This is not a peer-reviewed article.
Livestock Environment VIII
Proceedings of the 31 August - 4 September 2008 Conference (Iguassu Falls, Brazil)
Publication Date 31 August 2008
ASABE Publication Number 701P0408

Development and Validation of a Model to Compute the Surface Area of Broiler Chickens

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Abstract. *Surface area (A_s) of poultry is an important input parameter in heat and mass transfer calculation; thus, it was aimed with the present work to develop and to validate an empirical model to estimate the broiler chicken's surface area. Eighty-four Ross broiler chickens were used in this research, thirty-seven male and forty-seven female, with body masses covering all growth phase. In the laboratory, each randomly selected chicken had its dimensions (length, width and height) and body mass evaluated. The chicken skin with feathers was taken off to determine A_s. A portion of the data was used to fit the equation to estimate A_s and another portion was used to validate it. Results showed that the empirical equation to determine A_s was statically significant ($P<0.0001$) and it presented a coefficient of determination of 0.989, being subsequently validated via t test ($P>0.05$).*

Keywords. *Broiler chicken, Surface area, Empirical model*

Introduction

Among conventional methods to determine broiler surface area, can be cited the skin removal and the use of moulds based on gases that are adhered to animal surface for subsequent area calculation, and both require species sacrifice (Mitchell, 1930). Whatever the method, a fasting from 8 to 12 hours before slaughter is necessary, avoiding that amount of food in broiler gastrointestinal tract compromise the results (Mendes, 2001).

Mitchell (1930) developed an empirical model (equation 1) for calculating surface area of chickens of both sexes, based on data obtained through the use of moulds based on gases. According to the author, apparently equation 1 cannot be improved by introduction of a factor that defines nutrition condition of the animals.

$$A_S = 8.19 \cdot M_{c,chicken}^{0.705} \quad (1)$$

where:

A_s = superficial area of an specific animal (cm^2);

$M_{c,chicken}$ = body mass of an specific animal (g).

Leighton & Siegil (1966) cited by CIGR (1999) adjusted equation 2 for chickens, where A_s and M_c are in cm^2 and kg, respectively.

$$A_S = 0.10 \cdot M_{c,chicken}^{0.667} \quad (2)$$

Genetic improvement allowed toobtain broilers heavier, with higher daily weight gain, better feed conversion and higher meat deposition in carcass, resulting in better yield and a minor lodging time. With genetic improvement, the equations adjusted lose their efficiency, requiring that new equations are adjusted for broilers currently existent or even proposing new methods in order to improve the determination of broiler surface area.

Determination of broiler chickens surface area is important for calculation of heat and mass transfers between broilers and environment around them, enabling calculate ventilation and evaporative cooling systems, infer on broilers management through prediction of the amount of heat/humidity produced by broilers (Yanagi Junior, 2002; Aerts et al., 2003) and prediction of increased body temperature of these animals (YANAGI JUNIOR et al., 2001). Several models have been developed aimed at predicting heat transfer between the animal and the environment (Wathen et al., 1971; Mitchell, 1976; Mahoney & King, 1977; McArtur, 1991). Simmons & Lott (1996) state that, related with the environment, the specific interest is heat stress quantification to which the broiler is subject, providing that predictions can be used as support

producers decisions by the or implemented in controllers of heating or cooling systems at commercial poultry house. Medeiros (1997) proposed a model to predict heat or mass transfers in order to study thermal comfort conditions inside agricultural buildings. Severo et al. (2003) developed a computer program to predict thermal environment inside open poultry houses by globe and humidity index (ITGU), helping producers in the management of cooling system, allowing study of various production scenarios.

Methodology

Eighty four Ross broiler chickens from commercial poultry houses belonging to an integrator located in the region of Barbacena in the State of Minas Gerais, Brazil, were used in the experiment. The broilers, male and female, were captured in various poultry houses managed by the integrator, covering whole growth phases from 1 to 42 days, with one group for each week of creation (1 to 7 weeks).

