Poultry Production Losses and their Relationship with Lairage Time Effects: A Thermodynamic Study under Tropical Conditions

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Abstract. *The current challenges of poultry production are summarized in the reduction of losses during the production process. This stage requires a study of critical control points, especially on the pre-slaughter operations. Among these operations, few researches recommend ideal intervals of time, especially in warm and wet regions. Thus, the aim of this study was to compare different intervals of lairage time with environmental temperature influence on mortality rates. This trial was conducted in a commercial abattoir in the State of Sao Paulo, Brazil, in the year of 2006. The historical data set from more than 13,000 trucks, about broiler mortality during pre-slaughter operations, was given by the abattoir. Factors that influence the welfare of the birds were collected, such as the lairage time in abattoir and hourly dry-bulb temperature. Statistical analysis was performed using the Double Generalized Linear Models. The results showed that at highest temperatures (above 22 ºC), an increase in the lairage time reduced the mortality rates, being more pronounced in the critical (25 – 28 °C) and lethal intervals (above 29 °C). In relation to lairage time, the reduction in mortality rates was more pronounced in the intervals up to 1 hour of waiting. Therefore, the lairage time recommended for broilers during heat stress conditions is over 1 hour, and the greater intervals are more desirable for poultry welfare subjected to pre-slaughter operations.*

Keywords. *DOA, Lairage time, Poultry, Pre-slaughter, Temperature, Welfare*

Introduction

Nowadays, one of the major problems in the broiler industry is pre-slaughter stress, responsible for a great part of the losses before arrival at the abattoir (Death on Arrivals - DOA). Since the first week, the birds are raised in an industrial setting, where one of the main features is the high stocking density, which complicates any adjustment on the animal, aimed the thermal balance. An aggravating fact provided by the climatic conditions in Brazil, characterized by high temperature and relative humidity during most parts of the year. Thus, the birds reach slaughter age with limited ability to exchange heat due to the weight and size made in the last stage of growth, in addition to the rapid growth during the production cycle (Teeter and Belay, 1996).

High temperatures combined with large moisture variations and with additional low ventilation provide significant losses in the process. Hunter et al. (1998) related that there is an increase of 10 °C inside the transport module, where the lairage time exceeds 2 hours, resulting in negative consequences such as hyperthermia. Other more serious problems can occur, such as muscle hemorrhages and increased mortality (Kranen et al., 1998). Moreover, according to estimates, 40% of pre-slaughter losses are related to heat stress, whether by cold or heat (Ritz et al., 2005). The same authors related that the control of temperature becomes a problem in lairage environments if ventilation is not adequate or if environment is not protected from sunlight, in order to reduce mortality, especially considering a temperature peak that promotes an additional stress for the birds.

Whereas the thermal needs of birds ranges between 13 and 27 ºC, according to results of various authors (Milligan and Winn, 1964; Curtis, 1983; Silva, 2000; Macari and Furlan, 2001) and relative humidity between 65 and 70 % (Macari and Furlan, 2001), the birds are transported in severe stress condition during the year, indicating the need for concern about pre-slaughter steps. Considering changes in external temperature, the lairage environment in the slaughterhouse is the key to reducing the stress caused by previous operations.

Otherwise, one of the most crucial factors to the survival of the bird is the lairage time, which allows an appropriate contact with the birds' environment, reducing the prior heat stress. However, as evidence of Hunter et al. (1998), the waiting time in the slaughterhouse can range from 0 to 7 hours. Thus, the air conditioning makes a decisive role in the desirable duration of lairage time. In environments with little or without ventilation, previous research recommended time intervals less than 2 hours (Hunter et al., 1998) and between 1 and 2 hours (Warriss et al., 1999). In air conditioned environments, the time intervals ranging over 2 hours (Quinn et al., 1998) and Bressan and Beraquet (2002), in a trial conducted in Brazil, recommended that the ideal time is between 2 and 4 hours, targeting the thermal comfort of birds and consequently a reduction loss. However, the poultry industry still lacks of information about the variation of the length of lairage time and the implications on the welfare and survival of birds prior to arriving at slaughter plants.

