Fasted Heat Production and Body Composition of Broiler Breeder Females Ranging From 5 to 50 Weeks of Age

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Story in Brief

Broiler breeder females, ages 5 through 50 wk at 5-wk intervals, were examined to determine fasted heat production using indirect calorimetry and body composition using dual-energy X-ray absorptiometry and ultrasound. Examination of the relationship among these measurements revealed high correlations. Regression analysis was performed to generate equations to estimate heat production based on body composition determined with X-ray absorptiometry and to estimate lean body mass and total breast weight based on measurements taken with the ultrasound. These equations may be useful in monitoring changes in bird body composition and heat production. This information could be used to make adjustments in feeding regimens to enhance productivity.

Key Words: Broiler Breeders, Heat Production, Body Composition

Introduction

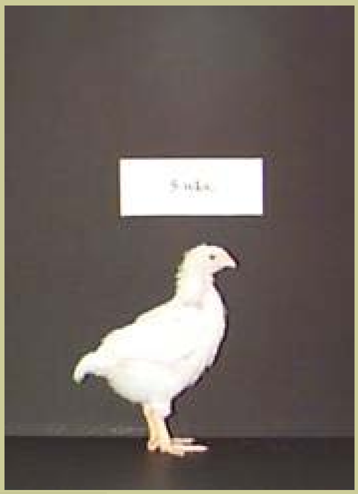
Breeder management programs include restrictive feeding regimens with the purpose of reaching a specified fed body weight (BWT) at specific ages (Cobb-Vantress, 1998). The goal is to match BWT and sexual maturity in order to attain acceptable reproductive performance (Robinson et al., 1993). However, research has shown that body composition (BC), rather than BWT alone, may be a better indicator of subsequent reproductive performance (Soller et al., 1984). That BC has an effect on heat production (HP) has been previously reported (Spratt et al., 1990). Bird energy needs may be determined by measuring HP through indirect calorimetry. Thus, the ability to determine BC in live birds could provide a basis for estimating HP. Historically, the determination of lean and fat proportions in the live animal is difficult at best. However, technological advances have provided methods that provide non-invasive methods of monitoring BC changes in live animals. Two of these are dual-energy X-ray absorptiometry (DEXA) (Mitchell et al., 1997) and ultrasound (U/S) (Smith et al., 1989).

Materials and Methods

In order to simultaneously attain females of the appropriate ages, commercial broiler breeder parent farms were selected to supply 10 age groups (1/farm) of Cobb females for a total of 105 birds. Bird ages ranged from 5 through 50 wk at 5-wk intervals (Figure 1). Birds were selected to fall within ± ¼ lb of the target live fed BWT. Targets were met for all age-live weight combinations with two exceptions. The 10-wk group live weight was lowered in order that the needed number of birds could be acquired and, due to non-availability of 30-wk-old birds, 32-wk-old birds were selected using the 30-wk target weights.

Figure 1: Examples of three ages of broiler breeder females used in this study

5 wk of age | 25 wk of age | 45 wk of age



Upon arrival at the research facility birds were held overnight in the dark at 72^0 F and then placed in 60 individual open-circuit metabolic chambers the following morning. Chambers were housed in three light- and temperature-controlled rooms (20/room). The lighting schedule was the same for all three rooms; three temperature levels were used, 60, 72 and 90^0 F. The gas concentration of O_2 and CO_2 exiting the chambers was recorded two to three times per hour for each chamber. An equation (Brouwer, 1965) was subsequently used to estimate HP from the O_2 consumption and CO_2 production values, this is known as indirect calorimetry. A 3-d fed period, with feed and feeding levels duplicating those of the source farm, was followed by a 44-h fast. Bird weights were recorded four times during the trial. All birds had free access to water during the entire trial. Upon completion of metabolic measurements, all birds were humanely euthanized. Each bird was subsequently scanned with both DEXA and U/S.

Statistical analysis included determination of the correlation coefficient (r) among the determined body composition measurements (breast cut-out weight, abdominal fat weight) and the indirect methods (DEXA, U/S). Linear regression was applied to test relationships with the correlation coefficients used to judge potential value for estimating the determined composition. In this manner the non-invasive methods of determining BC could be judged and compared. Non-linear regression was applied when the data revealed a quadratic rather than linear relationship between variables. Since BC is known to have an impact on HP, and BC is made up of more than one variable, multiple regression was used to relate HP estimates with lean and fat tissue mass. All analyses were performed using procedures of SAS (SAS Inst. Inc., Cary, NC) CORR (correlation) and REG (linear, non-linear and multiple regression).

