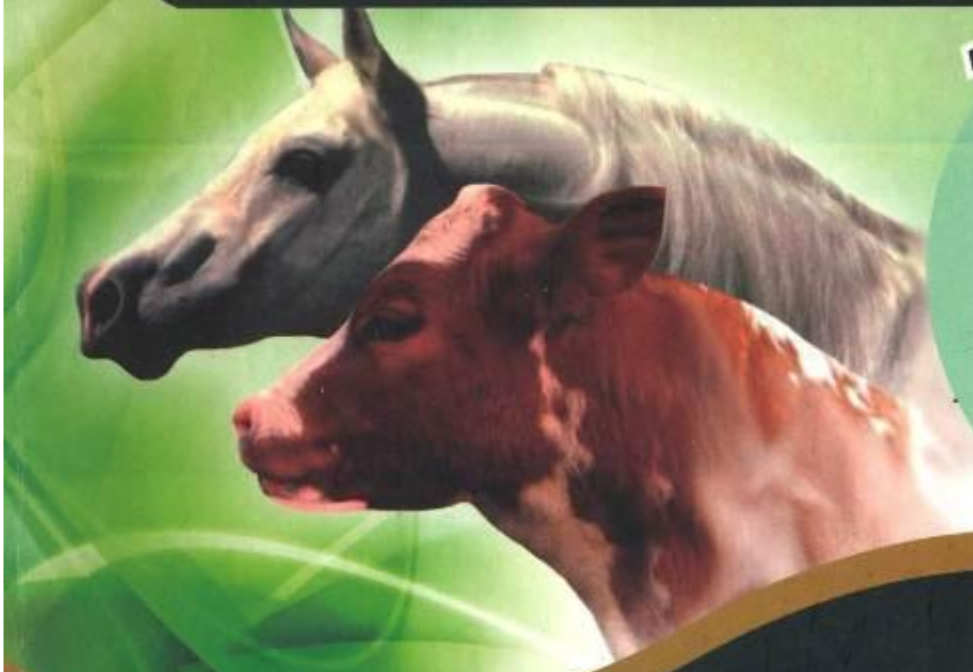
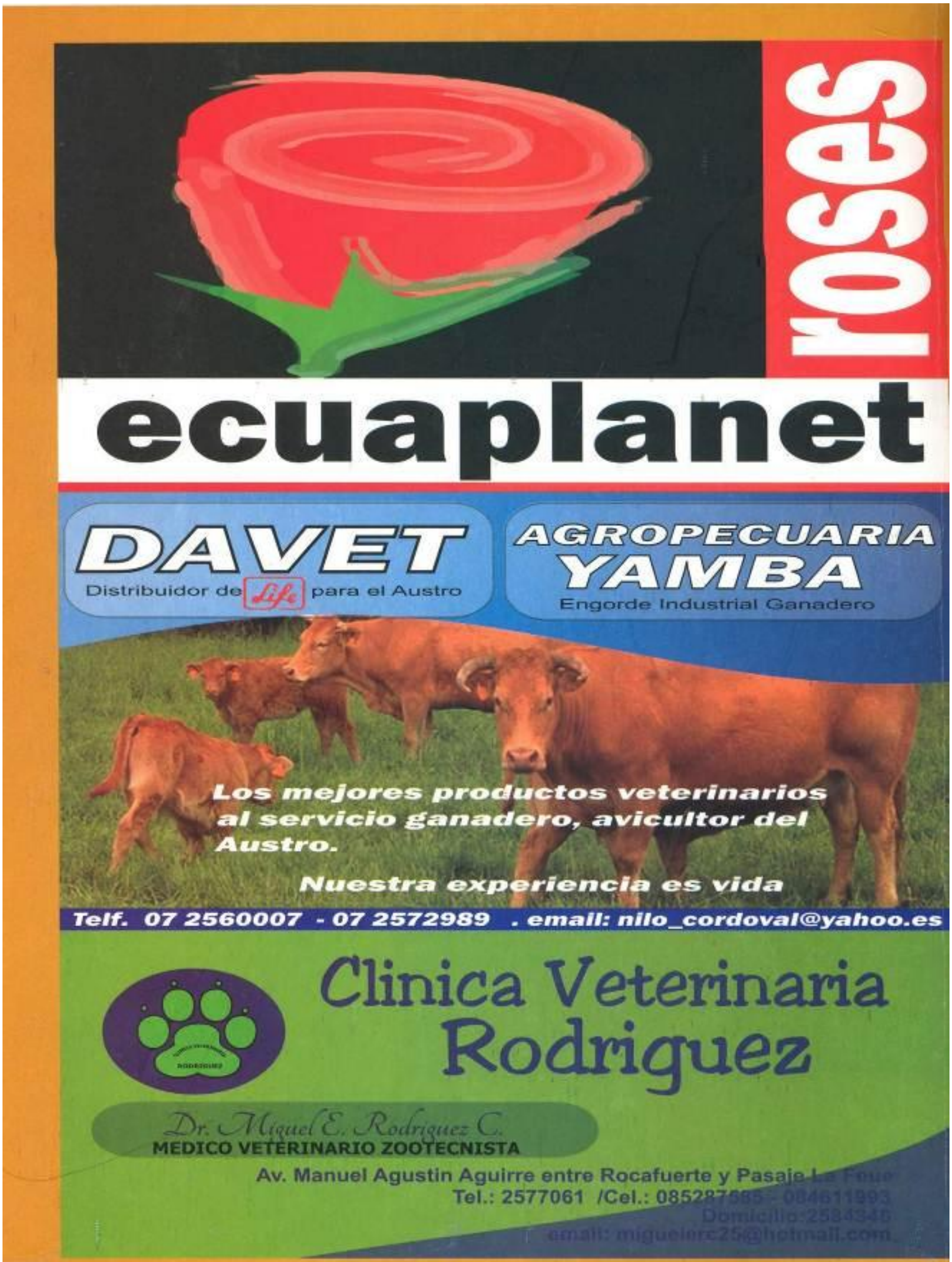
REVISTA DE MEDICINA VETERINARIA Y ZOOTECNIA