Thus, the aim of this study is to compare the different intervals of lairage time with environmental temperature's influence on mortality rates.

Material and Methods

The trial was conducted in a commercial poultry processing plant, located in the State of Sao Paulo, Brazil. For this study, a data set about the pre-slaughter operations in 2006 was used. 13,937 vehicles were studied, involving the following variables: stocking density per lorry, density per cage, lairage time (less than 1 hour, 1-2 hours, 2-3 hours, and more than 3 hours), seasons of the year (summer, autumn, winter, spring) and the daily variability (morning, afternoon and evening) were the main factors (Figure 1). Dry-bulb temperature (DBT, °C) and relative humidity (RH, %) was achieved using a weather station in the city, from January to December 2006.

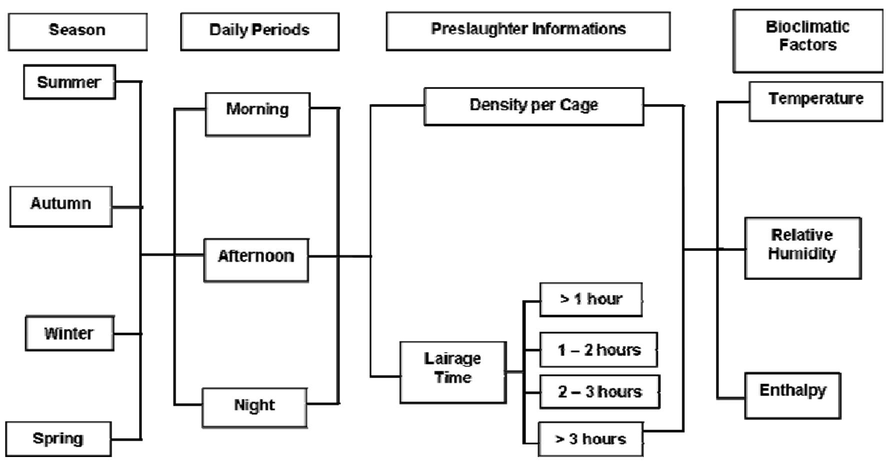

Figure 1. Flowchart of variables involved on pre-slaughter operations.

The productive loss variable used in this work was death on arrival at the abattoir (DOA), obtained by the slaughterhouse data set.

The experimental design was non-structured, explained by the observational study type, without disturbance in daily processing plant work. The statistical analysis used was a Double Generalized Linear Model, as proposed by Smyth and Verbyla (1999), an extension of Generalized Linear Models (GLM), which provides a framework for modeling the data mean and dispersion simultaneously. DOA's were treated as a response variable with Poisson distribution. The logarithmic function was assumed to make a link between the model linear predictor and the expected value of the response variable. The Wald statistic was used to test the hypothesis about β´s parameters; that is, to test the true contribution of these factors on the statistical model. This test consists of general inference of t-Student's test, widely used in GLM analysis. This analysis was processed using the statistical software R (R Development Core Team, 2006).

Results and Discussion

Regarding the annual variability throughout the day (Figure 2), it was observed in the night there was an average temperature of 18.1 °C, with a standard deviation of 3 °C. However, the variations were between maximum and minimum of 9 °C and 25 °C, approximately. At morning, there was an average of 20.3 °C, also with a standard deviation of 3 °C. The maximum and minimum during this period were 11 ºC and 27 °C, respectively. In the afternoon, the average recorded was 25.2 °C with a standard deviation of 3 °C, with maximum and minimum values of 18 and 33 °C, approximately.

