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RESÍDUOS OLERÍCOLAS EM DIETAS PARA COELHOS DE CORTE

Santa Maria, RS
2016

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Dissertação apresentada ao Curso de Mestrado do Programa de Pós-Graduação em Zootecnia, Área de Concentração em Cunicultura, da Universidade Federal de Santa Maria (UFSM, RS), como requisito parcial para obtenção do grau de **Mestre em Zootecnia**.

Orientadora: Prof[a]. Dr[a]. Leila Picolli da Silva

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RESUMO

RESÍDUOS OLERÍCOLAS EM DIETAS PARA COELHOS DE CORTE

AUTORA: Ana Carolina Kohlrausch Klinger
ORIENTADORA: Leila Picolli da Silva

Em dietas para coelhos de corte, o feno de alfafa figura como o ingrediente de maior custo. Desta forma, substituí-lo por resíduos agrícolas reduz os custos dos produtos cunículas. Além disso, o uso de resíduos reduz passivos no meio ambiente e melhora a sustentabilidade da cadeia produtiva. Dois ensaios foram realizados no Laboratório de Cunicultura do Departamento de Zootecnia, da Universidade Federal de Santa Maria, onde se estudou a influência de diferentes substratos, em substituição ao feno de alfafa, em dietas para coelhos de corte. O objetivo do primeiro estudo foi avaliar a viabilidade do uso de topos de cenoura (CT), em substituição ao feno de alfafa, em dietas para coelhos de corte. Para tal, utilizou-se 30 coelhos da raça Nova Zelândia, desmamados aos 35 dias de idade, divididos em três grupos, submetidos aos seguintes tratamentos: T0CT - dieta controle sem inclusão de TC; T25CT dieta com 25% de substituição do feno de alfafa por CT e T50CT - dieta com 50% de substituição do feno de alfa por CT. O ensaio biológico teve duração de 49 dias. Os parâmetros avaliados foram: ganho de peso, conversão alimentar, consumo de ração e viabilidade econômica da dieta. Verificou-se que o ganho médio diário de peso dos animais foi de 23,93g no T0CT, 22,65g no T25CT e 22,16 no T50CT. Já o consumo diário de ração foi de 86,71g no T0CT, 88,43g no T25CT e 89,57g no T50CT. Ainda o custo por kg de dieta reduziu linearmente com a inclusão dos TC em substituição ao feno alfafa, sendo a dieta T0CT a mais onerosa (R$0,74/kg) e a T50CT (R$0,60) a mais econômica. Concluiu-se que os CT podem substituir até 50% o feno de alfafa em dietas para coelhos em crescimento, otimizando o custo da dieta sem prejudicar o desempenho dos animais. O objetivo do segundo estudo foi determinar o efeito da substituição do feno de alfafa por baraço de batata-doce (SPV) sobre o desempenho, a carcaça e parâmetros de metabolismo hepático de coelhos de corte. Para tal, 27 coelhos Nova Zelândia (variedade branca) foram desmamados aos 35 dias e divididos em três tratamentos: 0SPV dieta sem a inclusão de SPV; dieta 10SPV - com 10% de feno de alfafa substituído por SPV; e 15SPV - dieta com 15% de feno de alfafa substituído por SPV. O ensaio durou 49 dias. O consumo diário de ração variou entre 73,17g e 78,02g; com ganho de peso diário entre 22,32g e 23,17g; e a conversão alimentar entre 3,16 a 03,49 e o peso vivo final entre 1839,44g e 1880,55g. Nenhum desses parâmetros de desempenho foi significativamente afetado pelos tratamentos dietéticos. Quanto aos dados pós-abate, os tratamentos não diferiram em peso da carcaça e do coração. No entanto, o peso do fígado foi significativamente menor nos animais do tratamento 10SPV. A glicose presente no fígado variou de 1,62mg/g^{-1} no grupo 10SLP a 5,02mg/g^{-1} no 15SPV e 5,6 mg/g^{-1} no grupo de controle (0SPV). A glicose liberada no tecido apresentou concentração de 2,35µmol, 2,13µmol e 2,59µmol liberado/g de tecido nos tratamentos 0SPV, 10SPV e 15SPV, respectivamente. Por conseguinte, concluiu-se que o SPV pode ser incluído em até 15% em substituição ao feno de alfafa, sem afetar negativamente o desempenho dos animais.

Palavras-chave: Cunicultura. Baraço de batata-doce. Folhas e caules de cenoura.

ABSTRACT

OLERICULTURE RESIDUES IN DIETS FOR GROWING RABBITS

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In diets for broiler rabbits alfalfa hay figure as the most cost ingredient. In this way, replace it with agricultural residues cheapens the rabbits products. In addition, the use of residues reduces liabilities in the environment and improves the sustainability of the production chain. Two experiments were conducted at the Cuniculture Laboratory of Department of Animal Science of the Federal University of Santa Maria, where he studied the influence of different substrates replacing alfalfa hay in diets for broiler rabbits. The aim of the first study was to evaluate the feasibility of using the carrot tops (CT) replacing alfalfa hay in diets for broiler rabbits. To this end, we used 30 rabbits of New Zealand kind, weaned at 35d, divided into 3 groups subjected to the following treatments: T0CT – control treatment without including CT; T25CT - diet with 25% CT replacement alfalfa hay and T50CT - diet with 50% CT replacement alfalfa hay. The biological assay lasted 49 days. The parameters evaluated were: weight gain, feed conversion, feed intake and economic viability of diet. It was found that the average daily weight gain of the animals was 23.93g in T0CT, 22.65g in T25CT and 22:16 in T50CT. The daily feed intake was 86.71g in T0CT, 88.43g in T25CT and 89.57g in T50CLS. The cost per kg of diet linearly reduced with the inclusion of CT to replace alfalfa hay, and the T0CT diet the most expensive (R $ 0.74 / kg) and T50CT (R $ 0.60) the most economical. It follows that the CT can replacement 50% alfalfa hay in diets for growing rabbit diet optimizing the cost without sacrificing performance of the animals. The purpose of the second study was to determine the effect of replacing alfalfa hay for sweet potato vines (SPV) on performance, carcass and liver metabolism parameters broiler rabbits. To this end, twenty-seven rabbits, New Zealand kind were weaned at 35d and divided into three treatments: 0SPV - diet without the inclusion of SPV; 10SPV- diet with 10% alfalfa hay replaced by SPV; and 15SPV - diet with 15% alfalfa hay replaced by SPV. The trial lasted 49 days. The daily feed intake ranged from 73.17 to 78.02g; daily weight gain, 22.32 to 23.17g; and feed conversion of 3.16 to 03.49 and the final live weight, from 1839.44 to 1880.55g. None of these performance parameters were significantly affected by dietary treatments. As for the post-slaughter data treatments did not differ in carcass weight and heart. However, the liver weight was significantly lower in animals 10SPV treatment. The glucose present in the liver ranged from 1.62mg/g^{-1} in 10SLP group to 5.02mg/g^{-1} in 15SPV and 5.6 mg/g^{-1} in the control group (0SPV). The glucose released into the tissue showed concentration 2,35µmol, 2,13µmol and 2,59µmol released / g tissue in the treatment 0SPV, 10SPV and 15SPV respectively. Therefore concluded that the SPV can be included in up to 15%, replacing alfalfa hay without adversely affecting the performance of the animals.

Key-words: Carrot tops. Rabbits. Sweet potato vines.

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LISTA DE ABREVIATURAS E SIGLAS

FAO Food Agricultural Organization
IBGE Instituto Brasileiro de Geografia e Estatística
NPK Nitrogênio, Fósforo e Potássio
NRC National Research Council

SUMÁRIO

1 INTRODUÇÃO

A formulação e o balanceamento de rações consistem na mistura de vários alimentos, com a finalidade de atender às exigências nutricionais dos animais, para que possam expressar o máximo de seu potencial genético (NUNES et al., 2001). Uma vez que a alimentação é responsável por 70% dos custos de produção, atender às exigências com baixo custo e diminuir o desequilíbrio de alguns nutrientes é imprescindível para o sucesso do criatório. Dentre as preocupações para a população mundial, está o fornecimento de fontes proteicas de boa qualidade, com baixo custo e oferta regular, que possam suprir as necessidades das pessoas, principalmente nos locais mais carentes (LOUSADA JUNIOR et al., 2006; VOLPATO et al., 2015).

Nesse sentido, o coelho tem a capacidade de aproveitar os alimentos relativamente ricos em fibras, competindo em menor grau com o homem do que aves e suínos, que consomem maior quantidade de grãos em suas dietas. Além disso, as suas características biológicas (rapidez do ciclo de produção, prolificidade, poder de transformação e ótima qualidade da carne) desempenham uma função importante no regime alimentar da população.

A exploração de coelhos pode ser iniciada em pequenos espaços, com baixo investimento inicial e com grande potencial para geração de lucros. Pode, também, ser facilmente consorciada com diversas culturas vegetais, de modo que os animais se beneficiem das partes comumente descartadas dessas culturas, gerando proteína animal de excelente qualidade. A exploração cunícola é vantajosa para a maioria das propriedades e ideal para as familiares.

Pesquisas demonstram que o aproveitamento de subprodutos e resíduos agrícolas, na nutrição das diversas espécies animais exploráveis zootecnicamente, influi decisivamente para a redução de passivos ambientais, promovendo maior sustentabilidade dos sistemas produtivos (MAERTENS et al., 2003; FERREIRA et al., 2007; MOLINA et al., 2015; TAMIR; TSEGA, 2010; NGUYEN, 2012; LOCHMANN et al., 2013). A indústria agrícola produz grande quantidade de subprodutos, resultando em relevante potencial nutricional para os animais, visto que esses subprodutos não são diretamente utilizados pelo ser humano, o que possibilita sua conversão em fontes alimentares menos onerosas e, posteriormente, em produtos animais para consumo humano (CHEEKE, 1987).

Devido aos avanços tecnológicos nos setores produtivos, a agroindústria vem investindo no aumento da capacidade de processamento, o que gera grandes quantidades de resíduos, que, em muitos casos, são considerados custo operacional para as empresas ou fonte de contaminação ambiental (LOUSADA JUNIOR et al., 2006). Nesse contexto, surge a necessidade de estudar os usos potenciais para esses resíduos, a fim de otimizar a cadeia produtiva.

Esse cenário demonstra que resíduos descartados em lavouras e agroindústrias levam consigo quantidades massivas de nutrientes, que poderão ser convertidos em nobre proteína animal, de modo a tornar os meios produtivos mais sustentáveis, promovendo a seguridade alimentar e a responsabilidade social e ambiental. O presente trabalho foi desenvolvido, portanto, para avaliar o uso de resíduos da produção de cenoura e de batata doce na dieta de coelhos de corte, visando à obtenção de informações que subsidiem os meios científico, acadêmico e produtivo.

2 REVISÃO DE LITERATURA

2.1 A CUNICULTURA NO BRASIL

De acordo com o último censo do Instituto Brasileiro de Geografia e Estatística em que a cunicultura foi considerada (IBGE, 2006), o Brasil possui um rebanho efetivo de pouco menos de 300.000 cabeças de coelhos, distribuído em 17.615 estabelecimentos, que movimentaram mais de R$300.000.000 no ano estudado. A maior parte desses animais (90%) se localiza em terras próprias, 3,4% em terras de produtores sem área, 2,7% em áreas de ocupação, 2,6% em regime de arrendamento e 1,2% em terras de assentados, sem titulação definitiva. De acordo com esse mesmo censo, os coelhos brasileiros estão em propriedades cujos focos são a pecuária e a criação de outros animais (65%), a produção de lavouras temporárias (21%), a horticultura e a floricultura (5,8%), a produção de lavouras permanentes (5,2%) e outros grupos de atividades econômicas, que possuem menos expressividade (IBGE, 2006). Também é de grande relevância citar que mais de dois terços desses animais localizam-se em propriedades com menos de 20 hectares, o que, na maioria dos casos, configura estrutura fundiária de agricultura familiar.

No Brasil, o consumo de carne de coelho é insignificante devido à baixa produção, com estimativa anual de 12 mil toneladas (ESPÍNDOLA et al., 2007), e a falta de organização no setor, que não consegue difundir o hábito do consumo nem mesmo divulgar as grandes qualidades dessa carne. Além da barreira cultural a ser vencida, o preço é elevado, por ser considerado alimento "exótico". No entanto, a cunicultura brasileira, como atividade de exploração intensiva, é uma alternativa viável para pequenas propriedades (SCAPINELLO et al., 2003; OLIVEIRA et al., 2015). Segundo Fernández-Carmona et al. (2005), diversas técnicas têm contribuído para a melhoria da produção e da reprodução animal. Dentre elas, encontra-se a inclusão de resíduos agrícolas das propriedades, para a agregação de valor ao produto e barateamento do custo de produção.

2.2 GERAÇÃO DE RESÍDUOS AGROINDUSTRIAIS

Rempel et al. (2015) expõe que, desde que o homem deixou de ser caçador/coletor e começou a cultivar alimentos, os impactos do uso da terra passaram a ser inevitáveis. É preciso que esses impactos inerentes ao processo sejam os menores possíveis, indo ao encontro do real desenvolvimento sustentável. Nesse sentido, Peresin et al. (2015) afirmam que o crescimento acelerado da produção agropecuária brasileira, nos últimos anos, levou ao agravamento dos problemas ambientais, decorrentes da intensificação na geração de resíduos e dejetos.

De acordo com o relatório acerca das exportações mundiais da Organização das Nações Unidas para a Alimentação e a Agricultura (FAO, 2011), os cinco produtos que o Brasil mais exportou (em dólares), no ano de 2011, somam mais de 32 milhões de toneladas de grãos de soja, 20 milhões de toneladas de açúcar, cerca de 1,8 milhões de toneladas de café, 3,5 milhões de toneladas de frango e mais de 14 milhões de toneladas de torta de soja. O Brasil figura, ainda, como grande produtor de trigo, milho, hortifrúti, algodão, café, entre outros.

