

Causes of carcass condemnation a broiler slaughterhouse under federal inspection in the summer and winter seasons

Causas de condenações de carcaças de frango em um frigorífico com inspeção federal nas estações de verão e inverno

Ariane do Carmo Mendes¹; Ana Clara Longhi Pavanello²; Cláudia Moreira Santa Catharina Weis²; Carina Moro Benis²; Guilherme Augusto Asai³; Adriana Lourenço Soares^{4*}

Highlights

Partial condemnations are higher in the winter and total condemnations in the summer. The highest causes of partial condemnations are arthritis, contusion and myopathy. Summer promoted higher condemnation losses and higher total mortality. Winter promoted an increase in total condemnations due to ascites and poor bleeding. The estimated total loss was R\$ 1,301,789.00, considering mortality and condemnation.

Abstract

Poultry farming is extremely important for the Brazilian economy, ranking first in broiler meat exports in the world, followed by the United States and the European Union. The high production and consumption were possible due to advances in genetic improvement associated with a balanced diet, management, and animal welfare, providing birds with higher carcass yield in a short space of time. High productivity has been achieved but health problems have arisen and been often detected during the slaughter process, leading to partial or total carcass condemnation and economic losses. This study aimed to investigate the relationship between the climate season (summer and winter) and the main causes of total or partial condemnation of broiler in a commercial slaughter line with the Federal Inspection and estimate the economic losses. Data from 10 broiler farms integrated to a slaughterhouse located in the north of Paraná were collected from 2018 to 2020. The data were grouped according to the climate season into summer (n = 1,485,630) and winter (n = 1,077,012). Partial condemnation represented 94.8% in the summer and

¹ Zootechnics Graduate Student, Universidade Estadual de Londrina, UEL, Londrina, PR, Brazil. E-mail: arianedocarmomendes@gmail.com

² Doctoral Students of Food Science PostGraduate, UEL, Londrina, PR, Brazil. E-mail: anaclara.longhi@uel.br; claudia.m.s.c.weis@uel.br; carina.moro.benis@uel.br

³ Prof. Dr., Department of Zootechnics, UEL, Londrina, PR, Brazil. Brazil. E-mail: guilherme.aa@udesc.br

⁴ Prof^a Dr^a, Food Science PostGraduate, UEL, Londrina, PR, Brazil. E-mail: adri.soares@uel.br

* Author for correspondence

96.1% in the winter, while total condemnation was 5.2% for the summer and 3.9% for the winter. The main causes among partial condemnations were arthritis (33% for the summer and 28% for the winter), contusion (28% for the summer and 27.9% for the winter), myopathy (14.7% for the summer and 16% for the winter) and fracture (10.3% for the summer and 12.6% for the winter). Summer promoted higher losses ($p < 0.05$) of partial condemnation due to airsacculitis, arthritis, contamination, and dermatosis than winter. The repugnant appearance was the main cause of total condemnations both in the summer (44.80%) and in the winter (70.97%), while arthritis was the second cause in the summer (41.34%) with no observations in the winter. Winter resulted in higher losses ($p < 0.05$) of total condemnation due to ascites and poor bleeding than summer. Total bird mortality was 4.13% in the summer, significantly higher than in the winter, which reached 3.85%. A loss of R\$ 146,000.00 was found for total carcass condemnations and R\$ 1,155,779.00 for mortality considering both seasons. The need to find strategies to reduce the occurrence of condemnations stood out due to the high economic losses.

Key words: Arthritis. Repugnant appearance. Mortality. Economic losses.

Resumo

A avicultura de corte é de extrema importância para a economia brasileira, ocupando o primeiro lugar em exportação de carne de frango do mundo, seguido dos Estados Unidos e União Europeia. A alta produção e consumo foi possível devido avanços no melhoramento genético associado a dieta equilibrada, manejo e bem-estar animal proporcionando aves com maior rendimento de carcaça em um curto espaço de tempo. A elevada produtividade foi alcançada, mas surgiram problemas sanitários que muitas vezes são detectados no processo de abate, levando a condenações parciais ou totais da carcaça e a prejuízos econômicos. O objetivo deste trabalho foi investigar a relação entre a estação climática (verão e inverno) e as principais causas de condenação total ou parcial de frangos em uma linha comercial de abate com Serviço de Inspeção Federal e estimar os prejuízos econômicos. Foram coletados dados de 10 granjas de frangos integradas a um frigorífico localizado no norte do Paraná, no período de 2018 a 2020. Os dados foram agrupados de acordo com a estação climática em verão ($n = 1.485.630$) e inverno ($n = 1.077.012$). A condenação parcial representou 94,8% no verão e 96,1% no inverno, enquanto que, a condenação total foi de 5,2% para o verão e 3,9% para o inverno. Entre as condenações parciais, a principal causa de condenação foi a artrite (33% para verão e 28% para inverno), contusão (28% para verão e 27,9% para inverno), miopatia (14,7% para verão e 16% para inverno) e fratura (10,3% para verão e 12,6% para inverno). O verão promoveu maiores perdas ($p < 0,05$) de condenação parcial por aerossaculite, artrite, contaminação e dermatose que o inverno. Dentre as condenações totais o aspecto repugnante foi a principal causa tanto para o verão (44,80%), quanto para o inverno (70,97%), a artrite foi a segunda causa no verão (41,34%) e não foi observada no inverno. O inverno promoveu maiores perdas ($p < 0,05$) de condenação total por ascite e má sangria que o verão. A mortalidade total das aves foi de 4,13% no verão significativamente maior que no inverno que foi de 3,85%. Foi constatado um prejuízo de R\$146.000,00 para condenações totais das carcaças e de R\$1.155.779,00 para mortalidade, considerando ambas as estações. Devido às elevadas perdas econômicas, destaca-se a necessidade de encontrar estratégias para diminuir as ocorrências de condenações.

