UNIVERSIDADE ESTADUAL DE MARINGÁ
CENTRO DE CIÊNCIAS AGRÁRIAS

ADITIVOS NATURAIS, IDADE DE CASTRAÇÃO E NÍVEIS DE PROTEÍNA NA DIETA DE BOVINOS CONFINADOS: DESEMPENHO ANIMAL, CARACTERÍSTICAS DE CARCAÇA E DA CARNE

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Estado do Paraná
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TITULAÇÃO: Doutora em Zootecnia - Área de Concentração Produção Animal

APROVADA em 26 de fevereiro de 2014.

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Prof. Dr. Ivanor Nunes do Prado
(Orientador)

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BIOGRAFIA

MARIBEL VELANDIA VALERO, filha de Ezequiel Velandia Torres e Maria Nubia Valero Vergel, nasceu no município de Otanche Departamento de Boyacá, Colômbia no dia 17 de janeiro de 1980.

Em março do ano 2002, iniciou o curso Medicina Veterinária e Zootecnia na Universidad del Tolima (Colômbia) e, em setembro do 2007, concluiu o curso.

No ano de 2008, iniciou o Programa de Pós Graduação em Zootecnia, em nível de Mestrado, área de concentração Produção Animal na Universidade Estadual de Maringá (Brasil) realizando estudos na área de Nutrição de Ruminantes e, no mês de março de 2010 defendeu sua dissertação. No mesmo ano ingressou no programa em nível de Doutorado, para continuar estudos na área de Nutrição de Ruminantes. No mês de fevereiro de 2013 foi aprovada pela banca da qualificação da tese. No mês de fevereiro de 2014 foi aprovada pela banca a defesa da Tese de Doutorado.

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RESUMO

Neste trabalho foram realizados quatro ensaios experimentais. No primeiro ensaio foi avaliado o efeito da própolis e óleos essenciais usando como volumoso a silagem de sorgo no consumo de alimentos, desempenho, digestibilidade e hemograma de bovinos alimentados *ad libitum* em confinamento. No segundo ensaio foi avaliado o efeito de propolis e óleos essenciais com silagem de milho no consumo de alimentos, desempenho, digestibilidade e características de carcaça de bovinos alimentados *ad libitum* em confinamento. No terceiro ensaio foi avaliado o efeito de própolis e óleos essenciais com silagem de milho na qualidade da carne de bovinos alimentados *ad libitum* em confinamento. No quarto ensaio foi avaliado o efeito da castração, idade, nível de proteína e razão lisina/metionina no consumo de alimentos, desempenho, características de carcaça e qualidade da carne de bovinos holandeses criados em confinamento. Os três primeiros estudos foram realizados no Departamento de Zootecnia da Universidade Estadual de Maringá. Trinta bovinos foram distribuídos em um sistema fatorial com três dietas. A dieta controle (CON) com silagem (sorgo ou milho) (41% ou 45.5 do total da MS) e concentrado (milho moído, farelo de soja, glicerol, ureia, calcário e sal mineral). O grupo própolis (PRO) recebeu a dieta controle e suplementado com 3 g/animal/dia de própolis misturado no concentrado. O grupo suplementado com óleos essenciais (OLE) recebeu a dieta controle mais 3 g/animal/dia do produto comercial de óleos essenciais misturado no concentrado. O quarto ensaio foi realizado no Departamento de Produção Animal e Ciência de Alimentos, Universidade de Zaragoza. Sessenta e quatro bovinos foram distribuídos aleatoriamente em esquema fatorial em oito tratamentos: duas idades de castração (15 dias versus 5 meses), dois níveis de proteína (13 *vs.* 15%) e dois proporções de Lisina/Metionina (3,0 *vs.* 3,4). A alimentação iniciou quando os animais estavam com 3 meses de idade e 92,9 kg de peso vivo. Os óleos essenciais melhoraram o desempenho na fase de crescimento e terminação de bovinos. A própolis melhorou o desempenho animal e eficiência alimentar na fase de terminação. Quando se acrescenta o nível de proteína se observa aumento de músculo na carcaça e aumento de ácidos graxos monoinsaturados da carne. Quando se utiliza maior razão lisina/metionina diminuiu os ácidos graxos saturados.

Key Words: Carne bovina, glicerina, ácidos graxos, eficiência alimentar, óleos de plantas

ABSTRACT

This work is composed by four studies. In the first, the effects of propolis and functional oils with sorghum silage were evaluated on performance, feed intake, digestibility and complete blood count in growing bulls fed *ad libitum* in feedlot. In the second study, the effects of propolis and functional oils with corn silage were evaluated on performance, feed intake, digestibility and carcass characteristics in finishing bulls fed *ad libitum* finished in feedlot. In the third study, the effects of propolis and functional oils with corn silage were evaluated on meat quality of crossbred bulls finished in feedlot. In the fourth study effects of castration age, protein level and lysine/methionine ratio were evaluated in the feed on animal performance, carcass and meat quality of Friesian steers intensively reared. In the first three studies were conducted at Department of Animal Science, State University of Maringá and the fourth at Department of Animal Production and Food Science, University of Zaragoza. In the first three studies, thirty bulls were randomly assigned in factorial system to three treatments: the control diet (CON) with silage (sorghum or corn) (41% or 45.5 total DM) and concentrate (cracked corn, soybean meal, glycerol, limestone and mineral salt); the propolis-supplemented group (PRO) fed with 3 g head-1 day-1 in the form of a premix added to the concentrate and the functional oils-supplemented group (FOL) fed with 3 g $head^{-1}$ day^{-1} added to the concentrate. The initial and final live weight were similar for bulls from three diets. However, the average daily gain and the feed efficiency were higher for bulls fed with FOL diet in comparison to bulls in CON and PRO diets. The nutrients digestibility, carcass characteristics, meat quality, lipid oxidation, chemical composition and fatty acid composition and PUFA/SFA and *n*-6/*n*-3 ratio on *Longissimus* muscle were not affected by the addition of propolis or essential oils in the diets. On the other hand, the final live weight, average daily gain, and hot carcass weights were similar among treatments. In the fourth study, sixty four steers were randomly assigned in factorial system to eight treatments: two castration ages (15 days *vs.* 5 months), two protein levels (13 *vs.* 15%) and two lys/met ratio (3.0 *vs.* 3.4). Feeding treatments started when animals were 3 months old and 92.9 kg of live weight. Castration age did not affect any parameter, not even fat percentage or fatty acid composition, except the ratio PUFA/SFA and *n*-6/*n*-3 that increased with late castration. Protein level increased the percentage of muscle in the animal, as well as high ratio lys/met.

Key Words: Beef meat, biodiesel, fatty acid, feed efficiency, plants oils

1. INTRODUÇÃO GERAL

1.1. Características do mercado de carne bovina e sistema de produção no Brasil

Atualmente, o Brasil possui o maior rebanho comercial de bovinos do mundo, com aproximadamente 190 milhões de cabeças e uma produção aproximada de 9,2 milhões de toneladas de equivalente carcaça ao ano. Deste total, 1,7 milhões de toneladas são exportadas (15% da produção) para diversos países do mundo. Estes números mostram o cenário importante em que está inserida a pecuária de corte brasileira. Nos últimos dez anos, o Brasil tornou-se o maior exportador de carne bovina do mundo e com perspectivas de manter-se nessa liderança até 2020 (FAPRI, 2013) (Tabela 1).

Tabela 1 – Exportações líquidas de carne bovina no mundo (principais países) – milhões de toneladas

	Ano				
Países	2000	2005	2010	2015*	2020*
Argentina	134	537	297	281	338
Austrália	1.341	1.264	1.317	1.547	1.667
Brasil	560	1.534	1.781	2.475	2.858
Canadá	250	447	290	115	148
China	41	7	22	-87	-287
Índia	550	605	700	753	746
Nova Zelândia	489	628	500	550	622
Tailândia	0	2	-1	-3	-14
Ucrânia	100	29	22	12	38
UE	198	-201	-330	-360	-391
USA	-440	-1.180	-70	-267	-424
Total	2.693	3.687	5.052	5.999	6.723
US Dólar/ton	1.597	1.831	2.091	2.430	2.530

FAPRI (2013) – Food Agricultural Policy Research Institute. *Previsão.

Estes dados mostram que países tradicionalmente exportadores de carne deverão oscilar pouco nos volumes exportados, como exemplo, Argentina, Austrália e Nova Zelândia. No entanto, com essas previsões, o Brasil teria um aumento de 500% entre os anos 2000 e 2020. Por outro lado, os Estados Unidos da América, países da União Europeia e China devem apresentar um mercado com maior importação do que exportação (Tabela 1).

No que concernem aos maiores importadores de carne bovina do mundo (Tabela 2), países tradicionais como o Japão, México e Coreia do Sul devem manter os volumes

estáveis, mas com tendência de alta nas importações de carne. Países pouco representativos nas importações de carne bovina, até então no cenário atual, apresentam um volume significativo de aquisições como, por exemplo, Hong Kong, Egito, Taiwan e Filipinas. Além disso, as perspectivas futuras são de que estes mercados aumentem seus volumes de compra de carne bovina (Tabela 2). A Rússia, país importador desde a década passada, apresentou o maior incremento na importação de carne bovina no mundo, passando das 592 mil toneladas no ano 2000 para uma esperada importação acima de 1 milhão de toneladas nos próximos anos, tornando-se o maior mercado para a carne bovina.

Tabela 2 – Importações líquidas de carne bovina no mundo (principais países) – milhões de toneladas

	Ano				
Países	2000	2005	2010	2015*	2020*
Rússia	592	637	935	1.103	1.172
Japão	940	604	694	871	908
México	422	260	275	512	568
Coreia do Sul	230	269	344	294	363
Egito	-	150	190	245	270
Filipinas	70	134	148	210	258
Hong Kong	71	82	200	235	254
Taiwan	79	83	135	138	158
Total	2.693	3.687	5.052	5.999	6.723
US Dólar/ton	1.597	1.831	2.091	2.430	2.530

(FAPRI, 2013) – Food Agricultural Policy Research Institute. *Previsão.

Este panorama resumido do mercado de carne bovina no mundo apresenta perspectiva favorável para o aumento da produção de carne nos países tradicionalmente produtores e exportadores como, por exemplo, Brasil, Austrália, Argentina e Nova Zelândia. Além disso, de acordo com os mesmos estudos de prospecção de mercado futuro, a tendência do preço da carne bovina é aumentar nos próximos anos (Tabelas 1 e 2). Os países importadores cada vez mais farão restrições às compras de carne de qualidade duvidosa ou com uso de substâncias invasivas à saúde animal e humana, entre eles, países da União Europeia e Japão. Desta forma, o sistema de produção de carne bovina do Brasil deve adequar-se às novas exigências dos países importadores.

Embora o Brasil esteja entre os maiores produtores e exportadores de carne bovina do mundo, ainda apresenta baixa produtividade e qualidade de carne, sobretudo dos animais terminados em pastagens (Moreira et al., 2003). Assim, observa-se a

necessidade de investimentos em tecnologias que promovam a produção de carne com eficiência, com a finalidade de incrementar a margem de lucro do produtor e com qualidade, para manter e conquistar novos mercados consumidores.

Isto pode ser alcançado com a intensificação do sistema de produção e uso de ferramentas e manejo como, por exemplo, cruzamentos orientados entre *Bos taurus indicus vs. Bos taurus taurus* (Ducatti et al., 2009; Perotto et al., 2000; Prado et al., 2008a; Prado et al., 2008c), intensificação da terminação de bovinos em confinamento que apresentem ganho em peso acima de 1,5 kg/dia (Abrahão et al., 2006; Dian et al., 2010; Maggioni et al., 2009), abate de animais com melhor espessura de gordura de cobertura e melhor qualidade da carcaça (Maggioni et al., 2012; Rotta et al., 2009a; Rotta et al., 2009b), produção de carne que atenda às exigências do consumidor nas características sensoriais e de composição química (Abrahão et al., 2008; Aricetti et al., 2008; Ito et al., 2012b; Maggioni et al., 2010; Scollan et al., 2006) e, sobretudo, respeito ao ambiente e ao bem-estar animal (Farias et al., 2012b; Partida et al., 2007; Silva et al., 2010b). Os sistemas de produção intensiva de carne bovina, com animais terminados em semiconfinamento ou confinamento apresentam maior custo de produção (El-Memari Neto et al., 2003; Silva et al., 2010a) em função da necessidade de aumentar a densidade energética da ração, o nível de proteína e adição de ionóforos, ou antioxidantes (Valero et al., 2011; Zawadzki et al., 2011a; Zawadzki et al., 2011b).

1.2. Desempenho de bovinos em confinamento

Com o aumento da prática de confinamento, como alternativa para terminação de animais, cresce a participação do abate de animais denominados novilhos precoces, abatidos aos 18 meses de idade (Abrahão et al., 2008; Ducatti et al., 2009; Ito et al., 2012a) e superprecoces, abatidos aos 14 ou 15 meses de idade (Ito et al., 2012b). Segundo Perotto et al. (2000), o aumento do peso e a melhoria da qualidade das carcaças estão entre os benefícios que os cruzamentos entre raças *Bos taurus taurus vs. Bos taurus indicus* proporcionam à pecuária de corte. A carcaça do animal cruzado é melhorada pela combinação das características superiores das raças paternas. Os cruzamentos entre raças podem melhorar importantes características, como grau de acabamento, porcentagem de cortes nobres e deposição de gordura (Prado et al., 2009b; Rotta et al., 2009b). Portanto, o cruzamento de bovinos de corte é uma ferramenta

necessária para rápida introdução, no rebanho, de características desejáveis, explorando a diferença entre as raças e, principalmente, permitindo explorar a heterose.

Quando são utilizadas as raças britânicas que possuem como característica a precocidade quanto à deposição de gordura, é possível o abate dos animais aos 14 meses de idade. Para produzir animais superprecoces é necessário um ganho de peso médio diário acima de 1,5 kg no período de confinamento (Dian et al., 2010) e um ganho diário da ordem de 1,0 kg ao longo da vida do animal para que ele seja abatido com 225 kg de peso de carcaça ou mais. Para atender esse objetivo é necessário que o animal apresente ganho em peso contínuo ao longo da vida, sem processo de perda e ganho em peso em determinados períodos, como é observado nos rebanhos de corte do Brasil terminados em pastagem, onde os animais ganham peso no verão e perdem no inverno. Além da redução na idade de abate os animais de sistemas precoces apresentam carcaça de melhor qualidade.

Para Restle et al (2001), dois pontos são importantes quando se busca a produção do novilho superprecoce: o peso de abate e o grau de acabamento da carcaça. O peso de carcaça buscado pelos frigoríficos está acima de 225 kg. O ponto crítico é a espessura de gordura de cobertura da carcaça que deve estar entre 3 a 6 mm. Abaixo de 3 mm, ocorre o escurecimento da parte externa dos músculos que recobrem a carcaça, depreciando o seu valor comercial, aumentando a quebra ao resfriamento, em função da maior perda de água, e pode ocorrer o encurtamento das fibras musculares pelo frio, prejudicando a maciez da carne (Seideman et al., 1987). Por outro lado, cobertura de gordura superior a 6 mm representa *toilette* (aparas com eliminação do excesso de gordura de cobertura) antes da pesagem da carcaça, o que acarreta maior custo operacional para o frigorífico e perda de peso da carcaça para o produtor.

A qualidade da carcaça pode ser melhorada por meio de práticas como manejo nutricional, idade de abate, conhecimento e controle de fatores genéticos, que são elementos que influenciam a composição da carcaça e a qualidade da carne (Scollan et al., 2006). Segundo Maggioni et al. (2012), existe tendência de aumentar o rendimento de carcaça em animais de maior peso, em consequência de maior deposição de gordura na carcaça. Além disso, Marcondes et al. (2012) colocam que ao aumentar o peso vivo, o peso relativo do conteúdo gastrintestinal, vísceras, órgãos, cabeça, pele e patas diminuem, resultando em incremento no rendimento. Todavia, o peso relativo dos órgãos também pode ser maior, influenciando negativamente o rendimento de carcaça, em função do rápido incremento de peso destes, quando existe ganho de peso

compensatório no início do período de terminação. Os efeitos da variação do peso de abate sobre as características da carcaça têm sido estudados em variadas condições de ambiente, grupos genéticos, sexo e idade. Os resultados obtidos, em um mesmo nível nutricional, a composição da carcaça varia em maior amplitude na proporção de gordura e menor de músculo e a percentagem do osso apresenta pequena variação (Rotta et al., 2009b).

Ducatti et al. (2009) avaliaram a composição química e de ácidos graxos no músculo *Longissimus dorsi* de diferentes grupos genéticos superprecoce (Purunã 1ª geração; Purunã 2ª geração; Caracu; Canchim *vs.* Angus e Charolês *vs.* Caracu) terminados em confinamento e observaram que existe influência dos grupos genéticos para a composição química e de ácidos graxos. Prado et al. (2009b) avaliaram as características de carcaça, composição química e de ácidos graxos no músculo *Longissimus dorsi* do Purunã 1ª geração; Purunã 2ª geração e ½ Purunã *vs.* ½ Canchim terminados em confinamento e observaram diferenças entre os grupos genéticos quanto a algumas características (peso vivo final, peso de carcaça quente e rendimento de carcaça quente), teor de lipídeos totais, colesterol e em alguns ácidos graxos.

Em outros estudos, Prado et al., 2008a; Prado et al., 2008c, avaliando as mesmas variáveis em novilhos cruzados (*Bos taurus vs. Bos indicus*) terminados em confinamento e abatidos aos 22 meses de idade, observaram variação na conformação (CON), espessura de gordura de cobertura (EGC) e área do músculo *Longissimus* (AML). Abrahão et al. (2008) avaliaram o efeito das diferentes proporções de sangue Simental e Nelore sobre as características de carcaça e da carne de bovinos superprecoces, terminados em confinamento e não observaram diferença para o peso de abate e rendimento de carcaça. Igarasi et al. (2008) avaliaram as características de carcaça e qualidade da carne de novilhos ½ Red Angus +. ½ Nelore, alimentados com grãos úmidos de milho ou sorgo, terminados em confinamento e abatidos aos 14 meses de idade. Os autores não observaram diferença para rendimento de carcaça, área do músculo *Longissimus* e espessura de gordura de cobertura. Desta forma, o grau genético dos animais usados para produção de carne e terminados em diferentes sistemas tem influência direta no desempenho animal, características de carcaça e qualidade da carne disponibilizada aos consumidores.

1.3. Volumosos na dieta de bovinos em confinamento

O sistema de confinamento é uma alternativa que deve ser utilizada para melhorar a produtividade e a qualidade da carne bovina produzida, principalmente pela redução da idade de abate dos animais (Rotta et al., 2009b). Isto pode ocorrer pela influência da idade de abate sobre a eficiência alimentar e qualidade da carne de bovinos (Igarasi et al., 2008). Animais mais jovens apresentam maior eficiência na transformação de alimentos em músculos e produção de carne de melhor qualidade (Ito et al., 2012b). Além da redução da idade, o sistema de alimentação tem influência direta sobre a eficiência do sistema de acabamento e qualidade da carcaça (Maggioni et al., 2009; Prado et al., 2008b; Rotta et al., 2009a;).

A melhoria do nível nutricional pode proporcionar aumento no custo de produção, o que pode tornar a atividade de menor rentabilidade. Assim, quando se fala na terminação de bovinos em confinamento, um fator relevante que deve ser considerado é a produção de alimentos volumosos. A produção de volumosos de alta qualidade e produtividade é uma condição básica para a diminuição dos custos com alimentos concentrados, uma vez que a alimentação é a fração que apresenta maior custo na produção (Brondani et al., 2004; Missio et al., 2009; Pacheco et al., 2006).

Para se determinar a qualidade de um volumoso deve ser considerado o seu valor nutritivo, a sua interação com o consumo e o potencial de desempenho do animal (Jobim et al., 2007). Para isto, a ingestão de matéria seca, a conversão alimentar, o ganho de peso e o rendimento de carcaça são importantes variáveis que devem ser avaliadas (Ferreira et al., 2000).

Os volumosos mais utilizados no Brasil na terminação de bovinos em confinamento são as silagens de milho e de sorgo (Neumann et al., 2004). O sorgo (*Sorghum bicolor*) é uma das culturas que se destaca na produção de silagens, pois apresenta alta produtividade por área (Neumann et al., 2002), maior tolerância ao déficit hídrico e ao calor quando comparado ao milho, além de haver a possibilidade do cultivo de sua rebrota que proporciona até 60% da produção no primeiro corte. O valor nutritivo da silagem de sorgo equivale de 72 a 92% da silagem de milho (Demarchi et al., 1995). Mesmo assim, o sorgo ainda se destaca por ser um alimento de alto valor nutritivo, que apresenta alta concentração de carboidratos solúveis, essenciais à adequada fermentação lática da silagem. Neumann et al. (2004) constataram menor custo de produção da silagem de sorgo, o que juntamente com o maior ganho de peso refletiu em maior retorno econômico para a dieta composta por silagem de sorgo.

1.4. Glicerol na dieta de bovinos

O glicerol é considerado uma fonte energética que poderia substituir o milho na alimentação animal (Avila et al., 2011; Donkin e Doane, 2007; Farias et al., 2012a; Wang et al., 2009). Em função do baixo teor de proteína da glicerina (abaixo de 1%) para o balanceamento de uma dieta isoproteica e isoenergética, outra fonte de proteína deve ser disponibilizada às dietas.

A glicerina é utilizada principalmente nos problemas metabólicos em período de transição em vacas no pós-parto (DeFrain et al., 2004; Goff and Horst, 2001). O glicerol não metabolizado pelos microrganismos da flora ruminal é absorvido na corrente sanguínea. Ao ser absorvido para circulação sanguínea o glicerol é metabolizado no fígado a glicerol-3-fosfato. Com a ação da enzima glicerol-cnase, o glicerol livre é fosforilado no fígado a glicerol-3-fosfato e destinado à formação de triacilgliceróis, fosfolipídeos ou glicose em conjunto com ácidos graxos livres (Freetly e Ferrell, 2000). No fígado, rim e intestino delgado ocorrem a fosforilação do glicerol livre em presença de glicerol-cinase. Os triacilgliceróis são sintetizados pela adição de acil-CoA graxo ao glicerol-3-fosfato ou à diidroxiacetona-fosfato (Freetly and Ferrell, 2000). Os acil-CoA empregados na síntese dos triacilgliceróis são provenientes de ácidos graxos livres ativados pela ação das acil−CoA−sintetases. O glicerol-3-fosfato além de sua formação com o glicerol livre é sintetizado a partir da diidroxiacetona-fosfato gerada na glicólise ou formado a partir do glicerol pela ação da glicerol-cinase. A diidroxiacetona-fosfato é transformada em glicerol-3-fosfato em reação catalisada pela glicerol-3-fosfato-desidrogenase (Freetly e Ferrell, 2000).

A glicerina na dieta de ruminantes é classificada como uma fonte energética assimilável pelos microrganismos da flora ruminal e metabolizada no fígado (Freetly e Ferrell, 2000). Ao ser disponibilizado para o ruminante, a glicerina é rapidamente utilizada pelos microrganismos ruminais na formação de ácidos graxos voláteis – AGVs (DeFrain et al., 2004; Ferraro et al., 2009; Wang et al., 2009).

DeFrain et al. (2004) relataram que a inclusão de glicerina na dieta de vacas leiteiras proporcionou maior concentração de AGVs totais e de propionato, com redução da razão acetato:propionato, com tendência de aumento nas concentrações de butirato. Ferraro et al. (2009) avaliaram a produção de gases "*in vitro*" de três fontes de energia utilizando glicerol, propilenoglicol e melaço. A fermentação do glicerol resultou maior

volume de gás e metabolização mais lenta em comparação as outras fontes, além de reduzir a produção de acetato com ligeiro aumento dos ácidos propiônico e butírico.

A inclusão de glicerol (100, 200 e 300 g/animal/dia), em dietas para bovinos de corte (450 kg), determinou aumento linear na concentração de ácidos graxos voláteis no rúmen e, por consequência, redução no pH (Wang et al., 2009). Na realidade, houve aumento nos teores de propionato e butirato sem, todavia, alterar os níveis de acetato e, assim, ocorreu redução na razão acetato:propionato. Ainda, foi observado aumento na degradabilidade efetiva da matéria seca e a redução da degradabilidade da proteína bruta, mas a digestibilidade aparente dos nutrientes apresentou efeito quadrático, com nível de máxima com 200 g/animal/dia de glicerol, enquanto que os níveis de inclusão do glicerol, por sua vez, foram baixos (1 a 3% da matéria seca).

Parsons et al. (2009) observaram que com os níveis de glicerol de 4, 8, 12 e 16% houve redução linear para ingestão da matéria seca e para a gordura subcutânea na 12ª costela e as pontuações de marmoreio.

De acordo com Ilse et al. (2009), a inclusão de 0, 6, 12, e 18% de glicerina da dieta de bovinos confinados não influenciou o peso vivo final, ganho médio diário e a eficiência alimentar. Entretanto, o consumo de matéria seca diminuiu linearmente com dias de confinamento. Lage et al. (2010) relatam que a inclusão de até 6% de glicerina bruta melhora a conversão alimentar dos animais e reduz o custo do ganho de carcaça quando o preço do co-produto representa até 70% do preço do milho. A inclusão de glicerina influenciou o desempenho, consumo, digestibilidade e as características quantitativas da carcaça. O provável comprometimento no desempenho pode estar relacionado aos teores de extrato etéreo das dietas que apresentaram com aumento dos níveis de inclusão de glicerina e consequentemente pela inibição de bactérias celulolíticas. Gomes et al. (2011) observaram ser possível a adição de até 30% de glicerol na dieta total (100% de substituição do milho) de cordeiros em confinamento durante 60 dias sem alterar o desempenho animal, ingestão de alimentos e rendimento de carcaça.

1.5. Atividade biológica da própolis e utilização como aditivo na dieta de bovinos

Própolis é o nome genérico para a substância resinosa de composição complexa coletada pelas abelhas dos mais heterogêneos tipos de plantas. A palavra própolis é derivada do grego em que “pro” significa “em defesa de” e “polis*”* “cidade”, isto é, em

defesa da cidade ou da colmeia (Burdock, 1998; Marcucci, 1996). A própolis é coletada por abelhas a partir de diversas partes das plantas como brotos, botões florais, casca e exsudatos resinosos. Durante a coleta, as abelhas misturam a cera e a própolis coletada juntamente com a enzima 13 – glicosidase presente em sua saliva, acarretando a hidrólise dos flavonoides glicosilados até suas respectivas agliconas (Park et al., 1997). A própolis recolhida de uma colmeia, também conhecida como própolis bruta, apresenta em sua composição básica cerca de 50% de resinas vegetais, 30% de cera de abelhas, 10% de óleos essenciais, 5% de pólen e 5% de detritos de madeira e terra (Monti et al., 2006).

