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SUPLEMENTAÇÃO COM FONTES DE FERRO EM DIETAS PARA MATRIZES PESADAS: EFEITOS NA PRODUÇÃO E QUALIDADE DE OVOS, VARIÁVEIS SANGUÍNEAS E DESEMPENHO DA PROGÊNIE

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SUPLEMENTAÇÃO COM FONTES DE FERRO EM DIETAS PARA MATRIZES PESADAS: EFEITOS NA PRODUÇÃO E QUALIDADE DE OVOS, VARIÁVEIS SANGUÍNEAS E DESEMPENHO DA PROGÊNIE [1]

Autor: Marco Antônio Ebbing
Orientador: Sergio Luiz Vieira

Resumo - esta dissertação tem como objetivo avaliar: o efeito da suplementação de Fe, a partir de duas fontes, em dietas para matrizes Cobb 500, no período de 40 a 67 semanas; os efeitos desta suplementação na coloração da casca e na progênie. No período experimental com as reprodutoras, o arranjo foi completamente casualizado com 3 suplementações: (1) 50 ppm de Sulfato ferroso (Fe-S), (2) 50 ppm de Fe-S + 40 ppm de complexo ferro-aminoácido (Fe-AA) e (3) 40 ppm de Fe-AA, onde foram mensuradas a produção de ovos, coloração da casca e qualidade dos ovos. Para avaliação da eclodibilidade, parâmetros sanguíneos e desempenho da progênie ovos da 65ª semana foram classificados em (I) claros e (II) escuros antes de serem incubados, em um arranjo fatorial 3 x 2. As amostras de sangue foram coletadas após eclosão e o desempenho foi medido de 1 a 34 dias de idade e em três fases: pré-inicial (1-7 d) inicial (8-21 d) e crescimento (22-35 d). O rendimento de carcaça foi medido aos 35 dias. A suplementação com Fe não teve efeito na produção, qualidade e coloração das cascas dos ovos (P>0,05). Não houve interação (P>0,05) entre os fatores,mas efeitos da suplementação e coloração das cascas foram observados. A suplementação 3 foi superior a 1 (P<0,05) porém ambas foram iguais à 2, para fertilidade dos ovos e eclodibilidade destes. Não foi observado efeito de coloração de casca para tais respostas. A hemoglobina e hematócrito não foram afetados por nenhum dos fatores. Para o ganho de peso houve influência da suplementação e da casca, onde no acumulado de 1 a 35 dias a resposta da 3 foi superior a da 2 e este superior a da 1, da mesma forma, II foi superior à I (P<0,05). A conversão alimentar foi afetada pela cor da casca nas fases inicial e crescimento, onde, em ambas, cascas escuras resultaram em melhores índices (P>0,05). O filé de peito foi o único corte comercial afetado pela suplementação, onde a 3 foi melhor que a 2 e a 1 (P>0,05) em relação à carcaça. O rendimento de carcaça e demais cortes comerciais não foram afetados pelos tratamentos. Em conclusão, a suplementação de dietas para matrizes pesadas com Fe-AA resulta em maior fertilidade e eclodibilidade dos ovos; na progênie, melhora o desempenho e rendimento de filé de peito. Além disso, ovos de casca escura proporcionam pintos com desempenho zootécnico superior.

Palavras chave: ferro, frangos de corte, hematócrito, hemoglobina

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SUPPLEMENTATION WITH IRON SOURCES IN BROILER BREEDERS DIETS: EFFECTS ON EGG PRODUCTION AND QUALITY, BLOOD VARIABLES AND PERFORMANCE OF PROGENY[1]

Author: Marco Antônio Ebbing
Advisor: Sergio Luiz Vieira

Abstract - this dissertation has the objective evaluate the effect of iron supplementation, from two sources, in diets for Cobb 500 broiler breeders, from 40 to 67 weeks; the effects of supplementation on eggshell color and progeny. In the broiler breeder experimental period, the trial was completely randomized with 3 supplementations: (1) 50 ppm of ferrous sulfate (Fe-S), (2) 50 ppm of Fe-S + 40 ppm of iron amino acid complex (Fe-AA) and (3) 40 ppm Fe-AA, where measured the egg production, quality and eggshell color. To evaluate the hatchability, blood variables and performance of progeny, eggs from the 65th week were classified in (I) pale and (II) dark before they were incubated, resulting a factorial 3 x 2. Blood samples were collected at hatching and performance was measured from 1 to 35 days of age and in four phases: pre-starter (1-7 d) starter (8-21 d) and grower (22-35 d). Carcass yield was measured at 35 days. Supplementation with Fe had no effect on production, quality of eggs and eggshells colors ($P>0.05$). No interactions were found ($P>0.05$) but effects of supplementation and eggshell colors were observed. Supplementation 3 was superior to 1 ($P<0.05$), but both were similar to 2 in fertility and hatchability of eggs. No effects of eggshell colors was observed to such responses. Hemoglobin and hematocrit were not affected by any of the factors. The body weight gain was influenced by supplementation and eggshell, where the accumulated from 1 to 35 days the response of the supplementation 3 was higher than 2 and this higher than 1, similarly, the II was superior than I ($P<0.05$). The feed conversion was affected by eggshell color in the initial stages and growth, which, in both dark eggshells resulted in better indexes ($P>0.05$). The breast fillet was the only commercial cut affected by supplementation, where 3 was better than 2 and 1 ($P>0.05$) in relative values. The carcass yield and other commercial cuts were not affected by treatments. In conclusion, supplementation of diets for broiler breeders with Fe-AA, results in higher fertility and hatchability of eggs; Progeny, improves performance and breast meat yield. In addition, dark shell eggs provide chicks with superior growth performance**.**

Key words: iron, broilers, breeders, hematocrit, hemoglobin.

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RELAÇÃO DE ABREVIATURAS

AA	Aminoácido
AAFCO	Association of American feed Control Officials
BW	Body weight
BWG	Body weight gain
CA	Conversão alimentar
DcytB	Redutase citocromo b duodenal
DMT	Transportadora de metal divalente
FADH	Dinucleotídeo de flavina e adenina
FCR	Feed conversion rate
Fe-AA	Complexo ferro-aminoácido
Fe-S	Sulfato ferroso
FI	Feed intake
GLM	General lineal model
HCP	Proteína carreadora de heme
HFE	Proteína da hemocromatase
kDa	Quilodalton
NADH	Dinucleotídeo de adenine nicotinamida
TfR	Receptor de transferrina
USA	United States of America

CAPÍTULO I

INTRODUÇÃO

O Fe é um micromineral essencial para aves domésticas, envolvido em vários processos metabólicos, sendo o transporte de oxigênio para a respiração celular o mais relevante. O Fe é encontrado nos ingredientes das rações na formas *heme* e não-*heme*, sendo a *heme* exclusiva dos ingredientes de origem animal e a inorgânica encontrada nos vegetais e na forma salina em *premixes* para rações. Estas, apresentam diferentes mecanismos de absorção, uma das razões para a ser considerada no momento da seleção da fonte.

Fontes orgânicas comerciais de microminerais estão disponíveis, apresentadas como quelatos, na forma de complexo ferro-aminoácido (Fe-AA), por exemplo. Estas podem ter maior solubilidade e serem mais estáveis no trato gastrointestinal quando comparados às fontes salinas tradicionais (Vieira, 2008). A literatura neste sentido, não apresenta comparação de dados para todos microminerais relativos às diversas fontes inorgânicas. Portanto, o estabelecimento de bioequivalências entre as diversas fontes orgânicas e inorgânicas é limitado, especialmente no caso das reprodutoras pesadas. Estudos com suplementação de Fe para matrizes são escassos. Bess et al. (2012) avaliaram suplementações de Fe nas formas de sulfato ferroso (Fe-S) e Fe-AA, e observaram aumento na produção de ovos e na quantidade de Fe nos ovos quando Fe-AA foi suplementado em dietas concomitantemente ao sulfato ferroso.

A atuação do Fe está ligada também a coloração das cascas de ovos, pois a protoporfirina, principal pigmento, demanda Fe para sua síntese (Liu & Cheng, 2010). De acordo com Godfrey & Jaap (1949) a pigmentação da casca tem importância na qualidade de ovos férteis, porém seu efeito no desempenho de frangos é desconhecido.

Melhorar o desempenho de frangos de corte é uma aspiração da comunidade científica. Determinar meios para que estes interesses sejam alcançados em segmentos abrangentes, como a produção de ovos férteis, vêm de encontro com as demandas de sustentabilidade e progresso da avicultura comercial.

Ovos qualitativamente superiores resultam em pintos potencialmente mais produtivos. A primeira semana após eclosão é considerada crucial para o desempenho final do frango, desta forma, alojar aves com melhor status nutricional e metabólico pode ser um fator favorável. Portanto, os nutrientes que a matriz transfere para os ovos podem ser eficazes para a obtenção de melhores índices produtivos.

Com o impedimento do uso de ingredientes de origem animal em dietas de matrizes, o ferro *heme* não está mais disponível a essas aves. Somando a isso a interação competitiva pelo sítio de absorção das fontes inorgânicas com outros minerais divalentes, evidencia-se a necessidade de realizar um estudo comparativo utilizando uma fonte orgânica alternativa capaz de proteger o Fe no trato gastrointestinal, e facilitar sua absorção.

REVISÃO BIBLIOGRÁFICA

Funções do Ferro

O Fe é um micromineral essencial associado a processos metabólicos e sua função mais importante é o transporte de oxigênio através da hemoglobina e mioglobina (Leeson & Summers, 2001). Estes complexos proteicos representam cerca de 67% do total de ferro corpóreo em mamíferos, sendo 60% na hemoglobina e de 3 a 7% na mioglobina (Hambidge et al., 1986). Nos ovos das aves a quantidade de Fe é cerca de 1,5 mg. Esse valor representa aproximadamente 25% das reservas hepáticas da matriz (Cao et al., 1996).

O ferro corporal é encontrado na forma *heme* complexado à porfirina, sendo essa fração correspondente a três quartos do total, este grupamento *heme* é o carreador de O_2 da hemoglobina (Oberleas et al., 1999). As porfirinas também são encontradas em hemoproteínas como citocromos, catalases, peroxidases e na mioglobina; atuando na formação de ligações moleculares entre o O_2 e o grupamento *heme*; na transferência de elétrons nos citocromos e na clivagem de peróxidos estruturais das reações de catalases e peroxidases.

A mioglobina muscular é a segunda maior fração que contém Fe. Sua estrutura fechada assemelha-se à hemoglobina com um grupamento *heme* e um átomo isolado de Fe ligado ao O_2, utilizado na contração muscular. Os citocromos (oxidase) *a*, *b* e *c* são cadeias transportadoras de elétrons das cristas das mitocôndrias em todas as células aeróbicas. O citocromo *c* é uma proteína abundante no músculo cardíaco, ligado à cadeia de globulina, isolada com um grupo *heme* e um átomo de Fe. O citocromo P-450 é encontrado dentro das membranas dos microssomos nas células hepáticas e da mucosa intestinal, atua na degradação oxidativa. Já as catalases atuam na quebra do peróxido de hidrogênio em água e oxigênio molecular (Grotto, 2008).

Existem outras atividades biológicas que o Fe desempenha sem estar ligado à porfirina. A aconitase converte o ácido cítrico em ácido aconítico no ciclo de Krebs. Os átomos de ferro servem para manter a relação espacial apropriada entre o grupo hidroxila e os íons carbono. As gliceraldeído-3-fosfato desidrogenases são enzimas encontradas no citoplasma e na mitocôndria. Elas usam NADH como co-enzima e reduz dihidróxiacetona fosfato em L-α-glicerolfosfato, composto necessário para a biossíntese dos triglicerídeos. A metaloflavoproteína é uma enzima mitocondrial que usa o $FADH_2$ como coenzima. Essas enzimas são transportadoras de íons, na mitocôndria auxiliam na transdução de energia (elétrons) (West & Oates, 2008).

As Oxigenases fenolíticas, são catalisadoras da reação de anéis aromáticos fenólicos com o O_2 molecular. Por sua vez a desidrogenase succínica, enzima do ciclo de Krebs, converte o succinato em fumarato. Essa enzima contém 4 átomos de Fe não-*heme* e uma riboflavina. Outras enzimas dependentes de Fe que não está ligado às porfirinas são a NADH desidrogenase, a xantina oxidase e a ribonucleotídeo redutase. Existem ainda aquelas enzimas que não contêm Fe, mas o necessitam como co-fator ou ativador, são elas: a triptofano pirrolase e fosfoenol-piruvato carboxiquinase (Grotto, 2008).

Absorção e Metabolismo do Ferro

A absorção do Fe depende, inicialmente, de sua natureza (*heme* e não-*heme*) e seu estado oxidativo (Fe^{+2} e Fe^{+3}). De acordo com Suttle (2010) o Fe é absorvido primeiramente no duodeno através de dois estágios: a captação pela mucosa e a transferência para a serosa. Na mucosa o ferro *heme* e não-*heme* são processados e regulados diferentemente.

A internalização do Fe *heme* da dieta é feita por uma proteína transportadora (HCP), posicionada na membrana apical das células duodenais. O *heme* liga-se à membrana da borda em escova dos enterócitos e a proteína transportadora atravessa intacta a membrana plasmática, importando o *heme* extracelular. A seguir o *heme* apresenta-se ligado à membrana de vesículas no citoplasma da célula. No interior da célula, o Fe é liberado da porfirina pela *heme* oxigenase passando a fazer parte das reservas corpóreas, como ferritina ou ligado à hemoglobina (Grotto, 2008). A HCP1 também é expressa em outros locais, como o fígado e baço, sua regulação é feita de acordo com o nível de Fe intracelular: havendo deficiência, a HCP1 posiciona-se do citoplasma para a membrana plasmática das células duodenais. Em condições de excesso, o posicionamento se dá a partir da borda em escova da célula para o seu citoplasma (West e Oates, 2008). Esse mecanismo regulador pós-tradução da proteína é interessante porque, de um lado, aproveita o *heme* da dieta antes que ele seja eliminado pelo peristaltismo intestinal e, no outro extremo, evita a captação desnecessária de Fe e o seu provável acúmulo, potencialmente patogênico. A hipóxia também induz a síntese da HCP1, facilitando a captação de *heme*.

A absorção da forma não-*heme* é regulada, em parte, pelas concentrações intracelulares de Fe nos enterócitos. Íons de Fe^{+3} podem ser reduzidos pela DcytB para Fe^{+2} na borda em escova da membrana duodenal sendo em seguida internalizados no enterócito pela DMT1. Uma vez no meio intracelular do enterócito, o Fe pode ser armazenado como ferritina ou transportado para a membrana basolateral por ação da ferroportina e da hefaestina. Essa última oxida o Fe^{+2} a Fe^{+3} liberando-o para a circulação (Ludwiczek et al., 2004) (Figura 1). A comunicação sistêmica entre as reservas, demandas, locais de absorção e utilização é feita pela hepcidina, hormônio peptídeo circulante (Grotto, 2008)

O Fe é absorvido de acordo com as demandas fisiológicas,sendo afetadas pela idade e pelas reservas corpóreas. A eficiência de absorção está aumentada em animais jovens e privados deste micromineral, através de uma maior expressão da DMT1. Existem estudos de absorção de Fe em ratos e humanos, porém raros em aves. Conrad et al. (2000) em um ensaio *in vitro* demonstrando duas vias de absorção de Fe não-*heme*, o Fe^{+3} é internalizado na célula via β_3-integrina e mobilferrina enquanto que o Fe^{+2} é internalizado via DMT, porém sem esclarecer qual a mais importante.

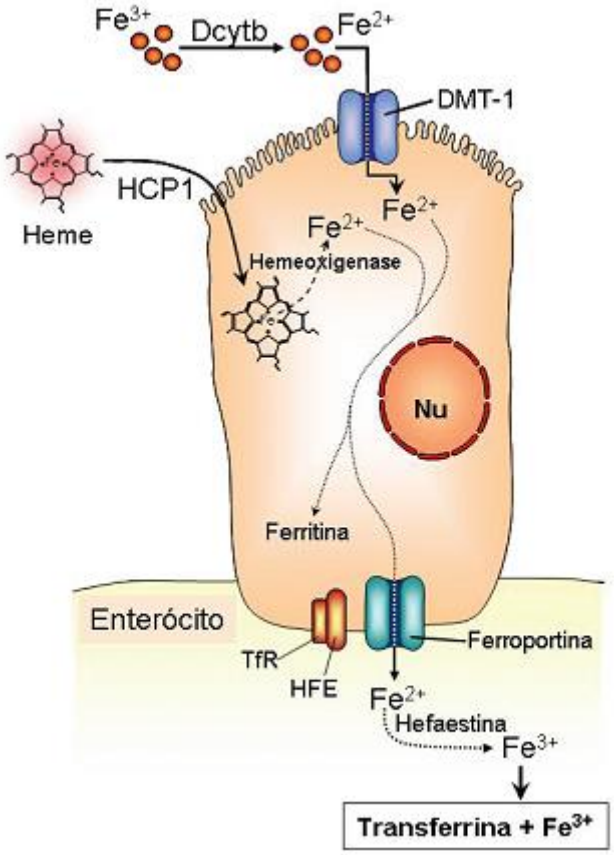

Figura 1**.** O enterócito e as proteínas envolvidas na absorção do Fe. Dcytb: ferroredutase; DMT1: transportador de metal divalente; HCP-1: proteína transportadora do heme; Nu: núcleo; HFE: proteína da hemocromatose; TfR: receptor da transferrina).

Propriedades da dieta podem influenciar a absorbilidade do Fe. Por exemplo, o uso de acidificantes pode melhorar a absorção. O ácido ascórbico, em condições de deficiência na dieta deste mineral, proporciona maior aproveitamento do Fe, onde a adição de 0,4% de ácido ascórbico, aumentou a concentração de hemoglobina e a retenção de Fe corporal em pintos com dietas deficientes (23 ppm). Quando esses pintos receberam dieta marginal (40 ppm) o fornecimento de 0,1% de ácido ascórbico foi suficiente para aumentar a retenção de Fe, e quando receberam nível adequado (100 ppm) o ácido ascórbico não teve mais efeito (Miski e Kratzer, 1976).

