R. Bras. Zootec., 48:e20180249, 2019
https://doi.org/10.1590/rbz4820180249

Non-ruminants
Full-length research article

Revista Brasileira de Zootecnia

Brazilian Journal of Animal Science
ISSN 1806-9290
www.rbz.org.br

Origin of broiler carcass condemnations

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ABSTRACT - The objective of the present research was to study the incidence of broiler carcass condemnations over eleven years and identify the productive phase that causes greater loss in slaughter process. The origin of these condemnations was determined before and after fasting. Evaluated broilers were reared in positive pressure warehouses and slaughtered between 28 and 34 days old with carcass weight ranging from 0.7 to 1.4 kg. Fasting occurred, on average, 9 h before the slaughter. Condemnation and slaughter data were collected from 2004 to 2014 in a slaughterhouse with slaughter capacity of 120,000 broilers/day. The causes of rearing condemnations were airsaccullitis, arthritis, abscess, ascites, cachexia, cellulitis, colibacillosis, dermatosis, salpingitis, hemorrhagic syndrome, and neoplasia; and the causes of pre-slaughter and slaughter condemnations were bruising, fracture, inadequate bleeding, excessive scaling, contamination, dehydration, death at the platform, disgusting appearance, and delayed evisceration. The mean values of total and partial condemnations per year, occurrence and proportion of condemnations index (OCI) for every thousand broilers slaughtered, and rates of pre and post-fasting condemnations were calculated. Condemnations rates (%) and OCI were higher after fasting; partial and total contamination stood out, with a frequency of 77% and 30%, respectively, after fasting. Long fasting, uneven lots or unbalanced equipment may cause extravasation of the gastrointestinal contents and contaminate broiler carcasses. Practices such as monitoring fasting and equipment adjustment to broiler carcass size may reduce carcass condemnation incidence.

Keywords: animal production, broilers, microbial diversity, slaughterhouse

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Received: March 12, 2019
Accepted: August 16, 2019

How to cite: 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:e20180249. https://doi.org/10.1590/rbz4820180249

Introduction

The Brazilian federal legislation on the production of broiler meat aims to maintain the quality of products avoiding them to be unsuitable for consumption. The presence of the imprint (or seal mark) of the Inspection Service (Federal, State, or Municipal) indicates that the meat and its products had the proper criteria of hygienic-sanitary slaughter as recommended by the Regulamento de Inspeção Industrial e Sanitária de Produtos de Origem Animal (RIISPOA). Such norms include the *ante-mortem* and *post-mortem* inspection of animals, handling, processing, preparation, conservation, packaging, storage, labeling, transit, and consumption of any products and byproducts intended for human consumption (Oliveira et al., 2016; Brasil, 2017).

An essential factor in the quality of the final product is that the broiler catching team should be well selected and trained (Grandin, 2014). Pre-slaughter operations, which include fasting, capture, loading, transport, and waiting time at the slaughterhouse, are considered crucial points in the optimization of the production processes (Khan et al., 2018; Kittelsen et al., 2018). Such procedures are part of the follow-up of technical observations of operations called the "after-gate" actions, carried out by staff and machinery that need to be set according to the size and weight of broilers (Grandin, 2014; Frisk et al., 2018).

The pre-slaughter period begins with fasting until slaughter of broilers, in which is included the pre-slaughter fasting, the period when the feed is withdrawn and chicken are kept only with access to water. The critical goal is to minimize contamination in the slaughterhouse due to the emptying of the digestive system (Silva and Vieira, 2010; Oliveira et al., 2016). Unproper maneuvers performed since the pre-slaughter fasting due to lack of equipment maintenance or due to worker's faults are called techno-pathologies.

The purpose of the present study was to identify the leading causes that affect *ante-mortem* and *post-mortem* condemnation of broiler chickens, in which pre-slaughter fasting is the critical point.