A resina contida na própolis é coletada na vegetação das cercanias da colmeia. O espectro de voo de uma abelha *A. mellifera* abrange um raio de cerca de 4 a 5 km em torno da colmeia, de onde abelhas campeiras coletam pólen e néctar para alimentação, bem como resina para a própolis. Dessa maneira, a composição da própolis é um reflexo direto da flora vegetal da qual se servem as abelhas (Burdock, 1998; Russo et al., 2002). Não são conhecidos os fatores que direcionam a preferência das abelhas coletoras de resina por uma determinada fonte vegetal, mas sabe-se que elas são seletivas nesta coleta (Salatino et al., 2005; Teixeira et al., 2005). Possivelmente, a escolha da planta onde a abelha coleta a própolis esteja relacionada com a atividade antimicrobiana da resina, uma vez que as abelhas utilizam a própolis como um antisséptico (Sahinler e Kaftanoglu, 2005). As abelhas usam a própolis para protegê-las contra insetos e microrganismos, empregando-a como antisséptico em finas camadas nas paredes internas das colmeias, para vedar buracos e rachaduras, reparar e fortalecer os favos de mel, proteger a entrada da colmeia, no preparo de locais assépticos para a postura da abelha rainha e na mumificação de insetos invasores (Bankova et al., 2000). A amplitude das atividades farmacológicas da própolis é maior em regiões tropicais do planeta e menor nas regiões temperadas, refletindo a diversidade vegetal destas regiões (Bankova, 2005).

As propriedades biológicas da própolis, obviamente, estão diretamente ligadas a sua composição química, e esta possivelmente é o maior problema para sua utilização em fitoterapia, tendo em vista que a sua composição química varia com a flora da região e época da colheita, com a técnica empregada, assim como com a espécie da abelha (grau de "africanização" da *Apis melífera*); conjunto de fatores que exerce enorme importância nas propriedades físicas, químicas e biológicas. A complexa composição química da própolis foi pioneiramente revelada pela técnica de cromatografia gasosa

acoplada à espectrometria de massa (CG/EM) o que permitiu a detecção de pelo menos 150 componentes (Greenaway et al., 1990). É considerada uma das misturas mais heterogêneas encontradas em fontes naturais, sendo que mais de 300 constituintes já foram identificados e/ou caracterizados em diferentes amostras de própolis (Burdock, 1998).

Os principais compostos químicos isolados da própolis podem ser organizados em alguns grupos principais como: ácidos e ésteres alifáticos, ácidos e ésteres aromáticos, açúcares, alcoóis, aldeídos, ácidos graxos, aminoácidos, esteroides, cetonas, charconas e di-hidrocharconas, flavonoides (flavonas, flavonóis e flavononas), terpenoides, proteínas, vitaminas B1, B2, B6, C, E, bem como diversos minerais. De todos esses grupos de compostos, certamente o que mais vem chamando a atenção dos pesquisadores é o dos flavonoides (Havsteen, 2002). Flavonoides são compostos fenólicos que compreendem um amplo grupo de substâncias naturais não sintetizadas por animais (Beecher, 2003; Manach et al., 2004). Cerca de 4.000 substâncias diferentes já foram listadas como flavonoides, entre elas apigenina, quercetina, hesperetina, rutina, luteolina, genisteina, daidzeina, antocianidina, kampferol etc. A presença e a concentração destes compostos é utilizada como índice de qualificação de amostras de própolis (Lu et al., 2004). A ingestão de flavonoides interfere em diversos processos fisiológicos, auxiliando na absorção e na ação de vitaminas, atuando nos processos de cicatrização como antioxidantes, além de apresentarem atividade antimicrobiana e moduladora do sistema imune (Williams et al., 2004). No entanto, apesar dos flavonoides serem os componentes da própolis mais extensivamente estudados, eles não são os únicos responsáveis pelas suas propriedades farmacológicas. Diversos outros compostos são relacionados com as propriedades medicinais da própolis (Awale et al., 2005).

Durante os últimos anos tem sido relatada "*in vitro"* a atividade antimicrobiana da própolis que se deve aos flavonoides, ácidos aromáticos e ésteres presentes na resina natural. A galangina, pinocembrina e pinostrombina são tidos como os flavonoides mais efetivos contra bactérias. Os ácidos ferúlicos e cafeíco também contribuem para a ação bactericida da própolis.

O mecanismo de atividade antimicrobiana é complexo e provavelmente baseado na inibição da RNA-polimerase bacteriana (Bosio et al., 2001), podendo decorrer de um efeito sinergístico entre flavonoides, hidroxiácidos e sesquiterpenos (Marcucci, 1995). Todas as pesquisas realizadas com substâncias isoladas de própolis demonstraram que

nenhum componente isolado tem uma atividade maior do que o extrato total inicial (Kujumgiev et al., 1999; Marcucci, 1996). Diversos pesquisadores têm demonstrado a atividade antibacteriana em culturas de *Staphylococcus aureus*, *Bacillus subtilis*, *Salmonella typhimurium*, *S. enteritides* etc. (Bankova et al., 1995). Ensaios de antibiose com a própolis, frente a dez bactérias Gram-positivas e 20 Gram-negativas, constataram que a atividade antibacteriana da própolis é mais efetiva sobre as Gram-positivas (Antunes et al., 1996). A maioria dos estudos não detecta a inibição no crescimento de *Candida albicans* em cultura, embora poucos estudos detenham constatada a inibição desta levedura pela própolis. A inibição de crescimento de *Helicobacter pylori* foi observada por Boyanova et al. (2005 e Ohsugi et al. (1997). Desta forma, a inibição de úlceras gástricas através da ingestão de própolis, possivelmente, está relacionada à atividade anti-helicobacter, já que esta bactéria é reconhecidamente associada às úlceras. Ensaios "*in vitro"* avaliaram o efeito da própolis sobre a proliferação de vírus da gripe de aves (Kujumgiev et al., 1999) que resultaram na inibição destes vírus. Todavia, ainda não existem relatos do estudo da ação antibacteriana da própolis sobre as diferentes bactérias anaeróbicas ruminais, nem quais seriam tolerantes a sua administração, mas existem indícios que há efeito o qual é medido pelos produtos de fermentação dessas bactérias. Assim, são necessários estudos para conhecer como a própolis atua no ambiente ruminal.

Para conhecer os efeitos do extrato de própolis sobre a microbiota ruminal, Broudiscou et al. (2000) testaram o efeito de 13 extratos secos de plantas com alto teor de flavonoides e própolis sobre a fermentação e metanogênese em cultura contínua de microrganismos ruminais e observaram que a própolis aumentou a produção de propionato (fonte de energia) em 10,3% e diminuiu a população de protozoários. Stradiotti Júnior et al. (2004b) estudaram a ação da própolis (30% de própolis em álcool 70% ou álcool 99,6%) sobre a desaminação de aminoácidos e a fermentação ruminal, e observaram que a própolis foi eficiente em inibir a atividade de desaminação pelos microrganismos ruminais tanto "*in vitro"* quanto "*in vivo*", embora não tenha alterado a proporcionalidade entre os ácidos graxos voláteis. A própolis aumentou a concentração total dos mesmos, o que, em linhas gerais, confere aos ruminantes maiores possibilidades de se manterem e produzirem a partir de uma mesma dieta. Stradiotti Júnior et al. (2004a) observaram que o extrato de própolis inibiu a produção de gases provenientes da fermentação de diferentes alimentos, e ainda observaram que a maior dosagem de extrato de própolis (66,7%) mostrou-se eficiente na produção final total de

gases tanto para carboidratos fibrosos quanto para não fibrosos. Observaram que o extrato não afetou o consumo de matéria seca, o pH e a amônia no rúmen e a concentração de proteína microbiana no líquido ruminal de bovinos alimentados com volumoso. Todavia, a própolis inibiu a desaminação pelos microrganismos ruminais, indicando que pode reduzir o nível ruminal de amônia, em situações de dietas contendo altas taxas de proteína degradável e carboidrato fermentável. Além do possível efeito benéfico na redução da razão acetato:propionato e produção de metano.

Com a finalidade de testar o extrato de própolis sobre a produção de amônia e degradabilidade "*in vitro"* da proteína bruta de diferentes fontes de nitrogênio, Oliveira et al. (2004) observaram que a própolis foi eficiente em reduzir a produção de amônia das diferentes fontes de nitrogênio, assim como foi mais eficiente que a monensina em reduzir a atividade de desaminação. Em experimento sequencial foi analisado o efeito da monensina e da própolis (30% de própolis em álcool 70% (p/V), diluição 1:1) sobre a atividade de fermentação de aminoácidos "*in vitro"* pelos microrganismos ruminais. Oliveira et al. (2006) observaram que a própolis apresentou-se mais eficiente que a monensina em reduzir a produção de amônia de culturas de microrganismos ruminais em meio contendo caseína hidrolisada. A produção de amônia normalizou-se assim que o ionóforo monensina foi removido do meio de cultura, provavelmente em razão do restabelecimento da população de bactérias produtoras de amônia, comprovando que esse antibiótico apenas inibe estes microrganismos. No tratamento com própolis, a produção de amônia manteve-se em níveis baixos mesmo após sua remoção do meio de cultura, sugerindo que a população proteolítica fosse eliminada pela própolis.

Com o objetivo de avaliar se o óleo pode agir como aditivo alimentar em conjunto ou não com o extrato de própolis Lana et al. (2005) testaram óleo de soja (4% de óleo de soja na MS) juntamente com a própolis (30% de própolis em álcool 70% – 10 mL por dia) na alimentação de cabras leiteiras e registraram que o óleo de soja reduz os consumos de matéria seca e de fibra em detergente neutro na presença de extrato etanólico de própolis e aumenta os teores de gordura, proteína e sólidos totais no leite de cabra, aumenta o pH e reduz a razão acetato:propionato no líquido ruminal. O extrato de própolis interfere pouco no consumo, na digestibilidade, produção e composição do leite e nos parâmetros de fermentação ruminal de cabras em lactação. Em continuidade à análise de possíveis aditivos naturais para a nutrição de ruminantes, Lana et al. (2007) avaliaram óleo de soja e própolis na alimentação de cabras leiteiras quanto ao consumo de matéria seca e de nutrientes e parâmetros de fermentação ruminal. A própolis foi

testada tanto em extrato (0,0; 1,0; 2,0; 4,0; 8,0 e 12,0 mL/animal/dia, 50% p/V de própolis moída em solução alcoólica a 70% em água); quanto em própolis bruta moída (0,0; 0,5; 1,0; 2,0; 4,0 e 6,0 g/animal/dia); os níveis de óleo de soja testados foram 0,0; 1,5; 3,0; 4,5; 6,0; e 7,5% da MS. Observou-se que não houve efeito de níveis de óleo de soja, extrato etanólico de própolis e própolis bruta moída sobre o consumo de MS e de nutrientes e sobre os parâmetros ruminais estudados.

Com a intenção de avaliar a influência do extrato de própolis sobre o desempenho de vacas leiteiras, Stelzer et al. (2009) avaliaram efeito de níveis de concentrado e própolis (30% de própolis em álcool 70% (p/V) em dose de 34 mL por dia) em rações com 20% e 40% de concentrado e observaram que a própolis líquida testada não interferiu sobre o desempenho. Também Freitas et al. (2009) trabalharam com extrato etanólico de própolis (extrato de própolis misturado à ração concentrada e seca em estufa de ventilação forçada a 55ºC) na alimentação de vacas leiteiras e observaram que a adição de própolis apresentou efeito somente sobre a produção de leite e teores de proteína do leite, não apresentando efeito sobre a produção de leite corrigido para 4% de gordura nem sobre o número de células somáticas e porcentagem de gordura do leite.

Testando adições de diferentes extratos de própolis secos em três teores alcoólicos e quatro concentrações de própolis, monensina sódica e testemunha em dietas com relação volumoso:concentrado 50:50%, Prado et al. (2010) observaram que o maior valor de digestibilidade foi para a dieta com adição de própolis e os menores valores foram para a dieta com monensina seguido da dieta testemunha.

1.6. Extratos vegetais de plantas na dieta animal

Muita atenção é dada para o consumo de carne e seus derivados com funções fisiológicas que promovam o bem-estar animal, humano e que previna riscos de doenças (Benchaar et al., 2008). Melhora da qualidade da carne pode ser realizada adicionando compostos funcionais incluindo ácido graxo conjugado, vitamina E, ácidos graxos ômega 3 e 6, selênio e produtos naturais na alimentação animal para melhorar o ganho em peso, qualidade da carcaça e composição físico química da carne (Zhang et al., 2010). Ingredientes funcionais como proteínas vegetais, condimentos, ervas, pimentas, leveduras podem ser diretamente incorporado à carne e seus derivados durante o processamento para melhorar o valor funcional para os consumidores. Como mencionado por Roberfroid. (2002), o alimento funcional deveria “conter um

componente com efeito seletivo sobre uma ou várias funções do organismo cujo efeito positivo pode ser justificado como funcional (fisiologicamente) ou mesmo saudável". Três exigências seriam necessárias para atender essa demanda: 1. derivado de produtos naturais, 2. ser consumido como parte da dieta diária e 3. envolver processos específicos sobre a saúde humana, como retardar o envelhecimento, prevenir o risco de doenças e melhorar a resistência imunológica (Jiménez-Colmenero et al., 2001).

A carne e seus derivados são importantes fontes de proteína, lipídeos, aminoácidos essenciais, minerais, vitaminas e outros nutrientes (Biesalski, 2005). Cada vez mais os consumidores exigem produtos mais saudáveis e produtos com reduzidos níveis de lipídeos, colesterol, reduzido teor de sódio, nitritos, melhor composição de ácidos graxos. O enriquecimento da carne com compostos bioativos e o efeito de substâncias sobre os produtos cárnicos como carnosina, anserina, L-carnitin, glutathiona, taurina e creatina sobre a saúde humana estão sendo estudadas (Arihara, 2004).

A aceitação do consumidor sobre os alimentos funcionais varia amplamente no mundo, dependendo da sua origem social, econômica, geográfica, política, cultural, religiosa e étnica (Jiménez-Colmenero et al., 2001). O Japão foi o primeiro país que desenvolveu a ideia de alimentos funcionais e estabeleceu um regulamento para uso desses produtos (Hardy, 2000; Kwak e Jukes, 2001). Entre os anos de 1988 e 1998 mais de 1.700 produtos funcionais foram introduzidos no mercado japonês que resultou num faturamento de 14 bilhões de dólares (Menrad, 2003).

Por outro lado, o uso rotineiro de antibióticos e promotores de crescimento na alimentação animal tem preocupado a saúde pública (Benchaar et al., 2008). As restrições impostas à utilização de antibióticos na alimentação animal têm como base preocupações ao desenvolvimento de microrganismos resistentes pelo uso inadequado de ionóforos comprometendo a ação terapêutica dos antibióticos em humanos (Dewulf et al., 2007; Guzmán-Blanco et al., 2000; Ray et al., 2007; Russell e Houlihan, 2003).

Em ruminantes, a inclusão de ionóforos na dieta tem como objetivo manipular a fermentação ruminal para melhorar os processos benéficos (seleção das bactérias Gram-negativas) e minimizar ou excluir processos ineficientes (produção de gás metano – CH_4 e gás carbônico – CO_2). De modo geral, a ação dos ionóforos nas bactérias Gram-positivas modifica o fluxo de íons na membrana celular (Bergen e Bates, 1984; Russell e Strobel, 1989). A ação de ionóforos sobre a população de bactérias Gram-positivas (*Peptostreptococcus anaerobius*, *Clostridium sticklandii* e *Clostridium aminophilum*)

desempenha papel importante na fermentação de aminoácidos, faz com que reduza a produção de amônia ruminal (Russell e Strobel, 1989; Russell e Wallace, 1997). A seleção das bactérias Gram-negativas está relacionada à dupla camada de membrana celular, constituídas por lipoproteínas e lipopolissacarídeos que impedem a passagem das moléculas da monensina sódica (Russell e Wallace, 1997).

Extratos naturais de plantas contêm ampla variedade de compostos com diferentes funções e mecanismos de ação. Os compostos naturais atuam de forma específica de acordo com sua estrutura química ligando-se a sítios específicos na célula bacteriana, acarretando na desintegração da membrana citoplasmática, alterando o fluxo de elétrons e coagulação do conteúdo celular. Dentre os compostos que apresentam características de ação antimicrobiana presentes nas plantas, encontra-se a classe dos compostos fenólicos (fenóis simples – cetocol, ácidos fenólicos – ácido anacárdico, cinâmico, cafeico e ricíninoleico, quinonas – hipericina, flavonóis – totarol, taninos – Elagitanina, Cumarinas – Warfarin); óleos essenciais e terpenoides (Capsaicina, Thimol Mentol, Carvacrol, Cânfora, Eugenol); alcaloides (Berberina Piperina Teofilina); polipetídeos e lectinas (Manose-aglutinina Fabatina Thionina); e poliacetilenos (Heptadeca-dieno-diol), cada um com seu respectivo mecanismo de ação (Cichewicz e Thorpe, 1996; King e Tempesta, 1994; Meyer et al., 1997; Peres et al., 1997; Perrett et al., 1995; Stern et al., 1996; Zhang et al., 2010). Compostos fenólicos determinam sua capacidade de atuar em função do grau de metoxilação e o número de hidroxilas para atuarem como agentes redutores contra o estresse oxidativo (Oldoni, 2007). O termo ácido fenólico é utilizado a fenóis associados a um ácido carboxílico funcional.

O cajueiro é uma planta nativa da Amazônia e Nordeste do Brasil, denominada cientificamente de *Anacardium occidentale* L. Além do consumo do fruto e do suco são usados na indústria outros derivados do caju. No processo industrial para obtenção da amêndoa origina-se o líquido da castanha de caju (LCC). Utilizado para diversas aplicações na indústria (Calo et al., 2007; Trevisan et al., 2006b), o LLC possui altas concentrações de lipídeos fenólicos que o torna a maior fonte de origem natural dos ácidos anacárdico, cardol e cardonol. As concentrações dos ácidos variam em função do processo de obtenção da amêndoa (Das et al., 2004; Lubi e Thachil, 2000; Mazzetto et al., 2009). De acordo com Mazzetto et al. (2009) a concentração dos ácidos graxos no LLC natural varia de 71,70 a 82,00% para o ácido anacárdico, de 13,80 a 20,10% para o ácido cardol e 1,60 a 9,20% para o ácido cardonol. O LLC técnico apresenta teores que variam de 1,09 a 1,75% para ácido anacárdico, de 3,80 a 18,86% para o ácido cardol e

67,82 a 94,60% para o ácido cardanol. De modo geral, o LLC técnico é obtido com temperaturas elevadas alterando a estrutura química dos ácidos graxos pela reação de descarboxilação originando maiores teores do ácido cardanol.

A planta mamona denominada de *Ricinus communis* L. está disseminada principalmente na região Nordeste pelas características de adaptação ao clima seco com elevadas temperaturas (Devide et al., 2010; Nóbrega, 2008). De acordo com Costa et al. (2004), o óleo extraído da semente da mamona varia de 35 a 55% apresentando altos teores do ácido ricinoleico (cis-12-hydroxyoctadeca-ácido-9-enoico). A concentração do ácido ricinoleico no óleo da semente de *Ricinus communis L*. corresponde de 85 a 90%, (Vaisman et al., 2008) seguido de outros ácidos graxos em menor proporção como o ácido linoleico (4,2%), ácido oleico (3,0%), esteárico (1,0%), palmítico (1,0%), ácido hidroxi esteárico (0,7%), ácido linolênico (0,3%) e ácido eicosanoico (0,3%) (Ogunniyi, 2006). De acordo com Ogunniyi (2006), o processo de extração do óleo de mamona pode ser obtido por prensagem mecânica e utilização de solventes, alterando sua composição química. O principal constituinte do óleo de *Ricinus communis* é o ácido ricinoleico. Segundo Costa et al. (2009), a presença de hidroxila em sua estrutura química aumenta sua densidade e viscosidade em comparação a outros óleos. A versatilidade do ácido ricinoleico permite a utilização do óleo na indústria farmacêutica e cosmética para fabricação de impermeabilizantes, lubrificantes, tintas, sabões, aditivos para polímeros e na produção do biodiesel (Chechetto et al., 2010; Costa et al., 2004; Santos et al., 2007; Zuchi et al., 2010). O óleo de *Ricinus communis L*. é caracterizado pela presença de uma hidroxila (cis-12-hydroxyoctadeca-9-enoic acid) o qual desempenha ação antimicrobiana semelhante ao ionóforo e ação anti-inflamatória (Maenz e Forsyth, 1982; Novak et al., 1961).

Os óleos *Anacardium occidentale* e *Ricinus communis* L. apresentam características desejáveis para o setor industrial em diversos seguimentos. Seus compostos podem ser utilizados tanto como produtos bioativos quanto como agentes antimicrobianos. De modo geral, compostos com hidroxila em sua estrutura permitem interação com proteínas da membrana celular bacteriana ocorrendo a ruptura e morte do microrganismo (Kubo et al., 2003; Mason e Wasserman, 1987; Novak et al., 1961; Toda et al., 1992). O óleo de *Anacardium occidentale* é composto pelos ácidos anacárdico, cardol e cardanol os quais possuem hidroxila em sua estrutura química (Trevisan et al., 2006a) que desempenham atividade antimicrobiana (Himejima e Kubo, 1991; Kubo et al., 2003; Muroi et al., 1993) e ação antioxidante (Kubo et al., 2006). Nos estudos

realizados por Muroi et al. (1993), os ácidos anacárdicos apresentam atividade antimicrobiana principalmente em bactérias Gram-positivas. De acordo com Lima et al. (2000), os ácidos anacárdicos presentes no óleo de caju apresentaram atividade antimicrobiana sobre os microrganismos *Streptococcus mutans*, *Staphylococcus aureus*, *Candida albicans* e *Candida utilis*, Houve maior atividade inibitória sobre a bactéria Gram-positiva *Streptococcus mutans*. A amostra de ácidos anacárdicos inibiu o crescimento microbiano no número de células/mL com aumento da concentração dos ácidos anacárdicos. Em outro trabalho, Muroi et al. (1993) também relataram atividade antibicrobiana dos ácidos anacárdicos, com maior efeito sobre as bactérias Gram-positivas.

O sinergismo dos compostos presentes no óleo de *Anacardium occidentale* e *Ricinus communis* L. apresentam grande potencial para ser utilizado como aditivo na manipulação da fermentação ruminal em substituição dos ionóforos convencionais utilizados na terminação de bovinos. A adição de óleos funcionais (*Anacardium occidentale* e *Ricinus communis* L) na dieta de bovinos auxiliam o processo de fermentação e manutenção do pH ruminal e melhora a eficiência microbiana.

1.7. Idade de castração

O sexo dos animais tem importância sobre a modulação do crescimento, desenvolvimento corporal e composição da carcaça dos bovinos (Prado et al., 2009a; Rotta et al., 2009b). Comportamento agressivo dos animais, carne mais dura e mais escura de animais não castrados têm sido algumas das razões que determinam a castração dos bovinos. Da mesma forma, os consumidores, sobretudo, as donas de casas são avessas à carne de bovinos não castrados. As diferenças na produtividade entre animais não castrados e castrados manifestam-se principalmente após a puberdade (Knight et al., 2000; 1999), que ocorre aos dez meses em animais europeus (Lunstra et al., 1978) e 18 meses nos animais zebuínos, embora alguns fatores como raça (Lunstra et al., 1978) e status nutricional podem alterar a idade à puberdade (NRC, 2000). Durante o período de puberdade, os testículos produzem andrógenos primários, sendo a testosterona a mais potente (Arey, 1965; Henricks, 1991). Os andrógenos são os responsáveis pelo desenvolvimento dos órgãos secundários, características sexuais secundárias e comportamento animal (Sadleir, 1973). Todavia, os andrógenos promovem o desenvolvimento muscular pelo aumento da retenção de nitrogênio nos

tecidos (Galbraith, 1978). Essas propriedades anabólicas dos andrógenos, principalmente a testosterona, melhoram o ganho médio diário dos animais não castrados em até 19% em relação aos animais castrados, com aumento de menos de 5% de ingestão de alimentos (Prado et al., 2009c; Rotta et al., 2009b).

Em razão do maior ganho médio diário e melhor eficiência alimentar dos animais não castrados, Knight et al. (1999) propuseram a castração após a puberdade dos animais, seguido de período de terminação dos animais castrados, como ferramenta de manejo para aproveitar os benefícios dos hormônios secundários durante o período da puberdade sobre a qualidade da carne. Todavia, em função da redução do ganho em peso dos animais castrados durante o período de terminação, estes não apresentaram o mesmo ganho em peso do que os animais não castrados (Field, 1971; Knight et al., 2000; 1999). Os métodos mais comuns de castração são os cirúrgicos e utilização de burdizzo (Fisher et al., 1996; Henricks, 1991; Restle et al., 1996). O cortisol plasmático é uma das medidas da resposta animal quando estes são submetidos à castração (Chase et al., 1995; Fisher et al., 1996). De modo geral, animais não castrados são mais agressivos do que os animais castrados, também animais com predominância de sangue zebuíno são mais agressivos.

1.8. Níveis de proteína na dieta animal

Bovinos de grande porte terminados logo após o desmame têm rápido ganho em peso e ótima eficiência alimentar, depositando grande percentagem de proteína e tecido muscular (Galyean, 1996). Estes animais apresentam grande exigência de proteína metabolizável que pode estar acima do fornecimento da proteína microbiana via fermentação ruminal e proteína escape da dieta. A suplementação de proteína que escapa do rúmen tem melhorado a eficiência alimentar, sobretudo, no início do período de alimentação (Sindt et al., 1993). Glúten de milho úmido e silagem de milho úmida são dois ingredientes usados na dieta de bovinos em terminação, mas são fontes pobres de proteína escape quando comparado com o milho seco (Sindt et al., 1993). O grão de milho é o principal constituinte da dieta de bovinos em confinamento com dietas de alto grão. O nível de proteína da dieta pode não atender às exigências dos animais de alta produção (NRC, 2000). As respostas dos bovinos suplementados com proteína escape têm sido variadas em dieta de alto grão (Galyean, 1996).

1.9. Razão lisina:metionina

O conceito de melhorar o desempenho animal, aumentando a eficiência do uso da proteína na alimentação de ruminantes pelo balanço eficiente da dieta com a inclusão de níveis específicos de aminoácidos não é recente (Galyean, 1996; NRC, 2000). Na realidade, o balanceamento de dietas de suínos e aves para atender suas exigências específicas de proteína metabolizável e aminoácidos data de 40 anos atrás. Estes estudos foram responsáveis pelo rápido aumento da produção e redução de custos com a inclusão de aminoácidos sintéticos na dieta de monogástricos. Da mesma forma, parece intuitivo que os benefícios do balanceamento de dietas com aminoácidos específicos poderia igualmente ser importante na dieta de ruminantes, uma vez que isso foi possível na dieta de não ruminantes. A razão mais óbvia porque os estudos de aminoácidos em ruminantes foram menos relevantes do que em animais não ruminantes é devido ao fato da composição de aminoácidos da dieta ser modificado pela microbiota ruminal e alterando a composição dos aminoácidos que entram no duodeno (Van Soest, 1994). Além disso, é provável que sob muitas práticas de sistema de alimentação a proporção de proteína que entra no intestino delgado é de origem bacteriana e de protozoários do rúmen (NRC, 2000). Todavia, há alguma evidência de que o perfil em aminoácidos da microbiota ruminal pode variar. Há pouca evidência para sugerir que isso seria importante (Van Soest, 1994).