Results and Discussion

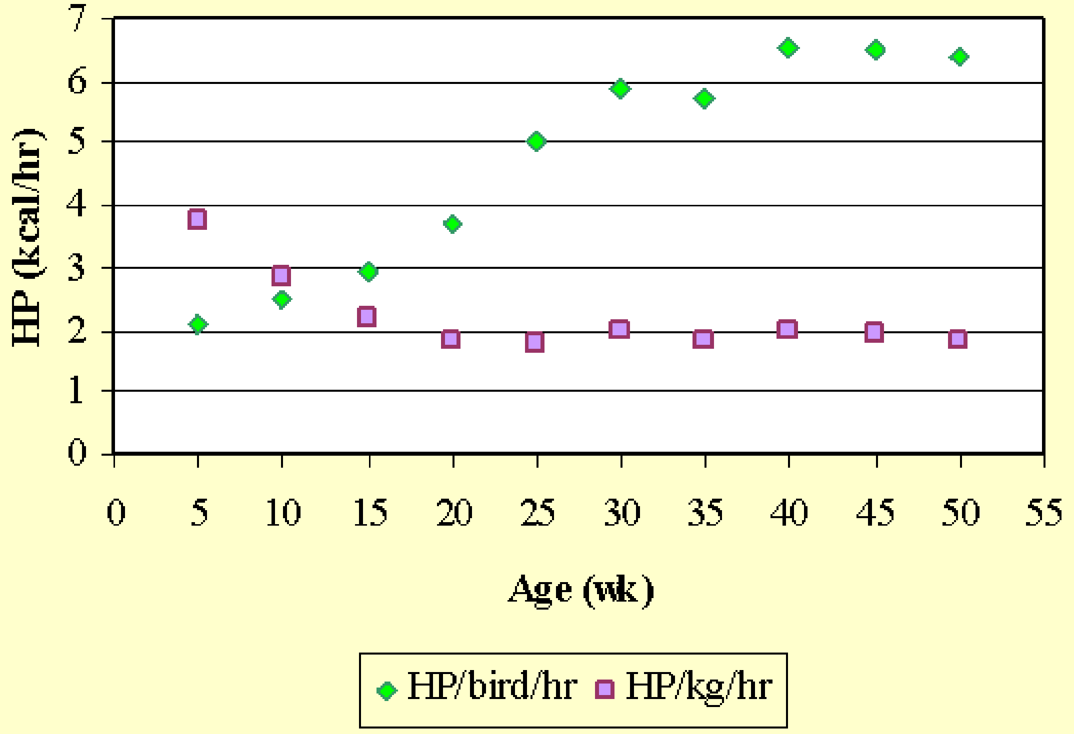


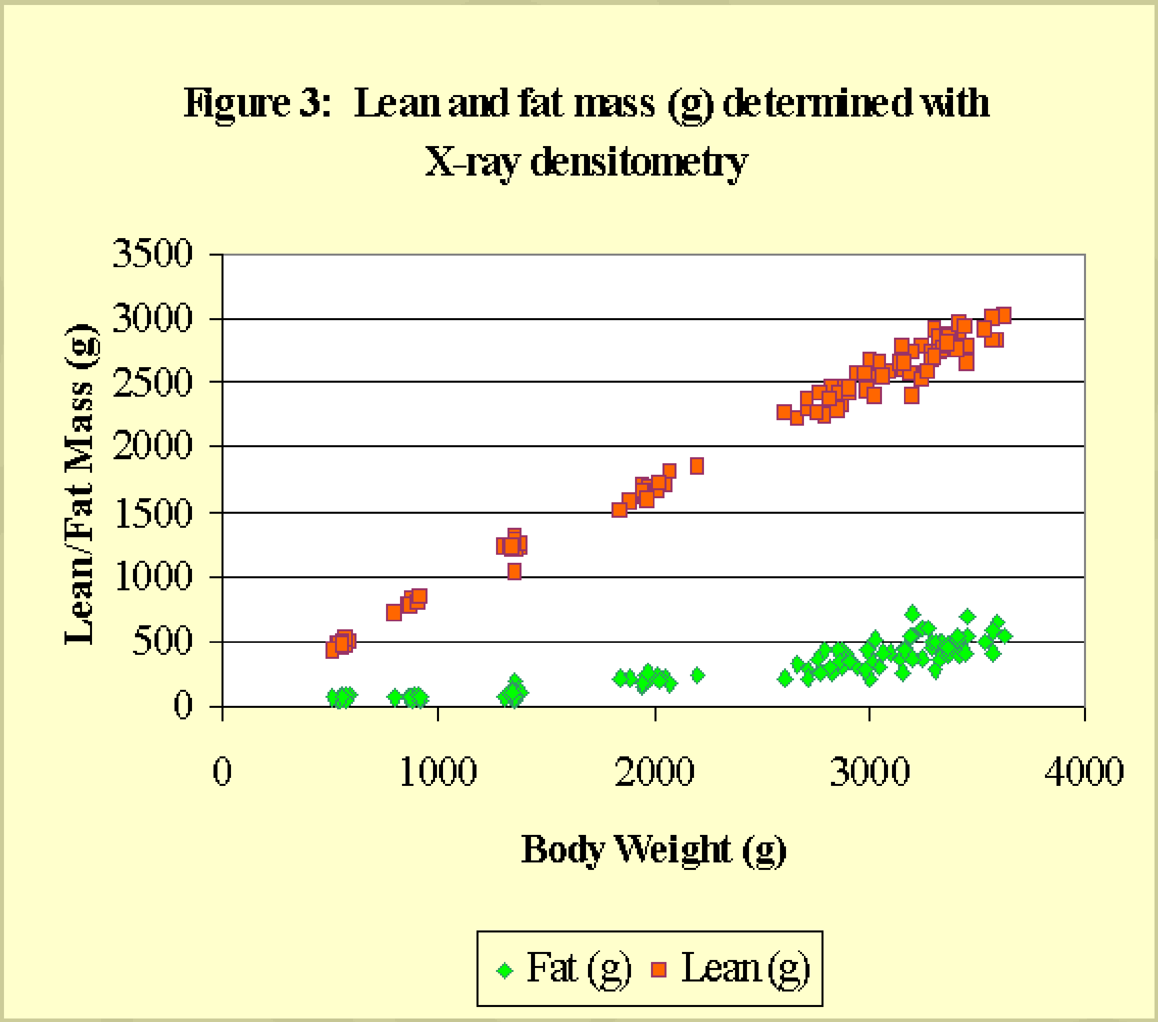
Figure 2: Fasted heat production (kcal/hr) observed in broiler breeder females 5 to 50 wk of age