1 VOLUMEN
1 NÚMERO



2012

LOJA - ECUADOR



IEPI Derechos de Autor:
Nro. cue-000816

ISBN: 978-9942-11-360-3

Revista
DE MEDICINA VETERINARIA Y ZOOTECNIA

Universidad Nacional de Loja
Carrera de Medicina Veterinaria y Zootecnia

Revista de Medicina Veterinaria y Zootecnia
Volumen 1, Nro. 1
2012
IEPI Derechos de Autor Nro. Cue-000816
ISBN:978-9942-11-360-3

Editor responsable
Dr. Tito Muñoz Guarnizo
E.mail: titoflaco@yahoo.com
Dirección: Ciudadela Universitaria "Guillermo Falconí Espinosa"
La Argelia, Loja-Ecuador

Portada
Impresión: Andinagrafika
Telf.: 07 2577401

Loja-Ecuador

CONTENIDO

ENERGY REQUIREMENT FOR MAINTENANCE AND EGG PRODUCTION FOR BROILER BREEDER HENS

REQUERIMIENTO DE ENERGÍA METABOLIZABLE PARA MANTENIMIENTO, PRODUCCIÓN DE HUEVOS, EN REPRODUCTORAS PESADAS.

Autores:
Reyes, M.E[1]., Salas, C[2]., and Coon, C. N[3]

[1]Universidad Nacional de Loja, Loja, Ecuador
Ciudad Universitaria Guillermo Falconí Espinosa "La Argelia" - PBX: 072547252 - Casilla Letra "S".
[2]Escuela de Zootecnia, Universidad de Costa Rica
[3]Center of Excellence for Poultry Science. University of Arkansas. Fayetteville, AR 72701

Publicado en

International Journal of Poultry Science 10 (12): 913-920, 2011
ISSN 1682-8356

ABSTRACT

Mathematical modeling is an accounting tool that can be used for predicting the nutritional requirements for poultry with different genetic strains, environments and stages of meat gain or egg production. Models are also useful for describing or predicting the animal's production process. Modeling the daily ME requirement of broiler breeder hens requires partitioning metabolizable energy (ME) requirements into maintenance, egg mass, and body weight gain. Determining the daily energy requirement for maintenance and egg production in breeders requires separating the daily energy needs for egg production from energy needs of maintenance. The objective of the research reported herein was: 1.) to obtain information about body tissue changes and egg composition for breeders being fed specific intakes of ME in a set environment and 2.) to evaluate a technique for partitioning the metabolizable energy (ME) requirement into maintenance and production for each individual breeder. An estrogen antagonist, TAMOXIFEN ([Z]-1-1[p-Dimethylaminoethoxyphenyl]-1,2-diphenyhl-1butene) (TAM), was used to separate the ME needs into two periods: laying and non-laying. Broiler breeder hens were provided TAM to stop egg production and their individual ME requirement for maintenance determined. Each broiler breeder resumed egg production when TAM was withdrawn and the ME requirement for egg production and BW gain determined. The estimated ME required for maintenance for breeders (ME_m) housed in a constant 21C was 98.3 kcal/kg$BW^{0.75}$, ME for gain was 5.6 kcal/g and ME for egg mass was 2.4 kcal/g. The energy efficiencies for protein gain (κp), fat gain (κf) and egg calories (κe) were 34%, 79% and 65.7%, respectively. The use of TAM provided an opportunity to estimate breeder maintenance requirements and reduce the interdependence in estimating factorial coefficients while partitioning production energy needs.

Keywords: metabolizable energy, broiler breeders, tamoxifen, energy efficiency, modeling

RESUMEN

El modelaje matemático es una herramienta de contabilidad que puede ser usada para predecir los requerimientos nutricionales de las aves de diferente línea genética, ambientes, etapas de ganancia de peso o de producción de huevos. Los modelos también son útiles para describir o predecir el proceso productivo del animal. El modelaje de los requerimientos diarios de energía metabolizable (EM) para reproductoras pesadas necesita particionarlos en requerimientos para mantenimiento, masa de huevos y ganancia de peso corporal. Determinar el requerimiento diario para mantenimiento y producción de huevos en reproductoras requiere separar las necesidades energéticas diarias para producción de huevos del requerimiento para mantenimiento. Los objetivos de esta investigación fueron: 1) obtener información sobre el cambio en los tejidos corporales y la composición de los huevos en reproductoras alimentadas con cantidades específicas de EM en un ambiente determinado y 2) evaluar una técnica para particionar el requerimiento de EM en mantenimiento y producción para cada ave. Se utilizó un antagonista del estrógeno, TAMOXIFEN ([Z]-1-1[p-Dimethylaminoethoxyphenyl]-1,2 diphenyhl-1butene) (TAM), para separar las necesidades de EM en dos periodos: producción y fuera de producción. Las gallinas recibieron TAM para que detengan la producción de huevos y su requerimiento de EM para mantenimiento pudo ser determinado. Cada reproductora reinició la producción cuando TAM fue retirado, así se pudo determinar los requerimientos de EM para producción. El requerimiento estimado de mantenimiento para reproductoras (EM_m) encasetadas a una temperatura constante de 21C fue de 98.3 kcal/kgPV$^{0.75}$, EM para ganancia de peso fue de 5.6 kcal/g y EM para masa de huevos, de 2.4 kcal/g. La eficiencia energética para ganancia de proteina (κp), ganancia de grasa (κf) y calorías de los huevos (κe) fueron 34%, 79% y 65.7%, respectivamente. El uso de TAM brindó la oportunidad de estimar los requerimientos para mantenimiento y reducir la interdependencia en la estimación de los coeficientes factoriales mientras se particiona la necesidad energética para producción.