A combinação da variabilidade da degradabilidade ruminal e a importante contribuição da proteína microbiana sobre a quantidade de proteína total que entra no duodeno tornam evidentes que o perfil desta proteína será diferente do perfil da proteína da dieta. Outra razão que torna difícil de mensurar os benefícios em ruminantes em comparação aos não ruminantes é de que não é possível manipular o perfil de aminoácidos fornecendo aminoácidos sintéticos por serem degradados no rúmen (Robinson, 2010). Este fato tem criado necessidade de encapsular, colocar em matrizes, desenvolver tecnologias para evitar a degradação dos aminoácidos pelos microrganismos do rúmen, para liberá-los e para serem absorvidos no intestino delgado. Entretanto, as dificuldades para desenvolver essas tecnologias têm mais de 30 anos de frustrações. Os esforços para encapsular estes produtos falharam em razão da resistência dos produtos encapsulados para as indústrias de alimentos, baixa estabilidade dos produtos em dietas ricas em silagem, reatividade de alguns aminoácidos com cobertura de polímeros que os tornam mais instáveis, degradação de alguns produtos no rúmen,

inconsistência da degradação pós-ruminal, dificuldades para obter regulamentação dos produtos cobertos com polímeros e alto custo de produção (Robinson, 2010). Por outro lado, esforços para criar matrizes estáveis no meio ruminal com ácidos graxos saturados (C:16 e C:18) que teve início na década de 90 mostraram algum sucesso (Sacadura et al., 2008). Na realidade, é virtual que alguns aminoácidos ruminalmente protegidos como metionina e lisina poderão ser comercializados em breve (Robinson, 2010). Assim, a grande questão é se a nutrição dos animais ruminantes (carne e leite) progrediu de forma consistente para saber se os aminoácidos protegidos serão liberados e absorvidos no intestino delgado para justificar sua utilização em função do elevado custo destes produtos.

1.10 Referências bibliográficas

Abrahão, J.J.S., Marques, J.A., Macedo, L.M., Prado, J.M., Visantainer, J.V., Prado, I.N., 2008. Composição química e perfil de ácidos graxos do músculo Longissimus de bovinos de diferentes grupos genéticos terminados em confinamento. Acta Scientiarum. Animal Sciences 30, 443-449.

Abrahão, J.J.S., Prado, I.N., Marques, J.A., Perotto, D., Lugão, S.M.B., 2006. Avaliação da substituição do milho pelo resíduo seco da extração da fécula de mandioca sobre o desempenho de novilhas mestiças em confinamento. Rev. Bras. Zootec. 35, 512-518.

Antunes, R.M.P., Catao, R.M.R., Cevallos, B.S.O., 1996. Antimicrobial activity of propolis. Revista Brasileira de Farmácia 77, 15-18.

Arey, L.B., 1965. Developmental Anatomy. A Textbook andLaboratory Manual of Embriology, In: Company, W.S. (Ed.), Philadelphia.

Aricetti, J.A., Rotta, P.P., Prado, R.M., Perotto, D., Moletta, J.L., Matsushita, M., Prado, I.N., 2008. Carcass characteristics, chemical composition and fatty acid profile of *Longissimus* muscle of bulls and steers finished in a pasture system. Asian-Australasian Journal of Animal Science 21, 1441-1448.

Arihara, K., 2004. Functional foods, Encyclopedia of Meat Sciences, Academic Press, pp. 492-499.

Avila, J., Chaves, A., Hernandez-Calva, M., Beauchemin, K., McGinn, S., Wang, Y., Harstad, O., McAllister, T., 2011. Effects of replacing barley grain in feedlot diets with increasing levels of glycerol on *in vitro* fermentation and methane production. Animal Feed Science and Technology 166, 265-268.

Awale, S., Shrestha, S.P., Tezuka, Y., Ueda, J., Matsushige, K., Kadota, S., 2005. Neoflavonoids and related constituents from Nepalese propolis and their nitric oxide production inhibitory activity. J. Nat. Prod. 68, 858-864.

Bankova, V., 2005. Chemical diversity of propolis and the problem of standardization. J. Ethnopharmacol. 100, 114-117.

Bankova, V., Christov, R., Kujumgiev, A., Marcucci, M., Popov, S., 1995. Chemical composition and antibacterial activity of Brazilian propolis. Zeitschrift fur Naturforschung C, Journal of biosciences 50, 167.

Bankova, V.S., Castro, S.L., Marcucci, M.C., 2000. Propolis: recent advances in chemistry and plant origin. Apidologie 31, 3-16.

Beecher, G.R., 2003. Overview of dietary flavonoids: nomenclature, occurrence and intake. The Journal of nutrition 133, 3248S-3254S.

Benchaar, C., Calsamiglia, S., Chaves, A.V., Fraser, G.R., Colombatto, D., McAllister, T.A., Beauchemin, K.A., 2008. A review of plant-derived essential oils in ruminant nutrition and production. Anim. Feed Sci. Technol. 145, 209-228.

Bergen, W.G., Bates, D.B., 1984. Ionophores: Their Effect on Production Efficiency and Mode of. Journal of Animal Science 58, 1465-1483.

Biesalski, H.K., 2005. Meat as a component of a healthy diet–are there any risks or benefits if meat is avoided in the diet? Meat Sci. 70, 509-524.

Bosio, K., Avanzini, C., D'avolio, A., Ozino, O., Savoia, D., 2001. In vitro activity of propolis against Streptococcus pyogenes. Lett. Appl. Microbiol. 31, 174-177.

Boyanova, L., Gergova, G., Nikolov, R., Derejian, S., Lazarova, E., Katsarov, N., Mitov, I., Krastev, Z., 2005. Activity of Bulgarian propolis against 94 Helicobacter pylori strains in vitro by agar-well diffusion, agar dilution and disc diffusion methods. J. Med. Microbiol. 54, 481-483.

Brondani, I.L., Sampaio, A.A.M., Restle, J., Bernardes, R., Pacheco, P.S., Freitas, A.K., Kuss, F., Peixoto, L.A.O., 2004. Aspectos quantitativos de carcaças de bovinos de diferentes raças, alimentados com diferentes níveis de energia. Rev. Bras. Zootec. 33, 978-988.

Broudiscou, L.P., Papon, Y., Broudiscou, A.F., 2000. Effects of dry plant extracts on fermentation and methanogenesis in continuous culture of rumen microbes. Anim. Feed Sci. Technol. 87, 263-277.

Burdock, G.A., 1998. Review of the biological properties and toxicity of bee propolis (propolis). Food Chem. Toxicol. 36, 347-363.

Calo, E., Maffezzoli, A., Mele, G., Martina, F., Mazzetto, S.E., Tarzia, A., Stifani, C., 2007. Synthesis of a novel cardanol-based benzoxazine monomer and

environmentally sustainable production of polymers and bio-composites. Green Chemistry 9, 754-759.

Chase, C.C., Larsen, R.E., Randel, R.D., Hammond, A.C., Adams, E.L., 1995. Plasma cortisol and white blood cell responses in different breeds of bulls: a comparison of two methods of castration. J. Anim. Sci. 73, 975-980.

Chechetto, R.G., Siqueira, R., Gamero, C.A., 2010. Balanço energético para a produção de biodiesel pela cultura da mamona (*Ricinus communis* L.). Revista Ciência Agronômica 41, 546-553.

Cichewicz, R.H., Thorpe, P.A., 1996. The antimicrobial properties of chile peppers (Capsicum species) and their uses in Mayan medicine. J. Ethnopharmacol. 52, 61-70.

Costa, H.M., Ramos, V.D., Abrantes, T.A.S., 2004. Efeito do óleo de manona em composições de borracha natural contendo sílica. Polímeros: Ciência e Tecnologia 14, 46-50.

Costa, T.L., Martins, M.E.D., Beltrão, N.A.E.M., Marques, L.F., Paixão, F.J.R., 2009. Características do óleo de mamona da Cultivar BRS-188 Paraguaçu. Revista Brasileira de Tecnologia Aplicada nas Ciências Agrárias 1.

DeFrain, J., Hippen, A., Kalscheur, K., Jardon, P., 2004. Feeding glycerol to transition dairy cows: Effects on blood metabolites and lactation performance. Journal of dairy science 87, 4195-4206.

Demarchi, J., Boin, C., Braun, G., 1995. A cultura do sorgo (Sorghum bicolor L. Moench) para a produção de silagens de alta qualidade. Zootecnia, Nova Odessa 33, 111-136.

Devide, A.C.P., Castro, C.M., Santos, R.D.F., Henriqueanacleto, A., 2010. Plantio direto de mamona 'IAC 80' com culturas alimentares. Cienc. Agrotecnol. 34, 653-659.

Dewulf, J., Catry, B., Timmerman, T., Opsomer, G., de Kruif, A., Maes, D., 2007. Tetracycline-resistance in lactose-positive enteric coliforms originating from Belgian fattening pigs: Degree of resistance, multiple resistance and risk factors. Prev. Vet. Med. 78, 339-351.

Dian, P.H.M., Prado, I.N., Valero, M.V., Rotta, P.P., Prado, R.M., Silva, R.R., Bertipaglia, L.M.A., 2010. Levels of replacing corn by cassava starch on performance and carcass characteristics of bulls finished in feedlot. Semin. Cienc. agrar. 31, 497-506.

Donkin, S.S., Doane, P., 2007. Glycerol as a feed ingredient in dairy rations, Proceeding from the Tri-State Dairy Nutrition Conference, Purdue, pp. 97-103.

Ducatti, T., Prado, I.N., Rotta, P.P., Prado, R.M., Perotto, D., Maggioni, D., Visentainer, J.V., 2009. Chemical composition and fatty acid profile in

crossbred (*Bos taurus vs. Bos indicus*) young bulls finished in a feedlot. Asian-Australas. J. Anim. Sci. 22, 433-439.

El-Memari Neto, A.C., Zeoula, L.M., Prado, I.N., Caldas Neto, S.F., Kazama, R., Oliveira, F.C.L.O., 2003. Suplementação de novilhos nelore em pastejo de Brachiaria brizantha com diferentes níveis e fontes de concentrado. Revista Brasileira de Zootecnia 32, 1945-1955.

FAPRI, 2013. Food and Agricultural Policy Research Institute. Iowa State University and University of Missouri-Columbia Ames, IA, USA http://www.fapri.iastate.edu/tools/outlook.aspx

Farias, M.S., Prado, I.N., Valero, M.V., Zawadzki, F., Silva, R.R., Eiras, C.E., Rivaroli, D.C., Lima, B.S., 2012a. Níveis de glicerina para novilhas suplementadas em pastagens: desempenho, ingestão, eficiência alimentar e digestibilidade. Semin. Cienc. agrar. 33, 1177-1188.

Farias, M.S., Silva, R.R., Zawadzki, F., Eiras, C.E., Lima, B.S., Prado, I.N., 2012b. Glycerin levels for crossbred heifers supplemented in pasture: intake behavior. Acta Scientiarum.Animal Sciences 34, 63-69.

Ferraro, S.M., Mendoza, G.D., Miranda, L.A., Gutiérrez, C.G., 2009. *In vitro* gas production and ruminal fermentation of glycerol, propylene glycol and molasses. Anim. Feed Sci. Technol. 154, 112-118.

Ferreira, M.A., Filho, S.C.V., Muniz, E.B., Veras, A.S.C., 2000. Características das carcaças, biometria do trato gastrintestinal, tamanho dos órgãos internos e conteúdo gastrintestinal de bovinos F1 Simental x Nelore alimentados com dietas contendo vários níveis de concentrado. Rev. Bras. Zootec. 29, 1174-1182.

Field, R.A., 1971. Effect of castration on meat quality and quantity. J. Anim. Sci. 32, 849-858.

Fisher, A.D., Crowe, M.A., Varga, M.E.A., Enright, W., 1996. Effect of castration method and the provision of local anesthesia on plasma cortisol, scrotal circumference, growth, and feed intake of bull calves. J. Anim. Sci. 74, 2336-2343.

Freetly, H., Ferrell, C., 2000. Net flux of nonesterified fatty acids, cholesterol, triacylglycerol, and glycerol across the portal-drained viscera and liver of pregnant ewes. J. Anim. Sci. 78, 1380-1388.

Galbraith, H., Demspter, D.G., Miller, T.B. , 1978. A note on the effect of castration on the growth performance and concentrations of some blood metabolites and hormones in British Friesian male cattle. Animal Production 26, 339-342.

Galyean, M.L., 1996. Protein levels in beef cattle finishing diets: industry application, university research, and systems results. J. Anim. Sci. 74, 2860-2870.

Goff, J., Horst, R., 2001. Oral glycerol as an aid in the treatment of ketosis/fatty liver complex. J. Dairy Sci 84.

Gomes, M.A.B., Moraes, G.V., Mataveli, M., Macedo, F.A.F., Carneiro, T.C., Rossi, R.M., 2011. Performance and carcass characteristics of lambs fed on diets supplemented with glycerin from biodiesel production. Rev. Bras. Zootec. 40, 2211-2219.

Greenaway, W., May, J., Scaysbrook, T., Whatley, F., 1990. Identification by gas chromatography-mass spectrometry of 150 compounds in propolis. Zeitschrift für Naturforschung, C 46, 111-121.

Guzmán-Blanco, M., Casellas, J.M., Silva Sader, H., 2000. Bacterial resistance to antimicrobial agents in Latin America: The giant is awakening. Infect. Dis. Clin. North Am. 14, 67-81.

Hardy, G., 2000. Nutraceuticals and functional foods: introduction and meaning. Nutrition 16, 688-689.

Havsteen, B.H., 2002. The biochemistry and medical significance of the flavonoids. Pharmacol. Ther. 96, 67-202.

Henricks, D.M., 1991. Biochemistry and physiology of the gonadal hormones, In: Cupps, P.T., Animals. Academic Press, I., San Diego, CA, pp. 81–118. (Eds.), Reprod. Domest. Anim., Academic Press, Inc., San Diego, pp. 81-118.

Himejima, M., Kubo, I., 1991. Antibacterial agents from the cashew Anacardium occidentale (Anacardiaceae) nut shell oil. J. Agric. Food Chem. 39, 418-421.

Igarasi, M.S., Arrigoni, M.B., Hadlich, J.C., Silveira, A.C., Martins, C.L., Oliveira, H.N., 2008. Características de carcaça e parâmetros de qualidade de carne de bovinos jovens alimentados com grãos úmidos de milho ou sorgo. Rev. Bras. Zootec. 37, 520-528.

Ito, R.H., Prado, I.N., Rotta, P.P., Oliveira, M.G., Prado, R.M., Moletta, J.L., 2012a. Carcass characteristics, chemical composition and fatty acid profile of *Longissimus* muscle of young bulls from four genetic groups finished in feedlot. Rev. Bras. Zootec. 41, 384-391.

Ito, R.H., Valero, M.V., Prado, R.M., Rivaroli, D.C., Perotto, D., Prado, I.N., 2012b. Meat quality from four genetic groups of bulls slaughtered at 14 months old. Acta Scientiarum.Animal Sciences 34, 425-432.

Jiménez-Colmenero, F., Carballo, J., Cofrades, S., 2001. Healthier meat and meat products: their role as functional foods. Meat Sci. 59, 5-13.

Jobim, C.C., Nussio, L.G., Reis, R.A., Schmidt, P., 2007. Avanços metodológicos na avaliação da qualidade da forragem conservada. Rev. Bras. Zootec. 36, 101-119.

King, S., Tempesta, M., 1994. From shaman to human clinical trials: the role of industry in ethnobotony, conservation and community reciprocity. Ethnobotany and the search for new drugs.

Knight, T.W., Cosgrove, G.P., Death, A.F., Anderson, C.B., 1999. Effect of interval from castration of bulls to slaughter on carcass characteristics and meat quality. N. Z. J. Agric. Res. 42, 269-277.

Knight, T.W., Cosgrove, G.P., Death, A.F., Anderson, C.B., 2000. Effect of age of pre-and post-pubertal castration of bulls on growth rates and carcass quality. N. Z. J. Agric. Res. 43, 585-588.

Kubo, I., Masuoka, N., Ha, T.J., Tsujimoto, K., 2006. Antioxidant activity of anacardic acids. Food Chem. 99, 555-562.

Kubo, I., Muroi, H., Himejima, M., 1992. Antibacterial activity of totarol and its potentiation. J. Nat. Prod. 55, 1436-1440.

Kubo, I., Nihei, K., Tsujimoto, K., 2003. Antibacterial action of anacardic acids against methicillin resistant Staphylococcus aureus (MRSA). J. Agric. Food Chem. 51, 7624-7628.

Kujumgiev, A., Tsvetkova, I., Serkedjieva, Y., Bankova, V., Christov, R., Popov, S., 1999. Antibacterial, antifungal and antiviral activity of propolis of different geographic origin. J. Ethnopharmacol. 64, 235.

Kwak, N., Jukes, D.J., 2001. Functional foods. Part 1: the development of a regulatory concept. Food Control 12, 99-107.

Lage, J.F., Paulino, P.V.R., Pereira, L.G.R., Valadares Filho, S.C., Oliveira, A.S., Detmann, E., Souza, N.K.P., Lima, J.C.M., 2010. Glicerina bruta na dieta de cordeiros terminados em confinamento. Pesqu. Agropecu. Bras. 45, 1012-1020.

Lana, R.P., Camardelli, M.M.L., Queiroz, A.C., Rodrigues, M.T., Eifert, E.C., Miranda, E.N., Almeida, I.C.C., 2005. Óleo de soja e própolis na alimentação de cabras leiteiras. Rev. Bras. Zootec. 34, 650-658.

Lana, R.P., Camardelli, M.M.L., Rodrigues, M.T., Eifert, E.C., Oliveira, M.V.M., Stradiotti Júnior, D., Oliveira, J.S., 2007. Óleo de soja e própolis na alimentação de cabras leiteiras: consumo de matéria seca e de nutrientes e parâmetros de fermentação ruminal. Rev. Bras. Zootec. 36, 191-197.

Lima, C.A.A., Pastore, G.M., Lima, E.D.P.A., 2000. Estudo da atividade antimicrobiana dos ácidos anacárdicos do óleo da casca da castanha de caju (CNSL) dos clones de cajueiro-anão-precoce CCP-76 e CCP-09 em cinco estágios de maturação sobre microrganismos da cavidade bucal. Sociedade Brasileira de Ciência e Tecnologia de Alimentos 20.

Lu, Y., Wu, C., Yuan, Z., 2004. Determination of hesperetin, cinnamic acid and nicotinic acid in propolis with micellar electrokinetic capillary chromatography. Fitoterapia 75, 267-276.

Lubi, M.C., Thachil, E.T., 2000. Cashew nut shell liquid (CNSL)-a versatile monomer for polymer synthesis. Designed Monomers and polymers 3, 123-153.

Lunstra, D.D., Ford, J.J., Echternkamp, S.E., 1978. Puberty in beef bulls: hormone concentrations, growth, testicular development, sperm production and sexual aggressiveness in bulls of different breeds. J. Anim. Sci. 46, 1054-1062.

Maenz, D.D., Forsyth, G.W., 1982. Ricinoleate and deoxycholate are calcium ionophores in jejunal brush border vesicles. J. Membr. Biol. 70, 125-133.

Maggioni, D., Marques, J.A., Perotto, D., Rotta, P.P., Ducatti, T., Matsushita, M., Silva, R.R., Prado, I.N., 2009. Bermuda grass hay or sorghum silage with or without yeast addition on performance and carcass characteristics of crossbred young bulls finished in feedlot. Asian-Australas. J. Anim. Sci. 22, 206-215.

Maggioni, D., Marques, J.A., Rotta, P.P., Perotto, D., Ducatti, T., Visentainer, J.V., Prado, I.N., 2010. Animal performance and meat quality of crossbred young bulls. Livest Sci 127, 176-182.

Maggioni, D., Prado, I.N., Zawadzki, F., Valero, M.V., Marques, J.A., Bridi, A.M., Moletta, J.L., Abrahão, J.J.S., 2012. Grupos genéticos e graus de acabamento sobre qualidade da carne de bovinos. Semin. Cienc. agrar. 33, 391-402.

Manach, C., Scalbert, A., Morand, C., Rémésy, C., Jiménez, L., 2004. Polyphenols: food sources and bioavailability. The American journal of clinical nutrition 79, 727-747.

Marcondes, M.I., Tedeschi, L.O., Valadares Filho, S.C., Chizzotti, M.L., 2012. Prediction of physical and chemical body compositions of purebred and crossbred Nellore cattle using the composition of a rib section. J. Anim. Sci. 90, 1280-1290.

Marcucci, M.C., 1995. Propolis: chemical composition, biological properties and therapeutic activity. Apidologie 26, 83-99.

Marcucci, M.C., 1996. Propriedades biológicas e terapêuticas dos constituintes químicos da própolis. Quim. Nova 19, 529-535.

Mason, T.L., Wasserman, B.P., 1987. Inactivation of red beet beta-glucan synthase by native and oxidized phenolic compounds. 26, 2197-2202.

Mazzetto, S.E., Lomonaco, D., Mele, G., 2009. Óleo da castanha de caju: oportunidades e desafios no contexto do desenvolvimento e sustentabilidade industrial. Quim. Nova 32, 732-741.

Menrad, K., 2003. Market and marketing of functional food in Europe. J. Food Eng. 56, 181-188.

Meyer, J.J.M., Afolayan, A.J., Taylor, M.B., Erasmus, D., 1997. Antiviral activity of galangin isolated from the aerial parts of Helichrysum aureonitens. J. Ethnopharmacol. 56, 165-169.

Missio, R.L., Brondani, I.L., Freitas, L.S., Sachet, R.H., Silva, J.H.S., Restle, J., 2009. Desempenho e avaliação econômica da terminação de tourinhos em confinamento alimentados com diferentes níveis de concentrado na dieta. Rev. Bras. Zootec. 38, 1309-1316.

Monti, M., Bertt, E., Carminati, G., Cusini, M., 2006. Occupational and cosmetic dermatitis from propolis. Contact Dermatitis 9, 163-163.

Moreira, F.B., Souza, N.E., Matsushita, M., Prado, I.N., Nascimento, W.G., 2003. Evaluation of carcass characteristics and meat chemical composition of *Bos indicus* and *Bos indicus x Bos taurus* crossbred steers finished in pasture systems. Braz. Arch. Biol. Technol. 46, 609-616.

Muroi, H., Kubo, A., Kubo, I., 1993. Antimicrobial activity of cashew apple flavor compounds. J. Agric. Food Chem. 41, 1106-1109.

Neumann, M., Restle, J., Alves Filho, D.C., Brondani, I.L., Pellegrini, L.G., Freitas, A.K., 2002. Avaliação do valor nutritivo da planta e da silagem de diferentes híbridos de sorgo (Sorghum bicolor, L. Moench). Rev. Bras. Zootec. 31, 293-301.

Neumann, M., Restle, J., Brondani, I.L., 2004. Avaliação de silagens de sorgo (*Sorghum bicolor*, L. Moench) ou milho (*Zea mays*, L.) na produção do novilho superprecoce. Revista Brasileira de Milho e Sorgo 3, 438-452.

Nóbrega, M.B.M., 2008. Avaliação de genótipos de mamona (*Ricinus communis* L.) em cruzamentos dialélicos parciais, Genética e Melhoramento de Plantas, ESALQ/USP, Piracicaba.

Novak, A., Clark, G., Dupuy, H., 1961. Antimicrobial activity of some ricinoleic acid oleic acid derivatives. J. Am. Oil Chem. Soc. 38, 321-324.

NRC, 2000. Nutrient Requirements of Beef Cattle. 7th ed. Natl. Acad. Press, Washington, DC.

Ogunniyi, D.S., 2006. Castor oil: A vital industrial raw material. Bioresour. Technol. 97, 1086-1091.

Ohsugi, M., BASNET, P., Kadota, S., Ishii, E., Tamura, T., Okamura, Y., Namba, T., 1997. Antibacterial activity of traditional medicines and an active constituent lupulone from Humulus lupulus against Helicobacter pylori.

Oldoni, T.L.C., 2007. Isolamento e identificação de compostos com atividade antioxidante de uma nova variedade de própolis brasilei produzida por abelhas da espécie Apis mellifera, Ciência e Tecnologia de Alimentos, Escola Superior de Agricultura "Luiz de Queiroz", Piracicaba, p. 104.

Oliveira, J.S., Lana, R., Borges, A.C., Queiroz, A., Almeida, I.C.C., 2004. Efeito da monensina e extrato de própolis sobre a produção de amônia e degradabilidade *in vitro* da proteína bruta de diferentes fontes de nitrogênio. Rev. Bras. Zootec. 33, 504-510.

Oliveira, J.S., Queiroz, A.C., Lana, R.P., Mantovani, H.C., Generoso, R.A.R., 2006. Effects of monensin and bee propolis on in vitro fermentation of amino acids by mixed ruminal bacteria. Revista Brasileira de Zootecnia 35, 275-281.

Pacheco, P.S., Restle, J., Vaz, F.N., Freitas, A.K., Padua, J.T., Neumann, M., Arboitte, M.Z., 2006. Avaliação econômica da terminação em confinamento de novilhos jovens e superjovens de diferentes grupos genéticos. Rev. Bras. Zootec. 35, 309-320.

Park, Y.K., Koo, M.H., Ikegaki, M., Contado, J., 1997. Comparison of the flavonoid aglycone contents of Apis mellifera propolis from various regions of Brazil. Arq. Biol. Tecnol 40, 97-106.

Parsons, G.L., Shelor, M.K., Drouillard, J.S., 2009. Performance and carcass traits of finishing heifers fed crude glycerin. J. Anim. Sci. 87, 653-657.

Partida, J.A., Olleta, J.L., Campo, M.M., Sañudo, C., María, G.A., 2007. Effect of social dominance on the meat quality of young Friesian bulls. Meat Sci. 76, 266-273.

Peres, M.T.L.P., Monache, F.D., Cruz, A.B., Pizzolatti, M.G., Yunes, R.A., 1997. Chemical composition and antimicrobial activity of Croton urucurana Baillon (Euphorbiaceae). J. Ethnopharmacol. 56, 223-226.

Perotto, D., Moletta, J.L., Cubas, A.C., 2000. Características quantitativas da carcaça de bovinos Charolês, Caracu e cruzamentos recíprocos terminados em confinamento. Rev. Bras. Zootec. 29, 117-124.

Perrett, S., Whitfield, P.J., Sanderson, L., Bartlett, A., 1995. The plant molluscicide Millettia thonningii (Leguminosae) as a topical antischistosomal agent. J. Ethnopharmacol. 47, 49-54.

Prado, I.N., Aricetti, J.A., Rotta, P.P., Prado, R.M., Perotto, D., Visentainer, J.V., Matsushita, M., 2008a. Carcass characteristics, chemical composition and fatty acid profile of the *Longissimus* muscle of bulls (*Bos taurus indicus vs. Bos taurus taurus*) finished in pasture systems. Asian-Australas. J. Anim. Sci. 21, 1449-1457.