Palavras-chave: Artrite. Aspecto repugnante. Mortalidade. Perdas econômicas.

Introduction

Brazil is a reference in the global poultry farming scenario, standing out in 2022 as the world's largest broiler meat exporter (4.48 million tons), followed by the United States and the European Union [USDA] (2023). The south of Brazil is responsible for 64% of the country's total production and, in this scenario, the State of Paraná presented the highest percentage of production, reaching 35.5%, which is equivalent to 1,636 million tons (Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA], 2021).

Broiler meat is widely consumed around the world due to its ease of preparing meals, low cost, and nutritional properties, in addition to its consumption being free from religious or cultural clashes, determining factors for considerably increasing its demand compared to other sources of animal protein (Petracchi et al., 2015).

Brazilian poultry farming has improved production efficiency through the applicability of genetic improvement, together with balanced nutrition, environment, management, and animal welfare to meet growing demand (Jesus et al., 2007; Paschoal et al., 2012). However, the intensification of production caused health problems in the birds, which were detected in the slaughter process through inspection by the Federal, State, or Municipal Inspection Service of the Ministry of Agriculture, Livestock, and Food Supply (MAPA), which follows criteria for classifying carcasses and defines its destination as partial utilization or total condemnation, that is, unfit for human consumption, following the principles of food safety (Lupo et al., 2008; Decreto N° 9.013, 2017; Souza et al., 2019).

The main causes of total condemnation of broiler carcasses reported in the literature have been repugnant appearance, colibacillosis, contamination, airsacculitis, dehydration, and cachexia (Souza et al., 2019; Kanabata et al., 2022). On the other hand, the main causes of partial condemnation are dermatosis, myopathies, contamination, cellulitis, airsacculitis, and contusion/fracture (Muchon et al., 2019; Kanabata et al., 2022).

Most of the causes of condemnations have multifactorial origins, occurring due to environmental influences, genetic, nutritional, or management factors. Stability in the poultry sector, which presents an extremely competitive market, rising input costs, and a focus on producing animal protein at an affordable price for the consumer, can be maintained by increasing the density of birds per square meter in sheds. However, the aggregation of birds together with climate conditions, especially in the summer, with elevated temperatures, favors the occurrence of thermal stress, leading to bird discomfort and mortality (Belintani et al., 2019).

According to Souza et al. (2019), the economic losses assessed in broiler slaughtering under Brazilian Federal Inspection between 2013 and 2017 were around 175 million reais. Condemnations are responsible for economic losses to the poultry sector, and investigating what are the most frequent causes of broiler carcass condemnation for subsequent interventions and prevention, minimizing economic losses in the broiler meat production chain, is essential.

Therefore, this study aimed to investigate the relationship between the climate season (summer and winter) and the main causes of total or partial condemnations of broilers in a commercial slaughter line under Federal Inspection and estimate economic losses.

Material and Methods

Data from ten broiler farms integrated to a slaughterhouse located in the State of Paraná, Brazil, which is registered with the Ministry of Agriculture, Livestock, and Food Supply (MAPA) and supervised by the Federal Inspection Service, were collected in the period 2018 to 2020. The plant has a slaughter capacity of 220,000 birds per day. The animals were slaughtered according to standard procedures, including the steps of electronarcosis, bleeding, scalding, plucking, evisceration, and cooling in a chiller.

The data were grouped according to the climate season in which the slaughter occurred, consisting of summer ($n = 1,485,630$) and winter ($n = 1,077,012$). The mean climate conditions during the data collection days for the summer were a mean temperature of $26.91\text{ }^{\circ}\text{C}$ (± 1.24), relative humidity of 64.68% (± 1.60), and total precipitation of 0.2146 mm (± 0.142), while the winter presented a mean temperature of $20.01\text{ }^{\circ}\text{C}$ (± 6.02), relative humidity of 60.24% (± 6.07), and total precipitation of 0.093 mm (± 0.121) (Instituto de Desenvolvimento Rural do Paraná [IDR], 2024).