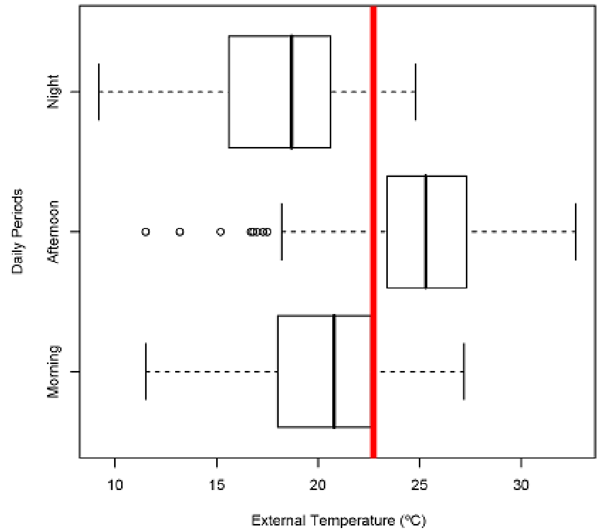

Figure 2. External temperature profile in relation with daily periods of 2006.
Wide line: average temperature of thermal comfort, as proposed by Macari and Furlan (2001).

The moisture variability during each period can be visualized through the Figure 3. At the night, the average humidity recorded was 86% with a standard deviation of 10 %. Similar values were found on morning, with an average of 80 % and a standard deviation of 11 % and during the afternoon, the average recorded was 63 % with a standard deviation of 17 %. Regarding desirable temperature and humidity values for broiler chickens, proposed by several authors (Milligan and Winn, 1964; Adams and Rogler, 1968; Curtis, 1983; Silva, 2000; Macari and Furlan, 2001), during the periods the animals were in heat stress conditions just on a few days throughout the afternoon, considering both the temperature and relative humidity. In the morning, concerning temperature values, the whole days were found within the range comfort, but it was not verified in relation to the relative humidity, because some days exceeded this limit. During the night, the chickens were in the stress range by cold in a few days, increased by high humidity in most of the year.

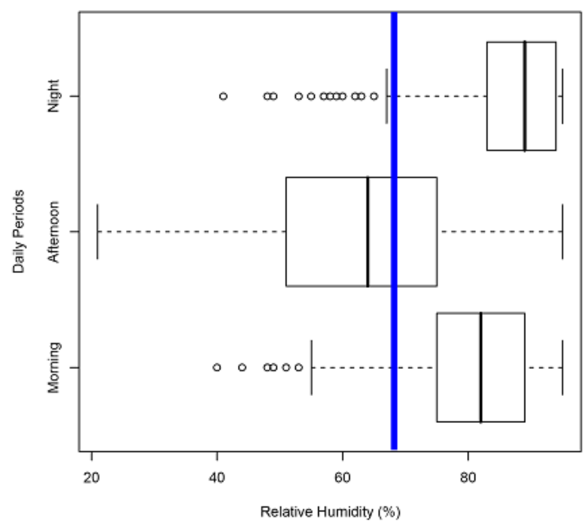

Figure 3 - External relative humidity profile in relation with daily periods of 2006.
Wide line: average relative humidity of thermal comfort, as proposed by Macari and Furlan (2001).

As seen in these figures, the temperature of the environment determines the best treatment given to the birds during the pre-slaughter operations, with emphasis on the condition of lairage on abattoirs. Given the feature of this work about the study of the historical data provided by the company, the effect of lairage internal temperature could not be examined. However, analysis of the variability of external temperature offers a legitimate approach to assess the internal environment due to the influence of the external environment inside the lorry.

As results of the statistical analysis, a double generalized linear model was adjusted, after the mean and dispersion model adjusting, for influence of lairage time in poultry mortality rates, related with external temperature, as indicated in eq. (1), for mean effect:

$$\hat{y} = \exp\{ - 5.01 * 10^{-2} + 3.25 * 10^{-2}\, t + 4.0 * 10^{-3}\, e - 9.63 * 10^{-5}\, te\} , \qquad (1)$$

where $\hat{y}$ = expected number of dead broilers; t = temperature and e = lairage time.