Prado, I.N., Ito, R.H., Prado, J.M., Prado, I.M., Rotta, P.P., Matsushita, M., Visentainer, J.V., Silva, R.R., 2008b. The influence of dietary soyabean and linseed on the

chemical composition and fatty acid profile of the Longissimus muscle of feedlot-finished bulls. J. Anim. Feed Sci. 17, 307-317.

Prado, I.N., Marques, J.A., Rotta, P.P., Prado, R.M., Visentainer, J.V., Souza, N.E., 2009a. Meat quality of the *Longissimus* muscle of bulls and steers (½ Nellore *vs.* ½ Simmental) finished in feedlot. J. Anim. Feed Sci. 18, 221-230.

Prado, I.N., Prado, R.M., Rotta, P.P., Visentainer, J.V., Moletta, J.L., Perotto, D., 2008c. Carcass characteristics and chemical composition of the *Longissimus* muscle of crossbred bulls (*Bos taurus indicus vs Bos taurus taurus*) finished in feedlot. J. Anim. Feed Sci. 17, 295-306.

Prado, J.M., Prado, I.N., Visentainer, J.V., Rotta, P.P., Perotto, D., Moletta, J.L., Prado, I.M., Ducatti, T., 2009b. The effect of breed on the chemical composition and fatty acid profile of the Longissimus dorsi muscle of Brazilian beef cattle. Journal of Animal and Feed Sciences 18, 231-240.

Prado, O.P.P., Zeoula, L.M., Moura, L.P.P., Franco, S.L., Prado, I.N., Gomes, H.C.C., 2010. Digestibilidade e parâmetros ruminais de dietas à base de forragem com adição de própolis e monensina sódica para bovinos. Rev. Bras. Zootec. 39, 1336-1345.

Prado, R.M., Prado, I.N., Marques, J.A., Rotta, P.P., Visentainer, J.V., Silva, R.R., Souza, N.E., 2009c. Meat quality of the *Longissimus* muscle of bulls and steers (1/2 Nellore vs 1/2 Simmental) finished in feedlot. J. Anim. Feed Sci. 18, 221-230.

Ray, K.A., Warnick, L.D., Mitchell, R.M., Kaneene, J.B., Ruegg, P.L., Wells, S.J., Fossler, C.P., Halbert, L.W., May, K., 2007. Prevalence of antimicrobial resistance among Salmonella on midwest and northeast USA dairy farms. Preventive Veterinary Medicine 79, 204-223.

Restle, J., Grässi, C., Feijó, G.L.D., 1996. Características das carcaças e da carne de bovinos inteiros ou submetidos a duas formas de castração, em condições de pastagem. Rev. Bras. Zootec. 25, 334-344.

Restle, J., Vaz, F.N., Roso, C., Oliveira, A.N., Rudnik, L., Meneses, L., 2001. Desempenho e características da carcaça de vacas de diferentes grupos genéticos em pastagem cultivada com suplementação energética. Rev. Bras. Zootec. 30, 1813-1823.

Roberfroid, M.B., 2002. Global view on functional foods: European perspectives. Br. J. Nutr. 88, S133-S138.

Robinson, P.H., 2010. Impacts of manipulating ration metabolizable lysine and methionine levels on the performance of lactating dairy cows: A systematic review of the literature. Livest Sci 127, 115-126.

Rotta, P.P., Prado, I.N., Prado, R.M., Moletta, J.L., Silva, R.R., Perotto, D., 2009a. Carcass characteristics and chemical composition of the *Longissimus* muscle of

Nellore, Caracu and Holstein-friesian bulls finished in a feedlot. Asian-Australasian Journal of Animal Science 22, 598-604.

Rotta, P.P., Prado, R.M., Prado, I.N., Valero, M.V., Visentainer, J.V., Silva, R.R., 2009b. The effects of genetic groups, nutrition, finishing systems and gender of Brazilian cattle on carcass characteristics and beef composition and appearance: a review. Asian-Australas. J. Anim. Sci. 22, 1718-1734.

Russell, J.B., Houlihan, A.J., 2003. Ionophore resistance of ruminal bacteria and its potential impact on human health. FEMS Microbiol. Rev. 27, 65-74.

Russell, J.B., Strobel, H.J., 1989. Effect of ionophores on ruminal fermentation. Appl. Environ. Microbiol. 55, 1-6.

Russell, J.B., Wallace, R.J., 1997. Energy-yielding and energy-consuming reactions. In: The Rumen Microbial Ecosystem. Spirnger.

Russo, A., Longo, R., Vanella, A., 2002. Antioxidant activity of propolis: role of caffeic acid phenethyl ester and galangin. Fitoterapia 73, S21-S29.

Sadleir, R.M.F.S., 1973. The Reproduction of Vertebrates, New York.

Sahinler, N., Kaftanoglu, O., 2005. Natural product propolis: chemical composition. Nat. Prod. Res. 19, 183-188.

Salatino, A., Teixeira, É.W., Negri, G., 2005. Origin and chemical variation of Brazilian propolis. Evid. Based Complement. Alternat. Med. 2, 33-38.

Santos, S.F., Cândido, M.J.D., Bomfim, M.A.D., Severino, L.S., Pereira, L.P.S., Arruda, P.C.L., 2007. Efeito da inclusão da casca de mamona na dieta de cabras leiteiras sobre a produção ea composição físico-química do leite. III Simpósio internacional sobre caprinos e ovinos de corte, João Pessoa - Pernambuco.

Scollan, N., Hocquette, J.F., Nuernberg, K., Dannenberger, D., Richardson, I., Moloney, A., 2006. Innovations in beef production systems that enhance the nutritional and health value of beef lipids and their relationship with meat quality. Meat Sci. 74, 17-33.

Seideman, S.C., Koohmaraie, M., Crouse, J.D., 1987. Factors associated with tenderness in young beef. Meat Sci. 20, 281-291.

Silva, R.R., Prado, I.N., Carvalho, G.G.P., Júnior, S., Paixão, M.L., Filho, G.A., 2010a. Níveis de suplementação na terminação de novilhos Nelore em pastagens: aspectos econômicos. Rev. Bras. Zootec. 39, 2091-2097.

Silva, R.R., Prado, I.N., Silva, F.F., Almeida, I.C.C., Santana Júnior, H.A., Queiroz, A.C., Carvalho, G.G.P., Barroso, D.S., 2010b. Comportamento ingestivo diurno de novilhos Nelore recebendo níveis crescentes de suplementação em pastejo de capim-braquiária. Rev. Bras. Zootec. 39, 2073-2080.

Sindt, M.H., Stock, R.A., Klopfenstein, T.J., Shain, D.H., 1993. Effect of protein source and grain type on finishing calf performance and ruminal metabolism. J. Anim. Sci. 71, 1047-1056.

Stern, J.L., Hagerman, A.E., Steinberg, P.D., Mason, P.K., 1996. Phlorotannin-protein interactions. J. Chem. Ecol. 22, 1877-1899.

Stradiotti Júnior, D., Queiroz, A.C., Lana, R.P., Pacheco, C.G., Camardelli, M.M.L., Detmann, E., Eifert, E.C., Nunes, P.M.M., Oliveira, M.V.M., 2004a. Ação do extrato de própolis sobre a fermentação *in vitro* de diferentes alimentos pela técnica de produção de gases. Rev. Bras. Zootec. 33, 1093-1099.

Stradiotti Júnior, D., Queiroz, A.C., Lana, R.P., Pacheco, C.G., Eifert, E.C., Nunes, P.M.M., 2004b. Ação da própolis sobre a desaminação de aminoácidos ea fermentação ruminal. Rev. Bras. Zootec. 33, 1086-1092.

Teixeira, É.W., Negri, G., Meira, R.M.S.A., Salatino, A., 2005. Plant origin of green propolis: bee behavior, plant anatomy and chemistry. Evid. Based Complement. Alternat. Med. 2, 85-92.

Toda, M., Okubo, S., Ikigai, H., Suzuki, T., Suzuki, Y., Hara, Y., Shimamura, T., 1992. The protective activity of tea catechins against experimental infection by Vibrio cholerae O1. Microbiol. Immunol. 36, 999.

Trevisan, M., Pfundstein, B., Haubner, R., Würtele, G., Spiegelhalder, B., Bartsch, H., Owen, R., 2006a. Characterization of alkyl phenols in cashew *Anacardium occidentale* products and assay of their antioxidant capacity. Food and Chemical toxicology 44, 188-197.

Trevisan, M.T.S., Pfundstein, B., Haubner, R., Würtele, G., Spiegelhalder, B., Bartsch, H., Owen, R.W., 2006b. Characterization of alkyl phenols in cashew (Anacardium occidentale) products and assay of their antioxidant capacity. Food and Chemical Toxicology 44, 188-197.

Vaisman, B., Shikanov, A., Domb, A., 2008. The isolation of ricinoleic acid from castor oil by salt-solubility-based fractionation for the biopharmaceutical applications. J. Am. Oil Chem. Soc. 85, 169-184.

Valero, M.V., Zawadzki, F., Françozo, M.C., Farias, M.S., Rotta, P.P., Prado, I.N., Visentainer, J.V., Zeoula, L.M., 2011. Sodium monensin or propolis extract in the diet of crossbred (½ Red Angus vs. ½ Nellore) bulls finished in feedlot: chemical composition and fatty acid profile of the *Longissimus* muscle. Semin. Cienc. agrar. 32, 1617-1626.

Van Soest, P.J., 1994. Nutritional ecology of the ruminant. Cornell University Press, Ithaca, NY, USA.

Wang, C., Liu, Q., Yang, W.Z., Huo, W.J., Dong, K.H., Huang, Y.X., Yang, X.M., He, D.C., 2009. Effects of glycerol on lactation performance, energy balance and

metabolites in early lactation Holstein dairy cows. Anim. Feed Sci. Technol. 151, 12-20.

Williams, R.J., Spencer, J.P.E., Rice-Evans, C., 2004. Flavonoids: antioxidants or signalling molecules? Free Radic. Biol. Med. 36, 838-849.

Zawadzki, F., Prado, I.N., Marques, J.A., Zeoula, L.M., Prado, R.M., Fugita, C.A., Valero, M.V., Maggioni, D., 2011a. Sodium monensin or propolis extract in the diet of Nellore bulls finished in feedlot: chemical composition and fatty acid profile of *Longissimus* muscle. Semin. Cienc. agrar. 32, 1627-1636.

Zawadzki, F., Prado, I.N., Marques, J.A., Zeoula, L.M., Rotta, P.P., Sestari, B.B., Valero, M.V., Rivaroli, D.C., 2011b. Sodium monensin or propolis extract in the diets of feedlot-finished bulls: effects on animal performance and carcass characteristics. J. Anim. Feed Sci. 20, 16-25.

Zhang, W., Xiao, S., Samaraweera, H., Lee, E.J., Ahn, D.U., 2010. Improving functional value of meat products. Meat Sci. 86, 15-31.

Zuchi, J., Bevilaqua, G.A.P., Zanuncio, J.C., Peske, S.T., Silva, S.D.A., Sediyama, C.S., 2010. Características agronômicas de cultivares de mamona em função do local de cultivo e da época de semeadura no Rio Grande do Sul. Cienc. Rural 40, 501-506.

2. PROPOLIS AND CASHEW AND CASTOR OILS ON ANIMAL PERFORMANCE, APPARENT DIGESTIBILITY AND COMPLETE BLOOD COUNT OF GROWING CROSSBRED BULLS REARED IN FEEDLOT

2.1. Abstract

This work was conducted to evaluate the propolis and functional oils (cashew and castor oils) on the feed intake, performance, digestibility and blood cells of thirty growing bulls fed *ad libitum* in feedlot for 49 days. The bulls fed a control diet (CON) with sorghum silage (41% of dry matter) and concentrate. The propolis-supplemented group (PRO) received 3 grams/animal/day in the form of a premix added to the concentrate. The functional oils-supplemented group (OIL) received 3 grams/animal/day added to the concentrate. At the end of the feedlot period, faeces were partially collected to determine the apparent digestibility (indigestible dry matter, as indicator). Intake of dry matter and other nutrients were similar among three diets. Animal performance and feed efficiency was higher for bulls fed the OIL diet when compared with bulls on the CON and PRO diets. The addition of additives to the diets had no effect on the apparent digestibility of dry matter and other nutrients. There was no effect of propolis and the addition of functional oils to the diets on the mean values of blood cells. However, the number of red blood cells was higher on the final day of experiment, while the number of white blood cells was lower. In conclusion o additive OIL increase the performance of cattle during growth in intensive system

Index terms: Biodiesel, co-products, feedlot, natural additives, plant oils.

2.2. Resumo

Este trabalho foi realizado para avaliar o efeito de própolis e óleos funcionais (caju e óleo de mamona) sobre a ingestão de matéria seca (MS), desempenho animal, digestibilidade aparente e células sanguíneas de 30 touros em confinamento durante 49 dias e alimentados com dieta controle (CON) – silagem de sorgo (41% MS) e concentrado. O grupo própolis (PRO) recebeu 3 g/animal/dia na forma de pré-mistura ao concentrado. O grupo óleos funcionais (OIL) recebeu 3 g/animal/dia na forma de pré-mistura ao concentrado. No final do período de confinamento, fezes foram coletadas para determinar a digestibilidade aparente (MS indigestível foi utilizada como indicador). A adição de própolis e óleos funcionais nas dietas não teve efeito sobre o consumo de MS e de outros nutrientes. O desempenho animal foi maior para os touros alimentados com a dieta de OIL quando comparado com animais das dietas CON e PRO. A adição dos aditivos não influenciou a digestibilidade aparente da MS e outros nutrientes. Não houve efeito da própolis e adição de óleos funcionais nas dietas sobre as células sanguíneas. No entanto, o número de glóbulos vermelhos foi maior no último dia da experiência, enquanto que o número de células brancas no sangue foi menor, indicando que os animais estavam bem nutridos e menos estressados. Em conclusão o uso do aditivo OIL melhora em 22% o desempenho de bovinos na fase de crescimento em sistema intensivo.

Termos para indexação: Aditivos naturais, biodiesel, coprodutos, óleos de plantas.

2.3 Introduction

The meat production cattle in Brazil generally use pastures systems (ARICETTI et al., 2008). However, due to increases in meat prices and consumption in Brazilian markets, finishing cattle in feedlots may be one tool used to maximise production and improve meat quality (PRADO et al., 2008; ROTTA et al., 2009; PRADO et al., 2012). In Brazil, bulls are finished in feedlots when they have a body weight of 380 kg and are 24 months old (MAGGIONI et al., 2009; ROTTA et al., 2009).

There has been an increase in using the feedlots system for the finishing of young bulls at 18 months (DIAN et al., 2010; ITO et al., 2010) and bulls after weaning at 10 and 12 months old (ITO et al., 2012). However, these bulls require a longer finishing period in feedlots (160 days). Thus, they begin the process of finishing with a lighter body weight and undergo two distinct periods for growing (from 300 to 400 kg) and fattening (from 400 to 480 kg), with different energy and protein requirements (NRC, 2000). For the maximum production efficiency for bulls finished in feedlots, it is necessary to utilise diets with high energy density (NRC, 2000).

To increase the energy density in the diet, is necessary to use cereals and co-products from the agri-food system that are rich in carbohydrates (MARQUES et al., 2000). Carbohydrates can degrade rapidly, which can disturb ruminal fermentation (MARTINS et al., 1999; GIGER-REVERDIN et al., 2002). Therefore, some substances have been used to control ruminal fermentation, including antibiotics and other compounds (ZAWADZKI et al., 2011). However, in recent years, public concern over the routine use of antibiotics in livestock nutrition has increased due to the emergence of antibiotic resistant bacteria that may represent a risk to human health (RUSSELL HOULIHAN, 2003).

Because of that, the use of ionophores in the European Union was prohibited in January 2006. Consequently, considerable effort has been devoted towards developing alternatives to antibiotics (BENCHAAR et al., 2008; VALERO et al., 2011). Propolis and plant extracts offer an opportunity in this regard (ZHANG et al., 2010; ZAWADZKI et al., 2011). ZAWADZKI et al. (2011) observed better animal performance and feed efficiency in Nellore bulls finished in feedlots and fed with propolis extract in a high-energy density diet.

On the other hand, natural plant extracts contain a wide variety of compounds with different functions and mechanisms of action (BENCHAAR et al., 2008; ZHANG et al., 2010). Among the compounds that have antimicrobial characteristics present in plants, the class of phenolic compounds, terpenoids, essential oils and polyacetylenes, all have their own mechanism of action (ZHANG et al., 2010). Many plants produce secondary metabolites, such as saponins and tannins, which have antimicrobial properties. These compounds have been shown to modulate ruminal fermentation to improve nutrient utilisation in ruminants (BENCHAAR et al., 2008). BENCHAAR et al. (2006) found no effect due to plant extracts on the feed intake of dairy cows. However, FANDIÑO et al. (2008) observed that adding functional oils increased the feed intake of bulls finished in feedlots. Data on the effects of essential oils and their compounds on beef cattle performance are almost nonexistent. In one study, BENCHAAR et al. (2006) evaluated the growth performance of beef cattle fed a silage-based diet supplemented with 2 or 4 grams/day of a commercial mixture of essential oil compounds consisting of thymol, eugenol, vanillin and limonene. Results showed that dry matter intake and average daily gain were not affected by the addition of this mixture. However, the DM efficiency was quadratically maximised with a dose of 2 grams/day additional plant extract.

This study evaluated the effect of the addition of propolis or plant oils in the diets on feed intake, animal performance, feed efficiency, apparent digestibility and blood cells of growing bulls reared on intensive system on a high-energy density diet based on corn and glycerine as the energy sources.

2.4. Material and Methods

2.4.1. Local, animals, management and diets

This experiment was approved by the ethics committee of Department of Animal Production of State University of Maringá (CIOMS/OMS, 1985). It was conducted at the Sector of the Experimental Station Farm Iguatemi at the State University of Maringá, Paraná State, Brazil.

Thirty crossbred bulls (½ Aberdeen Angus *x.* ½ Nellore) were used in a completely randomised design. The bulls were weighed and distributed into three diet groups with ten replications per group. At the beginning of the experimental period, the bulls weighed 321 ± 27 kg and were 18 months old. Bulls were housed in individual pens with 10 m² per bull on concrete floors, equipped with feeders with 60 cm deep and 2 m length and drinkers with a capacity for 250 litres of water. The concentrate used was based on corn, soybean meal, glycerine, urea, limestone and mineral salt. The provided diets had a ratio of 41% forage (sorghum silage) and 59% concentrate. The chemical composition of the foods is presented in Table 1. The composition of the diets is shown in Table 2. The bulls' body weight and intake of concentrate and sorghum silage were recorded daily until day 49 of the experimental period, when the bulls reached a final body weight of 387 ± 27.9 kg.

Table 1. Chemical composition of ingredients and diets (g/kg of dry matter) of growing crossbred bulls.

Ingredients	g/kg									
	DM[1]	OM[2]	Ash	CP[3]	EE[4]	NDF[5]	ADF[6]	CT[7]	NFC[8]	TDN[9]
Sorghum silage	260	937	62.5	54.6	26.7	665	426	856	190	540
Corn	875	988	11.7	93.4	33.5	154	49.3	861	707	900
Soybean meal	909	938	61.3	496	22.5	106	103	419	313	820
Glycerin	942	10.0	47.6	1.00	60.0					807
Urea	990			2620						
Mineral salt[10]	990		990							
Limestone	990		950							
Propolis	146									
Functional oils	976	559	440							
Diet										
	445	795	51.9	115	33.2	336	201	675	339	713

[1]Dry matter, [2]Organic matter, [3]Crude protein, [4]Ether extract, [5]Neutral detergent fiber, [6]Acid detergent fiber, [7]Total carbohydrates, [8]Non fibrous carbohydrates, [9]Total nutrients digestible, [10]Guarantee levels (per kg): calcium - 175 g; phosphorus – 100 g; sodium – 114 g; selenium – 15 g; magnesium – 15 g; zinc – 6.004 mg; manganese – 1.250 mg; copper – 1.875; iodine – 180 mg; cobalt – 125 mg; fluorine (maximum) – 1.000 mg.

Table 2. Diets composition (g/kg of dry matter).

	Diets		
Ingredients	CON	PRO	OIL
Sorghum silage	415	415	415
Corn	333	333	333
Soybean meal	80.7	80.7	80.7
Glycerine	153	153	153
Urea	8.20	8.20	8.20
Mineral salt	5.00	5.00	5.00
Limestone	5.00	5.00	5.00
Propolis		0.55	
Functional oils			0.55

[1]Control diet, [2]Diet with propolis inclusion. [3]Diet with functional oils inclusion.

The glycerine was produced in a soy-diesel facility (BIOPAR, Rolândia, Paraná, Brazil South). In this study, glycerine was used as an energetic ingredient in the diet; therefore, to obtain three isoenergetic diets. The functional oils contain ricinoleic acid, anacardic acid, cardanol and cardol. Ricinoleic acid was obtained from castor oil (extracted from castor seeds), and anacardic acid, cardanol and cardol were obtained from cashew nut shell liquid (from processing of cashew nuts). Both oils were produced

in Northern Brazil. Vermiculite was used for functional oil solidification. Functional oil was formulated at the laboratory Oligo Basics Agroindustrial Ltda.

The bulls were randomly assigned to 3 diets: CON – Control, PRO – propolis addition and OIL – functional oils addition. The bulls were fed twice a day at 08:00 and 16:00 h. The diets were weighed daily so that the refusals represented 5% of the total. The diet formulation and quantity supplied were designed to provide a weight gain of 1.4 kg/day, according to the NRC (2000).

2.4.2. Feed intake and animal performance

Daily feed intake was estimated as the difference between the supplied feed and the refusals remaining in the trough. During the collection period, samples of the supplied feed and refusals were collected, and a representative composite sample was drafted per animal in each treatment.

To determine animal performance, the bulls were weighed once at the beginning of the experiment and then once every 14 days (after abstaining from solid food for a period of 16 hours) during of the experiment (49 days).

2.4.3. Apparent total-tract digestibility

To obtain the apparent digestibility coefficient of dry matter and other nutrients, faecal collections were performed for a period of five days starting on the 40^{th} day of the feedlot period. Faecal samples (approximately 200 g wet weight) were collected for each bull from the floor (minimum 3-h intervals between samples) and pooled per bull. After drying at 55° C for 24 h, the samples were ground in a feed mill and passed through a 1-mm sieve in preparation for chemical analyses.

To estimate faecal dry matter; indigestible dry matter (iDM) was used as an internal marker (ZEOULA et al., 2002). Samples were milled through a 2 mm sieve, packed (5 mg of DM/cm²) in 4 x 5 cm Ankom (filter bags F57) that had been previously weighed, and incubated for 240 h in the rumen of a Holstein bull fed a mixed diet of equal parts forage (sorghum silage) and concentrate (the same concentrate used in the treatments). After incubation, the bags were removed, washed with water until clean and dried in a ventilated oven at 55 °C for 72 h, then removed and oven-dried again at 105 ºC. The iDM was estimated using the difference in sample weight before and after ruminal incubation. Faecal excretion was calculated using the following equations: FE = iDMI/iDMCF, where FE = faecal excretion (kg/day); iDMI = iDM intake (kg/day); and iDMCF = iDM concentration in faeces (kg/day). The apparent digestibility coefficients (ADC) for DM and nutrients were estimated according to the formula DC = [(Intake – Excreted)/Intake] x 100.

2.4.4. Chemical analyses

The DM content of the ingredients (silage and concentrate), refusals and faeces was determined by drying at 105 °C for 16 h by the methods 930.15 according to AOAC (1998). The OM content was calculated as the difference between the DM and ash contents, with the ash content determined by combustion at 550 °C for 5 h (AOAC, 1998) (method 930.15). The NDF contents were determined using the methods described by VAN SOEST et al. (1991) and ADF (AOAC, 1998) (method 973.18). The nitrogen (N) content was determined by the Kjeldahl method 976.05 (AOAC, 1998). Total carbohydrates (TC) were obtained using the following equation (SNIFFEN et al., 1992): TC = 100 – (% CP + % EE + % Ash). Non-fibrous carbohydrates (NFC) were determined as the difference between TC and NDF. The total digestible nutrient (TDN)

content of the diets was obtained by the methodology described by KEARL (1982). The samples were analysed at the laboratory of Feed Analyses and Animal Nutrition at the State University of Maringá.

2.4.5. Haemogram

Blood was collected twice: in the beginning (0 day) and final experimental periods (49 days). Blood samples were collected (vacutainer) for the measurement of blood cells. Before blood collection the bulls fasted for 14 h. Blood samples were obtained from the jugular vein. A total of 5 mL of blood was collected and mixed with the anticoagulant EDTA (diaminotetractic etilen acid and disodium salt). Haemogram (erythrocytes, haemoglobin, hematocrit, MCV, MCH and MCHC) and leukogram (eosinophils, segmented, lymphocytes and monocytes) measurements were performed according to JAIN & JAIN (1993). Samples were chilled until analyses, during which they were centrifuged at 1.500 rpm for 15 minutes to collect plasma.

2.4.6. Statistical analysis

The experimental design was completely randomised, with three treatments and ten replications. All characteristics under study were tested for normality. Those that showed normal distribution were analyzed using PROC GLM in SAS (2004) according to: $Y_{ij} = \mu + T_i + e_{ij}$, where Y_{ij} = dependent variables; T_i = treatment effect and e_{ij} = residual error.

2.5. Results and Discussion

2.5.1. Feed intake and animal performance

Propolis and functional oils did not affect (P>0.05) feed intake in kg/day of dry matter, organic matter, crude protein, ether extract, neutral detergent fiber, acid detergent fiber, total carbohydrates, non-fibrous carbohydrates and total digestible nutrients (Table 3). Feed intake in % of LW of dry matter, neutral detergent fiber and acid detergent fiber did not affected (P>0.05) by propolis and functional oils (Table 3).

Table 3. Feed intake (kg/day and % of body weight) of crossbred bulls reared in feedlot.

Item	Diets			SD[4]	P>F
	CON[1]	PRO[2]	OIL[3]		
n	10	10	10		
Dry matter, kg/day	8.40	8.47	8.69	1.32	0.54
Dry matter, % of LW	2.38	2.40	2.44	0.26	0.50
Organic matter, kg/day	7.98	8.05	8.26	1.24	0.54
Crude protein, kg/day	1.01	1.01	1.04	0.12	0.78
Ether extract, kg/day	0.29	0.29	0.30	0.04	0.81
Neutral detergent fiber, kg/day	2.64	2.70	2.78	0.43	0.78
Neutral detergent fiber, % of LW	0.75	0.76	0.78	0.09	0.76
Acid detergent fiber, kg/day	1.58	1.59	1.66	0.27	0.75
Acid detergent fiber, % of LW	0.45	0.45	0.47	0.06	0.75
Total carbohydrates, kg/day	6.68	6.75	6.91	0.93	0.86
Non fibrous carbohydrates, kg/day	4.03	4.04	4.13	0.51	0.90
Total digestible nutrients, kg/day	6.45	6.46	6.67	0.91	0.84

[1]Control diet, [2]Diet with propolis inclusion. [3]Diet with functional oils inclusion [4]Standard deviation.

