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PROGRAMA DE PÓS-GRADUAÇÃO EM ZOOTECNIA

AVALIAÇÃO DA PRODUÇÃO DE OVOS AO LONGO DE 51 SEMANAS EM GALINHAS POEDEIRAS ALIMENTADAS COM UMA VARIAÇÃO DE 400 KCAL EM/KG

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“Se eu vi mais longe, foi por estar sobre ombros de gigantes.”

– Isaac Newton.

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AVALIAÇÃO DA PRODUÇÃO DE OVOS AO LONGO DE 51 SEMANAS EM GALINHAS POEDEIRAS ALIMENTADAS COM UMA VARIAÇÃO DE 400 KCAL EM/KG

Autor: Raíssa Gabriela Dias Menezes

Orientador: Sergio Luiz Vieira

Resumo – Foi avaliada a produção de ovos de galinhas poedeiras alimentadas com dietas com níveis decrescentes de energia metabolizável (EM) ao longo de 51 semanas. As galinhas foram alojadas em 48 gaiolas, 4 tratamentos com 12 repetições de duas galinhas cada. Todas as galinhas foram alimentadas com ração de adaptação de 18 a 24 semanas (2.750 kcal EM/kg, 17,2% PB, 4,0% Ca e 0,48% Av. P), e após este período, com rações experimentais de 25 a 76 semanas e com energia decrescente (2.850, 2.750, 2.650 e 2.550 kcal EM/kg), mas com todos os nutrientes que compõem a formulação. Os tratamentos foram distribuídos em delineamento de blocos casualizados e para a análise de variância utilizou 13 períodos de 28 dias com medidas repetidas. Respostas lineares foram observadas para peso corporal, consumo de ração, consumo de EM, peso do ovo, massa do ovo, gema, albúmen, casca do ovo, bem como espessura da casca do ovo com reduções de 30 g, 2,2 g, 5,3 kcal, 0,7 g, 0,8 g, 0,24 g, 0,57 g, 0,07 g e 1,82 µm para cada redução de 100 kcal de EM, respectivamente (P <0,05). A produção total de ovos foi ajustada quadraticamente com a EM da dieta atingindo o ponto mais alto com 350 ovos totais por galinha e CA de 1,377 kg/dúzia de ovos a 2.733 kcal e 2.842 kcal, respectivamente (P < 0,05). O menor custo de produção de ovos associado à ração foi obtido com galinhas alimentadas com 2.650 kcal EM/kg (R$ 0,165 por unidade de ovo) durante todo o período experimental.

Palavras-chave: poedeiras, energia metabolizável, desempenho, ovos.

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A 51-WEEK EGG PRODUCTION ASSESSMENT OF WHITE LEGHORN HENS FED ON A 400 KCAL ME/KG RANGE.

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Abstract – Egg production of White Leghorn hens fed diets with decreasing ME contents through 51 wks were evaluated. Hens were allocated into 48 cages in 4 treatments with 12 replicates of two hens each. All hens were fed an adaptation feed from 18 to 24 wks (2,750 kcal ME/kg, 17.2% CP, 4.0% Ca and 0.48% Av. P) and then the experimental feeds from 25 to 76 wks with decreasing energy (2,850, 2,750, 2,650 and 2,550 kcal ME/kg) but with all nutrients commonly formulated. Treatments were distributed into a randomized block design and the analysis of variance used 13 periods of 28 d with repeated measures. Linear responses were observed for BW, feed intake, ME intake, egg weight, egg mass, yolk, albumen, eggshell, as well as eggshell thickness with decreases of 30 g, 2.2 g, 5.3 kcal, 0.7 g, 0.8 g, 0.24 g, 0.57 g, 0.07 g, and 1.82 µm for each 100 kcal ME reduction, respectively ($P < 0.05$). Total egg production was quadratically adjusted with dietary ME reaching a highest point with 350 total eggs per hen and FCR of 1.377 kg/dozen eggs at 2,733 kcal and 2,842 kcal, respectively ($P < 0.05$). The lowest egg production cost associated with the feed was obtained with hens fed 2,650 kcal ME (U$ 0.033 per egg unit) throughout the experimental period.

Key words: laying hens, metabolizable energy, performance, eggs.

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SUMÁRIO

LISTA DE TABELAS **10**

LISTA DE FIGURAS **11**

LISTA DE ABREVIATURAS **12**

CAPÍTULO I **13**

1. INTRODUÇÃO **14**

2. REVISÃO BIBLIOGRÁFICA **17**

2.1. Energia 17

2.2. Energia Metabolizável 20

2.3. Regulação da Ingestão Alimentar 22

3. HIPÓTESES E OBJETIVOS **23**

CAPÍTULO II **24**

CAPÍTULO III **43**

4. CONSIDERAÇÕES FINAIS 44

5. REFERÊNCIAS 45

6. APÊNDICES **48**

7. VITA **73**

LISTA DE TABELAS

Table 1. Composition of feeds having graded decreases in ME supplied to white Leghorn laying hens from 25 to 76 wks. 35

Table 2. Performance and egg characteristics of white Leghorn laying hens fed on graded decreases of ME from 25 to 76 wks. 36

Table 3. Effects of diets with gradual decreases of ME on egg characteristics of white Leghorn laying hens from 25 to 76 wks. 37

Table 4. Regression equations of white Leghorn laying hens fed diets with gradual ME decreases from 25 to 76 wks. 38

LISTA DE FIGURAS

Figure 1. Temperature and relative humidity throughout the trial. 39

LISTA DE ABREVIATURAS

EB	Energia Bruta
ED	Energia Digestível
EL	Energia Líquida
EM	Energia Metabolizável
EMA	Energia Metabolizável Aparente.

CAPÍTULO I

1. INTRODUÇÃO

Com uma produção impressionante de 52 bilhões de unidades, o setor de ovos do Brasil registra um Valor Bruto da Produção de R$ 20,2 bilhões. Além disso, o país exporta 9,4 mil toneladas, totalizando US$ 22,4 milhões em vendas para 89 países. Como o quinto maior produtor do mundo, o Brasil demonstra uma média de consumo per capita de 241 unidades por habitante ao ano (ABPA, 2023). Observa-se na avicultura, que a alimentação representa cerca de 70% dos custos de produção, sendo os níveis de energia e proteína das dietas os principais componentes desse gasto (Costa et al., 2004). A energia representa o componente nutricional primordial na alimentação de poedeiras comerciais, sendo gerada pela oxidação de carboidratos, gorduras, proteínas e fibras. A energia contida nos alimentos, resultado da metabolização dos nutrientes durante o processo metabólico, é considerada um dos fatores primordiais na nutrição animal (RODRIGUES 5 et al., 2002). Entre os componentes dos alimentos: carboidratos, lipídios, proteínas e frações de fibras desempenham um papel fundamental no fornecimento de energia para o organismo animal. (SAKOMURA: ROSTAGNO, 2007). Essa energia é essencial para manter as funções vitais do organismo, como locomoção, regulação da temperatura corporal e síntese de tecidos orgânicos. O excedente energético pode ser armazenado ou utilizado para promover atividades produtivas, como a produção de ovos (NRC, 1994). O nível de energia é comumente selecionado como ponto de partida na formulação de dietas, fornecendo uma base para a fixação dos níveis de outros nutrientes, como proteína bruta, aminoácidos, ácidos graxos e minerais. (Faria e Santos, 2005).

A exigência energética das aves varia significativamente de acordo com uma série de fatores, incluindo peso corporal, fase de produção, tamanho do ovo, linhagem e temperatura ambiente (Coon, 2002). Conforme observado por Morris (2004), as aves têm a capacidade de ajustar seu consumo de ração em resposta ao teor energético, aumentando-o quando esse teor é baixo para garantir uma ingestão adequada de energia até que suas demandas sejam atendidas. Esse mecanismo adaptativo destaca a complexidade e a flexibilidade do comportamento alimentar das aves em relação à energia disponível em sua dieta. Diversas pesquisas foram realizadas para explorar os impactos da energia presente na dieta sobre o consumo de ração em galinhas poedeiras. Dentro da faixa de 2.400 a 3.000 kcal, uma redução de 100 kcal na energia resulta, em média, em uma diminuição de 1,2% no consumo energético

quando se considera a diluição da ração, e de 1,4% quando se estuda a redução dos teores de gordura. Além disso, verificou-se que o nível energético da ração exerce pouco impacto sobre o número total de ovos produzidos, sendo que, em todos os casos, as diferenças observadas foram inferiores a 1% (BOUGON, 1997). Segundo Hill et al. (1956), galinhas poedeiras que receberam dietas com 1.850 kcal demonstraram um incremento de 10% no consumo de ração em comparação àquelas alimentadas com dietas contendo 2.050 kcal. COSTA et al. (2009), não encontrou evidências de influência dos diferentes níveis de energia metabolizável sobre conversão alimentar, massa dos ovos, peso de gema e casca, a proporção de gema para clara, a gravidade específica e ganho de peso das aves. Grobas et al. (1999), observou que aumentando a energia da dieta, de 2.680 para 2.810 kcal de EM/kg, diminuiu o consumo da ração em 4%. Danos et al. (2000) constataram que galinhas alimentadas com dietas contendo 2.519 kcal de EM/kg consumiram 8,5% mais ração do que aquelas alimentadas com dietas de 2.798 kcal de EM/kg. Summers e Leeson (1983) relataram que o peso do ovo não foi afetado pelo aumento na energia da dieta. Em contrapartida, vários estudos indicaram que o aumento da energia na dieta, resulta em um aumento no peso inicial do ovo (Keshavarz, 1995; Keshavarz & Nakajima, 1995; Harms et al., 2000; Bohnsack et al., 2002; Sohail et al., 2003).