The pre-slaughter factors evaluated were mean age at slaughter (kg), mean body weight (kg), stocking density (birds/m²), daily weight gain (g), feed conversion, and distance

from the farm to the slaughterhouse (km). All assessed farms had a conventional breeding system with a yellow or blue curtain. The causes of condemnation were counted following MAPA criteria in Decree No. 9,013 of 2017 (Decreto N° 9.013, 2017). The causes of total condemnation were classified into arthritis, ascites, repugnant appearance, cachexia, and poor bleeding and the causes of partial condemnation were classified into abscess, airsacculitis, arthritis, cellulitis, colibacillosis, contamination, contusion, dermatosis, fracture, myopathy, and ascites syndrome.

The results of total and partial condemnations were evaluated using descriptive analysis and presented in frequencies (%), calculated by the ratio between the number of condemnations for a specific cause and the total number of condemnations. Frequencies of causes of condemnation were calculated by the total number of birds for each climate season (summer and winter). The F-test ($p < 0.05$) was used to compare the causes of condemnation between seasons.

The estimations of economic losses referring to the data of total mortality of the lot and total condemnation were calculated. This calculation considered the value per kilo of broiler for the State of Paraná during the data collection period, between January 2018 and December 2020, based on data from the Agrolink portal (Agrolink, 2022). The monthly price correction was calculated using the Extended National Consumer Price Index (IPCA), setting the base date in December 2020. The updated value per kilo of broiler in reais was multiplied by the mean weight of each lot to obtain the value in reais per broiler. The estimate of economic losses

due to total condemnation was obtained by multiplying the number of cases of total condemnation by the value in reais of the broiler. The estimate of economic losses due to mortality was determined by multiplying the number of dead birds in the lot by the value in reais of the broiler.

Results and Discussion

Table 1 shows the data on pre-slaughter factors of broiler for the two climate seasons (summer and winter). The mean body weight of broilers was similar in both seasons (3.48 kg) ($p=0.305$). However, feed conversion in the summer was worse (1.74) than in the winter (1.72) ($p=0.03$), resulting in a lower

daily weight gain in the summer (70.8 g) than in the winter (72.9 g) ($p=0.047$), reflecting the higher age at slaughter in summer lots (48.8 days) than in winter lots (47.5 days) ($p=0.004$). The broiler breeding density was similar ($p=0.923$) between summer (12.8 birds/m²) and winter (11.9 birds/m²). Stocking density is an important pre-slaughter factor for animal welfare and condemnation and mortality rates (Bergeron et al., 2020). However, defining an optimal density value is difficult, as it depends on several other pre-slaughter factors. The distance between the farm and the slaughterhouse is a pre-slaughter factor that can predispose animals to stress during transport. The mean distance traveled in the summer (64.7 km) was similar ($p=0.755$) to that in the winter (67.3 km).

Table 1

Characterization of pre-slaughter factors of broilers from ten farms integrated to a slaughterhouse under Federal inspection in the State of Paraná, Brazil, according to the climate season (summer and winter).

Pre-slaughter factors	Groups		<i>p</i>
	Collective	Individual	
Mean age (days)	48.8 ± 2.8	47.5 ± 1.8	0.004
Mean body weight (kg)	3.48 ± 0.26	3.48 ± 0.22	0.305
Daily weight gain (g)	70.8 ± 3.99	72.9 ± 3.00	0.047
Feed conversion	1.74 ± 0.07	1.72 ± 0.05	0.030
Stocking density (birds/m ²)	12.8 ± 2.4	11.9 ± 2.4	0.923
Distance from the farm to the slaughterhouse (km)	64.7 ± 44.8	67.3 ± 42.7	0.755

In total, 2,562,642 birds were slaughtered, 1,485,630 in the summer, which presented 11.3% of condemnations (total + partial), and 1,077,012 birds in the winter, with 9.0% of condemnations. Therefore, a higher condemnation was observed in the summer ($p=0.02$) possibly due to thermal stress (Belintani et al., 2019).

Most condemnations were partial, reaching 94.8% in the summer and 96.1% in the winter. Total condemnation rates reached only 5.2% in the summer and 3.9% in the winter. Similarly, Kanabata et al. (2022) described values of 5.1% for total condemnation and 94.9% for partial condemnation of broiler carcasses in Brazil in the period from 2018 to

2020, while Oliveira et al. (2016) found 15% for total condemnation and 85% for partial condemnation when evaluating broiler carcasses in Brazil between 2006 and 2011.