A biodisponibilidade do Fe é condicionada as concentrações deste na dieta. De modo geral, quando as dietas são deficientes, mecanismos fisiológicos já descritos anteriormente, são ativados para facilitar a absorção evitando a excreção fecal. Em estudo conduzido por Tako et al., (2010) utilizando o isótopo[58] Fe, demonstrou-se que aves recebendo menor quantidade, apresentaram menores concentrações de hemoglobina e peso corporal, porém a eficiência na absorção foi maior, quando comparado ao grupo que recebeu mais. Neste mesmo ensaio foi verificado aumento na atividade de proteínas envolvidas na absorção e transporte deste micromineral essencial. Similarmente, Featheeston et al., (1968) avaliaram a absorção e retenção do Fe em pintos com a utilização do isótopo[59], onde observaram que

os pintos com dieta deficiente e marginal tiveram maior retenção, frente aqueles que receberam dose superior. Os pintos que receberam dieta deficiente também aumentaram o percentual de Fe no fígado, sangue e intestinos.

Ao abordarem a biodisponibilidade dos microminerais, Guimarães et al. (2013) salientam que as informações disponíveis são inconsistentes ou ultrapassadas, além disso, não há informações específicas para matrizes pesadas. McNaughton et al. (1974) conduziram ensaios de biodisponibilidade de Fe a partir de fontes orgânicas e inorgânicas para frangos de corte encontraram hematócrito e hemoglobina maiores nas aves que receberam Fe orgânico ou sulfato ferroso, frente às que receberam óxido de Fe.

Do mesmo modo, as respostas nas progênies também têm poucos estudos. No entanto, Guimarães et al. (2013), ao avaliarem o desempenho das matrizes e progênies com suplementação com fontes orgânicas e inorgânicas de Fe, Cu, Se, I e Zn não encontraram diferenças em nenhum parâmetro zootécnico.

Metodologias laboratoriais simplificadas auxiliam na quantificação da concentração deste metal no organismo. A mensuração da hemoglobina é uma forma precisa para avaliar o status de Fe no organismo animal, no entanto deve-se ter atenção à espécie e ao ciclo produtivo e/ou reprodutivo do indivíduo em questão. Poedeiras tendem a apresentar baixos níveis de hemoglobina quando estão prestes a entrar em produção, e essa queda persiste até o final do ciclo produtivo. Por outro lado, ocorre um aumento na concentração de Fe no plasma que está diretamente correlacionada com a deposição no ovo. Pouca alteração foi encontrada nos níveis armazenados no fígado e no baço dessas aves, sugerindo que o aumento na deposição de Fe no ovo está relacionado ao melhor aproveitamento do Fe da dieta (Ramsay e Campbell, 1954).

Nas aves existem duas proteínas carreadoras de Fe: a fosvitina, que é encarregada de carrear para o ovário; e a transferrina, que transporta para os demais tecidos e órgãos. Quando as aves estão no pico de produção de ovos (entre 29 e 41 semanas) a transferrina carrea 65% do Fe sérico, enquanto que a fosvitina é responsável pelos demais 35%. Durante o estágio produtivo a atividade da transferrina alcança até 80%, sendo essa variação regulada pelo estrogênio (Ramsay e Campbell, 1954)

A deposição de Fe no ovo pode ser um ponto crítico para a avicultura moderna. O estoque de Fe disponível para o embrião durante a incubação é limitado e rapidamente utilizado no estágio final do desenvolvimento embrionário. Assim, após a eclosão o status de Fe dos pintos é baixo e sem o adequado fornecimento via dieta o desempenho e a sobrevivência na primeira semana podem ser afetados (Tako & Glahn, 2011).

Fe e coloração da casca dos ovos

A forma do Fe presente na dieta pode ter influência na coloração dos ovos (Kennedy e Vevers, 1973). A linhagem é o principal fator que determina a cor da casca, porém os pigmentos estão estreitamente relacionados à protoporfirina-IX, componente da hemoglobina (Lang e Wells, 1987). As porfirinas são secretadas na mucosa da glândula da casca, conferindo tons

marrons mais intensos e maior resistência à casca frente aos medianamente pigmentados. Isso confere qualidade superior e pode melhorar a eclodibilidade (Godfrey e Jaap, 1949). No processo de formação do ovo, os pigmentos são depositados depois da calcificação. Porém o aprofundamento do conhecimento sobre a importância da coloração da casca em aves de interesse zootécnico é limitado.

Classificação das fontes orgânicas de minerais

Fontes de minerais orgânicos podem ter diferenças em suas disponibilidades e estão relacionados à possíveis melhorias em suas ações específicas a nível celular (Vieira, 2008). Isso é importante diante da necessidade de substituir os ingredientes de origem animal por vegetais em dietas de não-ruminantes sem prejuízos à biodisponibilidade de microminerais.

Para facilitar os estudos nessa área a *Association of American Feed Control Officials* - AAFCO (1997) distribuiu os compostos minerais ligados a moléculas orgânicas em 5 categorias:

- Quelato metal aminoácido – produto resultante da reação de um sal metálico solúvel com aminoácidos a uma taxa molar de 1:1 até 1:3. O peso molecular médio do aminoácido hidrolisado deve ser aproximadamente 150 e o peso molecular resultante não pode exceder 800.
- Complexo metal aminoácido – produto resultante do complexo entre um metal solúvel com um aminoácido.
- Complexo metal com aminoácido específico - produto resultante do complexo entre um metal solúvel com um aminoácido específico.
- Metal proteinado – produto resultante da quelação de um sal solúvel com aminoácidos ou proteínas parcialmente hidrolisada.
- Complexo metal polissacarídeo - produto resultante do complexo entre um sal solúvel e uma solução de polissacarídeo declarada como um ingrediente de um complexo metálico específico.

Interações entre Minerais

O entendimento da interação entre os minerais é importante, uma vez que,as semelhanças iônicas entre os diferentes metais podem afetar suas reações. Por exemplo, a Dcytb não é uma proteína transportadora exclusiva de Fe, ela transporta um grupo de minerais que interagem entre si. Segundo Skrivan et al. (2005) devido a essa interação quando somente o Fe é suplementado pode não ocorrer o efeito esperado. A suplementação de uma dieta basal (contendo 63,4 ppm de Zn; 92,8 ppm de Fe e 9,0 ppm de Cu) com 120 ppm de Fe aumentou 6,3 e 2,2% a suas concentrações na gema e na clara respectivamente. Por outro lado, a suplementação combinada de 80 ppm de Zn, 120 de Fe e 25 de Cu promoveu um aumento de 36,7 e 34,9% de Fe no ovo sem alterar a deposição de Cu e Zn.

A interação do Fe com o Mn também é expressiva, pois o excesso de Mn na dieta de frangos prejudica a utilização do Fe. Foi demonstrado que o Fe apresenta um pequeno efeito no status de Mn de pintos independentemente do nível de suplementação, enquanto que a suplementação de 1000 ppm de Mn diminuiu a hemoglobina quando o nível de ferro na dieta atingia a exigência

(Baker e Halpin, 1991). Fontes de minerais que possam proteger-se dessas interações apresentam vantagens, pois além de não interagirem, possuem outros mecanismos de absorção, como os complexados à aminoácidos (Vieira, 2008).

Desde modo, usufruir de variadas fontes de minerais abre possibilidades de melhores respostas produtivas. Assim, as vantagens de uma fonte sobre outra estão sendo estudadas e quantificadas, como é o caso deste estudo

HIPÓTESES E OBJETIVOS

Hipóteses

Matrizes Cobb 500 tem desempenho similar se suplementadas com Fe-AA ou Fe-S.

Frangos de corte obtidos a partir de ovos com pigmentação de casca clara ou escura têm desempenho similar.

Frangos de corte obtidos de reprodutoras suplementadas com Fe-S ou Fe-AA têm desempenho similar nos dias 1 a 7, 8 a 21 e 22 a 35 de idade.

Objetivos

Avaliar o efeito da suplementação de Fe inorgânico e orgânico no desempenho de matrizes de corte Cobb 500 no pós-pico de produção.

Avaliar o efeito da pigmentação de ovos de matrizes de corte Cobb 500 no hematócrito e concentração de hemoglobina, desempenho, rendimento de carcaça e cortes comerciais da progênie de 1 a 35 dias de idade.

Avaliar o efeito da suplementação de Fe em matrizes de corte Cobb 500 a partir de Fe-S ou Fe-AA no hematócrito e hemoglobina, desempenho, rendimento de carcaça e cortes comerciais da progênie de 1 a 35 dias de idade.

CAPÍTULO II[1]

[1] Artigo elaborado conforme as normas da periódico Poultry Science (Apêndice 1).

Running title: IRON SOURCES AND LEVELS FOR BREEDER HENS AND OFFSPRING

Performance of broiler breeder hens supplement with different sources and levels of iron and performance of their progeny obtained from different eggshell color eggs

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Section: Metabolism and Nutrition

Primary Audience: Broiler Managers, Nutritionists and Researchers

Keywords: broiler, eggshell color, hemoglobin, hematocrit, iron.

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ABSTRACT

This study was conducted to determine the effect of supplementing broiler breeder diets with different Fe sources and levels, and to determine the relationship between broiler breeder diets supplemented with Fe and eggshell color on chick hematological status and broiler performance. Six hundred forty slow-feathering Cobb 500 broiler breeder hens were assigned randomly to three dietary iron treatments. The breeder diets were supplemented with ferrous sulfate (**Fe-S**) to supply 40 ppm Fe, Fe-S plus Fe amino acid (**AA**) complex (**Fe-S +Fe-AA**) to supply a total of 90 ppm Fe, or Fe-AA to supply 40 ppm Fe..Breeder performance was evaluated in six periods, from 40 to 67 wk. Six hundred eggs (100 per group) were incubated to analyze hemoglobin and hematocrit in the chicks at hatching. Additionally, 1,200 slow-feathering Cobb 500 one-d-old male broilers were placed in 48 floor pens for a performance experiment.Chicks were assigned randomly to pens in a 3 x 2 factorial arrangement of treatments according to the broiler breeder diets and eggshell color (dark or pale). No differences were obtained in egg production, but hens receiving Fe-AA and Fe-S + Fe-AA had better fertility and hatchability than hens fed Fe-S alone ($P<0.05$). Hemoglobin, hematocrit and FCR were not affected ($P>0.05$) by Fe treatment or eggshell color. Broiler feed intake was affected ($P< 0.05$) by Fe treatment during grower phase, where as BW gain was influenced ($P< 0.05$) by Fe treatment during starter and grower phases and overall 34 d period. Although eggshell color was not affected by Fe treatment in this study, broilers from dark brown eggs had better growth rates and increased carcass and breast meat weight compared with broilers from pale eggshells ($P<0.05$). Supplementing hen diets with iron amino acid complex improved growth and carcass weights of their offspring.

Keywords: iron, hemoglobin, hematocrit, eggshell color, broiler

INTRODUCTION

Iron is a trace mineral linked to the oxygen transport, but it is essential for many metabolic processes (Leeson and Summers, 2001). This element is present in almost all the ingredients used in animal nutrition (Theil, 2004). Iron can be found in ingredients of animal origin complexed to hemoglobin, myoglobin, and porphyrin complexes, in the heme form (Björn-Rasmussen et al., 1974), in plants linked to phytate (Yu et al., 2000) and in mineral ingredients in two oxidative states, Fe^{+2} and Fe^{+3} (Park et al., 2004). Iron supplementation is indicated when ingredients of animal origin are replaced by vegetable sources during diet formulation. This is usually done by adding ferrous sulfate, but organic sources like Fe-amino acid complex (**Fe-AA**) are effective alternatives (Pineda and Ashmead, 2001). However, inorganic and organic sources may have differences in Fe bioavailability probably related to improvements at the cell level (Vieira, 2008).

The mechanism of Fe absorption in the duodenum and jejunum passes through three stages: (1) passage through the brush border, (2) transit or storage in the mucosal cells, and (3) releasing into the blood (Oberleas et al., 1999). If consumed as heme group, a heme carrier protein 1 is positioned on the apical membrane of the duodenum cells and makes the internalization of heme-Fe from the diet. Inside the cell, Fe^{+2} is released by an heme oxygenase (Schaer et al., 2008). On the other hand, a divalent metal transporter 1 (**DMT1**) transports inorganic Fe. This protein can internalize Fe^{+2} actively releasing this element directly in the cytoplasm (Mackenzie and Garrick, 2005). The absorption of inorganic Fe^{+3} is made by the integrin and mobilferrin pathway, or it can be oxidized to Fe^{+2} by the duodenal cytochrome b and then transported by DMT1(Conrad and Umbreit, 2002; McKie, 2008). The absorption of Fe complex is based on the principle that this compound is internalized as an AA and

then hydrolyzed, releasing the Fe ion (Ashmead, 2001). Iron will be absorbed through it inorganic pathway if the Fe complex is dissociates before absorption (Vieira, 2008). Thus, this complex must be stable enough to pass through the stomach and duodenum, not reacting with other compounds. Once inorganic and organic Fe are internalized and released, they will be part of the same pool (Grotto, 2008).

Studies assessing the Fe bioavailability are rare and the available information is inconsistent or outdated (Guimarães et al., 2013). Hematocrit and hemoglobin of birds receiving organic Fe or ferrous sulfate were high in comparison to birds receiving Fe oxide (McNaughton et al., 1974). In the other hand, the performance of breeder hens and their progeny were constant when diets were supplemented with organic or inorganic sources of Fe, Cu, Se, Zn, and I (Guimarães et al., 2013). In other study diets with organic source such as meat and bone meal were better than diets with inorganic sources (Bess et al., 2012). Thus, additional studies about supplementation of broiler and breeder hen diets with Fe may affect the poultry industry.

Eggshell color is mainly determined by lineage but the available Fe is an important factor. Iron is a component of protoporphyrin-IX, a precursors of shell pigment (Liu and Chen, 2010). There is a positive relationship between Fe and this protoporphyrin, where darker eggshells were found in hens receiving supplemental Fe (Park et al., 2004). The pigmentation was positively related to higher resistance to breaking, thermal protection, and specific gravity in some studies (Godfrey and Jaap, 1949; Bakken et al., 1978; Gosler et al., 2005). But, Zhang et al. (2005) reported a weak correlation between eggshell color and physical attributes of the shell and internal egg quality. Nevertheless, Park et al. (2004) showed that darker eggs have higher Fe, which content may serving as a determining factor for chick viability. Thus, the objectives of this paper were to determine the effect of different sources of Fe supplementation on

breeder hen diets and the relationship of eggshell color with hatchability and fertility of egg, performance and hematological status of the progeny.

MATERIAL AND METHODS

All procedures adopted throughout this study avoided unnecessary animal discomfort and were approved by the directives of Ethics and Research Committee of the Federal University of Rio Grande do Sul State, Porto Alegre, Brazil.

Breeder Hens groups Performance and Hatching

A total of 640 Cobb 500 broiler breeder hens were divided in three groups with 10 or 11 replications of 20 hens each per treatment. Dietary iron treatments included ferrous sulfate (**Fe-S;** 50 ppm supplemental Fe), Fe-S (50 ppm Fe) plus (Fe-AA; 40 ppm Fe) and Fe-AA (40 ppm Fe) and diets were fed from 40 to 67 wk. A rooster was provided for each 10 hens. Diets were formulated following the line recommendations (Cobb-Vantress, 2013) using the following Fe sources (Table 1): Eggs were collected four times a day and classified as normal, deformed,or cracked or broken. Weekly and for each period of 28 days, egg production was calculated. At each period of 28 days, egg quality (egg, yolk, albumen and shell weight, shell thickness, specific gravity) was measured, using 9 eggs per replication. Eggs from the 65^{th} week collected from these three dietary groups and stored in an acclimatized room with 18°C and 75% of relative humidity for five days and then, classified in pale and dark using the Konica Minolta colorimeter CR-400 with the **Lab** output (**L**=Lightness - 0 yields black and 100 indicates diffuse white. **a** = coordinate red/green - from green to red; lower values = green, higher values = red or brown and **b** = coordinate yellow/blue - from blue to yellow; lower values = blue, higher values = yellow) (Minolta, 2008),

resulting in a 3 x 2 factorial arrangement of treatment according to the broiler breeder diets and eggshell color. Eggs with (82.4 ± 8.9, 2.1 ± 3.14; 20.9 ± 6.1) L a b values were pale and eggs with (58.2 ± 5.2, 11.5 ± 0.2, 25.1 ± 2.1) L a b values were dark. After it, hatched in a single-stage incubator with 90 eggs trays. They were randomly placed in the incubator set to turn every h our at 37.5°C and 65% of relative humidity. The eggs were transferred to the hatcher after 18 d and kept at 36.5°C and 80% relative humidity until hatching. Chicks were sexed at hatch. Unhatched eggs were broken and evaluated if they were infertile. Hatchability of eggs and fertile eggs were calculated.

Hematology

Six hundred chicks (100 per group) from the 65th week eggs were used to determine blood hematology impacts of treatments. At 1 d birds were killed by decapitation and blood was collected individually using tubes with EDTA. Hemoglobin concentration was determined using the cyanmethemoglobin method (Crosby et al., 1954), while hematocrit was evaluated using microcapillaries and centrifuging for 5 min at 15,650 – 18,510 *g* separating red blood cells.

Progeny Performance Trial

A total of 1,200 slow feathering Cobb 500, one-d-old male broilers were placed randomly in 48 floor pens (1.65 x 1.65 m), 25 birds each. Birds were separated in a 3 x 2 factorial arrangement of treatments according to the broiler breeder diets and eggshell color, following the description for hatchability procedures above

Broilers received the same diet formulated according to Brazilian tables (Rostagno et al., 2011) and provided *ad libitum* (Table 1). Live performance was evaluated at 1 to 7 d, 8 to 21 d and 22 to 35 d, when feed intake (**FI**, g), body weight gain (**BWG**, g), and feed conversion rate (**FCR**, kg/kg) corrected for mortality were

measured and calculated. At 35 d six birds were selected randomly from each pen and processed for carcass and commercial cuts. Broilers were fasted for 8 hours and weighed individually prior to slaughter. Electrical stunning was used in the broiler slaughtering (45 V for 3s), followed by bleeding, through a jugular vein cut (3 min), scalding (60ºC for 45s), and de-feathering. Evisceration was performed manually and carcasses were chilled statically in ice for approximately 3 h. Eviscerated carcasses (without feet and neck but with lungs) were hung for 3 min to remove excess water prior to weighing. Industry-trained personal separate the carcass in bone, drumsticks, thighs, wings as well as deboned breast fillets (*pectoralis major* and *minor* plus skin) and breast tenders to perform the commercial cuts. Abdominal fat was weighed separately. Carcass yield was expressed relative to live weight while commercial cuts and abdominal fat were expressed as percentages of the cold eviscerated carcass.