As necessidades energéticas das aves, como indicado por Rosa et al. (1997), são um elemento crucial para garantir seu crescimento, produção e saúde geral. No entanto, a determinação precisa dessas necessidades é complexa devido a uma série de fatores interligados. É notório que muitas das recomendações energéticas presentes nos manuais de criação são baseadas em estudos realizados em ambientes controlados, os quais podem não representar fielmente as condições reais de produção. Esta desconexão é significativa porque o ambiente de criação das aves pode variar, influenciando diretamente suas exigências energéticas (Skinner et al., 1992). Aspectos como a linhagem das aves desempenham um papel crucial, pois podem ter taxas metabólicas distintas, influenciando assim suas necessidades energéticas específicas. Além disso, a idade das aves e as práticas de manejo adotadas, como o tipo de alojamento e sistema de alimentação utilizado, podem impactar significativamente o gasto energético das aves. Fatores ambientais, como temperatura, umidade relativa e velocidade do ar, também exercem influência sobre o metabolismo das aves, afetando sua capacidade de utilizar eficientemente a energia proveniente da alimentação. Dessa forma, é fundamental reconhecer que as

recomendações energéticas estabelecidas em condições controladas podem não se traduzir diretamente em ambientes reais de produção. Portanto, ajustes e monitoramento constantes das dietas são essenciais para atender às necessidades energéticas específicas das aves e garantir seu ótimo desempenho em diferentes ambientes de criação, como destacado também por Sakomura et al. (2005). De acordo com BRUM et al. (2000), a utilização de uma dieta desequilibrada acarreta um aumento nos custos de produção e prejudica o desempenho dos animais. Assim, é imprescindível possuir informações sobre a composição química e a energia metabolizável (EM) dos ingredientes, a fim de realizar o balanceamento adequado dos nutrientes nas rações, garantindo que as exigências nutricionais dos animais sejam atendidas de maneira eficaz. Dessa forma, o propósito deste estudo foi avaliar o desempenho e as características dos ovos de poedeiras Bovans White alimentadas com dietas com aumento gradual de energia metabolizável e estimar o impacto econômico para cada aumento gradual de energia.

2. REVISÃO BIBLIOGRÁFICA

2.1. Energia

Na nutrição, o conceito de energia refere-se às reações químicas que ocorrem nos organismos, resultando na liberação de energia. Essa energia é essencial para uma variedade de funções metabólicas e fisiológicas, incluindo o metabolismo basal, atividade física, regulação da temperatura corporal e síntese de compostos necessários para o crescimento e manutenção do organismo (Leeson e Summers, 1997). É importante ressaltar que a energia não é considerada um nutriente em si, mas sim o produto da oxidação dos nutrientes durante o processo de metabolismo. Os nutrientes, como carboidratos, lipídios e proteínas, fornecem energia quando oxidados pelo organismo, sendo assim a fonte primária de energia para suas funções vitais (NRC, 1994). A energia presente nos alimentos desempenha um papel fundamental na nutrição animal e pode ser dividida em diferentes frações, cada uma com sua própria importância e função. Essas frações incluem a energia bruta (EB), que representa a quantidade total de energia contida no alimento; a energia digestível (ED), que é a quantidade de energia que o animal é capaz de absorver após a digestão; a energia metabolizável (EM), que é a energia disponível para o organismo após a digestão e absorção dos nutrientes; e a energia líquida (EL), que é a energia líquida disponível para o animal após a consideração de todas as perdas de energia durante o processo digestivo e metabólico. Essas classificações são cruciais para compreender e formular dietas adequadas para animais, garantindo que suas necessidades energéticas sejam atendidas de forma eficiente e adequada (Bertechini, 2006). O conceito de "energia produtiva", definido por TITUS (1955) foi empregado como a energia líquida, que é avaliada pela comparação da energia retida no corpo das aves em forma de gordura ou proteína, em relação às diferentes quantidades de alimento consumido durante o crescimento ou engorda das aves. Mas, HILL & ANDERSON (1958) demonstraram com seu estudo, que os valores de energia metabolizável exibiam uma menor variação do que os valores de energia produtiva. Assim, a energia metabolizável emerge como a medida mais precisa para expressar a energia disponível dos alimentos para aves.

O teor de energia bruta de um alimento é determinado pelas proporções de seus componentes básicos. Carboidratos, como glicose e amido, fornecem 3,7 kcal/g e 4,2 kcal/g, respectivamente. As proteínas contribuem com 5,7 kcal/g, enquanto os

lipídios são a fonte mais densa de energia, fornecendo 9,4 kcal/g (Penz Júnior et al., 1999). De acordo com Chwalibog (1985) e Macleod & Jewitt (1988), aproximadamente 65% da EM consumida pelas aves é dissipada na forma de calor, restando apenas 35% disponíveis para a produção. Em relação à eficiência de utilização da EM em aves, estudos indicam que varia de acordo com o tipo de nutriente. Groote (1974), relata que a eficiência é aproximadamente de 60%, 90% e 75% para proteínas, lipídios e carboidratos, respectivamente. Essas variações são resultado das diferenças na eficiência de utilização entre os nutrientes, com os valores mais altos observados para lipídios e carboidratos, enquanto os valores mais baixos são associados à fibra dietética e proteína bruta.

O nível de energia é utilizado como ponto de partida para a formulação das dietas, servindo como base para a fixação dos níveis de outros nutrientes (COSTA et al., 2009). Segundo Ribeiro et al. (2011), entre os componentes da ração para poedeiras, a energia representa o maior custo. Um dos fatores cruciais para o sucesso na formulação de rações para aves é o conhecimento preciso do conteúdo energético dos alimentos. Isso possibilita o fornecimento adequado de energia para atender às necessidades das aves. (ALBINO et al.,1992). A exigência de energia para manutenção pode ser descrita como aquela requerida para o metabolismo basal, para produção de calor e atividades normais, estando intimamente ligada ao peso corporal e à temperatura (Grimbergen, 1974). Salientado por Ribeiro et al. (2019), os níveis de energia recomendados para poedeiras comerciais podem variar consideravelmente entre diferentes fontes de informações nutricionais. Essa disparidade pode resultar no uso inadequado de níveis de energia, prejudicando tanto a produtividade quanto a qualidade dos ovos. Portanto, é crucial alcançar um equilíbrio nutricional preciso para atender às exigências energéticas e nutricionais das aves, evitando tanto excessos quanto deficiências que possam comprometer seu desempenho. De acordo com Snetsinger e Zimmerman (1974), nas poedeiras, é comum uma regulação do consumo de ração em resposta ao teor energético da dieta. Contudo, o consumo voluntário de energia muitas vezes ultrapassa as exigências para manutenção e produção de ovos. Acarretando um aumento no peso corporal das aves, elevando as demandas energéticas para manutenção. Como resultado, ocorre uma perda de eficiência energética, além de uma redução na longevidade das aves, levando a uma diminuição na produção de ovos por ave alojada e aumento de custos, visto que as aves consomem mais ração do que necessitam.

Apesar dos avanços significativos no entendimento da energia na nutrição animal, ainda há uma clara necessidade de estudos adicionais para aprimorar nossa compreensão dos requerimentos energéticos específicos das aves, especialmente no contexto da produção comercial. Além disso, é crucial considerar os custos associados à formulação de rações, garantindo que o fornecimento de energia seja eficiente e economicamente viável para otimizar tanto a produtividade quanto a qualidade dos produtos avícolas.

2.2. Energia Metabolizável

A energia metabolizável emerge como o indicador mais preciso para representar a quantidade efetivamente disponível de energia nos alimentos para as aves (Silva, 2008), estando estreitamente relacionada aos requisitos tanto para manutenção quanto para o ganho de peso corporal e/ou produção de ovos (De Groote, 1974; Scott et al., 1982; Spratt et al., 1990; Pesti et al., 1992).

A energia metabolizável aparente (EMA) é uma medida utilizada para estimar a porção de energia ingerida que as aves realmente utilizam. Esse processo começa com a subtração da energia fecal da energia ingerida, resultando na energia digestível aparente. Para determinar essa energia em aves, é necessária coleta do conteúdo ileal terminal após o abate das aves. No entanto, a energia metabolizável aparente pode ser determinada diretamente através da coleta das excretas sem distinção entre fezes e urina. Em essência, tanto a EMA quanto a EMAn são determinadas pela diferença entre a energia presente na dieta consumida e a energia encontrada nas excretas, considerando tanto fezes quanto urina (NRC,1994).

Durante os processos de digestão, absorção e metabolismo dos nutrientes, ocorre uma perda aproximada de 15% da energia por incremento calórico (IC). Notavelmente, o IC das gorduras é inferior ao dos carboidratos e proteínas, o que leva a uma diminuição na utilização desses nutrientes em dietas com maior teor calórico, geralmente através da inclusão de gorduras. As aves têm uma tendência a consumir quantidades específicas de ração para satisfazer suas necessidades energéticas, e para elevar o conteúdo energético da ração, são utilizados óleos e gorduras com baixo IC (NOBAKHT et al., 2011). A presença de lipídios no duodeno desencadeia a liberação do hormônio colecistoquinina, que estimula a secreção pancreática e atua no centro de saciedade, diminuindo assim o consumo de ração. Esses efeitos têm um papel crucial na regulação do consumo alimentar e nas necessidades energéticas das aves. Vale ressaltar que o IC dos nutrientes em poedeiras apresenta algumas diferenças em relação a outras espécies monogástricas, o que destaca a importância da determinação precisa do conteúdo de energia das rações para otimizar a ingestão dos ingredientes pelas aves (OLIVEIRA et al., 2000). Embora as poedeiras comerciais em gaiolas possam exercer certo controle sobre sua ingestão calórica, o aumento da energia dietética pode acarretar uma maior ingestão diária de calorias, potencialmente

influenciando o metabolismo hepático das aves (BERTECHINI, 2012). Ainda não há um entendimento completo sobre a quantidade necessária de energia considerando que essas aves são criadas em piso. D'Alfonso et al. (1996), em sua revisão, investigaram os efeitos de três diferentes níveis de energia metabolizável aparente (EMAn) (2580, 2814 e 3010 kcal/kg), em poedeiras com idades entre 23 e 31 semanas, observaram que o aumento dos níveis de EMAn resultou em uma redução tanto no consumo de ração quanto na ingestão de EMAn. Mas, não foram encontradas correlações significativas entre os diferentes níveis de energia e a produção de ovos, a massa dos ovos ou o peso das aves.

2.3. Regulação da Ingestão Alimentar

Compreendemos que tanto o sistema nervoso central (SNC) quanto o sistema nervoso entérico (SNE) desempenham papéis cruciais na regulação da ingestão alimentar. Esses sistemas formam uma rede de comunicação que integra duas vias principais: a parassimpática, composta por fibras colinérgicas, e a simpática, que inclui fibras noradrenérgicas. Essas vias são dotadas de uma vasta gama de sensores e receptores que orquestram a comunicação entre o intestino e o cérebro, desempenhando um papel fundamental na regulação das funções digestivas e da ingestão alimentar (Konturek et al., 2004). Embora a regulação da ingestão alimentar seja primariamente controlada pelo SNC e SNE, esse processo é influenciado por uma complexa interação de sinais neuroendócrinos sensíveis ao estado metabólico e à ingestão calórica do animal (Munsch et al., 2005). Um exemplo marcante desse mecanismo é a colecistocinina (CCK), um peptídeo intestinal que desempenha um papel crucial na promoção da saciedade (Woods et al., 1998). Pesquisas destacam que a sensação de saciedade após uma refeição é amplamente atribuída à ação da CCK, a qual é liberada pelas células I do trato gastrointestinal em resposta à presença de gordura e proteína. Além de induzir a sensação de saciedade, a CCK também desencadeia a secreção pancreática, a liberação de bile e a contração da vesícula biliar (Konturek et al., 2004).

