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NET ENERGY FOR MAINTENANCE IN POULTRY

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TÍTULO DA TESE: NET ENERGY FOR MAINTENANCE IN POULTRY

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Jaboticabal, 13 de outubro de 2022

DADOS CURRICULARES DO AUTOR

FREDDY ALEXANDER HORNA MORILLO, nascido no dia 21 de abril de 1989 em Nuevo Chimbote, Ancash, Peru. Ingressou no curso de Zootecnia na Universidad Nacional Agraria de La Molina em março de 2006. Em novembro de 2011 obteve o título de Zootecnista. Ingressou no Programa de Mestrado na Universidad Nacional Agraria de La Molina em abril de 2012. Em novembro de 2017 obteve o título de Mestre em Nutrição. Trabalhou 2 anos em uma integradora avícola no Peru e em agosto de 2018 ingressou no Doutorado do Programa de Pós-Graduação em Zootecnia da Universidade Estadual Paulista – “Júlio de Mesquita Filho” (UNESP) – Faculdade de Ciências Agrárias e Veterinárias, Campus de Jaboticabal, sob orientação da Profª. Drª. Nilva Kazue Sakomura, submetendo-se à defesa da tese em outubro de 2022.

Dedico

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UNIVERSIDADE ESTADUAL PAULISTA
"JÚLIO DE MESQUITA FILHO"
Câmpus de Jaboticabal

CEUA – COMISSÃO DE ÉTICA NO USO DE ANIMAIS

CERTIFICADO

Certificamos que o projeto de pesquisa intitulado **"Determinação da energia liquida de mantença em aves"**, protocolo nº 5397/20, sob a responsabilidade da Profa. Dra. Nilva Kazue Sakomura, que envolve a produção, manutenção e/ou utilização de animais pertencentes ao Filo Chordata, subfilo Vertebrata (exceto o homem), para fins de pesquisa científica (ou ensino) - encontra-se de acordo com os preceitos da lei nº 11.794, de 08 de outubro de 2008, no decreto 6.899, de 15 de julho de 2009, e com as normas editadas pelo Conselho Nacional de Controle de Experimentação Animal (CONCEA), e foi aprovado pela COMISSÃO DE ÉTICA NO USO DE ANIMAIS (CEUA), da FACULDADE DE CIÊNCIAS AGRÁRIAS E VETERINÁRIAS, UNESP - CÂMPUS DE JABOTICABAL-SP, em reunião ordinária de 10 de dezembro de 2020.

Vigência do Projeto	16/01/2021 a 20/05/2021
Espécie / Linhagem	*Gallus gallus domesticus* / Cobb 500 e Lohmann
Nº de animais	1190
Peso / Idade	40 g / 1 dia e 1500 g / 24 semanas
Sexo	Machos e fêmeas
Origem	Incubatório Pluma, Descalvado – SP, Granja Mayra, Pedralva - MG

Jaboticabal, 10 de dezembro de 2020.