Material and Methods

The Animal Use Ethics Committee BRF/SIF 18 under No. 076/18/14 approved this research. The data about broiler condemnation and slaughter were collected at a facility registered at the Serviço de Inspeção Federal (SIF), located in Grande Dourados, Brazilian Center-West region (latitude 22°13'18.54" South, longitude 54°48'23.09" West, and average altitude of 430 m). The slaughter capacity was 120,000 broilers/day. The facility was fully mechanized and with the production aimed at the foreign market.

The data covered a period from 2004 to 2014, directly from the SIGSIF central database, under the responsibility of the Departamento de Inspeção de Produtos de Origem Animal (DIPOA). About 310 million broilers were slaughtered during this period, and the variables considered were: "name of condemnation," "month," "year," "condemnation destination" (partial or total), and "number of broilers slaughtered." The broilers were reared in positive pressure warehouses and were slaughtered between 28 and 34 days, with carcasses weight of 0.7 to 1.4 kg, without the giblets. The broiler catching team was subcontracted, and catching was performed manually and followed up by a technical manager.

The data were analyzed descriptively with calculation of the averages of total and partial condemnation per year to verify condemnation seasonality during the studied period. In addition, we calculated the occurrence and proportion of condemnations index (OCI) for every thousand broilers slaughtered following the equation, adapted from Moretti et al. (2010):

$$OCI = \frac{\text{Annual value of condemnation}}{\text{Number of broilers slaughtered in the period of obtaining the numerator}} \times 1{,}000$$

Pre-fasting and post-fasting condemnation rates (% condemnations/slaughtered broilers) were calculated to verify losses in the farm related to condemnations, resulting from incorrect handling during pre-slaughter and slaughter (techno-pathologies). The causes of condemnations during rearing were airsacculitis, arthritis, abscess, ascites, cachexia, cellulitis, colibacillosis, dermatosis, salpingitis, hemorrhagic syndrome, and neoplasia, while the causes of condemnations attributed to pre-slaughter and slaughter were bruising, fracture, inadequate bleeding, excessive scaling, contamination, dehydration, death at the platform, disgusting appearance, and delayed evisceration. Carcass condemnation followed the criteria of visual classification, according to SIF, described in the Regulamento Técnico da Inspeção Tecnológica e Higiênico-Sanitária de Carnes de Aves, recommended in the Ordinance 210/1998 (Brasil, 1998).

The condemnations were sorted before and after the pre-slaughter to observe condemnation causes, calculating the condemnation frequency in the total period (% condemnation cause/total condemnations) and categories (before and after fasting).

The economic impact considered the price of frozen chicken meat per kilogram in the studied period according to CEPEA/ESALQ and converted into the US Dollar quotation (CEPEA, 2017). Then, the average value, in US dollars, was calculated for the period, according to the indices released by the Banco Central do Brasil (2017). Therefore, the average price of frozen chicken was R$ 2.72/kg, and the average price of the dollar was R$ 2.11; thus, the kilogram of frozen chicken meat cost US$ 1.19.

Data of slaughtered broilers, condemned broilers, and condemnation frequency was analyzed using the SAS software (Statistical Analysis System, version 9.0), PROC GLIMMIX command, and tested for gamma and beta distributions. The rates of condemnations (%) and OCI, between 2004 and 2014, were calculated by using the model:

$$Y_{ijl} = \mu + F_i + Y_j + Y_j(F_i) + e_{ijl},$$

in which μ = overall average, F_i = effect of fasting, Y_j = effect of year, $Y_j(F_i)$ = effect of fasting and year interaction, and e_{ijl} = error. Data was subjected to the SAS analysis of frequency, adopting a 5% significance level.

Results

During the reporting period, 311 million broiler chickens were slaughtered. In 2004, 25 million chicken were slaughtered; the following year, there was an increase of 2 million; and in 2006, there was a 20% drop in the volume of poultry slaughtered in relation to 2005 (Table 1). Production resumed growth, reaching 34 million broilers slaughtered in 2010. In 2012, there was a drop in the production again, with 25 million broilers slaughtered, and it stabilized in 2013 and 2014, about 27 million broilers were slaughtered per year (Table 1).