Schneider et al. (2011), ao estudarem diversas culturas, mostram os seguintes valores de geração de resíduos e subprodutos nas seguintes culturas temporárias: 73% para o feijão de soja, 27% para o milho, 20% para o arroz e 60% para o trigo. Os autores ainda mencionam que os principais resíduos e subprodutos provenientes das culturas temporárias são vagens, palhas, cascas, e farelos.

Quanto às culturas permanentes brasileiras, a produção de frutas contribui com quantidade expressiva de produtos não comestíveis, denominados polpas, fibras, bagaços, etc. Apenas na produção de laranjas, de acordo com Gobbi et al. (2014), 42% do total do fruto corresponde ao bagaço. Estima-se que 13% do peso das uvas seja composto por resíduos (KLINGER et al., 2013). Já os vegetais frescos apresentam resíduos, como talos, folhas e caules. No caso das verduras de mesa, como a cenoura e a beterraba, a parte aérea é usualmente descartada (RODRIGUES et al., 2014). Esse fato se repete com os baraços (como da batata doce) e muitos outros.

Além do exposto, o Brasil apresenta grande potencial para a produção de biocombustíveis. O país dispõe de uma gama diversa de culturas oleaginosas próprias para a produção de biodiesel, bem como tecnologias de ponta e estrutura fabril com alta capacidade para desenvolver essa produção. No entanto, resíduos da produção do biodiesel não podem ser utilizados para a alimentação humana, acarretando um problema para o meio ambiente.

2.3 UTILIZAÇÃO DE SUBPRODUTOS NA NUTRIÇÃO CUNÍCOLA

A produção cunícola, em países de clima tropical e subtropical, enfrenta limitações que a prejudicam seriamente, como a falta de alimentos equilibrados a preços competitivos (MOLINA et al., 2015). Nesse contexto, o conhecimento sobre alimentos alternativos em dietas para animais apresenta importância cada vez maior, uma vez que, diante dos baixos níveis mundiais de grãos e da crescente utilização desses cereais na alimentação animal, a oferta de grãos disponíveis para a alimentação humana diminui, aumentando o custo de produção (SILVA et al., 2000; OLIVEIRA et al., 2015).

Os resíduos da agroindústria podem ser fontes de proteína, energia e fibra (OLIVEIRA, 2013). A maioria dos estudos que objetiva avaliar ingredientes alternativos e seus efeitos sobre o desempenho de coelhos na fase de crescimento tem demonstrado grande variabilidade na eficiência alimentar, principalmente em relação ao aproveitamento proteico, que é influenciado pelo teor de frações diferenciadas de fibra e por suas respectivas ações sobre a disponibilidade dos nutrientes (SANTOS et al., 2004). Contudo, devido a diferenças na composição bromatológica, torna-se difícil categorizar alguns subprodutos como substitutos clássicos dos concentrados ou forragens, principalmente devido à palatabilidade (NRC, 2001).

O peculiar sistema digestivo do coelho permite a inclusão de subprodutos vegetais e industriais de todo tipo nas dietas dessa espécie (MATEOS; VIDAL, 1996). Diferentemente da maioria dos monogástricos, o ceco do coelho é funcional e, por meio da ingestão de cecotrofos, o animal tem acesso a proteínas, minerais e vitaminas produzidas ou disponibilizadas pela fermentação microbiana (CARABAÑO; PIQUER, 1998). A flora é de implantação lenta (até o terceiro dia de vida, os láparos não apresentam flora microbiana) e tem composição relativamente simples (sobretudo bacilos gram-negativos não esporulados) (GIDENNE, 1997). Ainda de acordo com o referido autor, o perfil de ácidos graxos voláteis, resultantes da fermentação cecocólica, também é específico no caso de coelhos, com predominância de acetato, seguido por butirato e propionato.

O ingrediente de maior custo da dieta para coelhos é o feno de alfafa, que compreende cerca de 40% do custo da ração para coelhos (SCAPINELLO et al., 2003), devido às altas exigências de crescimento dessa leguminosa, especialmente com relação às condições de fertilidade do solo, boa drenagem e pH próximo à neutralidade, características encontradas em poucas unidades de mapeamento de solos brasileiros (SILVA et al., 1995). Aliado a isso, a oferta desse produto é pequena no mercado e sua composição química é muito variável.

Subprodutos, como resíduos olerícolas, cascas, restevas e palhas, são produzidos em grande escala no Brasil e apresentam, além da fibra dietética, teores consideráveis de energia e/ou proteína. Porém, seu uso na nutrição animal ainda é muito restrito e seu descarte para o ambiente é a prática mais comum, causando desperdício de quantidades massivas de nutrientes que poderiam ser usados para a produção de proteínas nobres de origem animal. O uso racional desses resíduos pode trazer benefícios ambientais, sociais e econômicos, tanto à cadeia produtiva olerícola como à de criações zootécnicas.

2.4 PRINCIPAIS RESÍDUOS UTILIZADOS PARA COELHOS DE CORTE NO BRASIL

2.4.1 Cascas

A casca é o envoltório do grão separado do embrião no processo industrial de preparação, sendo retirada após a quebra dos grãos. É usualmente descartada, e possui valor comercial baixo ou nulo. O milho é o ingrediente mais utilizado, no Brasil, para a confecção de rações, sendo consumidas mais de 36 milhões de toneladas anuais desse ingrediente para tal fim (SINDIRAÇÕES, 2012). Após pesagem e recepção, esse cereal recebe uma primeira limpeza, havendo separação de um resíduo fibroso, denominado de pericarpo ou casquinha de milho, o qual, normalmente, não é utilizado nas fábricas de ração (RIBEIRO et al., 2012). Os referidos autores expõem, também, que a casquinha de milho pode substituir o feno de alfafa, com eficiência, para coelhos em crescimento, ocorrendo melhoria na conversão alimentar.

A casca de soja figura como um produto secundário da produção do feijão de soja, com grande concentração de polissacarídeos não amiláceos, como pectinas, hemiceluloses e celulose, e baixo teor de ligninas (TOLEDO et al., 2012). Esses polímeros presentes na casca podem ser degradados mais intensamente no intestino grosso, quando comparados aos presentes no feno de alfafa, devido à maior acessibilidade dos constituintes fermentáveis à microbiota cecocólica (NICODEMUS et al., 2007).

Para a nutrição animal, é necessário que a casca seja tostada, a fim de destruir metabólicos antinutricionais. Cada 100 kg de farelo de soja "hipro" (alta proteína) produzidos resultam em 8 kg de casca de soja (GOES; SILVA; SOUZA, 2013). Em níveis em que a substituição do feno de alfafa pela casca de soja não afeta o desempenho animal, a viabilidade econômica pode ser melhorada devido ao menor custo desse ingrediente, visto que ele não chega a 50% do custo do feno de alfafa.

A casca de mandioca desidratada também pode ser incorporada às rações de coelhos em crescimento, em níveis de até 24,3%, com substituição total da energia digestível do farelo de trigo, ficando a sua utilização na dependência de preço e oferta de mercado (MICHELAN et al., 2008). Também a casca de arroz pode ser incorporada à dieta cunícola, em nível de até 6%, proporcionando ao animal fibra de lastro, importantíssima para lagomorfos. Entretanto, níveis desbalanceados de casquinha de arroz conferem à dieta baixa digestibilidade e pior conversão alimentar.

2.4.2 Bagaços e polpas

Bagaços e polpas são os resíduos vegetais resultantes da extração da parte líquida dos mesmos. São muito comuns no Brasil, com destaque para o bagaço de cana (resultante da extração do caldo) e da polpa cítrica (oriunda da produção de suco de laranja).

A polpa cítrica desidratada, fonte de fibra digestível por possuir elevados níveis de pectinas e reduzida lignificação, é bem aproveitada, na forma de energia, pelos coelhos, além de ser composta por pequenas quantidades de fibra indigestível, características que aliam valor nutritivo a efeito lastro (MARIA et al., 2013). Pode substituir o milho, em até 20%, nas dietas para coelhos (MARIA et al., 2013).

Ferreira et al. (2015) avaliaram a viabilidade do uso de bagaço de cana enriquecido com vinhaça e concluíram que a utilização desse ingrediente era viável para coelhos em crescimento. A inclusão de vinhaça promoveu a melhoria dos valores de energia e proteína digestíveis do bagaço de cana-de-açúcar *in natura*.

Klinger et al. (2013) estudaram a inclusão de bagaço de uva em substituição ao feno de alfafa, nos níveis 25 e 50%, em dietas para coelhos. Os autores constataram que a presença, em maior proporção, dos ácidos graxos essenciais ômega 3 e ômega 6, nos tratamentos com o bagaço, promoveu melhores respostas zootécnicas, uma vez que esses nutrientes agem positivamente no equilíbrio homeostático. Por consequência, concluíram que a inclusão de bagaço de uva, em dietas para coelhos na fase de crescimento, melhora o desempenho dos animais, devido ao aumento do consumo total de ração e ao ganho de peso.

2.4.3 Partes aéreas

As partes aéreas, componentes majoritários dos resíduos olerícolas, estão entre os ingredientes potenciais menos estudados. Essas partes constituem-se, basicamente, por folhas e caules e têm como objetivo principal a realização da fotossíntese. O baraço caracteriza-se pela parte aérea de certos vegetais, como batata-inglesa, batata-doce, abóbora, melão e chuchu. Difere da parte aérea de outras plantas por possuir crescimento horizontal e por apresentar gavinhas e outros mecanismos de fixação no solo ou em “tutores” de madeira.

O Brasil possui vasta gama de vegetais, cujas partes aéreas são descartadas, mesmo tendo grande potencial para uso na nutrição animal. Dentre eles, destacam-se o baraço de amoreira e as folhas de mandioca (Ferreira et al. 2007), que apresentam propriedades similares às do feno de alfafa, as folhas e os caules de cenoura, que podem substituir, em até 50%, o feno de alfafa (Rodrigues et al. 2014), as folhas e os caules de batata-doce, que, de acordo com Galarreta et al. (2015), podem substituir, com sucesso, parte do feno de alfafa.

Culturas como as da batata-doce e da cenoura são conduzidas em pequenas propriedades familiares, onde é preponderante a melhoria da geração de renda. Apenas na propriedade familiar onde obtivemos material para conduzir parte deste estudo, é colhido cerca de 0,02 hectare mensais de cenouras, ou seja, cerca de 4.200 plantas/mês. Essa população de plantas gera, em média, 23 kg de massa seca da parte aérea, por colheita (LOPES et al., 2008). Se esse resíduo fosse incluído na alimentação, no nível de 30%, poderia sustentar 13 coelhos do desmame ao abate (42 dias), quatro matrizes e um reprodutor, poupando o produtor do custo com ingredientes como o feno de alfafa.

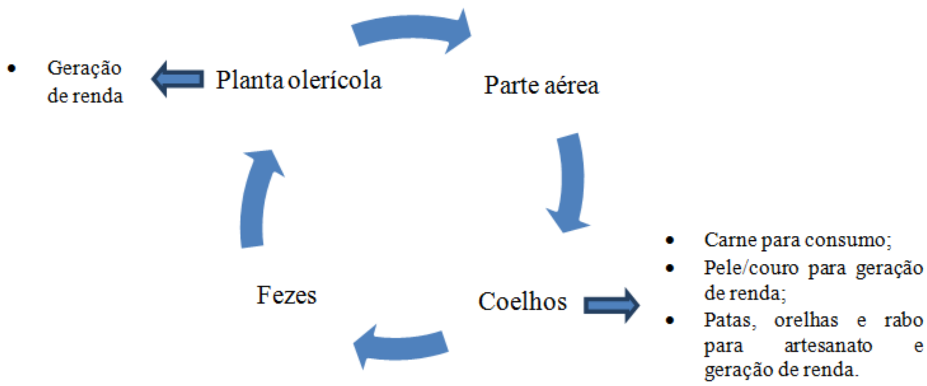
Dessa forma, o produtor teria produção mensal de 13 coelhos gerando 13 carcaças (para consumo), 52 patas (para comercializar como amuletos), 26 orelhas (para comercializar como suvenires), 13 caudas (para comercializar como "pompom"/adorno) e 13 peles (para comercializar cruas ou curtidas ou confeccionar itens para venda). O espaço necessário seria um galpão (ou outra estrutura coberta), com 3,6 x 2,4 m de dimensão, ou seja, 8,64 m².

Ainda como consequência, os coelhos reduziriam o custo do produtor com adubo, já que suas fezes figuram como esterco de excelente qualidade. Dessa forma, é possível obter um modelo sustentável de produção, com grande geração de produtos, como ilustra a Figura 1.

A motivação para desenvolver este trabalho surgiu da confiança na possibilidade de se implantar uma cunicultura sustentável, ecologicamente correta e justa – tanto para o produtor quanto para o meio ambiente –, da crença no potencial da agricultura familiar para o fortalecimento do país e do desejo de se aplicar, no campo, os estudos desenvolvidos nas universidades.

Assim, foram desenvolvidos dois estudos, com o propósito de substituir resíduos da olericultura pelo feno de alfafa em dietas para coelhos. Foram escolhidos materiais substitutos para esse ingrediente, uma vez que é o mais oneroso em dietas cunícolas. Substitutos potenciais, portanto, reduzem significativamente o custo produtivo.

Figura 1 – Esquema de modelo sustentável de produção, com geração de produtos



Fonte: Autora.

