International Journal of Agricultural Technology 2022Vol. 18(6):2535-2544
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Factors influencing dead on arrival and condemnation of broilers during catching, transport, lairage and slaughter

Pirompud, P., Sivapirunthep, P.* and Chaosap, C.

Department of Agricultural Education, Faculty of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand 10520.

Pirompud, P., Sivapirunthep, P. and Chaosap, C. (2022). Factors influencing dead on arrival and condemnation of broilers during catching, transport, lairage and slaughter. International Journal of Agricultural Technology 18(6):2535-2544.

Abstract The effects of each factor in the final model of a multilevel analysis of the risk factors for dead on arrival (DOA) and condemnation were expressed as an estimate ratio (ER). The results showed that risk factors associated with the percentage of DOA were season, time of transport, rearing density, weight per crate, and feed withdrawal time. Risk factors associated with the percentage of condemnations are season, time of transport, mean body weight, rearing mortality and culling rate, and rearing stocking density. The key factors that significantly affected the percentage of DOA and could be relatively easily reduced were weight per crate (ER =0.045 for each additional 1 kg) and feed withdrawal time (ER =0.001 for each additional 60 minutes). Reducing or eliminating these factors results in a reduction in DOA, which improves profitability and animal welfare. In addition, reducing the stocking density per crate and transporting at night or in the morning should be implemented to reduce the percentage of DOA and the percentage of condemnation.

Keywords: Broiler, Risk factor, Time of transport, Stocking density

Introduction

In 2021, Thailand produced 2.30 million tonnes of broiler. At 0.93 million tonnes per year, it was the fourth largest chicken exporter in the world (Office of Agricultural Economics, 2022). Due to hot and humid weather, commercial intensive broiler farming requires the renovation of the house, good management of water, feed, and ventilation system up until the day the chickens are caught and transported to slaughter to reduce the mortality rate and condemnation.

Broilers are mostly fast-growth animals with an average daily gain of more than 60 grams/day (Procter *et al*., 2013). Nowadays, the intensive production system of the chicken production industry has an impact on chicken health, so chicken welfare has been established and considered in chicken production and pre-processing procedures (Council F.A.W., 2009). The broiler chicken welfare standard was established by OIE (2021). According to the broiler chicken welfare standards, the percentage of dead-on arrival (% DOA) should not exceed 0.50 % (European Union, 2005), and

*Corresponding Author: Sivapirunthep, P.; Email: panneepa.si@kmitl.ac.th

the percentage of condemnation should be less than 1.04 % (Saline *et al*., 2017). Health conditions, physical injuries, and thermal stress are the causes of DOA percentage (Gregory and Austin, 1992; Ritz *et al.*, 2005), and infections and trauma are associated with the percentage of condemnation (Lupo *et al*., 2010).

There were several risk factors that affected the mortality and condemnation percentages during broiler production and pre-processing. The physiological well-being of broiler and health status of the flock as well as sudden death syndrome (SDS), diseases and infections, heat stress due to weather condition, and stocking density during rearing were the causes of DOA (Gregory and Austin, 1992; Ritz *et al.*, 2005; Estevez, 2007) and also physical injury, thermal stress, and stocking density in crates (Bayliss and Hinton, 1990; Nijdam *et al*., 2004; Chauvin *et al*., 2011), time of transportation (Bayliss and Hinton, 1990; Warriss *et al*., 1999; Nijdam *et al.*, 2004; Bianchi *et al.*, 2005; Luptakova *et al*., 2012; Arikan *et al*., 2017), transport distance (Nijdam *et al*., 2004; Vecerek *et al*., 2006; Voslarova *et al.*, 2007; Ondrašovičová *et al.*, 2008; Sowinska *et al*., 2013; Arikan *et al.*, 2017), lairage time (Bayliss and Hinton, 1990; Nijdam *et al*., 2004, Vieira *et al*., 2010), feed withdrawal time (Nijdam *et al.*, 2005), seasonal (Vecerek *et al*., 2006; Petracci *et al*., 2006; Voslarova *et al*., 2007; Drain *et al*., 2007; Elsayed, 2014; Arikan *et al*.,2017), age at slaughter (Bayliss and Hinton, 1990; Arikan *et al.*, 2017), mean body weight (Mayes, 1980; Griffiths and Nairn, 1984; Nijdam *et al,* 2004). The percentage of condemnation was dependent on infection, mean body weight, age at slaughter, mortality (Lupo *et al*., 2009), rearing stocking density (Lupo *et al*., 2009; Chauvin *et al*.,2011; Muchon *et al*, 2019), trauma, stocking density in crates, time of transport, lairage time (Lupo *et al.*, 2009), feed withdrawal time (Lupo *et al*., 2009; Mendes and Komiyama, 2011; Rui *et al*., 2011), and seasonal (Aliabad *et al*.,1998; Lupo *et al*., 2008).