The Figure 4 shows the influence of thermal variability on mortality rates, when submitted to different lairage time intervals. The effect of the air environment of the lairage is quite significant in the range of lethal temperature (above 28 ºC, with lairage relative humidity around 75%). Birds are submitted to the external environment, especially in the loading and transport, aggravated with the high density per cage, where recorded temperatures are often greater than the external environment. The condition of heat stress by severe heat is reduced on the lairage with environmental control, where it is expected that the temperature is less than the external temperature. Given the heterogeneity between the internal and external layer of boxes in the truck, holding birds on an environmentally controlled lairage for a longer period is essential. However, in thermal comfort band, efficiency of environmental control is reduced gradually until they reach a level as to the variation in lairage time, on situation of thermal comfort for the birds (below 21 °C, relative humidity around 75 %). Due the transport under comfort situations, the mortality rates are not influenced by the thermal condition of lairage module.

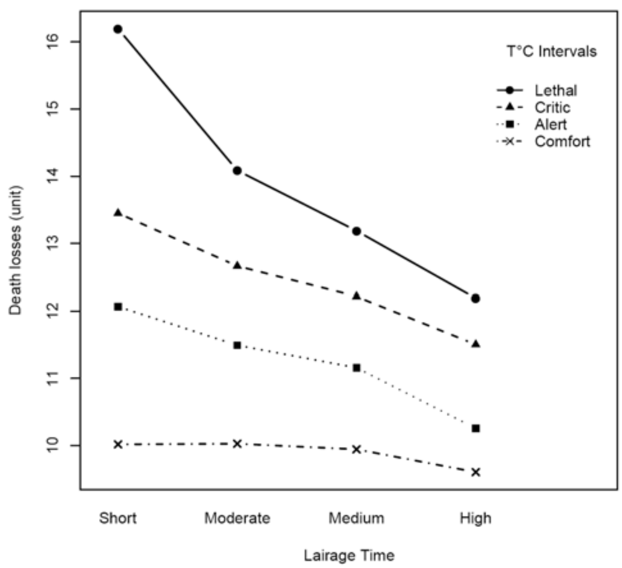

Figure 4 – Interaction between lairage time and temperature range, on the expected number of dead birds. Short: less than 1 hour, Moderate: 1- 2 hours, Medium: 2 - 3 hours, High: more than 3 hours. Temperature ranges: Comfort: less than 21 ºC; Alert: 22 – 24 ºC; Critical: 25 – 28 ºC; and Lethal: more than 28 ºC.

Ritz et al. (2005) reported that the environmental temperature has great influence on mortality at the stage of lairage, which increases the concern by the adoption of environmental control, through a waiting time that allows the birds to return to thermal balance, and therefore enhance the survival of the load. Improving on this point, Furlan et al. (2000) found satisfactory results in the first 10 minutes, concerning the broilers body temperature, with the gradual increase wind speed, when the temperature was high (above 29 ºC) and average relative humidity of 66 %. The enthalpy in this case was 75.6 kJ / kg of dry air, considered critical (Barbosa Filho et al, 2007) for the chickens of the 6th weeks old. However, even in heat stress, the authors related that the use of forced ventilation promotes a cooling towards the core to the periphery of the body of the bird, promoted by the loss of latent heat. Extending such results for the expected pre-slaughter, the chickens are thermally advantaged in an environment adequate air, within a space of time allowing for such heat exchange and thus reducing body temperature.

Therefore, in accordance with the recommendations proposed in Table 1, on condition of heat stress considered lethal, the lairage time to be adopted is the highest, to enable the birds return to the state of thermal balance through the air conditioning on lairage module with the waiting time. For the tracks alert and critical of the external temperature, it is recommended the Medium interval, due to reduced thermal load on the external environment. Already in the comfort range, it can be preferably used the Moderate interval of the waiting time, since the birds are transported in thermal comfort, with no need to be held for a long time on lairage module.

Table 1. Recommended values for lairage times related with each temperature interval and expected mortality rates.

Temperature Intervals	Lairage time (intervals)	% of expected mortality
Comfort	Moderate	0.29*
Alert	Medium	0.32*
Critic	Medium	0.32*
Lethal	High	0.32*

* Significant difference (P<0.005), derived by Wald Test.

Conclusion

For the different external temperature ranges, the best lairage time was between 1 to 2 hours when below 21 °C, between 2 and 3 hours in the range between 22 to 28 ºC and more than 3 hours for temperatures above 28 ºC.

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