Concomitantly with the drop in the number of broiler chickens slaughtered 2006, the number of condemnations increased; the same fact was not observed in 2012 (Table 1).

The evidence appears when analyzing data without the effect of number of broilers slaughtered, with OCI, highlighting the increase in the number of broilers condemned partially and entirely in the studied years (Table 1).

The rates of condemnations (%) and OCI, between 2004 and 2014, were higher after fasting ($P<0.05$), and the condemnation rate (%) suffered the effect from fasting and year ($P<0.05$), being 40 and 134% higher for total and partial condemnations, respectively (Table 2).

The interactions between fasting and year observed in the rates of partial condemnations showed an increase in 2006 (Figure 1A). The OCI was also influenced after fasting ($P<0.05$) for total and partial condemnations, with year effect during the period ($P<0.05$). The condemnations occurred more intensively between 2005 and 2007 ($P<0.05$), with a peak in 2006.

Table 1 - Total broiler chickens slaughtered and totally and partially condemned carcass from 2004 to 2014

Variable	Year											Total
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
Slaughter (million)	25.62	27.23	21.65	26.66	30.37	31.62	34.22	32.20	25.39	27.25	27.80	311
Partial condemnation[1]	249.93	295.26	302.23	278.79	223.76	225.93	156.22	148.59	102.23	88.69	101.16	2,172
Total condemnation[1]	22.09	26.42	29.20	48.54	30.14	22.19	24.65	27.26	26.98	24.61	23.55	306

[1] Thousand broiler chickens.

When analyzing the interaction between fasting and year in partial OCI (Figure 1B), a peak occurred in 2006, which was evident due to the absence of influence of the number of slaughtered broilers. The difference observed in 2007 occurred because OCI excludes the effect of number of slaughtered broilers. For this reason, by excluding this effect, it was observed that the condemnations were much higher. In 2007, the industry was having problems due to bad equipment adjustment and changes in the work team.

The frequency (%) of condemnations from before pre-slaughter fasting in birds slaughtered during the studied period showed the highest prevalence of the partial condemnations mainly by dermatosis, airsaccullitis, and cellulitis, with an average frequency of ~40, ~28, and ~30%, respectively (Table 3).

The frequency of total condemnations originating during rearing showed a frequency about 76% of colibacillosis (Table 3), while after the pre-slaughter fasting, contamination (~77%) and contusion and fracture (~23%) contributed to frequency increase of partial condemnations (Table 4).

It was not possible to identify a standard in the causes of total condemnation of broilers for the period studied (Table 4). Although they occurred in smaller proportions, the leading causes of this type of loss were contamination, (~30%), dehydration (~25%), and death at the platform (~26%).