Portanto, a complexidade da regulação da ingestão alimentar pelos sistemas nervoso central e entérico, é possível reconhecer a importância desses mecanismos na manutenção do equilíbrio nutricional e na promoção da saúde e produtividade dos animais.

3. HIPÓTESES E OBJETIVOS

HIPÓTESES

A redução gradual na quantidade de EM na dieta das galinhas poedeiras resultará em uma diminuição linear na produção de ovos e na qualidade ao longo das 51 semanas de estudo.

A quantidade de EM na dieta das galinhas poedeiras está diretamente relacionada à eficiência econômica da produção de ovos, onde uma dieta específica com teor ótimo de EM resultará em menor custo por unidade de ovo produzido.

OBJETIVO GERAL

Avaliar o desempenho e as características dos ovos de poedeiras Bovans White alimentadas com dietas com reduções graduais de EM.

OBJETIVO ESPECÍFICO

Avaliar o impacto econômico das dietas com a redução gradual de energia metabolizável.

CAPÍTULO II

NUTRITION

DIETARY ENERGY FOR LAYING HENS

A 51-week egg production assessment of White Leghorn hens fed on a 400 kcal ME/kg range

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SUMMARY

Egg production of White Leghorn hens fed diets with decreasing ME contents through 51 wks were evaluated. Hens were allocated into 48 cages in 4 treatments with 12 replicates of two hens each. All hens were fed an adaptation feed from 18 to 24 wks (2,750 kcal ME/kg, 17.2% CP, 4.0% Ca and 0.48% Av. P) and then the experimental feeds from 25 to 76 wks with decreasing energy (2,850, 2,750, 2,650 and 2,550 kcal ME/kg) but with all nutrients commonly formulated. Treatments were distributed into a randomized block design and the analysis of variance used 13 periods of 28 d with repeated measures. Linear responses were observed for BW, feed intake, ME intake, egg weight, egg mass, yolk, albumen, eggshell, as well as eggshell thickness with decreases of 30 g, 2.2 g, 5.3 kcal, 0.7 g, 0.8 g, 0.24 g, 0.57 g, 0.07 g, and 1.82 μm for each 100 kcal ME reduction, respectively ($P < 0.05$). Total egg production was quadratically adjusted with dietary ME reaching a highest point with 350 total eggs per hen and FCR of 1.377 kg/dozen eggs at 2,733 kcal and 2,842 kcal, respectively ($P < 0.05$). The lowest egg production cost associated with the feed was obtained with hens fed 2,650 kcal ME (U$ 0.033 per egg unit) throughout the experimental period.

Key words: laying hens, metabolizable energy, performance, eggs.

DESCRIPTION OF PROBLEM

Energy is required for all physiological processes, including growth, reproduction, body temperature regulation, metabolic activities and synthesis of egg components. However, energy daily intake by laying hens in commercial settings should be optimized with feeds that are able to maintain egg production while maximizing economic returns. Daily energy required by laying hens depends on body weight, age, laying rate, and environment (Sakomura, 2004; Jehl et al., 2019; Barzegar et al., 2020). Laying hens are very effective in adjusting their feed intake (FI) to match their daily energetic needs such that, within practical feed formulation ranges, dietary energy and FI present a reverse relationship. This, eventually, affects the feed conversion ratio (FCR) and egg production costs (Junqueira et al., 2006; Kang et al., 2018).

Practical recommendations of ME for laying hens during egg production may range from 2,760 to 2,880kcal/kg (NRC, 1994; Hendrix Genetics, 2020; Hy-Line, 2023). Feed addition with fat is frequently needed such that minimum dietary linoleic acid contents meet the requirements to sustain egg production and adequate egg weights (Jensen et al.1958; Guenter et al. 1971; Scragg et al. 1987). Supplemental fats to provide linoleic acid, such as the most common vegetable oils, may eventually lead to an increase in dietary ME.

Practical ME recommendations for laying hens have to take in consideration variations in the costs of feed ingredients since variations in their market prices affect final feed costs. This eventually leads to changes in the feed ME contents, which may lead to uncertainty of the potential responses of laying hens. Variations observed in the costs of dietary energy in different regions demand up-to-date information on impact of daily ME intake in egg production such that feed energy content can optimize returns. The present research was conducted to evaluate the impacts on overall performance indicators of Bovans White laying hens fed on graded decreases in ME, starting from the usual ME contents in practical Brazilian feeds. Economic returns on the

investment made on feed energy was taken into consideration using analyses of regression whenever the adjustment was possible.

MATERIAL AND METHODS

All procedures used in the present study were approved by the Ethics and Research Committee of the Federal University of Rio Grande do Sul, Porto Alegre under the project number 40247.

Hen management

Ninety-six Bovans White laying hens were obtained from a commercial breeder farm (Mercoaves Avicultura LTDA, Bom Princípio, RS, Brazil) with 18 wks of age. Hens were individually weighed at arrival and only hens having the group average body weight ± 5% were placed into experimental cages (0.33 m length, 0.46 m width, 0.40 m height). Arrangement of treatments was randomized with blocking done by placing cage replications longitudinally distributed within the house at the same proportions between treatments. The metal cages have one stainless steel nipple drinker and one plastic trough feeder. The study was conducted in a completely randomized block design with four treatments assigned to 48 replicate cages, totaling 12 replicates per treatment, with 2 hens per replicate. Lights were on 16 hrs a day during the study and environmental temperature targeted bird comfort as suggested by Hendrix Genetics (2020).

Experimental diets and study design

Feeds had corn, soybean meal (SBM) and wheat bran and were formulated as usual by white egg producers in Brazil. Ingredients were mixed in a 500 kg capacity horizontal mixer with feed samples being collected from each feed batch and stored at -20ºC for further analyses. Hens were given *ad libitum* access to feed in the adaptation period (18 to 24 wks) with all birds receiving

a common feed with 2,750 kcal ME/kg, 17.2% CP, 4.0% Ca and 0.48% Av.P. The experimental feeds were provided from 25 to 76 wks of age, which was divided in 13 periods of 28 d each for the sake of statistical analyses and consisted of dietary ME contents of 2,850, 2,750, 2,650 and 2,550 kcal/kg (Table 1).

Laying Performance and Egg Characteristics

Productive performance was analyzed using cumulative data for each of 4 wks period. Observations were done on BW, FI, daily energy intake, hen day and total egg productions, FCR per dozen and kg of eggs, egg contents and egg mass and body weight change. The feeding cost to produce one egg unit was calculated using Brazilian and U$ currencies at the exchange rates obtained on 01/03/2024. Eggs were collected 4 times a day (08:30 am, 11:00 am, 2:00 pm, and 4:00 pm). Egg contents and eggshell thickness were recorded with 30 eggs per treatment collected on three consecutive days at 36, 48, 60, and 72 wks of age. Shell, albumen, and yolk percentage were calculated as their proportion of egg weight. Eggshell weight was obtained after washing using filtered water and drying shells at 105˚C overnight, whereas eggshell thickness was measured using a digital micrometer (Model I P65; Mitutoyo Corp., Kawasaki, Japan) three times in the equatorial region, with these values being averaged for statistical analysis.

ME determination

An assay for determination of the apparent ME of the treatment feeds was conducted during the last three days of the trial. A pool of feeds provided throughout the study, previously stored at -20 ^{o}C, was mixed and added with 1% insoluble marker (Celite, Celite Corp., Lompoc, CA). This was provided for three days with the corresponding excreta collected twice daily on aluminum foil trays. Excreta was pooled by cage and stored at -20 ºC, for dry matter (DM) analysis, which was carried out after drying the samples at 105 °C for 16 h (method 934.01; AOAC International,

2006). Excreta and feed samples were analyzed for gross energy (GE) using a calorimeter calibrated with benzoic acid as a standard (IKA Werke, Parr Instruments, Staufen, Germany). Calculations of ME were done afterwards. Acid insoluble ash in excreta and diets were determined as described by Vogtmann et al. (1975) and Choct and Annison (1992). Calculations of ME was done as suggested by Kong and Adeola, 2014.

Statistical Analysis

Data were tested for homoscedasticity and normality of the variance (Levene, 1960; Shapiro and Wilk, 1965) prior to other statistical analyses. Analysis of variance was performed using the PROC MIXED model procedure of SAS with effects of dietary treatments and periods, as well as their interactions, using the repeated statement of SAS program (SAS, 2013). Akaike's information criterion was used to indicate the relative goodness-of-test for each covariate structure. The Tukey-Kramer test was used for means comparison, where differences were considered significant at $P < 0.05$ (Tukey, 1991). Regression analyses were conducted for the effects of dietary ME using linear (L) and quadratic polynomial (QP) models.

Egg production feeding cost

The cost per dozen eggs associated with feed intake was calculated using the corresponding overall FCR of each treatment. Feed ingredient market prices were updated to the current in Brazil in March of 2024 (Table 5).

RESULTS

Feed formulations as well as CP, GE, Ca and P analyses are presented in Table 1. Feed ME contents evaluated at the end of the experiment were 2,866, 2,727, 2,632, 2,532 kcal ME/kg, which were acceptable for the planned experimental assessment since they were close to the expected

values of 2,850, 2,750, 2,650, 2,550 kcal ME/kg. Overall, there were no interactions between dietary ME and period on the responses evaluated ($P > 0.05$).

Performance

Performance results are presented in Table 2. There were treatment effects on all performance data evaluated ($P < 0.05$). Regression analyses showed that dietary ME had linear relationships with BW, daily ME intake, egg weight, egg mass, and FI as follow: Body weight = $Y = 891.95351 + 0.26973x$, R^2 0.0907 =, $P < 0.001$; daily intake kcal/day = $174.75915 + 0.04790x$ $R^2 = 0.1176$, $P < 0.001$; egg weight = $45.09732 + 0.00632$ x, $R^2 = 0.0618$, $P < 0.001$; egg mass = $39.38019 + 0.00744x$; $R^2 = 0.0395$; $P < 0.001$; and feed intake = $165.41294 – 0.1968x$; $R^2 = 0.1176$, $P < 0.001$. On the other hand, the reduction in ME led to quadratic responses for total egg production and FCR (kg/dozen) as follow: total eggs produced = $- 242.8669422 + 0.2484120x - 0.0000455x2$, $R^2 = 0.0098$, $P < 0.0497$; FCR (kg/dozen) = $9.567823249 - 0.005763746x + 0.000001014x^2$, $R^2 = 0.1045$, $P < 0.001$. The linear effects for BW, FI, daily intake kcal/day, egg weight and egg mass led to 30g, 2.2 g, and 5.3g increase, and 0.7 g and 0.8 g decreases for every 100 kcal of ME reduction in the feeds, respectively. Quadratic adjustments showed the highest egg production occurring when hens were fed at 2,733 kcal/kg ME with a maximum hen day egg production of 96.2% or a total of 350 eggs per hen in the 51 wk cycle. Feed conversion ratio was optimized at 2,842 kcal/kg with a an FCR of 1,377 kg/dozen.