3 ARTIGO 1 – TOPOS DE CENOURA COMO SUBSTITUTO PARCIAL DO FENO DE ALFAFA EM DIETAS PARA COELHOS

Este capítulo é apresentado de acordo com as normas para publicação na Revista **Asian-Australian Journal of Animal Science.**

Diets for growing rabbits: Carrot tops as a partial substitute for alfalfa hay

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ABSTRACT

The aim of this study was to evaluate the feasibility of partially replacing alfalfa hay with carrot tops in diets for broiler rabbits. In this assay 30 New Zealand rabbits, weaned at 35 days of age, were divided into three groups and submitted to one of three dietary treatments: T0CT – 100% alfalfa hay without the inclusion of carrot tops; T25CT - diet with 25% carrot tops and 75% alfalfa hay; and T50CT - diet with 50% carrot tops and 50% alfalfa hay. Water and feed were offered ad libitum. The biological assay lasted for 49 days during the months of December 2014 and January 2015 (summer season). The evaluated parameters were: weight gain, feed conversion, feed intake and economic viability of the diet. Means were statistically analyzed by analysis of variance (ANOVA) followed by Tukey test (0.05). The average daily weight gain of the rabbits was 23.93g for T0CT, 22.65g for T25CT and 22.16 for T50CT. Feed intake was 86.71g in T0CT, 88.43g in T25CT and 89.57g in T50CT. The cost per kg of diet reduced linearly with the inclusion carrot tops, the T0CT diet was the most expensive (R$ 0.74/kg) and T50CT (R$ 0.60/kg) the most economically viable. Our findings indicate that carrot tops can replace up to 50% of the alfalfa hay in diets for growing broiler rabbits optimizing the cost of diet without negatively affecting animal performance.

Keywords: by-products; nutrition; rabbit

INTRODUCTION

In developing countries, there is growing demand for lower cost animal-protein sources. The fact that rabbits have early sexual maturity, short gestation and can be slaughtered for meat as early as 74 days in addition to the fact that they require reduced living spaces and a relatively easy management with minimum environmental impact makes rabbit meat one of the best low-cost animal protein (De Blas et al., 2015; Molina et al., 2015).

In cuniculture, feed may correspond to as much as 70% of the total costs (Scapinello et al., 2003) and the alfalfa hay is the most expansive ingredient. In order to lower production cost, an alternative is to replace this expensive ingredient with an ingredient of lower commercial value, such as carrot tops, which can be easily and cheaply acquired and has protein content similar to the ones found in the alfalfa hay (Sharma et al., 2012).

Studies addressing the use of kitchen waste - such as carrot tops and other by-products considered waste by the food industry - are rare and practically unheard of in Brazil. Thus, the aim of this study was to evaluate the effect of using carrot tops, in place of alfalfa hay, in growing rabbits in Brazil.

MATERIALS AND METHODS

This experiment was carried out in December and January (2014/2015) at the Cuniculture laboratory at the Federal University of Santa Maria (Brazil). Thirty New Zealand rabbits were kept in cages within a barn with minimum and maximum temperatures ranging from 23ºC to 31°C with no artificial light schedule.

Experimental diets

The animals were evenly separated and assigned one of three diets. The control diet (T0CT) with 100% alfalfa hay ; diet T25CT with 75% of the alfalfa hay and 25% carrot tops and diet T50CT, with 50% alfalfa hay and 50% carrot tops (Table 1). Diets were formulated as to have a similar crude protein (18%) and digestible energy (2323 Kcal/Kg) content and to comply with the growth requirements (AEC, 1987). No antibiotics were added either to the diets or to the water.

The feed was offered as mash and placed in woven galvanized wire mesh feeders. Twice a day residual feed was removed from the feeders, homogenized and again offered to the animals as a strategy to prevent the animals from selecting the larger particles.

Animals and measurements

A total of 30 mixed-sex New Zealand White rabbits, weaned at 35d and weighing on average 789±37.49g, were randomly assigned to one of the 3 experimental groups (10 rabbits/diet), according to weaning weight.

Rabbits were allocated in individual galvanized wire cages (50×50×50cm) and fed ad libitum until the end of the experiment. Fresh water was always available. The biological assay lasted 49 days during which, animal live weight and feed consumption were registered weekly, whereas, the mortality was verified daily, according to the guidelines for applied nutrition experiments in rabbits (Fernandez-Carmona et al., 2005 apud LounaouCi-ouYeD et al., 2014). At the end of the bioassay all rabbits were 84d old. The following parameters were evaluated: daily weight gain, feed conversion, and daily feed intake.

Economic analyses

The efficiency index of the diets was assessed by multiplying the total cost of the ingredients in the diet by feed conversion.

Statistical analyses

Data were analyzed as a completely randomized design with the Statistical Analysis System (SAS, 1988) using the general linear model (GLM procedure). The variance analysis was performed with the diet as the sole source of variation. Each animal was considered to be an experimental unit. The means were compared by variance analysis followed by Tukey test ($p < 0.05$).

RESULTS AND DISCUSSION

The experimental diets T0CT and T25CT differed significantly from the T50CT diet for feed conversion, average daily gain, and weight at 49 days in the post-weaning period (35d - 49d). However, no significant effects were found in daily weight gain (DWG); feed conversion (FC), and feed intake (FI) in other growth periods or considering the entire period of the assay (Table 2). These results corroborate with Gidenne et al. (2010) whose findings show that diets for growing rabbits can include up to 30% of carrot tops .However, El Medany et al. (2008) state that carrot tops can make up more than 50% of a diet for growing rabbits without effecting animal performance.

In study with isoprotein diets (18.13%) formulated to contain five different levels of carrot leaf meal (0, 15, 30, 45 and 60%), Abdu et al. (2012), found a significant ($p < 0.05$) effect with the increase in levels of carrot leaf meal inclusion in the experimental diets. Nonetheless, these authors state that the treatment with 15% carrot leaf meal had the highest daily FI (81.677 g), which is similar to the control treatment.

A marked difference between this experiment and recent studies of the same nature was found for the absolute values of feed conversion. Alves (2013) studied the performance of four groups of rabbits between the ages of 21 and 63 days, fed diets with two different levels of neutral detergent fiber (37% and 30%) with and without carrot tops and found an average feed conversion of 2.38; 2.65; 2.02; and 2.18. One reason for this discrepancy in the conversion is the fact that the average temperature during the bioassay was around 31 ° C (maximum) and 23ºC (minimum) which may have thermally stressed rabbits,, lowering energy intake and weight gain and consequently, increasing conversion.

Another reason for the differences in feed conversion from similar studies is the fact that rabbits in this study were fed pure mash. In this sense, it is likely to have occurred more waste and less use of the same animals by virtue of their physical form. However, there was no mortality during the experimental period.

Economic Viability

Our findings indicate that the inclusion of carrot tops in diets of growing rabbits may ultimately reduce overall costs (Table 3).

CONCLUSION

It was concluded that carrots tops can replace up to 50% of alfalfa hay in diets of growing rabbits without hindering animal performance. However, we encourage further research on the topic.

REFERENCES

Abdu S.B., G.E. Jokthan, M.R. Hassan, H.Y. Adamu, S.M. Yashim and E. Ikani. 2012. Effects of Inclusion Levels of Carrot (Daucus carota) Leaf Meal on Performance of Growing Rabbits. *World Jornal Life Science and Medical Research.* 2:65-70.

AEC. **Recomendações para nutrição**. 5.ed. Antony, France: RHÔNE-POULENC, 1987. 86p.

Alves, R.J.P.M. **A cenoura de refugo e a sua utilização pelo coelho.** 2013. 57f. Dissertation (Master degree in animal Science). Instituto Superior de Agronomia. Universidade Técnica de Lisboa.

Costa, P.T.C. Avaliação econômica do frango de corte na fase final. In: CONFERENCIA APINCO DE CIENCIA E TECNOLOGIA AVICOLA, 1999, Campinas, SP. **Anais...** Campinas: FACTA, 1999. p.71-82.

De Blas, J.C., C.A. Rodriguez, F. Bacha, R. Fernandez and R. Abad-Guamán. 2015. Nutritive value of co-products derived from olivecake in rabbit feeding. *World Rabbit Science*. 23:255-262.

El-Medany, N. M., N. A. Hashem and F. Abdl-Azeem. 2008. Effect of incorporating dried carrot processing waste in growing rabbit diets. *Egyptian J. Nutrition and Feeds* 11: 25-37.

Fernández-Carmona J., E. Blas, J.J. Pascual, L. Maertens, T. Gidenne and G. Xiccato. 2010. Recommendations and guidelines for applied nutrition experiments in rabbits. *World Rabbit Science*. 13 : 209-228.

Lounaouci-ouyed G., M. Berchiche, T. Gidenne, T. Effects of substitution of soybean meal-alfalfa-maize by a combination of field bean or pea with hard wheat bran on digestion and growth performance in rabbits in Algeria. 2014. *World Rabbit Science***.** 22: 137-146.

Molina E., González-Redondo P., Moreno-Roja R., Montero-Quintero K, Bracho B., Sánchez-Urdaneta A. 2015. Effects of diets with Amaranthus dubius Mart. ex Thell. on performance and digestibility of growing rabbits. *World rabbit Science*. 23:9-18

Gidenne, T., et al.. **Nutrition of the rabbit – 2 ed**. CAB international, UK. 2010.

Sharma K.D., Karki S, Thakur NS, Attri S. 2012. Chemical composition, functional properties and processing of carrot—a review. *J Food Sci Technol.* 49:22–32.

SAS. 1988. SAS/STAT User's Guide (Release 6.03). *SAS Inst. Inc., Cary NC, USA.*

Scapinello, C., E. B. Antunes, A. C. Furlan, C. C. Jobim, H. G. Faria. 2003. Fenos de leucena (Leucaena leucocephala e Leucaena leucocephala cv. Cunningham) para coelhos em crescimento: digestibilidade e desempenho. *Acta Scientiarum. Anim. Sci.* 25:301-306.

Table 1: Composition of control and experimental diets

	Experimental diets		
	T0CT	T25CT	T50CT
Ingredients (% as fed)			
Corn	17.25	17.25	17.25
Wheat meal	25.00	25.00	25.00
Soy-bean meal	17.50	17.50	18.00
Soy-bean oil	2.50	2.50	2.40
Rice hulls	6.00	6.00	5.45
Alfafa hay	30.00	22.50	15.00
Carrot tops	-	7.50	15.00
Dicalcium phosphate	0.80	0.80	0.80
Calcitic Limestone	0.25	0.25	0.40
Salt	0.50	0.50	0.50
Vitamin/mineral premix	0.20	0.20	0.20
Nutritional Levels in Dry Matter			
Crude Protein (%)	18.00	18.00	18.00
Ether Extract (%)	4.39	4.58	4.67
FDA (%)	20.78	19.84	18.05
FDN (%)	35.30	33.37	31.10
Calcium	1.10	1.00	1.00
Phosphorus	0.60	0.54	0.52

T0CT: Treatment without carrot leaves and stems, T25CT: Treatment with 25% of carrots leaves and stems as replacement for alfafa hay, T50CT: treatment with 50% carrots leaves and stems as replacement for alfafa hay. Levels calculated according to INRA (2004). Composition of carrot and leaves and stems: Crude Protein = 15.12%, Crude Fiber=12%, Ether Extract=2.5%, Nitrogen free extract=52.65, and Ash = 10.5 (Pereira et al., 2003)

Table 2 – Effect of the substitution of alfafa hay by carrots tops on live weight gain (LWG), feed intake (FI), feed conversion (FC) of growing rabbit.

	Experimental diets		
	T0CT	T25CT	T50CT
Number of rabbits	10	10	10
Post-weaning period (35-49 d):			
Body weight at 28 d (g)	789.00	787.00	787.00
Body weight at 49 d (g)	1133.89 ^{a}	1138.33 ^{a}	1066.11^{b}
Daily weight gain (g/d)	24.57^{a}	25.09^{a}	19.94^{b}
Daily feed intake (g/d)	70.24	70.75	65.87
Feed conversion rate (g/g)	2.85^{a}	2.82^{a}	3.30^{b}
Intermediate period (49-70 d):			
Body weight at 49 d (g)	1133.89	1138.33	1066.11
Body weight at 70 d (g)	1690.00	1658.33	1607.22
Daily weight gain (g/d)	26.48	24.76	25.76
Daily feed intake (g/d)	89.76	92.38	91.00
Feed conversion rate (g/g)	3.40 ^{a}	3.73 ^{a}	3.54 ^{a}
Finishing period (70-84 d):			
Body weight at 70 d (g)	1690.00	1658.33	1607.22
Body weight at 84 d (g)	1961.67	1897.22	1872.77
Daily weight gain (g/d)	19.40	17.06	18.96
Daily feed intake (g/d)	98.61	106.94	104.02
Feed conversion rate (g/g)	5.10 ^{a}	6.26 ^{a}	5.50^{a}
Whole fattening period (35-84 d):			
Daily weight gain (g/d)	23.93	22.65	22.16
Daily feed intake (g/d)	86.71	88.43	89.57
Feed conversion rate (g/g)	3.62^{a}	3.90 ^{a}	4.04 ^{a}

T0CT: Treatment without carrot leaves and stems, T25CT: Treatment with 25% of carrots leaves and stems as replacement for alfafa hay, T50CT: Treatment with 50% carrot leaves and stems as replacement for alfafa hay. ^{a,b} Mean values in the same row with a different superscript differ at $P<0.05$.