The main causes for partial condemnations in the summer season were arthritis (32.96%), contusion (28.12%), myopathy (14.73%), fracture (10.29%), and cellulitis (8.37%) (Figure 1A). Similarly, the main causes of condemnations in the winter were arthritis (27.97%), contusion (27.95%), myopathy (16.07%), fracture (12.58%), and cellulitis (10.14%) (Figure 1B). In general, partial condemnations were similar between the two seasons.

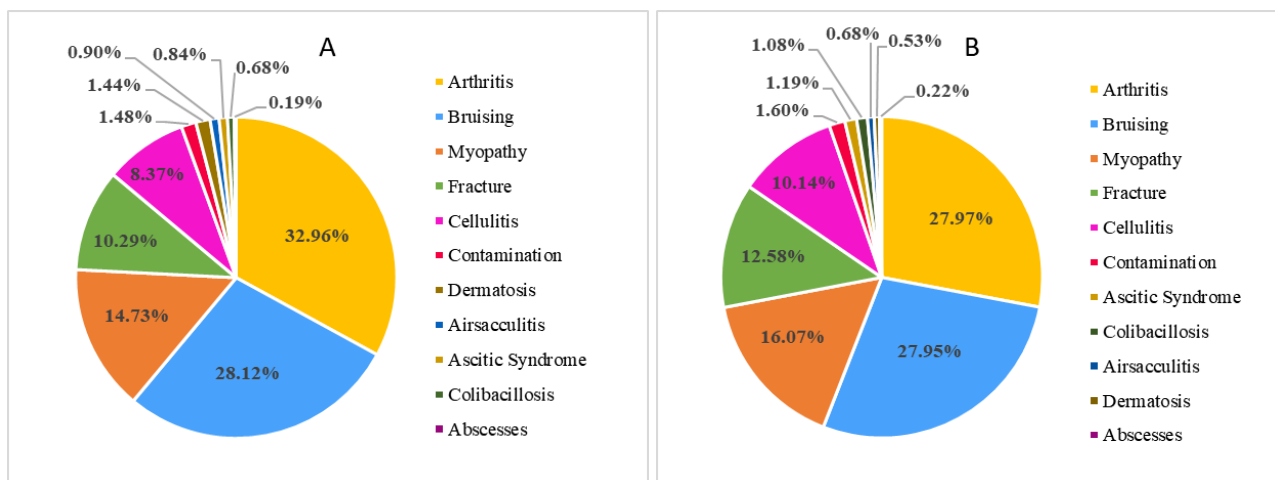


Figure 1. Percentage of the most frequent causes of partial condemnation of animals from ten farms integrated to a slaughterhouse under Federal inspection in the State of Paraná, Brazil, from 2018 to 2020 according to the climate season: A for summer and B for winter.

Table 2 shows that the condemnation rates for airsacculitis, arthritis, contamination, and dermatosis were significantly higher in the summer than in the winter. Jaguezski et al. (2020) analyzed data from commercial broiler carcasses in the State of Paraná from April 2015 to March 2016 and also found higher condemnations in the summer for arthritis, but the dermatosis and contamination rates were higher in the winter. Aisacculitis is caused by *Mycoplasma gallisepticum* and can cause coughing and eye and nasal secretion (Nascimento & Pereira, 2009), resulting in worsening food conversion, as observed in

this study (Table 1). High temperature is a risk factor for its occurrence, justifying higher values in the summer.

Arthritis is an inflammatory process caused by different viruses and/or bacteria that are normally present on breeding farms (Palomino-Tapia et al., 2018) and reduces feed consumption and animal well-being, affecting weight gain (Assunção et al., 2018). It may justify the worse feed conversion and lower daily weight gain observed for broilers in the summer (Table 1).

Table 2

Frequency of the causes of partial condemnation of the total birds slaughtered in the summer (n = 1,485,630) and winter (n = 1,077,012) from ten farms integrated to a slaughterhouse under Federal inspection in the State of Paraná, Brazil, from 2018 to 2020.

Causes of condemnations (%)	Summer	Winter	F-test
Abscess	0.024 ± 0.019	0.024 ± 0.019	0.814
Airsacculitis	0.095 ± 0.418	0.068 ± 0.241	<0.01
Arthritis	3.596 ± 2.390	2.389 ± 1.201	<0.01
Cellulitis	0.907 ± 0.556	0.938 ± 0.489	0.361
Colibacillosis	0.086 ± 0.082	0.113 ± 0.105	0.086
Contamination	0.155 ± 0.171	0.142 ± 0.283	<0.01
Contusion	2.969 ± 1.426	2.317 ± 1.173	0.191
Dermatosis	0.138 ± 0.289	0.048 ± 0.030	<0.01
Fracture	1.159 ± 0.593	1.080 ± 0.478	0.132
Myopathy	1.599 ± 1.038	1.497 ± 0.817	0.094
Ascites syndrome	0.092 ± 0.085	0.105 ± 0.069	0.166

Values represent the mean ± standard deviation.

