioactive for poultry health and productivity. British Poultry Science 51: 461-487.

World Health Organization (WHO). 2006. Global SLAM survey progress report 2000-2005. Geneva: WHO.

Zhao, C., Ge, B., De Villena, J., Sudler, R., Yeh, E., Zhao, S., … and Meng, J. 2001. Prevalence of Campylobacter spp., *Escherichia coli*, and *Salmonella* serovars in retail chicken, turkey, pork, and beef from the Greater Washington, D.C. area. Applied and Environmental Microbiology 67(12): 5431-5436.

Zhao, S., Blickenstaff, K., Bodeis-Jones, S., Gaines, S. A., Tong, E. and McDermott, P. F. 2012. Comparison of the prevalences and antimicrobial resistances of *Escherichia coli* isolates from different retail meats in the United States, 2002 to 2008. Applied and Environmental Microbiology 78(6): 1701-1707.