There are several factors during production and pre-processing procedures that influence broiler health (Gregory and Austin, 1992; De Jong *et al*., 2012). Broiler health is related to %DOA and %condemnation (Ritz *et al*., 2005, Lupo *et al.,* 2008; Lupo *et al*., 2010; Muchon *et al*., 2019). The percentage of DOA affects farmers income as they are responsible for the cut-off weight of the dead broilers during transport, while the percentage of condemnation has an economic impact on the processing plant. Finally culled carcasses had to be sold at a low price. Determining the factors influencing the percentage of DOA and of condemnation in broilers during catching, transport, lairage, and slaughter could help broiler producers improve chicken productivity by controlling the risk factors associated with the percentage of DOA and percentage of condemnation.

The objectives were to identify factors affecting %DOA and % condemnation occurring during catching, transport, lairage, and slaughter of broilers flocks slaughtered at one processing plant in Thailand in 2021, and to quantify their effect by using multilevel analysis.

Materials and methods

The data were obtained from 12 farms of one broiler production company in Thailand, which comprised of 211 broiler flocks recorded at farms and processing plant in 2021. The company's approved catching team caught all broiler flocks. The birds were transported to the processing plant in a transport truck with plastic crates. One transport truck was able to stack all 495 crates on top of each other. After transport, the broilers were laired in a holding area with fans and evaporative cooling systems. After lairaging, the trucks were unloaded, and the crates were transported by belt conveyor to the dark room where the broilers were moved to a table and hung on a shackle line. Dead broilers were removed from the table and recorded as a DOA percentage. The condemnation of broilers from each flock was recorded according to the legal standards of the Thai Department of Livestock Development (DLD, 2005). All 13 recorded independent and dependent variables were selected as follows: The dependent variables where the birds DOA was calculated as a percentage (%). The total number of dead broilers per flock counted at the processing plant was the numerator and the total number of broilers transported per flock was the denominator, which was then multiplied by 100. The condemnation was calculated as a percentage (%). The total number of condemned broilers per flock counted at the processing plant was the numerator and the total number of transported broilers per flock was the denominator which was then multiplied by 100. The lesions of condemnation were purulent abscess, dermatitis, arthralgia, offal not suitable for consumption, thin, small, red body, contaminated chicken carcass, and chicken carcass without organs, jaundice, peritonitis, and tumors. The independent variables or studied factors were divided into the category and continuous variables. The category independent variables were age at slaughter (d); 41-43 days and 44-46 days, seasons (winter, summer, and rainy), time of transport (night =last load that departed from farm before 8:00 am., morning = between night and daytime, daytime = first load that departed from farm after 08:00 am. – 06:00 pm.). The continuous independent variables were mean body weight (g), flock size (n), rearing stocking density (kg/m^2), rearing mortality and culling percentage (%), number of birds per crate (n), weight per crate (kg), feed withdrawal time (min), transport time (min), distance (km), and lairage time (min).

Statistical analysis

The SPSS-PC System Version 22 for Windows was used for data analysis. Before analyzing the data, the normality test was performed.

Descriptive statistics were generated. The mixed model method was used for the multilevel analyses. The distribution of the DOA percentage and condemnation percentage was skewed, a logarithmic transformation was performed. Flock size was used as a weight variable or a covaraite. Poultry farm was included in the model as a random effect to account for the fact that most farms occurred more than once in the data set. Categorical variables were expressed as dummy variables. In addition, the interaction term of the independent variable was not included in the model. The effect of each factor examined in the final model was expressed as an estimate ratio (ER). This value essentially corresponded to the relative risk with which each specific factor was evaluated in relation to its reference class. Thus, a 95% confidence interval excluding ER = 0 implied statistical significance at the level of $P < 0.05$.