According to the Regulation of Industrial and Sanitary Inspection of Products of Animal Origin (Decreto N° 9.013, 2017), contamination is a cause of multifactorial condemnation and occurs by the contact of carcasses with various contaminants, some coming from animals gastrointestinal contents, urine, and bile and others in the

environment contaminated water, employees, refrigerator equipment, and others. Possibly, the summer favored condemnation due to contamination probably due to the higher mortality observed on farms (Table 3), as birds from these farms can be carriers of infectious or non-infectious diseases.

Table 3

Frequency of the causes of total condemnation of total birds slaughtered in the summer (n = 1,485,630) and winter (n = 1,077,012) and the total mortality of ten farms integrated to a slaughterhouse under Federal inspection in the State of Paraná, Brazil, from 2018 to 2020.

Causes of condemnations (%)	Summer	Winter	F-Test
Arthritis	1.925 ± 0.991	0.000 ± 0.000	NC
Ascites	0.032 ± 0.024	0.046 ± 0.046	<0.01
Repugnant appearance	0.255 ± 0.133	0.245 ± 0.132	0.966
Cachexia	0.034 ± 0.022	0.035 ± 0.023	0.835
Poor bleeding	0.022 ± 0.026	0.034 ± 0.078	<0.01
Total mortality	4.13 ± 1.72	3.85 ± 1.21	0.01

Values represent the mean ± standard deviation. NC = Not calculated due to null value in the winter.

Myopathies are associated with rapid weight gain, a problem in modern broilers, and an increase in their frequency has been observed in slaughterhouses in Brazil. However, no difference was observed between occurrence in the summer and winter (Zanetti et al., 2018; Candido et al., 2021). Wooden breast (Geronimo et al., 2021), white striping (Kato et al., 2019), cranial dorsal myopathy (Pavanello et al., 2023), and spaghetti meat (Tasoniero et al., 2020) are among the most recently described myopathies.

Cellulitis is characterized by the thickening of the dermis and formation of fibrino-caseous plaques due to acute and diffuse purulent inflammation of the subcutaneous tissue, with changes in skin color ranging from yellow to brown, with the main etiological agent consisting of *Escherichia coli* (Jaguezeski et al., 2020). Paschoal et al. (2012) studied the causes of condemnation of broiler carcasses in the State of Paraná between 2011 and 2012 and found that the condemnation due to cellulite was 13.66%, a value higher than that observed in this study, which reached 8.37% for the summer and 10.14% for the winter.

The main causes of total condemnations were repugnant appearance (44.80%), arthritis (41.34%), cachexia (5.28%), and ascites (5.11%) in the summer (Figure 2A)

and repugnant appearance (70.97%), ascites (11.76%), bad bleeding (8.90%), and cachexia (8.37%) in the winter (Figure 2B).

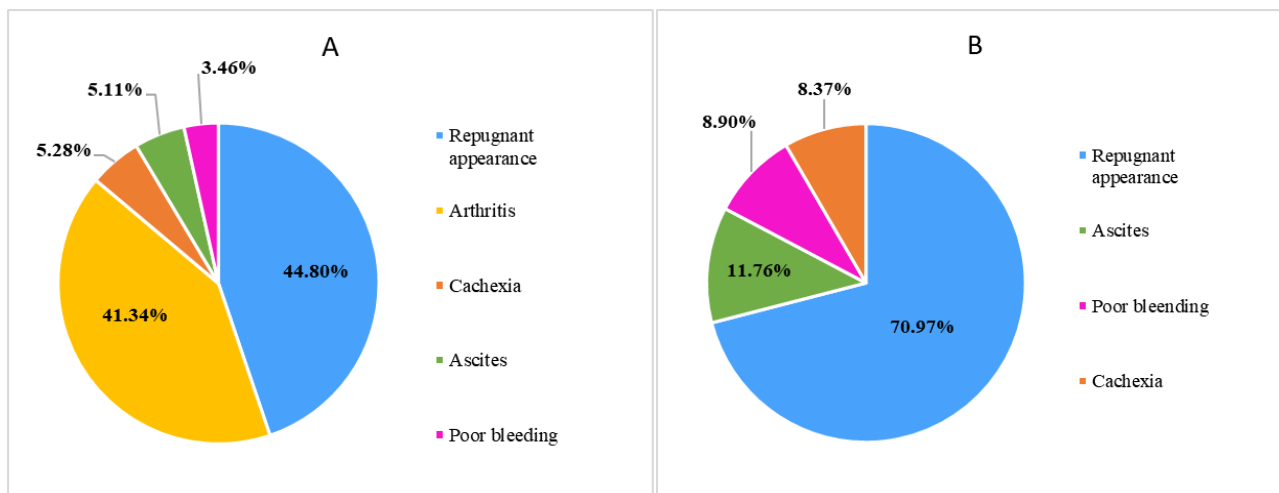


Figure 2. Percentage of the most frequent causes of the total condemnation of birds from ten farms integrated to a slaughterhouse under Federal inspection in the State of Paraná, Brazil, from 2018 to 2020 according to the climate season: A for summer and B for winter.