The addition of propolis in the diet had no effect feed intake, as has been previously observed in dairy cows (STELZER et al., 2009). Dry matter feed intake was 2.4% of the live weight. Thus, the dry matter feed intake observed here is close the values observed by several authors when growing and finishing cattle on a diet that contained a forage-to-concentrate ratio of 50% (ZAWADZKI et al., 2011). Dry matter feed intake for this animal category is between 2.2 and 2.5% of the live weight (MAGGIONI et al., 2009; ZAWADZKI et al., 2011).

The mean crude protein intake for bulls on the three diets was 1.02 kg/animal/day. Bulls with alive weight between 320 and 360 kg, depending on their genotype, food

type, and environmental conditions, have a crude protein requirement of around 1.0 kg/animal/day (NRC, 2000). The low intake of NDF and ADF was due to the low NDF and ADF content in glycerine. According to MERTENS (1994), the NDF intake can be up to 1.2% of body weight per day to allow for the correct supplementation of concentrates and to prevent intake by limiting filling the rumen. Thus, the NDF was not the limiting factor with respect to the feed intake. The different intakes of the carbohydrate fractions were low because 15% of the dry matter of the diet was provided by added glycerine. The mean TDN feed intake was 6.52 kg/animal/day, which is the requirement of this animal category (NRC, 2000).

The mean final weight was 14 kg higher ($P<0.06$) in the OIL diet than bulls fed the CON diet and 11 kg higher than bulls fed the PRO diet (Table 4). The average daily gain was superior ($P<0.05$) for bulls fed OIL diet than bulls fed the CON (0.27 kg) and PRO (0.21 kg) diets (Table 4). The dry matter conversion was 1.0 kg better ($P<0.05$) in the OIL diet than bulls fed the CON diet and 0.73 kg better than bulls the PRO diet. The crude protein conversion and dry matter efficiency were better in the OIL diet ($P<0.01$ and $P<0.04$, respectively). The experimental period of 49 days was considered as the growing phase of bulls. The mean final weight of bulls was 387 kg the cattle would be the ideal weight to enter the final stage of finishing. Bulls used for feedlot finishing exhibit live weights between 380 and 400 kg (DIAN et al., 2009; VALERO et al., 2011; ZAWADZKI et al., 2011).

Glycerine was included in the three diets (15.3% of the DM – 25% corn replacing) as an energy source. Glycerine is used to replace corn as an energy source for cattle finished in feedlots to reduce feeding costs (PARSONS et al., 2009; FRANÇOZO et al., 2013).

Table 4. Animal performance and feed efficiency of crossbred bulls reared in feedlot

Item	Diets			SD[4]	P>F
	CON[1]	PRO[2]	OIL[3]		
N	10	10	10		
Initial weight, kg	320	320	320	27.57	0.99
Final weight, kg	382b	385b	396a	34.05	0.06
Average daily gain, kg	1.26b	1.32b	1.53a	0.32	0.05
Dry matter conversion	6.67b	6.41b	5.68a	1.09	0.05
Crude protein conversion	0.82b	0.79b	0.70a	0.13	0.01
Dry matter efficiency	0.15b	0.15b	0.17a	0.03	0.04

[1]Control diet, [2]Diet with propolis inclusion. [3]Diet with functional oils inclusion [4]Standard deviation. Means followed by different letters in the same line were different (Tukey test).

In ruminants, propolis has been used as ruminal fermentation modulator (STRADIOTTI JÚNIOR et al., 2004; PRADO et al., 2010). ZAWADZKI et al. (2011) observed higher slaughter weights and better average daily gain in feedlot finished Nellore bulls fed a diet that contained the addition of alcoholic propolis extract. These authors attributed the improved performance of the bulls to the antimicrobial properties present in the propolis extract (HEGAZI et al., 2000). Furthermore, flavonoids inclusion in the diet can improve animal production (BENCHAAR et al., 2008). Previous studies ALBERTÍ et al. (2005) and DEVANT et al. (2007) reported that flavonoids (*citrus* extracts) added in the diets of feedlot-finished cattle, no differences were observed in any of the parameters studied: average daily gain, carcass weight, conformation and yield grade.

2.5.2. Apparent total-tract digestibility

The addition of propolis and functional oils did not affect apparent digestibility of dry matter, organic matter, crude protein, ether extract, neutral detergent fiber, total carbohydrates, non-fibrous carbohydrates and total digestible nutrients (Table 5). PRADO et al. (2010) observed lower dry matter digestibility when two different

propolis extracts were included in the diets of cattle fed 72.5% roughage (sorghum silage and Tifton grass hay) and 27.5% concentrate. As in the present experiment, ÍTAVO et al. (2011) observed an apparent dry matter digestibility of close to 63% in sheep fed a 50% roughage (*Brachiaria brizantha* grass hay) and 50% concentrate mix with four different levels of propolis extracts.

Table 5. Apparent digestibility of dry matter and other nutrients of crossbred bulls reared in feedlot (g/kg).

Nutrients	Diets			SD[4]	P>F
	CON[1]	PRO[2]	OIL[3]		
N	10	10	10		
Dry matter	661.2	690.4	671.3	4.08	0.27
Organic matter	616.8	648.1	629.9	4.51	0.31
Crude protein	548.6	594.2	585.4	5.63	0.16
Ether extract	724.7	774.4	753.8	7.38	0.33
Neutral detergent fiber	450.7	470.1	458.0	4.89	0.68
Acid detergent fiber	340.2	382.4	345.7	7.29	0.39
Total carbohydrates	640.1	667.6	648.3	4.46	0.38
Non fibrous carbohydrates	821.0	857.6	833.6	4.97	0.25
Total digestible nutrients	761.6	735.7	716.0	5.32	0.37

[1]Control diet, [2]Diet with propolis inclusion. [3]Diet with functional oils inclusion [4]Standard deviation.

The apparent digestibility of crude protein was low (close to 576 g/kg). Previous studies reported that addition of propolis extracts to the diets reduced the apparent digestibility of crude protein from 65.4% to 58.0% in cattle fed a mixture of 72.5% roughage and 27.5% concentrate (PRADO et al., 2010). ÍTAVO et al. (2011) observed an apparent digestibility of crude protein of around 75% in diets that contained four different levels of crude propolis extract. Thus, the method of preparation of propolis extract (crude residue, crude extract with alcohol extraction and purified propolis extract with alcohol extraction) has a different effect on the apparent digestibility of crude protein in several animal species.

PRADO et al. (2010) observed a reduction in the apparent digestibility of ether extract in diets with different added propolis extracts fed to cattle. According to these

authors, the provable reduction in apparent digestibility of ether extracts was due to substances present in these products, which may have hindered the action of lipolytic bacteria. In contrast, ÍTAVO et al. (2011) observed no effect on the apparent digestibility of ether extract (65.0%) due to the addition of propolis in the diet in sheep fed 50% forage and 50% concentrate. Thus, the action of propolis is related to the method of obtaining the extract.

The apparent digestibility of neutral detergent fiber (459 g/kg) and acid detergent fiber (356 g/kg) was lower than the observed digestibility of diets with different levels of forage and concentrate (PRADO et al., 2010; ÍTAVO et al., 2011). RAMOSKERLEY (2012) observed significant reduction in the digestibility of diet components in beef cattle with the addition of 20% glycerol. In previous studies, it was found that bacterial strains that are tolerant of propolis extract products mostly degrade soluble carbohydrates such as glucose, fructose and lactose. No influence was observed on the composition of the total digestible nutrients due to the additives. The value of total digestible nutrients obtained from the control diet was close to the present values for growing cattle (NRC, 2000) and the addition of propolis and functional oils did not reduce the levels of total digestible nutrients in the diet.

2.5.3. Haemogram

The addition of propolis and functional oils did not affect (P>0.05) red blood cells mean (erythrocytes, haemoglobin, haematocrit, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration) and white blood cells mean (leukocytes, eosinophils, segmented, lymphocytes, and monocytes), mean platelets and plasma proteins, (Table 6). There was no interaction between diets *vs*. period on haemogram.

There was no difference (P>0.05) among diets on beginning of experimental period (0 day) on red and white blood cells (Table 6).

However, red blood cells were higher when compared initial values *vs.* final values – at 49th day of experiment. On the other hand, white blood cells had reduction at 49th day of the experiment. Likewise, plasma protein had reduction at 49th day of experiment; whereas mean corpuscular haemoglobin concentration and lymphocytes were similar between day 0 and 49 (Table 6).

Haematological evaluation in cattle is used to assess disease in an animal or to evaluate groups of animals within a herd, to detect hidden diseases and to guide clinical decisions. The value variables observed in this study for red blood cells are in accordance with the reference values described by BIONDO et al. (1998). Furthermore, according to the values reported by BIONDO et al. (1998) and JONES & ALLISON (2007), the MCV, MCH and MCHC values in our study are within the normal range for cattle.

The measurements of white blood cells in this study were aimed at monitoring the health of bulls and observing the behaviour of these cells upon supplementation with propolis and functional oils, due to its recent introduction into ruminant nutrition. The results found in all groups are in accordance with the reference values for cattle in this phase of growth (JONES & ALLISON, 2007). The red blood cells series are a reflection of the health and nutrition of the animals (JONES & ALLISON, 2007). Thus, in this study, the animals were fed a diet with high percentage of protein and high density-energy and all necessary minerals; it is normal to see an increase in red blood cells due an increased metabolism.

Plasma proteins are compounds that increase or decrease in the plasma as a result of injury or inflammation. Plasma proteins in the blood are investigated as a means of

detecting and monitoring inflammatory processes in ruminants (JONES & ALLISON, 2007). In summary, the plasma proteins can provide wealth of information to the clinician. Evaluation of plasma proteins is an essential adjunct to detect significant abnormalities in cattle (GONZÁLEZ et al., 2000). Therefore, during the experimental period, we did not observe any inflammatory processes in the bulls.

Table 6. Red blood and white cells and plasma proteins of crossbred bulls reared in feedlot.

Parameters	Diets						SD[4]	Diets	Diets *vs.* Period	Initial *vs.* Final
	CON[1]		PRO[2]		OIL[3]					
	Period		Period		Period					
	Initial	Final	Initial	Final	Initial	Final				
Erythrocytes, million/mm^3	8.80	9.84	8.34	9.70	8.50	9.48	1.20	0.32	0.12	<0.01
Hemoglobin, g/dL	13.0	15.4	12.6	15.0	12.4	15.0	1.72	0.41	0.16	<0.01
Hematocrit, %	37.2	44.4	36.6	43.4	35.7	43.2	4.74	0.33	0.21	<0.01
MCV[5], fL	42.5	45.6	44.2	44.9	42.4	46.0	4.61	0.45	0.11	0.05
MCH[6], pg	14.9	15.8	15.1	15.5	14.6	15.9	1.28	0.28	0.24	0.01
MCHC[7], %	35.6	34.7	34.6	34.6	34.6	34.7	1.40	0.29	0.22	0.21
Platelets, million/m^3	330.4	226.1	355.9	199.3	400.2	234.2	19.12	0.33	0.27	<0.01
Leukocytes, mm^3	17.85	12.53	17.54	12.48	19.13	11.89	4.53	0.33	0.19	<0.01
Eosinophils, mm^3	813.0	375.7	629.1	473.0	541.5	491.0	321.83	0.41	0.19	0.05
Segmented, mm^3	7.507	4.401	8.823	4.184	9.950	3.908	372.9	0.27	0.24	<0.01
Lymphocytes, mm^3	8.621	7.179	7.366	7.231	7.860	6.950	1.720	0.29	0.27	0.25
Monocytes, mm^3	908.2	580.8	721.3	595.2	777.9	547.7	33.77	0.35	0.29	0.01
Plasma proteins, mg/dL	7.05	6.94	7.10	6.87	7.19	6.95	0.35	0.52	0.16	0.05

References values: Erythrocytes (5 - 10 million/mm^3), Hemoglobin (8 - 15 g/dL), Hematocrit (24 - 46%), MCV (40 - 50 fL), MHC (11 - 17 pg), MCHC (30 -36%), Platelets (100 – 800 million/m^3), Leukocytes (4.000 – 12.000/mm^3), Eosinophlis (80 – 2.400/mm^3), Segmented (600 – 5.400/mm^3), Lymphocites (1.800 – 9.000mm^3), Monocytes (80 – 840mm^3), Plasma proteins (5.7 – 8.0 mg/dL). [1]Control diet, [2]Diet with propolis inclusion. [3]Diet with functional oils inclusion [4]Standard deviation. [5]Mean corpuscular volume, [6]Mean corpuscular haemoglobn, [7]Mean corpuscular haemoglobin concentration.

The results observed in this experiment are due to the improvement of nutrition throughout the experimental period. The bulls were reared in a pasture system from birth to their entrance into the feedlot. Thus, during the period in which the animals were kept in a grazing system, parasite infestation may occur several times. This infestation triggers an immune response in the animals, with an increase in the defence cells (white blood cells) and plasma proteins. At the beginning of the experimental (feedlot) period, all animals were treated for endo- and ecto-parasites that are common

in the region. Moreover, these animals had no further contact with other animals during the experimental period and were kept on concrete floor stalls that were washed 3 times a week. The correct management and nutrition during the feedlot period could explain the lower levels of white blood cells and plasma proteins in the animals in our experiment.

2.6. Conclusions

The addition of propolis to the diet of bulls finished in feedlots did not change the average daily weight gain, feed efficiency and apparent digestibility. However, the addition of functional oils to the diet of bulls finished in feedlots improved the average daily weight gain and feed efficiency. Thus, functional oils can be added to the diets of cattle finished in feedlots to improve animal performance and feed efficiency, substituting for other products such as antibiotics and ionophores.

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information and do not imply recommendations or endorsement by the Department of Animal Science, State University of Maringá, Paraná, Brazil.

2.8. References (Journal Ciência e Agrotecnologia)

ALBERTÍ, P.; RIPOLL, G.; CASASÚS, I.; BLANCO, M.; CHAPULLÉ, J.L.G.; SANTAMARÍA, J. Efecto de la inclusión de antioxidantes en dietas de acabado sobre la calidad de la carne de terneros. **Información Técnica Económica Agraria,** v. 101, n. 2, p. 91-100, 2005.

AOAC. Association of Official Analytical Chemists. **Official Methods of Analysis**, Inc., Arlington, VA, U.S.A., 1998.

ARICETTI, J.A.; ROTTA, P.P.; PRADO, R.M.; PEROTTO, D.; MOLETTA, J.L.; MATSUSHITA, M.; PRADO, I.N. Carcass characteristics, chemical composition and fatty acid profile of *Longissimus* muscle of bulls and steers finished in a pasture system. **Asian-Australasian Journal of Animal Science,** v. 21, n. 10, p. 1441-1448, 2008.

BENCHAAR, C.; CALSAMIGLIA, S.; CHAVES, A. V.; FRASER, G. R.; COLOMBATTO, D.; MCALLISTER, T. A.; BEAUCHEMIN, K. A. A review of plant-derived essential oils in ruminant nutrition and production. **Animal Feed Science and Technology,** v. 145, n. 1-4, p. 209-228, 2008.

BENCHAAR, C.; PETIT, H. V.; BERTHIAUME, R.; WHYTE, T. D.; CHOUINARD, P. Y. Effects of addition of essential oils and monensin premix on digestion, ruminal fermentation, milk production, and milk composition in dairy cows. **Journal of Dairy Science,** v. 89, n. 11, p. 4352-4364, 2006.

BIONDO, A.W.; LOPES, S.T.A.; KOHAYAGAWA, A.; TAKAHIRA, R.K.; ALENCAR, N.X. Hemograma de bovinos (*Bos indicus*) sadios da raça nelore no primeiro mês de vida, criados no estado de São Paulo. **Ciência Rural,** v. 28, n. 2, p. 251-256, 1998.

CIOMS/OMS. **Council for International Organizations of Medical Services - International Guiding Principles for Biomedical Research Involving Animals**. 1st. Geneva, Switzerland: ERIC Clearinghouse, 1985.

DEVANT, M.; ANGLADA, A.; BACH, A. Effects of plant extract supplementation on rumen fermentation and metabolism in young Holstein bulls consuming high levels of concentrate. **Animal Feed Science and Technology,** v. 137, n. 1, p. 46-57, 2007.

DIAN, P.H.M.; PRADO, I.N.; FUGITA, C.A.; PRADO, R.M.; VALERO, M.V.; BERTIPAGLIA, L.M.A. Replacing corn with cassava starch by-products on the

performance, digestibility and carcass characteristics of bulls in confinement. **Acta Scientiarum. Animal Sciences,** v. 31, n. 4, p. 381-387, 2009.

DIAN, P.H.M.; PRADO, I.N.; VALERO, M.V.; ROTTA, P.P.; PRADO, R.M.; SILVA, R.R.; BERTIPAGLIA, L.M.A. Levels of replacing corn by cassava starch on performance and carcass characteristics of bulls finished in feedlot. **Semina: Ciências Agrárias,** v. 31, n. 2, p. 497-506, 2010.

FANDIÑO, I.; CALSAMIGLIA, S.; FERRET, A.; BLANCH, M. Anise and capsicum as alternatives to monensin to modify rumen fermentation in beef heifers fed a high concentrate diet. **Animal Feed Science and Technology,** v. 145, n. 1, p. 409-417, 2008.

FRANÇOZO, M.C.; PRADO, I.N.; CECATO, U.; VALERO, M.V.; ZAWADZKI, F.; RIBEIRO, O.L.; PRADO, R.M.; VISENTAINER, J.V. Growth performance, carcass characteristics and meat quality of finishing bulls fed crude glycerine-supplemented diets. **Brazilian Archives of Biology and Technology,** v. 56, n. 2, p. 327-336, 2013.

GIGER-REVERDIN, S.; DUVAUX-PONTER, C.; SAUVANT, D.; MARTIN, O.; PRADO, I.N.; MÜLLER, R. Intrinsic buffering capacity of feedstuffs. **Animal Feed Science and Technology,** v. 96, n. 1, p. 83-102, 2002.

GONZÁLEZ, F. H. D.; CONCEIÇÃO, T. R.; SIQUEIRA, A. J. S.; LA ROSA, V. L. Variações sangüíneas de uréia, creatinina, albumina e fósforo em bovinos de corte no Rio Grande do Sul. **A Hora Veterinária,** v. 20, p. 59-62, 2000.

HEGAZI, A. G.; ABD EL HADY, F. K.; ABD ALLAH, F. A. Chemical composition and antimicrobial activity of European propolis. **Zeitschrift für Naturforschung C,** v. 55, n. 1-2, p. 70-75, Jan-Feb 2000.

ÍTAVO, C.; MORAIS, M.G.; COSTA, C.; ÍTAVO, L.C.V.; FRANCO, G.L.; SILVA, J.A.; REIS, F.A. Addition of propolis or monensin in the diet: behavior and productivity of lambs in feedlot. **Animal Feed Science and Technology,** v. 165, n. 3, p. 161-166, 2011.

ITO, R. H.; VALERO, M. V.; PRADO, R. M.; RIVAROLI, D. C.; PEROTTO, D.; PRADO, I. N. Meat quality from four genetic groups of bulls slaughtered at 14 months old. **Acta Scientiarum.Animal Sciences,** v. 34, n. 4, p. 425-432, 2012.

ITO, R.H.; DUCATTI, T.; PRADO, J.M.; PRADO, I.M.; ROTTA, P.P.; VALERO, M.V.; PRADO, I.N.; SILVA, R.R. Soybean oil and linseed grains on performance and carcass characteristics of crossbred bulls finished in feedlot. **Semina: Ciências Agrárias,** v. 31, n. 1, p. 259-268, 2010.

JAIN, N. C.; JAIN, A. H. **Essentials of Veterinary Hematology**. 1st. Davis, CA, USA: Wiley-Blackwell, 1993.

JONES, M.L.; ALLISON, R.W. Evaluation of the ruminant complete blood cell count. **Veterinary Clinics of North America: Food Animal Practice,** v. 23, n. 3, p. 377-402, 2007.

KEARL, L. C. **Nutrient Requirements of Ruminants in Developing Countries**. 1st. Utah, UT, USA: International Feedstuffs Institute, Utah Agricultural Experiment Station, Utah State University, 1982. 382.

LAGE, J.F.; PAULINO, P.V.R.; PEREIRA, L.G.R.; VALADARES FILHO, S.C.; OLIVEIRA, A.S.; DETMANN, E.; SOUZA, N.K.P.; LIMA, J.C.M. Glicerina bruta na dieta de cordeiros terminados em confinamento. **Pesquisa Agropecuária Brasileira,** v. 45, n. 9, p. 1012-1020, 2010.

MAGGIONI, D.; MARQUES, J.A.; PEROTTO, D.; ROTTA, P.P.; DUCATTI, T.; MATSUSHITA, M.; SILVA, R.R.; PRADO, I.N. Bermuda grass hay or sorghum silage with or without yeast addition on performance and carcass characteristics of crossbred young bulls finished in feedlot. **Asian-Australasian Journal of Animal Sciences,** v. 22, n. 2, p. 206-215, 2009.

MARCUCCI, M.C. Propolis: chemical composition, biological properties and therapeutic activity. **Apidologie,** v. 26, n. 2, p. 83-99, 1995.

MARQUES, J. A.; PRADO, I.N.; ZEOULA, L.M.; ALCALDE, C.R.; NASCIMENTO, W.G. Avaliação da mandioca e seus resíduos industriais em substituição ao milho no desempenho de novilhas confinadas. **Revista Brasileira de Zootecnia,** v. 29, n. 5, p. 1528-1536, 2000.

MARTINS, A.S.; ZEOULA, L. M.; PRADO, I. N.; MARTINS, E. N.; LOYOLA, V. R. Ruminal in situ degradability of dry matter and crude protein of corn and sorghum silages and some concentrate feeds. **Revista Brasileira de Zootecnia,** v. 28, n. 5, p. 1109-1117, 1999.

MERTENS, D. R. Regulation of Forage Intake. In: R., FAHEY J. (Ed.). **Forage Quality, Evaluation, and Utilization**. Madison, WI, USA: American Society of Agronomy, 1994. p.450-493.

NRC. **Nutrient Requirements of Beef Cattle**. 7th ed. Natl. Acad. Press, Washington, DC., 2000. 276.

PARSONS, G.L.; SHELOR, M.K.; DROUILLARD, J.S. Performance and carcass traits of finishing heifers fed crude glycerin. **Journal of Animal Science,** v. 87, n. 2, p. 653-657, 2009.

PRADO, I. N.; ROTTA, P. P.; PRADO, R. M.; VISANTAINER, J. V.; MOLETTA, J. L.; PEROTTO, D. Carcass characteristics and chemical composition of the *Longissimus* muscle of Purunã and 1/2 Purunã vs. 1/2 Canchin bulls meat quality of bulls. **Asian-Australasian Journal of Animal Sciences,** v. 21, n. 9, p. 1296-1302, 2008.

PRADO, I.N.; MAGGIONI, D.; ABRAHÃO, J.J.S.; VALERO, M.V.; PRADO, R.M.; SOUZA, N.E. Meat quality of crossbred bulls fed with sorghum silage or sugar cane and slaughtered at two levels of fat thickness. **Acta Scientiarum.Technology,** v. 34, n. 3, p. 337-344, 2012.

PRADO, O.P.P.; ZEOULA, L.M.; MOURA, L.P.P.; FRANCO, S.L.; PRADO, I.N.; GOMES, H.C.C. Digestibilidade e parâmetros ruminais de dietas à base de forragem com adição de própolis e monensina sódica para bovinos. **Revista Brasileira de Zootecnia,** v. 39, n. 6, p. 1336-1345, 2010.

RAMOS, M. H.; KERLEY, M. S. Effect of dietary crude glycerol level on ruminal fermentation in continuous culture and growth performance of beef calves. **Journal of Animal Science,** v. 90, n. 3, p. 892-899, March 1, 2012 2012.

ROTTA, P.P.; PRADO, R.M.; PRADO, I.N.; VALERO, M.V.; VISENTAINER, J.V.; SILVA, R.R. The effects of genetic groups, nutrition, finishing systems and gender of Brazilian cattle on carcass characteristics and beef composition and appearance: a review. **Asian-Australasian Journal of Animal Sciences,** v. 22, n. 12, p. 1718-1734, 2009.

RUSSELL, J. B.; HOULIHAN, A. J. Ionophore resistance of ruminal bacteria and its potential impact on human health. **FEMS Microbiology Reviews,** v. 27, n. 1, p. 65-74, 2003.

SAS. **SAS/STAT User guide, Version 9.1.2**. Cary, NC, USA: SAS Institute Inc, 2004.

SNIFFEN, C. J.; O'CONNOR, J. D.; VAN SOEST, P. J.; FOX, D. G.; RUSSELL, J. B. A net carbohydrate and protein system for evaluating cattle diets: II. Carbohydrate and protein availability. **Journal of Animal Science,** v. 70, n. 11, p. 3562-77, 1992.

STELZER, F.S.; LANA, R.P.; CAMPOS, J.M.S. Desempenho de vacas leiteiras recebendo concentrado em diferentes níveis, associado ou não à própolis. **Revista Brasileira de Zootecnia,** v. 38, n. 7, p. 1381-1389, 2009.

STRADIOTTI JÚNIOR, D.; QUEIROZ, A.C.; LANA, R.P.; PACHECO, C.G.; CAMARDELLI, M.M.L.; DETMANN, E.; EIFERT, E.C.; NUNES, P.M.M.; OLIVEIRA, M.V.M. Ação do extrato de própolis sobre a fermentação *in vitro* de diferentes alimentos pela técnica de produção de gases. **Revista Brasileira de Zootecnia,** v. 33, n. 4, p. 1093-1099, 2004.

VALERO, M.V.; ZAWADZKI, F.; FRANÇOZO, M.C.; FARIAS, M.S.; ROTTA, P.P.; PRADO, I.N.; VISENTAINER, J.V.; ZEOULA, L.M. Sodium monensin or propolis extract in the diet of crossbred (½ Red Angus vs. ½ Nellore) bulls finished in feedlot: chemical composition and fatty acid profile of the *Longissimus* muscle. **Semina: Ciências Agrárias,** v. 32, n. 4, p. 1617-1626, 2011.

VAN SOEST, P. J.; ROBERTSON, J. B.; LEWIS, B. A. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. **Journal of Dairy Science,** v. 74, n. 10, p. 3583-3597, 1991.

ZAWADZKI, F.; PRADO, I.N.; MARQUES, J.A.; ZEOULA, L.M.; ROTTA, P.P.; SESTARI, B.B.; VALERO, M.V.; RIVAROLI, D.C. Sodium monensin or propolis extract in the diets of feedlot-finished bulls: effects on animal performance and carcass characteristics. **Journal of Animal and Feed Sciences,** v. 20, n. 1, p. 16-25, 2011.

ZEOULA, L.M.; PRADO, I.N.; DIAN, P. H. M.; GERON, L. J. V.; CALDAS NETO, S. F.; MAEDA, E.M.; PERON, P.D.P.; MARQUES, J.A.; FALCÃO, A.J.S. Recuperação fecal de indicadores internos avaliados em ruminantes. **Revista Brasileira de Zootecnia,** v. 31, n. 4, p. 1865-1874, 2002.