Results

Descriptive statistics results of the studied variables

The 211 bird flock's data set in this study were from 12 broiler farms of one large poultry-producing company. The number of flocks per farm ranged from 3 to 20 flocks with a median of 7 flocks. The summary statistics of technical characterristics of the 211 broiler flocks are shown in Table 1. The average DOA percentage was 0.18%, with minimum and maximum values of 0.04% and 0.46%, respectively. The average condemnation percentage was 0.63%, with minimum and maximum values of 0.10% and 1.63%, respectively.

Table 1. Summary statistics of technical characteristics of 211 broiler flocks in the data set included in this study

Variable (n=211)	**Mean**	**SD**	**Min**	**Max**	**%CV**
Age(days)	43.12	1.16	41	46	2.69
Flock size (n)	27220	7572.01	9941	37879	27.82
Mean body weight (g)	2888.70	181.17	2367	3325	6.27
Stocking density (kg/m^2)	29.42	1.97	24.46	33.86	6.70
Mortality and culling (%)	3.20	1.46	0.44	8.52	45.75
Number of birds per crate (n)	6.2	0.42	5	7.2	6.79
Weight per crate (kg)	17.86	1.36	14.40	22.07	7.61
Feed withdrawal time (min)	533	63.05	297	677	11.83
Transportation time (min)	180	108.29	18	425	60.17
Distance (km)	154.98	82.05	45	354	52.94
Lairage time (min)	123	47.44	18	316	38.70
Dead on arrival (DOA) (%)	0.18	0.09	0.04	0.46	48.91
Condemn percentage (%)	0.63	0.36	0.10	1.63	56.83

Multivaraite analysis for DOA percentage

In the multivariate model for DOA percentage, five independent variables were associated with log-transformed DOA percentage (Table 2). The DOA percentage in winter significantly increased compared with the rainy season (estimate ratio, ER = 0.184). When broilers were transported in the morning and at night, the DOA percentage decreased compared to the daytime (ER -0.137 and -0.075, respectively). The DOA percentage increased significantly when rearing stocking density decreased by 1 kg/m^2 (ER = -0.026). For each additional kilogram of bird in a crate, the percentage of DOA increased significantly (ER = 0.045). Finally, the percentage of DOA increased significantly when the feed withdrawal time was increased by 60 minutes each time (ER = 0.001).

Table 2. Factor associated with the percentage of dead on arrival (DOA) birds in 211 flocks slaughtered at a processing plant in 2021

Variable	n	DOA (%)	SD	Estimate Ratio[/1]	SE	95% Confidence Interval	
Season							
Winter	50	0.224	-	0.184***	0.038	0.108	0.259
Summer	92	0.170	-	0.056	0.029	-0.001	0.114
Rainy	69	0.175	-	0			
Time of transport[/2]							
Night	98	0.169	-	-0.075**	0.025	-0.125	-0.025
Morning	22	0.146	-	-0.137**	0.041	-0.217	-0.057
Daytime	91	0.210	-	0			
Stocking density(kg/m^2) Per 1 kg increase				-0.026**	0.009	-0.044	-0.008
Weight per crate(kg) Per 1 kg increase				0.045**	0.017	0.012	0.079
Feed withdrawal time (min) Per 60 min increase				0.001**	0.000	0.000	0.001
Total	211	0.184	0.09				

[1/] Estimate ratio 0 = reference value for that variable; SE = 0.093
[2/] Time of transport: Night =last load that departed form farm before 08:00 am h; Morning = between night and daytime; Daytime = first load that departed from farm after 08:00 am. - 6:00pm.
*P<0.05, **P<0.01, ***P<0.001

Multivariate analysis for condemnation percentage

In the multivariate model for the condemnation percentage, five variables were associated with the dependent variable (Table 3). The condemnation percentage was significantly higher in the winter season (ER = 0.247). Transporting broilers in the morning resulted in a significantly lower condemnation percentage (ER = -0.119) than transporting birds during the day. The condemnation percentage increased significantly with increasing mean body weight per 100 grams. (ER = 0.001). The condemnation percentage increased significantly with increasing rearing mortality and culling (ER = 0.036). In addition, the condemnation percentage increased significantly when rearing stocking density decreased (ER = -0.042).