Feed costs are presented in Table 1 and show the lowest feed related production costs occurring when hens were fed 2,650 kcal/kg ME.

Egg quality

Results from egg composition are summarized in Table 3. Effects of ME were found for all evaluated variables ($P < 0.05$), except for the percentage of albumen and eggshell ($P > 0.05$).

157 On the other hand, all period variables showed effects ($P < 0.05$), except for the percentage of
158 albumen ($P > 0.05$). Reducing ME led to a decrease in the weight of the egg yolk, albumen and
159 eggshell, as well as eggshell thickness (Yolk = 10.910000 + 0.00214x, $R^2 = 0.0309$, $P < 0.001$;
160 albumen = 25.32007 + 0.00515x, $R^2 = 0.0370$, $P < 0.001$; eggshell = 4.14856 + 0.00070685x, R^2
161 = 0.0429, $P < 0.001$; thickness = 446.97495 – 0.01632x, $R^2 = 0.0131$, $P < 0.001$). The linear
162 decreases in albumen weight, yolk weight, eggshell weight and eggshell thickness had respective
163 reductions of 0.57, 0.24, 0.07 g, and 1.82 μm for every 100 kcal ME/kg reduction ($P < 0.05$).
164
165 **DISCUSSION**
166 Reducing the dietary ME for 51 wks significantly influenced the performance of laying
167 hens. Many responses were linear, however, egg production and FCR were quadratically adjusted
168 indicating that the hens needed more daily dietary energy to optimize their FCR and maintain egg
169 production, but lower ME contents were needed when it comes to the economics of production
170 cost.
171 In the present study there was clear evidences that feed intake was increased as dietary
172 energy decreased. This has been previously demonstrated by Wu et al. (2005; 2007) and others.
173 The two highest dietary ME treatments showed to lead to an increase in daily egg production, egg
174 weight and body weight compared to the others. This is relevant and show that hens fed low energy
175 diets for long periods may have a negative impact on egg production. The reduction in body weight
176 as hens advanced in the feeding program with reduced ME occurred in parallel to the ME intake.
177 It seems that the hens fed on lower ME continued to produce eggs at the expense of their energy
178 reserves until 76 wks of age. Unfortunately, this study did not follow through circa 100 wks, which
179 are practical commercial white hen cycles. Therefore, we can only suppose that the lower
180 production of hens fed the lower ME feeds could accentuate if another 30-40 wks period followed.

Regarding egg weight, the present study obtained a linear reduction of 0.7 g for every 100 kcal reduction. Similar results were found by Harms et al., (2000) when 2,519 kcal ME was compared to 3,078 kcal ME with an increase of 2.1g in egg weight with the highest ME. Therefore, reducing ME contents seem to be a good strategy to reduce egg weight from extra to large whenever this condition reduce egg salability, which frequently occurs in the last periods of production. In parallel, reducing ME in the feeds affected several egg quality characteristics, including yolk, albumen and shell weight, as well as shell thickness. Increases in egg yolk proportion occur as chickens age, which is concurrent with a reduction in eggshell thickness. This is correlated with the increase in egg weight as it has been shown previously (McDaniel et al., 1981; Noetzold et al., 2022 a,b). Increasing energy in the feeds as laying hens advance in age and body weight leads to heavier yolks due to the corresponding increase in daily caloric intake, resulting in heavier eggs with a higher proportion of yolks (Leeson and Summers, 2005).

Egg production costs related to feed consumed varied according to dietary ME content with graded increases as energy content were higher. Although layers fed diets with higher energy contents in the present study had lower FCR and produced a few more eggs, those fed low energy diets were more cost efficient in terms of the cost per egg produced over the evaluated period. The results highlight the importance of taking dietary energy content into account when formulating diets for layers in production, not only aiming for production performance, but also considering egg quality and economic efficiency. In a context in which the use of alternative raw materials allow for the reduction in feed costs, this study suggests the need to investigate whether the option for the use of feed ingredients having higher fiber and, therefore, lower energy content, allows for better economic returns.

CONCLUSIONS AND APPLICATIONS

1. White Leghorn laying hens respond to dietary energy to reduction in feed intake and FCR.
2. The overall egg production characteristics from peak of laying to 76 wks indicate that hens fed with 2,650 kcal ME/kg present the best economic response.
3. Outcomes from the present study can be used to predict the impact of dietary energy on the final production costs when using Bovans White laying hens.

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DISCLOSURES

All authors declare that they have no conflict of interest or personal relationships that could have appeared to influence the work reported in this article.

REFERENCES

AOAC International. 2006. Official Methods of Analysis. 18th ed. Gaithersburg, MD, US: Association of Official Analyses Chemists.

Barzegar, S., S. Wu, M. Choct, and R. A. Swick. 2020. Factors affecting energy metabolism and evaluating net energy of poultry feed. Poult. Sci. 99:487-498. doi: 10.3382/ps/pez554.

Choct, M., and G. Annison. 1992. Anti-nutritive effect of wheat pentosans in broiler chickens: roles of viscosity and gut microflora. Br. Poult. Sci. 33:821-834. doi: 10.1080/00071669208417524.

228 Costa, F. G. P., J. S. Costa, C. C. Goulart, D. F. F. Lima, R. C. L. Neto, and B. J. S. Quirino.
229 2009. Metabolizable energy levels for semi-heavy laying hens at the second production cycle. R.
230 Bras. Zootec. 38:857-862. doi: 10.1590/S1516-35982009000500011.

231 Guenter, W., D. B. Bragg, and P. A. Kondra, 1971. Effect of dietary linoleic acid on fatty
232 acid composition of egg yolk, liver and adipose tissue. Poult. Sci. 50:845–850. doi:
233 10.3382/ps.0500845.

234 Harms, R. H., G. B. Russell, and D. R. Sloan. 2000. Performance of four strains of
235 commercial layers with major changes in dietary energy. J. Appl. Poult. Res. 9:535-541. doi:
236 10.1093/japr/9.4.535.

237 Hendrix Genetics. 2020. Nutrition Management Guide. Version L7121-2. Boxmeer, the
238 Netherlands.

239 Hy-Line International. 2023. W-80 Management Guide. West Des Moines. IA.

240 Jehl, F., C. Désert, C. Klopp, M. Brenet, A. Rau, S. Leroux, M. Boutin, L. Lagoutte, K.
241 Muret, Y. Blum, D. Esquerré, D. Gourichon, T. Burlot, A. Collin, F. Pitel, A. Benani, T. Zerjal,
242 and S. Lagarrigue. 2019. Chicken adaptive response to low energy diet: main role of the
243 hypothalamic lipid metabolism revealed by a phenotypic and multi-tissue transcriptomic approach.
244 BMC Genomics. 20:1033. doi: 10.1186/s12864-019-6384-8.

245 Jensen, L. S., J. B. Allred, R. E. Fry, and J. McGinnis, 1958. Evidence for an unidentified
246 factor necessary for maximum egg weight in chickens. J. Nutr. 65:219–233. doi:
247 10.1093/jn/65.2.219.

248 Junqueira, O. M., A. C. Laurentiz, R. S. E. A. Filardi, and E. M. Casartelli. 2006. Effects of
249 energy and protein levels on egg quality and performance of laying hens at early second production
250 Cycle. J. Appl. Poult Res. 15:110-115. doi: 10.1093/japr/15.1.110.

Kang, H., S. B. Park, J. J. Jeon, H. S. Kim, K. T. Park, S. H. Kim, E. C. Hong, and C. H. Kim. 2018. Effect of increasing levels of apparent metabolizable energy on laying hens in barn system. Asian-Australas J. Anim. Sci. 11:1766-1772. doi: 10.3390/ani12243513.

Kong, C., and O. Adeola. 2014. Evaluation of amino acid and energy utilization in feedstuff for swine and poultry diets. Asian-Australas J. Anim. Sci. 27:917-925. doi: 10.5713/ajas.2014.r.02.

Leeson, S., and J. D. Summers. 2005. Commercial Poultry Nutrition. 3rd ed. Nottingham University Press, Nottingham, UK.

Levene, H. 1960. Robust Tests for the Equality of Variance Contributions to probability and statistics. I. Olkin. Stanford University Press, Palo Alto, CA, 278-292.

McDaniel, J. Brake, and M. K. Eckman. 1981. Factors that affect the performance of breeding matrices: 4. The interrelationship of some reproductive characteristics. Poult. Sci. 60: 1792 – 1797. doi: 10.3382/ps.0601792.

Noetzold, T. L., S. L. Vieira, B. B. Xavier, Y. J. Olabarriaga, and A. K. Fireman. 2022a. Supplemental effects of amino acid-complexed trace minerals on broiler breeder hen performance. Anim. Feed Sci. Technol. 209:0377-8401. doi: 10.1016/j.anifeedsci.2022.115371.

Noetzold, T. L., S. L. Vieira, R. M. Horn, C. R. Freitas, and A. K. Fireman. 2022b. Improved offspring performance of broiler breeder hens fed amino acid complexed trace minerals. J Appl Poult Res. 31:1056-6171. doi: 10.1016/j.japr.2022.100284.

NRC, National Research Council. 1994. Nutrient Requirements of Poultry, 9th rev ed. Washington, DC, US: Natl. Acad. Press.

Rosniecek, M., Schneider A., Souza C., Oliveira V. and Gewehr C. 2015. Energy levels metabolizable of the white laying hen rearing in the open shelter. 20:149-154. Arch. Vet. Sci. doi: 10.5380/avs.v20i2.37380

Sakomura, N. K. 2004. Modeling energy utilization in broiler breeders, laying hens and broilers. Braz. J. of Poult. Sci. 6:1-11. doi: 10.1590/S1516-635X2004000100001.

SAS User's Guide. 2013. Version 9.4. Cary, NC: SAS Institute Inc.

Scragg, R. H., Logan, N. B., and N. Geddes. 1987. Response of egg weight to the inclusion of various fats in layer diets. Br. Poult. Sci. 28:15–21. doi:10.1080/00071668708416932.