ZHANG, W.; XIAO, S.; SAMARAWEERA, H.; LEE, E.J.; AHN, D.U. Improving functional value of meat products. **Meat Science,** v. 86, n. 1, p. 15-31, 2010.

3. PROPOLIS AND FUNCTIONAL OILS (CASHEW AND CASTOR OIL) ON ANIMAL PERFORMANCE, APPARENT DIGESTIBILITY AND CARCASS CHARACTERISTICS OF CROSSBRED BULLS FINISHED IN FEEDLOT

3.1 Abstract

This work was conducted to evaluate the effect of propolis and functional oils on animal performance, feed intake, apparent digestibility and carcass characteristics of bulls finished in feedlot. Thirty bulls were kept in feedlot (individual pen) for 55 days. One group of bulls was fed control diet (CON) containing corn silage (45.5% total dry matter) and concentrate (cracked corn, soybean meal, glycerine, limestone and mineral salt). The propolis-supplemented group (PRO) received 3 grams/animal/day in the form of a premix added to the concentrate. The functional oil-supplemented group (OIL) received 3 grams/animal/day added to the concentrate. The initial weight, final weight and average daily gain were higher for the bulls fed OIL diet than for bulls fed the CON and PRO diets. The bulls that received the OIL diet demonstrated the best feed efficiency. The addition of the additives to the diets did not affect the apparent digestibility of dry matter and other nutrients. Carcass characteristics (carcass dressing, conformation, muscle, fat and bone percentages) were similar among the three diets.

Keys words: Additives, co-products; glycerine; ruminant; plant oils

3.2. Introduction

The beef production system in Brazil is based principally on finishing zebu cattle in a pasture system (ANUALPEC, 2013). However, the average daily gain, feed efficiency and meat quality of these animals are poor, and the cattle are relatively old when they are slaughtered (Moreira et al., 2003b; Prado et al., 2009; Rotta et al., 2009).

One of the biggest challenges facing the livestock industry in developing countries is the general increasing demand by foreign consumers for high-quality, healthy products with enhanced safety from food production systems with improved environmental and carbon footprints (Hocquette et al., 2012). The export of beef from Brazil has increased greatly in the last decade, and this trend is expected to continue until 2020 (FAPRI, 2012). Thus, to meet the demands of the foreign market, it will be necessary to improve at quality and protect the environment, as required by these markets, while increasing the profitability of the system. The rapid changes occurring in the beef cattle production system in Brazil include the use of *Bos taurus taurus* and *Bos taurus indicus* crossbred cattle and the supplementation of these animals in pastures (Moreira et al., 2003a; Moreira et al., 2004) or finishing them in feedlot systems (Rotta et al., 2009).

For cattle finishing system with high energy requirements, it is necessary to increase the use of grains and cereals (Ito et al., 2010; Kazama et al., 2008). When ruminants are fed forages, the ruminal pH is close to neutral, but when finishing rations containing large amounts of cereal grain are provided, the ruminal pH can decrease drastically (Van Soest, 1994). Rumen acidosis is often associated with an increase in lactate, a much stronger acid than the typical volatile fatty acids found in the rumen. In severe cases, acute indigestion, founder, rumen ulceration and even death can occur. To

modulate rumen fermentation, diets are supplemented with ionophores additives (Russell and Strobel, 1989).

However, no animal-based food products containing these substances has entered or been produced in Europe since January 2006, according to the European Union legislation published in the Official Journal of the European Union (2003). Thus, it´s necessary is natural alternatives to ionophores additives (Benchaar et al., 2008; Calsamiglia et al., 2007).

Propolis is a promising alternative to ionophores and has numerous pharmacological properties, including antimicrobial activity (Righi et al., 2011). Several in vivo and in vitro experiments have shown that propolis acts similarly to ionophores when administered to animals (Oliveira et al., 2004; Prado et al., 2010a; Stradiotti Júnior et al., 2004). The ability of propolis to inhibit the growth of microorganisms is most widely known and scientifically proven pharmacological activity (Marcucci, 1996; Prado et al., 2010a; Scazzocchio et al., 2006). Studies on ruminant nutrition the propolis have shown positive results such as increase in *in vitro* dry matter digestibility, increase in the flow and digestibility of crude protein in the intestines and a better feed conversion ratio(Prado et al., 2010b; Zawadzki et al., 2011). However, propolis production is limited because it is bee-dependent and exhibits greats chemical variability (Bankova, 2005).

Plant oils may also be able to replace the use of antibiotics in ruminant nutrition because many plants produce secondary metabolites, including saponins and tannins, that have antimicrobial properties (Benchaar et al., 2008; Burt, 2004; Zhang et al., 2010). These compounds have been shown to modulate ruminal fermentation and improve nutrient utilisation in ruminants (Calsamiglia et al., 2007; Hart et al., 2008; Wang et al., 1996). The well-documented antimicrobial activities of plant oils and their

active components has prompted a number of scientists to examine the ability of these secondary metabolites to manipulate rumen microbial fermentation and to improve the production efficiency of ruminants (Benchaar et al., 2008; Greathead, 2003; Hart et al., 2008).

The objective of paper this was to evaluate the effects of propolis and functional oil (cashew and castor oils) additives on animal performance, apparent digestibility and carcass characteristics of crossbred bulls finished in feedlot.

3.3. Materials and methods

3.3.1. Local, animals, housing and diets

This experiment was approved by the ethic committee of Department of Animal Production at the State University of Maringá (CIOMS/OMS, 1985). It was conducted at the Rosa & Prado Sector in Experimental Station at the Iguatemi Farm in Maringá, Paraná State, Brazil.

Thirty crossbred bulls (½ Aberdeen Angus *x*. ½ Nellore) with 20-months-old were used in randomised studies. The bulls were weighed and distributed into three diet group of ten bulls each. At the beginning of the experimental period, the bulls weighed 387 ± 6.3 kg, were vaccinated against clostridial diseases, treated for ectoparasites and wormed. The bulls were housed in individual 10m² pens with concrete floors. The pens were equipped with feeders that were 60cm deep and 2m length and automatic drinker. The diets consisted of 45.5% roughage (corn silage) and 55.5% concentrate. The feed concentrate used was based on corn, soybean meal, glycerine, urea, limestone and mineral salt. The chemical compositions of the ingredients used in diets are presented in Table 1. The compositions (g/kg) of the diets are shown in Table 2.

The bulls body weight and food intake were recorded daily until day 55 of the experimental period when the bulls reached a final BW of 470 ±8.0 kg.

The glycerine was produced in a soy-diesel facility (BIOPAR, Rolândia, Paraná, Brazil). All diets were formulated to be isonitrogenous (Table 1). The functional oils contained ricinoleic acid, anacardic acid, cardanol and cardol. Ricinoleic acid was obtained from castor oil (extracted from castor seed), and the anacardic acid, cardanol and cardol were obtained from the cashew nut shell liquid (obtained from processing of cashew nut); these substances were all produced in northern Brazil. Vermiculite was used for the functional oil solidification. The functional oil was formulated at Oligo Basics Agroindustrial Laboratory Ltda.

The bulls were randomly assigned to 1 of 3 diets: CON (control), PRO (propolis addition) and OIL (functional oils addition). The bulls were separate troughs and fed *ad libitum* concentrate and corn silage. The bulls were fed twice a day at 08:00 and 16:00 h. The diets were weighed daily so that the refusals represented 5% of the total. The diet formulation and quantity were designed to provide a weight gain of 1.5 kg/day, according to the NRC recommendations (NRC, 2000).

3.3.2. Animal performance and feed intake

To evaluate animal performance, the bulls were weighed once at the beginning of the experiment and then once every 14 days (after a fasting from solid food for a period of 16 hours).

The daily feed intake was estimated as the difference between the supplied feed and the refusals in the trough. During the experimental period, samples of the supplied feed and refusals were collected weekly, and a representative composite sample was drafted for each animal in each treatment.

3.3.3. Apparent total-tract digestibility

To calculate the apparent digestibility coefficient of the dry matter and other nutrients, faeces were collected for a period of five days starting on the 40th day of the feedlot period. Faecal samples (approximately 200 g wet weight) were collected for each bull from the floor with spun (minimum 3-h intervals between samples) for five consecutive days and were pooled by bull. After drying at 55^{o}C for 72 h, the samples were ground in a feed mill and passed through a 1mm sieve in preparation for chemical analyses.

To estimate the flux of the faecal dry matter, indigestible dry matter (iDM) was used as an internal marker (Zeoula et al., 2002). Samples were milled through a 2 mm sieve, packed (5 mg of DM/cm²) in 4 x 5 cm Ankom filter bags (F57) that had been previously weighed and incubated for 240 h in the rumen of a Holstein bull fed a mixed diet of equal parts forage (corn silage) and concentrate (the same concentrate used in the treatments). After incubation, the bags were removed, washed with water until clean and dried in a ventilated oven at 55°C for 72 h. The bags were then removed and oven-dried at 105ºC. The iDM was estimated using the difference in sample weight before and after ruminal incubation. Faecal excretion was calculated using the following equations: FE = iDMI/iDMCF, where FE = faecal excretion (kg/day), iDMI = iDM intake (kg/day) and iDMCF = iDM concentration in faeces (kg/day). The apparent digestibility coefficients for DM and nutrients were estimated according to the formula DC = [(Intake – Excreted)/Intake] x 100.

3.3.4. Chemical analyses

The DM content of the samples was determined by drying at 105 °C for 24 h according to the methods described by the AOAC (1998) (method 930.15). The OM

content was calculated as the difference between the DM and ash contents, with ash determined by combustion at 550 °C for 5 h (AOAC, 1998). The NDF contents were determined using the methods described by Van Soest et al. (1991) with heat stable alpha-amylase for solubilisation of the amylaceous compound (Mertens, 2002)and ADF (AOAC, 1990) (method 973.18). The nitrogen (N) content was determined by the Kjeldahl method (AOAC, 1998) (Method 976.05), and the total carbohydrates (TC) were calculated using the following equation: TC = 100 – (%CP + % EE + % Ash) (Sniffen et al., 1992). Non-fibrous carbohydrates (NFC) were determined as the difference between the TC and NDF. The total digestible nutrient (TDN) content of the diets was obtained by the following methodology described by Kearl (1982): silage = -17.2649 + 1.2120 (% CP) + 0.8352 (% ENN) + 2.4637 (% EE) + 0.4475 (% CF); energetic foods = 40.2625 + 0.1969 (% CP) + 0.4228 (% ENN) + 1.1903 (% EE) + 0.1379 (% CF); and protein foods= 40.3227+0.5398 (% CP) + 0.4448 (% ENN) + 1.4218 (% EE) – 0.7007 (% CF). The samples were analysed at the laboratory of Feed Analyses and Animal Nutrition at the State University of Maringá.

3.3.5. Ultrasound measurements in vivo

After 55 days on the feedlot diets, the *Longissimus* muscle area, fat depth and marbling was measured at the 13th thoracic rib using a dynamic imaging real time ultrasound scanner (model – Concept MLV, with 3.5 MHz transducer). All measurements were obtained from the right side of each animal by the same operator. pelage was clipped from the areas to be scanned, and vegetable oil was applied to obtain adequate acoustic contact. The cattle were restrained by the head in a chute, and physical palpation was used to accurately ascertain the scanning sites. The animals were only scanned when they were in a relaxed posture, thus permit ting a more accurate

measurement. The transducer had a built-in stand-off with a silicone rubber strip attached to facilitate contact with the curvature of the animal's body. The probe was placed perpendicular to the horizontal trajectory of the rib eye muscle (*Longissimus dorsi*) at the13th thoracic rib until bones appeared on the monitor. When a satisfactory image was achieved, it was frozen on the monitor and the depth of the eye muscle, fat depth and marbling was then measured using internal electronic callipers and measurement software. Fat depth was measured at 3 points at the 13th thoracic rib across the width (0.4, 0.6 and 0.8) of the muscle and at four points (0.2, 0.4, 0.6 and 0.8) at the 13th thoracic rib. The fat depth was calculated as the mean of the average values at the 13th thoracic rib.

3.3.6. Measurements of carcass characteristics

The bulls were slaughtered according to industrial practices in Brazil at a commercial slaughterhouse 10 km from the Iguatemi Experimental Farm. The carcasses were then identified and chilled for 24 h at 4ºC. The right half of the carcass was used to determine the following characteristics:

Hot carcass weight (HCW) was determined soon after slaughter and prior to carcass chilling.

Hot carcass dressing (HCD), the percentage of individual animal dressing was defined by the ratio HCW/live weight multiplied by 100.

Carcass conformation (CONF). Muscle development was determined where the highest value indicated the best conformation may be inferior (1 to 3), poor (4 to 6), regular (7 to 9), good (10 to 12), very good (13 to 15), superior (16 to 18); ratings may also be reported as plus, average and minus.

Percentage of carcass muscle (MP), fat (FP) and bone (BP). The muscle, fat and bone were physically separated from the *Longissimus* section, which corresponds to the 9^{th}, 10^{th} and 11^{th} ribs, and weighed individually according to the methods of Hankins and Howe (1946).

3.3.7. Statistical analysis

The experimental design was completely randomised with three treatments and ten animals per treatment. The results were statistically interpreted using SAS (2004) software. According to': $Y_{ij} = \mu + T_i + e_{ij}$, where Y_{ij} = dependent variables; T_i = treatment effect and e_{ij} = residual error.

3.4. Results

3.4.1. Animal performance and feed intake

The final weight and average daily gain were highest ($P<0.05$) for bulls fed the OIL diet, intermediate for bulls fed the PRO diet and lowest for bulls fed CON diet (Table 3). The intake of dry matter and other nutrients was similar ($P>0.05$) for bulls fed the three diets (Table 3).

The dry matter and crude protein conversion were better ($P<0.05$) for bulls fed the PRO diet (6.38 and 0.76, respectively) and OIL diet (6.38 and 0.76, respectively) than for those fed the CON diet (7.05 and 0.83, respectively, Table 3). On the other hand, dry matter efficiency was better ($P<0.05$) for bulls fed the OIL (0.16) than for those fed the CON diet (0.14, Table 3). Whereas crude protein efficiency was better for bulls fed the PRO and OIL diet (1.32 and 1.32, respectively) than for those fed the CON diet (1.20, Table 3).

3.4.2. Apparent total-tract digestibility

In the present study, the dry matter apparent digestibility and others nutrients were similar (P>0.05) among the CON, PRO and OIL diets (Table 4).

3.4.3. Ultrasound measurements in vivo

Carcass characteristics evaluated *in vivo* by ultrasound were similar (P>0.05) among the CON, PRO and OIL diets (Table 5).

3.4.4. Measurements of carcass characteristics

Hot carcass weight was highest (P<0.05) for bulls fed the OIL diet, intermediate for bulls fed the PRO diet and lowest for bulls fed CON diet (Table 6). On the other hand hot carcass dressing and conformation were similar (P>0.05) among the three diets (Table 6). Likewise, muscle, fat and bone percentages after rib dissection were similar (P>0.05) among the three diets (Table 6).

3.5. Discussion

3.5.1. Animal performance and feed intake

The initial weight was higher for the bulls fed OIL diet (12 kg) than the bulls of the CON and PRO diets (Table 3) due to greater weight gain during the growing period (Valero et al., 2013, in press). There is little data in the literature regarding the use of propolis and plants extracts as additives in the diets for cattle finishing. However, the data show great variation between the results of various propolis and plant extracts included in the diets of ruminants (Benchaar et al., 2008; Yang et al., 2010; Zhang et al., 2010). As with our study, Zawadzki et al. (2011) observed better animal performance in

bulls finished in a feedlot with propolis extract added to the diet. The improvement of animal performance and feed efficiency with the addition of propolis to the diet can be explained by the antimicrobial activity of propolis compounds (Prado et al., 2010a; Stradiotti Júnior et al., 2004).

As observed for propolis extract, the plant extract (cashew oil and castor oil) improved animal performance and feed efficiency. In livestock production systems, antibiotics are commonly fed to animals to prevent disease and metabolic disorders and to improve feed efficiency (Goodrich et al., 1984). However, public concern regarding the routine use of antibiotics in livestock has recently increased because of the emergence of antibiotic resistant bacteria that may pose a risk to human health (Russell and Houlihan, 2003). Consequently, considerable effort has been devoted to developing alternatives to antibiotics. Others (Benchaar et al., 2008; Hart et al., 2008) have shown that plant extracts may be useful alternatives to antibiotics because many plants produce secondary metabolites, such as saponins and tannins, that have antimicrobial properties.

The dry matter intake was 10.0 kg/animal/day or 2.3% of body weight. Generally, the dry matter intake for cattle finished in a feedlot and fed a diet containing 50% roughage and 50% concentrate ranges between 2.0% and 2.5% of the body weight (Dian et al., 2010; Maggioni et al., 2009; Prado et al., 2000).The crude protein intake was 1.2 kg/animal/day, according to NRC (2000), cattle in the final period of growing and finishing require 1.0 to1.2 kg/day of crude protein to gain an average of 1.4 kg/day. The neutral detergent fibre content and acid detergent fibre intake were low for all three diets because the diets included glycerine as an energy source, and glycerine has low fibre content.

The superior dry matter and crude protein conversion for the bulls fed the PRO and OIL diets may be due to the bioactivities of the propolis and plants extracts,

particularly the anti-bacterial action due to bio-flavonoids (Benchaar et al., 2008; Marcucci, 1995; Zhang et al., 2010). Propolis extract reduces the number of gram-positive microorganisms responsible for methane production in the rumen (Benchaar et al., 2007; Prado et al., 2010b). Broudiscou et al. (2000) studied the effects of thirteen dry plant extracts with high flavonoids levels on fermentation and methanogenesis in cultures of rumen microorganisms, and they observed that plant extracts increased propionate production (energy source) by 10.3% and reduced the population of the microorganisms. They also observed that the plants extracts did not alter the dry matter intake, pH, ammonia levels or microbial protein in the rumen liquid of cat tle fed roughage. However, plant extracts hindered deamination by rumen microorganisms. This suggests that ammonia levels may be reduced in the rumen of animals on diets that have elevated protein degradable/fermentation carbohydrates.

3.5.2. Apparent total-tract digestibility

There is very limited information available on the effects of the addition of propolis and functional oils on digestion in ruminants. The dry matter digestibility was 70% and the digestibility of the crude protein was 65%. The results observed for the dry matter digestibility differ from those reported by Prado et al. (2010b) for diets containing a similar forage-to-concentrate ratio (50:50). They observed an *in vitro* increase of 8.3% and 6.2% in dry matter digestibility with the addition of propolis compared to the control and monensin diets, respectively. The difference between our results may be due to the volume of the rumen, the dry matter intake, the passage rate in the rumen and the basal diet. In dairy cows, Benchaar et al. (2006b) observed that the apparent digestibilities of dry matter, organic matter, neutral detergent fibre and starch were similar among animals fed a control diet and those supplemented with functional

oils or sodium monensin. However, the apparent digestibility of acid detergent fibre increased when diets were supplemented with functional oils. Benchaar et al. (2006a) Study indicates that in beef cattle, the dry matter digestibility and nitrogen digestibility are not changed by the addition of functional oils to the diet. Likewise,Ando et al. (2003) observed no changes in total tract digestibility of dry matter and crude protein when steers were fed peppermint (200 grams/steer/d) in which menthol is the main functional oil. Castillejos et al. (2005) observed no effect on nitrogen degradation when a mixture of essential oils (Crina Ruminants®) was added to continuous culture fermenters. McIntosh et al. (2003) observed a reduction in the rate of ammonia production when casein acid hydrolysate (i.e., free amino acids) was incubated *in vitro* with strained rumen fluid collected from cows receiving a TMR supplemented with 1 gram/animal/d of a blend of oil components (Crina Ruminants®). The discrepancies between studies could be explained by differences in the procedure used (*in vivo vs. in vitro*), the duration for which bacteria were exposed to the functional oils and by a possible adaptation of the ruminal bacteria to the functional oils.

3.5.3. Ultrasound measurements in vivo

The LM area, ratio, marbling and fat thickness were measured by linear array ultrasound before and after slaughter. Real-time ultrasound has been shown to be an accurate predictor of carcass 12^{th} rib fat thickness and LM area in beef cattle (Hamlin et al., 1995). However, in this study the LM area and fat thickness were 78.6 cm^2 and 5.9 mm, respectively, by ultrasound methods and 57.9 cm^2 and 5.0 mm, respectively, after slaughter (Table 5). Thus, ultrasonic 12^{th} rib fat thickness and LM area were greater when estimated on live animals, due clearness which animals were submited at slaughterhouse. This research suggests that ultrasonic measurements of fat thickness

and LM area taken before slaughter can be a predictors of final carcass fat thickness and LM area. Real-time, linear array ultrasound offers a means of predicting these measures of individual carcass merit on alive animal basis, and this could be important in identifying animals with superior genetic potential to take advantage of incentives offered under a value-based marketing system.

2.5.4. Measurements of carcass characteristics

The hot carcass weight was highest for bulls fed OIL diet, intermediate for PRO diet and lower for CON diet. The diets did not affect the hot carcass dressing or carcass conformation (Table 6). The hot carcass dressing was 54%, and the carcass conformation was 12.5 points. In Brazil, crossbred bulls (*Bos taurus vs. Bos indicus*) fed high-energy density diets and finished in feedlot generally present hot carcass dressing percentages between 52 and 56% and carcass conformation scores between 10 to 12 points (Prado et al., 2012; Rotta et al., 2009). Thus, the inclusion of propolis and functional oils in the levels studied had no effect on the dressing percentage of beef cattle finished in the feedlot.

The muscle, fat and bone percentages after rib dissection were similar among the three diets (Table 6) and featured average values of 60, 25 and 15%, respectively. Generally, the muscle, fat and bone percentages of carcasses of *Bos taurus vs. Bos indicus* crossbred bulls finished in a feedlot and fed high-energy density diets that are slaughtered between 460 and 520 kg ranges from 60 to 64% for muscle, 20 to 25% for fat and 14 to 18% for bone (Ito et al., 2010; Ito et al., 2012; Maggioni et al., 2009; Maggioni et al., 2010). Thus, the inclusion of propolis and functional oils in the diets no had effect on tissue percentages in the carcasses of bulls finished in a feedlot.

3.6. Conclusions

The addition of propolis extracts to diets of bulls finished in feedlot improved animal performance and carcass characteristics. Thus, this compound could be used in the diets of feedlot bulls if desired by the producer. Likewise, the addition of functional oils (cashew and castor oils) to diets of bulls finished in feedlot improved animal performance and feed efficiency but did not change the carcass characteristics. Thus, addition functional oils could also be used in diets of bulls finished in feedlot.

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3.8. References (Journal Animal Science)

Ando, S., T. Nishida, M. Ishida, K. Hosoda, and E. Bayaru. 2003. Effect of peppermint feeding on the digestibility, ruminal fermentation and protozoa. Livest. Prod. Sci. 82: 245-248.

ANUALPEC. 2013. Anuário da Pecuária Brasileira. 20th ed. Instituto FNP, São Paulo, SP, BR.

AOAC. 1990. Association of Official Analytical Chemists. 16th ed. Association of Official Analytical Chemists, Arlington, VA, USA.

AOAC. 1998. Association of Official Analytical Chemists. 17th ed. Association of Official Analytical Chemists, Arlington, VA, USA.

Bankova, V. 2005. Recent trends and important developments in propolis research. Evid. Based Complement. Alternat. Med. 2: 29-32.

Benchaar, C., S. Calsamiglia, A. V. Chaves, G. R. Fraser, D. Colombatto, T. A. McAllister, and K. A. Beauchemin. 2008. A review of plant-derived essential oils in ruminant nutrition and production. Anim. Feed Sci. Technol. 145: 209-228.

Benchaar, C., A. V. Chaves, G. R. Fraser, Y. Wang, K. A. Beauchemin, and T. A. McAllister. 2007. Effects of essential oils and their components on *in vitro* rumen microbial fermentation. Can. J. Anim. Sci. 87: 413-419.

Benchaar, C., J. L. Duynisveld, and E. Charmley. 2006a. Effects of monensin and increasing dose levels of a mixture of essential oil compounds on intake, digestion and growth performance of beef cattle. Can. J. Anim. Sci. 86: 91-96.

Benchaar, C., H. V. Petit, R. Berthiaume, T. D. Whyte, and P. Y. Chouinard. 2006b. Effects of addition of essential oils and monensin premix on digestion, ruminal fermentation, milk production, and milk composition in dairy cows. J. Dairy Sci. 89: 4352-4364.

Broudiscou, L. P., Y. Papon, and A. F. Broudiscou. 2000. Effects of dry plant extracts on fermentation and methanogenesis in continuous culture of rumen microbes. Anim. Feed Sci. Technol. 87: 263-277.

Burt, S. 2004. Essential oils: their antibacterial properties and potential applications in foods—a review. Int. J. Food Microbiol. 94: 223-253.

Calsamiglia, S., M. Busquet, P. W. Cardozo, L. Castillejos, and A. Ferret. 2007. Invited review: essential oils as modifiers of rumen microbial fermentation. J. Dairy Sci. 90: 2580-2595.

Castillejos, L., S. Calsamiglia, A. Ferret, and R. Losa. 2005. Effects of a specific blend of essential oil compounds and the type of diet on rumen microbial fermentation and nutrient flow from a continuous culture system. Anim. Feed Sci. Technol. 119: 29-41.

CIOMS/OMS. 1985. Council for International Organizations of Medical Services - International Guiding Principles for Biomedical Research Involving Animals. 1st ed. ERIC Clearinghouse, Geneva, Switzerland.

Dian, P. H. M., I. N. Prado, M. V. Valero, P. P. Rotta, R. M. Prado, R. R. Silva, and L. M. A. Bertipaglia. 2010. Levels of replacing corn by cassava starch on performance and carcass characteristics of bulls finished in feedlot. Semin-Cienc Agrar 31: 497-505.

FAPRI. 2012. World Agricultural Outlook Database. http://www.fapri.iastate.edu/tools/outlook.aspx Accessed 20/01/2013 20 January 2013.

Goodrich, R. D., J. E. Garrett, D. R. Gast, M. A. Kirick, D. A. Larson, and J. C. Meiske. 1984. Influence of monensin on the performance of cattle. J. Anim. Sci. 58: 1484-1498.

Greathead, H. 2003. Plants and plant extracts for improving animal productivity. Proc. Nutr. Soc. 62: 279-290.

Hamlin, K. E., R. D. Green, L. V. Cundiff, T. L. Wheeler, and M. E. Dikeman. 1995. Real-time ultrasonic measurement of fat thickness and longissimus muscle area: II. Relationship between real-time ultrasound measures and carcass retail yield. J. Anim. Sci. 73: 1725-1734.

Hankins, O. G., and P. E. Howe. 1946. Estimation of the composition of beef carcasses and cuts. USDA technical bulletin 926.

Hart, K. J., D. R. Yáñez-Ruiz, S. M. Duval, N. R. McEwan, and C. J. Newbold. 2008. Plant extracts to manipulate rumen fermentation. Anim. Feed Sci. Technol. 147: 8-35.

Hocquette, J. F., R. Botreau, B. Picard, A. Jacquet, D. W. Pethick, and N. D. Scollan. 2012. Opportunities for predicting and manipulating beef quality. Meat Sci. 92: 197-209.