Table 3. Factor associated with the percentage of condemnation in 211 broilers flocks slaughtered at a processing plant in 2021

Variable	n	DOA (%)	SD	Estimate Ratio[1]	SE	95% Confidence Interval	
Season							
Winter	44	0.936	-	0.247***	0.049	0.150	0.343
Summer	93	0.581	-	0.027	0.034	-0.040	0.095
Rainy	74	0.510	-	0			
Time of transport[2]							
Night	98	0.601	-	-0.048	0.031	-0.109	0.013
Morning	22	0.564	-	-0.119*	0.050	-0.217	-0.021
Daytime	91	0.675	-	0			
Mean body weight(g) Per 100 g increase				0.001***	0.000	0.000	0.001
Mortality and culling percentage Per 1% increase				0.036***	0.008	0.020	0.052
Stocking density(kg/m^2) Per 1 kg increase				-0.042***	0.011	-0.064	-0.020
Total	211	0.630	0.36				

[1] Estimate ratio 0 = reference value for that variable; SE = 0.054
[2] Time of transport: Night =last load that departed from farm before 08:00 am.; Morning = between night and daytime; Daytime = first load that departed from farm after 08:00 am -6:00pm.
*P<0.05, **P<0.01, ***P<0.001

Discussion

In the present study, the average percentage of DOA and condemnation of the broiler chickens raised by the one large poultry-producing company in Thailand in 2021 were 0.18% and 0.63%, respectively. This was within the normal range compared to general commercial broiler rearing. It has been reported that the acceptable range for % DOA is 0.1-0.6% (Bayliss and Hinton, 1990; Gregory and Austin, 1992; Warriss *et al.*, 1999; Nijdam *et al.*, 2004; Warriss *et al.*, 2005; Petracci *et al.*, 2006; Haslam *et al.*, 2008; Chauvin *et al.*, 2011; Jacobs *et al.*, 2017) and the acceptable range for % condemnation does not exceed 1.04% (Saline *et al.*, 2017).

The factor related to the percentage of DOA was the season because the highest percentage DOA was reached in winter. This could be due to the optimal temperature in the litter during brooding, which should be 30-32 ℃ (Cobb, 2018). The brooding temperature in winter could be achieved as required during the day, but the temperature was lower at night. To keep the broiler house warm by increasing the temperature but not increasing the ventilation, carbondioxide and ammonia accumulate which caused the risk of lung disease and ascites (Mwimali *et al*., 2018), or when the internal body temperature of broilers decreases, it affects the development of internal organs and affects the heart and circulation (Nijdam *et al.*, 2006). As a result, the broiler chicken's physiological ability to respond to the challenges of handling and transportation was decreased that they were more likely to die from heart failure and ascites than healthy birds (Drain *et al*., 2007; Whiting *et al*., 2007).

When chickens were transported in the morning and at night the percentage DOA was lower than during the day. These results are due to the fact that the temperature during transport in the morning and at night was not only lower than during the day, but also there was no heat stress (Nijdam *et al.*, 2004).

In this study, the percentage DOA increased when the rearing stocking density decreased. It was due to the lower rearing stocking density that the broilers were unhealthy resulting in a low daily growth rate and high mortality or percentage DOA (Chauvin *et al*., 2011). Estevez (2007) indicated that the maximum rearing stocking density should be 34-38 kg/m^2. The rearing stocking density in the study was 24.46-33.86 kg/m^2 which was lower than the range of 34-38 kg/m^2 and could be caused the high percentage of DOA.

During transport, when the weight of broilers per crate increased, exposing broilers to microclimate stress, the percentages of DOA increased, consistent with the reports of Nijdam *et al*., (2004); Whiting *et al*., (2007); Chikwa *et al*., (2019).

Feed withdrawal time was usually in the range of 6-12 hours (Council Directive, 2007). In this study, an increase in feed withdrawal time resulted in a higher percentage DOA, which increased feed withdrawal time (Nijdam *et al*., 2005).