Shahram, B., W. Shu-Biao, J. Noblet, and R. A. Swick. 2019. Metabolizable energy of corn, soybean meal and wheat for laying hens. Poult Sci. 98(11):5876-5882.

Shapiro, S. S., and M. B. Wilk. 1965. An analysis of variance test for normality (complete samples). Biometrika. 52,591-611. doi: 10.2307/2333709.

Tukey, J. W. 1991. The philosophy of multiple comparisons. Stat.Sci. 6:100-116. doi: 10.1214/ss/1177011945.

Vogtmann, H., P. Frirter, and A. L. Prabuck. 1975. A new method of determining metabolisability of energy and digestibility of fatty acids in broiler diets. Br. Poult. Sci. 16:531-534. doi: 10.1080/00071667508416222.

Wu, G., M. M. Bryant, P. Gunawardana, and D. A. Roland Sr. 2007. Effect of nutrient density on performance, egg components, egg solids, egg quality, and profits in eight commercial leghorn strain during phase one. Poult. Sci. 86:691-697. doi: 10.1093/ps/86.4.691.

Wu, G., M. M. Bryant, R. A. Voitle, and D. A. S. Roland. 2005. Effect of dietary energy on performance and egg composition of Bovans White and Dekalb White hens during phase I. Poult Sci. 10:1610-1615. doi: 10.1093/ps/84.10.1610.

Table 1. Composition of feeds having graded decreases in metabolizable energy (ME) supplied to white Leghorn laying hens from 25 to 76 wks[1].

Ingredients, %.	ME, kcal/kg[2]			
	2,550	2,650	2,750	2,850
Corn	53.70	57.49	57.54	54.98
Soybean meal 45%	24.19	23.60	18.43	10.72
Wheat bran	8.19	2.00	-	-
Full fat soy	1.00	4.00	11.11	21.39
Limestone	10.32	10.23	10.20	10.18
Dicalcium phosphate	1.67	1.80	1.84	1.84
Salt	0.42	0.42	0.42	0.42
Vitamin-mineral mix[2]	0.30	0.30	0.30	0.30
DL-Methionine 99%	0.16	0.15	0.15	0.16
L-Lysine 78%	0.04	-	-	-
L-Threonine 98%	0.01	0.01	0.01	0.01
Total	100.00	100.00	100.00	100.00
U$/kg	0.278	0.285	0.293	0.313
	Formulated composition, % or as shown[3]			
ME, kcal/kg	2,550	2,650	2,750	2,850
CP	17.00 (17.9 ± 0.73)	17.00 (17.80 ± 0.12)	17.00 (17.49 ± 0.33)	17.00 (17.59 ± 0.20)
Ca	4.20 (4.2 ± 0.08)	4.20 (4.43 ± 0.15)	4.20 (4.39 ± 0.28)	4.20 (4.34 ± 0.23)
Av P	0.42	0.42	0.42	0.42
Total P	0.69 (0.68 ± 0.04)	0.69 (0.69 ± 0.05)	0.69 (0.66 ± 0.05)	0.69 (0.67 ± 0.03)
Na	0.18			
Dig. Lys	0.82			
Dig. TSAA	0.65			
Dig. Thr	0.56			
Dig. Trp	0.18			
Dig. Arg	1.03		1.04	
Dig. Val	0.71	0.73	0.74	0.77

[1]Supplied the following per kg of feed: Cu, 10 mg; Zn, 110 mg; Fe,50 mg; Se, 0.15 mg; I, 2 mg; vitamin A, 12,000 IU; vitamin D3, 3,000 IU; vitamin E, 100 IU; vitamin K3, 6mg; vitamin B12, 40 mg; thiamine, 3.5mg; riboflavin, 16mg; vitamin B6, 6mg; niacin,40mg; pantothenic acid,25mg; folic acid, 4mg; biotin, 0.3mg.

[2]Analyzed: 2,532, 2,632, 2,727 and 2,866 kcal/kg.

[3]Values within parenthesis are analyzed.

Table 2. Performance and egg characteristics of white Leghorn laying hens fed on graded decreases of ME from 25 to 76 wks.

ME, kcal/kg[1]	Body weight	Daily intake		Egg weight	Egg mass	Hen/d egg production	Total eggs[3]	FCR	FCR	Feeding cost[4]	Feeding cost[5]
	g	g/bird/day	kcal/day[2]	g		%		kg/kg	kg/dozen	US$[6] /dozen	R$ /dozen
2,550	1,568	116^{a}	296^{c}	61.0^{b}	57.8^{b}	94.9^{b}	345^{b}	1.996^{a}	1.460^{a}	0.406	2.033
2,650	1,602	114^{ab}	302^{bc}	61.7^{ab}	60.1^{ab}	97.1^{a}	353^{a}	1.896^{b}	1.404^{b}	0.400	2.002
2,750	1,638	111^{b}	305^{ab}	62.2^{ab}	60.3^{a}	96.9^{ab}	352^{a}	1.851^{bc}	1.378^{b}	0.404	2.019
2,850	1,656	110^{b}	313^{a}	63.2^{a}	61.1^{a}	96.5^{ab}	351^{ab}	1.799^{c}	1.364^{b}	0.427	2.135
Period, wks											
25-28	1,553^{f}	102^{c}	276^{c}	57.2^{f}	51.7^{c}	90.4^{f}	-	1.978^{a}	1.355^{cd}	0.396	1.980
29-32	1,570^{ef}	112^{b}	302^{ab}	60.7^{e}	60.0^{ab}	98.9^{a}	-	1.881^{bc}	1.361^{d}	0.398	1.989
33-36	1,602^{d}	113^{ab}	305^{ab}	61.8^{cde}	60.6^{ab}	98.2^{abc}	-	1.875^{bc}	1.386^{bcd}	0.405	2.025
37-40	1,639^{bc}	112^{ab}	303^{ab}	62.3^{bc}	61.4^{a}	98.7^{ab}	-	1.836^{c}	1.369^{cd}	0.400	2.000
41-44	1,655^{ab}	113^{ab}	305^{ab}	60.9^{de}	59.0^{b}	96.8^{bcd}	-	1.926^{ab}	1.405^{abcd}	0.411	2.053
45-48	1,599^{de}	115^{ab}	310^{ab}	62.4^{bc}	60.2^{ab}	96.5^{abcde}	-	1.912^{abc}	1.431^{ab}	0.418	2.091
49-52	1,605^{de}	114^{ab}	307^{ab}	62.6^{bc}	60.8^{ab}	97.2^{abcd}	-	1.880^{bc}	1.411^{abc}	0.412	2.062
53-56	1,626^{bcd}	114^{ab}	308^{ab}	63.3^{ab}	61.9^{a}	97.9^{abcd}	-	1.847^{bc}	1.400^{abcd}	0.409	2.046
57-60	1,611^{cd}	114^{ab}	307^{a}	63.1^{bc}	60.8^{ab}	95.9^{abcde}	-	1.846^{bc}	1.398^{abcd}	0.409	2.043
61-64	1,620^{bcd}	112^{b}	303^{b}	62.2^{bcd}	60.6^{ab}	97.1^{cd}	-	1.854^{bc}	1.390^{bcd}	0.406	2.031
65-68	1,679^{a}	115^{a}	310^{a}	63.2^{b}	60.2^{ab}	95.4^{de}	-	1.915^{ab}	1.449^{a}	0.423	2.117
69-72	1,620^{bcd}	113^{ab}	305^{ab}	62.6^{bc}	58.9^{b}	93.8^{e}	-	1.898^{bc}	1.425^{ab}	0.416	2.082
73-76	1,599^{de}	114^{ab}	309^{ab}	64.4^{a}	61.6^{a}	95.8^{cde}	-	1.868^{bc}	1.441^{a}	0.421	2.106
SEM	4.562	0.282	0.741	0.127	0.164	0.193	0.688	0.0068	0.0043	-	-
Probability											
Energy	0.0636	0.0034	0.0004	0.0525	0.0088	0.0459	0.0435	<0.0001	<0.0001	-	-
Period	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	<0.0001	<0.0001	-	-
Energy*period	0.1085	0.1620	0.2843	0.8313	0.0743	0.0704	-	0.0509	0.0522	-	-

[a-e] Means with different letters in the same column indicate significant differences (P < 0.05).

[1]Analyzed: 2,532, 2,632, 2,727 and 2,866 kcal/kg respectively.

[2]Intake/hen/day*feed kcal/1,000.

[3]Total eggs set at the end of 13 periods of 28 d.

[4] Feeding cost was based on the multiplication between the diet cost and the FCR; diet cost (US$) for 2,550; 2,650; 2,750; 2,850 kcal/kg were: US$ 0.278, US$ 0.285, US$ 0.293, US$ 0.313, respectively.

[5] Feeding cost was based on the multiplication between the diet cost and the FCR; diet cost (R$) for 2,550; 2,650; 2,750; 2,850 kcal/kg were: R$ 1,393, R$ 1,426, R$ 1,465, R$ 1,565, respectively.

Table 3. Effects of diets with gradual decreases of ME on egg characteristics of white Leghorn laying hens from 25 to 76 wks.

	Albumen	Yolk	Shell	Albumen	Yolk	Shell	Thickness
ME, kcal/kg[1]	g			%			µm
2,550	38.8[c]	16.4[b]	5.9[b]	63.3	26.9[b]	9.7	402[a]
2,650	39.0[bc]	17.0[a]	6.0[b]	63.0	27.5[a]	9.7	401[a]
2,750	39.6[ab]	17.0[a]	6.1[a]	63.2	27.1[ab]	9.7	396[b]
2,850	40.3[a]	17.3[a]	6.1[a]	63.3	27.2[ab]	9.6	390[b]
Period, wks							
36	38.4[c]	16.3[c]	6.1[a]	63.1	26.8[c]	10.1[a]	417[a]
48	39.1[b]	17.1[b]	6.1[a]	63.1	27.4[ab]	9.9[b]	399[b]
60	39.9[a]	17.0[b]	6.0[a]	63.2	27.1[bc]	9.6[c]	393[c]
72	40.3[a]	17.5[a]	5.9[b]	63.3	27.5[a]	9.2[d]	386[d]
SEM	0.102	0.042	0.013	0.064	0.059	0.021	0.070
Probability							
Energy	<0.0001	<0.0001	<0.0001	0.0767	0.0122	0.6087	0.0001
Period	<0.0001	<0.0001	<0.0001	0.7886	<0.0001	<0.0001	<0.0001
Energy*period	0.0701	0.0976	0.0825	0.1118	0.1031	0.0632	0.0836

[a-e] Means with different letters in the same column indicate significant differences ($P < 0.05$).