Fabiana Pilarski

Profa. Dra. Fabiana Pilarski
Coordenadora – CEUA

NET ENERGY FOR MAINTENANCE IN POULTRY

RESUMO

O sistema energia líquida (**EL**) tem sido bem sucedido na nutrição de suínos e bovinos; no entanto, a nutrição avícola apresentou dificuldades na adoção do **EL**. Para o sucesso do sistema **EL** em aves, é necessário quantificar a energia necessária por ave e os valores energéticos dos alimentos no sistema **EL**. Com base na abordagem fatorial, a necessidade de energia **EL** pode ser dividida em energia para mantença (produção de calor em jejum, FHP) e produção (energia retida no corpo ou ovo). Fatores internos e externos são comumente considerados como um aumento na necessidade de energia de manutenção. Além disso, tem sido sugerido que a taxa metabólica se ajusta com a lei dos ¾ segundo a função potência ($y = a * x^b$), porém, nas últimas décadas, a universalidade deste expoente tem sido enfraquecida e a relevância deste escalar para algumas espécies de aves deve ser testado. Além disso, existem muitas discrepâncias no ajuste da quantidade de energia usada para atividade física (**AF**). Devido à AF abranger comportamentos múltiplos e complexos, este estudo utiliza a metodologia do time-energy budget como uma tentativa de quantificar a energia necessária para a AF. Portanto, os objetivos deste estudo são: (1) determinar um escalar alométrico adequado para frangas e galinhas poedeiras bem como quantificar o efeito da T no FHP, (2) determinar como o peso corporal e a temperatura ambiente afetam o FHP em frangos de corte, (3) Explorar o efeito do grau de empenamento (**F**) e T sobre FHP, e (4) Determinar o custo energético de AF para alguns tipos de atividade física. Câmaras calorimétricas foram utilizadas para realizar esses experimentos e, com base nas trocas gasosas e na equação de Brouwer, foi calculado o calor produzido durante o jejum. Os resultados desses experimentos são os seguintes: (1) O escalar mais adequado para galinhas poedeiras foi 0,67 enquanto 89 foi a energia necessária para mantença (kcal/kg^{0,67}) e a equação descreve a relação entre T e FHP é definida por: $0,247*T^2-11,9*T+220$. (2): $FHP_{kcal/ave} = BW^{0,75}*[85 + 2,65*(CT-T)*(T<CT) + 4,41*(T-CT)*(T \geq CT)]$; onde $CT=22,46+(35,83-22,46)*e^{-0,4906*BW}$, BW é o peso corporal (kg) e T é a Temperatura (°C). (3) A relação entre FHP, F e T foi descrita da seguinte forma: FHP = 100,7 + U*[CT-T]*[T<CT] + V*[T-CT]*[T≥CT], em que, CT = 30,48+1,06*F, U=6,94-6,44*F e V=2,06+4,21*F. O custo energético para comer, beber e movimentação foi calculado como 0,607, 0,352 e 0,938 cal.kg$^{-0,75}$.s^{-1}, respectivamente.

Palavras-chave: Produção de calor em jejum, temperatura ambiental, atividade física, empenamento, calorimetria indireta.

NET ENERGY FOR MAINTENANCE IN POULTRY

ABSTRACT

The **NE** system has been fully implemented in swine and cattle nutrition; despite that, the poultry industry has been slower to adopt the **NE**. For the successful implementation of **NE** system, it is necessary to quantify the energy required per bird and the energy values of feedstuffs in the same system. Based on the factorial approach, the **NE** energy requirement can be divided into energy for maintenance (Fasting heat production, **FHP**) and production (retained energy in body or egg). Internal and external factors are commonly considered to result in an increase in the maintenance energy requirement. Moreover, it has been suggested that the metabolic rate scales with ¾ law according to the power function ($y = a * x^b$), however, in the last decades, the universality of this exponent has been weakened and the relevance of this scalar for some poultry species needs to be tested. Also, there are many discrepancies in the adjustment of energy used for physical activity (**PA**). Due to **PA** covering multiple and complex behaviors, this study uses the time-energy budget approach as an attempt to quantify the energy required for **PA**. Therefore, the objectives of this study are: (1) to determine an appropriate allometric scalar for pullets ad laying hens, and, also, to quantify the effect of **T** on **FHP**, (2) To determine how body weight and environmental temperature affect the **FHP** in broilers, (3) Explore the effect of feathering degree (**F**) and **T** over **FHP**, and (4) Determine the energy cost of **PA** for further adjustment of total energy expenditure **PA**. Calorimetry chambers were used to perform these experiments, and, based on gas exchange and the Brouwer equation, the heat produced during fasting status was calculated. The results of these experiments are as follows: (1) The most appropriate scalar for laying hens was 0.67 and 89 was the energy required for maintenance ($kcal/kg^{0.67}$), also, the following equation describes the relationship between **T** and **FHP**: above **CT** is described by: $0.247*T^2-11.9*T+220$. (2) $FHP_{kcal/bird} = BW^{0.75}*[85 + 2.65*(CT-T)*(T<CT) + 4.41*(T-CT)*(T\geq CT)]$; where $CT=22.46+(35.83-22.46)*e^{-0.4906*BW}$, **BW** is body weight (kg) and **T** is Temperature (°C). (3) The relationship between FHP, F, and T were described as follows: FHP = 100.7 + U*[CT-T]*[T<CT] + V*[T-CT]*[T≥CT], in which, CT = 30.48+1.06*F, U=6.94-6.44*F, and V=2.06+4.21*F. The energy cost for eating, drinking, and motion was calculated as 0.607, 0.352, and 0.938 $cal.kg^{-0.75}.s^{-1}$, respectively.