The experiment was conducted at Structure and Environment Sector of Engineering Department (DEG) and at Animal Production Sector of Animal Science Department (DZO) of the Federal University of Lavras (UFLA). Part of broilers, aged less than 3 weeks, were transported and housed in Structure and Environment Sector, and the rest was housed in an experimental housing located at the Animal Production Sector of DZO. During the waiting period for tests, broilers received balanced diet and water ad libitum.

Determination of Surface Area

For determination of broiler chickens surface area by conventional method, each animal, selected randomly by age, was subjected to a fasting from 8 to 12 hours, in order that the food contained in digestive tract do not influence in body mass (Mendes, 2001 and Denadai et al. 2002). After fasting, broiler body mass was measured through a digital balance with accuracy ± 0.05 g; broiler was sacrificed and its skin with feathers were removed through a surgical scalpel.

Later, the skin with feathers was placed on plywood with 1 m of wide and 1 m of length, resulting in a total area of 1 m^2. The plywood was covered with black synthetic leather to create contrast between the background and skin, and the skin of feet and legs were fixed with pins. Laterally, rules that served as reference for digital images calibration were placed perpendicularly to detect any distortion between horizontal and vertical axes. Several images were captured through the top. Digital images were obtained using a digital camera with maximum resolution of 5.2 Mega pixels and digital zoom of 3 times), being imported to the program AutoCAD® 2006 (Autodesk, 2005) for calculation of surface area. Image adjusting to scale 1:1, in centimeters, was conducted through command SCALE and the area was determined by command AREA.

Adjust and validation of empirical model for calculating surface area and statistical analysis

Forty four broilers, male and female, with weight distributed along whole creation process, were used for empirical model adjust. Based on data of body mass and surface area or broiler area of a single foot and leg, empirical models were adjusted by sub-routine PROC REG of statistical program SAS® (SAS, 2001). The significance of models and coefficients of equations adjusted was evaluated by F and t tests, respectively. For validation, empirical models results were compared to measured surface areas by test t.

Results and Discussion

A preliminary statistical analysis found that there is no statistically significant difference between surface areas from male and female broilers chickens (test t, P = 0.1938). Soon, only one equation for surface area determination in function of broiler body mass was adjusted (equation 3), resulting in a value of determination coefficient (r^2) from 0.9886. Values followed by sign positive / negative (±) related with standard errors of each coefficient adjusted. Adjusted equation is statistically significant (test F, P <0.0001), providing average error of 6.34 ± 5.13 cm^2. Figure 1 illustrates behavior of surface area measured and estimated by equation 3, in which it's possible see a good correlation between these areas. As mentioned earlier, Equation 3 may be coupled with models of heat and mass transfer, such as those proposed by Yanagi Junior (2002).

$$As = 3.86 \pm 1.06\ Mc^{0.74 \pm 0.01} \quad (3)$$

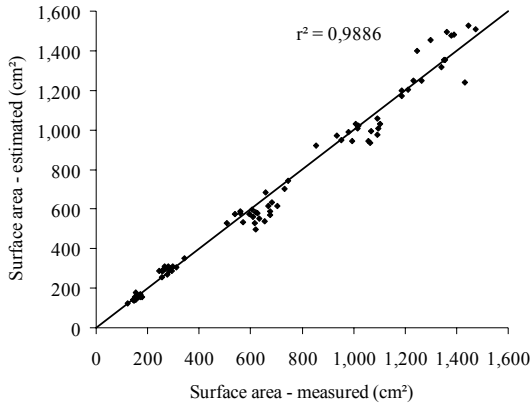

Figure 1. Profile of surface area measured and estimated by Equation 3.

According Figure 2, it verifies that surface area estimate by proposed model is lower than other models, and the difference increases with increasing chicken body mass. This fact probably is due to differences in physical structure related with genetics evolution or with own lineage used in evaluations, and due to differences in the methodologies employed for surface area determination. Among differences due to physical structure are included mainly sizes of comb and wattles and quantity and distribution of feathers.