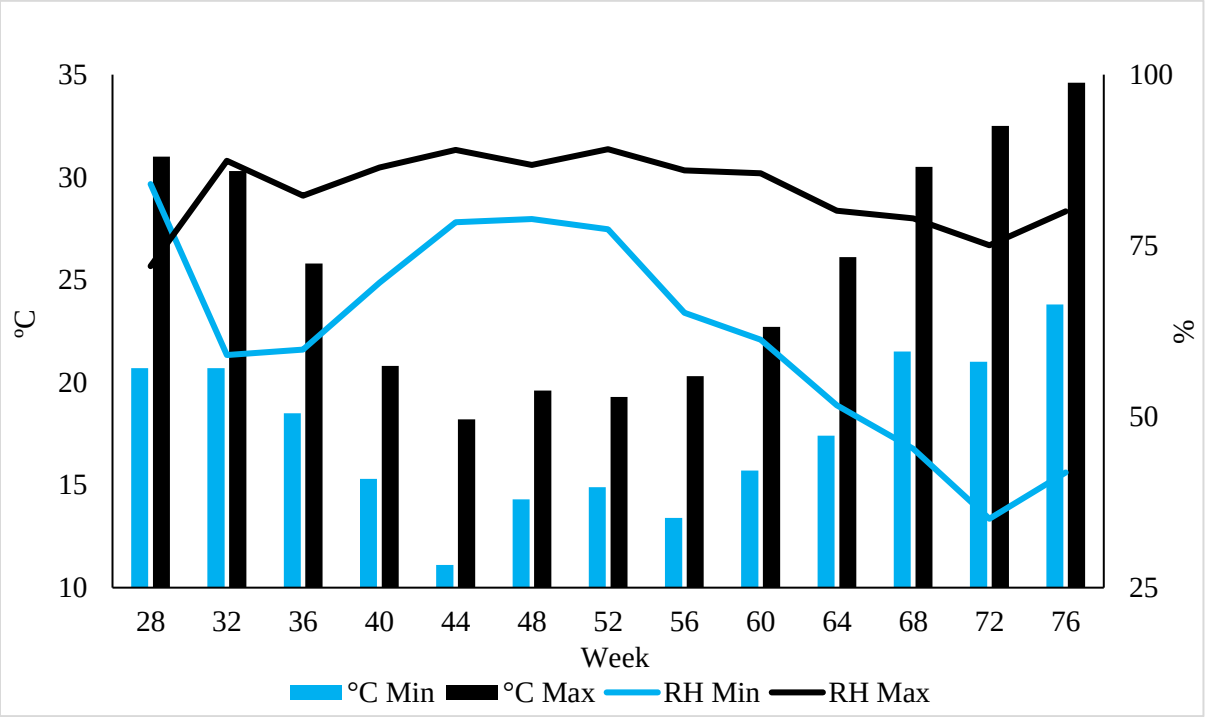
[1]Recovered values of ME 2,550, 2,650, 2,750 and 2,850 kcal/kg were: 2,532, 2,632, 2,727 and 2,866 kcal/kg respectively.

313 **Table 4.** Regression equations of white Leghorn laying hens fed diets with gradual ME decreases from 25 to 76 wks.

Item	Regression equations	Model[1]	R^2	P	Maximum ME (kcal/kg)
Body weight, g	$Y = 891.95351 + 0.26973x$	L	0.0907	<0.0001	- 30g
Feed intake, g/bird/day	$Y = 165.41294 – 0.01968x$	L	0.1176	<0.0001	- 2.2
ME daily intake, kcal/day	$Y = 174.75915 + 0.04790x$	L	0.1176	<0.0001	- 5.3
Egg weight, g	$Y = 45.09732 + 0.00632x$	L	0.0618	<0.0001	- 0.7
Hen day egg production, %	$Y = -169.7687295 + 0.1946032x – 0.0000356x^2$	Q	0.0092	0.0449	2,733
Egg mass, g	$Y = 39.38019 + 0.00744x$	L	0.0395	<0.0001	- 0.8
FCR, kg/dozen	$Y = 9.567823249 - 0.005763746x + 0.000001014x^2$	Q	0.1045	<0.0001	2,842
Yolk, g	$Y = 10.910000 + 0.00214x$	L	0.0309	<0.0001	- 0.24
Albumen, g	$Y = 25.32007 + 0.00515x$	L	0.0370	<0.0001	- 0.57
Eggshell, g	$Y = 4.14856 + 0.00070685x$	L	0.0429	<0.0001	- 0.07
Eggshell thickness, µm	$Y = 446.97495 – 0.01632x$	L	0.0131	0.0046	- 1.82

314 [1]Linear model ($Y = \beta1 + \beta2X$) has Y as the dependent variable and X as dietary ME (kcal/kg), β1 as the intercept, and β2 as the linear coefficient. Quadratic
315 polynomial model: $Y = \beta1 + \beta2 \times ME + \beta3 \times (ME)^2$) has Y as the dependent variable as a function of AME in the diet; β1 as the intercept; β2 as the linear coefficient
316 and β3 as the quadratic coefficient. The maximum response for ME was defined as $ME = - \beta2 \div (2 \times \beta3)$.

317 **Figure 1.** Temperature and relative humidity throughout the trial.



CAPÍTULO III

4. CONSIDERAÇÕES FINAIS

Este estudo proporcionou uma análise abrangente sobre o impacto dos níveis de energia metabolizável na produção de ovos de galinhas poedeiras Bovans White ao longo de 51 semanas. Os resultados obtidos demonstram a importância crucial da energia metabolizável na formulação da dieta das aves, influenciando diretamente seu desempenho e a qualidade dos ovos produzidos.

Ao longo do período de avaliação, foi observado que os maiores níveis de EM, resultaram em melhorias significativas no peso e na massa dos ovos, indicando uma correlação positiva entre a energia disponível na dieta e a produção de ovos. Além disso, foi constatado que o consumo de ração diminuiu linearmente em resposta ao aumento da energia metabolizável, evidenciando a eficiência no uso dos recursos alimentares pelas aves.

A análise econômica revelou que o menor custo de produção de ovos foi alcançado em 2.650 kcal EM/kg na dieta, ressaltando a importância de um planejamento nutricional preciso para otimizar não apenas o desempenho das aves, mas também a rentabilidade da produção de ovos.

Estes resultados desempenham um papel significativo no avanço da compreensão científica no campo da nutrição animal, oferecendo informações importantes para a indústria avícola no desenvolvimento de abordagens mais eficazes e sustentáveis para a produção de ovos. No entanto, é importante reconhecer que este estudo representa apenas um ponto de partida. Futuras pesquisas poderiam explorar de forma mais aprofundada outras variáveis nutricionais e examinar o impacto de diferentes estratégias de manejo na produção de ovos de galinhas poedeiras, permitindo uma análise mais abrangente e precisa deste aspecto essencial da produção avícola.

Portanto, podemos concluir que a EM desempenha um papel crucial na nutrição e desempenho das aves poedeiras. No entanto, há espaço para investigações adicionais visando explorar ainda mais esse aspecto. A manipulação adequada da EM pode potencialmente gerar benefícios na indústria da avicultura, constituindo um interessante ponto de partida para futuros experimentos e estudos mais aprofundados nesta área.

5. REFERÊNCIAS

ABPA. **Relatório Anual da Produção de Ovos no Brasil**. São Paulo: Associação Brasileira de Proteína Animal, 2023. Disponível em: https://abpa-br.org/wp-content/uploads/2023/04/Relatorio-Anual-2023.pdf. Acesso em: 10/01/2023.

BRUM, P. A. R.; ZANOTTO, D. L.; LIMA, G. J. M. M.; VIOLA, E. S. Composição química e energia metabolizável de ingredientes para aves. **Pesquisa Agropecuária Brasileira**, Brasília, DF, v. 35, n. 5, p. 995-1002, 2000.

BOUGON, M.; JOLY, P. Influence du niveau énergétique sur les performances des pondeuses à oeufsroux et évolution de l'ingéré en fonction de l`âge. **Journée de la Recherche Avicole**, Tours, v. 2, p. 115–120, 1997.

COON, N. C. Feeding egg-type replacement pullets. *In*: BELL, D. D. **Commercial chicken meat and egg production 5th**. Massachusetts: Kluwer Academic, 2002. p. 287-393.

COSTA, F. G. P.; SOUZA, H. C.; GOMES, C. A. V.; BARROS, L.R.; BRANDÃO, P. A.; NASCIMENTO, G. A. J.; SANTOS, A.W. R.; AMARANTE JUNIOR, V. S. Níveis de proteína bruta e energia metabolizável na produção e qualidade dos ovos de poedeiras da linhagem Lohmann Brown. **Ciência e Agrotecnologia**, Lavras, v. 28, n. 6, p. 1421-1427, nov./dez. 2004.

COSTA, F. G. P.; QUIRINO, B. J. S.; GIVISIEZ, P. E. N. *et al*. Poedeiras Alimentadas com Diferentes Níveis de Energia e Óleo de Soja na Ração. **Archivos de Zootecnia**, Córdoba, v. 58, n. 223, p. 405-411, 2009.

D'ALFONSO, T. H.; MANBECK, H. B.; ROUSH, W. B. Effect of day to day variation of dietery energy on residual feed intake of laying hens. **Poultry Science**, Champaign, v. 75, p. 362-369. 1996.

DE GROOTE, G. Utilization of metabolizable energy. *In*: MORRIS, T.R.; FREEMAN, B.M. (eds.). **Energy requirements of poultry**. Edinburgh: British Poultry Science, 1974. p. 113-133.

EMMANS, G.C. Growth, body composition and feed intake. **World's Poultry Science Journal**, Cambridge, v. 43, p. 208-227, 1987.

FARIA, D. E.; SANTOS, A. L. Exigências nutricionais de galinhas poedeiras. *In*: SIMPÓSIO INTERNACIONAL SOBRE EXIGÊNCIAS NUTRICIONAIS DE AVES E SUÍNOS, 2005, Viçosa. **Anais**[...]. Viçosa: UFV, 2005. p. 229-315.

GRIMBERGEN, A. H. M. Energy expenditure under productive conditions. *In*: MORRIS, T. R.; FREEMAN, B. M. (ed.). **Energy requirements of poultry**. Edinburgh: British Poultry Science, 1974. p. 61-71.

GROBAS, S.; MENDEZ, J.; DE BLAS, C.; MATEOS, G. G. Laying hen productivity as affected by energy, supplemental fat, and linoleic acid

concentration of the diet. **Poultry Science**, Champaign, v. 78, p. 1542–1551, 1999.