Statistical Analysis

Analysis of variance by MIXED procedure to breeder responses and GLM procedure was performed to examine the 3 x 2 full factorial arrangement of treatments considering the supplemented hen diets, eggshell color, and the interaction (SAS User's Guide, 2001). Significance was accepted at $P \leq 0.05$ and mean differences were separated using Tukey's test (Tukey, 1991).

RESULTS AND DISCUSSION

Treatments did not affect the responses evaluated in each period, so only the average of the full trial time were shown. Treatments did not affect the egg production (58.8% on average) and production was with in the expected range for the genetic line. Egg quality measurements (Egg weight,71.5 g; yolk, 30.5%; albumen,

56.6%; and eggshell, 8.8%; eggshell thickness, 378.5µm; and specific gravity, 1.085 g/mL) were similar ($P > 0.05$) among dietary groups and eggshell colors (L, 75.0 ± 6.1; a, 7.83 ± 2.6; b, 22.5 ± 3.2). Fertility and hatchability were affected ($P < 0.05$) by Fe source groups,with an improvement of 7.5 and 15.9%, respectively, comparing Fe-S and Fe-AA (Table 2). No differences ($P > 0.05$) in fertility and hatchability were observed between Fe-S + Fe-AA and Fe-S or Fe-AA sources. Fertility and hatchability were not affected ($P > 0.05$) by eggshell color.

Hemoglobin and hematocrit were not affected ($P > 0.05$) by Fe source or eggshell color (Table 3) and were on average 7.78 ± 0.33 g/dL and 30.4 ± 1.0%, respectively. These results shown that chicks have similar physiological blood status independent of the Fe source provide to hen. The idea that eggshell color could reflect the Fe content in the yolk (Park et al., 2004) also was tested over the blood variables at hatching. As it was found in other studies, the Fe content in the yolk does not affect the hemoglobin and hematocrit of chick at 1d of age. Apparently, this element is important for other physiological processes beyond blood parameters, and for this reason, other variables were evaluated.

The effect of Fe sources and eggshell color on chick live performance was evaluated (Table 4). Overall mortality in the progeny study was low (0.54 ± 0.08%). Birds from hens fed with Fe-AA and Fe-S + Fe-AA sources had greater BWG when compared with Fe-S ($P < 0.05$), except in the first week, when no difference ($P > 0.05$) was detected (Table 4). At 6 d of age chicks from dark brown eggs gain more BW (9 g) than chicks from pale eggs ($P < 0.05$). In the same way, at the end of the study those chicks had increased BWG (15 g; $P < 0.05$). The FCR (Table 4) was similar among all eggshell color and Fe sources in pre-starter (1.250 ± 0.1134), starter (1.337 ± 0.038), and grower (1.701 ± 0.122) phases. Nevertheless, chicks from hens fed only with Fe-

AA show a tendency (P = 0.07) for an improvement in the FCR. It is recognized that few studies have been performed to evaluate the hen Fe status over progeny and our results agree in part with the literature (Guimarães et al., 2013).

Carcass and commercial meat cuts yield were evaluated in the performance study Relative values (Table 5) all meat cuts were similar (P > 0.05) among Fe sources and eggshell colors. The exception was the breast tenders, where birds from Fe-AA show higher yield (P <0.05). These results suggest birds from pale eggs may have high fat deposition rather than muscle. It seems that even if those birds from pale eggs have enough Fe for keeping the hematological status at 1 d age, other physiological processes could be compromised and are reflected in reduced lean meat deposition. Maybe this is also related with the low BWG in the first wk (Table 4).

The animal organism has very efficient mechanisms to control Fe intestinal absorption. In addition, this element is present in almost all the ingredients used in animal nutrition (Theil, 2004) and its requirement for growth is relatively low (Rostagno et al., 2011). Even so, the results obtained in this study consistently showed that broiler breeder hens diets supplemented with a most available source of Fe, like meat meal and blood meal, has influence not only in the breeder performance but also in the progeny performance and carcass characteristics. A well known pathway to modulate Fe uptake is related with the hepatic hormone hepcidin (Frazer et al., 2002). A stress situation, such as heat, high humidity, or density, induces a Fe deficiency, because it induces hepcidin secretion. Hepcidin synthesis is rapidly mediated by cytokine release, especially interleukin-6. The main two functions of this hormone are inhibiting the presentation of one or more of the Fe transporters (e.g. DMT1 and Ireg1) in intestinal membranes, preventing excess of Fe absorption and controlling the exportation of iron from macrophages to plasma, decreasing, consequently, the

intracellular level of this element in the enterocytes and in serum (Frazer et al., 2002; Priwitzerova et al., 2005). Potentially stressed hens will generate eggs for which they cannot transfer Fe suitably, and this may be reflected in the progeny performance.

CONCLUSIONS AND APPLICATIONS

Fe-AA improves the fertility and hatchability of eggs, and the chicks origindated from dark brown eggs and supplemented with Fe-AA have greater body weight gain, but iron sources and eggshell color were not important factors modulating blood variables measured at 1 d old. Therefore, the inclusion of Fe-AA in broiler breeder's diets had a significant effect on their progeny and is a way to improve the productivity in broilers production.

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Table 1. Ingredient and nutrient composition of the diets (as-is basis) for hens and broilers

Item	Hens[1]	Broilers		
	40 to 67 w	Pre-starter 1 to 7 d	Starter 8 to 21 d	Grower 22 to 34 d
Ingredient, %				
Corn	63.33	49.54	53.92	58.2
Soybean meal	22.20	43.29	38.65	34.4
Wheat bran	2.00	–	–	–
Soybean oil	1.82	3.11	3.76	4.36
Dicalcium phosphate	1.91	1.34	1.11	0.75
Limestone	7.31	1.20	1.09	0.91
Salt	0.13	0.48	0.51	0.42
Sodium bicarbonate	0.48	0.12	0.04	0.06
MHA Ca(84%)	0.24	0.46	0.41	0.37
L-Lys	0.03	0.15	0.16	0.17
L-Thr (98.5%)	0.03	0.05	0.07	0.06
Choline chloride	0.10	0.04	0.06	0.06
Potassium chloride	0.29	–	–	–
Phytase 1000 FTU	–	0.01	0.01	0.01
Vitamin and mineral premix[2, 3]	0.15	0.15	0.15	0.15
Monensin 200	–	0.05	0.05	0.05
Avilamycin 100	–	0.01	0.05	0.01
AME, kcal/kg	2,840	2,950	3,050	3,150
CP	15.40	23.88	22.14	20.55
Ca	3.20	1.05	0.95	0.8
Available P	0.45	0.52	0.48	0.4
Na	0.20	0.24	0.23	0.2
K	0.75	0.94	0.86	0.8
Cl	0.29	0.37	0.39	0.34
DEB, mEq/kg	200	240	210	195
Choline, mg/kg	1,500	1,650	1,650	1,550
Digestible Lys	0.73	1.32	1.22	1.13
Digestible Met	0.40	0.70	0.64	0.59
Digestible Met + Cys	0.62	1.02	0.94	0.87
Digestible Thr	0.54	0.86	0.82	0.76
Digestible Val	0.65	1.02	0.94	0.87
Digestible Ile	0.60	0.95	0.87	0.8
Digestible Leu	1.31	1.83	1.72	1.62
Digestible Arg	0.16	1.54	1.41	1.29
Digestible Trp	0.17	0.28	0.25	0.76
Digestible Hys	0.40	0.59	0.55	0.51

[1]Iron sources: Fe-S, ferrous sulfate, 50 ppm Fe; Fe AA complex, 40 ppm Fe; or Fe-S + Fe-AA. The basic diet have 650 ppm of Fe (calculated value)

[2] Composition per kg of hen feed: zinc, 110 mg; manganese, 120 mg; copper, 13 mg; iodine, 2 mg; selenium, 0.3mg;VitA, 12000 IU; VitD3, 3000 IU; VitE, 100 IU; Vit K3, 6 mg; thiamine, 3 mg; riboflavin, 15 mg; vitamin C, 50 mg; Vit B12, 0.035 mg; pantothenic acid, 25 mg; VitB6, 6 mg; niacin, 40 mg; folic acid, 4 mg; biotin, 0.3 mg.

[3]Composition per kg of broiler feed: iron, 40 mg; zinc, 80 mg; manganese, 80 mg; copper, 10 mg; iodine, 0.7 mg; selenium, 0.3 mg; Vit A, 8,000 UI; Vit D_3, 2,000 IU; Vit E, 30 IU; Vit K_3, 2 mg; thiamine, 2 mg; riboflavin, 6 mg; pyridoxine, 2.5 mg; Vit B_{12}, 0.012 mg, pantothenicacid, 15 mg; niacin, 35 mg; folicacid, 1 mg; biotin, 0.08 mg.

Table 2. Fertile eggs, hatchability of eggs and hatchability of fertility eggs, (%).

Item		Fertility	Hatchability	Hatchability of fertile eggs
Fe, source[1]				
Fe-S		83.7[b]	64.8[b]	78.5
Fe-S +Fe-AA		85.1[ab]	68.6[ab]	80.6
Fe-AA		90.0[a]	75.1[a]	83.7
Eggshell color				
Pale		86.5	71.0	82.0
Dark		86.0	68.0	80.0
Fe source	Eggshell color			
Fe-S	Pale	84.7	66.3	78.5
Fe-S	Dark	82.6	63.3	78.5
Fe-S + Fe AA	Pale	86.7	71.4	82.4
Fe-S + Fe AA	Dark	83.3	65.8	78.8
Fe-AA	Pale	88.1	74.0	85.0
Fe-AA	Dark	91.7	75.4	82.5
SEM		0.97	1.20	1.28
P-values				
Fe source		0.0331	0.0049	0.2610
Eggshell color		0.7436	0.2692	0.4366
Fe source X Eggshell color		0.3037	0.5873	0.8466

[a–b]Values within a column not sharing a common superscript differ ($P \leq 0.05$) by Tukey test.

[1] Fe-S: 50 ppm of iron from ferrous sulfate; Fe-S + Fe-AA: 50 ppm of iron from ferrous sulfate plus 40 ppm iron from Fe amino acid complex; Fe-AA: 40 ppm iron from Fe amino acid complex.

Table 3. Hemoglobin and hematocrit of slow-feathering Cobb X Cobb 500 broilers1 d oldfrom hens fed different sources of dietary Feandfrom pale or dark brown eggshell color.

Item		Hemoglobin, g/dL	Hematocrit, %
Fe source[1]			
Fe-S		7.69	30.8
Fe-S + Fe-AA		7.83	30.4
Fe-AA		7.81	30.0
Eggshell color			
Pale		7.83	30.6
Dark		7.72	30.2
Fe source	Eggshell color		
Fe-S	Pale	7.74	30.7
Fe-S	Dark	7.64	30.8
Fe-S + Fe-AA	Pale	7.96	30.4
Fe-S + Fe-AA	Dark	7.71	30.4
Fe-AA	Pale	7.80	30.8
Fe-AA	Dark	7.82	29.3
SEM		0.052	0.15
P-values			
Fe source		0.5020	0.1170
Eggshell color		0.3000	0.1190
Fe source X Eggshell color		0.5740	0.0630

[1]Fe-S: 50 ppm of iron from ferrous sulfate; Fe-S + Fe-AA: 50 ppm of iron from ferrous sulfate plus 40 ppm iron from Fe amino acid complex; Fe-AA: 40 ppm iron from Fe amino acid complex.

Table 4. Body weight gain (BWG) and feed conversion rate (FC) of slow-feathering Cobb X Cobb 500 male broilers from hens fed different sources of dietary Fe and from pale or dark brown eggshell color.

		1-7 d		8-21 d		22-35 d		1-35 d	
Fe source[1]		BWG	FC	BWG	FC	BWG	FC	BWG	FC
Fe-S		108.6	1.30	815.1[b]	1.36	1,478.3[b]	1.74	2,401.0[c]	1.52
Fe-S + Fe-AA		110.3	1.28	824.4[a]	1.34	1,471.2[b]	1.66	2,427.3[b]	1.51
Fe-AA		107.4	1.25	848.3[a]	1.34	1,516.0[a]	1.69	2,467.0[a]	1.48
Eggshell color									
Pale		105.5	1.33	833.1	1.36	1,483.5	1.70	2,417.0	1.50
Dark		112.0	1.22	837.4	1.33	1,493.3	1.69	2,447.0	1.50
Fe source	Eggshell								
Fe-S	Pale	106.2	1.33	813.6	1.39	1,473.0	1.76	2,391.2	1.52
Fe-S	Dark	111.0	1.26	816.5	1.34	1,484.0	1.71	2,410.1	1.51
Fe-S + Fe-AA	Pale	107.2	1.36	847.5	1.34	1,460.0	1.67	2,410.4	1.52
Fe-S + Fe-AA	Dark	113.4	1.19	837.4	1.33	1,483.0	1.66	2,444.2	1.50
Fe-AA	Pale	103.2	1.28	838.4	1.36	1,518.1	1.67	2,448.2	1.46
Fe-AA	Dark	111.6	1.22	858.4	1.31	1,513.3	1.71	2,486.0	1.49
SEM		0.81	0.025	3.60	0.010	4.42	0.014	4,07	0.006
P-values									
Fe source		0.2079	0.7550	0.0001	0.3936	0.0003	0.0901	0.0001	0.0714
Eggshell color		0.0001	0.0407	0.4625	0.0388	0.2766	0.8322	0.0006	0.9263
Fe X Eggshell color		0.5326	0.5885	0.1167	0.7322	0.4519	0.3993	0.6192	0.3327

[a–c]Values within a column not sharing a common superscript differ ($P \leq 0.05$) by Tukey test.

[1]Fe-S: 50 ppm of iron from ferrous sulfate; Fe-S + Fe-AA: 50 ppm of iron from ferrous sulfate plus 40 ppm iron from Fe amino acid complex; Fe-AA: 40 ppm iron from Fe amino acid complex.

Table 5. Carcass and yields of commercial cuts (%) from slow feathering Cobb X Cobb 500 broilers from hens fed different sources of dietary Fe andfrom pale or dark brown eggshell color.

		Carcass	Abdominal fat	Breast fillets	Breast tenders	Drumsticks	Thighs	Wings
Fe source[1]								
Fe-S		78.8	1.70	27.9	5.37[b]	12.6	17.9	10.0
Fe-S + Fe-AA		79.1	1.73	28.1	5.35[b]	12.5	18.0	9.94
Fe-AA		78.7	1.80	27.8	5.53[a]	12.6	17.9	9.90
Eggshell color								
Pale		78.8	1.78	28.0	5.43	12.5	18.0	9.90
Dark		79.0	1.71	28.0	5.40	12.6	17.9	10.0
Fe source	Eggshell color							
Fe-S	Pale	78.9	1.72	27.9	5.44	12.6	17.9	10.0
Fe-S	Dark	78.7	1.68	28.0	5.30	12.6	17.9	10.0
Fe-S + Fe-AA	Pale	79.1	1.77	27.9	5.37	12.5	18.1	9.87
Fe-S + Fe-AA	Dark	79.1	1.67	28.3	5.33	12.6	18.0	10.0
Fe-AA	Pale	79.0	1.84	27.8	5.47	12.5	17.9	9.81
Fe-AA	Dark	78.9	1.77	27.8	5.60	12.6	17.7	9.95
SEM		0.087	0.019	0.056	0.023	0.039	0.043	0.024
P-values								
Fe source		0.2427	0.0838	0.1039	0.0046	0.7929	0.2917	0.1409
Eggshell color		0.7778	0.0845	0.1822	0.6357	0.3431	0.2092	0.0708
Fe source X Eggshell color		0.6932	0.8519	0.1956	0.0611	0.7795	0.4257	0.4252

[a–b]Values within a column not sharing a common superscript differ ($P \leq 0.05$) by Tukey test.

[1]Fe-S: 50 ppm of iron from ferrous sulfate; Fe-S + Fe-AA: 50 ppm of iron from ferrous sulfate plus 40 ppm iron from Fe amino acid complex; Fe-AA: 40 ppm iron from Fe amino acid complex.

CAPÍTULO III

CONSIDERAÇÕES FINAIS

Os microminerais são fundamentais na produção e manutenção da homeostasia em aves, evidenciado neste estudo ao abordar o Fe. A fonte orgânica deste mineral mostrou ser mais eficientes que o sulfato ferroso, isso deve ser considerado na hora de selecionar os ingredientes das rações, especialmente nas dietas vegetarianas para reprodutoras. Isso está evidenciado na fertilidade e eclodibilidade dos ovos. Esse efeito refletiu-se também nas progênies, possibilitando desta forma abranger através da nutrição da matriz, o desempenho do frango de corte e o rendimento em produto comercial ao consumidor final: quantidade de carne produzida por ave alojada.

Optar por ingredientes que melhorem a qualidade dos ovos, neste caso na coloração da casca, têm reflexo desejado no desempenho dos frangos. Ovos marrons resultam em progênies com maior potencial de produção, na mesma linhagem. Adotar a cor da casca como parâmetro de classificação dos ovos é uma alternativa que pode preconizar a incubação de ovos potencialmente superiores, considerando o pinto que dele nascerá.

Diferentemente do que se previa ao elaborar o projeto de estudo, o complexo ferro-aminoácido foi superior ao sulfato ferroso para fertilidade e eclodibilidade dos ovos, desempenho das progênies e rendimento em produto comercial. Similar a isso, os ovos escuros resultam em frangos com melhor desempenho, e ao abate foram observados menores pesos de gordura abdominal, fator interessante na produção de frangos de corte.

Embora os resultados deste estudos sejam interessantes, há carência de informações que justifiquem essas respostas, como o entendimento da função gástrica para digestão e absorção de minerais; de que forma há maior desenvolvimento sem ter diferença na hemoglobina, há evidências de melhor aproveitamento do Fe da dieta pré-inicial, no que a qualidade da casca influencia a progênie, desta forma abrindo a possibilidade de novos ensaios e desta forma, fundamentar cientificamente as modificações fisiológicas que proporcionam este desempenho.