Ito, R. H., T. Ducatti, J. M. Prado, I. M. Prado, P. P. Rotta, M. V. Valero, I. N. Prado, and R. R. Silva. 2010. Soybean oil and linseed grains on performance and carcass characteristics of crossbred bulls finished in feedlot. Semin-Cienc. Agrar. 31: 259-267.

Ito, R. H., I. N. Prado, P. P. Rotta, M. G. Oliveira, R. M. Prado, and J. L. Moletta. 2012. Carcass characteristics, chemical composition and fatty acid profile of *Longissimus* muscle of young bulls from four genetic groups finished in feedlot. Rev. Bras. Zootec. 41: 384-391.

Kazama, R., L. M. Zeoula, I. N. Prado, D. C. Silva, T. Ducatti, and M. Matsushita. 2008. Características quantitativas e qualitativas da carcaça de novilhas alimentadas com diferentes fontes energéticas em dietas à base de cascas de algodão e de soja. Rev. Bras. Zootec. 37: 350-357.

Kearl, L. C. 1982. Nutrient Requirements of Ruminants in Developing Countries. 1st ed. International Feedstuffs Institute, Utah Agricultural Experiment Station, Utah State University, Utah, UT, USA.

Maggioni, D., J. A. Marques, D. Perotto, P. P. Rotta, T. Ducatti, M. Matsushita, R. R. Silva, and I. N. Prado. 2009. Bermuda grass hay or sorghum silage with or without yeast addition on performance and carcass characteristics of crossbred young bulls finished in feedlot. Asian-Australas. J. Anim. Sci. 22: 206-215.

Maggioni, D., J. A. Marques, P. P. Rotta, D. Perotto, T. Ducatti, J. V. Visentainer, and I. N. Prado. 2010. Animal performance and meat quality of crossbred young bulls. Livest Sci 127: 176-182.

Marcucci, M. C. 1995. Propolis: chemical composition, biological properties and therapeutic activity. Apidologie 26: 83-99.

Marcucci, M. C. 1996. Propriedades biológicas e terapêuticas dos constituintes químicos da própolis. Quim. Nova 19: 529-535.

McIntosh, F. M., P. Williams, R. Losa, R. J. Wallace, D. A. Beever, and C. J. Newbold. 2003. Effects of essential oils on ruminal microorganisms and their protein metabolism. Appl. Environ. Microbiol. 69: 5011-5014.

Mertens, D. R. 2002. Gravimetric determination of amylase-treated neutral detergent fiber in feeds with refluxing in beakers or crucibles: collaborative study. J. AOAC Int. 85: 1217-1240.

Moreira, F. B., I. N. Prado, U. Cecato, F. Y. Wada, W. G. Nascimento, and N. E. Souza. 2003a. Suplementação com sal mineral proteinado para bovinos de corte, em crescimento e terminação, mantidos em pastagem de grama estrela roxa (Cynodon plectostachyrus Pilger) no inverno. Rev. Bras. Zootec. 32: 449-455.

Moreira, F. B., I. N. Prado, U. Cecato, L. M. Zeoula, F. Y. Wada, and M. S. Torii. 2004. Níveis de suplementação com sal mineral proteinado para novilhos Nelore terminados em pastagem no período de baixa produção forrageira. Rev. Bras. Zootec. 33: 1814-1821.

Moreira, F. B., N. E. Souza, M. Matsushita, I. N. Prado, and W. G. Nascimento. 2003b. Evaluation of carcass characteristics and meat chemical composition of *Bos indicus* and *Bos indicus x Bos taurus* crossbred steers finished in pasture systems. Braz. Arch. Biol. Technol. 46: 609-616.

NRC. 2000. Nutrient Requirements of Beef Cattle. 7th ed. National Academy Press, Washington, DC, USA.

Oliveira, J. S., R. P. Lana, A. C. Borges, A. C. Queiroz, and I. C. C. Almeida. 2004. Efeito da monensina e extrato de própolis sobre a produção de amônia e degradabilidade *in vitro* da proteína bruta de diferentes fontes de nitrogênio. Rev. Bras. Zootec. 33: 504-510.

Prado, I. N., D. Maggioni, J. J. S. Abrahão, M. V. Valero, R. M. Prado, and N. E. Souza. 2012. Meat quality of crossbred bulls fed with sorghum silage or sugar cane and slaughtered at two levels of fat thickness. Acta Sci. Technol. 34: 337-344.

Prado, I. N., A. D. Pinheiro, C. R. Alcalde, L. M. Zeoula, W. G. Nascimento, and N. E. Souza. 2000. Níveis de substituição do milho pela polpa de citrus peletizada sobre o desempenho e características de carcaça de bovinos mestiços confinados. Rev. Bras. Zootec. 29: 2135-2141.

Prado, O. P. P., L. M. Zeoula, L. P. P. Moura, S. L. Franco, S. B. Paiva, and P. B. Arcuri. 2010a. Isolation and expeditious morphological, biochemical and kinetic

characterization of propolis-tolerant ruminal bacteria. Rev. Bras. Zootec. 39: 2048-2054.

Prado, O. P. P., L. M. Zeoula, L. P. P. Moura, S. L. Franco, I. N. Prado, and H. C. C. Gomes. 2010b. Digestibilidade e parâmetros ruminais de dietas à base de forragem com adição de própolis e monensina sódica para bovinos. Rev. Bras. Zootec. 39: 1336-1345.

Prado, R. M., I. N. Prado, J. A. Marques, P. P. Rotta, J. V. Visentainer, R. R. Silva, and N. E. Souza. 2009. Meat quality of the *Longissimus* muscle of bulls and steers (1/2 Nellore vs 1/2 Simmental) finished in feedlot. J. Anim. Feed Sci. 18: 221-230.

Righi, A. A., T. R. Alves, G. Negri, L. M. Marques, H. Breyer, and A. Salatino. 2011. Brazilian red propolis: unreported substances, antioxidant and antimicrobial activities. J. Sci. Food Agric. 91: 2363-2370.

Rotta, P. P., R. M. Prado, I. N. Prado, M. V. Valero, J. V. Visentainer, and R. R. Silva. 2009. The effects of genetic groups, nutrition, finishing systems and gender of Brazilian cattle on carcass characteristics and beef composition and appearance: a review. Asian-Australas. J. Anim. Sci. 22: 1718-1734.

Russell, J. B., and A. J. Houlihan. 2003. Ionophore resistance of ruminal bacteria and its potential impact on human health. FEMS Microbiol. Rev. 27: 65-74.

Russell, J. B., and H. J. Strobel. 1989. Effect of ionophores on ruminal fermentation. Appl. Environ. Microbiol. 55: 1-6.

SAS. 2004. SAS/STAT User guide, Version 9.1.2. SAS Institute Inc, Cary, NC, USA.

Scazzocchio, F., F. D. D'Auria, D. Alessandrini, and F. Pantanella. 2006. Multifactorial aspects of antimicrobial activity of propolis. Microbiol. Res. 161: 327-333.

Sniffen, C. J., J. D. O'Connor, P. J. Van Soest, D. G. Fox, and J. B. Russell. 1992. A net carbohydrate and protein system for evaluating cattle diets: II. Carbohydrate and protein availability. J. Anim. Sci. 70: 3562-3577.

Stradiotti Júnior, D., A. C. Queiroz, R. P. Lana, C. G. Pacheco, M. M. L. Camardelli, E. Detmann, E. C. Eifert, P. M. M. Nunes, and M. V. M. Oliveira. 2004. Ação do extrato de própolis sobre a fermentação *in vitro* de diferentes alimentos pela técnica de produção de gases. Rev. Bras. Zootec. 33: 1093-1099.

Valero, M. V., M. S. Farias, F. Zawadzki, C. A. Fugita, B. S. Lima, D. C. Rivaroli, M. Ornaghi, and I. N. Prado. 2013, in press. Propolis and functional oils (cashew and castor oils) on animal performance, apparent digestibility and blood cells of growing crossbred bulls reared in an intensive system. Anim. Feed Sci. Technol. in press.

Van Soest, P. J. 1994. Nutritional ecology of the ruminant. Cornell University Press, Ithaca, NY, USA.

Van Soest, P. J., J. B. Robertson, and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74: 3583-3597.

Wang, H., G. H. Cao, and R. L. Ronald. 1996. Total antioxidant capacity of fruits. J. Agric. Food Chem. 44: 701-705.

Yang, W. Z., B. N. Ametaj, C. Benchaar, M. L. He, and K. A. Beauchemin. 2010. Cinnamaldehyde in feedlot cattle diets: Intake, growth performance, carcass characteristics, and blood metabolites. J. Anim. Sci. 88: 1082-1092.

Zawadzki, F., I. N. Prado, J. A. Marques, L. M. Zeoula, P. P. Rotta, B. B. Sestari, M. V. Valero, and D. C. Rivaroli. 2011. Sodium monensin or propolis extract in the

diets of feedlot-finished bulls: effects on animal performance and carcass characteristics. J. Anim. Feed Sci. 20: 16-25.

Zeoula, L. M., I. N. Prado, P. H. M. Dian, L. J. V. Geron, S. F. Caldas Neto, E. M. Maeda, P. D. Pra Peron, J. A. Marques, and A. J. S. Falcão. 2002. Fecal recuperation of internal markers in assay with ruminants. Rev. Bras. Zootec. 31: 1865-1874.

Zhang, W., S. Xiao, H. Samaraweera, E. J. Lee, and D. U. Ahn. 2010. Improving functional value of meat products. Meat Sci. 86: 15-31.

Table 1.
Chemical composition of ingredients and diets (g/kg of dry matter)

Ingredients	g/kg									
	DM[1]	OM[2]	CP[3]	Ash	TDN[4]	EE[5]	NDF[6]	ADF[7]	CT[8]	NFC[9]
Corn silage	266	964	72.7	35.4	620	18.2	524	316	873	349
Corn grain	900	987	93.4	12.5	900	33.5	154	49.3	860	706
Soybean meal	896	941	488	58.3	820	30.0	106	103	422	316
Glycerine	942	10.0	1.00	47.6	807	60.0				
Urea	990		262							
Mineral salt[10]	990			100						
Limestone	990			950						
Propolis	146									
Functional oils	976	559		440		150				
	Diet									
	434	807	115	40.1	738	29.8	292	166	689	396

[1]Dry matter.[2]Organic matter. [3]Crude protein. [4]Total nutrients digestible. [5]Ether extract. [6]Neutral detergent fiber.[7]Acid detergent fiber. [8]Total carbohydrates. [9]Non fibrous carbohydrates.[10]Guarantee levels (per kg): calcium - 175 g; phosphorus – 100 g; sodium – 114 g; selenium – 15 g; magnesium – 15 g; zinc – 6.004 mg; manganese – 1.250 mg; copper – 1.875; iodine – 180 mg; cobalt – 125 mg; fluorine (maximum) – 1.000 mg.

Table 2.
Diets composition (g/kg of dry matter)

	Diets		
Ingredients	CON	PRO	OIL
Corn silage	455	455	455
Corn grain	304	304	304
Soybean meal	70.8	70.8	70.8
Glycerine	154	154	154
Urea	7.26	7.26	7.26
Mineral salt	4.47	4.47	4.47
Limestone	4.47	4.47	4.47
Propolis		0.55	
Functional oils			0.55

Table 3.
Animal performance, feed intake and feed efficiency of crossbred bulls finished in feedlot

Item	Diets			SEM[4]	P<F
	CON[1]	PRO[2]	OIL[3]		
n	10	10	10		
Initial weight, kg	382b	385b	396a	6.28	0.05
Final weight, kg	457c	469b	484a	8.02	0.05
Daily weight gain, kg	1.38c	1.55b	1.63a	0.06	0.05
Dry matter intake, kg/day	9.72	9.90	10.43	0.33	0.67
Dry matter intake, %/LW	2.31	2.30	2.39	0.06	0.82
Organic matter intake, kg/day	9.34	9.51	10.02	0.31	0.67
Crude protein intake, kg/day	1.15	1.17	1.24	0.04	0.64
Ether extract intake, kg/day	0.29	0.30	0.31	0.01	0.61
Neutral detergent fiber intake, kg/day	2.65	2.75	2.88	0.10	0.67
Neutral detergent fiber intake %/LW	0.63	0.64	0.66	0.02	0.83
Acid detergent fiber intake, kg/day	1.51	1.55	1.63	0.06	0.72
Acid detergent fiber/LW, %	0.36	0.36	0.37	0.01	0.86
Total carbohydrates intake, kg/day	7.89	8.04	8.47	0.27	0.67
Non fibrous carbohyd. intake, kg/day	5.24	5.29	5.59	0.17	0.67
Total digestible nutrient intake, kg/day	7.17	7.31	7.70	0.24	0.67
Dry matter conversion[5]	7.05b	6.38a	6.38a	0.12	0.04
Crude protein conversion[5]	0.83b	0.76a	0.76a	0.01	0.03
Dry matter efficiency[6]	0.14b	0.15ab	0.16a	0.01	0.04
Crude protein efficiency[6]	1.20b	1.32a	1.32a	0.02	0.04

[1]Control diet.[2]Diet with propolis inclusion.[3]Diet with functional oils inclusion.[4]Standard error of mean.[5]Dry matter intake/Average daily gain (kg). [6]Avarage daily gain/Dry matter intake (kg). Means followed by different letters were different (Tukey test).

Table 4.
Apparent digestibility of crossbred bulls finished in feedlot (%)

Item	Diets			SEM[4]	P<F
	CON[1]	PRO[2]	OIL[3]		
n	10	10	10		
Dry matter intake, kg/day	8.57	9.55	9.69	0.44	0.55
Dry matter	69.8	70.9	69.9	0.75	0.83
Organic matter	64.2	66.1	65.1	0.83	0.68
Crude protein	64.3	65.0	64.6	0.73	0.93
Ether extract	75.5	78.4	77.1	1.03	0.52
Neutral detergent fiber	48.3	49.4	48.2	0.95	0.86
Acid detergent fiber	44.5	46.3	44.6	0.91	0.68
Non fibrous carbohydrates	81.4	81.9	81.5	0.35	0.83
Total carbohydrates	65.4	67.2	66.2	0.89	0.73
Total digestible nutrients	71.7	73.5	72.4	0.94	0.74

[1]Control diet.[2]Diet with propolis inclusion.[3]Diet with functional oils inclusion.[4]Standard error of mean.

Table 5.
Carcass characteristics evaluated *in vivo* by software BIA PRO PLUS of crossbred bulls finished in feedlot

Item	Diets			SEM[4]	P<F
	CON[1]	PRO[2]	OIL[3]		
n	10	10	11		
Longissimus muscle, cm^2	76.2	80.6	79.0	1.52	0.50
Longissimus muscle, cm^2/100 kg/PV	16.6	17.3	16.3	0.30	0.44
Longissimus muscle ratio	0.45	0.47	0.45	0.01	0.10
Fat thickness, mm	5.02	6.19	5.52	0.27	0.21
Marbling, points	1.80	1.94	1.88	0.11	0.89

[1]Control diet.[2]Diet with propolis inclusion.[3]Diet with functional oils inclusion.[4]Standard error of mean.

Table 6.
Carcass weight and characteristics of crossbred bulls finished in feedlot

Item	Diets			SEM[4]	P<F
	CON[1]	PRO[2]	OIL[3]		
N	10	10	10		
Hot carcass weight, kg	249c	252b	260a	4.66	0.05
Hot carcass dressing, %	54.5	53.8	53.8	0.23	0.31
Conformation, points[5]	11.9	11.8	12.5	0.14	0.22
Muscle, %	59.4	58.3	59.7	0.86	0.70
Fat, %	25.1	27.2	25.6	0.76	0.34
Bone, %	15.5	14.5	14.7	0.55	0.45

[1]Control diet.[2]Diet with propolis inclusion.[3]Diet with functional oils inclusion.[4]Standard error of mean.[5]Scale – 1 to 3 inferior, 4 to 6 poor, 7 to 9 regular, 10 to 12 good, 13 to 15 very good, 16 to 18 superior. Means followed by different letters were different (Tukey test).

4. PROPOLIS OR CASHEW AND CASTOR OILS ON MEAT OF CROSSBRED BULLS FINISHED IN FEEDLOT

4.1. Abstract

This study was performed to evaluate the effect of natural additives as propolis or essential oils on meat quality of crossbred (Angus *x* Nellore) bulls. Thirty bulls were kept in feedlot (individual pen) for 55 days and randomly assigned in one of three diets (n = 10): control (CON), propolis (PRO) or essential oils (OIL) . CON diet consists of corn silage (45% of DM) and concentrate (cracked corn, soybean meal, glycerine, limestone and mineral salt – 55% of DM). The PRO group received same diet that control plus 3 grams to animal day^{-1} of propolis premix added to the concentrate. The OIL group received same diet that control and 3 grams to animal day^{-1} of a premix (cashew and castor oils) added to the concentrate. Fat thickness, *Longissimus* muscle area, marbling, texture, colour, lipid oxidation and Warner-Bratzler shear force were unaffected by the diet. PRO and OIL had no effect neither on moisture, ashes, protein and lipids, fatty acid composition or PUFA/SFA and *n*-6/*n*-3 ratio on *Longissimus* muscle. Addition of natural additives as propolis extract or cashew and castor oils in the diet of bulls in feedlot did not change meat quality. Thus, these two additives could be added in animal feedlot finished without to change meat quality.

Keywords: Additives; cattle; essential oils; fatty acid; glycerine

4.2. Introduction

For intensive finishing systems in beef cattle requiring high energy, it is necessary to increase the use of grains and cereals (Ito et al., 2010). When ruminants are fed forage, rumen pH is generally near neutral (*i.e.* 6.8); however, when finishing rations containing large amounts of cereal grain are fed, rumen pH can drop drastically.

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Therefore, ionophores additives were used in cattle diets to modulate rumen fermentation (Valero et al., 2011, Zawadzki et al., 2011). The use of ionophores is well-documented in ruminant nutrition; they improve growth, feed intake and efficiency. However, the use of ionophores can cause the transmission and proliferation of resistant bacteria via food chain which has led to the prohibition of ionophores growth promoters in livestock feed within the European Union since.

New natural products have been studied as a partial alternative for feed strategies to improve animal production including propolis or essential oils (Benchaar et al., 2008, Valero et al., 2011, Zawadzki et al., 2011). Such products have several advantages over commonly used ionophores, since they are residue free and are generally regarded as safe in the food industry. These compounds have received increased attention in the previous decade as possible growth promoters for animals (Benchaar et al., 2008, Patra, 2011).

Propolis is a potential growth promoter, with numerous pharmacological properties (Righi et al., 2011). When propolis is administered to animals it action is similar to ionophores, as observed through *in vivo* and *in vitro* experiments (Prado et al., 2010). Propolis has positive results in studies involving animal nutrition, such as increased *in vitro* digestibility and better feed efficiency (Zawadzki et al., 2011).

Essential oils are aromatic compounds obtained from plant parts (flowers, buds, seeds, leaves, twigs, bark, herbs, wood, fruits, and roots), being complex mixtures of secondary plant metabolites consisting of low-boiling-phenylpropenes and terpenes. Essential oils are particularly associated with plant characteristic essences and fragrances (Greathead, 2003). In addition to their traditional uses, valuable effects have been reported by experimental studies during the previous three decades, including positive influences on lipid metabolism, ability to stimulate digestion, antimicrobial, antioxidant and anti-inflammatory properties (Benchaar et al., 2008, Patra, 2011). Essential oils and plant extracts are associated with the current concern about the future of global agriculture and consumers' preferences for natural products.

The objective of this study was assess the effect of natural dietary additives as propolis and essential oils (cashew and castor oils) on meat quality of crossbred bulls finished in a feedlot.

4.3. Materials and Methods

4.3.1. Local, animals, housing and diets

This experiment was approved by the Department of Animal Production at State University of Maringá and it the study was conducted at Rosa Prado Sector of Experimental Station at Farm Iguatemi in Maringá, Paraná, Brazil South. Thirty crossbred bulls (½ Aberdeen Angus x ½ Nellore) with 20-months-old and weighed 387 ± 6.3 kg were used in a completely randomised design. The bulls were weighed and randomly distributed into three diet groups (n = 10): control (CON), propolis addition (PRO) or essential oils addition (OIL). The bulls were housed in individual pens with 10m² concrete floors. The diet compositions and proportion are shown in Table 1 and Table 2, respectively. The bulls were fed twice a day at 08:00 and 16:00 h. Diets were weighed daily for 5% of refusals. The intake of concentrate and corn silage were recorded daily until day 55 of the experimental period. Both diet formulation and quantity supplied were designed to provide a weight gain of 1.5 kg. day^{-1}. The glycerine was used as an energetic ingredient in the diet; therefore, the glycerine level was counterbalanced, mainly by a decrease in corn grain content. The glycerine was produced in a soy-diesel facility (BIOPAR, Rolândia, Paraná, Brazil). PRO group was supplemented with 3 grams to animal day^{-1} as a premix added to the concentrate. The propolis product contained 0.054 mg $g^{-1}$of total flavonoids in chrysin. For the OIL group, was added 3 grams to animal day^{-1} of the commercial mix from laboratory Oligo Basics Agroindustrial Ltda® which contained ricinoleic acid, anacardic acid, cardanol and cardol. Ricinoleic acid was obtained from castor oil (extracted from castor seed), anacardic acid, cardanol and cardol were obtained from cashew nut shell liquid (obtained from the processing of cashew nuts), and both were produced in northern Brazil.

Animals were slaughtered at a commercial slaughterhouse 30 km from the experimental farm, according to Brazilian industrial practices, when the bulls reached a final BW of 470 ± 8.0 kg.

4.3.2. Sampling and meat quality

After slaughter, carcasses were labelled and a cut was carried out following the vertebral column, yielding two similar halves. Carcasses were chilled for 24 h at 4ºC. After chilling, the right side of the carcasses was used to measurements and sampling of

Longissimus dorsi muscle (*LM*) excised between ribs 10^{th} to 13^{th}. After measures of pH_{24h}, fat thickness, *LM* area, marbling, texture and colour, the steaks of *LM* from 10^{th}, 11^{th} and 12^{th} ribs were placed in unsealed plastic bags and frozen immediately per analysed Thiobarbituric acid reactive substances, Warner-Bratzler Shear Force, chemical composition and fatty acid, respectively.

pH_{24h} was measured using a pH Meter Text Model (Tradelab, Contagem - MG - Brazil) and a penetration ph-electrode at the point of the 10^{th} rib on muscle *Longissimus*. Fat thickness, *LM* area, marbling, texture and colour were determined on surface of 12^{th} rib after a cross-sectional cut was performed between 12^{th} and 13^{th} ribs, past 24 hours post slaughter. Fat thickness was measured using a calliper to average three points over the *Longissimus* muscle. *LM* area was measured using a compensating planimeter that measures the area of irregular shaped objects. Marbling was measured using scoring system (18 to 16 – abundant, 15 to 13 – moderate, 12 to 10, mean, 9 to 7 small, 6 to 4, light and 3 to 1 traces). Texture was determined by fascicle size (muscular "grain" size) and evaluated subjectively on a point scale (very fine – 5, fine – 4, slightly – 3, coarse – 2 and very coarse – 1).

The development of meat colour in the CIE Lab space was assessed using a Minolta CR-400 spectrophotometer (Illuminant D65, observer angle 10°, Konica Minolta Holdings, Inc., Osaka, Japan) at 30 min after blooming. Colour coordinates expressed as L^*, a^* and b^* were recorded, where L^* is the lightness of colour whose values range from 0 for black to 100 for white, a^* is redness which values range from ($+a^*$) for red to ($-a^*$) for green, and b^* is yellowness which values range from ($+b^*$) for yellow to ($-b^*$) for blue. The Chroma (C^*) and hue angle (H^*) indexes were calculated as $C^* = (a^{*2} + b^{*2})^{0.5}$ and $H^* = \tan^{-1} (b^* / a^*)^*[360° / (2^*3.14)]$ expressed in degrees.

Samples analysed for thiobarbituric acid reactive substances (TBARS) were obtained of 10^{th} *LM* rib after 12 months of freezing. Ten grams of meat was homogenized with 20 mL of 10% (w/v) trichloroacetic acid using an Ultra-Turrax (90 s, 20 000 rpm). The homogenate was centrifuged and the supernatant decanted through a paper filter (Schleicher & Schiill no. 311643, Dassel, Germany). Two milliliters of the filtrate was mixed with 2 mL of the TBA reagent (300 mg of 2-thiobarbituric acid 100 mL of H_20). The mixture was heated in a water bath for 20 min to 97 "C. After the mixture had cooled to ambient temperature, the extinction was measured at 532 nm. The TBARS values are expressed as milligrams of malonaldehyde per kilogram of meat.

Warner-Bratzler Shear Force (WBSF) was performed on *LM* from 11th rib after defrosting. The muscle samples were separated into individual standardised 3.5 cm thick slices, placed in an electric oven and cooked at a defined internal temperature (72°C). When the endpoint temperature was reached, the samples were removed from the electric oven and maintained at room condition until they equilibrated. The WBSF mechanical properties of the meats (4-8 readings) were obtained using a texture analyser (Stable Micro Systems TAXT Plus; Texture Technologies Corp., UK) with a 5.0 kg load cell.

The chemical composition was determined with specific portion of the *LM* from the 12th rib after defrosting. The samples were ground, homogenised and analysed in triplicate to determined moisture, protein, fat and ash contents according to standardized protocols (ISO-R-1442, ISO-R-937, ISO-R-1443 and ISO-R-1998), respectively (AOAC, 1998).

For the fatty acids analyses, intramuscular fat was extracted with specific portion of the *LM* at the 12th rib level with a chloroform/methanol mixture (Bligh and Dyer, 1959). Fatty acid methyl esters (FAMEs) were prepared using triacylglycerol methylation. To quantify the fatty acid composition of the meat and the diets, the methyl ester preparation included KOH in methanol with C21:0 as an internal standard. Fatty acid methyl esters were analysed through a gas chromatograph (Varian, USA) equipped with a flame ionisation detector and CP-7420 Select Fame fused silica capillary column (100 m, 0.25 mm and 0.39 μmo.d., Varian, USA). The column temperature was programmed at 165°C for 18 minutes, 180°C (30°C min^{-1}) for 22 minutes, and 240°C (15°C min^{-1}) for 30 minutes with a 45-psi pressure. The injector and detector were both maintained at 220 and 245°C, respectively. Gas fluxes (White Martins) comprised 1.4 mL min^{-1} for carrier gas (H_2), 30 ml min^{-1} for make-up gas (N_2), and 30 mL min^{-1} and 300 mL min^{-1} for H_2 and synthetic flame gas, respectively. The sample injection split mode was 1/80. The fatty acids were identified by comparing the relative retention time of the FAME peaks of the samples with the fatty acid methyl ester standards from Sigma (USA) by spiking the samples with the standard. The peak areas were determined by the Star software (Varian). Data were expressed as percentages for normalised area of fatty acids.