GUNAWARDANA, P.; ROLAND, D. A.; BRYANT, M. M. Effect of dietary energy, protein, and a versatile enzyme on hen performance, egg solids, egg composition, and egg quality of Hy-line W-36 hens during second cycle, phase two. **Journal of Applied Poultry Research**, Athens, v. 18, n. 1, p. 43–53, 2009.

HARMS, R. H. Specifications for feeding commercial layers based on daily feed intake. **Feedstuffs**, [S. l.], v. 53, n. 47, p. 40-41, 1981.

HARMS, R. H.; RUSSELL, G. B.; SLOAN, D. R. Performance of four strains of commercial layers with major changes in dietary energy. **The Journal of applied poultry research**, Athens, v. 9, p. 535–541, 2000.

HILL, F. W.; ANDERSON, D. L.; DANSKY, L. M.. Studies of the energy requirements of chickens: 3. The effect of dietary energy level on the rate and gross efficiency of egg production. **Poultry science**, Champaign, v. 35, p. 54-59, 1956.

JUNQUEIRA, O. M. ET AL. Effects of energy and protein levels on egg quality and performance of laying hens at early second production cycle. **Journal of Applied Poultry Research**, Athens, v. 15, n. 1, p. 110–115, 2006.

KONTUREK, S. J.; KONTUREK, J. W.; PAWLIK, T.; BRZOZOWKI T. Brain gut axis and its role in the control of food intake. **Journal of Physiology and Pharmacology**, Warszawa, n. 55, p. 137-54, 2004.

MCDONALD, M. W. Feed intake of laying hens. **World's Poultry Science Journal**, Ithaca, v. 34, p. 209-221, 1978.

MORRIS, T. R. Nutrition of chicks and layers. **World’s Poultry Science Association**, Ithaca, v. 60, p. 5-12, 2004.

NATIONAL RESEARCH COUNCIL – NRC. **Nutrient requirements of poultry**. 9. ed. Washington, DC: National Academy of Science, 1994. 157 p. (Nutrient requirements of domestic animals).

NOBAKHT, Ali; TABATBAEI, Shahram; KHODAEI, Sabir. Effects of Different Sources and Levels of Vegetable Oils on Performance, Carcass Traits and Accumulation of Vitamin E in Breast Meat of Broilers. **Journal of Biological Sciences**, Iran, v. 3, n. 6, p. 601-605, 2011.

OLIVEIRA, RITA F. M. *et al*. Níveis de energia metabolizável para frangos de corte de 1 a 21 dias de idade mantidos em ambiente de alta temperatura. **Revista Brasileira de Zootecnia**, Viçosa, MG, v. 29, n. 3, p. 810-816, 2000.

PESTI, G. M.; DORFMAN, J. H.; GONZALES, M. J. Comparison of equations for predicting the metabolizable energy intake of laying pullets. **British Poultry Science**, Edinburgh, v. 33, p. 553-9, 1992

RODRIGUES, P. B.; ROSTAGNO, H. S.; ALBINO, L. F. T. *et al*. Valores energéticos da soja e subprodutos da soja, determinados com galos adultos cecectomizados. **Revista Brasileira de Zootecnia**, Viçosa, MG, v. 31, n. 4, p. 1771-1782, 2002.

ROSA, A.P.; ZANELLA, I.; THEIR, J.; VIEIRA, N. S. Influência de diferentes níveis de proteína bruta e energia metabolizável no desempenho de poedeiras Rhode Island Red na fase. **Revista brasileira de zootecnia**, Viçosa, MG, v. 26, n. 1, p. 159-163, 1997.

SAKOMURA N. K.; BENATTI, M. R. B.; BASAGLIA, R.; FERNANDES, J. B. K.; NEME, R.; LONGO, F. A. Avaliação de equações de predição de exigências proteicas na alimentação de frangas de postura. **ARS VETERINARIA**, Jaboticabal, v. 21, n. 1, p. 7- 14, 2005.

SAKOMURA, N. K.; ROSTAGNO, H. S. Metodologias para avaliar o conteúdo de energia dos alimentos. *In*: SAKOMURA, N. K.; ROSTAGNO, H. S. **Métodos de pesquisa em nutrição de monogástricos**. Jaboticabal: Funep, 2007. p. 41-71.

SCOTT, M. L.; NESHEIM, M. C.; YOUNG, R. J. **Nutrition of the chicken**. 3. ed. Ithaca: M. L. Scott, 1982. 562p.

SILVA, C.R. DA. **Uso de probiótico em rações de frangos de corte: Desempenho, digestibilidade e energia metabolizável.** 64 f. Dissertação (Mestrado em Zootecnia) Viçosa: Universidade Federal de Viçosa, 2008.

SKINNER, J. T.; WALDROUP, A. L.; WALDROUP, P. W. Effects of dietary nutrient density on performance and carcass quality of broilers 42 to 49 days of age. **Journal of Applied Poultry Research**, Athens, v. 1, p. 367-372, 1992.

SPRATT, R. S.; BAYLEY, H. S.; McBRIDE, B. W. *et al*. Energy metabolism of broiler breeder hens. 1. The partition of dietary energy intake. **Poultry Science**, Champaign, v. 65, n. 8, p. 1339-1347, 1990.

SILVA, D.J. **Análise de alimentos**: métodos químicos e biológicos. Viçosa, MG: Universidade Federal de Viçosa, 1990. 166 p.

WU, G.; BRYANT, M. M.; VOITLE, R. A.; ROLAND, D. A. S. R. Effect of dietary energy on performance and egg composition of Bovans White and Dekalb White hens during phase I. **Poultry science**, Champaign, v. 10, p. 1610-1615, 2005.

ALBERS, N. *et al*. **Vitamins in animal nutrition**. Bonn: Arbeitsgemeinschaft für Wirkstoffe in der Tierernährung, 2002.

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Bagley, L. G., and V. L. Christensen. 1991. Hatchability and physiology of turkey embryos incubated at sea level with increased eggshell permeability. Poult. Sci. 70:1412-1418.

Bagley, L. G., V. L. Christensen, and R. P. Gildersleeve. 1990. Hematological indices of turkey embryos incubated at high altitude as affected by oxygen and shell permeability. Poult. Sci. 69:2035- 2039.

Witter, R. L., and I. M. Gimeno. 2006. Susceptibility of adult chickens, with and without prior vaccination, to challenge with Marek's disease virus. Avian Dis. 50:354-365. doi:10.1637/7498-010306R.1

Book:

Metcalfe, J., M. K. Stock, and R. L. Ingermann. 1984. The effects of oxygen on growth and development of the chick embryo. Pages 205- 219 in Respiration and Metabolism of Embryonic Vertebrates. R. S. Seymour, ed. Dr. W. Junk, Dordrecht, the Netherlands.

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

Federal Register:

Department of Agriculture, Plant and Animal Health Inspection Service. 2004. Blood and tissue collection at slaughtering and rendering establishments, final rule. 9CFR part 71. Fed. Regis. 69:10137-10151.

Other:

Choct, M., and R. J. Hughes. 1996. Long-chain hydrocarbons as a marker for digestibility studies in poultry. Proc. Aust. Poult. Sci. Symp. 8:186. (Abstr.)

Dyro, F. M. 2005. Arsenic. WebMD. Accessed Feb. 2006. http:// www.emedicine.com/neuro/topic20.htm.

El Halawani, M. E., and I. Rosenboim. 2004. Method to enhance reproductive performance in poultry. Univ. Minnesota, as- signee. US Pat. No. 6,766,767.

Hruby, M., J. C. Remus, and E. E. M. Pierson. 2004. Nutritional strategies to meet the challenge of feeding poultry without antibiotic growth promotants. Proc. 2nd Mid-Atlantic Nutr. Conf., Timonium, MD. Univ. Maryland, College Park.

Luzuriaga, D. A. 1999. Application of computer vision and electronic nose technologies for quality assessment of color and odor of shrimp and salmon. PhD Diss. Univ. Florida, Gainesville.

Peak, S. D., and J. Brake. 2000. The influence of feeding program on broiler breeder male mortality. Poult. Sci. 79(Suppl. 1):2. (Abstr.)

TABLES

Tables must be created using the MS Word table feature and inserted in the manuscript after the references section. When possible, tables should be organized to fit across the page without running broadside. Be aware of the dimensions of the printed page when planning tables (use of more than 15 columns will create layout problems). Place the table number and title on the same line above the table. The table title does not require a period. Do not use vertical lines and use few horizontal lines. Use of bold and italic typefaces in the table should be done sparingly; you must define such use in a footnote. Each table must be on a separate page. To facilitate placement of all tables into the manuscript file (just after the references) authors should use "section breaks" rather than "page breaks" at the end of the manuscript (before the tables) and between tables.

Units of measure for each variable must be indicated. Papers with several tables must use consistent format. All columns must have appropriate headings. Abbreviations not found on the inside front cover of the journal must be defined in each table and must match those used in the text. Footnotes to tables should be marked by superscript numbers. Each footnote should begin a new line. Superscript letters shall be used for the separation of means in the body of the table and explanatory footnotes must be provided [i.e., "Means within a row lacking a common superscript differ ($P < 0.05$)."]; other significant P-values may be specified. Comparison of means within rows and columns should be indicated by different series of superscripts (e.g., a,b,… in rows; x-z … in columns) The first alphabetical letter in the series (e.g., a or A) shall be used to indicate the largest mean. Lowercase super- scripts indicate $P \leq 0.05$. Uppercase letters indicate $P \leq 0.01$ or less.

Probability values may be indicated as follows: *$P \leq 0.05$, **$P \leq 0.01$, ***$P \leq 0.001$, and †$P \leq 0.10$. Consult a recent issue of Poultry Science for examples of tables.

Generally, results should be presented to the significant figure of the instrument used to collect the data. For example, results should not be presented to 5 digits when the instrument used only reads to 2 digits.

MISCELLANEOUS USAGE NOTES

Abbreviations

• Abbreviations shall not be used in the title, key words, or to begin sentences, except when they are widely known throughout science (e.g., DNA, RNA) or are terms better known by abbreviation (e.g., IgG, CD). A helpful criterion for use of abbreviation is whether it has been accepted into thesauri and indexes widely used for searching major bibliographic databases in the scientific field. Abbreviations may be used in heads within the paper, if they have been first defined within the text. The inside back cover of every issue of the journal lists abbreviations that can be used without definition. The list is subject to revision at any time, so authors should always consult the most recent issue of the journal for relevant information. Abbreviations are allowed when they help the flow of the manuscript; however, excessive use of abbreviations can confuse the reader. The suitability of abbreviations will be evaluated by the reviewers and editors during the review process and by the technical editor during editing. As a rule, author-derived abbreviations should be in all capital letters. Terms used less than three times must be spelled out in full rather than abbreviated. All terms are to be spelled out in full with the abbreviation following in bold type in parentheses the first time they are mentioned in the main body of the text. Abbreviations shall be used consistently thereafter, rather than the full term.
• The abstract, text, each table, and each figure must be understood independently of each other. Therefore, abbreviations shall be defined within each of these units of the manuscript.