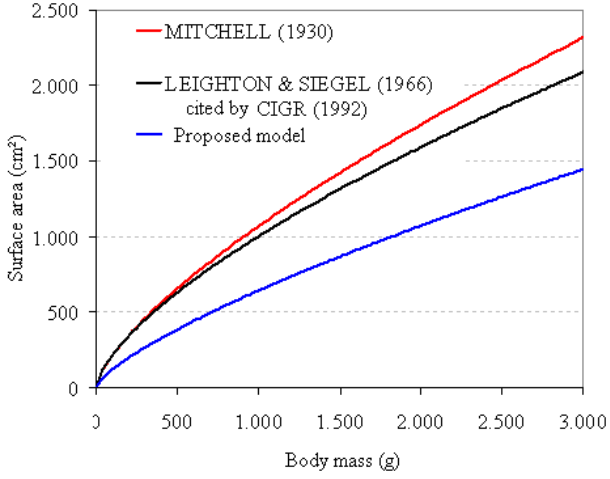

Figure 2. Surface area estimated through models proposed by two authors and by Equation 3 of this work.

An empirical equation to estimate surface area of a single foot and leg of a broiler chicken (equation 4) was adjusted due to commercial importance of skin as raw material for production of clothing and accessories (Tinôco et al., 2003; Brazil Alimentos, 2007). Adjusted equation was statistically significant (test F, P <0.0001), with r^2 equal to 0.9729. Due to size of combs and wattles of broilers used in this work are small and not developed, calculation of its area was negligible.

$$A_{pp} = 0.42 \pm 1.09\ M_c^{0.69 \pm 0.01} \quad (4)$$

where:

A_{pp} = surface area of a single foot or leg (cm^2)

Figure 3 shows the profile of surface areas measures of feet and legs of broilers and values estimated by Equation 4, with average error of 10.28 ± 7.53 cm^2.

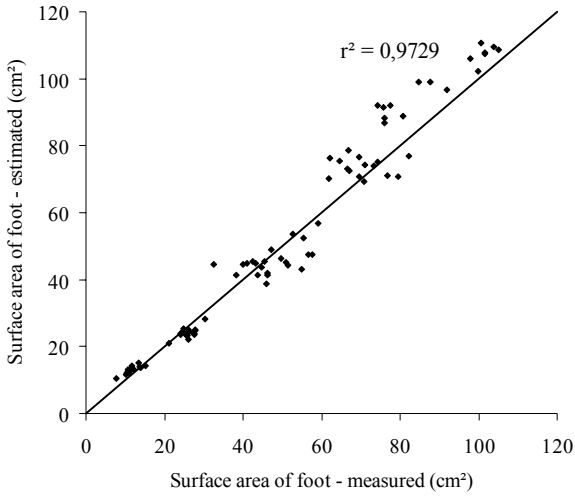

Figure 3. Profile of surface areas measured and estimated by the Equation 4 of a single foot and leg of a broiler chicken.

Among leather types used as raw material, the fish's skin has been processed in order to obtaining high economic value with its tanning process and its traction resistance (Souza, 2004; Souza et al., 2006). Leather of ostrich feet has already been sold, depending on condition and quality of product (UFV, 2007). Then, equation 4 may help to define the broiler chickens quantity in function of their body mass necessary to make particular product using leather of their feet and legs.

Conclusions

Results allowed to conclude that: a) the method used to obtain bird surface area and the surface area of a single foot and leg, is appropriate and feasible to be applied to broiler chickens, and b) empirical equations adjusted for determination of surface area and a single foot and leg of broiler chickens were statistically significant and showed values of determination coefficient of 0.9886 and 0.9729, respectively.

Acknowledgements. The authors acknowledge FAPEMIG, CAPES and Nogueira Rivelli Alimentos Company for support to this research.

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