As bird age increased HP (kcal/bird/hr) increased (Figure 2). However, when adjusted for BWT, HP (kcal/kg/hr) decreased. The increase in total HP per bird as bird age increases is primarily due to the increase in body size. The decrease in HP on a per unit BWT basis agrees with the generally accepted theory that larger animals have a lower HP per unit BWT than do smaller animals (Blaxter, 1989).

X-ray absorptiometry scans revealed a linear relationship between lean tissue mass and BWT and a quadratic relationship between fat mass and BWT. Regression of lean and fat mass as determined with DEXA on body weight (Figure 3) yielded the following predictive equations

Predicted Lean (g) = 78.6451 + .8084 BWT (P<.0001; r^2 = .98)

Predicted Fat (g) = 67.2917 - .0312BWT + .000045 BWT^2 (P<.0001; r^2 = .91)



Comparison of ultrasound measurements of the deep breast muscle that lies along the keel to the actual weight of cutout breast tissue and to whole body protein as determined by X-ray absorptiometry revealed a high correlation coefficient (r) among these measurements (Table 1). However, measurements taken of the abdominal fat pad using U/S were very poorly correlated with actual abdominal fat weight (r<.25) and with fat mass determined by DEXA (r<.10).

Table 1: Correlation coefficient (r) found among breast cutout weight (WT), lean tissue mass as determined by X-ray absorptiometry (DEXA), and ultrasound (U/S) measurements of breast muscle

r-value	Breast cutout WT	DEXA lean tissue WT	U/S breast measures
Breast cutout WT	1.00000 0.0	.98820 0.0001	.96509 0.0001
DEXA lean tissue WT	.98820	1.00000	.96452

	0.0001	0.0	0.0001
U/S breast measures	.96509 0.0001	.96452 0.0001	1.00000
Note: all P-values for above correlations were P<.0001			

Since there were high correlations present, equations for estimating total breast weight (BrstWT) and total lean tissue weight (LTWT) were developed using regression analysis based on U/S measurements of the deep breast muscle.

Estimated total BrstWT (g) = -18.577 + .538 (U/S measurements of deep breast muscle) ($P<.0001$; $r^2 = 0.94$)

Estimated total LTWT (g) = 258.14 + 2.300 (U/S measurements of deep breast muscle) ($P<.0001$; $r^2 =.93$)

Multiple regression of fasted HP on lean and fat tissue mass as determined by DEXA yielded an equation that estimates fasted HP.

Fasted HP = 1.507586 + .000976(lean tissue wt) + .004524(fat wt) ($P<.0005$; $r^2 = .93$)

Implications

It appears that measurements made with U/S and DEXA may be reliably used as a basis for developing predictive equations. Heat Production in broiler breeder females may be estimated using the lean and fat tissue masses determined with DEXA. Total breast weight and total body protein may be estimated based on U/S measurements of the deep breast muscle. Since these measurements can be made without sacrificing the birds, data on birds can be gathered over time with said data then being used to predict future body composition and heat production. This information could allow adjustments in feeding regimens that may result in higher productivity and, ultimately, increased income for the producer.

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