The repugnant appearance was also the highest cause of total condemnation of broiler carcasses in the State of Paraná. Kanabata et al. (2022) found rates of 48.67% for broiler carcasses between 2018 and 2020. Paschoal et al. (2012) evaluated the causes of condemnations in the period between 2011 and 2012 and obtained a rate of 47.33%. Moreover, Souza et al. (2019) obtained a value of 33.62% in the period between 2013 and 2017 whereas Oliveira et al. (2016) found a prevalence of 28.7%.

Condemnation for repugnant appearance includes changes in carcasses such as color, odor, appearance, technopathies, or quality defects (Decreto N°

9.013, 2017) due to several causes, with one of them being related to pre-slaughter stress.

Table 3 shows the comparison between the frequencies of causes of total condemnation in the summer and winter. Differences were observed for ascites, poor bleeding, and mortality between the summer and winter. No occurrence of arthritis was found in the winter season but only in the summer. In fact, Jaguezski et al. (2020) found that arthritis occurs more frequently in the summer (0.85 ± 0.69) than in the winter (0.33 ± 0.36).

Condemnation due to ascites was higher ($p < 0.01$) in the winter (0.046) than in the summer (0.032). The ascites syndrome

can be caused by environmental factors such as altitude and cold, as well as management and genetic factors such as growth, need for oxygen, and hematological parameters (Biswas, 2019), which justifies a higher occurrence in the winter.

Poor bleeding was also higher ($p < 0.01$) in the winter (0.034) than in the summer (0.022), being characterized by red areas on the skin of the broiler carcass and resulting from failures in the regulation of bleeding equipment or manual incision (Maschio & Raszl, 2012), compromising the microbiological and sensorial quality of the meat. Souza et al. (2019) found 6.63% of condemnations for this cause, a value similar to that obtained for the winter, while Kanabata et al. (2022) observed a 4.72% condemnation rate, similar to the value obtained for the summer.

Cachexia is characterized by the loss of muscle mass and adipose tissue, it is related to inadequate weight gain resulting from illnesses and high density in the poultry house (Rabaiolli et al., 2016). Jaguezski et al. (2020) also did not observe significant differences in the occurrence of cachexia between the summer and winter. Souza et al (2019) reported a 6.63% condemnation rate for cachexia in broiler carcasses in the State of Paraná, which are values similar to those obtained in this study, that is, 5.28% for the summer and 8.37% for the winter, while Paschoal et al. (2012) found higher values for this condemnation (15.82%).

Total mortality of the lot was higher ($p = 0.01$) for the summer (4.13%) than for the winter (3.85%) (Table 3). Total mortality is multifactorial and depends on external environmental factors such as temperature

and relative humidity, and breeding. It may also be related to several causes such as neoplastic and lymphdegenerative, infectious, and non-infectious diseases (Cadmus et al., 2019), standing out Marek's disease (Thofner et al., 2019). The total mortality assessed in this study included death on arrival related to animal transportation. Summer normally causes a microclimate in the truck that is more stressful for the animals due to the high temperature and relative humidity (Barbosa et al., 2014), which may have led to higher mortality.

The analysis of economic losses due to the total condemnation of carcasses presented a loss of R\$ 146,000.00, which represents a loss of 0.5% of the total lot. Souza et al. (2019) analyzed economic losses due to the total condemnation in seventeen states in Brazil during the years 2013 and 2017 and also obtained a mean of 0.5% of losses between the states, totaling an amount of US\$ 175,580 million in losses related to 95.556 million cases of total condemnation. Importantly, the economic losses due to partial condemnation were not calculated, as the condemned carcass weight cannot be estimated, but it represents most of the observed condemnation (95%). Therefore, it would contribute substantially to increasing estimated economic losses. A loss due to mortality of R\$ 1,155,779.00 was verified, considering the mean mortality rate of 4%.

The total loss, considering the loss due to mortality and total condemnation, was R\$ 1,301,789.00, demonstrating the importance of investigating the causes of condemnation and its factors to minimize economic losses for the poultry sector.

Conclusion

The climate season influenced total and partial condemnations and mortality. Summer provided higher mortality and higher losses due to partial condemnation related to airsacculitis, arthritis, contamination, and dermatosis, while winter promoted higher losses due to total contamination related to ascites and poor bleeding. Summer tends to be the most critical season for economic losses. The need to find strategies to reduce the occurrence of condemnations and mortality and minimize economic losses stands out.