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APÊNDICE

Apêndice 1: Normas para publicação de artigos no periódico Poultry Science
POULTRY SCIENCE INSTRUCTIONS TO AUTHORS
Editorial Policies and Procedures
Poultry Science publishes the results of fundamental and applied research concerning poultry, poultry products, and avian species in general. Submitted manuscripts shall provide new facts or confirmatory data. Papers dealing with experimental design, teaching, extension endeavors, or those of historical or biographical interest may also be appropriate. A limited number of review papers will be considered for publication if they contribute significant additional knowledge, or synthesis of knowledge, to a subject area. Papers that have been, or are scheduled to be, published elsewhere will not be accepted. Publication of a preliminary report, such as an abstract, does not preclude consideration of a complete report for publication as long as it has not been published in full in a proceedings or similar scientific publication; appropriate identification of previously published preliminary reports should be provided in a title page footnote. Translation of an article into other languages for publication requires approval by the editor-in-chief. Opinions or views expressed in papers published by Poultry Science are those of the author(s) and
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Authors must make it clear that experiments were conducted in a manner that avoided unnecessary discomfort to the animals by the use of proper management and laboratory techniques. Experiments shall be conducted in accordance with the principles and specific guidelines presented in Guidelines for the Care and Use of Agricultural Animals in Agricultural Research and Teaching, 1st revised edition, 1999 (Association Headquarters, 2441 Village Green Place, Champaign, IL 61822); and, if applicable,
Guide for the Care and Use of Laboratory Animals (United States Department of Human Health and Services, National Institutes of Health, Publication Number ISBN 0-309-05377-3, 1996); or Guide to the Care and Use of Experimental Animals, 2nd ed. Volume 1, 1993 (Canadian Council on Animal Care). Methods of killing experimental animals must be described in the text. In

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Symposium Papers. The symposium organizer or chair must present the proposal and tentative budget to the Board of Directors at the summer meeting one full year before the symposium is to be scheduled. The symposium chair must then develop detailed symposium plans, including a formal outline of the talks approved and full budgetary expectations, which must be brought to the Board of Directors at the January meeting prior to the meeting at which the symposium is scheduled.

The symposium chair must decide whether or not the symposium is to be published and will inform the editor-in-chief of this decision at the January meeting. If the decision is not to publish the symposium, the individual authors retain the right to submit their papers for consideration for the journal as ordinary manuscripts. If publication is decided upon, all manuscript style and form guidelines of the journal shall be followed. Manuscripts must be prepared electronically, including figures and tables, and then uploaded onto the Poultry Science Manuscript Central site within 2 weeks after the annual meeting. The symposium chair will review the papers and, if necessary, return them to the authors for revision. The symposium chair then forwards the revised manuscript to the editor-in-chief for final review. Final revisions by the author and recommendations for acceptance or rejection by the chair must be completed by December 31 of the year in which the symposium was presented. Manuscripts not meeting this deadline will not be included in the published symposium proceedings. Symposium papers must be prepared in accordance

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Major Headings. Major headings are centered (except ABSTRACT), all capitals, boldface, and consist of ABSTRACT, INTRODUCTION, MATERIALS AND METHODS, RESULTS, DISCUSSION (or RESULTS AND DISCUSSION), ACKNOWLEDGMENTS (optional), APPENDIX (optional), and REFERENCES.

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names are capitalized, and the remainder of the title is lowercase. The title must have no abbreviations, and numbers must be given in words rather than in numerals (e.g., One-Day-Old Broilers).

Under the title, names of authors should be typed with initial capital letters and a space between initials

(e.g., T. E. Smith). Affiliations will be footnoted using the following symbols: *, †, ‡, §, #, ‖, and be placed below the author names. Do not give authors' titles, positions, or degrees. Numbered footnotes may be used to provide supplementary information, such as present address, acknowledgment of grants, and experiment station or journal series number. The corresponding author should be indicated with a numbered footnote (e.g.,1Corresponding author: myname@university.edu). Note that there is no period after the corresponding author's e-mail address. The title page shall include the name and full address of the corresponding author. Telephone and FAX numbers and e-mail address must also be provided. The title page must indicate the appropriate scientific section for the paper (i.e., Education and Production; Environment, Well-Being, and Behavior; Genetics; Immunology, Health, and Disease; Metabolism and Nutrition; Molecular, Cellular, and Developmental Biology; Physiology, Endocrinology, and Reproduction; or Processing, Products, and Food Safety). Authors may create a full title page as a one-page document, in a file separate from the rest of the paper. This file can be uploaded and marked "not for review." Authors who choose to upload manuscripts with a full title page at the beginning will have their papers forwarded to reviewers as is.

Abbreviations

Author-derived abbreviations should be defined at first use in the abstract and again in the body of the manuscript. The abbreviation will be shown in bold type at first use in the body of the manuscript. Refer to the Miscellaneous Usage Notes for more information on abbreviations.

Abstract

The Abstract disseminates scientific information through abstracting journals and through convenience for the readers. The Abstract, consisting of not more than 325 words, appears at the beginning of the manuscript with the word ABSTRACT without a following period. It must summarize the major objectives, methods, results, conclusions, and practical applications of the research. The Abstract must consist of complete sentences and use of abbreviations should be limited. References to other work and footnotes are not permitted. The Abstract and Key Words must be on a separate sheet of paper.

Key Words

The Abstract shall be followed by a maximum of five key words or phrases to be used for subject indexing. These should include important words from the title and the running head and should be singular, not plural, terms (e.g., broiler, not broilers). Authors should consult a current "Subject Index " in Poultry Science for additional key words. Key words should be formatted as follows:

Key words: . . .

Introduction

The Introduction, while brief, should provide the reader with information necessary for understanding research presented in the paper. Previous work on

the topic should be summarized, and the objectives of the current research must be clearly stated.

Materials and Methods

All sources of products, equipment, and chemicals used in the experiments must be specified parenthetically at first mention in text, tables, and figures [i.e., (model 123, ABC Corp., Provo, UT)]. Model and catalog numbers should be included. Information shall include the full corporate name (including division, branch, or other subordinate part of the corporation, if applicable), city, and state (country if outside the United States), or Web address. Street addresses need not be given unless the reader would not be able to determine the full address for mailing purposes easily by consulting standard references. Age, sex, breed, and strain or genetic stock of animals used in the experiments shall be specified. Animal care guidelines should be referenced if appropriate.

Papers must contain analyzed values for those dietary ingredients that are crucial to the experiment. In other papers, authors should state whether experimental diets meet or exceed the National Research Council (1994) requirements as appropriate. If not, crude protein and metabolizable energy levels should be stated. For layer diets, calcium and phosphorus contents should also be specified.

When describing the composition of diets and vitamin premixes, the concentration of vitamins A and E should be expressed as IU/kg on the basis of the following equivalents:

Vitamin A

1 IU = 0.3 μg of all-trans retinol

1 IU = 0.344 μg of retinyl acetate

1 IU = 0.552 μg of retinyl palmitate

1 IU = 0.60 μg of β-carotene

Vitamin E

1 IU = 1 mg of dl-α-tocopheryl acetate

1 IU = 0.91 mg of dl-α-tocopherol

1 IU = 0.67 mg of dl-α-tocopherol

In the instance of vitamin D3, cholecalciferol is the acceptable term on the basis that 1 IU of vitamin D3 = 0.025 μg of cholecalciferol.

The sources of vitamins A and E must be specified in parentheses immediately following the stated concentrations.

Statistical Analysis. Biology should be emphasized, but the use of incorrect or inadequate statistical methods to analyze and interpret biological data is not acceptable. Consultation with a statistician is recommended. Statistical methods commonly used in the animal sciences need not be described in detail, but adequate references should be provided. The statistical model, classes, blocks, and experimental unit must be designated. Any restrictions used in estimating parameters should be defined. Reference to a statistical package without reporting the sources of variation (classes) and other salient features of the analysis, such as covariance or orthogonal contrasts, is not sufficient. A statement of the results of statistical analysis should justify the interpretations and conclusions. When possible, results of similar experiments should be pooled statistically. Do not report a number of similar experiments separately.

The experimental unit is the smallest unit to which an individual treatment is imposed. For group-fed animals, the group of animals in the pen is the experimental unit; therefore, groups must be replicated. Repeated chemical analyses of the same sample usually do not constitute independent experimental units. Measurements on the same experimental unit over time also are not independent and must not be considered as independent experimental units. For analysis of time effects, use timesequence analysis. Usual assumptions are that errors in the statistical models are normally and independently distributed with constant variance. Most standard methods are robust to deviations from these assumptions, but occasionally data transformations or other techniques are helpful. For example, it is recommended that percentage data between 0 and 20 and between 80 and 100 be subjected to arc sin transformation prior to analysis. Most statistical procedures are based on the assumption that experimental units have been assigned to treatments at random. If animals are stratified by ancestry or weight or if some other initial measurement should be accounted for, the model should include a blocking factor, or the initial measurement should be included as a covariate. A parameter [mean (μ), variance (σ2)], which defines or describes a population, is estimated by a statistic (x, s2). The term parameter is not appropriate to describe a variable, observation, trait, characteristic, or measurement taken in an experiment.

Standard designs are adequately described by name and size (e.g., “a randomized complete block design with 6 treatments in 5 blocks”). For a factorial set of treatments, an adequate description might be as follows: “Total sulfur amino acids at 0.70 or 0.80% of the diet and Lys at 1.10%, 1.20%, or 1.30% of the diet were used in a 2 × 3 factorial arrangement in 5 randomized complete blocks consisting of initial BW.” Note that a factorial arrangement is not a design; the term “design” refers to the method of grouping experimental units into homogeneous groups or blocks (i.e., the way in which the randomization is restricted). Standard deviation refers to the variability in a sample or a population. The standard error (calculated from error variance) is the estimated sampling error of a statistic such as the sample mean. When a standard deviation or standard error is given, the number of degrees of freedom on which it rests should be specified. When any statistical value (as mean or difference of 2 means) is mentioned, its standard error or confidence limit should be given. The fact that differences are not “statistically significant” is no reason for omitting standard errors. They are of value when results from several experiments are combined in the future. They also are useful to the reader as measures of efficiency of experimental techniques. A value attached by “±” to a number implies that the second value is its standard error (not its standard deviation). Adequate reporting may require only 1) the number of observations, 2) arithmetic treatment means, and 3) an estimate of experimental error. The pooled standard error of the mean is the preferred estimate of experimental error. Standard errors need not be presented separately for each mean unless the means are based on different numbers of observations or the heterogeneity of the error variance is to be emphasized. Presenting individual standard errors clutters the presentation and can mislead readers.

For more complex experiments, tables of subclass means and tables of analyses of variance or covariance may be included. When the analysis of variance contains several error terms, such as in split-plot and repeated measures designs, the text should indicate clearly which mean square was used for the denominator of each F statistic. Unbalanced factorial data can present special problems.

Accordingly, it is well to state how the computing was done and how the parameters were estimated. Approximations should be accompanied by cautions concerning possible biases.

Contrasts (preferably orthogonal) are used to answer specific questions for which the experiment was designed; they should form the basis for comparing treatment means. Nonorthogonal contrasts may be evaluated by Bonferroni t statistics. The exact contrasts tested should be described for the reader. Multiple-range tests are not appropriate when treatments are orthogonally arranged. Fixed-range, pairwise, multiple-comparison tests should be used only to compare means of treatments that are unstructured or not related. Least squares means are the correct means to use for all data, but arithmetic means are identical to least squares means unless the design is unbalanced or contains missing values or an adjustment is being made for a covariate. In factorial treatment arrangements, means for main effects should be presented when important interactions are not present. However, means for individual treatment combinations also should be provided in table or text so that future researchers may combine data from several experiments to detect important interactions. An interaction may not be detected in a given experiment because of a limitation in the number of observations.

The terms significant and highly significant traditionally have been reserved for $P < 0.05$ and $P < 0.01$, respectively; however, reporting the P-value is preferred to the use of these terms. For example, use ". . . there was a difference ($P < 0.05$) between control and treated samples" rather than ". . . there was a significant ($P < 0.05$) difference between control and treated samples." When available, the observed significance level (e.g., $P = 0.027$) should be presented rather than merely $P < 0.05$ or $P < 0.01$, thereby allowing the reader to decide what to reject. Other probability (α) levels may be discussed if properly qualified so that the reader is not misled. Do not report Pvalues to more than 3 places after the decimal. Regardless of the probability level used, failure to reject a hypothesis should be based on the relative consequences of type I and II errors. A "nonsignificant" relationship should not be interpreted to suggest the absence of a relationship.

An inadequate number of experimental units or insufficient control of variation limits the power to detect relationships. Avoid the ambiguous use of $P > 0.05$ to declare nonsignificance, such as indicating that a difference is not significant at $P > 0.05$ and subsequently declaring another difference significant (or a tendency) at $P < 0.09$. In addition, readers may incorrectly interpret the use of $P > 0.05$ as the probability of a β error, not an α error. Present only meaningful digits. A practical rule is to round values so that the change caused by rounding is less than one-tenth of the standard error. Such rounding increases the variance of the reported value by less than 1%, so that less than 1% of the

relevant information contained in the data is sacrificed. In most cases, 2 or 3 significant digits (not decimal places) are sufficient.

Results and Discussion

Results and Discussion sections may be combined, or they may appear in separate sections. If separate, the Results section shall contain only the results and summary of the author's experiments; there should be no literature comparisons. Those comparisons should appear in the Discussion section.

Acknowledgments

An Acknowledgments section, if desired, shall follow the Discussion section. Acknowledgments of individuals should include affiliations but not titles, such as Dr., Mr., or Ms. Affiliations shall include institution, city, and state. Review copies shall have authors' institutions omitted.

Appendix

A technical Appendix, if desired, shall follow the Discussion section or Acknowledgments, if present. The Appendix may contain supplementary material, explanations, and elaborations that are not essential to othermajor sections but are helpful to the reader. Novel computer programs or mathematical computations would be appropriate. The Appendix will not be a repository for raw data.

References

Citations in Text. In the body of the manuscript, refer to authors as follows: Smith and Jones (1992) or Smith and Jones (1990, 1992). If the sentence structure requires that the authors' names be included in parentheses, the proper format is (Smith and Jones, 1982; Jones, 1988a,b; Jones et al., 1993). Where there are more than two authors of one article, the first author's name is followed by the abbreviation et al. More than one article listed in the same sentence of text must be in chronological order first, and alphabetical order for two publications in the same year. Work that has not been accepted for publication shall be listed in the text as: "J. E. Jones (institution, city, and state, personal communication)." The author's own unpublished work should be listed in the text as "(J. Smith, unpublished data)." Personal communications and unpublished data must not be included in the References section.

References Section. To be listed in the References section, papers must be published or accepted for publication. Manuscripts submitted for publication can be cited as "personal communication" or "unpublished data" in the text. Citation of abstracts, conference proceedings, and other works that have not been peer reviewed is strongly discouraged unless essential to the paper. Abstract and proceedings references are not apropriate citations in the Materials and Methods section of a paper. In the References section, references shall first be listed alphabetically by author(s)' last name(s), and then chronologically. The year of publication follows the authors' names. As with text citations, two or more publications by the same author or set of authors in the same year shall be differentiated by adding lowercase letters after the date. The dates for papers with the same first author that would be abbreviated in the text as et al., even though the second and subsequent authors differ, shall also be differentiated by letters. All authors' names must appear in the Reference section. Journals shall be abbreviated according to the conventional ISO abbreviations given in journals database of the National Library of Medicine

(http://www.ncbi.nlm.nih.gov/entrez/query. fcgi?db=journals). One-word titles must be spelled out. Inclusive page numbers must be provided. Sample references are given below. Consult recent issues of Poultry Science for examples not included below.

Article:

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. 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. Regist. 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. http://www.emedicine.com/ neuro/topic20.htm Accessed Feb. 2006.

El Halawani, M. E., and I. Rosenboim. 2004. Method to enhance reproductive performance in poultry. Univ. Minnesota, assignee. 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 body should be done sparingly; such use must be defined 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 superscripts 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.

Figures

To facilitate review, figures should be placed at the end of the manuscript (separated by section breaks). Each figure should be placed on a separate page, and identified by the manuscript number and the figure number. A figure with multiple panels or parts should appear on one page (e.g., if Figure 1 has parts a, b, and c, place all of these on the same page). Figure captions should be typed (double spaced) on a separate page.

• Figure Size. Prepare figures at final size for publication. Figures should be prepared to fit one column
(8.9 cm wide), 2 columns (14 cm wide), or full-page width (19 cm wide).

• Font Size. Ensure that all type within the figure and axis labels are readable at final publication size.
A minimum type size of 8 points (after reduction) should be used.

• Fonts. Use Helvetica or Times New Roman. Symbols may be inserted using the Symbol palette in Times New Roman.

• Line Weight. For line graphs, use a minimum stroke weight of 1 point for all lines. If multiple lines are to be distinguished, use solid, long-dash, short-dash, and dotted lines. Avoid the use of color, gray, or
shaded lines, as these will not reproduce well. Lines with different symbols for the data points may also be used to distinguish curves.

• Axis Labels. Each axis should have a description and a unit. Units may be separated from the descriptor by a comma or parentheses, and should be consistent within a manuscript.

• Shading and Fill Patterns. For bar charts, use different fill patterns if needed (e.g., black, white, gray, diagonal stripes). Avoid the use of multiple shades of gray, as they will not be easily distinguishable in print.

• Symbols. Identify curves and data points using the following symbols only: □, ■, ○, ●, ▲, ▼, n, ,, e, r, +, or ×. Symbols should be defined in a key on the figure if possible.
• File Formats. Figures can be submitted in Word, PDF, EPS, TIFF, and JPEG. Avoid PowerPoint files and other formats. For the best printed quality, line art should be prepared at 600 ppi. Grayscale and color images and photomicrographs should be at least 300 ppi.
• Grayscale Figures. If figures are to be reproduced in grayscale (black and white), submit in grayscale. Often color will mask contrast problems that are apparent only when the figure is reproduced in grayscale.
• Color Figures. If figures are to appear in color in the print journal, files must be submitted in CMYK color (not RGB).
• Photomicrographs. Photomicrographs must have their unmagnified size designated, either in the caption or with a scale bar on the figure. Reduction for publication can make a magnification power designation (e.g., 100×) inappropriate.
• Caption. The caption should provide sufficient information that the figure can be understood with excessive reference to the text. All author-derived abbreviations used in the figure should be defined in the caption.
• General Tips. Avoid the use of three-dimensional bar charts, unless essential to the presentation of the data. Use the simplest shading scheme possible to present the data clearly. Ensure that data, symbols, axis labels, lines, and key are clear and easily readable at final publication size.
Color Figures. Submitted color images should be at least 300 ppi. The cost to publish each color figure is $995; a surcharge for color reprints ordered will be assessed. Authors must agree in writing to bear the costs of color production after acceptance and prior to publication of the paper. The form “Color Charge Agreement” is available on the journal web site (http://ps.fass.org) and should be completed and returned to PSA Headquarters upon submission.
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 ab-breviations 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 (or the updated list at http://ps.fass.org/) 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 intake
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
G:F	gain-to-feed ratio
GLM	general linear model
h	hour
HEPES	N-2-hydroxyethyl piperazine-N′-ethane-sulfonic acid
HPLC	high-performance (high-pressure) liquid chromatography
ICU	international chick units
Ig	immunoglobin
i.m.	intramuscular
i.p.	intraperitoneal
IU	international units

i.v.	intravenous
kb	kilobase pairs
kDa	kilodalton
L	liter*
L:D	hours light:hours darkness in a photoperiod
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
QTL	quantitative trait loci
r	correlation coefficient
r2	coefficient of determination, simple
R2	coefficient of determination, multiple
RFLP	restriction fragment length polymorphism
RH	relative humidity
RIA	radioimmunoassay
RNA	ribonucleic acid
rpm	revolutions per minute
s	second
s.c.	subcutaneous
SD	standard deviation
SDS	sodium dodecyl sulfate
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 GenBank 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 cameraready figures no larger than 21.6 × 27.9 cm in standard (portrait) orientation. Abbreviations should follow Poultry Science guidelines.