Keywords: Fasting heat production, temperature, physical activity, feathering, indirect calorimetry.

Chapter 1 – CONSIDERAÇÕES GERAIS

1.1. Introduction

The primary goal of poultry nutritionists is to formulate diets to supply energy and nutrients that meet the objective of production. In this regard, given that birds eat primarily to meet their energy requirements mainly, it is necessary to first implement an energy system that allows a better understanding of energy partitioning; secondly, define energy requirements under the energy system implemented; and, thirdly, be aware of the energy value of the feedstuffs. This knowledge will allow the formulation of efficient and economic diets. The metabolizable energy (**ME**) system has been widely used as it is a simple method to assess both energy requirements and energy value for feedstuffs; however, it has been suggested that the net energy (**NE**) system is more reliable due to the differences in metabolic utilization between nutrients, so this characteristic avoids under or overestimation of energy values for poultry diets.

In contrast to the ME system, the NE system has been fully implemented in swine and cattle nutrition, despite that, the poultry industry has been slower to adopt the NE. This is plausible because, in the ME system, there is a high amount of information about the energy requirements and the energy values of feedstuffs. Under the ME system, the energy requirements of birds were well defined based on corn-soybean diets, so these energy requirements are appropriate for birds fed corn-soybean diets. However, a future change to non-conventional feedstuffs could result in a different response because the metabolic utilization may be different due to variations in the chemical composition of feedstuffs. Due to the NE system considering differences in metabolic utilization of nutrients, an expression of energy requirements and feed energy values based on the NE system should be independent of feed composition. Thus, for future implementation of the NE system, it is necessary to define the energy values of feedstuffs and bird energy requirements; however, published data on this subject is limited or scarce. The present research will therefore focus on studying the energy requirements of birds under the NE system.

Traditionally, energy and nutrient requirements have been determined using a dose-response approach, in which the energy or nutrient under analysis is related to the response criteria using regression analyses. On the other hand, the factorial approach is been used to study how animals use the energy and nutrients from feed for vital processes, so that, based on the additive assumption, the energy and nutrient are divided into maintenance and production, thus the energy and nutrient requirements are obtained by combining them. The factorial approach is widely used in mathematical modeling to predict energy and nutrient requirements, body composition, and growth under multiple conditions. Due to these characteristics, the factorial approach allows nutritional corrections to animals subjected to environments with constant changes. Based on this approach, it has been demonstrated that environmental factors have no effects on the efficiency of energy used for production; consequently, it is common practice to conduct studies on factors that influence maintenance in order to make further adjustments to maintenance requirements. Moreover, under the NE system, the estimation of maintenance is a crucial point to estimate the NE values of feedstuffs.

In the absence of feed, the vital functions of the animal can be supported at the expense of the body reserves, so, fasting animals in resting status allows for quantifying the energy to maintain the vital processes, eliminating the thermal effect produced by the digestion and absorption processes or by requirements for growth. In the present study, birds subjected to fasting conditions were used to quantify the NE for maintenance and the factors affecting it. Moreover, as birds age, their body size increases; however, the metabolic rate does not increase at the same proportional rate. As a result, the metabolic rate, between and within animal species, scales with the power function ($y = a * x^b$) had been suggested. The 3/4 exponent has been proposed as a universal scaling; however, in the last decades, the universality of this exponent has been weakened. Therefore, this study aims to propose the most appropriate allometric scale for laying hens.

There are some challenges to including the energy used for physical activity for further calculation of the energy required per day. This is probably a consequence of the lack of a robust definition of what maintenance means. Most mathematical modelers consider the energy required for physical activity as a fixed portion of maintenance while others do not consider it in their calculations; however, considering the arbitrary time frame of physical activity, it is difficult to define how to insert this energy under the factorial approach. Due to physical activity covering multiple and complex behaviors, this study uses the time-energy budget approach as an attempt to quantify the energy required for physical activity. Finally, to perform these studies, indirect calorimetry was used to measure the heat production from oxygen consumption and carbon dioxide production. This technique allows for measuring the oxidation of carbohydrates, proteins, and fats, which releases the energy to fuel metabolic processes.

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