1. INTRODUCTION

Feed costs represent around 70% of the poultry production costs. Nutritional requirements for any nutrient needs to be fully understood in order to know the potential risk in production when trying to reduce feed costs and develop appropriate margins of safety. Research in the area of the energy requirements has been focused on estimating the energy requirements for laying hens while for broiler breeder hens the information is slowly being developed. Metabolizable energy (ME) requirements for broiler breeder hens are higher than for commercial layers primarily because of their larger body size. Nevertheless, in many cases the maintenance energy requirement of metabolizable energy (MEm) has been extrapolated from studies conducted mainly with Leghorn type hens (Leeson, 2003).

The accurate determination of energy utilization coefficients needed for modeling the ME requirement for broiler breeder hens is complex due to the interdependency among factors involved. Sakomura et al (2011), reported on the current estimation methods for nutritional requirements (dose-response or factorial methods) and elaborated on the need to define nutrient partitioning, intake, and the animal's growth potential in these models. Nutrient assignment for maintenance, growth and production determines the nutrient partitioning, where maintenance is a priority, and the remaining available nutrient is used for growth and production.

In order to develop factorial breeder ME requirements, estimates of ME for maintenance, egg synthesis, and tissue gain are needed. An estimate of ME needed for egg formation requires obtaining specific breeder information on the amount of energy contained in eggs and also the amount of energy in breeder BW gain. The use of non-laying breeder hens should reduce the errors in accurately calculating the maintenance requirements for broiler breeder hens by eliminating the interfering factors involved in production. An estrogen antagonist, TAMOXIFEN® ([Z]-1-1[p-Dimethylaminoethoxyphenyl]-1,2-diphenyhl-1butene) (TAM) has been shown to stop egg production for White Leghorn layers (Jaccoby, 1992). Zhang and Coon (1997)previously utilized TAM to model ME requirements for commercial layers by injecting TAM intramuscularly to stop egg productionand then separate the ME needs into laying and non-laying periods. TAM is a trans-isomer of triphenylethylene that blocks estrogen when administrated in high doses to laying hens. TAM acts as an absolute estrogen antagonist in the avian oviduct that competes for estrogen receptors; as a result, egg production is suppressed.

The objectives of the present study were1.) to determine if TAM may serve as a tool for reducing the interdependence in estimating factorial coefficients for breeders and 2.) to determine the energy requirement for breeders for maintenance, body weight gain, and egg mass output.

2. MATERIALS AND METHODS

Birds and management

A total of 60 Cobb 500 broiler breeder hens, 53 weeks old were individually housed in an environmentally controlled room in individual broiler breeder female cages. Temperature was kept constant at 21°C throughout the trial. The lighting regimen was 16 h light and 8 h darkness per day. Initially, ten birds were randomly selected and slaughtered (by using CO_2) and frozen at -4 °C until they were processed for comparative carcass analysis. The broiler breeder hens that continued in the feeding experiment were injected intramuscularly with doses of TAM (5 mg/kg body weight) in corn oil at days 1 and 4 in order to stop egg production.

A diet containing 2798 kcal AME_n/kg and 14.6 % of crude protein (CP) was fed to breeders at a level of 110 g/bird/d during the non-laying period, and a level of 136 g/bird/d during the laying period (Table 1). Individual body weight was recorded daily starting on day 5 of the trial for a period of 9 weeks (Table 2). Feed residuals for each breeder were recorded weekly.

Table 1. Composition and analysis of diet

Ingredients	Composition (g/kg)
Corn grain 7.25 % protein	66.47
Soybean meal solvent ext. 47.5 % protein	22.26
Choline Chloride 60%	0.070
Alimet88	0.11
Dicalcium PO_4	1.62
Ethoxyquin 66%	0.02
Poultry fat	1.43
Limestone	7.36
Kemin Mold Curb 50% propionic acid	0.05
Salt	0.39
Trace mineral CVI Breeders [A]	0.06
CVI Breeder premix 2960 [B]	0.15
Crude protein PCT	15.5
Calculated metabolizable energy (kcal/kg)	2816
Analyzed AME_N [C]	2798
Calculated crude protein [D]	15.5
Analyzed crude protein	14.6

[A] *Provided per kg of diet: Mn 120 mg; Zn 120 mg; Fe 60; Cu 12 mg; I 1.2 mg; Mg 31.8 mg; and Ca 855.*

[B] *Provided per kg of diet: vitamin D_3 4.95 KICU; vitamin A 14.7 KIU; vitamin E 80.7 IU; niacin 94.7 mg; D-Pantothenic acid 39.2 mg; riboflavin 21.1 mg; pyridoxine 12.4 mg; thiamine 6.3 mg; folic acid 3.9 mg; biotin 0.44 mg; 29.7 MCG.*

[C] *AME_N= kcal/kg.*

[D] *Crude protein= %*

The first ten hens that resumed egg production after TAM was withdrawn were slaughtered by using $CO_2$and kept frozen at -4 °C until carcass analysis was conducted. All eggs were collected and weighed daily, and refrigerated for further analysis. Shell-less eggs were counted and their weight was estimated from the average weight of all eggs laid by that breeder hen during the total laying period. Three eggs from each broiler breeder hen, collected at the beginning, middle, and end of the 9 wklaying period, were used to determine fat and nitrogen content. Using an egg separator, yolk and albumen were separated, weighed and refrigerated for proximate analysis. Yolks were first rolled on a paper towel (to eliminate the remaining albumen), poured in a plastic cup, and weighed. Shells were washed, wiped, and put in individual plastic cups overnight to dry. Wet albumen weight was calculated by the following formula:

Wet albumen weight = Egg weight – (wet yolk weight + dried shell weight)

Pooled wet yolk and pooled wet albumen samples were freeze-dried for 7 and 9 days, respectively. Egg shells also were freeze dried for four days. Dried yolks and albumen samples from the same individual breeders were weighed and finely ground in a mortar and pestle in order to obtain homogeneous sub-samples for fat and protein content analyses.