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 (=, –, +, ×, >, 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.
Supplemental Information (Online)
The following information is available online and updated regularly. Please refer to these pages when preparing a manuscript for submission.
Journal Title Abbreviations. A list of standard abbreviations for common journal titles is available online (http://ps.fass.org/misc/ifora.dtl).
SI Units. The following site (National Institute of Standards and Technology) provides a comprehensive guide to SI units and usage: http://physics.nist.gov/Pubs/SP811/ contents.html
Figure and Table Preparation Guidelines. Current detailed information on figure and table preparation can be found at http://ps.fass.org/misc/ifora.dtl
Manuscript Central Instructions. Manuscripts are submitted online (http://mc.manuscriptcentral.com/psa). Full user instructions for using the Manuscript Central system are available on the Mansuscript Central home page

Apêndice 2. Produção de ovos, no período de 40 a 67 semanas, %.

Tratamento	Período	Descartados	Produção	Incubáveis
Fe-S	1	1,25	72,14	98,74
Fe-S	1	1,73	68,87	98,23
Fe-S	1	2,01	70,89	97,99
Fe-S	1	0,48	73,92	99,51
Fe-S	1	0,47	71,93	99,52
Fe-S	1	0,46	73,63	99,53
Fe-S	1	0,50	71,25	99,49
Fe-S	1	0,76	63,94	99,23
Fe-S	1	2,50	68,02	97,49
Fe-S	1	0,77	72,74	99,22
Fe-S + Fe-AA	1	1,48	68,70	98,51
Fe-S + Fe-AA	1	1,22	69,21	98,77
Fe-S + Fe-AA	1	1,69	70,40	98,30
Fe-S + Fe-AA	1	1,70	69,82	100,00
Fe-S + Fe-AA	1	1,01	70,17	98,98
Fe-S + Fe-AA	1	0,24	72,85	99,75

Fe-S + Fe-AA	1	0,00	67,85	100,00
Fe-S + Fe-AA	1	0,25	66,32	99,74
Fe-S + Fe-AA	1	0,52	65,81	99,47
Fe-S + Fe-AA	1	1,91	73,92	98,08
Fe-S + Fe-AA	1	0,54	62,24	99,45
Fe-AA	1	2,34	72,61	97,65
Fe-AA	1	0,45	75,68	99,55
Fe-AA	1	0,76	66,32	99,23
Fe-AA	1	0,79	63,94	99,20
Fe-AA	1	1,65	71,76	98,34
Fe-AA	1	0,27	64,46	99,72
Fe-AA	1	4,53	67,51	95,46
Fe-AA	1	0,77	68,75	99,22
Fe-AA	1	0,78	68,03	99,21
Fe-AA	1	0,00	67,29	100,00
Fe-AA	1	0,53	69,10	99,46
Fe-S	2	0,81	69,54	99,18
Fe-S	2	0,74	68,36	99,25
Fe-S	2	1,31	68,21	98,68
Fe-S	2	1,28	70,00	98,71
Fe-S	2	1,05	65,81	98,95
Fe-S	2	1,25	68,02	98,75
Fe-S	2	1,08	64,82	98,91
Fe-S	2	0,57	58,50	99,42
Fe-S	2	1,63	63,06	98,36
Fe-S	2	0,00	68,04	100,00
Fe-S + Fe-AA	2	1,33	63,26	98,67
Fe-S + Fe-AA	2	1,86	63,77	98,13
Fe-S + Fe-AA	2	1,80	65,81	98,19
Fe-S + Fe-AA	2	0,54	65,71	99,45
Fe-S + Fe-AA	2	0,80	66,60	99,19
Fe-S + Fe-AA	2	1,33	66,78	98,66
Fe-S + Fe-AA	2	0,27	62,41	99,78
Fe-S + Fe-AA	2	0,85	59,86	99,14
Fe-S + Fe-AA	2	2,68	63,94	97,31
Fe-S + Fe-AA	2	1,00	71,42	99,00
Fe-S + Fe-AA	2	0,57	58,84	99,42
Fe-AA	2	1,22	69,55	98,77
Fe-AA	2	1,44	70,74	98,55
Fe-AA	2	2,43	62,58	97,56
Fe-AA	2	1,07	63,60	98,93
Fe-AA	2	1,07	66,32	98,93
Fe-AA	2	1,77	63,09	98,22
Fe-AA	2	2,16	62,92	97,83
Fe-AA	2	1,41	63,92	98,58
Fe-AA	2	0,56	63,57	99,44
Fe-AA	2	0,28	64,84	99,71
Fe-AA	2	0,80	68,76	99,19

Fe-S	3	0,61	61,27	99,38
Fe-S	3	1,29	65,98	98,70
Fe-S	3	2,03	62,14	97,96
Fe-S	3	1,11	64,10	98,88
Fe-S	3	1,10	61,39	98,89
Fe-S	3	1,53	66,15	98,46
Fe-S	3	0,29	61,78	99,70
Fe-S	3	1,00	50,68	98,99
Fe-S	3	0,29	60,71	99,70
Fe-S	3	1,17	63,90	98,82
Fe-S + Fe-AA	3	0,87	59,86	99,12
Fe-S + Fe-AA	3	1,51	58,18	98,48
Fe-S + Fe-AA	3	0,77	66,15	99,22
Fe-S + Fe-AA	3	1,14	63,75	98,86
Fe-S + Fe-AA	3	0,85	62,67	99,14
Fe-S + Fe-AA	3	1,72	62,14	98,27
Fe-S + Fe-AA	3	0,28	60,37	99,71
Fe-S + Fe-AA	3	0,86	59,01	99,13
Fe-S + Fe-AA	3	2,46	55,27	97,53
Fe-S + Fe-AA	3	2,10	67,85	97,89
Fe-S + Fe-AA	3	1,15	58,50	98,84
Fe-AA	3	1,65	61,56	98,34
Fe-AA	3	2,16	69,72	97,83
Fe-AA	3	2,31	51,70	97,69
Fe-AA	3	0,97	54,48	99,02
Fe-AA	3	1,81	65,47	98,18
Fe-AA	3	1,16	64,84	98,83
Fe-AA	3	4,26	59,86	95,73
Fe-AA	3	0,31	57,32	99,68
Fe-AA	3	1,52	58,39	98,47
Fe-AA	3	1,88	59,21	98,11
Fe-AA	3	0,88	63,90	99,11
Fe-S	4	0,93	59,77	99,06
Fe-S	4	0,84	60,78	99,15
Fe-S	4	1,47	60,17	98,52
Fe-S	4	0,62	56,78	99,37
Fe-S	4	1,26	52,89	98,73
Fe-S	4	1,42	59,69	98,57
Fe-S	4	0,67	52,85	99,32
Fe-S	4	0,33	50,93	99,66
Fe-S	4	0,96	55,71	99,03
Fe-S	4	0,64	58,45	99,35
Fe-S + Fe-AA	4	1,89	53,74	98,10
Fe-S + Fe-AA	4	2,20	56,07	97,79
Fe-S + Fe-AA	4	0,55	61,05	99,44
Fe-S + Fe-AA	4	0,00	55,53	100,00

Fe-S + Fe-AA	4	0,95	55,89	99,04
Fe-S + Fe-AA	4	0,00	57,67	100,00
Fe-S + Fe-AA	4	1,23	54,93	98,76
Fe-S + Fe-AA	4	1,54	54,59	98,45
Fe-S + Fe-AA	4	2,75	48,63	97,24
Fe-S + Fe-AA	4	0,89	60,17	99,11
Fe-S + Fe-AA	4	0,00	51,36	100,00
Fe-AA	4	0,85	60,20	99,15
Fe-AA	4	0,28	60,20	99,71
Fe-AA	4	2,22	55,56	97,77
Fe-AA	4	0,00	50,66	100,00
Fe-AA	4	0,53	63,77	99,46
Fe-AA	4	0,31	59,58	99,68
Fe-AA	4	2,86	53,23	97,13
Fe-AA	4	1,04	53,38	98,95
Fe-AA	4	0,33	54,10	99,67
Fe-AA	4	0,65	57,89	99,34
Fe-AA	4	0,95	59,21	99,04
Fe-S	5	0,67	55,82	99,32
Fe-S	5	0,61	60,00	99,38
Fe-S	5	1,29	56,60	98,70
Fe-S	5	1,38	51,60	98,61
Fe-S	5	1,09	46,76	98,90
Fe-S	5	3,59	51,87	96,40
Fe-S	5	0,34	51,78	99,65
Fe-S	5	0,46	38,03	99,53
Fe-S	5	2,06	43,21	97,93
Fe-S	5	0,35	54,69	99,64
Fe-S + Fe-AA	5	2,99	44,89	97,00
Fe-S + Fe-AA	5	3,37	52,32	96,62
Fe-S + Fe-AA	5	1,48	57,31	98,51
Fe-S + Fe-AA	5	0,00	47,50	100,00
Fe-S + Fe-AA	5	0,65	53,57	99,34
Fe-S + Fe-AA	5	0,63	57,34	99,36
Fe-S + Fe-AA	5	1,90	44,60	98,09
Fe-S + Fe-AA	5	0,78	43,19	99,21
Fe-S + Fe-AA	5	1,61	44,10	98,38
Fe-S + Fe-AA	5	1,32	58,08	98,67
Fe-S + Fe-AA	5	1,09	47,95	98,90
Fe-AA	5	0,99	53,25	99,00
Fe-AA	5	0,61	55,61	99,38
Fe-AA	5	1,38	52,23	98,61
Fe-AA	5	1,17	45,71	98,82
Fe-AA	5	0,61	56,63	99,38

Fe-AA	5	1,03	53,19	98,96
Fe-AA	5	4,04	41,83	95,95
Fe-AA	5	0,83	45,30	99,16
Fe-AA	5	1,96	47,56	98,03
Fe-AA	5	0,87	45,83	99,13
Fe-AA	5	0,34	53,94	99,65
Fe-S	6	0,78	48,87	99,21
Fe-S	6	1,01	52,67	98,98
Fe-S	6	0,66	53,92	99,34
Fe-S	6	1,63	43,03	98,36
Fe-S	6	0,00	44,55	100,00
Fe-S	6	2,08	40,30	97,91
Fe-S	6	1,42	38,70	98,57
Fe-S	6	0,00	35,53	100,00
Fe-S	6	0,50	35,71	99,50
Fe-S	6	2,62	50,00	97,37
Fe-S + Fe-AA	6	0,39	48,14	99,60
Fe-S + Fe-AA	6	2,39	52,61	97,60
Fe-S + Fe-AA	6	0,69	47,39	99,30
Fe-S + Fe-AA	6	0,45	37,14	99,54
Fe-S + Fe-AA	6	2,50	41,19	97,50
Fe-S + Fe-AA	6	1,74	53,63	98,25
Fe-S + Fe-AA	6	2,56	33,80	97,43
Fe-S + Fe-AA	6	0,89	36,96	99,10
Fe-S + Fe-AA	6	2,45	27,38	97,54
Fe-S + Fe-AA	6	2,16	43,85	97,83
Fe-S + Fe-AA	6	0,38	43,99	99,62
Fe-AA	6	1,60	42,61	98,39
Fe-AA	6	1,00	52,61	98,99
Fe-AA	6	0,39	47,61	99,60
Fe-AA	6	0,52	32,38	99,47
Fe-AA	6	2,00	50,56	97,99
Fe-AA	6	0,81	44,36	99,18
Fe-AA	6	1,37	37,41	98,63
Fe-AA	6	0,00	25,56	100,00
Fe-AA	6	3,29	42,85	96,70
Fe-AA	6	2,15	29,11	97,84
Fe-AA	6	1,98	38,34	98,02

Apêndice 3. Parâmetros de qualidade dos ovos de 40 a 67 semanas.

Tratamento	Per.	Peso	% Gema	% Clara	% Casca	Espe.	Den.
Fe-S	1	69,28	30,38	54,90	9,29	389,55	0,87
Fe-S	1	67,91	31,02	53,80	8,88	384,00	0,87

Fe-S	1	68,00	30,69	56,21	8,58	369,75	0,86
Fe-S	1	67,76	29,28	57,00	8,75	369,70	0,87
Fe-S	1	70,25	29,40	57,34	8,35	378,16	0,85
Fe-S	1	64,36	30,09	55,77	5,68	371,66	0,86
Fe-S	1	65,65	29,75	55,81	8,57	341,77	0,88
Fe-S	1	68,68	29,35	56,13	8,91	370,33	0,88
Fe-S	1	69,83	29,69	56,40	8,91	383,70	0,88
Fe-S	1	66,10	29,47	56,30	8,70	372,15	0,88
Fe-S + Fe-AA	1	67,87	30,63	55,28	8,50	365,77	0,88
Fe-S + Fe-AA	1	65,94	30,14	54,94	9,33	408,88	0,89
Fe-S + Fe-AA	1	71,70	29,56	56,13	9,13	390,83	0,88
Fe-S + Fe-AA	1	67,75	30,68	53,30	8,87	385,44	0,88
Fe-S + Fe-AA	1	68,42	28,66	57,60	9,41	399,95	0,86
Fe-S + Fe-AA	1	64,75	30,35	55,96	9,29	375,91	0,86
Fe-S + Fe-AA	1	68,96	29,82	56,94	9,67	377,80	0,88
Fe-S + Fe-AA	1	68,85	30,05	54,42	8,87	382,66	0,87
Fe-S + Fe-AA	1	66,70	29,10	56,48	9,15	383,81	0,89
Fe-S + Fe-AA	1	67,55	30,01	55,75	8,77	371,15	0,85
Fe-S + Fe-AA	1	70,16	29,84	56,02	8,65	375,94	0,88
Fe-AA	1	67,88	30,34	55,68	11,11	375,25	0,87
Fe-AA	1	67,44	28,43	57,11	9,20	397,79	0,87
Fe-AA	1	69,99	30,40	56,28	8,52	386,29	0,86
Fe-AA	1	68,25	29,73	56,42	8,71	381,85	0,86
Fe-AA	1	67,97	30,43	56,43	8,42	338,33	0,87
Fe-AA	1	67,83	29,26	56,98	9,24	383,60	0,89
Fe-AA	1	68,02	29,49	56,07	8,80	370,33	0,89
Fe-AA	1	68,11	30,03	55,75	9,07	391,43	0,88
Fe-AA	1	68,62	29,49	56,44	8,82	361,33	0,89
Fe-AA	1	68,52	29,28	56,12	9,11	393,85	0,88
Fe-AA	1	70,00	30,37	56,21	8,98	378,97	0,87
Fe-S	2	71,00	33,89	53,65	9,34	391,33	0,83
Fe-S	2	69,53	30,80	56,82	8,80	356,67	0,83
Fe-S	2	71,05	30,20	57,14	8,70	370,67	0,82
Fe-S	2	70,28	29,87	57,43	8,66	385,33	0,82
Fe-S	2	72,71	29,79	57,40	8,67	374,89	0,84
Fe-S	2	68,63	31,09	56,37	8,71	415,63	0,83
Fe-S	2	68,13	29,18	58,33	8,60	394,78	0,84
Fe-S	2	70,60	29,93	57,51	8,49	379,92	0,84
Fe-S	2	67,46	30,62	57,16	8,64	378,63	0,84
Fe-S	2	66,24	29,71	56,74	8,39	409,38	0,81
Fe-S + Fe-AA	2	67,84	32,03	56,22	8,61	409,11	0,83
Fe-S + Fe-AA	2	71,31	30,00	57,57	8,89	384,21	0,82
Fe-S + Fe-AA	2	69,45	30,45	57,19	8,83	382,83	0,83
Fe-S + Fe-AA	2	68,67	30,50	56,51	9,07	396,46	0,89
Fe-S + Fe-AA	2	67,21	30,66	56,62	8,50	415,67	0,81
Fe-S + Fe-AA	2	67,16	30,22	57,02	9,18	380,22	0,82
Fe-S + Fe-AA	2	69,51	30,62	56,59	9,47	405,78	0,85
Fe-S + Fe-AA	2	71,47	29,93	57,02	8,75	401,56	0,84