The three factors that affected %DOA and %condemnation were a season, time of transport, and rearing stocking density and the results were in the same direction. The other two factors that affected percentage DOA were weight per crate and feed withdrawal time. However, the two factors that affected percentage condemnation were different from those that affected percentage DOA. They were mean body weight, and rearing mortality and culling percentage. It was found that as the mean body weight increased, the percentage of condemnation increased. It could be due to the broilers with high daily growth rates raised in critical environments had lower immunity and were more susceptible to infection with the most common strain of *E. coli* (Ferreira and Knobl, 2009).

In addition, a higher percentage of rearing mortality and culling resulted in a higher percentage of condemnation. It could be concerned to broilers that were not healthy during their rearing, for example, because they were previously infected with the pathogen and had a high mortality rate. However, the broilers that were still alive, weak, and secondary infection, then they were a higher percentage of condemnation at the processing plant (Nascimento and Pereira, 2009).

It is concluded that an average of the percentage of dead on arrival (DOA) and the percentage of condemnation were 0.18% and 0.63%, respectively. The important factors that significantly affected the percentage of DOA and could be relatively easily reduced were weight per crate and feed withdrawal time. Reducing or eliminating these factors results in a reduction in DOA, which improves profitability and animal welfare. In addition, reducing the stocking density per crate, and transporting at night or in the morning should be implemented to reduce the percentage of DOA and the percentage of condemnation.

Acknowledgments

I would like to express my gratitude and appreciation to all those who provided me with the data to prepare this manuscript. I am deeply grateful to the sungroup company, Thailand which is my workplace for the supporting and allowing me to write this manuscript.

References

Aliabad, S. H., Mortazavi, P., Khoshbakht, R. and MOUSAVI, A. (1998). Causes of Broiler Carcasses Condemnation in Nowshahr Poultry Slaughters (North of Iran) with Histopathologic Study of Cases Suspected to Marek’s. Journal of Agricultural Science and Technology, 1:1069-1.

Arikan, M. S., Akin, A. C., Akcay, A., Aral, Y., Sariozkan, S., Cevrimli, M. B. and Polat, M. (2017). Effects of transportation distance, slaughter age, and seasonal factors on total losses in broiler chickens. Brazilian Journal of Poultry Science, 19:421-428.

Bayliss, P. and Hinton, M. (1990). Transportation of broilers with special reference to mortality rates. Applied Animal Behaviour Science 28: 93-118.

Bianchi, M., Petracci, M. and Cavani, C. (2005). Effects of transport and lairage on mortality, liveweight loss and carcass quality in broiler chickens. Italian Journal of Animal Science, 4:516-518.

Chauvin, C., Hillion, S., Balaine, L., Michel, V., Peraste, J., Petetin, I., Lupo, C. and Le Bouquin, S. (2011). Factors associated with mortality of broilers during transport to slaughterhouse. Animal, 5:287-293.

Chikwa, K., Atkare, S., Bhardwaj, J., Nema, R., Kumar, J., Padwar, P. and Viswakarma, R. (2019). Transportation of broilers: An issue of welfare.

Cobb Broiler Management Guide. (2018). Retrieved from http://www.cobb-vantress.com/docs/default-source/management-guides/broiler-management-guide. pdf. (Accessed on 24th February 2018)

Council Directive 43/EC, E. U. C. D. (2007). Laying down minimum rules for the protection of chickens kept for meat production. Official Journal of the European Union, 182:19-28.

Council, F. A. W. (2009). Farm Animal Welfare Council: Five freedoms. Retrieved June, 5, 2009.

De Jong, I. and Berg, C., Butterworth, A. and Estevéz, I. (2012). Scientific report updating the EFSA opinions on the welfare of broilers and broiler breeders. EFSA Supporting Publications 9(6), pp.295.

DLD (2005). Poulytry Meat and Poultry Products Inspection Regulations B.E. 2548(2005), Department of Livestock Development Ministry of Agriculture and Cooperatives Thailand section 5, pp.74-86.

Drain, M. E., Whiting, T. L., Rasali, D. P. and D'Angiolo, V. A. (2007). Warm weather transport of broiler chickens in Manitoba. I. Farm management factors associated with death loss in transit to slaughter. The Canadian Veterinary Journal, 48:76.

Elsayed, M. A. (2014). Effects of length of shipping distance and season of the year temperature stress on death rates and physiological condition of broilers on arrival to slaughterhouse. Journal of Nuclear Technology in Applied Science 2.