At the end of the trial, all birds were slaughtered and froze at -4 °C for future carcass composition analysis. Individual carcasses of all the sampling periods were autoclaved and homogenized in a blender to obtain homogeneous whole-body samples. Homogenized samples were frozen at -4 °C and then freeze-dried for 7 days for further analysis.

Apparent metabolizable energy (AME_n) was determined for ten randomly selected birds. Two percent acid insoluble ash (Celite) was added to the diets and used as a marker. Breeder hens were fed the diet containing the insoluble marker for ten days. Excreta were collected on trays at days 5 and 10, frozen, and freeze-dried prior to analysis. Diets and excreta were analyzed for acid insoluble ash and nitrogen by standard AOAC procedures (AOAC, 1990). The gross energy of diets and excreta were measured using a Parr adiabatic bomb calorimeter. The metabolizability of nitrogen and energy (AME) were determined using the measured acid insoluble ash marker along with the determined nutrients in both the feed and excreta, and using the equation of Scott and Balnave (1991).

Energy Retention calculations

Pooled freeze-dried yolks and albumen, and whole-body samples were analyzed for dry matter (DM), nitrogen, and ether extract. Nitrogen was analyzed on freeze-dried samples by Method 990.03-Combustion Method of the AOAC (AOAC, 1995) and fat was analyzed by Method 920.39 C (AOAC, 1990). Carcass energy was estimated by multiplying fat and protein content on a dry matter basis by 9.3 and 5.4 kcal, respectively, and then adding up those two values (Mayes, 2000).

Energy retained (ER) during the non-egg production period was measured by subtracting carcass energy from non-laying breeder hens at the beginning of the maintenance feeding study (BMP) from carcass energy from breeders at the end of the maintenance period (EMP). ER as protein (ER_p) was calculated as the difference of initial protein content (DM basis) of BMP and final protein content (DM basis) of EMP and was multiplied by 5.4 (Mayes, 2000). ER in body as fat (ER_f) was calculated as the difference of initial fat content of BMP and final fat content of EMP, on dry matter basis, and was multiplied by 9.3 (Mayes, 2000). Total ER was obtained by the sum of ER_p and ER_f. ER was later used to calculate the efficiency of energy utilization for body weight gain (κg) with the following formula:

κg = ER (kcal)/ME consumed above maintenance (kcal) x 100

Partial efficiencies for fat retention (κf) and for protein retention (κp) were calculated from simultaneous equations using the known values of: ERp, ERf (measured in carcass); κg; ME_g; and the constant values of 9.3 and 5.4 (gross energy available from 1 g of fat and protein), respectively (Mayes, 2000). Efficiency of energy utilization for egg mass synthesis (κe) was calculated by dividing energy used for egg synthesis: (ME_e) = [MEintake- (ME_m + ME_g)]

by the energy output in egg: (EOE) = GE concentration in the hen's egg x egg mass output. Energy for body weight change (ME_g) was calculated as: ME_g = (MEintake $-ME_m$)/BWΔ, where BWΔ = body weight change (g/d).

Statistical Analysis

Standard statistical procedures were used to obtain linear regression equations for predicting ME_m (Mendenhall and Sincich, 2003). Regression analyses and polynomial equations were fitted using the least squares procedure of JMP IN® Software (SAS Institute) (1999-2000a). Data were subjected to a one-way ANOVA using the General Linear Models procedure of SAS® (1999-2000b). When a significant F statistic was detected, means were separated using Tukey's test at 5 % of probability (Freund and Wilson, 1997).

3. RESULTS AND DISCUSSION

Egg production (EP) dropped to zero five days after the first TAM administration. Eighty percent of the hens resumed egg production three weeks after TAM injections. Only 5% of broiler breeder hens did not resume egg production before the 9 wk experiment was terminated.

ME for maintenance

The energy requirement for maintenance was calculated using the individual data collected during the non-laying period in order to reduce interdependence among factors involved in egg production. The linear relationship between body weight change (BWΔ) (g/hen/d) and ME intake (kcal/kgBW$^{0.75}$) provided the ME_m at the intercept, with the *x*-axis being ME intake at 0 body weight change (Figure 1). Data from the last 3 days of the non-laying period were not used in calculating ME_m and ME_g to avoid erroneous estimations due to physiological processes involving egg production. The estimated ME_m of broiler breeder hens housed at thermo neutral temperatures (21°C) was 98.3 kcal/kgBW$^{0.75}$.

Reported ME_m requirements for broiler breeders reared in individual cages at thermo neutral temperatures (21 to 23°C) are lower than that found in the present study. Johnson and Farrell (1983) suggested a daily allotment of 87.2 kcal/kgBW$^{0.75}$ for group-caged broiler breeder hens 42 to 49 weeks of age. A similar ME_m requirement (87.7 kcal/kgBW$^{0.75}$) was reported by Spratt et al. (1990) for caged Hubbard broiler breeder hens, 28 to 36 weeks of age. Sakomura (2001) reported a requirement of 91 kcal/kgBW$^{0.75}$ of ME for maintenance for Hubbard Hy-Yield broiler breeders housed in individual cages. Rabello et al. (2004) found a maintenance requirement of 91.5 kcal/kgBW$^{0.75}$for broiler breeders in cages kept at 21°C. Rabello et al. (2006) determined the ME_m of broiler breeders in floor pens was 112.8 kcal/kgBW$^{0.75}$. Romero et al. (2009a, 2009b) reported higher ME_m for broiler breeder hens in cages(104.4 to 115.6 kcal/kgBW$^{0.75}$) compared to the estimate for ME_m(98.3 kcal/kgBW$^{0.75}$) for Cobb 500 breeders in the present study. The differences in ME_m reported by previous research may be attributed to the breeder strain utilized, differences in the methodology, type of diet, environment, and duration of the studies. For instance, Johnson and Farrell (1983) and Spratt et al. (1990) measured heat production (HP) using indirect calorimetry, whereas Sakomura (2001) and Rabello et al. (2006) used the comparative slaughter technique. The differencein ME_m (112.8 kcal/kgBW$^{0.75}$)reported by Rabello et al. (2006)compared to the ME_m (98.3 kcal/kgBW$^{0.75}$) shown in Figure 1 can be attributed to the differences in housing systems; birds in floor pens expend more energy for activity than birds kept in cages or respiratory calorimeters.