Table 3 – Cost and economic viability of the experimental diets

	Experimental diets		
	T0CT	T25CT	T50CT
Cost per Kg of diet (R$)	0.74	0.66	0.60
Cost per Kg of carcass (R$)	2.68	2.60	2.40
Cost per ingredient needed to produce one Kg of feed			
Corn (R$/Kg)	0.1725	0.1725	0.1725
Wheat meal (R$/Kg)	0.1155	0.1155	0.1155
Soy-bean meal (R$/Kg)	0.1837	0.1837	0.1890
Soy-bean oil (R$/Kg)	0.0550	0.0550	0.053
Rice hulls (R$/Kg)	-	-	-
Alfafa hay (R$/Kg)	0.3000	0.2250	0.1500
Carrot tops (R$/Kg)	-	-	-
Dicalcium phosphate	0.0104	0.0104	0.0104
Calcitic Limestone (R$/Kg)	0.0003	0.0003	0.0003
Salt (R$/Kg)	0.005	0.005	0.005
Vitamin/mineral premix (R$/Kg)	0.009	0.009	0.009

T0CT: Treatment without carrot leaves and stems, T25CT: Treatment with 25% of carrots leaves and stems as replacement for alfafa hay, T50CT: Treatment with 50% carrot tops as replacement for alfafa hay. Amounts calculated based on price of 2014 crop in Brazil.

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Body weight at 70 d (g)	1690.00	1658.33	1607.22
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Wheat meal (R$/Kg)	0.1155	0.1155	0.1155
Soy-bean meal (R$/Kg)	0.1837	0.1837	0.1890
Soy-bean oil (R$/Kg)	0.0550	0.0550	0.053
Rice hulls (R$/Kg)	-	-	-
Alfafa hay (R$/Kg)	0.3000	0.2250	0.1500
Carrot tops (R$/Kg)	-	-	-
Dicalcium phosphate	0.0104	0.0104	0.0104
Calcitic Limestone (R$/Kg)	0.0003	0.0003	0.0003
Salt (R$/Kg)	0.005	0.005	0.005
Vitamin/mineral premix	0.009	0.009	0.009

T0CT: Treatment without carrot leaves and stems, T25CT: Treatment with 25% of carrots leaves and stems as replacement for alfafa hay, T50CT: Treatment with 50% carrot tops as replacement for alfafa hay. Amounts calculated based on price of 2014 crop in Brazil.

4 ARTIGO 2 – BARAÇO DE BATATA-DOCE E SEU EFEITO SOBRE PARÂMETROS DE DESEMPENHO DE COELHOS

Este capítulo é apresentado de acordo com as normas para publicação na Revista **Journal of the Science of Food and Agriculture.**

Effect of sweet potato vines on performance parameters of rabbits

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BACKGROUND: Conventional feedstuffs different levels of SPV.

RESULTS: Alfalfa hay was replaced with three different levels of SPV (0%, 10% and 15%) in diets fed to growing rabbits. None of the evaluated performance parameters as well as carcass weight and heart weight were significantly affected by any of the tested dietary treatments. However, the liver weight was statistically lower in animals fed the diets containing 10% of SPV, mainly due to lower glucose content. Glycogen within the tissue, did not differ not significantly among treatments.

CONCLUSION: It can therefore be concluded that up to 15% of sweet-potato vines can successfully be included in the diet of rabbits as a cheaper replacement for alfalfa hay without adversely affecting performance.

Key-words: animal nutrition, by-products, cuniculture, unconventional feedstuff

Introduction

The use of alternative ingredients for animal nutrition has been of great interest to many researchers over several decades particularly, in developing countries, where conventional sources are usually more expensive[1]. In Brazilian cuniculture most of the ingredients used as part of the diets are grown solely for this purpose, occupying farm areas that could be otherwise be used for growing grains for intended for human consumption and hence increasing the overall cost of the final product[2].

Alfalfa hay is the most commonly used fiber source in diets for rabbits in Brazil even though it is considered expensive and the crop management requires specifics such as increased soil fertility and drainage, pH close to neutral and deep soils[3]. This justifies the search for alternatives to alfalfa, which may comprise up to 40% of the total cost of feed for rabbits.

Sweet potato *(Ipomoea batatas)* vines (SPV) are common in Brazil. The tuberous root is popularly used in cooking, and has recently started being used as raw material in fuel production[4]. In 2012 alone, Brazil produced over 479,000 tons of sweet potatoes in an area totaling approximately 46,000 hectares[5]. The sweet potato plant also has a highly branched root system with high capacity of land use, which makes it efficient in absorbing nutrients, which requires less fertilizer to be used[6].

Recent research has highlighted the importance of the use of agro-industrial residues, which are abundant in Brazil due to the country's intensive agricultural production[7,8,9]. Researchers from different countries have studied the effect of sweet potato vines in animal nutrition as a means of not only reducing the environmental impact of the production chain, but also lowering the final cost of the product[10,11,12,13].

Data concerning the inclusion of sweet potato vines in rabbit diets are scarce and insufficient in the literature. In this context, the objective of this study was to evaluate the weight gain, feed intake, feed conversion, carcass characteristics and metabolic parameters of the liver of rabbits fed diets containing different levels of sweet potato vines as a partial hay alfalfa substitute.

Experimental

Animals and location of the study

A total of 27 mixed-sex White New Zealand rabbits (14 male and 13 female), weaned at 35 d of age and weighing on average 755.0g, were randomly assigned, according to weaning weight to one of the 3 experimental groups (9 rabbits/diet). The individual cages measuring 50x50x50cm. Rabbits were offered *ad libitum* one of the 3 experimental diets, without a transition period from the maternal diet, until the end of the experiment at 81 d of age. Fresh water was always available. During the experiment, body weight and feed consumption were registered weekly, and mortality was checked daily in accordance with the guidelines for applied nutrition experiments in rabbits [14,15].

The experiment was carried out during the months of May and June of 2016, in a rabbit breeding unit located at the main *campus* of the Federal University of Santa Maria (Brazil), located at 29º68' S latitude, 53 º 80' W longitude. Animals were kept in a closed room without temperature control and hygrometry. The temperature and averages ranged from 16 to 25ºC. No artificial light schedule was applied.

Diets and feeding management

Three mash diets were formulated. The control diet (0SPV) diet without dry SPV; 10SPV, experimental diet with 10% sweet-potato leaves as alfalfa hay substitute; and 15SPV, experimental diet with 15% potato leaves as alfalfa hay substitute. The SPV used in both the 10SPV e 15SPV diets were previously dried in a forced air circulation oven at 52ºC for 36 hours. No synthetic amino acids were present in any of the tested diet formulations. Diets were formulated to contain a similar crude protein and fiber content (Table 1) and to comprise with growth requirements[14],[15].

Slaughter and organ collection

Upon completion of the bioassay animals were stunned and slaughtered by jugular bleeding. The carcass weight was obtained after the removal of the skin, viscera (except liver and kidney) heads and feet. Viscera used for analysis were weighed while hot and immediately stored in containers with ice for sequential analysis. The carcasses were also submitted to bio-impedance analysis using a bio-impedance device.

Metabolic Analysis

In the liver, the glucose concentration was determined by the Park and Johnson method[16]. This method consists in incubating a sample aliquot in a medium containing potassium ferricyanide and sodium carbonate, for 15 minutes in a boiling water bath. Soon after, ferric ammonium sulphate and acid solution with sodium lauryl sulfated are added to the solution. The reading was performed in a spectrophotometer at absorbance of 660 nm. Liver glycogen was extracted hot and determined according to the methodology described by Bidinotto[17].

Statistical analyses

Data were analyzed in a completely randomized design with the Statistical Analysis System[18] using the general linear model (GLM procedure). The variance analysis was performed with the diet as the sole source of variation. Each animal was considered an experimental unit. The means were compared by variance analysis followed by Tukey test ($p < 0.05$).

RESULTS AND DISCUSSION

Weight gain, feed conversion and daily feed intake were similar in the three treatments (Table 2). Researchers[19] studied the effects of feed intake, average daily gain and feed conversion on white New Zealand rabbits in two dietary systems: sweet potato leaves with rice husk supplementation, and Guinea grass with commercial concentrate at different levels. It was thus concluded that with treatments containing sweet potato leaves and rice husk, the animals were able to achieve higher growth rates and feed conversion than with treatments containing Guinea grass and concentrate. In contrast in the sweet potato treatment, feed conversion was the same regardless of supplementation the level.

Still, several authors[20] followed the development and growth performance of forty-five weaned rabbits distributed within diet five treatments containing different levels of sweet potato leaves (SPL) and concentrated pelleted (PCF): T1 (0% SPL and 100% PCF); T2 (25% SPL, 75% PCF); T3 (SPL 50%, 50% PCF); T4 (SPL 75%, 25% PCF) and T5 (SPL 100%; 0% PCF), respectively. It was reported that there were significant differences ($P <0.05$) in final weight, total weight gain, daily weight gain, daily feed intake and feed conversion. In this sense the rabbits from T1 and T3 groups had higher body final weight and weight gain.

In a bioassay with pigs[21] which studied the effect of diets with different types of bulky ingredients, including the sweet potato leaves. They were able to conclude that pigs fed sweet potato leaves, had weight gain and performance parameters similar to those fed other ingredients (such as grape and mulberry vines). Thus, the benefits of including sweet potato dry vines in animal feed has been widely documented in numerous studies in the past five years suggest that it is possible to replace part of the conventional protein sources, such as soy flour by tropical foliage in diets for growing pigs[22].

Also broilers supplemented with different levels of dried SPL, concluded that its inclusion in levels of up to 1% in the dry matter can be considered the optimal level of supplementation when birds are sold on the basis of live weight[10]. These authors also mention that if the birds are to be sold gutted, the inclusion of up to 1.5% of dry matter can be economically viable since it enabled higher carcass yield components.

Regarding the data after slaughter (Table 3), it was observed that the treatments did not differ in carcass and heart weight. However, the liver weight was statistically lower in animals from treatment 10SPV. The bio-impedance analysis of carcass, indicated no difference in the percentages of fat and protein in meat. This can be explained by the concentration of glucose present in the liver, ranging from 1.62mg g^{-1} in the 10SPV treatment to 5.02mg g^{-1} in the 15SPV treatment and 5.6 mg g^{-1} in the control group (0SPV). This difference seems to be related to the lower energy intake from the treatment [24]. As for glycogen in the tissue, treatments concentrations of 2,35μmol, 2,13μmol and 2,59μmol glycogen release/g tissue were found for treatments 0SPV, 10SPV and 15SPV, respectively.

Conclusion

It was therefore concluded that up to 15% of sweet-potato vines can successfully be included in the diet of rabbits as a more affordable replacement for alfalfa hay without adversely affecting performance.

References

1. Akande K, Dietary Effects of Increasing Levels of Pigeon Pea Meal on Rabbit Performance. ***J Agri Sci*** DOI: 10.5539/jas.v7n7p156 (2015)
2. Klinger ACK, Toledo GSP, Eggers DP, Pretto A, Chimainski M and Silva LP, Soybean hulls on diets for growing rabbits. *Cienc Rural* DOI: 10.1590/0103-8478cr20130514. (2015)
3. Scapinello C, Antunes EB, Furlan AC, Jobim CC and Faria HG, Leucaena hays (Leucaena leucocephala and Leucaena leucocephala cv. Cunningham) for growing rabbits: digestibility and performance. *Acta Scientiarum Anim Sci*. DOI: 10.4025/actascianimsci.v25i2.2006. (2003)
4. Gonçalves Neto AC, Maluf WR, gomes LAA, Gonçalves RJS, Silva VF and Lasmar, Aptitudes of sweet potato genotypes for fresh consumption, ethanol production and animal feed. *Pesq agropec Brasil*. DOI: 10.1590/S0100-204X2011001100013 (2011)
5. IBGE Instituto Brasileiro de Geografia e Estatística. 2012. Avaiable in: <ftp://ftp.ibge.gov.br/Producao_Agricola/Producao_Agricola_Municipal_[anual]/2012/pam2012.pdf.>

6. Oliveira AP, Santos JF, Cavalcante LS, Pereira WE, Santos MCCA, Oliveira ANP and Silva NV, Yield of sweet potato fertilized with cattle manure and biofertilizer. *Hort Bras* DOI:10.1590/S0102-05362010000300006
7. LEBAS, F. Reflections on rabbit nutrition with a special emphasis on feed ingredients utilization. *Proc.: 8th World Rabbit Congress, 7-10 September, 2004. Puebla, Mexico. 686*. Vol. 736. 2004.
8. Giordani Junior R, Cavali J, Porto MO, Ferreira E and Stachiw R, Agroindustrial waste and ruminantes supplementary. *Rev Brasi de Cien Amaz*, **3**: 93-104 (2014).
9. Volpato RM, Oliveira VD, Gewehr CE, Perez Neto D. Agro-industrial co-products in feed for piglets. *Cinc Rural*. DOI: 10.1590/0103-8478cr20130391 (2015)
10. Tamir, Berhan, and Wude Tsega. Effects of different levels of dried sweet potato (Ipomoea batatas) leaves inclusion in finisher ration on feed intake, growth, and carcass yield performance of Ross broiler chicks. *Trop Anim Health Prod* DOI: 10.1007/s11250-009-9476-7 (2010)
11. Nguyen TH, Ngoan LD, Bosch G, Verstegen MW, Hendriks WH. Ileal and total tract apparent crude protein and amino acid digestibility of ensiled and dried cassava leaves and sweet potato vines in growing pigs. *Anim feed sci and technol*. DOI:10.1016/j.anifeedsci.2011.11.009 (2012).
12. Lochmann, RT, Islam S, Phillips H, Adam Z and Everette, J, Effects of dietary sweet potato leaf meal on the growth, non-specific immune responses, total phenols and antioxidant capacity in channel catfish (*Ictalurus punctatus*). *J. Sci. Food Agric*. DOI: 10.1002/jsfa.5898 (2012)
13. Fernández-Carmona J, Blas E, Pascual JJ, Maertens L, Gidenne T, Xiccato G and García J. Recommendations and guidelines for applied nutrition experiments in rabbits. *World Rabbit Sci*. DOI: 10.4995/wrs.2005 (2005)