Estevez, I. (2007). Density allowances for broilers: where to set the limits? Poultry Science, 86:1265-1272.

European Union. (2005). Proposal for a Council Directive (2005/ 0099/CNS) laying down minimum rules for the protection of chickens kept for meat production. Retrieved from http://europa.eu.int/comm/food/animal/welfare/farm/proposal_EN.pdf. (Accessed on May 2005)

Ferreira, A. J. P. and Knobl, T. (2009). Colibacilose. In: Doenças das aves. 2. ed. Berchieri Júnior, A.; Silva, E. N.; Di Fábio, J.; Sesti, L. and Zuanese, M. A. F., eds. Fundação APINCO de Ciência e Tecnologia Avícola, Campinas, pp.457-471.

Gregory, N. G. and S. D. Austin. (1992). Causes of trauma in broilers arriving dead at poultry processing plants. Veternary Record, 131:501-503.

Griffiths, G. L. and Nairn, M. E. (1984). Carcase downgrading of broiler chickens. British Poultry Science, 25:441-446.

Haslam, S. M., Knowles, T. G., Brown, S. N., Wilkins, L. J., Kestin, S. C., Warriss, P. D. and Nicol, C. J. (2008). Prevalence and factors associated with it, of birds dead on arrival at the slaughterhouse and other rejection conditions in broiler chickens. British Poultry Science, 49:685-696.

Jacobs, L., Delezie, E., Duchateau, L., Goethals, K. and Tuyttens, F. A. M. (2017). Broiler chickens dead on arrival: associated risk factors and welfare indicators. Poultry Science, 96:259-265.

Lupo, C., Chauvin, C., Balaine, L., Petetin, I., Péraste, J., Colin, P. and Le Bouquin, S. (2008). Postmortem condemnations of processed broiler chickens in western France. Veterinary Record, 162:709-713.

Lupo, C., Le Bouquin, S., Balaine, L., Michel, V., Peraste, J., Petetin, I. and Chauvin, C. (2009). Feasibility of screening broiler chicken flocks for risk markers as an aid for meat inspection. Epidemiology & Infection, 137:1086-1098.

Lupo, C., Bougeard, S., Balaine, L., Michel, V., Petetin, I., Colin, P. and Chauvin, C. (2010). Risk factors for sanitary condemnation in broiler chickens and their relative impact: application of an original multiblock approach. Epidemiology & Infection, 138:364-375.

Luptakova, O., Nagy, J., Popelka, P., Turek, P. and Nagyova, A. (2012). Trend analysis of the dead-on arrival and condemnation causes of broiler chickens from farm LIESKOVEC (THE SLOVAK REPUBLIC) in the years 2006—2010. FOLIA, 56: 37-38.

Mayes, F. J. (1980). The incidence of bruising in broiler flocks. British Poultry Science, 21:505-509.

Mendes, A. A. and Komiyama, C. M. (2011). Estratégias de manejo de frangos de corte visando qualidade de carcaça e carne. Revista Brasileira de Zootecnia/Brazilian Journal of Animal Science, 352-357.

Mwimali, M. I., Kitaa, J. M. A. and Osoro, L. N. (2018). An analysis of the causes of poultry condemnations at a Nairobi slaughterhouse, Kenya (2011-2014). International Journal of Veterinary Science, 7:121-126.

Muchon, J. L., Garcia, R. G., Gandra, É. R. D. S., Assunção, A. S. D. A., Komiyama, C. M., Caldara, F. R. and Santos, R. A. D. (2019). Origin of broiler carcass condemnations. Revista Brasileira de Zootecnia, 48.

Nascimento, E. R. and Pereira, V. L. A. (2009). Micoplasmoses. In: Doenças das aves. Di Fabio, J. and Rossini, L. I., eds. FACTA, Campinas. pp. 485-500.

Nijdam, E., Arens, P., Lambooij, E., Decuypere, E. and Stegeman, J. A. (2004). Factors influencing bruises and mortality of broilers during catching, transport, and lairage. Poultry Science, 83:1610-1615.

Nijdam, E., Delezie, E., Lambooij, E., Nabuurs, M., Decuypere, E. and Stegeman, J. (2005). Comparison of bruises and mortality, stress parameters, and meat quality in manually and mechanically caught broilers. Poultry Science, 84:467-474.