References

- Agrolink (2022). *Cotações*. <https://www.agrolink.com.br/cotacoes/historico/pr/frango-1kg>
- Assunção, T. R. da S., Palka, A. P. G., & Pavoni, D. P. (2018). Reovirose aviária: um panorama. *Revista de Educação Continuada em Medicina Veterinária e Zootecnia do CRMV-SP*, 16(2), 48-59. doi: 10.36440/recmvz.v16i2.37781
- Barbosa, J. A. D., F^o., Queiroz, M. L., Brasil, D. F., Vieira, F. M. C., & Silva, I. J. (2014). Transport of broilers: load microclimate during Brazilian summer. *Engenharia Agrícola*, 34(3), 405-421. doi: 10.1590/S0100-69162014000300003
- Belintani, R., Garcia, R. G., Nääs, I. A., Borille, R., Sgavioli, S., Caldara, F. R., & Lima, N. D. D. S. (2019). Broiler carcass condemnation pattern during processing. *Revista Brasileira de Zootecnia*, 48(1), e20180046. doi: 10.1590/rbz4820180046
- Bergeron, S., Pouliot, E., & Doyon, M. (2020). Commercial poultry production stocking density influence on bird health and performance indicators. *Animals*, 10(8), 1-8. doi: 10.3390/ani10081253
- Biswas, A. (2019). Pulmonary hypertension syndrome in broiler chickens: a review. *Veterinarski Arhiv*, 89(5), 723-734. doi: 10.24099/vet.arhiv.0396
- Cadmus, K. J., Mete, A., Harris, M., Anderson, D., Davison, S., Sato, Y., Helm, J., Boger, L., Odani, J., Ficken, M. D., Pabilonia, K. L. (2019). Causes of mortality in backyard poultry in eight states in the United States. *Journal of Veterinary Diagnostic Investigation*, 31(3), 318-326. doi: 10.1177/1040638719848718
- Candido, M. J. S., Zanini, S. F., Ferreira, M. F., Araujo, F. A. C., Teixeira, A. P. M., Cipriano, R. C., Moulim, M. A. P. D. L. (2021). Principais causas de condenações de carcaça de frango no Espírito Santo, Brazil. *Semina: Ciências Agrárias*, 42(3), 112-114. doi: 10.5433/1679-0359
- Decreto N° 9.013 (2017). Decreto N° 9.013, de 29 de março de 2017. Regulamenta a Lei n° 1.283, de dezembro de 1950, e a Lei n° 7.889, de 23 de novembro de 1989, que dispõem sobre a inspeção industrial e sanitário de produtos de origem animal. *Diário Oficial da União*, Brasília, D.F, 30(p. 3).
- Empresa Brasileira de Pesquisa Agropecuária (2021). *Abates e exportação no Brasil em 2021: frangos de corte*. Centro de inteligência de aves e suínos. <https://www.embrapa.br/suinos-e-aves/cias/estatisticas/frangos/brasil>
- Geronimo, B. C., Prudencio, S. H., & Soares, A. L. (2022). Biochemical and technological