14. Lounaouci-Ouyed G, Berchiche M and Gidenne T, Effects of substitution of soybean meal-alfalfa-maize by a combination of field bean or pea with hard wheat bran on digestion and growth performance in rabbits in Algeria. *World Rabbit Sci* DOI: 10.4995/wrs.2014.1487 (2014)
15. Gidenne**,** T., et al. 2010. Nutrition of the rabbit – 2 ed. CAB international, UK. 2010.
16. Park JT and Johnson MJ, A submicro determination of glucose. J Biol Chem 181:149-151 (1949).
17. Bidinotto, PM, Moraes G and Souza, RDS, Hepatic glycogen and glucose in eight tropical freshwater teleost fish: a procedure for field determinations of micro samples. *Boletim Técnico do Cepta*, **10**: 53-60. (1998)
18. SAS. 1988. SAS/STAT User's Guide (Release 6.03). SAS Inst. Inc., Cary NC, USA.
19. Luyen LT and Preston TR, Growth performance of New Zealand White rabbits fed sweet potato (Ipomoea batatas) vines supplemented with paddy rice or Guinea grass supplemented with commercial concentrate. *Livestock R. for Rural Devel*, **24**: ?-? (2012).
20. Aboyi FO, Iyi EO and Machebe NS, Effects of feeding sweet potato (Ipomoea batatas) leaves on growth performance and nutrient digestibility of rabbits. *Afri J Biotec*. DOI: 10.5897/AJB11.3103 (2012)
21. Ty C, Borin, K and Phiny C, A note on the effect of fresh mulberry leaves, fresh sweet potato vine or a mixture of both foliages on intake, digestibility and N retention of growing pigs given a basal diet of broken rice.Livestock *R for Rural Development*, **19**: ?-?. (2007)
22. Régnier C, Jaguelin Y, Noblet J and Rnaudeau D, Ileal digestibility of amino acids of cassava, sweet potato, cocoyam and erythrina foliages fed to growing pigs. *Animal* DOI: 10.1017/S1751731111001959 (2012)

23. Tsega W and Tamir B (2009). The effect of increasing levels of dried leaves of sweet potato (Ipomoea batatas) on dry matter intake and body weight gain performance of broiler finisher chickens. *Livestock Research for Rural Development*, *21*(12).

24. Pretto A, Silva LP, Neto JR, Nunes LM, Freitas IL, Loureiro SA. In natura or reduced antinutrients forms of crambe meal in the silver catfi sh diet. *Ciênc. Rural*. DOI: 10.1590/S0103-84782014000400020 (2014)

Table 1. Ingredients and chemical composition (%) of sweet-potato vines as a partial substitute for alfalfa hay in rabbit diets.

Ingredients	Experimental diets		
	0SPV	10SPV	15SPV
Corn	17.25	17.25	17.25
Wheat meal	25.00	25.00	25.00
Soy-bean meal	17.50	17.50	18.00
Soy-bean oil	2.50	2.50	2.40
Rice hulls	6.00	6.00	5.45
Alfalfa hay	30.00	22.50	15.00
Sweet potato vines	-	7.50	15.00
Dicalcium phosphate	0.80	0.80	0.80
Calcitic Limestone	0.25	0.25	0.40
Salt	0.50	0.50	0.50
Vitamin/mineral premix*	0.20	0.20	0.20
Nutritional Levels in Dry Matter			
Crude protein (%)	17,25	16,81	16,60
Ether Extract (%)	4.39	4.58	4.67
ADF (%)	20.78	19.84	18.05
NDF (%)	35.30	33.37	31.10
Calcium (%)	1.15	1.00	1.00
Phosphorus (%)	0.60	0.54	0.52

Note. 0SPV: Treatment without sweet-potato vines, 10SPV: Treatment with sweet potato vines replacing 10% of alfalfa hay, 15SPV: treatment with 15% sweet potato vines replacing alfalfa hay. *Premix supplied per kg of diet; Vitamin A 600,000 IU; Vitamin D 100,000 IU; Vitamin E 8,000; Vitamin K3 200 mg; Vitamin B1 400 mg; Vitamin B2 600 mg; Vitamin B6 200,00 mg; Vitamin B12 2,000 mg; Pantothenic acid 2,000 mg; Choline 70,000 mg; Fe 8,000 mg; Cu 1,200 mg; Co 200 mg; Mn 8,600 mg; Zn 12,000 mg; I 65 mg; Se 16 mg.

Table 2. Effect of partially replacing alfalfa hay with sweet-potato vines on the performance of growing rabbit.

Parameters	Experimental dietary treatments			
	0SPV	10SPV	15SPV	P value
Post-weaning period (35-49 d):				
Live weight at 35 days (g)	755.00	755.00	755.00	0.99
Live weight at 49 days (g)	1055.55	1047.22	1020.5	0.78
daily weight gain (g / d)	21.46	20.87	18.96	0.37
daily feed intake (g / d)	57.53	59.48	61.06	0.58
Feed conversion (g / g)	2.68	2.85	3.22	0.13
Intermediate Period (49-63 d):				
Live weight at 49 days (g)	1055.55	1047.22	1020.5	0.78
Live weight at 63 days (g)	1413.33	1433.88	1401.6	0.85
daily weight gain (g / d)	25.55	27.61	27.22	0.51
daily feed intake (g / d)	81.77	86.16	87.38	0.77
Food conversion (g / g)	3.20	3.12	3.21	0.90
Final period (63-81 d):				
Live weight at 63 days (g)	1413.33	1433.88	1401.6	0.85
Live weight at 81 days (g)	1880.55	1854.44	1839.4	0.85
daily weight gain (g / d)	25.95	23.36	24.32	0.55
daily feed intake (g / d)	90.97	92.91	98.92	0.22
Food conversion (g / g)	3.50	3.97	4.06	0.23
Trial period (35 to 81d)				
final body weight (g)	1880.55	1854.44	1839.4	0.85
daily feed intake (g)	77.99	80.68	83.88	0.28
daily fear gain (g)	24.46	23.90	23.57	0.83
feed Conversion (g)	3.18	3.37	3.55	0.23

0SPV: Treatment without sweet potato vines, 10SPV: Treatment with 10% of sweet potato vines as replacement for alfalfa hay, 15SPV: Treatment with 15% sweet potato vines as replacement for alfalfa hay. [a,b] Mean values in the same row with a different superscript differ at P<0.05.

Table 3.Post slaughter data of rabbits fed diets containing different levels of sweet potato vines as a partial replacement of alfalfa hay

	Experimental diets			
	0SPV	10SPV	15SPV	P value
Number of rabbits	4	4	4	
Body weight at 84d (g)	2013.75	1932.50	1941.25	0.49
Hot carcass (g)	1049.10	974.85	982.67	0.39
Heart (g)	6.25	5.85	6.15	0.66
Liver (g)	55.8^{a}	44.17^{b}	47.65^{ab}	0.02

0SPV: Treatment without sweet potato leaves,10SPV: Treatment with10% of sweet potato leaves as replacement foralfalfahay,15SPV: Treatment with15% sweet potato leaves as replacement foralfalfahay.^{a,b}Mean values in the same row with a different superscript differ at $P<0.05$.

5 DISCUSSÃO

No Brasil, embora sejam poucos os resíduos em dietas para coelhos estudados, quando comparados com outras espécies (como suínos e aves), novos ingredientes vêm ganhando cada vez mais espaço. Isso se deve ao fato de que a introdução de alimentos não convencionais pode auxiliar na redução dos passivos ambientais e na melhora da lucratividade do produtor.

Em virtude de a produção cunícola ser majoritária em criações familiares, tanto no Brasil como em outros países em desenvolvimento, é indispensável a gestão consciente dos recursos, visando, desta forma, à conservação do ambiente produtivo. Nesse sentido, o consórcio de culturas, como olericultura/cunicultura, auxilia na minimização de perdas, não só das olerícolas (partes foliares), mas também dos coelhos (esterco).

Os coelhos exigem pequenos espaços criatórios. Podem ser alojados em praticamente qualquer área da propriedade e se adaptam bem a diferentes condições. Se criados em gaiolas com boas condições de higiene, dificilmente adoecem. Além disso, são calmos, dóceis e silenciosos, o que torna possível o manejo por qualquer pessoa da propriedade com o mínimo treinamento.

No contexto de criações sustentáveis, os coelhos figuram como modelo entre os animais zootecnicamente exploráveis, porque apresentam uma gama muito grande de produtos. A carne, de excelente qualidade nutricional, serve para consumo na propriedade (caso o abate não seja efetuado em frigorífico); a pele (couro) pode ser curtida e comercializada; as patas e as orelhas podem ser vendidas como amuletos de sorte; a cauda também pode ser comercializada, para ser utilizada como adorno. Ainda a urina (rica em cálcio) e as fezes (ricas em NPK) constituem excelente adubo orgânico. Até mesmo o sangue pode ser utilizado para fins condimentares.

Por serem consumidores primários, adaptam-se bem a praticamente qualquer resíduo de culturas temporárias, sobretudo aqueles de olericultura/floricultura, que são pouco lignificados e possuem níveis satisfatórios de proteína bruta (10,5 – 18%). Ainda convertem bem componentes vegetais em carne e conseguem, com rações fareladas (que têm baixo custo de produção), apresentar conversão alimentar de 2,8:1.

Todavia, devem ser observados possíveis efeitos negativos nos “novos ingredientes”, como a presença de fatores antinutricionais, que comprometem o desempenho dos animais, bem como a palatabilidade da dieta. Recomenda-se, portanto, estudo criterioso para a introdução segura desses resíduos na dieta cunícola.

6 CONCLUSÃO

Constatou-se que os resíduos da olericultura, como o baraço de batata-doce e a parte aérea da cenoura, podem ser incluídos em dietas para coelhos de corte, substituindo o feno de alfafa em até 15 e 50%, respectivamente, sem afetar negativamente o desempenho dos animais. Dessa forma há viabilidade no uso dos referidos resíduos, nos níveis citados, para coelhos de corte na fase de crescimento.

REFERÊNCIAS

BOLETIM INFORMATIVO [do] Setor de Alimentação Animal. São Paulo: SINDIRAÇÕES. 2012. Maio.

CARABAÑO, R.; PÍQUER, J. The digestive system of the rabbit. In: **The nutrition of the rabbit**. Cambridge: CABI Publishing, 1998. p. 1-16.

CHEEKE, Peter. **Rabbit Feeding and Nutrition**. Corvallis: Academic Press, 1987.

ESPÍNDOLA, G. B. et al. Parâmetros reprodutivos e desenvolvimento ponderal dos láparos das raças Nova Zelândia e Califórnia no Brasil. **Caatinga**, Mossoró, v. 20, n. 1, p. 01- 04, 2007.

FERNÁNDEZ-CARMONA , J. et al. Recommendations and guidelines for applied nutrition experiments in rabbits. **World Rabbit Sci**, Valência, v. 13, p. 209-228, 2005. Disponível em: <http://wrs.webs.upv.es/files/guides/egranguides.pdf>. Acesso em: 20 abr. 2016.

FERREIRA, W. M. et al. Digestibilidade aparente dos nutrientes de dietas simplificadas baseadas em forrageiras para coelhos em crescimento. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, Belo Horizonte, v. 59, n. 2, p. 451-458, 2007.

FERREIRA, F. N. A. et al. Avaliação nutricional do bagaço de cana-de-açúcar enriquecido com vinhaça em dietas para coelhos em crescimento. **Caatinga**, Mossoró, v. 28, n. 4, p. 217-226, 2015.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. Exports: Commodities by country. Disponível em: <http://faostat.fao.org/desktopdefault.aspx?pageid=342&lang=en&country=21>. Acesso em: 20 abr. 2016.

GALARRETA, B. et al. Folhas de batata-doce em dietas para coelhos de corte. In: JORNADA ACADÊMICA INTEGRADA, 30., 2015, Santa Maria. **Anais**... Santa Maria: UFSM, 2015. p. 1

GIDENNE, T, 1997. Caeco-colic digestion in the growing rabbit: impact of nutritional factors and related disturbances. **Livestock Production Science.** v. 51, n. 1, p. 73-88, 1997.

GOBBI, K. F. et al. Desempenho e características de carcaça de tourinhos alimentados com dietas contendo silagem de bagaço de laranja substituindo a silagem de sorgo. **Revista Brasileira de Saúde e Produção Animal**, Salvador, v. 15, n. 4, p. 917-927, 2014. Disponível em: <http://dx.doi.org/10.1590/S1519-99402014000400019>. Acesso em: 20 maio 2016.

GOES, R. H. T. B.; SILVA, L. H. X.; SOUZA, K. A. **Alimentos e Alimentação Animal**. Dourados: Ed. da UFGD, 2013.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Censo Agropecuário 2006** – Brasil, Grandes Regiões e Unidades da Federação: segunda apuração. Rio de Janeiro, 2012. Disponível em:

<ftp://ftp.ibge.gov.br/Censos/Censo_Agropecuario_2006/Segunda_Apuracao/censoagro2006_2aapuracao.pdf>. Acesso em: 28 abr. 2015.

KLINGER, A. C. K. et al. Bagaço de uva como ingrediente alternativo no arraçoamento de coelhos em crescimento. **Ciência Rural**, Santa Maria, vol. 43, n. 9, p. 1654-1659, 2013. Disponível em: <http://dx.doi.org/10.1590/S0103-84782013000900019>. Acesso em: 06 jun. 2016.