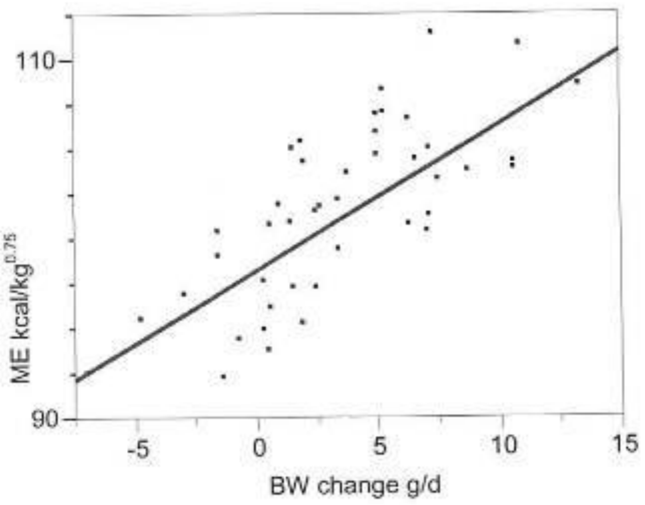


Figure 1.ME intake as a function of body weight change.
$ME = 98.25 + 0.81BW\Delta$ R^2 0.61

The ME_m requirements estimated for laying hens by indirect calorimetry have been lower than ME_m estimated by energy balance and comparative slaughter (Fuller et al., 1983; Chwalibog and Baldwin, 1995). Jadhao et al. (1999) reported the same ME_m for layers when using indirect calorimetry and the slaughter technique, although the efficiency of utilization of ME for maintenance was lower when the comparative slaughter technique was used.

Zhang and Coon (1997) found a higher ME_m when studying TAM treated laying hens than ME_m established using calorimetry. The researchers conducted a trial using 120 Dekalb TAM treated hens, 62 wk of age, housed in 6 different environmentally controlled rooms in order to determine the effect of environmental temperature on ME_m. The prediction equations developed by the Zhang and Coon (1997) were later evaluated in another trial using a total of 480 White Leghorn hens from four different strains. The estimates for ME_m reported by Zhang and Coon were 19.2% higher than that calculated by studies conducted by using indirect calorimetry and 13.3% lower that ME_m proposed by the NRC (1994). The higher estimates for ME laying hens utilized in the study by Zhang and Coon (1997) study were housed in cages and in practical environmental conditions compared to layers confined in respiratory calorimeters.

The reduced physical activity of breeders used in the present study can be compared to that of birds used in calorimetric studies. Measurements of heat production (HP) from birds in respiratory chambers cannot be distinguishing from the actual heat produced from feed or mobilized body tissue heat (Grimbergen, 1974) and errors in estimating the actual ME_m may occur. Besides the choice of method used to determine HP, respiration calorimetry or comparative slaughter technique, HP may differ because of other factors such as age, genetic strain, environmental temperature, and energy concentration of diets (Sakomura et al., 2003).

Physical activity is an energy-demanding process that is considered part of the ME for maintenance (Chwalibog, 1991). Activity of poultry may comprise 4.3 to 35% of the total heat production (Chwalibog, 1991; Balnave, 1974; and Luiting, 1990) depending on feeding system, housing, lighting, space allowance, age, strain of birds, and environmental conditions. McDonald (1978) reported that caged pullets needed between 5.6 and 11% less energy for maintenance than floor pen housed pullets, and caged hens spent 4.1% less energy than hens reared on the floor. Sakomura (2001) reported a larger ME_m difference of 20% for26-33 wk old broiler breeders housed in cages compared to floor pens. Leeson and Summersb (2000) suggested an allotment of 17% and 11% of the total energy for activity for broiler breeder hens 32 and 55 weeks of age, respectively. These values corresponded to requirements at thermo neutral temperatures. Wenk (1997) stated that in growing farm animals reared under practical conditions, physical activity might represent around 20% of the total maintenance requirements.

Assuming that physical activity can account for around 20% of the total ME_m, the results of the present study would yield a ME_m of 118 kcal/kgBW$^{0.75}$ for broiler breeder hens housed on the floor at 21C.

The genetic strain of breeders may influence the reported ME_m by different researchers. Spratt et al. (1990) and Johnson and Farrell (1983) used older genetic lines of broiler breeder hens that probably had a different body composition and performance characteristics compared to the broiler breeder hens (Cobb 500) utilized in the present study.

Grimbergen (1974) hypothesized that the use of non laying hens would allow the estimation of ME_m by the regression of energy retained in body on ME intake. In the present study, the energy expended for maintenance was calculated by plotting energy intake (kcal/kgBW$^{0.75}$) of each individual broiler breeder hen against individual weight change (g/d), and the intercept of such a plot provided the estimate of ME_m. Thus, the use of non-laying (TAM treated hens) in the present study should have reduced the errors involved in calculating the actual ME_m coefficient. After birds stoplaying, ME intake should have been partitioned only into ME for maintenance and ME for body weight change since ME was no longer needed for yolk follicle synthesis on the ovary and for eggs being produced.

ME for weight gain

The calculated ME_g for the present experiment was 5.6 kcal per gram of body weight gain and κg was 57%. This ME_g value is close to the value estimated by the NRC (1994) (5.5 kcal/g) and by Emmans (1974) (5 kcal/g) for laying hens. However, estimated ME_g in the present study is larger than other estimates (Waldroup et al., 1976; Byerly et al., 1980; Sakomura et al., 1993), and smaller than those estimated by Spratt et al. (1990) and Rabello et al. (2000) for broiler breeder hens. The variation in these data might have been caused by the method used to determine protein and fat accretion rates (respiration calorimetry or comparative slaughter) (Webster, 1989).