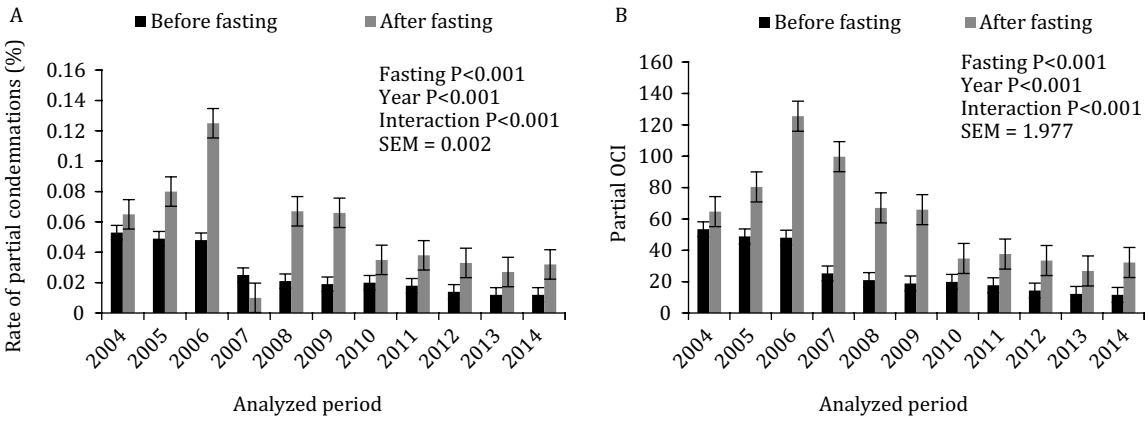
Discussion

In 2003 and 2007, there were records of avian influenza (AI) in broilers in Asia, Africa, and Europe, with the slaughter of approximately 1.5 million broilers as a preventive measure to the spread of the virus (Andrade et al., 2009).

Table 2 - Condemnation rate (%) and occurrence and condemnation proportion index (OCI) for every thousand birds slaughtered in commercial slaughterhouses from 2004 to 2014

Rate (%)	Pre-slaughter fasting		SEM	P-value		
	Before	After		Fasting	Year	Interaction
Total	0.005	0.007	0.0002	<0.0001	<0.0001	0.1261
Partial	0.026	0.061	0.0020	<0.0001	<0.0001	<0.0001
OCI						
Total	4.893	7.177	0.1987	<0.0001	<0.0001	0.1261
Partial	26.468	60.736	1.9767	<0.0001	<0.0001	<0.0001

SEM - standard error of mean.



SEM - standard error of mean.

Figure 1 - Rate of partial condemnations (%) before and after pre-slaughter fasting in the period from 2004 to 2014 (A) and occurrence and proportion of condemnations index (OCI) for every 1,000 birds slaughtered before and after the pre-slaughter fasting from 2004 to 2014 (B).

Table 3 - Means and frequency (%) of condemnations before pre-slaughter fasting in slaughtered broiler chickens from 2004 to 2014

Variable	Year											Frequency average (total period %)
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
Total condemnation frequency (%)												
Colibacillosis	47.82	62.55	68.52	78.23	80.05	84.72	89.84	88.16	75.41	81.13	79.42	75.99
Cachexia	12.28	5.00	6.56	4.52	3.78	2.43	2.20	4.95	11.24	12.24	13.00	7.11
Ascites	9.79	10.16	7.62	8.49	10.72	9.04	2.57	3.80	3.74	4.91	4.32	6.83
Airsacculitis	26.27	18.13	12.41	4.98	2.74	1.75	1.96	1.08	2.91	0.55	1.06	6.71
Others[1]	3.84	4.16	4.89	3.78	2.72	2.06	3.42	2.02	6.70	1.17	2.20	3.36
Partial condemnation frequency (%)												
Dermatosis	89.36	77.22	73.60	26.95	24.15	32.46	13.54	14.00	23.16	28.06	40.07	40.23
Airsacculitis	3.60	11.03	10.93	37.81	51.86	32.30	22.26	44.58	28.19	38.15	24.58	27.75
Cellulitis	6.24	10.56	13.70	33.21	22.23	33.10	55.90	39.08	46.63	32.02	33.95	29.69
Others[2]	0.80	1.19	1.77	2.03	1.76	2.14	8.30	2.34	2.02	1.77	1.40	2.33

[1] Abscess, arthritis, neoplasia, and hemorrhagic syndrome.
[2] Arthritis, abscess, ascites, and salpingitis.

Table 4 - Means and frequency (%) of condemnations after pre-slaughter fasting in slaughtered broiler chickens from 2004 to 2014