LOCHMANN, R. T. et al. Effects of dietary sweet potato leaf meal on the growth, non-specific immune responses, total phenols and antioxidant capacity in channel catfish (*Ictalurus punctatus*). **Journal of the Science of Food and Agriculture**, [S.l.], v. 93, n. 6, p. 1365-1369, 2013. Disponível em: <http://onlinelibrary.wiley.com/doi/10.1002/jsfa.5898/full>. Acesso em: 20 maio 2016.

LOPES, W. A. R. et al. Produtividade de cultivares de cenoura sob diferentes densidades de plantio. **Revista Ceres,** Viçosa, v. 55, n. 5, p. 482-487, 2008. Disponível em: <http://www.ceres.ufv.br/ojs/index.php/ceres/article/view/3358/1250>. Acesso em: 10 maio 2016.

LOUSADA JUNIOR, J. E. et al. Caracterização físico-química de subprodutos obtidos do processamento de frutas tropicais visando seu aproveitamento na alimentação animal. **Revista Ciência Agronômica**, Fortaleza, v. 37, n. 1, p. 70-76, 2006. Disponível em: <http://www.ccarevista.ufc.br/seer/index.php/ccarevista/article/view/225/220>. Acesso em: 28 abr. 2015.

MAERTENS, L. et al. Nutritive value of raw materials for rabbits: EGRAN Tables 2002. **World Rabbit Science**, [S.l], v. 10, n, 4, p. 157-166, 2003. Disponível em: <http://www.wrs.upv.es/files/journals/vol10_4_maertens.pdf >. Acesso em: 28 abr. 2015.

MARIA, B. G. et al. Digestibilidade da polpa cítrica desidratada e efeito de sua inclusão na dieta sobre o desempenho de coelhos em crescimento. **Acta Scientiarum. Animal Sciences**, Maringá, v. 35, n. 1, p. 85-92, 2013.

MATEOS, G. G.; VIDAL, J. P. Diseño de programas alimenticios para conejos: aspectos teóricos y formulación prática. **Cuniculture**, Barcelona, v. 21, n. 119, p. 27-42, 1996. Disponível em : <http://ddd.uab.cat/pub/cunicultura/cunicultura_a1996m2v21n119/cunicultura_a1996m2v21n119p27.pdf>. Acesso em: 16 maio 2016.

MICHELAN, A. C. et al. Utilização da casca de mandioca desidratada na alimentação de coelhos. **Acta Scientiarum. Animal Sciences**, Maringá, v. 28, n. 1, p. 31-37, 2008.

MOLINA, E. et al. Effects of diets with Amaranthus dubius Mart. ex Thell. on performance and digestibility of growing rabbits. **Word Rabbit Science**, Valencia, v. 23, n. 1, p. 9-18, 2015. Disponível em: <http://dx.doi.org/10.4995/wrs.2015.2071>. Acesso em: 12 maio 2016.

NATIONAL RESEARCH COUNCIL. **Nutrient requirements of dairy cattle**. 7. ed. Washington, D.C.: NAS., 2001.

NGUYEN, T. H. L. et al. Ileal and total tract apparent crude protein and amino acid digestibility of ensiled and dried cassava leaves and sweet potato vines in growing pigs. **Animal feed science and technology**, Philadelphia, v. 172, n. 3, p. 171-179, 2012.

NICODEMUS, N. et al. Effect of substitution of soybean hull and grape seed meal mixture for traditional fiber sources on digestion and performance of growing rabbits and lacting does. **Journal of Animal Science**, Champaign, v. 85, p. 181-187, 2007.

NUNES, R.V. et al. Composição Bromatológica, Energia Metabolizável e Equações de Predição da Energia do Grão e de Subprodutos do Trigo para Pintos de Corte. **Revista Brasileira de Zootecnia**, Viçosa, v. 30, n. 3, p. 785-793, 2001. Disponível em: <http://dx.doi.org/10.1590/S1516-35982001000300025>. Acesso em: 16 maio 2016.

OLIVEIRA, A. F. G. et al. Avaliação de dieta formulada com subprodutos de mandioca na produção de sêmen de coelhos. **Arquivo Brasileiro de Medicina Veterinária e** Zootecnia, Belo Horizonte, v. 67, n. 1, p. 109-118, 2015. Disponível em: <http://dx.doi.org/10.1590/1678-7252>. Acesso em: 16 maio 2016.

OLIVEIRA, E. R. A. **Subprodutos agroindustriais na dieta de coelhos em crescimento**. 2013. 108 p. Tese (Doutorado em Zootecnia)–Universidade Federal da Paraíba, Areia, PB, 2013. Disponível em: <http://ww2.pdiz.ufrpe.br/sites/ww2.prppg.ufrpe.br/files/elton_roger_alves_de_oliveira.pdf>. Acesso em: 20 maio 2016.

PERESIN, D. et al. Estimativa do potencial de geração de biomassa, metano e energia pelas principais criações pecuárias do Brasil. **Revista AIDIS**, [S.l.], v. 8, n. 1, p. 102-113, 2015. Disponível em: <http://revistas.unam.mx/index.php/aidis/article/view/48449>. Acesso em: 27 abr. 2015.

REMPEL, C. et al. Urbanidade, produção agrícola e conservação ambiental – estudo de caso na região do Vale do Taquari/RS/Brasil. **HOLOS**, Natal, v. 1, p. 87-98, 2015. Disponível em: <http://dx.doi.org/10.15628/holos.2015.2365>. Acesso em: 14 mai. 2016.

RIBEIRO, B. P. V. B. et al. Avaliação nutricional da casquinha de milho em dietas para coelhos em crescimento. **Archives of Veterinary Science**, Curitiba, v. 18, n. 4, p. 20-24, 2013.

RODRIGUES, M. O. et al. Folhas e caules de cenoura em substituição ao feno de alfafa em dietas para coelhos em crescimento. In: JORNADA ACADÊMICA INTEGRADA, 29., 2014, Santa Maria. **Anais**... Santa Maria: UFSM, 2014. Disponível em: <http://portal.ufsm.br/jai/trabalho/arquivo.html?arquivo=14759>. Acesso em: 28 abr. 2015.

SANTOS, E. A. et al. Efeito dos níveis de fibra em detergente ácido sobre os coeficientes de digestibilidade das dietas e desempenho de coelhos em crescimento. **Acta Scientiarum. Animal Sciences**, Maringá, v. 26, n. 1, p. 79-86, 2004. Disponível em: <10.4025/actascianimsci.v26i1.1932>. Acesso em: 20 mai. 2016.

SCAPINELLO, C. et al. Fenos de leucena *(Leucaena leucocephala e Leucaena leucocephala* cv. Cunningham) para coelhos em crescimento: digestibilidade e desempenho. **Acta Scientiarum. Animal Sciences**, Maringá, v. 25, n. 2, p. 301-306, jul./dez. 2003.

SCAPINELLO, C.; MICHELAN, A. C.; FURLAN, A. C. Valor nutritivo e utilização de feno do terço superior da rama de mandioca para coelhos em crescimento. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA. 2002. **Anais**... Recife: Sociedade Brasileira de Zootecnia, [2002]. 1 CD-ROM.

SCHNEIDER, V. E. et al. **Resíduos agrossilvipastoris I** - Resíduos orgânicos. Brasília: Ministério do Meio ambiente, 2011. Disponível em: <http://www.cnrh.gov.br/projetos/pnrs/documentos/cadernos/08_CADDIAG_Res_Agrosilvopastoril_Org.pdf>. Acesso em: 8 Mai.2016

SILVA, H. O.; FONSECA, R. A.; FILHO, R. S. G. Características produtivas e digestibilidade da farinha de folhas de mandioca em dietas de frangos de corte com e sem adição de enzimas. **Revista da Sociedade Brasileira de Zootecnia**, Viçosa, v. 29, n. 3, p. 823-829, 2000.

SILVA, R. M. et al. Produção e qualidade da matéria seca de sete leguminosas estivais em Eldorado do Sul, RS. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 32., 1995, Brasília. **Anais**... Brasília: SBZ, 1995. p. 113-115.

TAMIR, B.; TSEGA, W. Effects of different levels of dried sweet potato (Ipomoea batatas) leaves inclusion in finisher ration on feed intake, growth, and carcass yield performance of Ross broiler chicks. **Tropical animal health and production**, Edinburgh, v. 42, n. 4, p. 687-695, 2010.

TOLEDO, G. S. P. et al. Casca de soja em substituição ao feno de alfafa em dietas fareladas para coelhos em crescimento. **Ciência Rural**, Santa Maria, v. 42, n. 10, p. 1896-1900, 2012.

VOLPATO, R. M. et al. Coprodutos da agroindústria na alimentação de leitões. **Ciência Rural**, Santa Maria, v. 45, n. 1, p. 86-91, 2015.

Instructions to Authors

> For Authors and Reviewers > Instructions to Authors

SUBMISSION OF A MANUSCRIPT

1. Manuscripts must be prepared in double space with Times New Roman font (size 10) and submitted via on-line system (www.ajas.info). All pages should be numbered consecutively in the top right hand corner, beginning with the title page.
2. The lines on all pages, including those pages for REFERENCES and figure-legends, must be numbered consecutively in the left margin, beginning with number one at the top of the title page. A 2.5 cm margin on both sides of the page is desirable. The type should be large enough to be easily read (i.e. a font size of at least 10 points).
3. Tables, typed double-spaced, should be as few and as simple as is feasible. Each table should be on a separate sheet. Weights and measures must be expressed in the metric system and temperatures in the celsius (centigrade) scale.
4. The legends for figures should be typed on a separate sheet. Photographs should be carefully prepared so that clear image can be printed. Use large letters and numbers, especially for figures that are to be published in one columnin the journal.
5. Manuscripts will be edited in the order received and accepted papers will be published in the order submitted if at all possible.
6. Authors whose native language is not English are strongly encouraged to have their papers proof read, prior to submission, to improve the English content of their paper.
7. It is important to indicate in the text that the protocol for the animal research has been approved by a suitably constituted ethics committee of the institute. Refer to the provisions of the Declaration of Helsinki (as revised in Seoul, 2008), available at WMA Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects. AJAS retains the right to reject any manuscript on the basis of unethical conduct of animal studies.
8. Authors must declare, if any, financial support or relationships that may pose conflict of interest.

STRUCTURE OF MANUSCRIPTS

1. **TITLE PAGE**
   The first page of each manuscript starts with the title of the paper which should be typed in bold-faced print using both upper and lower case letters and set in the center of the page. Although the title should be as brief as possible, include the species involved in the research when applicable. Abbreviations are not permitted in the title.
   The names of the authors follow and you may choose to use either initials (first and middle) or full name(s) and last name but you should be consistent and use the same format for all authors. Indications of professorial rank or other professional titles should not be used. Naming an author on a paper implies that the person named is aware of the research reported and agrees with and accepts responsibility for any results or conclusions reported.
   The address of the institution where the research was conducted follows and the address should include the name of the institution, city, country and zip code. This should be typed on as few lines as possible using upper and lower case letters. When a paper has several authors from different institutions, key the author to the address with superscript Arabic numerals and present the additional addresses as footnotes at the bottom of the page. Addresses for reprints and changes of address should also be given as footnotes and should be keyed using the same number system as for addresses. Footnotes on the first page and other text pages are referenced sequentially by superscript numbers. A running head (an abbreviated title consisting of no more than 45 characters plus spaces) should also appear centered on the title page. Also include the phone number, fax number, and E-mail address of the contact author on the title page.
2. **ABSTRACT**
   The abstract, consisting of no more than 400 words, appears on a separate page following the title page. The word ABSTRACT (aligned with the left margin) is printed in bold face print using capital letters and should be followed by a colon. The text of the abstract should start on the same line immediately following the colon. The abstract should summarize pertinent results in a brief but understandable form. The abstract should start with a clear statement of the objectives of the experiment and must conclude with one or two sentences that highlight important conclusions. References are never cited in the abstract. Abbreviations that appear in the abstract that are not included in the standard abbreviation listing found in each issue of AJAS must be defined before they are first used.