Fe-S + Fe-AA	2	68,63	29,99	57,22	7,58	390,17	0,84
Fe-S + Fe-AA	2	68,76	30,12	57,11	8,77	385,89	0,81
Fe-S + Fe-AA	2	71,46	29,58	57,37	8,73	401,85	0,83
Fe-AA	2	70,28	31,33	57,10	8,98	395,96	0,81
Fe-AA	2	70,43	30,62	57,37	8,78	379,48	0,83
Fe-AA	2	70,67	30,47	57,77	8,63	392,52	0,85
Fe-AA	2	70,90	30,51	57,16	8,88	401,07	0,84
Fe-AA	2	68,75	30,62	56,92	8,99	388,33	0,81
Fe-AA	2	71,23	29,55	57,66	8,42	353,55	0,85
Fe-AA	2	71,40	30,10	57,08	8,65	361,37	0,83
Fe-AA	2	69,32	30,74	56,35	8,60	391,81	0,81
Fe-AA	2	69,98	30,63	57,28	8,95	378,22	0,81
Fe-AA	2	69,02	29,61	57,05	8,27	340,37	0,84
Fe-AA	2	72,38	29,48	57,73	9,34	373,22	0,87
Fe-S	3	73,60	30,24	57,06	8,80	364,22	0,88
Fe-S	3	70,12	29,92	56,05	8,70	343,40	0,87
Fe-S	3	72,60	31,66	56,22	8,66	378,29	0,85
Fe-S	3	70,52	30,96	56,30	8,67	390,07	0,86
Fe-S	3	74,24	30,10	57,04	8,71	375,77	0,85
Fe-S	3	72,71	30,77	57,25	8,60	394,37	0,87
Fe-S	3	69,95	30,16	57,48	8,49	361,70	0,84
Fe-S	3	73,10	30,49	57,54	8,64	376,59	0,86
Fe-S	3	76,13	30,08	58,16	8,39	358,85	0,85
Fe-S	3	70,86	30,56	56,78	8,61	363,25	0,85
Fe-S + Fe-AA	3	72,07	30,87	56,40	8,89	372,85	0,88
Fe-S + Fe-AA	3	73,38	30,18	56,75	8,83	306,79	0,88
Fe-S + Fe-AA	3	68,23	30,24	57,53	9,01	353,29	0,87
Fe-S + Fe-AA	3	71,47	56,64	56,64	8,24	385,74	0,85
Fe-S + Fe-AA	3	71,37	29,88	57,59	8,50	396,93	0,83
Fe-S + Fe-AA	3	70,31	31,22	56,42	9,18	376,88	0,85
Fe-S + Fe-AA	3	72,44	30,83	56,57	9,47	381,29	0,87
Fe-S + Fe-AA	3	73,94	29,91	57,34	8,75	382,11	0,86
Fe-S + Fe-AA	3	70,61	30,26	51,17	7,58	376,40	0,89
Fe-S + Fe-AA	3	70,93	30,36	57,53	8,77	333,18	0,85
Fe-S + Fe-AA	3	72,11	30,25	57,18	8,73	320,55	0,87
Fe-AA	3	70,43	24,22	56,45	8,98	381,51	0,85
Fe-AA	3	69,71	29,76	56,58	8,78	391,33	0,85
Fe-AA	3	70,25	29,84	57,32	8,63	356,67	0,88
Fe-AA	3	72,35	31,54	55,79	8,88	370,67	0,89
Fe-AA	3	70,50	27,57	56,81	8,99	385,33	0,84
Fe-AA	3	67,88	32,15	54,86	8,42	374,89	0,86
Fe-AA	3	69,64	30,53	56,37	9,37	415,63	0,86
Fe-AA	3	72,06	30,28	57,01	9,11	394,78	0,85
Fe-AA	3	72,78	26,91	57,68	8,88	379,92	0,89
Fe-AA	3	70,14	30,07	56,45	7,90	378,63	0,86
Fe-AA	3	71,04	31,05	57,10	9,35	409,38	0,86
Fe-AA	3	72,81	29,56	56,64	8,84	403,30	0,89
Fe-S	4	74,62	30,51	56,19	8,71	396,88	0,89

Fe-S	4	72,54	31,95	55,54	9,03	386,10	0,90
Fe-S	4	68,91	31,60	56,51	9,21	394,72	0,89
Fe-S	4	71,25	31,93	56,56	8,50	397,70	0,89
Fe-S	4	72,72	30,75	56,31	9,37	379,41	0,87
Fe-S	4	70,15	30,30	56,77	9,11	407,46	0,87
Fe-S	4	72,37	31,33	56,02	8,88	388,26	0,85
Fe-S	4	69,73	32,26	55,27	7,90	391,33	0,86
Fe-S	4	73,41	31,72	55,37	8,76	356,67	0,85
Fe-S	4	68,82	32,17	55,50	9,02	370,67	0,87
Fe-S + Fe-AA	4	73,73	31,61	55,93	8,65	385,33	0,87
Fe-S + Fe-AA	4	72,11	30,62	56,48	9,51	374,89	0,87
Fe-S + Fe-AA	4	70,37	30,51	55,53	9,21	415,63	0,89
Fe-S + Fe-AA	4	71,27	32,14	54,83	8,91	394,78	0,88
Fe-S + Fe-AA	4	69,24	33,17	53,94	8,88	379,92	0,88
Fe-S + Fe-AA	4	72,85	30,96	60,79	9,18	378,63	0,87
Fe-S + Fe-AA	4	72,52	31,38	56,18	9,41	409,38	0,87
Fe-S + Fe-AA	4	70,83	31,00	55,89	8,97	409,11	0,87
Fe-S + Fe-AA	4	70,90	31,31	56,23	8,84	384,21	0,87
Fe-S + Fe-AA	4	72,32	30,33	56,36	9,10	382,83	0,88
Fe-S + Fe-AA	4	69,36	31,71	55,35	9,17	396,46	0,86
Fe-AA	4	73,38	30,85	56,45	8,71	415,67	0,88
Fe-AA	4	73,98	29,67	57,77	9,16	380,22	0,87
Fe-AA	4	70,54	30,04	56,17	9,11	405,78	0,89
Fe-AA	4	69,61	31,12	55,76	9,32	401,56	0,90
Fe-AA	4	72,38	31,75	54,74	8,98	390,17	0,89
Fe-AA	4	71,04	30,53	55,47	9,46	385,89	0,87
Fe-AA	4	71,96	31,24	54,67	8,74	401,85	0,86
Fe-AA	4	74,33	31,07	56,81	8,90	395,96	0,85
Fe-AA	4	71,55	31,67	55,15	8,87	379,48	0,89
Fe-AA	4	72,54	30,46	56,85	9,34	392,52	0,86
Fe-AA	4	71,08	30,02	56,82	8,80	401,07	0,85
Fe-S	5	74,47	30,72	56,95	8,70	388,33	0,84
Fe-S	5	73,67	31,05	56,62	8,66	353,55	0,85
Fe-S	5	73,40	31,39	55,96	8,67	361,37	0,84
Fe-S	5	73,36	33,12	56,64	8,71	391,81	0,86
Fe-S	5	72,33	30,96	56,73	8,60	378,22	0,86
Fe-S	5	74,78	30,36	57,14	8,49	340,37	0,88
Fe-S	5	72,33	29,64	58,00	8,64	373,22	0,86
Fe-S	5	75,33	30,29	55,89	8,39	364,22	0,84
Fe-S	5	72,90	28,06	56,04	8,61	343,40	0,87
Fe-S	5	73,81	30,73	56,51	8,89	378,29	0,87
Fe-S + Fe-AA	5	74,17	29,79	56,65	8,83	390,07	0,86
Fe-S + Fe-AA	5	74,08	30,81	56,76	9,01	375,77	0,86
Fe-S + Fe-AA	5	72,96	31,04	55,90	8,24	394,37	0,89
Fe-S + Fe-AA	5	71,74	31,20	56,56	8,50	361,70	0,89

Fe-S + Fe-AA	5	72,48	30,99	56,65	9,18	376,59	0,84
Fe-S + Fe-AA	5	72,21	31,88	55,68	9,47	358,85	0,88
Fe-S + Fe-AA	5	74,26	30,37	51,85	8,75	363,25	0,86
Fe-S + Fe-AA	5	74,63	30,52	57,14	7,58	372,85	0,88
Fe-S + Fe-AA	5	73,18	31,40	56,06	8,77	306,79	0,85
Fe-S + Fe-AA	5	75,71	30,86	56,40	8,73	353,29	0,87
Fe-S + Fe-AA	5	70,54	30,60	58,72	8,98	385,74	0,85
Fe-AA	5	71,86	30,98	56,62	8,78	396,96	0,85
Fe-AA	5	72,32	30,42	56,65	8,63	376,88	0,86
Fe-AA	5	75,08	30,45	57,06	8,88	381,29	0,87
Fe-AA	5	72,21	30,45	56,39	8,99	382,11	0,88
Fe-AA	5	74,06	30,20	57,05	8,42	376,40	0,84
Fe-AA	5	74,71	30,41	57,22	8,65	333,18	0,86
Fe-AA	5	72,31	29,99	57,32	8,60	320,55	0,87
Fe-AA	5	75,34	30,39	57,08	8,95	381,51	0,86
Fe-AA	5	74,87	30,03	56,63	8,27	387,51	0,86
Fe-AA	5	73,94	29,41	58,17	8,88	343,88	0,85
Fe-AA	5	73,35	31,40	56,34	8,83	385,40	0,88
Fe-S	6	71,02	31,40	55,54	8,65	393,18	0,87
Fe-S	6	77,68	31,02	56,15	8,40	382,22	0,84
Fe-S	6	74,74	30,53	57,07	9,07	380,92	0,85
Fe-S	6	74,71	30,06	56,32	8,85	401,48	0,87
Fe-S	6	73,95	31,02	56,51	8,56	395,14	0,85
Fe-S	6	75,11	31,83	55,49	8,72	397,00	0,84
Fe-S	6	75,53	29,05	58,39	8,59	389,51	0,87
Fe-S	6	77,31	30,66	57,25	8,21	386,11	0,89
Fe-S	6	72,75	29,81	57,54	8,27	395,44	0,84
Fe-S	6	72,10	31,84	55,85	8,74	361,66	0,85
Fe-S + Fe-AA	6	75,66	30,33	57,00	7,80	385,92	0,85
Fe-S + Fe-AA	6	71,92	30,86	56,92	8,74	377,66	0,88
Fe-S + Fe-AA	6	73,08	30,67	56,61	8,28	389,55	0,86
Fe-S + Fe-AA	6	73,13	30,83	56,88	8,50	357,81	0,84
Fe-S + Fe-AA	6	74,52	30,96	57,24	8,35	386,18	0,85
Fe-S + Fe-AA	6	72,74	30,92	56,41	8,68	372,40	0,84
Fe-S + Fe-AA	6	75,61	30,96	51,91	8,84	388,66	0,87
Fe-S + Fe-AA	6	75,28	30,88	56,32	8,27	393,33	0,84
Fe-S + Fe-AA	6	76,55	30,21	57,93	8,70	376,48	0,84
Fe-S + Fe-AA	6	75,77	30,51	56,90	8,84	386,29	0,87
Fe-S + Fe-AA	6	70,77	33,04	54,21	9,03	389,85	0,86
Fe-AA	6	72,17	29,53	57,55	8,95	390,18	0,85
Fe-AA	6	73,82	30,81	55,88	8,62	390,40	0,84
Fe-AA	6	73,88	30,82	56,10	9,13	374,51	0,84
Fe-AA	6	74,65	31,02	55,88	8,85	387,81	0,86
Fe-AA	6	72,16	30,95	56,16	8,46	388,90	0,85
Fe-AA	6	71,00	30,77	56,76	8,83	376,96	0,84

Fe-AA	6	73,97	31,14	55,94	8,59	381,92	0,86
Fe-AA	6	79,36	30,60	56,53	8,70	400,88	0,86
Fe-AA	6	77,86	29,56	58,01	8,29	385,62	0,88
Fe-AA	6	74,77	30,25	58,25	8,34	383,62	0,88

Apêndice 4. Eclosão dos ovos e eclosão dos ovos férteis, %.

Fonte Fe	Casca	Período	Eclosão	E. Férteis
Fe-S	Claro	1	83,33	86,96
Fe-S	Claro	1	85,00	94,44
Fe-S	Claro	1	57,69	93,55
Fe-S	Claro	1	77,27	80,95
Fe-S	Claro	1	73,91	94,44
Fe-S	Escuro	1	75,00	85,71
Fe-S	Escuro	1	77,27	85,00
Fe-S	Escuro	1	66,67	85,71
Fe-S	Escuro	1	80,00	82,35
Fe-S + Fe-AA	Claro	1	87,50	95,45
Fe-S + Fe-AA	Claro	1	90,91	100,00
Fe-S + Fe-AA	Claro	1	76,67	85,19
Fe-S + Fe-AA	Claro	1	89,47	100,00
Fe-S + Fe-AA	Claro	1	80,00	92,31
Fe-S + Fe-AA	Escuro	1	79,67	78,26
Fe-S + Fe-AA	Escuro	1	88,89	96,00
Fe-S + Fe-AA	Escuro	1	68,18	83,33
Fe-S + Fe-AA	Escuro	1	83,33	90,91
Fe-S + Fe-AA	Escuro	1	81,00	76,92
Fe-AA	Claro	1	81,82	96,43
Fe-AA	Claro	1	78,26	81,82
Fe-AA	Claro	1	77,78	87,50
Fe-AA	Claro	1	88,89	96,00
Fe-AA	Claro	1	80,00	85,71
Fe-AA	Escuro	1	76,47	81,25
Fe-AA	Escuro	1	83,33	86,21
Fe-AA	Escuro	1	90,48	90,48
Fe-AA	Escuro	1	90,91	95,24
Fe-S	Claro	2	69,83	85,86
Fe-S	Escuro	2	67,67	86,57
Fe-S + Fe-AA	Claro	2	77,67	88,09
Fe-S + Fe-AA	Escuro	2	73,83	89,13
Fe-AA	Claro	2	71,83	84,02
Fe-AA	Escuro	2	74,50	87,48
Fe-S	Claro	3	74,50	87,48
Fe-S	Claro	3	62,50	76,92
Fe-S	Claro	3	75,00	100,00
Fe-S	Claro	3	91,67	100,00
Fe-S	Claro	3	63,64	77,78
Fe-S	Claro	3	57,14	100,00
Fe-S	Claro	3	66,67	100,00

Fe-S	Escuro	3	80,00	100,00
Fe-S	Escuro	3	60,00	75,00
Fe-S	Escuro	3	70,00	87,50
Fe-S	Escuro	3	60,00	100,00
Fe-S	Escuro	3	50,00	70,00
Fe-S	Escuro	3	80,00	88,89
Fe-S + Fe-AA	Claro	3	100,00	100,00
Fe-S + Fe-AA	Claro	3	87,50	100,00
Fe-S + Fe-AA	Claro	3	63,16	92,31
Fe-S + Fe-AA	Claro	3	50,00	83,33
Fe-S + Fe-AA	Claro	3	71,43	83,33
Fe-S + Fe-AA	Claro	3	83,33	90,91
Fe-S + Fe-AA	Claro	3	75,00	100,00
Fe-S + Fe-AA	Claro	3	100,00	100,00
Fe-S + Fe-AA	Claro	3	75,00	100,00
Fe-S + Fe-AA	Claro	3	75,00	75,00
Fe-S + Fe-AA	Escuro	3	88,89	100,00
Fe-S + Fe-AA	Escuro	3	100,00	100,00
Fe-S + Fe-AA	Escuro	3	100,00	100,00
Fe-S + Fe-AA	Escuro	3	83,33	90,91
Fe-S + Fe-AA	Escuro	3	66,67	93,33
Fe-S + Fe-AA	Escuro	3	46,15	100,00
Fe-S + Fe-AA	Escuro	3	66,67	66,67
Fe-S + Fe-AA	Escuro	3	69,23	81,82
Fe-S + Fe-AA	Escuro	3	72,22	86,67
Fe-AA	Claro	3	76,92	76,92
Fe-AA	Claro	3	85,00	100,00
Fe-AA	Claro	3	52,00	76,47
Fe-AA	Claro	3	57,14	80,00
Fe-AA	Claro	3	75,00	75,00
Fe-AA	Claro	3	87,50	87,50
Fe-AA	Claro	3	87,50	87,50
Fe-AA	Claro	3	75,00	75,00
Fe-AA	Claro	3	42,86	100,00
Fe-AA	Claro	3	66,67	100,00
Fe-AA	Claro	3	81,82	81,82
Fe-AA	Escuro	3	91,67	91,67
Fe-AA	Escuro	3	66,67	100,00
Fe-AA	Escuro	3	84,62	88,00
Fe-AA	Escuro	3	100,00	100,00
Fe-AA	Escuro	3	100,00	100,00
Fe-AA	Escuro	3	57,14	88,89
Fe-AA	Escuro	3	60,00	75,00
Fe-AA	Escuro	3	55,56	71,43

Apêndice 5. Parâmetros hematológicos das progênies de 1 dia: hemoglobina (mg/dL), hematócrito (%.)

Fonte Fe	Cor ovo	hemoglobina	hematócrito
Fe-S	claro	7,51	30,10
Fe-S	Claro	7,69	30,40
Fe-S	Claro	8,01	29,80
Fe-S	Claro	7,56	30,60
Fe-S	Claro	8,03	32,30
Fe-S	Claro	8,10	30,30
Fe-S	Claro	7,69	31,05
Fe-S	Claro	7,35	31,39
Fe-S	Escuro	8,52	30,30
Fe-S	Escuro	8,23	30,91
Fe-S	Escuro	8,38	30,85
Fe-S	Escuro	7,64	30,77
Fe-S	Escuro	6,60	31,50
Fe-S	Escuro	7,23	31,75
Fe-S	Escuro	7,18	29,88
Fe-S	Escuro	7,17	30,44
Fe-S + Fe-AA	Claro	7,97	28,56
Fe-S + Fe-AA	Claro	7,95	29,28
Fe-S + Fe-AA	Claro	7,87	30,71
Fe-S + Fe-AA	Claro	8,09	31,50
Fe-S + Fe-AA	Claro	7,66	30,50
Fe-S + Fe-AA	Claro	7,82	31,45
Fe-S + Fe-AA	Claro	8,35	30,75
Fe-S + Fe-AA	Claro	6,83	30,16
Fe-S + Fe-AA	Escuro	8,08	30,44
Fe-S + Fe-AA	Escuro	7,62	28,25
Fe-S + Fe-AA	Escuro	7,73	31,37
Fe-S + Fe-AA	Escuro	7,88	29,73
Fe-S + Fe-AA	Escuro	7,68	31,00
Fe-S + Fe-AA	Escuro	8,10	32,08
Fe-S + Fe-AA	Escuro	7,51	29,75
Fe-S + Fe-AA	Escuro	7,04	30,67
Fe-AA	Claro	7,63	28,86
Fe-AA	Claro	7,71	28,88
Fe-AA	Claro	7,93	31,65
Fe-AA	Claro	8,57	33,14
Fe-AA	Claro	8,10	31,05
Fe-AA	Claro	8,22	30,83
Fe-AA	Claro	7,22	31,45
Fe-AA	Claro	6,74	30,66
Fe-AA	Escuro	7,93	29,05
Fe-AA	Escuro	8,18	27,73
Fe-AA	Escuro	7,95	30,00
Fe-AA	Escuro	7,44	32,00
Fe-AA	Escuro	7,93	30,04
Fe-AA	Escuro	7,62	29,40
Fe-AA	Escuro	7,72	29,27

Fe-AA	Escuro	7,70	29,35

Apêndice 6. Peso vivo (Kg), conversão alimentar (Kg:Kg), ganho de peso (Kg) e consumo de ração (Kg) das progênies de 1 a 3 dias.