• Plural abbreviations do not require "s." Chemical symbols and three-letter abbreviations for amino acids do not need definition. Units of measure, except those in the standard Poultry Science abbreviation list, should be abbreviated as listed in the CRC Handbook for Chemistry and Physics (CRC Press, 2000 Corporate Blvd., Boca Raton, FL, 33431) and do not need to be defined.

• The following abbreviations may be used without definition in Poultry Science:

A adenine
ADG average daily gain
ADFI average daily feed
AME apparent metabolizable energy
AMEn nitrogen-corrected apparent metabolizable energy
ANOVA analysis of variance
B cell bursal-derived, bursal-equivalent derived cell bp base pairs
BSA bovine serum albumin
BW body weight
C cytosine
cDNA complementary DNA
cfu colony-forming units
CI confidence interval
CP crude protein
cpm counts per minute
CV coefficient of variation
d day
df degrees of freedom
DM dry matter
DNA deoxyribonucleic acid

EDTA ethylenediaminetetraacetate
ELISA enzyme-linked immunosorbent antibody assay
EST expressed sequence tag
g gram
g gravity
G guanine
GAT glutamic acid-alanine-tyrosine
GLM general linear model
h hour
HEPES N-2-hydroxyethyl piperazine-N'-ethane-sulfonic acid
HPLC high-performance (high-pressure) liquid chromatography
i.m. intramuscular
i.p. intraperitoneal
i.v. intravenous
ICU international chick units
Ig immunoglobulin
IL interleukin
IU international units
kb kilobase pairs
kDa kilodalton
L liter*
L:D hours light:hours darkness in a photoperiod (e.g., 23L:1D)
m meter
µ micro M molar
MAS marker-assisted selection
ME metabolizable energy
MEn nitrogen-corrected metabolizable energy
MHC major histocompatibility complex
mRNA messenger ribonucleic acid
min minute
mo month
MS mean square
n number of observations
N normal
NAD nicotinamide adenine dinucleotide
NADH reduced nicotinamide adenine dinucleotide
NRC National Research Council
NS not significant
PAGE polyacrylamide gel electrophoresis
PBS phosphate-buffered saline
PCR polymerase chain reaction
pfu plaque-forming units
ppm parts per million
QTL quantitative trait loci
r correlation coefficient
r2 coefficient of determination, simple
R2 coefficient of determination, multiple
RH relative humidity
RIA radioimmunoassay
RNA ribonucleic acid

rpm revolutions per minute
s second
s.c. subcutaneous
SD standard deviation
SDS sodium dodecyl sulphate
SE standard error
SEM standard error of the mean
SRBC sheep red blood cells
SNP single nucleotide polymorphism
T thymine
TBA thiobarbituric acid
T cell thymic-derived cell
TME true metabolizable energy
TMEn nitrogen-corrected true metabolizable energy
Tris tris(hydroxymethyl)aminomethane
TSAA total sulfur amino acids
U uridine
USDA United States Department of Agriculture
UV ultraviolet
vol/vol volume to volume
vs. versus
wt/vol weight to volume
wt/wt weight to weight
wk week
yr year
*Also capitalized with any combination, e.g., mL.

International words and phrases

Non-English words in common usage (defined in recent editions of standard dictionaries) will not appear in italics (e.g., in vitro, in vivo, in situ, a priori). However, genus and species of plants, animals, or bacteria and viruses should be italicized. Authors must indicate accent marks and other diacriticals on international names and institutions. German nouns shall begin with capital letters.

Capitalization

Breed and variety names are to be capitalized (e.g., Single Comb White Leghorn).

Number style

Numbers less than 1 shall be written with preceding zeros (e.g., 0.75). All numbers shall be written as digits. Measures must be in the metric system; however, US equivalents may be given in parentheses. Poultry Science requires that measures of energy be given in calories rather than joules, but the equivalent in joules may be shown in parentheses or in a footnote to tables. Units of measure not preceded by numbers must be written out rather than abbreviated (e.g., lysine content was measured in milligrams per kilogram of diet) unless used parenthetically. Measures of variation must be defined in the Abstract and in the body of the paper at first use. Units

of measure for feed conversion or feed efficiency shall be provided (i.e., g:g).

Nucleotide sequences

Nucleotide sequence data must relate to poultry or poultry pathogens and must complement biological data published in the same or a companion paper. If sequences are excessively long, it is suggested that the most relevant sections of the data be published in Poultry Science and the remaining sequences be submitted to one of the sequence databases. Acceptance for publication is contingent on the submission of sequence data to one of the databases. The following statement should appear as a footnote to the title on the title page of the manuscript. "The nucleotide sequence data reported in this paper have been submitted to Embank Submission (Mail Stop K710, Los Alamos National Laboratories, Los Alamos, NM 87545) nucleotide sequence database and have been assigned the accession number XNNNNN." Publication of the description of molecular clones is assumed by the editors to place them in the public sector. Therefore, they shall be made available to other scientists for research purposes.

Nucleotide sequences must be submitted as camera- ready figures no larger than 21.6 x 27.9 cm in standard (portrait) orientation. Abbreviations should follow Poultry Science guidelines.

Gene and protein nomenclature

Authors are required to use only approved gene and protein names and symbols. For poultry, full gene names should not be italicized. Gene symbols should be in uppercase letters and should be in italics. A protein symbol should be in the same format as its gene except the protein symbol should not be in italics.

General usage

• Note that "and/or" is not permitted; choose the more appropriate meaning or use "x or y or both."

• Use the slant line only when it means "per" with numbered units of measure or "divided by" in equations. Use only one slant line in a given expression (e.g., g/d per chick). The slant line may not be used to indicate ratios or mixtures.

• Use "to" instead of a hyphen to indicate a range. Insert spaces around all signs (except slant lines) of operation (=, -, +, x, >, or <, etc.) when these signs occur between two items.

• Items in a series should be separated by commas (e.g., a, b, and c).

• Restrict the use of "while" and "since" to meanings related to time.

• Appropriate substitutes include "and," "but," or "whereas" for "while" and "because" or "although" for "since."

• Leading (initial) zeros should be used with numbers less than 1 (e.g., 0.01).

• Commas should be used in numbers greater than 999.

•Registered (®) and trademark (©) symbols should not be used, unless as part of an article title in the References section. Trademarked product names should be capitalized.

FIGURES/ILLUSTRATIONS

General points

• Submit each illustration as a separate file.

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SUPPLEMENTARY DATA

Supplementary material such as applications, images and sound clips, can be published with your article to enhance it. Submitted supplementary items are published exactly as they are received (Excel or PowerPoint files will appear as such online). Please submit your material together with the article and supply a concise, descriptive caption for each supplementary file. If you wish to make changes to supplementary material during any stage of the process, please make sure to provide an updated file. Do not annotate any corrections on a previous version. Please switch off the 'Track

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The corresponding author will, at no cost, receive a customized Share Link providing 50 days free access to the final published version of the article on ScienceDirect. The Share Link can be used for sharing the article via any communication channel, including email and social media. For an extra charge, paper offprints can be ordered via the offprint order form which is sent once the article is accepted for publication.

Reporting sex- and gender-based analyses

Reporting guidance

For research involving or pertaining to humans, animals or eukaryotic cells, investigators should integrate sex and gender-based analyses (SGBA) into their research design according to funder/sponsor requirements and best practices within a field. Authors should address the sex and/or gender dimensions of their research in their article. In cases where they cannot, they should discuss this as a limitation to their research's generalizability. Importantly, authors should explicitly state what definitions of sex and/or gender they are applying to enhance the precision, rigor and reproducibility of their research and to avoid ambiguity or conflation of terms and the constructs to which they refer (see Definitions section below). Authors can refer to the

Sex and Gender Equity in Research (SAGER) guidelines and the SAGER guidelines checklist. These offer systematic approaches to the use and editorial review of sex and gender information in study design, data analysis, outcome reporting and research interpretation - however, please note there is no single, universally agreed-upon set of guidelines for defining sex and gender.

Definitions

Sex generally refers to a set of biological attributes that are associated with physical and physiological features (e.g., chromosomal genotype, hormonal levels, internal and external anatomy). A binary sex categorization (male/female) is usually designated at birth (""sex assigned at birth""), most often based solely on the visible external anatomy of a newborn. Gender generally refers to socially constructed roles, behaviors, and identities of women, men and gender-diverse people that occur in a historical and cultural context and may vary across societies and over time. Gender influences how people view themselves and each other, how they behave and interact and how power is distributed in society. Sex and gender are often incorrectly portrayed as binary (female/male or woman/man) and unchanging whereas these constructs actually exist along a spectrum and include additional sex categorizations and gender identities such as people who are intersex/have differences of sex development (DSD) or identify as non-binary. Moreover, the terms ""sex"" and ""gender"" can be ambiguous—thus it is important for authors to define the manner in which they are used. In addition to this definition guidance and the SAGER guidelines, the resources on this page offer further insight around sex and gender in research studies.

7. VITA

Raíssa Gabriela Dias Menezes, filha de Edmilson Cunha de Menezes e Ângela Dias Menezes, nascido em 12 de março de 1994, em Viamão – RS. Realizou o ensino fundamental na Escola Municipal de Ensino Fundamental Farroupilha, e o ensino médio na Escola Estadual de Ensino Médio Farroupilha, concluindo os estudos em dezembro de 2011. Em agosto de 2013 iniciou a graduação em Zootecnia na Universidade Federal do Rio Grande do Sul. Fez parte do grupo de pesquisa Aviário de Ensino e Pesquisa, supervisionado pelo professor PhD. Sergio Luiz Vieira, desde janeiro de 2014, totalizando 4 anos de estágio na graduação. No último semestre da faculdade, em 2018, foi estagiária na empresa Mercoaves, na cidade de Bom Princípio – RS, tendo a oportunidade de conhecer todo o processo de produção de matrizes de postura, fábrica de ração, incubatório e recria de poedeiras. Ao concluir o estágio, foi efetivada e atualmente desempenha o papel de coordenadora no setor de PCP. Formou-se em março de 2019. No primeiro semestre de 2022 ingressou como aluna de mestrado tendo vínculo empregatício durante o Programa de Pós-Graduação em Zootecnia da UFRGS, sob orientação do professor Ph.D. Sergio Luiz Vieira.