Variable	Year											Frequency average (total period %)
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
Total condemnation frequency (%)												
Contamination	37.00	39.46	34.41	24.31	34.97	26.43	31.49	22.60	29.15	27.56	21.75	29.92
Death at the platform	30.23	27.48	21.58	27.98	21.53	29.63	33.76	35.96	23.77	20.91	18.48	26.48
Dehydration	18.04	17.05	28.31	38.26	25.18	23.46	20.66	25.58	25.48	23.16	31.03	25.11
Excessive scaling	3.67	4.70	4.68	3.02	8.54	9.23	4.18	5.81	8.85	15.72	12.20	7.33
Disgusting appearance	8.45	5.71	8.76	5.42	6.93	6.54	2.26	2.62	4.93	3.39	11.40	6.04
Others[1]	2.61	5.60	2.26	1.01	2.85	4.71	7.65	7.43	7.82	9.26	5.14	5.12
Partial condemnation frequency (%)												
Contamination	68.01	76.02	80.45	86.81	76.75	84.96	79.30	82.59	78.39	68.82	63.88	76.90
Contusion and fracture	31.71	23.65	19.37	13.07	22.94	14.70	20.27	17.10	20.66	30.13	36.06	22.70
Others[2]	0.28	0.33	0.18	0.12	0.31	0.34	0.43	0.31	0.95	1.05	0.06	0.40

[1] Inadequate bleeding, delayed evisceration, and bruising/fractures.
[2] Inadequate bleeding and excessive scaling.

Although the AI did not reach Brazil, new biosecurity requirements became necessary, raising production costs and, therefore, making it impossible for many producers to remain in the activity (Yalçin et al., 2010). When facing the health issue, the supply chain is also impacted by reduced poultry consumption and production as the meat industry is an essential buyer of inputs, among them, those necessary for poultry nutrition, which represents nearly 70% of the production cost (Morgan and Prakash, 2006).

The effect of fasting and year on total and partial condemnations were predominantly due to the post-fasting technopathologies. Likewise, the increase observed in 2006 in the rates of partial condemnations, due to interactions between fasting and year, originated in the technopathologies occurred during flock management after pre-slaughter fasting.

Technopathologies are identified in any broiler meat industry, because this is a lengthy procedure and depends on several processing steps, ranging from the hanging of the broiler to the dispatch of the finished product. They originate in the technological processing along with inadequate management and, therefore, it is suggested to extend this terminology, including losses occurred since pre-slaughter fasting (Souza et al., 2016). According to Lima et al. (2014), training and encouragement of employees, who provide service in the industry, are critical factors for improving the production and reducing economic losses, just as the equipment that needs adequate setting.

Another point was the use of modern equipment with easy and quick regulation, whose objective is to operate to different chicken weights and sizes, simplifying the slaughter process and turning the result more competitive and improving quality to the consumers.

It was not possible to estimate economic losses due to partial condemnation of broiler carcass. Study estimations takes account only of condemnation of the entire carcass and, according to Ferreira et al. (2012), the losses in a slaughterhouse are around ~US$ 1.4 million per year only in the south of Brazil.

Considering the ~311 million broilers slaughtered during the study period, 1.6 million presented total condemnation classified as originating in the field, while ~2 million were classified as originating in pre-slaughter and slaughter management after fasting.

For the approximate quotation of chicken at US$ 1.19 per live kg and the average slaughter weight of 1 kg, during the studied period, there was a financial loss of ~US$ 370 million, being the flock rearing responsible for ~US$ 1.9 million, and the processing plant, for ~US$ 2.38 million.

Litter moisture, which causes ulcerative dermatitis and feet lesions, can affect other body parts in direct contact with the litter, such as the breast. The high content of contaminants can also cause cellulitis (Part et al., 2016), which is associated with serositis, airsaccullitis, pericarditis, perihepatitis, peritonitis, and salpingitis (Kasuya et al., 2017) and constitutes one of the main causes of condemnation in slaughterhouses, with implications for public health due to its principal etiologic agent, *Escherichia coli* (Andrade et al., 2006; Wijesurendra et al., 2017).

The pathological agents that cause airsacculitis are *Mycoplasma gallisepticum* and *Mycoplasma synoviae*; clinical indicators are the presence of cough, nasal and ocular discharge, reduction in feed intake, decrease in performance, and mortality (Nascimento and Pereira, 2009). The decrease of immunological resistance causes opportunistic bacterial infections (Ferreira and Knobl, 2009). Thus, airsacullitis is one of the leading causes of total and partial broiler carcass condemnation (Machado et al., 2012). The affected broilers present lower weight, contributing to flock unevenness and causing problems during slaughter, especially in the evisceration session, increasing frequency of fecal and biliary carcass contamination.