Energy retained as protein observed in the present study was 35% and ER_f was 65%. The partial efficiencies for fat and protein retention were 0.79 and 0.34, respectively (Table 2). These results can be compared with the partial efficiencies of 0.96 and 0.51 for fat and protein, respectively, reported by Spratt et al. (1990).

Based on the carcass composition of broiler breeder hens in the present study, actual energy deposited as BW gain above maintenance was stored primarily as fat. There was variation in the individual composition of hens mainly due to the variation in fat content of individual hens (Table 4). Emmans (1974) concluded that the energy content of weight gain and the efficiency for utilization of energy deposited in carcass would determine the energy needs for growth or BW gain.

The variation in ME for weight gain previously reported may have been caused by the different methods used for estimating energy balance, and because body composition depends on age, genetics, nutrition, productive stage and environment. Modern strains of broiler breeders producing high yield progeny may deposit a larger amount of protein into breast meat during the production period compared to older genetic lines.

The percentage of protein and fat gain for high yield producing breeders in production may be dependent upon stage of egg production and the amount of dietary energy being fed. Salas et al. (2011) reported a large increase in lean mass with a reduction in fat mass for breeders in production from 45 -65 wk of age. The researchers showed the relative body composition changes were independent of dietary energy being fed. The ME_m of breeders would also change dependent upon the body composition because of the differences in maintaining daily energy needs of lean tissue compared to maintaining fat tissue.

In the present trial, body weight gain was related to high fatretention which is agreement with the findings of Pearson and Herron (1981),Spratt and Leeson (1987) and Spratt et al. (1990). Recent experiments conducted by Sun and Coon (2005) and Sun et al. (2006)during the complete laying period with Cobb 500 broiler breeder hens housed in individual cages showed that breeder hens retained energy at 75% fat and 25% protein. Heavy broiler breeders retained more energy as fat than as protein, whereas lighter body weight breeders retained more protein during the productive cycle (20-65 weeks). Boekholt et al. (1997) concluded that daily retention of protein and fat was linearly related to energy retention. The authors found that more fat than protein was retained when growing broilers were fed at increasing energy intakes, but when energy intakes were lower, a constant daily protein retention and a variable fat retention occurred.

Table 2. Body weight, daily body weight change, and retained energy of broiler breeder hens during the non-laying period.

Variable	Mean and SEM
Initial body weight, g	4.39 ± 0.04
Final body weight, g	4.43 ± 0.04
Body weight change, g	41.62 ± 12.06
Body weight change, g/d	2.60 ± 0.74
κg, %	57
ER, kcal/d	7.40 ± 1.79
ER_p, %	35
ER_f, %	65
κf	0.79
κp	0.34

Table3. Egg composition

Variable	Mean and SEM
Albumen, %	31.67 ± 0.28
Yolk, %	59.30 ± 0.25
Shell, %	9.03 ± 0.14
Albumen DM, %	51.93 ± 0.15
Yolk DM, %	12.88 ± 0.26
Albumen fat, % as DM	0.003 ± 0.000007
Albumen protein, % as DM	81.53 ± 0.24
Yolk fat, %	57.83 ± 0.0003
Yolk protein, %	29.45 ± 0.36
Egg gross energy, kcal/g	1.62 ± 0.0016

Table 4. Body composition of broiler breeder hens

Measurement	Initial[1]	First egg[2]	Final[3]
Fat, %	18.78^{ab}	19.66^{a}	17.29^{b}
Protein, %	15.38	16.73	16.17
DM, %	42.49	41.80	40.26
Fat, % as DM	44.90	46.23	42.48
Protein, % as DM	45.10^{b}	47.70^{a}	47.85^{a}

[1] Carcass composition of breeders slaughtered at the beginning of the non-laying period
[2] Carcass composition of breeders slaughtered at the end of the non-laying period
[3] Carcass composition of breeders slaughtered at end of the trial
[a,b] Means within a variable with no common superscript differ significantly (P< 0.05)

ME for egg production

Broiler breeder performance and egg composition parameters are presented in Table 3 and Table 5, respectively. After broiler breeder hens resumed egg production after TAM was withdrawn in present study, the breederse gg production reached 71% and was at a higher rate than suggested (< 57 %) by the Cobb 500 Breeder Management Guide (2002) for that age. The increase in egg production is similar to what should be expected after a forced molt. The daily feed needed (energy intake) for each breeder during the laying period was underestimated (136 g/bird/d) because the breeders lost BW during the last week of the 9 wktrial (Table 5).

Previous research by Sun and Coon (2005) indicated that breeders in cages only needed approximately 390 kcal per day at peak for maximum egg production. The diet used in present study contained 2816 kcal/kg and 136 g intake provided approximately 383 kcal per day for each breeder.

The breeders were only producing at a 71% rate instead of 86% that would be expected at peak. The loss in BW during the 8-9th week indicates energy was mobilized from tissues in order to sustain egg production. The mobilized energy from tissue and dietary ME intake were utilized in estimating ME energy for egg production (MEe). Eight broiler breeder hens were excluded from the study for calculating the conversion of dietary ME into egg energy (κe) because the breeders did not resume adequate egg production after the TAM was withdrawn during the laying period.

The average gross energy content of an egg was determined to be 1.62 kcal/g (including egg content and eggshell plus membrane). MEe was estimated to be 2.4 kcal per gram of egg mass from the production study by subtracting the ME_m and ME_g from ME required for production. The average κe was determined to be 65.7%. The MEe value is in the range of 2.04 and 3.13 reported in the literature for broiler breeder hens (Waldroup et al., 1976; Sakomura et al., 1993; Rabello et al., 2000).