Fonte Fe	Cor ovo	Peso	Ganho de peso	Conversão alimentar	Consumo
Fe-S	Claro	0,087	0,037	1,227	0,045
Fe-S	Claro	0,090	0,039	1,127	0,044
Fe-S	Claro	0,089	0,038	1,162	0,045
Fe-S	Claro	0,085	0,035	1,181	0,041
Fe-S	Claro	0,081	0,030	1,305	0,039
Fe-S	Claro	0,083	0,032	1,178	0,038
Fe-S	Claro	0,086	0,036	1,197	0,043
Fe-S	Claro	0,086	0,035	1,197	0,042
Fe-S	Escuro	0,088	0,038	1,109	0,043
Fe-S	Escuro	0,088	0,038	1,095	0,042
Fe-S	Escuro	0,089	0,039	1,156	0,045
Fe-S	Escuro	0,087	0,037	1,171	0,044
Fe-S	Escuro	0,089	0,039	1,288	0,050
Fe-S	Escuro	0,091	0,040	1,230	0,050
Fe-S	Escuro	0,087	0,037	1,108	0,041
Fe-S	Escuro	0,086	0,033	1,389	0,046
Fe-S + Fe-AA	Claro	0,085	0,034	1,376	0,048
Fe-S + Fe-AA	Claro	0,088	0,038	1,166	0,044
Fe-S + Fe-AA	Claro	0,090	0,039	1,065	0,042
Fe-S + Fe-AA	Claro	0,090	0,038	1,138	0,044
Fe-S + Fe-AA	Claro	0,083	0,032	1,238	0,040
Fe-S + Fe-AA	Claro	0,086	0,034	1,201	0,041
Fe-S + Fe-AA	Claro	0,087	0,036	1,141	0,041
Fe-S + Fe-AA	Claro	0,085	0,033	1,400	0,047
Fe-S + Fe-AA	Escuro	0,091	0,040	1,215	0,049
Fe-S + Fe-AA	Escuro	0,090	0,040	1,173	0,048
Fe-S + Fe-AA	Escuro	0,090	0,039	1,009	0,040
Fe-S + Fe-AA	Escuro	0,088	0,038	1,082	0,041
Fe-S + Fe-AA	Escuro	0,088	0,038	1,099	0,042
Fe-S + Fe-AA	Escuro	0,092	0,043	1,075	0,046
Fe-S + Fe-AA	Escuro	0,089	0,039	1,091	0,042
Fe-S + Fe-AA	Escuro	0,089	0,038	1,053	0,040
Fe-AA	Claro	0,087	0,036	1,320	0,048
Fe-AA	Claro	0,079	0,027	1,447	0,040
Fe-AA	Claro	0,085	0,034	1,241	0,042
Fe-AA	Claro	0,085	0,035	1,140	0,040
Fe-AA	Claro	0,084	0,033	1,163	0,039
Fe-AA	Claro	0,085	0,035	1,065	0,037
Fe-AA	Claro	0,082	0,032	1,237	0,040
Fe-AA	Claro	0,088	0,038	1,311	0,049
Fe-AA	Escuro	0,091	0,042	1,057	0,044
Fe-AA	Escuro	0,089	0,039	1,128	0,044

Fe-AA	Escuro	0,093	0,043	1,010	0,044
Fe-AA	Escuro	0,091	0,042	1,246	0,052
Fe-AA	Escuro	0,089	0,040	1,128	0,045
Fe-AA	Escuro	0,093	0,041	1,046	0,043
Fe-AA	Escuro	0,086	0,035	1,123	0,040
Fe-AA	Escuro	0,088	0,038	1,301	0,050

Apêndice 7. Peso vivo (Kg), conversão alimentar (Kg:Kg), ganho de peso (Kg) e consumo de ração (Kg) das progênies de 4 a 6 dias.

Fonte Fe	Cor ovo	Peso	Ganho de peso	Conversão alimentar	Consumo
Fe-S	claro	0,159	0,071	1,185	0,085
Fe-S	Claro	0,164	0,073	1,349	0,099
Fe-S	Claro	0,158	0,068	1,324	0,090
Fe-S	Claro	0,156	0,071	1,223	0,086
Fe-S	Claro	0,155	0,073	1,184	0,086
Fe-S	Claro	0,151	0,067	1,193	0,080
Fe-S	Claro	0,157	0,071	1,244	0,088
Fe-S	Claro	0,157	0,071	1,244	0,088
Fe-S	Escuro	0,160	0,071	1,328	0,094
Fe-S	Escuro	0,167	0,078	1,334	0,104
Fe-S	Escuro	0,156	0,069	1,338	0,089
Fe-S	Escuro	0,156	0,069	1,373	0,095
Fe-S	Escuro	0,166	0,076	1,225	0,094
Fe-S	Escuro	0,162	0,071	1,241	0,088
Fe-S	Escuro	0,158	0,070	1,396	0,098
Fe-S	Escuro	0,164	0,077	1,143	0,088
Fe-S + Fe-AA	Claro	0,160	0,074	1,246	0,092
Fe-S + Fe-AA	Claro	0,160	0,072	1,303	0,094
Fe-S + Fe-AA	Claro	0,160	0,069	1,204	0,083
Fe-S + Fe-AA	Claro	0,161	0,071	1,214	0,086
Fe-S + Fe-AA	Claro	0,157	0,069	1,390	0,096
Fe-S + Fe-AA	Claro	0,156	0,070	1,245	0,087
Fe-S + Fe-AA	Claro	0,156	0,068	1,347	0,092
Fe-S + Fe-AA	Claro	0,158	0,072	1,504	0,109
Fe-S + Fe-AA	Escuro	0,170	0,078	1,332	0,104
Fe-S + Fe-AA	Escuro	0,164	0,073	1,231	0,090
Fe-S + Fe-AA	Escuro	0,164	0,073	1,257	0,091
Fe-S + Fe-AA	Escuro	0,153	0,064	1,503	0,097
Fe-S + Fe-AA	Escuro	0,160	0,071	1,165	0,083
Fe-S + Fe-AA	Escuro	0,169	0,076	1,232	0,094
Fe-S + Fe-AA	Escuro	0,166	0,077	1,185	0,091
Fe-S + Fe-AA	Escuro	0,161	0,072	1,144	0,082
Fe-AA	Claro	0,153	0,065	1,565	0,102
Fe-AA	Claro	0,154	0,068	1,268	0,086
Fe-AA	Claro	0,155	0,070	1,298	0,091
Fe-AA	Claro	0,154	0,068	1,306	0,090
Fe-AA	Claro	0,149	0,065	1,228	0,079

Fe-AA	Claro	0,150	0,065	0,800	0,052
Fe-AA	Claro	0,151	0,068	1,316	0,090
Fe-AA	Claro	0,161	0,073	1,361	0,100
Fe-AA	Escuro	0,170	0,078	1,238	0,096
Fe-AA	Escuro	0,152	0,062	1,556	0,097
Fe-AA	Escuro	0,166	0,073	1,175	0,086
Fe-AA	Escuro	0,164	0,072	1,348	0,097
Fe-AA	Escuro	0,160	0,070	1,125	0,079
Fe-AA	Escuro	0,162	0,071	1,285	0,091
Fe-AA	Escuro	0,153	0,066	1,355	0,090
Fe-AA	Escuro	0,164	0,075	1,195	0,090

Apêndice 8. Peso vivo (Kg), conversão alimentar (Kg:Kg), ganho de peso (Kg) e consumo de ração (Kg) das progênies de 7 a 13 dias.

Fonte Fe	Cor ovo	Peso	Ganho de peso	Conversão alimentar	Consumo
Fe-S	claro	0,465	0,306	1,321	0,404
Fe-S	Claro	0,477	0,313	1,288	0,403
Fe-S	Claro	0,465	0,307	1,352	0,415
Fe-S	Claro	0,469	0,312	1,245	0,389
Fe-S	Claro	0,450	0,295	1,349	0,398
Fe-S	Claro	0,447	0,296	1,281	0,380
Fe-S	Claro	0,436	0,279	1,415	0,395
Fe-S	Claro	0,459	0,301	1,322	0,397
Fe-S	Escuro	0,483	0,323	1,230	0,397
Fe-S	Escuro	0,484	0,317	1,291	0,410
Fe-S	Escuro	0,470	0,314	1,237	0,388
Fe-S	Escuro	0,474	0,312	1,322	0,412
Fe-S	Escuro	0,496	0,330	1,250	0,413
Fe-S	Escuro	0,470	0,308	1,485	0,458
Fe-S	Escuro	0,451	0,292	1,350	0,395
Fe-S	Escuro	0,461	0,297	1,409	0,418
Fe-S + Fe-AA	Claro	0,437	0,277	1,340	0,371
Fe-S + Fe-AA	Claro	0,459	0,298	1,352	0,403
Fe-S + Fe-AA	Claro	0,485	0,325	1,286	0,418
Fe-S + Fe-AA	Claro	0,472	0,311	1,246	0,386
Fe-S + Fe-AA	Claro	0,448	0,295	1,473	0,435
Fe-S + Fe-AA	Claro	0,469	0,312	1,325	0,414
Fe-S + Fe-AA	Claro	0,474	0,318	1,232	0,392
Fe-S + Fe-AA	Claro	0,474	0,316	1,403	0,443
Fe-S + Fe-AA	Escuro	0,501	0,331	1,300	0,430
Fe-S + Fe-AA	Escuro	0,467	0,303	1,326	0,402
Fe-S + Fe-AA	Escuro	0,483	0,319	1,237	0,394
Fe-S + Fe-AA	Escuro	0,483	0,319	1,237	0,394
Fe-S + Fe-AA	Escuro	0,475	0,315	1,246	0,393
Fe-S + Fe-AA	Escuro	0,483	0,319	1,264	0,403
Fe-S + Fe-AA	Escuro	0,483	0,319	1,264	0,403
Fe-S + Fe-AA	Escuro	0,489	0,327	1,236	0,404

Fe-AA	Claro	0,484	0,331	1,204	0,399
Fe-AA	Claro	0,465	0,311	1,328	0,413
Fe-AA	Claro	0,446	0,290	1,408	0,409
Fe-AA	Claro	0,443	0,288	1,461	0,422
Fe-AA	Claro	0,465	0,311	1,328	0,413
Fe-AA	Claro	0,451	0,300	1,222	0,367
Fe-AA	Claro	0,476	0,325	1,283	0,417
Fe-AA	Claro	0,490	0,328	1,388	0,456
Fe-AA	Escuro	0,500	0,330	1,294	0,427
Fe-AA	Escuro	0,461	0,309	1,275	0,394
Fe-AA	Escuro	0,504	0,337	1,267	0,428
Fe-AA	Escuro	0,489	0,325	1,258	0,409
Fe-AA	Escuro	0,463	0,303	1,262	0,383
Fe-AA	Escuro	0,505	0,343	1,307	0,448
Fe-AA	Escuro	0,472	0,318	1,261	0,402
Fe-AA	Escuro	0,500	0,336	1,241	0,417

Apêndice 9. Peso vivo (Kg), conversão alimentar (Kg:Kg), ganho de peso (Kg) e consumo de ração (Kg) das progênies de 14 a 20 dias.

Fonte Fe	Cor ovo	Peso	Ganho de peso	Conversão alimentar	Consumo
Fe-S	claro	0,987	0,521	1,353	0,705
Fe-S	Claro	0,980	0,502	1,358	0,682
Fe-S	Claro	0,961	0,496	1,360	0,675
Fe-S	Claro	0,990	0,521	1,331	0,694
Fe-S	Claro	0,951	0,501	1,350	0,677
Fe-S	Claro	0,962	0,515	1,480	0,762
Fe-S	Claro	0,962	0,525	1,357	0,713
Fe-S	Claro	0,971	0,512	1,370	0,701
Fe-S	Escuro	1,005	0,522	1,326	0,692
Fe-S	Escuro	0,978	0,510	1,345	0,686
Fe-S	Escuro	0,975	0,504	1,342	0,676
Fe-S	Escuro	0,978	0,510	1,352	0,689
Fe-S	Escuro	0,978	0,511	1,352	0,690
Fe-S	Escuro	0,981	0,511	1,374	0,702
Fe-S	Escuro	0,949	0,498	1,352	0,674
Fe-S	Escuro	0,977	0,516	1,374	0,709
Fe-S + Fe-AA	Claro	1,006	0,538	1,333	0,717
Fe-S + Fe-AA	Claro	1,006	0,538	1,333	0,717
Fe-S + Fe-AA	Claro	1,006	0,538	1,333	0,717
Fe-S + Fe-AA	Claro	1,009	0,536	1,347	0,723
Fe-S + Fe-AA	Claro	1,034	0,586	1,167	0,685
Fe-S + Fe-AA	Claro	0,993	0,524	1,378	0,722
Fe-S + Fe-AA	Claro	0,964	0,490	1,410	0,691
Fe-S + Fe-AA	Claro	1,026	0,552	1,362	0,752
Fe-S + Fe-AA	Escuro	1,001	0,520	1,346	0,699
Fe-S + Fe-AA	Escuro	1,000	0,533	1,323	0,706
Fe-S + Fe-AA	Escuro	1,007	0,524	1,350	0,707

Fe-S + Fe-AA	Escuro	0,962	0,479	1,323	0,634
Fe-S + Fe-AA	Escuro	1,001	0,525	1,345	0,706
Fe-S + Fe-AA	Escuro	1,028	0,545	1,341	0,731
Fe-S + Fe-AA	Escuro	1,002	0,519	1,349	0,700
Fe-S + Fe-AA	Escuro	1,005	0,516	1,385	0,716
Fe-AA	Claro	1,003	0,519	1,361	0,707
Fe-AA	Claro	0,992	0,527	1,347	0,709
Fe-AA	Claro	0,960	0,514	1,355	0,696
Fe-AA	Claro	0,967	0,523	1,353	0,709
Fe-AA	Claro	0,992	0,527	1,347	0,709
Fe-AA	Claro	0,977	0,526	1,321	0,695
Fe-AA	Claro	1,015	0,538	1,332	0,717
Fe-AA	Claro	1,028	0,538	1,359	0,731
Fe-AA	Escuro	1,050	0,550	1,318	0,725
Fe-AA	Escuro	0,964	0,502	1,341	0,673
Fe-AA	Escuro	1,054	0,550	1,345	0,740
Fe-AA	Escuro	1,012	0,523	1,343	0,703
Fe-AA	Escuro	0,990	0,526	1,333	0,701
Fe-AA	Escuro	1,050	0,545	1,349	0,736
Fe-AA	Escuro	0,992	0,520	1,347	0,701
Fe-AA	Escuro	1,044	0,543	1,343	0,730

Apêndice 10. Peso vivo (Kg), conversão alimentar (Kg:Kg), ganho de peso (Kg) e consumo de ração (Kg) das progênies de 21 a 27 dias.

Fonte Fe	Cor ovo	Peso	Ganho de peso	Conversão alimentar	Consumo
Fe-S	claro	1,653	0,684	1,520	1,040
Fe-S	Claro	1,620	0,640	1,613	1,032
Fe-S	Claro	1,636	0,674	1,538	1,037
Fe-S	Claro	1,706	0,715	1,509	1,079
Fe-S	Claro	1,660	0,708	1,509	1,068
Fe-S	Claro	1,633	0,670	1,464	0,981
Fe-S	Claro	1,704	0,742	1,544	1,146
Fe-S	Claro	1,612	0,641	1,466	1,055
Fe-S	Escuro	1,700	0,694	1,562	1,085
Fe-S	Escuro	1,732	0,754	1,505	1,136
Fe-S	Escuro	1,653	0,678	1,617	1,098
Fe-S	Escuro	1,623	0,645	1,486	1,093
Fe-S	Escuro	1,680	0,697	1,531	1,090
Fe-S	Escuro	1,700	0,718	1,507	1,082
Fe-S	Escuro	1,680	0,697	1,531	1,090
Fe-S	Escuro	1,672	0,695	1,510	1,050
Fe-S + Fe-AA	Claro	1,622	0,701	1,534	1,075
Fe-S + Fe-AA	Claro	1,712	0,706	1,512	1,068
Fe-S + Fe-AA	Claro	1,709	0,703	1,552	1,091
Fe-S + Fe-AA	Claro	1,706	0,696	1,563	1,089
Fe-S + Fe-AA	Claro	1,691	0,656	1,520	0,997
Fe-S + Fe-AA	Claro	1,714	0,721	1,471	1,061

Fe-S + Fe-AA	Claro	1,664	0,700	1,501	1,051
Fe-S + Fe-AA	Claro	1,750	0,723	1,506	1,090
Fe-S + Fe-AA	Escuro	1,773	0,772	1,521	1,064
Fe-S + Fe-AA	Escuro	1,727	0,726	1,510	1,097
Fe-S + Fe-AA	Escuro	1,701	0,694	1,494	1,038
Fe-S + Fe-AA	Escuro	1,678	0,716	1,510	1,082
Fe-S + Fe-AA	Escuro	1,697	0,696	1,499	1,043
Fe-S + Fe-AA	Escuro	1,753	0,724	1,500	1,087
Fe-S + Fe-AA	Escuro	1,653	0,651	1,553	1,011
Fe-S + Fe-AA	Escuro	1,731	0,725	1,499	1,087
Fe-AA	Claro	1,744	0,741	1,545	1,145
Fe-AA	Claro	1,594	0,602	1,513	1,077
Fe-AA	Claro	1,703	0,705	1,496	1,056
Fe-AA	Claro	1,695	0,728	1,499	1,091
Fe-AA	Claro	1,703	0,705	1,496	1,056
Fe-AA	Claro	1,700	0,722	1,498	1,082
Fe-AA	Claro	1,716	0,701	1,498	1,050
Fe-AA	Claro	1,769	0,740	1,424	1,054
Fe-AA	Escuro	1,800	0,749	1,493	1,119
Fe-AA	Escuro	1,711	0,747	1,518	1,134
Fe-AA	Escuro	1,763	0,708	1,542	1,092
Fe-AA	Escuro	1,749	0,736	1,485	1,094
Fe-AA	Escuro	1,741	0,751	1,478	1,110
Fe-AA	Escuro	1,777	0,727	1,457	1,060
Fe-AA	Escuro	1,763	0,740	1,489	1,102
Fe-AA	Escuro	1,804	0,760	1,452	1,103

Apêndice 11. Peso vivo (Kg), conversão alimentar (Kg:Kg), ganho de peso (Kg) e consumo de ração (Kg) das progênies de 28 a 34 dias.