Colibacillosis, a disease caused by *E. coli*, present in the gastrointestinal tract of broilers, can cross the intestinal barrier and reach other organs, beginning an respiratory infection, and can also cause septicemia with colonization of internal organs (Casagrande et al., 2017).

The Avian Pathogenic *Escherichia coli* (APEC), from the group of extraintestinal pathogenic *E. coli*, is also responsible for colibacillosis and is associated with different pathologies such as coliseptcemia, peritonitis, pneumonia, pleuropneumonia, airsacullitis, pericarditis, cellulitis, and coligranulomatosis. Airsacullitis and cellulitis stood out in the current study amongst the leading causes of partial condemnation of broiler chicken carcasses.

According to Ferreira and Knobl (2009), critical environmental factors predisposing to the presence of colibacillosis are high concentrations of ammonia in the shed, deficiency in ventilation in poultry environments, extreme temperatures, litter moisture, high-density rearing, and deficiencies in the disinfection process.

Contamination of poultry carcasses is due to the presence of intestinal contents both inside and outside the eviscerated carcass (Mendes and Komiyama, 2011), and it occurs when the digestive tract is broken

or cut, or when any contaminating material (food, excreta, bile, bedding, or degraded intestinal wall) is expelled and gets in contact with the carcass.

Carcass contamination was highly frequent in all evaluated years in the present study and is directly related to the fasting time before slaughter, which is recommended to be from 6 to 8 h. If fasting time is excessive, broilers will drink plenty of water and ingest litter material, which may result in liquid excreta, causing the same effect of very short fasting. After 12 h of fasting, the walls of the intestine begin to weaken, and with 18 h of fasting, the intestine breaks easily, releasing bile that contaminates the whole carcass (Mendes and Komiyama, 2011; Rui et al., 2011). Increasing fasting time may also cause stress, destabilizing intestinal flora, inducing entrance of opportunistic bacteria, and helping in the development of *Salmonella sp*. in the cecum.

Bruising and fracture are considered the most financially impacting causes, and investments in training employees to the properly poultry management from the farm to the slaughter processs minimize the incidence of red and white fractures, which occur when the bird is dead (Maschio and Raszl, 2012). After 2009, the incidence of bruises and fractures was lower due to the training of employees, through the interposition of the company's quality control.

Conclusions

The highest condemnation index occurred after broiler pre-slaughter fasting, demonstrating how managements and technical recommendations before slaughter are not well executed. Greater investment in technology and skilled and trained manpower are necessary to mitigate these losses.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: J.L. Muchon, R.G. Garcia, C.M. Komiyama, F.R. Caldara and I.A. Nääs. Data curation: J.L. Muchon, R.G. Garcia, E.R.S. Gandra and C.M. Komiyama. Formal analysis: R.G. Garcia, E.R.S. Gandra and C.M. Komiyama. Funding acquisition: J.L. Muchon, R.G. Garcia and R.A. Santos. Investigation: J.L. Muchon and R.A. Santos. Methodology: J.L. Muchon, R.G. Garcia, E.R.S. Gandra, C.M. Komiyama, F.R. Caldara and R.A. Santos. Project administration: J.L. Muchon and R.G. Garcia. Resources: R.G. Garcia, E.R.S. Gandra and R.A. Santos. Software: E.R.S. Gandra. Supervision: R.G. Garcia, C.M. Komiyama and I.A. Nääs. Validation: R.G. Garcia, E.R.S. Gandra, C.M. Komiyama and I.A. Nääs. Visualization: R.G. Garcia, E.R.S. Gandra, F.R. Caldara and I.A. Nääs. Writing-original draft: J.L. Muchon. Writing-review & editing: R.G. Garcia, E.R.S. Gandra, A.S.A. Assunção, C.M. Komiyama, F.R. Caldara, I.A. Nääs and R.A. Santos.

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