Nijdam, E., Zailan, A. R., Van Eck, J. H., Decuypere, E. and Stegeman, J. A. (2006). Pathological features in dead on arrival broilers with special reference to heart disorders. Poultry Science, 85:1303-1308.

Office of Agricultural Economics. (2022). Chicken meat products and products. Retrieved from https://api.dth.go.th. (Accessed on March 2022).

OIE Terrestrial Animal Health Code 19/07/2021. (2021). Chapter 7.1. Introduction to the Recommendations for Animal Welfare.Retrieved from https://www.woah.org/fileadmin/Home/eng/Health_standards/tahc/current/chapitre_aw_introduction. pdf (Accessed on 12 December 2021).

Ondrašovičová, O. L.G.A., Saba, L.E.O.N., Šmirkjáková, S., Vargová, M. I. L. A. D. A., Ondrašovič, M. I. L. O. S. L. A. V. and Matta, S. T. A. N. I. S. L. A. V. (2008). Effects of vehicle-road transport on blood profile in broiler chickens. Medycyna Weterynaryjna, 64:292-293.

Petracci, M., Bianchi, M., Cavani, C., Gaspari, P. and Lavazza, A. (2006). Preslaughter mortality in broiler chickens, turkeys, and spent hens under commercial slaughtering. Poultry Science, 85:1660-1664.

Proctor, H. S., Carder, G. and Cornish, A. R. (2013). Searching for animal sentience: A systematic review of the scientific literature. Animals, 3:882-906.

Ritz, CW., Webster, AB. and Czarick, M. (2005). Evaluation of hot weather thermal environment and incidence of mortality associated with broiler live haul. Journal of Applied Poultry Research, 14:594-602.

Rui, B. R., Angrimani, D. D. S. R. and Silva, M. A. A. D. (2011). Pontos cr ficos no manejo pré-abate de frango de corte: jejum, captura, carregamento, transporte e tempo de espera no abatedouro. Ciência Rural, 41:1290-1296.

Salines, M., Allain, V., Roul, H., Magras, C. and Le Bouquin, S. (2017). Rates of and reasons for condemnation of poultry carcases: harmonised methodology at the slaughterhouse. Veterinary Record, 180:516.

Sowinska, J., Wojcik, A., Pomianowski, J. F., Chorazy, L., Mituniewicz, T., Witkowska, D. and Kuczynska, P. (2013). Effects of different variants of pre-slaughter transport on body weight loss and meat quality in broiler chickens. Medycyna Weterynaryjna, 69:420-423.

Vecerek, V., Grbalova, S., Voslarova, E., Janackova, B. and Malena, M. (2006). Effects of travel distance and the season of the year on death rates of broilers transported to poultry processing plants. Poultry Science, 85:1881-1884.

Vieira, F. M. C., Silva, I. J. O. D., Barbosa Filho, J. A. D. and Vieira, A. M. C. (2010). Productive losses on broiler preslaughter operations: effects of the distance from farms to abattoirs and of lairage time in a climatized holding area. Revista Brasileira de Zootecnia, 39:2471-2476.

Voslarova E, Janackova B, Vitula F, Kozak.A. and Vecerek V. (2007). Effects of transport distance and the season of the year on death rates among hens and roosters in transport to poultry processing plants in the Czech Republic in the period from 1997 to 2004. Veterinární Medicína, 2007:262-266.

Warriss, P., Knowles, T., Brown, S., Edwards, J., Kettlewell, P., Mitchell, M. and Baxter, C. (1999). Effects of lairage time on body temperature and glycogen reserves of broiler chickens held in transport modules. Veterinary Record, 145:218-222.

Warriss, P. D., Pagazaurtundua, A. and Brown, S. N. (2005). Relationship between maximum daily temperature and mortality of broiler chickens during transport and lairage. Br. Poultry Sciene, 46:647-651.

Whiting, T. L. Drain, M. E. and Rasali, D. P. (2007). Warm weather transport of broiler chickens in Manitoba. II. Truck management factors associated with death loss in transit to slaughter. Canadian Veterinary Journal, 48:148-154.

(Received: 10 August 2022, accepted: 30 October 2022)