Fonte Fe	Cor ovo	Peso	Ganho de peso	Conversão alimentar	Consumo
Fe-S	claro	2,508	0,855	1,685	1,441
Fe-S	Claro	2,460	0,840	1,665	1,399
Fe-S	Claro	2,377	0,740	1,677	1,242
Fe-S	Claro	2,470	0,764	1,679	1,283
Fe-S	Claro	2,455	0,795	1,625	1,292
Fe-S	Claro	2,404	0,771	1,690	1,303
Fe-S	Claro	2,520	0,815	1,671	1,362
Fe-S	Claro	2,423	0,810	1,671	1,354
Fe-S	Escuro	2,468	0,791	1,588	1,256
Fe-S	Escuro	2,517	0,785	1,646	1,292
Fe-S	Escuro	2,402	0,748	1,665	1,247
Fe-S	Escuro	2,426	0,803	1,641	1,319
Fe-S	Escuro	2,494	0,813	1,696	1,380
Fe-S	Escuro	2,510	0,810	1,636	1,325
Fe-S	Escuro	2,478	0,790	1,645	1,301
Fe-S	Escuro	2,452	0,780	1,646	1,283
Fe-S + Fe-AA	Claro	2,461	0,762	1,695	1,291

Fe-S + Fe-AA	Claro	2,457	0,745	1,709	1,274
Fe-S + Fe-AA	Claro	2,474	0,765	1,714	1,312
Fe-S + Fe-AA	Claro	2,438	0,732	1,693	1,240
Fe-S + Fe-AA	Claro	2,461	0,770	1,709	1,316
Fe-S + Fe-AA	Claro	2,485	0,771	1,685	1,300
Fe-S + Fe-AA	Claro	2,451	0,787	1,659	1,307
Fe-S + Fe-AA	Claro	2,461	0,762	1,695	1,291
Fe-S + Fe-AA	Escuro	2,555	0,782	1,653	1,294
Fe-S + Fe-AA	Escuro	2,516	0,788	1,683	1,327
Fe-S + Fe-AA	Escuro	2,453	0,751	1,672	1,257
Fe-S + Fe-AA	Escuro	2,408	0,729	1,817	1,325
Fe-S + Fe-AA	Escuro	2,474	0,777	1,659	1,290
Fe-S + Fe-AA	Escuro	2,516	0,763	1,640	1,252
Fe-S + Fe-AA	Escuro	2,492	0,769	1,739	1,338
Fe-S + Fe-AA	Escuro	2,523	0,792	1,695	1,343
Fe-AA	Claro	2,517	0,773	1,845	1,427
Fe-AA	Claro	2,498	0,788	1,666	1,313
Fe-AA	Claro	2,514	0,810	1,641	1,331
Fe-AA	Claro	2,505	0,810	1,659	1,344
Fe-AA	Claro	2,420	0,716	1,589	1,139
Fe-AA	Claro	2,483	0,783	1,668	1,306
Fe-AA	Claro	2,552	0,836	1,595	1,333
Fe-AA	Claro	2,498	0,788	1,666	1,313
Fe-AA	Escuro	2,563	0,763	1,737	1,325
Fe-AA	Escuro	2,496	0,784	1,714	1,345
Fe-AA	Escuro	2,518	0,755	1,725	1,304
Fe-AA	Escuro	2,555	0,805	1,652	1,330
Fe-AA	Escuro	2,528	0,787	1,653	1,302
Fe-AA	Escuro	2,506	0,728	1,670	1,216
Fe-AA	Escuro	2,535	0,771	1,690	1,304
Fe-AA	Escuro	2,581	0,777	1,682	1,307

Apêndice 12. Rendimentos de carcaça e cortes comerciais, %.

Fonte Fe	Cor ovo	Carc.	G.ab	Peito	Coxa	Sobrecoxa	Asas	Filé
Fe-S	claro	78,41	1,70	28,30	12,43	17,48	10,00	5,44
Fe-S	Claro	78,87	1,66	27,87	12,91	18,44	9,96	5,50
Fe-S	Claro	78,97	1,65	28,19	12,67	17,74	10,00	5,69
Fe-S	Claro	78,34	1,72	27,97	12,70	17,88	10,06	5,28
Fe-S	Claro	78,87	1,72	27,87	12,48	18,02	10,13	5,62
Fe-S	Claro	78,74	2,02	27,37	12,68	18,02	9,75	5,25
Fe-S	Claro	79,57	1,76	28,01	12,44	17,42	10,11	5,58
Fe-S	Claro	79,22	1,56	27,36	12,62	17,88	10,00	5,20
Fe-S	Escuro	78,19	1,51	28,91	12,62	17,91	10,16	5,35
Fe-S	Escuro	79,09	1,85	28,19	12,56	17,76	9,77	5,51
Fe-S	Escuro	79,22	1,76	27,24	12,90	17,69	10,11	5,40
Fe-S	Escuro	78,59	1,77	27,00	12,60	17,88	10,09	5,25
Fe-S	Escuro	78,73	1,68	27,75	12,95	18,51	10,05	5,09

Fe-S	Escuro	78,76	1,55	28,16	12,76	17,44	9,89	5,21
Fe-S	Escuro	78,72	1,77	27,90	12,49	18,18	9,99	5,35
Fe-S	Escuro	78,51	1,55	28,27	12,10	17,92	9,95	5,22
Fe-S + Fe-AA	Claro	79,62	1,82	27,98	12,78	17,88	9,85	5,16
Fe-S + Fe-AA	Claro	79,12	1,61	27,63	12,96	17,93	9,66	5,69
Fe-S + Fe-AA	Claro	79,81	1,57	27,81	12,29	18,38	10,02	5,36
Fe-S + Fe-AA	Claro	78,97	1,45	27,68	12,81	18,12	9,85	5,22
Fe-S + Fe-AA	Claro	79,06	1,97	28,13	12,48	18,18	9,88	5,37
Fe-S + Fe-AA	Claro	77,34	1,95	27,52	12,35	18,34	10,15	5,55
Fe-S + Fe-AA	Claro	79,88	1,83	28,49	12,41	18,40	9,76	5,30
Fe-S + Fe-AA	Claro	78,84	1,99	27,89	11,76	17,71	9,83	5,33
Fe-S + Fe-AA	Escuro	79,11	1,69	28,47	12,25	17,38	10,04	5,51
Fe-S + Fe-AA	Escuro	78,36	1,59	28,52	12,99	17,87	10,04	5,43
Fe-S + Fe-AA	Escuro	79,59	1,68	28,33	12,88	18,42	10,12	5,29
Fe-S + Fe-AA	Escuro	79,05	1,83	28,31	12,45	17,71	9,95	5,35
Fe-S + Fe-AA	Escuro	79,65	1,66	28,52	12,87	17,95	9,88	5,08
Fe-S + Fe-AA	Escuro	78,04	1,65	28,80	12,51	17,59	10,01	5,26
Fe-S + Fe-AA	Escuro	79,40	1,65	27,59	12,62	18,37	9,92	5,20
Fe-S + Fe-AA	Escuro	79,55	1,68	28,07	12,40	18,17	10,01	5,49
Fe-AA	Claro	78,52	1,84	27,95	12,63	17,93	9,94	5,45
Fe-AA	Claro	78,61	1,99	28,11	12,76	17,47	9,72	5,47
Fe-AA	Claro	79,42	1,76	28,06	12,30	17,92	9,81	5,53
Fe-AA	Claro	78,84	1,76	27,94	12,16	17,97	9,55	5,28
Fe-AA	Claro	78,72	1,80	27,98	12,52	18,33	10,00	5,21
Fe-AA	Claro	78,04	1,80	27,03	12,74	18,20	9,78	5,47
Fe-AA	Claro	78,14	1,89	27,84	12,75	17,97	10,11	5,74
Fe-AA	Claro	78,61	1,84	27,84	12,61	17,97	9,57	5,57
Fe-AA	Escuro	78,89	1,72	27,98	13,09	18,12	10,02	5,69
Fe-AA	Escuro	79,79	1,77	27,80	12,56	17,53	9,80	5,57
Fe-AA	Escuro	78,19	1,53	27,80	12,45	17,41	9,61	5,39
Fe-AA	Escuro	78,47	1,94	28,04	12,50	17,63	10,12	5,75
Fe-AA	Escuro	77,90	1,80	27,56	13,02	17,77	9,96	5,36

Fe-AA	Escuro	79,23	1,85	28,16	12,63	17,83	9,63	5,71
Fe-AA	Escuro	78,36	1,66	27,49	12,30	18,01	10,22	5,59
Fe-AA	Escuro	80,31	1,89	27,58	12,54	17,90	10,28	5,67

Apêndice 13. Análise do efeito da suplementação de Fe sobre a produção de ovos.

ANOVA					
Fonte	GL	SQ	QM	F	P
Fe	2	14,5	29	0,47	0,6305
Período	5	29	145	359,94	<0,0001
Interação	10	14,5	145	0,36	0,9623

Apêndice 14. Análise do efeito da suplementação de Fesobre o peso dos ovos.

ANOVA					
Fonte	GL	SQ	QM	F	P
Fe	2	14,5	29	0,05	0,9527
Período	5	24	120	67,09	<0,0001
Interação	10	12	120	0,58	0,8271

Apêndice 15. Análise do efeito da suplementação de Fesobre o peso das gemas, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Fe	2	14,5	29	1,35	0,2743
Período	5	25,8	129	14,96	<0,0001
Interação	10	12,9	129	0,56	0,8412

Apêndice 16. Análise do efeito da suplementação de Fesobre o peso das claras, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Fe	2	14,5	29	0,32	0,7302
Período	5	25,8	129	15,91	<0,0001
Interação	10	12,9	129	0,92	0,5142

Apêndice 17. Análise do efeito da suplementação de Fesobre o peso das cascas, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Fe	2	14,5	29	0,88	0,4236
Período	5	26	130	7,43	<0,0001
Interação	10	13	130	1,23	0,2780

Apêndice 18. Análise do efeito da suplementação de Fesobre o peso a espessura das cascas, mm.

ANOVA					
Fonte	GL	SQ	QM	F	P

Fe	2	14,5	29	0,72	0,4931
Período	5	25,6	128	20,17	<0,0001
Interação	10	12,8	128	1,01	0,4349

Apêndice 19. Análise do efeito da suplementação de Fesobre a densidade dos ovos, g/d^3.

ANOVA					
Fonte	GL	SQ	QM	F	P
Fe	2	14,5	29	0,50	0,6100
Período	5	24,6	123	54,98	<0,0001
Interação	10	12,3	123	0,28	0,9855

Apêndice 20. Análise do efeito dos tratamentos sobre a eclosão dos ovos, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	666,3312	133,8662	2,50	0,0487
Erro	35	1871,777	53,47935		
Total	40	2541,108			

Apêndice 21. Análise do efeito dos tratamentos sobre a eclosão dos ovos férteis, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	133,7417	26,7483	0,87	0,5139
Erro	36	1113,0993	30,9194		
Total	41	1246,8411			

Apêndice 22. Análise do efeito dos tratamentos sobre a hemoglobina dos pintos, g/dL.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,1764	0,0352	0,15	0,9776
Erro	42	9,5993	0,2285		
Total	47	9,7758			

Apêndice 23. Análise do efeito dos tratamentos sobre o hematócrito dos pintos, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	7,7419	1,5483	1,34	0,2653
Erro	42	48,4368	1,1532		
Total	47	56,1788			

Apêndice 24. Análise do efeito dos tratamentos sobre o peso vivo dos frangos aos 3 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,0001	0,00003	7,17	<0,0001

Erro	42	0,0002	0,000005		
Total	47	0,0004			

Apêndice 25. Análise do efeito dos tratamentos sobre o ganho de peso dos frangos de 1 a 3 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,00025	0,000051	7,67	<0,0001
Erro	42	0,00027	0,000006		
Total	47	0,00053			

Apêndice 26. Análise do efeito dos tratamentos sobre o consumo de ração dos frangos de 1 a 3 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,00008	0,000016	1,34	0,2647
Erro	42	0,00052	0,000012		
Total	47	0,00060			

Apêndice 27. Análise do efeito dos tratamentos sobre a conversão alimentar dos frangos de 1 a 3 dias, Kg:Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,1149	0,0229	2,47	0,0478
Erro	42	0,3913	0,0093		
Total	47	0,5062			

Apêndice 28. Análise do efeito dos tratamentos sobre o peso vivo dos frangos aos 6 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,00050	0,00010	4,98	0,0011
Erro	24	0,00085	0,00002		
Total	47	0,00135			

Apêndice 29. Análise do efeito dos tratamentos sobre o ganho de peso dos frangos de 4 a 6 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,00013	0,000026	2,05	0,0904
Erro	42	0,00053	0,000012		
Total	47	0,00066			

Apêndice 30. Análise do efeito dos tratamentos sobre o consumo de ração dos frangos de 4 a 6 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,0003	0,00006	0,86	0,5161

Erro	42	0,0032	0,00007		
Total	47	0,0035			

Apêndice 31. Análise do efeito dos tratamentos sobre a conversão alimentar dos frangos de 4 a 6 dias, Kg:Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,02402	0,0048	0,29	0,9170
Erro	42	0,70062	0,0166		
Total	47	0,72464			

Apêndice 32. Análise do efeito dos tratamentos sobre o peso vivo dos frangos aos 13 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,0049	0,00099	4,36	0,0028
Erro	42	0,0096	0,00022		
Total	47	0,0145			

Apêndice 33. Análise do efeito dos tratamentos sobre o ganho de peso dos frangos de 7 a 13 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,00297	0,00059	3,37	0,0120
Erro	42	0,00743	0,00017		
Total	47	0,01041			

Apêndice 34. Análise do efeito dos tratamentos sobre o consumo de ração dos frangos de 7 a 13 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,00148	0,00029	0,76	0,5866
Erro	42	0,01652	0,00039		
Total	47	0,01800			

Apêndice 35. Análise do efeito dos tratamentos sobre a conversão alimentar dos frangos de 7 a 13 dias, Kg:Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,03725	0,00745	1,66	0,1665
Erro	42	0,18899	0,00449		
Total	47	0,22625			

Apêndice 36. Análise do efeito dos tratamentos sobre o peso vivo dos frangos de aos 20 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,01322	0,00264	5,36	0,0007

Erro	42	0,02071	0,00049		
Total	47	0,03394			

Apêndice 37. Análise do efeito dos tratamentos sobre o ganho de peso dos frangos de 14 a 20 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,004935	0,00098	3,65	0,0079
Erro	42	0,011368	0,00027		
Total	47	0,016303			

Apêndice 38. Análise do efeito dos tratamentos sobre o consumo de ração dos frangos de 14 a 20 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,00375	0,00075	1,60	0,1823
Erro	42	0,01977	0,00047		
Total	47	0,02353			

Apêndice 39. Análise do efeito dos tratamentos sobre a conversão alimentar dos frangos de 14 a 20 dias, Kg:Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,00641	0,00128	0,94	0,4680
Erro	42	0,05759	0,00137		
Total	47	0,06401			

Apêndice 40. Análise do efeito dos tratamentos sobre o peso vivo dos frangos de aos 27 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,05505	0,01101	7,40	<0,0001
Erro	42	0,06247	0,00148		
Total	47	0,11753			

Apêndice 41. Análise do efeito dos tratamentos sobre o ganho de peso dos frangos de 21 a 27 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,01412	0,00282	2,76	0,0303
Erro	42	0,04294	0,00102		
Total	47	0,05707			

Apêndice 42. Análise do efeito dos tratamentos sobre o consumo de ração dos frangos de 21 a 27 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,012677	0,00253	2,48	0,0472

Erro	42	0,043018	0,00102		
Total	47	0,055696			

Apêndice 43. Análise do efeito dos tratamentos sobre a conversão alimentar dos frangos de 21 a 27 dias, Kg:Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,01015	0,00203	1,68	0,1595
Erro	42	0,05066	0,00120		
Total	47	0,06082			

Apêndice 44. Análise do efeito dos tratamentos sobre o peso vivo dos frangos aos 34, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,03765	0,00753	5,22	0,0008
Erro	42	0,06063	0,00144		
Total	47	0,09829			

Apêndice 45. Análise do efeito dos tratamentos sobre o ganho de peso dos frangos de 28 a 34 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,00838	0,00167	2,27	0,0653
Erro	42	0,03110	0,00074		
Total	47	0,03948			

Apêndice 46. Análise do efeito dos tratamentos sobre o consumo de ração dos frangos de 28 a 34 dias, Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,00886	0,00177	0,67	0,6507
Erro	42	0,11168	0,00265		
Total	47	0,12055			

Apêndice 47. Análise do efeito dos tratamentos sobre a conversão alimentar dos frangos de 28 a 34 dias, Kg:Kg.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,01576	0,00315	1,54	0,1988
Erro	42	0,08611	0,00205		
Total	47	0,10188			

Apêndice 48. Análise do efeito dos tratamentos sobre o rendimento de carcaça, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	1,44912	0,28982	0,81	0,5514

Erro	42	15,0892	0,35926		
Total	47	16,5384			

Apêndice 49. Análise do efeito dos tratamentos sobre a gordura abdominal, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,15185	0,03037	1,74	0,1462
Erro	42	0,73235	0,01743		
Total	47	0,88420			

Apêndice 50. Análise do efeito dos tratamentos sobre o rendimento em peito, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	1,48944	0,29788	2,00	0,0979
Erro	42	6,24606	0,14871		
Total	47	7,73551			

Apêndice 51. Análise do efeito dos tratamentos sobre o rendimento em coxa, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,14211	0,02843	0,39	0,8507
Erro	42	3,03838	0,07234		
Total	47	3,18058			

Apêndice 52. Análise do efeito dos tratamentos sobre o rendimento em sobrecoxa, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,52320	0,10464	1,18	0,3344
Erro	42	3,71933	0,08855		
Total	47	4,24254			

Apêndice 53. Análise do efeito dos tratamentos sobre o rendimento em asas, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,25412	0,05082	1,86	0,1224
Erro	42	1,14901	0,02735		
Total	47	1,40313			

Apêndice 54. Análise do efeito dos tratamentos sobre o rendimento em filé de peito, %.

ANOVA					
Fonte	GL	SQ	QM	F	P
Tratamento	5	0,46534	0,09306	3,69	0,0074
Erro	42	1,05932	0,02522		

Total	47	1,52467

VITA

Marco Antônio Ebbing, filho de Inelo Ebbing e Apolônia Eidt Ebbing, nascido em 21 de junho de 1986, em Itapiranga – SC. Completou o ensino fundamental e médio na Escola de Educação Básica Humberto Machado da Linha Ipê Popi no município de Itapiranga – SC em 2003. Em 2009 ingressou no curso de Medicina Veterinária na Faculdade de Itapiranga, formando-se em fevereiro de 2014. Em abril de 2014 ingressou no Mestrado em Zootecnia na área Produção Animal na Universidade Federal do Rio Grande do Sul, sob orientação do professor PhD. Sergio Luiz Vieira. Foi submetido à banca de defesa de Dissertação em março de 2016.