- characteristics of wooden breast chicken fillets and their consumer acceptance. *Journal of Food Science and Technology*, 59(3), 1185-1192. doi: 10.1007/s13197-021-05123-3
- Instituto de Desenvolvimento Rural do Paraná (2024). *Dados meteorológicos históricos e atuais*. IDR. <https://www.idrparana.pr.gov.br/Pagina/Dados-Meteorologicos-Historicos-e-Atuais>
- Jaguezeski, A. M., Engelmann, A. M., Machado, I. N., D. R., Batti, B. P. B. (2020). The effect of commercial broiler hybrids and the season on the occurrence of broiler condemnations in the abattoirs. *Ciência Rural*, 50(10), 1-8. doi: 10.1590/0103-8478cr20200177
- Jesus, C. Jr., De Paula, S. R., Ormond, J. G. P., Braga, N. M. (2007). A cadeia da carne de frango: tensões, desafios e oportunidades. *BNDES Setorial*, 1(26), 191-232. <http://web.bndes.gov.br/bib/jspui/handle/1408/2681>
- Kanabata, B. T., Souza, F. L., Biz, G., Pescim, R. R., & Soares, A. L. (2022). Relationship between pre-slaughter factors and major causes of carcass condemnation in a broiler slaughterhouse under federal inspection. *Brazilian Journal of Poultry Science*, 25(1), 1-6. doi: 10.1590/1806-9061-2022-1669
- Kato, T., Mastelini, S. M., Campos, G. F. C., Barbon, A. P. A. C., Prudencio, S. H., Shimokomaki, M., Soares, A. L., & Barbon, S. (2019) White striping degree assessment using computer vision system and consumer acceptance test. *Asian-Australasian Journal of Animal Sciences*, 32(7), 1015-1026. doi: 10.5713/ajas.18.0504
- Lupo C., Chauvin, C., Balaine, L., Petetin, I., Péraste, J., Colin, P., Le Bouquin, S. (2008). Postmortem condemnations of processed broiler chickens in western France. *The Veterinary Record*, 162(22), 709-713. doi: 10.1136/vr.162.22.709
- Maschio, M. M., & Raszl, S. M. (2012). Economic impact from convictions post-mortem total and partials in a poultry slaughterhouse. *Revista E-Tech: Tecnologias para Competitividade Industrial*, 1(1), 26-38. doi: 10.18624/e-tech.v0i0.208.
- Muchon, J. L., Garcia, R. G., Gandra, E. R. S., Assunção, A. S. A., Komiyama, C. M., Caldara, F. R., Nääs, I. A. and Santos, R. A. (2019). Origin of broiler carcass condemnations. *Revista Brasileira de Zootecnia*, 48(1), 1-9. doi: 10.1590/rbz4820180249
- Nascimento, E. R., & Pereira, V. L. A. (2009). Microplasmose. In J. Di Fabio, & L. I. Rossini (Eds.), *Doenças das aves* (pp. 485-500). Campinas.
- Oliveira, A., Andarade, M. A., Armendaris, P. M., Bueno, P. H. S. (2016). Principais causas de condenação ao abate de aves em matadouros frigoríficos registrados no serviço brasileiro de inspeção federal entre 2006 e 2011. *Ciência Animal Brasileira*, 17(1), 79-89. doi: 10.1590/1089-6891v17i123020
- Palomino-Tapia, V., Mitevski, D., Inglis, T., Meer, F. V. D., Abdul-Careem, M. F. (2018). Molecular characterization of emerging avian reovirus variants isolated from viral arthritis cases in Western Canada 2012-2017 based on partial sigma (σ) C gene. *Virology*, 522(1), 138-146. doi: 10.1016/j.virol.2018.06.006

- Paschoal, E. C., Otutumi, L. K., & Silveira, A. P. (2012). Principais causas de condenações no abate de frangos de corte de um abatedouro localizado na região noroeste do Paraná, Brasil. *Arquivos de Ciências Veterinárias e Zoologia da UNIPAR*, 15(2), 93-97. eISSN 1982-1131
- Pavanello, A. C. L., Mendonça, F. J., Oliveira, T. E. S., Torezan, G. B., Di Santis, G. W., & Soares, A. L. (2023). Physicochemical and histopathological parameters of broilers with dorsal cranial myopathy. *Animal Bioscience*, 36(6), 953-961. doi: 10.5713/ab.22.0109
- Petracci, M., Mudalal, S., Soglia, F., Claudio, C. (2015). Meat quality in fast-growing broiler chickens. *World's Poultry Science Journal*, 71(2), 363-374. doi: 10.5713/ab.22.0109
- Rabaiolli, J. F., Vicensi, J. B., Calasans, M. W. M., Corazza, J., Tedesco, D. C., Klein, J., Seibel, L. I., Kissmann, K. E., Pascoeti, R., Nery, L. C. (2016). Avaliação microbiológica de carcaças de frangos caquéticos. *Anais da Semana do Conhecimento, Universidade e Comunidade em Transformação*, Passo Fundo, RS, Brasil, 3.
- Souza, W. F., Granjeiro, M. D. B., & Procópio, D. P. (2019). Analysis of the economic loss and the main causes of total condemnation of poultry carcasses under Brazilian federal inspection between 2013 and 2017. *Archives of Veterinary Science*, 24(4), 36-49. doi: 10.5380/avs.v24i4.66871
- Tasoniero, G., Zhuang, H., Gamble, G. R., & Browker, B. C. (2020). Effect of spaghetti meat abnormality on broiler chicken breast meat composition and technological quality. *Poultry Science*, 99(3), 1724-1733. doi: 10.1016/j.psj.2019.10.069.
- Thofner, I. C. N., Poulsen, L. L., Bisgaard, M., Christensen, H., Olsen, R. H., & Christensen, J. P. (2019). Longitudinal study on causes of mortality in Danish broiler breeders. *Avian Diseases*, 63(3), 400-410. doi: 10.1637/12006-113018-Reg.1
- United States Department of Agriculture (2023). *USDA.gov - United States department of agriculture*. <https://www.ers.usda.gov/topics/animal-products/poultry-eggs/>
- Zanetti, M. A., Tedesco, D., Schneider, T., Teixeira, S. T. F., Daroit, L., Pilotto, F., Pilotto, F., Santos, S. P., Santos, L. R. D. (2018). Economic losses associated with wooden breast and white striping in broilers. *Semina: Ciências Agrárias*, 39(2), 887-892. doi: 10.5433/1679-0359.2018v39n2p887