Table5. Performance characteristics of broiler breeder during the laying period.

Characteristics	Mean and SEM
Egg weight, g	68.27± 0.81
Egg mass, g/hen/d	48.44± 0.92
Egg production, %	71.05 ± 0.25
Initial body weight, kg	4.51 ± 0.38
Final body weight, kg	4.46 ± 0.43
Body weight change, g	-53.75 ± 12.53
Feed consumption above maintenance, kcal/d	78.94 ± 2.92

Estimated values of κe reported in the literature are variable and range between 60 and 86% (Grimbergen, 1974) depending on strain, age, egg composition and egg size, lighting pattern, and nutritional and environmental factors (Pearson and Herron, 1982). High efficiencies for egg production have been observed when broiler breeder hens use body energy to compensate for a dietary energy shortage (Spratt et al, 1990; Pearson and Herron, 1982; Attia et al., 1995; and Neuman et al., 1998).

The κe found in this trial is similar to other estimated values for broiler breeder hens (Byerly et al., 1980; Rabello et al., 2000). Spratt et al. (1990) reported κe between 0.81 and 1.72 for broiler breeder hens receiving different energy levels. Energy balance was negative in those hens that had the highest efficiency for egg synthesis. Johnson and Farrell (1983) concluded that a non-linear relationship "between retained energy and total ME intake from maintenance to production" in broiler breeder hens might explain the κe above 70%.

The present study shows the use of TAM provides an opportunity to accurately determine ME_m during the non-laying period without interdependence of egg production for each breeder. The coefficients for predicting MEI for broiler breeder hens housed in a 21 C environment were determined to be 98.3 kcal/kgBW$^{0.75}$for ME_m , 5.6 kcal/g for ME_g and 2.4 kcal/g for ME_e. The energy efficiencies for protein gain (κp), fat gain (κf) and egg calories (κe) were 34%, 79% and 65.7%, respectively.

4. ACKNOWLEDGEMENTS

The authors would like to acknowledge Cobb-Vantress, Inc. for financial support and for providing pullets utilized for the breeder studies.

7. LITERATURE CITED

Anonymous. 2002. Cobb 500 Broiler breeder management guide. Cobb-Vantress Inc. PO Box 1030, Siloam Springs, AR. 72761

Association of Official Analytical Chemists. 1990. Official Methods of Analysis, 15th Edition. Washington, DC.

Association of Official Analytical Chemists. 1995. Official Methods of Analysis, 16th ed. Washington, DC.

Attia, Y. A., W. H. Burke, K. A. Yamani and L. S. Jensen. 1995. Daily energy allotments and performance of broiler breeders. 2. Females. Poult. Sci. 74: 261-270.

Balnave, D. 1974. Energy requirements of Poultry. In: Morris, T.R. and B.M. Freeman (Eds). Biological factors affecting energy expenditure. Br. Poult. Sci., Edinburgh, pp. 25-46.

Boekholt, H. A., V. V. A. M Schreurs, and R. A. H. M. ten Doeschate. 1997. Energy metabolism of farm animals. In McCracken K., E. F. Unsworth, and A. R. G.Wylie (eds.). Partitioning of energy in protein and fat retention at increasing energy intakes in growing animals.CAB Intl. Wallingford U.K. pp. 327-334.

Byerly, T. C., J. W. Kessler, R. M. Gous and O. P. Thomas. 1980. Feed requirements for egg production Hens. Poult. Sci. 59:2500-2507.

Chwalibog, A. 1991.Energetics of animal production. Acta Agriculturae Scandinavica 41:147-160.

Chwalibog, A., and R. L. Baldwin. 1995. Systems to predict the energy and protein requirements of laying fowl. World's Poult. Sci. J. 51: 187-196.

Emmans, G. C. 1974. Energy requirements of Poultry. In: Morris, T.R. and B.M. Freeman (Eds). The effect of temperature on performance of laying hens. Br. Poult. Sci., Edinburgh, pp. 79-90.

Farrell, D. J. 1974. Energy requirements of Poultry.Pages 1-24 *In*: Morris, T.R. and B.M. Freeman (Eds).General Principles and assumptions of calorimetry.

Freund, R. J., and J. W. Wilson, 1997.Statistical Methods.ACADEMIC PRESS. London, UK.

Fuller, H. L., N. M. Dale, and C. F. Smith. 1983. Comparison of heat production of chickens measured by energy balance and by gaseous exchange. J. Nutr. 113: 1403-1408.

Grimbergen, A. H. M. 1974. Energy requirements of Poultry.Pages 61-71 *In*: Morris, T.R. and B.M. Freeman (Eds).Energy expenditure under productive conditions. Br. Poult. Sci., Edinburgh.

Jaccoby, S., N. Snapir, I. Rozenboim, E. Arnon, R. Meidan and B. Robinzon. 1992. Tamoxifen advances puberty in the White Leghorn hen. Br. Poult. Sci. 33: 101-111.

Jadhao, S. B., C. M. Tiwari, S.B.J. Chandramoni and M. Y. Khan. 1999. Energy requirement of Rhode Island Red hens for maintenance by slaughter technique. Asian-Australas. J. Anim. Sci. 12:1085-1089.

Johnson, R. J., and D. J. Farrell. 1983. Energy metabolism of groups of broiler breeders in open-circuit respiration chambers. Br. Poult. Sci. 24: 439-453.

Leeson, S. and J.D. Summers. 2000. Broiler breeder production. University books, Guelph, Ontario.

Leeson, S. 2003. Broiler breeder nutrition: What's new and what challenges do we face. Pages 59-63 in Proceedings of the 50th Maryland Nutrition Conference and 1st Mid-Atlantic Nutrition Conference. College Park, MD.

Luiting, P. 1990. Genetic variation of energy partitioning in laying hens: causes of variation in residual feed consumption. Worlds Poult. Sci. J. 46: 133-152.