3. **KEY WORDS**
   At the end of the abstract, list up to six key words that best describe the nature of the research. The term "Key Words" is typed in bold-faced print followed by a colon. The first letter of each key word is capitalized and key words are separated by commas. The entire line should be centered on the page and surrounded by brackets. Key words should include the species, variables tested, and the major response criteria. Key words must be selected from the most recent issues of the CAB Thesaurus (available from C.A.B. International, 845 North Park Avenue, Tucson, AZ 85719; Telephone: 800-528-4841 .) American spelling of words is used. Key words form the basis for the subject index, which is published in the last issue of each volume of AJAS. Because major words in the title are not used in the subject index, appropriate words from the title (or synonyms) should be listed as key words.
4. **HEADINGS**
   Major headings (INTRODUCTION, MATERIALS AND METHODS, RESULTS, DISCUSSION [or RESULTS AND DISCUSSION], and REFERENCES) are centered and appear in roman type, with the entire heading capitalized using bold-faced type. Major headings of review papers or papers from symposia may deviate from this standard format; however, all papers must contain an abstract, key words, and an introduction. Abbreviations should be avoided in headings.
   First subheadings appear at the left margin on a separate line in bold-faced print and are not followed by punctuation. Only the first word is capitalized. First subheadings are used when subsections below major headings consist of several paragraphs, especially if some or all of the paragraphs begin with a second subheading.
   Second subheadings appear at the beginning of the first line of a paragraph. They are italicized and followed by a period. They do not require labeling (a, b, c, etc.). Second subheadings may be used with or without first subheadings; generally second subheadings introduce sections three to four paragraphs in length or longer sections below a first subheading.
5. **INTRODUCTION**
   The introduction starts on a new page following the abstract. The introduction briefly justifies the research and specifies the hypotheses to be tested. Extensive discussion of relevant literature should be included in the discussion of results, not in the introduction. To minimize length and avoid redundancy, generally no more than three references should be cited to support a specific concept.
6. **MATERIALS AND METHODS**
   - General: A clear description or specific original reference is required for all biological, analytical, and statistical procedures used in the experiment. All modifications of procedures must be explained. Diets, animals (breed, sex, age, body weight, and weighing conditions [i.e., with or without restriction of feed and (or) water]), surgical techniques, measurements, and statistical models should be described clearly and fully. Brand names and company names and locations for all substances and equipment referred to in the text should be included in parentheses within the text, not in footnotes.
   - Statistics: 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.
7. **RESULTS**
   Results (may be combined with discussion) should be presented in tabular form when feasible. The text should explain or elaborate on the tabular data, but numbers should not be repeated extensively within the text. Sufficient data, all with some index of variation attached, should be presented to allow the reader to interpret the results of the experiment.
8. **DISCUSSION**
   The discussion (may be combined with results) should interpret the results clearly and concisely in terms of biological mechanisms and should integrate literature results with the research findings to provide the reader with a broad base on which to accept or reject the hypotheses tested. Results and references to tables and figures already described in the RESULTS section should not be repeated in the DISCUSSION section.
9. **IMPLICATIONS (Optional)**
   This section, consisting of no more than 1,000 characters plus spaces in one paragraph, follows the discussion and should explain in lay terms, without abbreviations, acronyms, or citations, what the findings of this research imply for animal production and (or) biology. Though some speculation is permitted, this section should also caution the reader against over extrapolation of results. For manuscripts with direct applications, this section will consist of an interpretive summary. If results have no implications, this should be stated.
10. **REFERENCES**
    The Harvard (author, date) system of referencing is used (examples are given below).
    - Reference citations in the text: Black (1971) or (Black, 1971); Dickerson et al. (1974) or (Dickerson et al., 1974); Smith and Jones (1977) or (Smith and Jones, 1977).
    - Groups of references cited in a sentence in the text must be listed in chronological order as in the previous sentence.
    - REFERENCES lists should be typed in alphabetical order.
    - Refrain from citing unnecessary references. Less than 30 references are recommended.

Samples of reference citations.

Standard Journal Articles:

Jensen, M. S., S. K. Jensen, and K. Jakobsen. 1997. Development of digestive enzymes in pigs with emphasis on lipolytic activity in the stomach and pancreas. J. Anim. Sci. 75:437-445.
Jin, C. F., J. H. Kim, H. K. Moon, W. T. Cho, Y. K. Han, and I. K. Han. 1998a. Effects of various carbohydrate sources on the growth performance and nutrient utilization in pigs weaned at 21 days of age. Asian Australas. J. Anim. Sci. 11:285-292.
Jin, C. F, J. H. Kim, I. K. Han, H. J. Jung, and C. H. Kwon. 1998b. Effects of various fat sources and lecithin on the growth performance and nutrient utilization in pigs weaned at 21 days of age. Asian Australas. J. Anim. Sci. 11:176-184.

Journal Article with a Subtitle :

Ackerson, R. C. 1981. Osmoregulation in cotton in response to water stress: 1. Alterations in photosynthesis, translocation and ultrastructure. Plant Physiol. 67:484-488.

Online article not yet published in an issue :

An online article that has not yet been published in an issue can be cited by its Digital Object Identifier (DOI).

Devendra C. 2013. Investments on pro-poor development projects on goats: Ensuring success for improved livelihoods. Asian Australas. J. Anim. Sci. http:/dx.doi.org/10.5713/ajas.2013.r.01

Citation from web sites :

Sample size calculation. Grapentine Co. Inc. http://www.grapentine.com/calculator.htm. Accessed December 6, 2005

Abstracts and Supplements :

Mahan, D. C., E. M. Weaver, and L. E. Russell. 1996. Improved postweaning pig performance by adding NaCl or HCl to diets containing animal plasma. J. Anim. Sci. 74(Suppl. 1):58(Abstr.).
Smith, J. W., M. D. Tokach, R. D. Goodband, J. L. Nelssen, W. B. Nessmith, K. Q. Owen, and B. T. Richert. 1995. The effect of increasing zinc oxide supplementation on starter pig growth performance. J. Anim. Sci. 73(Supp. 1):72(Abstr.).

Journal Article Accepted but not yet Published :

Li, D. F., J. L. Nelssen, P. G. Reddy, F. Bleccha, R. D. Klemm, D. W. Giesting, J. D. Hancock, G. L. Allee, and R. D. Goodband. 1999. Measuring suitability of soybean products for early-weaned pigs with immunological criteria. J. Anim. Sci. (In press).

Standard Book :

AOAC. 1990. Official Methods of Analysis. 15th edn. Association of Official Analytical Chemists, Arlington, VA, USA.
National Research Council. 1998. Nutrient Requirements of Swine. 10th Ed. National Academy Press, Washington, DC, USA.
SAS Institute Inc. 1989. SAS/STAT User's Guide: Version 6. 4th edn. SAS Institute Inc., Cary, NC, USA.
Snedecor, G. W. and W. C. Cochran. 1989. Statistical Methods. 8th Ed. Iowa State University Press, Ames, IA, USA.
Steel, R. G. D. and J. H. Torrie. 1980. Principles and Procedures of Statistics: A Biometrical Approach. 2nd edn. McGraw-Hill Book Company, New York, NY, USA.

Chapter in an Edited Book :

Cranwell, P. D. and P. J. Moughan. 1989. Biological limitations imposed by the digestive system to the growth performance of weaner pigs. In: Manipulating Pig Production II (Eds. J. L. Barnett and D. P. Hennessy). Australasian Pig Science Association, Werribee, Australia. pp. 140-159.
Cromwell, G. L. 1991. Antimicrobial agents. In: Swine Nutrition (Eds. E. R. Miller, D. E. Ullrey, and A. J. Lewis). Butterworth-Heinemann, Stoneham, MA, USA. pp. 297-314.
Mayes, P. A. 1990. Digestion and absorption. In: Harpers Biochemistry, 22nd Ed. (Eds. R. K. Murray, D. K. Granner, P. A. Mayes, and V. W. Rodwell). Appleton & Lange, Norwalk, CT, USA. pp. 580-590.

Thesis :

Thacker, P. A. 1981. Effects of Dietary Propionate on Lipid Metabolism in Growing Swine. Ph.D. Thesis, University of Alberta, Edmonton, Alberta, Canada.
Trottier, N. L. 1995. Protein Metabolism for the Lactating Sow. Ph.D. Thesis, University of Illinois, Urbana, IL, USA.

Conference Proceedings :

Goodband, R. D., M. D. Tokach, S. S. Dritz, and J. L. Nelssen. 1995. Practical nutrition for the segregated early weaned pig. In: Proceedings of the 1995 Saskatchewan Pork Industry Symposium, Saskatoon, Saskatchewan, Canada. pp. 15-22.
Shurson, J., L. Johnston, J. E. Pettigrew, and J. Hawton. 1995. Nutrition and the early weaned pig. Proceedings

of the Manitoba Swine Seminar. 9:21-32.

Research Reports etc .:

Lutz, T. L. and T. S. Stahly. 1996. Dietary folic acid needs of high lean growth pigs. Iowa State University 1997 Swine Research Report. pp. 4-6.

Unpublished Memos, Letters, Personal Communications (Cited in Text Only)
(L. G. Campbell, pers. comm., University of Saskatchewan, Saskatoon, SK). (A. J. Smith, unpubl. data).

11. **TABLES**

Tables are used to present numerical data in a self-explanatory manner. They should be intelligible without consulting the text and should not duplicate data already given in the text or in illustrations. Any abbreviation used in a table must be defined in that table. Tables should be typed double-spaced with each table on a separate sheet. Place tables immediately after the list of figure legends or references if there are no figures. Paginate the tables in series with the text.

All tables should be cited in the text. Arabic numerals are used to number tables. The table number (i.e. Table 4.) is typed in bold face followed by a period. The title of the table continues on the same line with only the first letter capitalized. Do not use a period at the end of the title. Column headings should have the first letter of each word capitalized while the names of variables are typed with only the first letter capitalized (i.e. Average daily gain).

For numerals less than 1, insert a zero to the left of the decimal point (columns should be set up so that decimal points are aligned if possible). If there are no data for a particular entry, insert a dash. If an explanation is necessary, use an abbreviation in the body of the table (e.g. ND) and explain clearly in footnotes what the abbreviation means. Care should be taken to ensure that greater accuracy is not implied in the table than is possible from a particular analysis and only significant figures should be used. It is exceedingly rare where accuracy greater than two decimal places is obtained.

References to footnotes in a table are specified by superscript numbers, independently for each table. Superscript letters are used to designate statistical significance. Use a lower case p to indicate probability values (i.e. p0.05).

Presentation of pooled standard errors, the general basis for statistical comparisons of means is recommended when variance is homogeneous. These should be presented in a separate column or row. Standard errors can be attached to each mean by ± signs when variance or SE are heterogeneous (e.g. unbalanced experiments or unequal numbers of observations in treatment means). The pooled standard error is the preferred estimate of experimental error because presenting individual standard errors tends to clutter up the table.

For diet composition, present major ingredient inclusion levels as a percentage of the total rather than in g/kg of diet.

12. **Figures**

Figures should be placed at the end of the manuscript with each figure placed on a separate page. Figure legends should be typed (double spaced) on a separate page.

Prepare figures to fit one column (8cm wide), or full-page width (17 cm wide). A minimum type size of 8 points (Times New Roman) is recommended so as to be readable a final publication size.

For multiple lines tables, please use solid, long-dash, short-dash, and dotted lines, and avoid 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. Also remove unnecessary backgrounds and grid lines from graphs. Each axis should have a description and a unit.

For bar charts, please use different fill patterns if needed (black, white, gray, and stripes). Identify curves and data points using the following symbols (●, ○, ■, □, ♦, ◊, ▲, △, +, and ×). Symbols should be defined in the figure legend or in a key on the figure.

Preferred format for figures are Word, EPS, JPEG , PDF, and TIFF. If figures are to be reproduced in grayscale (black and white), submit in grayscale. If figures are to appear in color in the print journal, files must be submitted in CMYK color (not RGB). Minimum resolution is 300 dpi for color and grayscale figures and 600 dpi for line art.

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.

Prepare legend to provide sufficient information and all abbreviations and symbols used in the figure should be defined in the legend.

13. **USE OF NUMBERS**

Follow the rules given below for writing numbers:

- In general, spell out numbers one through nine and use numerals for 10 and above.
- Use Arabic numerals with abbreviated units of measure: 2 g, 5 d, $4.00, 3% and numerical designations in the text: exp 1, group 3, etc.
- Use Arabic numerals to express time and date: 08:00 h, 3 Sept. 1985, etc.
- In a series using some numbers less than 10 and some more than 10 use numerals for all (i.e. 2 Holsteins, 6 Charolais and 15 Friesians).
- When writing a large number ending in several zeros, use a word for part of the number (i.e. 1.8 million rather than 1,800,000).
- When two numbers appear adjacent to each other, spell out the first (i.e. ten 2-d-old chicks rather than 10 2-d-old chicks).
- Do not begin a sentence with a numeral. Spell it out or rearrange the sentence.
- Use the 24-h clock system: 09:30, 13:40 h, etc. Give day length in quantitative hours (e.g. 2 h 16 min). Abbreviate the terms hour (h), minute (min) second (s) and year (yr) when used with a number in the text but spell them out when they are used alone.

- Do not use a hyphen to indicate inclusiveness (e.g. use 12 to 14 mg or wk 3 and 4 not 12-14 mg or wk 3-4).