Mayes, P. A. 2000. Harper's Biochemistry. Nutrition.In. Murray, R. K., D. K. Granner, P. A. Mayes, and V. W. Rodwell, ed. Nutrition.McGraw-Hill. USA. pp 653-661.

McDonald, M. W. 1978. Feed intake of laying hens. Worlds Poult. Sci. J. 34:209.

Mendenhall, W., and T. Sincich. 2003. A second course in Statistics: Regression Analysis. Pearson Education Inc. New Jersey, USA.

National Research Council. 1994. Nutrient Requirements of Poultry. 9th rev. ed. , National Academy Press, Washington, DC.

Neuman, S. L., R. H. Harms and G. B. Russell. 1998. An innovative change in energy restriction for broiler breeder hens. . J. Appl. Poult. Res. 7: 328-335.

Pearson, R. A., and K. M. Herron. 1981. Effects of energy and protein allowance during lay on the reproductive performance of broiler breeder hens. Br. Poult. Sci. 22:227–239.

Pearson, R. and K.M. Herron. 1982. Relationship between energy and protein intakes and laying characteristics in individually-caged broiler breeder hens. Br. Poult. Sci. 23: 145-159.

Rabello, C. B. V., N. K. Sakomura, C.R. Pacheco, K. T. Resende, and F. A. Longo, 2000. Prediction equation of metabolizable energy requirements for broiler breeders In. XXI World´S Poultry Congress.Montreal - Canada - CD-Room.

Rabello, C.B.V.; N.K. Sakomura, F.A. Longo, and K.T. Resende.2004.Efeito da temperature e do sistema de criação sobre as exigencies de energiametabolizável para mantença de aves reproductoras pesadas. Revista Brasileira de Zootecnia, 33: 382-390.

Rabello, C.B.V.; N.K. Sakomura, F.A.Longo, H.P. Couto, C.R. Pacheco, and J.B.K. Fernades. 2006. Modeling energy utilisation in broiler breeder hens. Bri.Poult. Sci. Volume 47, Number 5, pp. 622-631.

Romero, L.F., M.J. Zuidhof, R.A. Renema, F.E. Robinson, and A. Naeima.2009a. Nonlinear mixed models to study metabolizable energy utilization in broiler breeder hens. Poultry Science 88:1310–1320.

Romero, L.F., M.J. Zuidhof, R.A. Renema, A. Naeima, and F.E. Robinson. 2009b. Characterization of energetic efficiency in adult broiler breeder hens.PoultrySci. 88:227-235.

Sakomura, N.K., H. S., Rostagno, S.A. Torres, andJ. B. Fonseca. 1993. Efeito da temperature sobre o consume de ração e de energia metabolizável para matrizes pesadas, Revista de Sociedade Brasileira Zootecnia 22:707-714.

Sakomura, N. K., R. Silva, H. P. Couto, C. Coon, and C. R. Pacheco. 2003. Modeling metabolizable energy utilization in broiler breeder pullets. Poult. Sci. 82: 419-427.

Sakomura, N.K. 2001. Subject: Confira os modelos para determinar as exigências energéticas para matrizes pesadas, poedeiras comerciais e frangos de corte. Avicultura
Industrial.
http://www.aviculturaindustrial.com.br/site/dinamica.asp?id=1819&tipo_tabela=cet&categoria=nutricao. Accessed: May, 2003.

Sakomura, N.K., L.Hauschild, E.P. Silva and J.A. Araújo.2011. Factorial Model to estimate poultry nutrition requirements. III International symposium on Nutritional Requiremetns of Poultry and Swine.Viçosa, Brazil.

SAS Institute Inc. 1999-2000a.JMP IN® Software. SAS Institute. Cary, N.C.

SAS Institute Inc. 1999-2000b.SAS/STAT® User's Guide.Version 8. SAS Institute Cary, N.C.

Scott, T.A., and D. Balnave. 1991. Influence of temperature, dietary energy, nutrient concentration and self-selection feeding on the retention of dietary energy,protein and calcium by sexually-maturing egg-laying pullets. Br. Poult. Sci. 32:1005-1016.

Spratt, R. S. and S. Leeson. 1987. Broiler breeder performance in response to diet protein and energy. Poult. Sci. 66: 683-693.

Spratt, R. S., H. S. Bayley, B. W. McBride and S. Leeson. 1990. Energy metabolism of broiler breeder hens. 1. The partition of dietary energy intake. Poult. Sci. 69: 1339-1347.

Sun, J.M., M.P. Richards, R.W. Rosebrough, C.M. Ashwell, J.P. McMurtry, and C.N. Coon. 2006. The relationship of body composition, feed intake, and metabolic hormones for broiler breeder females. Poult. Sci. 85:1173-1184.

Sun, J. and C. N. Coon, 2005. The effects of body weight, dietary fat, and feed withdrawal rate on the performance of broiler breeders. J. Appl. Poult. Res. 14:728-739.

Waldroup, P. W., Z. Johnson, and W. D Russel. 1976. Estimating daily nutrient requirement for broiler breeder hens. Feedstuffs 48 (28).

Webster, A.J.F. 1989. Energy utilisation during growth and reproduction–discussion. In: Energy Metabolism of Farm Animals. EAAP Publ. No. 43. Pudoc, Wageningen, Netherlands, pp. 85–88.

Wenk, C. Energy metabolism of farm animals. 1997. In McCracken K., E. F. Unsworth, and A. R. G.Wylie (eds.). Growth (Summary of the discussion).CAB Intl. Wallingford U.K. pp. 265-267.

Zhang, B. and C. N. Coon, 1997.Modeling metabolizable energy utilization in laying hens. *P89-92 In:* Energy Metabolism of Farm Animals. 14th Symposium on Energy Metabolism of Farm Animals. Newcastle, Northern Ireland. (Eds.) K.J. McCracken, E.F. Unsworth and A.R.G. Wylie.CAB International, New York, NY.