LIST of Abbreviations of Frequently Cited Periodicals and Journals

Acta Agric. Scand.
Acta Endocrinol.
Adv. Appl. Microbiol.
Adv. Carbohydr. Chem.
Adv. Biochem.
Adv. Food Res.
Adv. Genet.
Adv. Lipid Res.
Adv. Protein Chem.
Agric. Eng.
Agron. J.
Am. J. Anat.
Am. J. Clin. Nutr.
Am. J. Clin. Pathol.
Am. J. Hum. Genet.
Am. J. Obstet. Gynecol.
Am. J. Pathol.
Am. J. Physiol.
Am. J. Vet. Res.
Anal. Biochem.
Anal. Chem.
Anim. Chem.
Anim. Behav.
Anim. Breed. Abstr.
Anim. Feed Sci. Technol.
Anim. Genet.
Anim. Prod.
Anim. Sci.
Anim. Sci. Technol. (Jpn.)
Ann. Hum. Genet.
Annu. Rev. Biochem.
Annu. Rev. Nutr.
Annu. Rev. Pharmacol.
Annu. Toxicol.
Annu. Rev. Physiol.
Antibiot. Chemother.
Antibiot. (Washington DC)
Antibiot. Chemother. (Basel)
Appl. Environ. Microbiol.
Appl. Microbiol.
Arch. Biochem. Biophys.
Asian Australas. J. Anim. Sci.
Aust. J. Agric. Res.
Aust. J. Exp. Agric.
Biochem. J.
Biochemistry
Biochem. Biophys. Acta
Biol. Reprod.
Biometrics
Biometrika
Blood
Br. J. Nutr.
Br. Poult. Sci.
Can. J. Anim. Sci.
Cell
Cereal Chem.
Clin. Toxicol.
Comp. Biochem. Physiol.
Domest. Anim. Endocrinol.
Endocrinology
Eur. Assoc. Anim.
Eur. Prod. Publ.
Fed. Proc.
Feedstuffs
Fertil. Steril.
Food Res.
Food Technol.
Gastroenterology
Genetics
Grass Forage Sci.
Growth
Gut
Horm. Behav.
Immunology
Infec. Immun.
Ir. J. Agric. Res.
J. Agric. Food Chem.
J. Agric. Sci.
J. Am. Oil Chem. Soc.
J. Anim. Breed. Genet.
J. Anim. Physiol.
J. Anim. Nutr.
J. Anim. Sci.
J. Assoc. Off. Anal. Chem.
J. Clin. Endocrinol. &
J. Metab.
J. Clin. Invest.
J. Dairy Sci.
J. Food Compos. Anal.
J. Gen. Physiol.
J. Hered.
J. Nutr.
J. Nutr. Biochem.
J. Physiol. (Lond.)
J. Physiol. (Paris.)
J. Range Manage.
J. Rech. Porcine Fr.
J. Reprod. Fertil.
J. Sci. Food Agric.
Jpn. Poult. Sci.
Korean J. Poult. Sci.
Korean J. Anim.
Nutr. Feed.
Korean J. Anim. Sci.
Korean J. Animal Reprod.
Korean J. Dairy Sci.
Korean J. Nutr.
Lab. Anim.
Lipids
Livest. Prod. Sci.
Meat Sci.
Metabolism
Methods Enzymol.
Mol. Cell. Endocrinol.
N. Engl. J. Med.
N. Z. J. Agric. Res.
Nature (Lond.)
Nature (Paris)
Neth. J. Agric. Res.
Neuroendocrinology
Nutr. Abstr. Rev.
Nutr. Metab.
Nutr. Rep. Int.
Nutr. Res.
Nutr. Rev.
Obstet. Gynecol.
Pharmacol. Rev.
Physiol. Rev.
Pig News Info.
Poult. Sci.
Proc. N. Z. Grassl. Assoc.
Proc. Nutr. Soc.
Proc. R. Soc. Lond.
B. Biol. Sci.
Proc. Soc. Exp. Biol. Med.
Prof. Anim. Sci.
Q. J. Exp. Physiol.
Rec. Prog. Horm. Res.
Reprod. Fertil. Dev.
Residue Rev.
S. Afr. J. Anim. Sci.
Sci. Agric.
Science
Steroids
Theor. Appl. Genet.
Theriogenology
Toxicol. Appl.
Pharmacol.
Trans. Am. Soc. Agric. Eng.
Vet. Rec.
Vet. Res.
Vitam. Horm.
World Anim. Rev.
World's Poult. Sci. J.
Z. Tierz. Zuechtungsbiol.
Zentralbl. Veterinaermed.
Reihe A

List of Abbreviations Used in the Asian-Australasian Journal of Animal Science

Item	Unit/Term	Item	Unit/Term	Item	Unit/Term
AA	amino acid(s)	g	gravity	NSP	nonstarch polysaccharide
ACTH	adrenocorticotrophic hormone	G:F	gain-to-feed ratio	o.d.	outside diameter
ADF	acid detergent fiber (assumed	GAPDH	glyceraldehyde 3-phosphate	OM	organic matter
	sequential unless designated		dehydrogenase	p	probability
	otherwise)	GAT	lutamic acid-alanine-tyrosine	Pa	pascal
ADFI	average daily feed intake (not to be	GC-MS	gas chromatography-mass	PAGE	polyacrylamide gel
	confused with DMI)		spectrometry		electrophoresis
ADG	average daily gain	GE	ggross energy	PBS	phosphate-buffered saline
ADIN	acid detergent insoluble nitrogen	GH	growth hormone	PCR	polymerase chain reaction
ADL	acid detergent lignin	GHRH	growth hormone-releasing	pfu	plaque-forming units
ADP	adenosine diphosphate	GLC	hormone	PG	prostaglandin
AI	artificial insemination		gas-liquid chromatography	PGF2α	prostaglandin F2α
AIA	acid insoluble ash	GLM	general llinear model	PMNL	polymorphonuclearneutrophilic
AID	apparent ileal digestibility	GnRH	gonadotropin-releasing hormone		leukocyte
AME	apparent metabolizable energy	h	hour	PMSG	pregnant mare's serum
AMEn	nitrogen-corrected apparent	h2	heritability (use only in tables		gonadotropin
	metabolizableenrgy		and parenthetical expressions)	PPAR	peroxisome proliferator-
AMP	adenosine monophosphate	ha	hectare		activated receptor
amu	atomic mass unit	hCG	human chorionic gonadotropin	ppb	parts/billion parts
ANOVA	analysis of variance	HCW	hot carcass weight	ppm	parts/million parts
ARS	Agricultural Research Service	HEPES	N-(2-hydroxyethyl) piperazine-	ppt	parts/trillion parts
Assoc.	Association		N- 2-ethanesulfonic acid	PSE	pale, soft, and exudative (meat)
atm	atmosphere	HPLC	high performance (pressure)	PTA	predicted transmitting ability
ATP	adenosine triphosphate		liquid chromatography	Publ.	publication
ATPase	adenosine triphosphatase	HTST	high temperature, short time	PUFA	polyunsaturated fatty acid(s)
Avg	average (use only in tables, not in the	Hz	hertz	QTL	quantitative trait locus (loci)
	text)	i.d.	inside diameter	R	multiple correlation
B cell	bursal-derived, bursal-equivalent	i.e.	that is		coefficient
	derived cell	i.m.	intramuscular(ly)	r	simple correlation
BCS	body condition score	i.p.	intraperitoneal(ly)		coefficient
BHBA	β-hydroxybutyrate	i.v.	intravenous(ly)	R2	multiple coefficient of
BLUE	best linear unbiased estimate	ICU	international chick units		determination
BLUP	best linear unbiased prediction bp	IU	international unit	r2	simple coefficient of
	base pair	IFN	interferon		determination

bp	base pair
Bq	becquerel
BSA	bovine serum albumin
bST	bovine somatotropin
Bull.	Bulletin
BUN	blood urea nitrogen
BW	body weight (not after feed deprivation unless designated otherwise)
℃	degree Celsius
C/EBP	CAAT-enhancer biding protein
ca.	circa
cal	calorie
cDNA	complementary deoxyribonucleic acid
cfu	colony-forming unit
CI	confidence interval (use only in tables and parenthetical expressions)
ci	curie
CIE	International Commission on Illumination (Commission Internationaled'Eclairage)
Circ	Circular
CLA	conjugated linoleic acid
cM	centimorgan (spell out morgan if used without a prefix)
CN	casein
CNS	coagulase-negative staphylococci
Co-EDTA	cobalt ethylenediamine- tetraacetate
CoA	coenzyme A
Coll.	College
Conf.	Conference
Congr.	Congress
CP	crude protein (N×6.25)
cP	centipoise
cpm	counts per minute
cps	counts per second
CPU	central processing unit
CRD	completely randomized design
cRNA	complementary ribonucleic acid
cu	cubic
CV	coefficient of variation
D	dextro-
d	day
Da	dalton
DCAD	dietary cation-anion difference
DE	digestible energy
DEAE	(dimethylamino) ethyl (as in DEAE-cellulose)
df	degree (s) of freedom
DFD	dark, firm and dry (meat)
DHI(A)	Dairy Herd Improvement (Association)
diam.	diameter
DIM	days in milk
DM	dry matter
DMI	dry matter intake
DNA	deoxyribonucleic acid
DNase	deoxyribonuclease
dpm	disintegrations/minute
e.g.,	for example
EBV	estimated breeding value
eCG	equine chorionic gonadotropin
ECM	energy-corrected milk
Ed.	Edition, Editor(s)
EDTA	ethylenediaminetetraacetic acid
EFA	essential fatty acid
EIA	enzymeimmunoassay
ELISA	enzyme-linked immunosorbent assay
EPD	expected progenydifference
Eq	equivalent
Eq	equation(s)
EST	expressed sequence tag
et al.	et alia
ETA	estimated transmitting ability
etc.	et cetera
Exp.	experiment (always followed by a numeral)
Ext.	extension
F	F-distribution (variance ratio)
FA	fatty acid(s)
FCM	fat corrected milk
FFA	free fatty acid(s)
FSH	follicle-stimulating hormone
Ig	immunoglobulin (when used to identify a specific immunoglobulin)
IGF	insulin-like growth factor
IL	interleukin
IMI	intramammary infection
Inst.	institute
IU	international unit
IVDMD	in vitro dry matter disppearance
kb	kilobase(s)
KB	kilobyte
kg (g)	kilogram (gram)
KPH	kidney, pelvic, heart fat
KU	klett units
l	levo-
L	litter
L:D	hours light:hours darkness in a photoperiod
LA	lactalbumin
LD50	lethal dose 50%
LG	lactoglobulin
LH	luteinizing hormone
LHRH	luteinizing hormone- releasing hormone
LM	longissimus muscle
LPS	lipopolysaccharide
LSD	least significant difference
LSM	lease squares means (use only in tables and parenthetical expressions)
lx	lux
m	meter
M	molar (concentration)
mAb	monoclonal antibody
MAS	marker-assisted selection
ME	metabolizable energy
MEn	nitrogen-corrected metabolizable energy
MHC	major histocompatibility complex
MIC	minimum inhibitory concentration
min	minute
Misc.	miscellaneous
MJ, kJ, J	mega-, kilo-, joule
mm HG	millimeters of mercury
mo	month
mol	mole
Monogr.	monograph
MP	metabolizable protein
mRNA	messenger ribonucleic acid
MS	mean square (use only in tables and parenthetical expressions)
MUFA	monounsaturated fatty acid
MUN	milk urea nitrogen
N	newton
N	normal (concentration)
n	sample size (used paren-thetically or in footnotes)
NAD	nicotinamide adenine dinucleotide
NADH	reduced form of NAD
NADP	nicotinamide adenine dinucleotide phosphate
NADPH2	reduced form of NADP
NAN	nonammonia nitrogen
Natl.	national
NDF	neutral detergent fiber
NDIN	neutral detergent insoluble nitrogen
NDM	nonfat dry milk
NE	net energy
NEFA	nonesterified fatty acid
NEg	net energy for gain
NEl	net energy for lactation
NEm	net energy for maintenance
No.	number (use only in table, not in the text)
NPN	nonprotein nitrogen
NRC	National research council
NS	nonsignificant (use only in tables and parenthetical expressions)
NSC	nonstructural carbohydrates
RCBD	randomized completely block design
RDP	ruminally degradable protein
REML	restricted maximum likelihood
Rep.	Report
RFLP	restriction fragment length polymorphism
RH	relative humidity
RIA	radioimmunoassay
RNA	ribonucleic acid
RNase	ribonuclease
RQ	respiratory quotient
rRNA	ribosomal ribonucleic acid
RUP	ruminallyundegradable protein
S	siemens
s,sec	second
s.c.	subcutaneous(ly)
s2	variance (sample)
SARA	subacuteruminal acidosis
SAS	Statistical Analysis System
SCC	somatic cell count
SCM	solids-corrected milk
SCS	somatic cell score
SD	standard deviation (sample)
SDS	sodium dodecyl sulfate
SE	standard error
SEM	standard error of the mean
SFA	saturated fatty acid
SID	standardized ileal digestibility
SNF	solids-not-fat
SNP	single nucleotide polymorphism
sp., spp.	one species, several species
SPC	standard plate count
SPC	standard plate count
SRBC	sheep red blood cells
SS	sums of squares (use only in tables and parenthetical expressions)
SSC	Susscrofa chromosome
ssp.	subspecies
ST	somatotropin
Sta.	station
Suppl.	supplement
Symp.	symposium
t	metric ton (1,000 kg)
t	t- (or Student) distribution
T cell	thymic-derived cell
TBA	thiobarbituric acid
TCA	trichloroacetic acid
TDN	total digestible nutrients
Tech.	technical
TLC	thin layer chromtography
TME	true metabolizable energy
TMEn	nitrogen-corrected true metabolizable energy
TMR	total mixed ration
Tris	tris (hydroxymethyl) aminomethane
tRNA	transfer ribonucleic acid
TS	total solids
TSAA	total sulfur amino acids
U	unit
UF	ultrafiltration, ultrafiltered
UHT	ultra-high temperature
univ.	university
USDA	U.S. Department of Agriculture
UV	ultraviolet
VFA	volatile fatty acid
vol	volume
vol/vol	volume/volume (used only in parentheses)
vs	versus
V	volt
W	watt
wk	week
wt	weight (use only in tables, not in the text)
wt/vol	weight/volume (used only in parentheses)
wt/wt	weight/weight (used only in parentheses)
×	multiplied by or crossed with
	mean (sample)
yr	year
α	probability of Type I error

β	probability of Type II error
μ	mean (population)
σ	standard deviation (population)
σ2	variance (population)
χ2	chi-squared distribution

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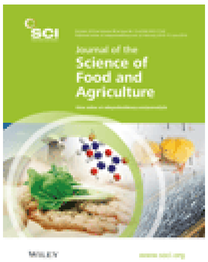

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APPENDIX I: QUANTITIES, UNITS AND SYMBOLS

Recommended SI units and symbols

SI base units	*Name*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Multiples

To form decimal multiples of SI units the following prefixes may be used, but for mass the prefix is added to the gram (g) and not the kilogram (kg).

Multiple	*Prefix*	*Symbol*	*Multiple*	*Prefix*	*Symbol*
10^{3}	kilo	k	10^{-6}	micro	μ
10	deca	da	10^{-9}	nano	n
10^{-1}	deci	d	10^{-12}	pico	p
10^{-2}	centi	c	10^{-15}	femto	f
10^{-3}	milli	m			

Derived units

Physical quantity	*Name*	*Symbol*	*Definition*	
Energy	joule	J	kg m^{2} s^{-2}	= Nm
Force	newton	N	kg m s^{-2}	= J m^{-1}
Pressure	pascal	Pa	kg m^{-1}	