4.3.3. Statistical analysis

The experimental design was completely randomised with three treatments and ten replications. Data were interpreted by variance analyses and the differences were tested by Tukey test, being the variables measured following the model: $Y_{ij} = \mu + d_i + e_{ij}$, where: Y_{ij} = observation on animal j fed with diet i; μ = mean treatments; d_i =effect of diet i; 1, 2, and 3; e_{ij} = residual error.

4.4. Results and Discussion

4.4.1. pH

The addition of propolis and essential oils in the diet had no effect on the pH measured 24 h (pH_{24h}) after slaughter (Table 3). However, the mean value for pH (5.9) is slightly above the normal pH of meat, which is from 5.5 to 5.8 (Mounier et al., 2006). It implies that the bulls were stressed before slaughter, likely influenced because they were crossed with Zebu breed (½ Aberdeen Angus *x* ½ Nellore). Animals with *Bos indicus* genes are stressed more easily during transportation and/or handling of animals at abattoirs that *Bos taurus*, thus explaining the cause of this change in meat pH_{24h} (Voisinet et al., 1997). Meat with pH_{24h} above 5.8 has a potential quality problem to presents dark red colour meat and could causes industry economic losses. The main problems of its meat are increased tenderness variation, increased water holding capacity, poor palatability, microorganisms growing to unacceptable levels and developing off-odours, and often slime formation (Campo et al., 2006). Meat with pH_{24} greater than 5.8 is thought to be the result of pre-slaughter glycogen depletion, and the consequent inability of muscle to accumulate adequate lactic acid concentration. Glycogen depletion depends on physical exhaustion and psychological pre-slaughter stress of cattle.

4.4.2. Mean fat thickness, LM area, marbling and texture

Mean fat thickness, *LM* area, marbling and texture were unaffected by the addition of natural additives (Table 3) 24 h after slaughter. The values observed for the fat thickness (5.0 mm), *LM* area (58 cm^2), marbling (3.5 points) and texture (3.5 points) were consistent with results observed in Brazilian cattle finished in a feedlot (Rotta et al., 2009). Thus, the inclusion of propolis and essential oils in the diets of crossbred bulls finished in a feedlot and pH_{24h} slightly above the normal of meat, had no effect on

the fat thickness an meat subjective characteristics, as was observed previous studies with cattle Nellore (Zawadzki et al., 2011).

4.4.3. Colour

Colour parameters, lightness (L^*), redness (a^*) and yellowness (b^*) were not different among the CON, PRO and OIL diets (Table 3). Additionally, in previous publications (Arnold et al., 1993) the supra-nutritional supplementation of grain-fed cattle did not affect meat stability when compared to non-supplemented cattle. This characteristic could be partially attributed to the levels of *α*-tocopherol present at the beginning of the experiment and the protective action of other antioxidants in the muscles from non-supplemented grain-fed animals. Others studies (Realini et al., 2004) indicated little or no benefit from vitamin antioxidant supplementation on the colour stability of fresh beef from cattle fed good quality pasture immediately before grain feeding. The depletion of *α*-tocopherol in muscle is slow (Arnold et al., 1993) when cattle have access to good quality grass prior to grain feeding, as was the case in the current study. Meat from non-supplemented cattle will have a high content of *α*-tocopherol and other antioxidants from the pasture (Aerts et al., 1999).

Chroma (C^*) and hue angle (H^*) values of the *LM* are shown in table 3. Propolis and essential oil supplementation did not alter C^* or $H^*$of the *LM* values. Propolis and essential oil supplementation maintained the saturation over the limiting value of 18, which is considered acceptable in beef (Liu et al., 1995). Both C^* and H^* values reported in this study (18 and 31) are similar to those reported in strip-loin and cube-roll steaks (Rodas-González et al., 2011).

4.4.4. Thiobarbituric acid reactive substances (TBARS)

TBARS values were not different among the CON, PRO and OIL diets (Table 3). One of the most important causes of meat deterioration is lipid oxidation (Faustman et al., 2010). Lipid oxidation may lead to drip losses, off-odour and off-flavour development, the production of potentially toxic compounds and induce the oxidation of myoglobin (Faustman et al., 2010). The oxidation levels observed in the present study are consistent with animals fed forage and finished with concentrates 55 days before slaughter (Realini et al., 2004). Thus, propolis and essential oils in the bulls' diets did not affect the lipid oxidation of the meat. Meat from steers at 0 h had low TBARS values (0.08 mg MDA kg $meat^{-1}$), which was a logical observation once the meat had

been chilled after slaughter. However, the MDA levels were below the acceptance limit, which is at 02 mg MDA kg fresh tissue (Campo et al., 2006). The diets in the current study consisted of corn silage and cereal, which would possess good vitamin E contents and make the samples oxidatively stable (Campo et al., 2006).

4.4.5. Warner-Bratzler Shear Force (WBSF)

The value of the WBSF in the *LM* was similar among the diets (Table 3). Although the meat pH_{24h} was high, which characterizes low quality meat, the WBSF observed (3.3kgf) in this experiment classifies the meat as extremely tender (Wheeler et al., 1997). The crossbred *Bos taurus vs. Bos indicus* cattle are known for producing meat with less tenderness than animals with *Bos taurus* genes (O'Connor et al., 1997). However, a study performed under similar conditions with similar genetic groups of cattle showed a WBSF from 2.0 to 3.3kg (Maggioni et al., 2012). The low WBSF could be partially attributed to the high pH (5.9) observed in the meat, which classifies it as type "DFD" (dark, firm, and dry). "DFD" meat is typically softer, since it has higher myofibrillar fragmentation, which occurs when cooked, and there are lower cooking losses (Viljoen et al., 2002). Also, the smaller diameter of the muscle fibres of cattle with Zebu genes could have contributed to this results (Maggioni et al., 2012). Studies have shown that muscle fibres with smaller diameters also decreased shear force (Lepetit, 2008) and intramuscular fat content could have associated with tenderness (Purchas et al., 2002). Nevertheless, the obtained WBSF results (< 4.0 kg) ensure a tenderness that should result in high consumer acceptance (Shackelford et al., 1994).

4.4.6. Chemical composition

Moisture, ash, protein and total lipid measurements of *LM* were unaffected among the CON, PRO and OIL diets (Table 4). The moisture percentage from bulls in all diets had low variations (from 73.1 to 74.0%). Moisture percentage variations for meat from intensively reared cattle occurs when there is a variation in lipid percentage (Rotta et al., 2009). The ash percentage is rarely influenced by the nutrition system (Padre et al., 2007). Protein percentage for meat from the bulls ranged from 23.6 to 24.1%. Some authors (Aricetti et al., 2008, Rotta et al., 2009) reported that the protein percentage in the *LM* varied minimally, between 21 and 24%, with nutritional status. In this study, the lipid percentages varied from 1.4 to 1.8%. Total lipids in the *LM* of beef cattle finished in a feedlot system can vary from 02 to 04% (Padre et al., 2007, Prado et al., 2009). This

percentage is the parameter that is most influenced by nutrition. Thus, the lipid percentages in meat were low since the bulls were crossbred between *Bos taurus* and *Bos indicus*. *Bos indicus* cattle tend to have low lipid contents in the *LM* (Prado et al., 2008, Prado et al., 2009). Therefore, propolis and essential oil additions to the diets of crossbred bulls finished in a feedlot and fed a high-energy diet did not affect the meat chemical composition, as observed by other authors using similar conditions (Valero et al., 2011, Zawadzki et al., 2011).

4.4.7. Fatty acid composition

The addition of propolis and essential oils in the diet had no effect on fatty acid composition of *LM* (Table 5). Previous studies with bulls Nellore (Zawadzki et al., 2011) observed a minimal effect on LM when propolis included in the diet of crossbred cattle finished in similar condition to this experiment on the fatty acid composition for the *LM*. Similarly, Valero et al. (2011) observed an effect of propolis only for two fatty acids of 20 analysed (an increase in18:2 *cis* 9, *trans* 11 and decrease in 22:6 *n*-3 – DHA) for the *LM* of crossbred bulls finished in a feedlot.

The additives (propolis or essential oils) had no influence to saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acid percentages on *LM* of bulls finished in a feedlot. The majority of the fatty acids observed on *LM* were MUFA (47.9%) followed by SFA (46.0%) and PUFA (6.0%). Similarly, other study (Valero et al., 2011) did not observe changes in total fatty acid for *LM* from crossbred bulls finished in feedlot. However, (Zawadzki et al., 2011) observed that the inclusion of propolis in the diets, decreased MUFA for the *LM* of bulls finished in feedlot. Similarly, Prado et al. (2008) observed similar percentages of SFA, MUFA and PUFA in bulls finished on similar handling conditions as the ones in this experiment. Thus, SFA, MUFA and PUFA fatty acid percentages vary minimally in function this diet.

Likewise, propolis and essential oils had no effect on the percentage of *n*-3 and *n*-6 fatty acids on *LM* (Table 6). Previous studies (Valero et al., 2011, Zawadzki et al., 2011) observed no effect of propolis inclusion on *n*-3 or *n*-6 fatty acid percentages on *LM* of bulls finished in feedlot. The percentage of *n*-3 fatty acids was low in comparison to *n*-6 primarily due to C18:2n-6, it appears on high concentrations when compared to C18:3*n*-3.

The PUFA/SFA ratio (0.13) was low for all diets (Table 6). Human diet should have PUFA/SFA values of 0.4 (HMSO, 1994). No difference was observed for *n*-6/*n*-3

ratio among the different diets. This ratio should be lower than 4.0 (HMSO, 1994). In this study, the average observed for *n*-6/*n*-3 was 6.9, a value close than what recommended by the English Department of HMSO (HMSO, 1994).

Several gram-positive bacteria are involved in ruminal biohydrogenation of unsaturated dietary fatty acids. Therefore, feeding essential oils could lower the biohydrogenation of fatty acids by reducing the number and activity of bacteria involved in the biohydrogenation of unsaturated fatty acids. However, the essential oils mix (*i.e.*, 02 g day^{-1}) increased the concentration of conjugated linoleic acid (CLA), a health-promoting fatty acid, in milk fat (Benchaar et al., 2007). However, data on the effects of essential oils and their compounds on fatty acid composition for the *LM* of beef cattle are required.

4.5. Conclusions

Addition of natural additives as propolis extract or essential oil from cashew and castor in the diet of bulls finished in a feedlot did not change meat quality. Thus, these two additives could be added in animal feedlot finished without to change meat quality.

4.6. Acknowledgements

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4.7. Literature cited (Chilean Jornalof agricultural research)

Aerts, R.J., T.N. Barry and W.C. McNabb. 1999. Polyphenols and agriculture: beneficial effects of proanthocyanidins in forages. Agriculture, Ecosystems & Environment 75: 1-12.

AOAC. 1998. Association of Official Analytical Chemists. Official Methods of Analysis. Inc., Arlington, VA, U.S.A.

Aricetti, J.A., P.P. Rotta, R.M. Prado, D. Perotto, J.L. Moletta, M. Matsushita and I.N. Prado. 2008. Carcass characteristics, chemical composition and fatty acid profile of *Longissimus* muscle of bulls and steers finished in a pasture system. Asian-Australasian Journal of Animal Science 21: 1441-1448.

Arnold, R.N., K.K. Scheller, S.C. Arp, S.N. Williams and D.M. Schaefer. 1993. Dietary α-tocopheryl acetate enhances beef quality in Holstein and beef breed steers. Journal of Food Science 58: 28-33.

Benchaar, C., S. Calsamiglia, A.V. Chaves, G.R. Fraser, D. Colombatto, T.A. McAllister and K.A. Beauchemin. 2008. A review of plant-derived essential oils in ruminant nutrition and production. Animal Feed Science and Technology 145: 209-228. doi:10.1016/j.anifeedsci.2007.04.014.

Benchaar, C., H.V. Petit, R. Berthiaume, D.R. Ouellet, J. Chiquette and P.Y. Chouinardt. 2007. Effects of essential oils on digestion, ruminal fermentation, rumen microbial populations, milk production, and milk composition in dairy cows fed alfalfa silage or corn silage. Journal of Dairy Science 90: 886-897. doi:10.3168/jds.S0022-0302(07)71572-2.

Bligh, E.G. and W.J. Dyer. 1959. A rapid method of total lipid extraction and purification. Canadian Journal of Biochemistry and Physiology 37: 911-917.

Campo, M.M., G.R. Nute, S.I. Hughes, M. Enser, J.D. Wood and R.I. Richardson. 2006. Flavour perception of oxidation in beef. Meat Science 72: 303-311. doi:10.1016/j.meatsci.2005.07.015.

Faustman, C., Q. Sun, R. Mancini and S.P. Suman. 2010. Myoglobin and lipid oxidation interactions: Mechanistic bases and control. Meat Science 86: 86-94.

Greathead, H. 2003. Plants and plant extracts for improving animal productivity. Proceedings of the Nutrition Society 62: 279-290.

HMSO. 1994. England Department of Health Nutritional. Aspects of cardiovascular disease. Report on Health and Social Subjects 46: 37-46.

Ito, R.H., T. Ducatti, J.M. Prado, I.M. Prado, P.P. Rotta, M.V. Valero, I.N. Prado and R.R. Silva. 2010. Soybean oil and linseed grains on performance and carcass characteristics of crossbred bulls finished in feedlot. Semina: Ciências Agrárias 31: 259-268.

Lepetit, J. 2008. Collagen contribution to meat toughness: Theoretical aspects. Meat Science 80: 960-967. doi:10.1016/j.meatsci.2008.06.016.

Liu, Q., M. Lanari and D. Schaefer. 1995. A review of dietary vitamin E supplementation for improvement of beef quality. Journal of Animal Science 73: 3131-3140.

Maggioni, D., I.N. Prado, F. Zawadzki, M.V. Valero, J.A. Marques, A.M. Bridi, J.L. Moletta and J.J.S. Abrahão. 2012. Grupos genéticos e graus de acabamento sobre qualidade da carne de bovinos. Semina: Ciências Agrárias 33: 391-402.

Mounier, L., H. Dubroeucq, S. Andanson and I. Veissier. 2006. Variations in meat pH of beef bulls in relation to conditions of transfer to slaughter and previous history of the animals. Journal of Animal Science 84: 1567-1576.

O'Connor, S.F., J.D. Tatum, D.M. Wulf, R.D. Green and G.C. Smith. 1997. Genetic effects on beef tenderness in *Bos indicus* composite and Bos taurus cattle. Journal of Animal Science 75: 1822-1830.

Padre, R.G., J.A. Aricetti, S.T.M. Gomes, R.H.T.B. Goes, F.B. Moreira, I.N. Prado, J.V. Visentainer, N.E. Souza and M. Matsushita. 2007. Analysis of fatty acids in *Longissimus* muscle of steers of different genetic breeds finished in pasture systems. Livestock Science 110: 57-63.

Patra, A.K. 2011. Effects of essential oils on rumen fermentation, microbial ecology and ruminant production. Asian Journal of Animal Veterinary Advances 6: 416-428.

Prado, I.N., P.P. Rotta, R.M. Prado, J.V. Visantainer, J.L. Moletta and D. Perotto. 2008. Carcass characteristics and chemical composition of the *Longissimus* muscle of Purunã and 1/2 Purunã vs. 1/2 Canchin bulls meat quality of bulls. Asian-Australasian Journal of Animal Sciences 21: 1296-1302.

Prado, J.M., I.N. Prado, J.V. Visentainer, P.P. Rotta, D. Perotto, J.L. Moletta, R.M. Prado and T. Ducatti. 2009. The effect of breed on the chemical composition and

fatty acid profile of the *Longissimus dorsi* muscle of Brazilian beef cattle. Journal of Animal and Feed Sciences 18: 231-240.

Prado, O.P.P., L.M. Zeoula, L.P.P. Moura, S.L. Franco, S.B. Paiva and P.B. Arcuri. 2010. Isolation and expeditious morphological, biochemical and kinetic characterization of propolis-tolerant ruminal bacteria. Revista Brasileira de Zootecnia 39: 2048-2054.

Purchas, R.W., D.L. Burnham and S.T. Morris. 2002. Effects of growth potential and growth path on tenderness of beef *Longissimus* muscle from bulls and steers. Journal of Animal Science 80: 3211-3221.

Realini, C.E., S.K. Duckett, G.W. Brito, M. Dalla Rizza and D. Mattos. 2004. Effect of pasture vs. concentrate feeding with or without antioxidants on carcass characteristics, fatty acid composition, and quality of Uruguayan beef. Meat Science 66: 567-577. doi:http://dx.doi.org/10.1016/S0309-1740(03)00160-8.

Righi, A.A., T.R. Alves, G. Negri, L.M. Marques, H. Breyer and A. Salatino. 2011. Brazilian red propolis: unreported substances, antioxidant and antimicrobial activities. Journal of Science and Food Agriculture 91: 2363-2370. doi:10.1002/jsfa.4468.

Rodas-González, A., C. Narváez-Bravo, M.M. Brashears, H.B. Rogers, J.L. Tedford, G.O. Clark, J.C. Brooks, B.J. Johnson, R.J. Rathmann and M.F. Miller. 2011. Evaluation of the storage life of vacuum packaged Australian beef. Meat Science 88: 128-138.

Rotta, P.P., R.M. Prado, I.N. Prado, M.V. Valero, J.V. Visentainer and R.R. Silva. 2009. The effects of genetic groups, nutrition, finishing systems and gender of Brazilian cattle on carcass characteristics and beef composition and appearance: a review. Asian-Australasian Journal of Animal Sciences 22: 1718-1734.

Shackelford, S.D., M. Koohmaraie and J.W. Savell. 1994. Evaluation of Longissimus dorsi muscle pH at three hours Post mortem as a predictor of beef tenderness. Meat Science 37: 195-204. doi:10.1016/0309-1740(94)90080-9.

Suguisawa, L., W.R.S. Mattos, H.N. Oiliveira, A.C. Silveira, M.B. Arrigoni and A.A. Souza. 2006. Correlações simples entre as medidas de ultra-som ea composição da carcaça de bovinos jovens. Revista Brasileira de Zootecnia 35: 169-176.

Valero, M.V., F. Zawadzki, M.C. Françozo, M.S. Farias, P.P. Rotta, I.N. Prado, J.V. Visentainer and L.M. Zeoula. 2011. Sodium monensin or propolis extract in the diet of crossbred (½ Red Angus vs. ½ Nellore) bulls finished in feedlot: chemical composition and fatty acid profile of the *Longissimus* muscle. Semina: Ciências Agrárias 32: 1617-1626.

Viljoen, H.F., H.L. Kock and E.C. Webb. 2002. Consumer acceptability of dark, firm and dry (DFD) and normal pH beef steaks. Meat Science 61: 181-185. doi:10.1016/s0309-1740(01)00183-8.

Voisinet, B.D., T. Grandin, S.F. O'Connor, J.D. Tatum and M.J. Deesing. 1997. *Bos indicus*-cross feedlot cattle with excitable temperaments have tougher meat and a higher incidence of borderline dark cutters. Meat Science 46: 367-377. doi:http://dx.doi.org/10.1016/S0309-1740(97)00031-4.

Wheeler, T.L., S.D. Shackelford, L.P. Johnson, M.F. Miller, R.K. Miller and M. Koohmaraie. 1997. A comparison of Warner-Bratzler shear force assessment within and among institutions. Journal of Animal Science 75: 2423-2432.

Zawadzki, F., I.N. Prado, J.A. Marques, L.M. Zeoula, R.M. Prado, C.A. Fugita, M.V. Valero and D. Maggioni. 2011. Sodium monensin or propolis extract in the diet of Nellore bulls finished in feedlot: chemical composition and fatty acid profile of *Longissimus* muscle. Semina: Ciências Agrárias 32: 1627-1636.

Zawadzki, F., I.N. Prado, J.A. Marques, L.M. Zeoula, P.P. Rotta, B.B. Sestari, M.V. Valero and D.C. Rivaroli. 2011. Sodium monensin or propolis extract in the diets of feedlot-finished bulls: effects on animal performance and carcass characteristics. Journal of Animal and Feed Sciences 20: 16-25.

Table 1. Chemical composition of ingredients and diets (g kg^{-1} of DM)

Parameters	g kg^{-1} DM									
	Corn silage	Corn grain	Soybean meal	Glycerine	Urea	Mineral salt[1]	Limestone	Propolis	Essential oils	Diet
Dry matter	266	900	896	942	990	990	990	146	976	434
Organic matter	964	987	942	10.0	--	--	--	--	559	807
Crude protein	72.7	93.4	489	1.00	262	--	--	--	--	115
Ash	35.4	12.5	58.3	47.6	--	990	950	--	440	40.1
TND[2]	620	900	820	807	--	--	--	--		73.8
Ether extract	18.2	33.5	30.0	60.0	--	--	--	--	150	29.8
NDF[3]	524	154	107	--	--	--	--	--	--	293
Acid detergent fiber	316	49.3	103	--	--	--	--	--	--	166
Total carbohydrates	874	861	423	--	--	--	--	--	--	689
NFC[4]	350	706	316	--		--	--	--	--	396
Main fatty acids										
14:0	0.10	0.70	0.10	5.80	--	--	--	--	--	1.1
16:0	99.5	131	131	191	--	--	--	--	--	178.5
18:0	34.7	23.5	34.3	64.5	--	--	--	--	--	35.9
18:1 *n*-9	178	339	131	288	--	--	--	--	--	241.9
18:1 *n*-7	7.80	6.40	12.6	16.2	--	--	--	--	--	9.0
18:2 *n*-6 *cis*	391	489	545	402	--	--	--	--	--	434.1
18:3 *n*-3	13.6	10.8	54.7	26.1	--	--	--	--	--	74.2

[1]Guarantee levels (per kg): calcium– 175 g; phosphorus – 100 g; sodium – 114 g; selenium – 15 g; magnesium – 15 g; zinc – 6.004 mg; manganese – 1.250 mg; copper – 1.875; iodine– 180 mg; cobalt – 125 mg; fluorine (maximum) – 1.000 mg. [2]Total nutrients digestible, [3]Neutral detergent fiber, [4]Non fibrous carbohydrates

Table 2. Diets composition (g kg^{-1} of DM)

Ingredients	Diets		
	CON[1]	PRO[2]	OIL[3]
Corn silage	454	454	454
Corn grain	305	305	305
Soybean meal	70.8	70.8	70.8
Glycerine	154	154	154
Urea	7.26	7.26	7.26
Mineral salt	4.47	4.47	4.47
Limestone	4.46	4.42	4.42
Propolis	--	0.55	--
Essential oils	--	--	0.55

[1]Control diet, [2]Diet with propolis inclusion, [3]Diet with essential oils inclusion.

Table 3. Meat quality of crossbred bulls finished in feedlot

Item	Diets			SEM[4]	P < F
	CON[1]	PRO[2]	OIL[3]		
pH	5.92	5.91	5.90	0.35	0.60
Fat thickness, mm	4.35	5.81	4.78	0.30	0.12
Longissimus muscle, cm^2	58.3	57.2	58.4	1.27	0.93
Marbling, points[5]	4.60	5.90	5.70	0.25	0.45
Texture, points[6]	4.70	4.60	4.40	0.28	0.34
L^*	37.1	35.0	37.6	0.58	0.18
a^*	17.0	17.0	18.0	0.43	0.53
b^*	5.60	5.51	6.52	0.33	0.45
C^*	17.9	17.8	19.2	0.51	0.49
H^*	31.1	32.0	32.1	0.13	0.49
Thiobarbituric acid reactive substances[7]	0.09	0.08	0.07	0.01	0.40
WBSF[8], kg	3.34	3.34	3.22	0.30	0.20

[1]Control diet, [2]Diet with propolis inclusion, [3]Diet with essential oils inclusion, [4]Standard error of mean, [5]Scale (18 to 16 – abundant, 15 to 13 – moderate, 12 to 10, mean, 9 to 7 small, 6 to 4, light and 3 to 1 traces), [6]Scale (very fine – 5, fine – 4, slightly – 3, coarse – 2 and very coarse – 1), [7]milligrams of malonaldehyde per kilogram of meat, [8]Warner-Bratzler Shear Force

Table 4. Chemical composition (%) of *Longissimus* muscle of crossbred bulls finished in feedlot

Item	Diets			SEM[4]	P < F
	CON[1]	PRO[2]	OIL[3]		
Moisture	74.0	73.0	74.0	0.21	0.10
Ash	1.09	1.10	1.09	0.01	0.87
Protein	24.1	23.7	23.6	0.24	0.69
Total lipids	1.78	1.79	1.43	0.12	0.38

[1]Control diet, [2]Diet with propolis inclusion, [3]Diet with essential oils inclusion [4]Standard error of mean.

Table 5. Fatty acid composition (% of fatty acid identified) of *Longissimus* muscle of crossbred bulls finished in feedlot

Fatty acid	Diets			SEM[4]	P < F
	CON[1]	PRO[2]	OIL[3]		
12:0	0.03	0.02	0.02	0.01	0.42
14:0	2.49	2.52	2.57	0.08	0.63
14:1 *n*-7	0.53	0.61	0.54	0.03	0.31
15:0	0.44	0.48	0.47	0.01	0.56
15:1 *n*-9	0.15	0.14	0.14	0.01	0.74
16:0	25.0	24.9	25.5	0.28	0.47
16:1 *n*-9	3.02	3.27	3.08	0.10	0.13
16:1 *n*-7	0.39	0.39	0.39	0.01	0.62
17:0	1.42	1.49	1.49	0.05	0.98
17:1 *n*-9	1.07	1.24	1.14	0.04	0.27
18:0	16.3	15.1	16.0	0.33	0.09
18:1 *n*-7	1.02	1.16	1.13	0.09	0.57
18:1 *n*-9 *cis*	40.7	41.0	39.8	0.51	0.92
18:1 *n*-11 *trans*	1.03	0.96	0.96	0.04	0.80
18:2 *n*-6c	3.58	3.78	3.78	0.18	0.69
18:2 *cis* 9, *trans* 11	0.27	0.27	0.27	0.01	0.85
18:3 *n*-3	0.41	0.44	0.46	0.02	0.82
18:3 *n*-6	0.12	0.13	0.13	0.01	0.37
20:0	0.08	0.09	0.08	0.01	0.83
20:1 *n*-9	0.01	0.01	0.01	0.01	0.18
20:2 *n*-6	0.01	0.01	0.01	0.01	0.59
20:3 *n*-3	0.04	0.05	0.05	0.01	0.79
20:4 *n*-6	1.18	1.21	1.19	0.09	0.82
20:5 *n*-3 (EPA)	0.05	0.05	0.04	0.01	0.53
22:0	0.17	0.20	0.19	0.01	0.58
22:4 *n*-6	0.18	0.21	0.17	0.01	0.29
22:5 *n*-3 (DPA)	0.15	0.17	0.16	0.01	0.33
22:6 *n*-3 (DHA)	0.18	0.21	0.19	0.08	0.27

[1]Control diet, [2]Diet with propolis inclusion, [3]Diet with essential oils inclusion, [4]Standard error of mean.

Table 6. Fatty acid sum and ratio (% of fatty acid identified) of *Longissimus* muscle of crossbred bulls finished in feedlot

Item	Diets			SEM[4]	P < F
	CON[1]	PRO[2]	OIL[3]		
Saturated fatty acid	46.2	45.1	46.7	0.46	0.30
Monounsaturated fatty acid	47.9	48.7	47.2	0.58	0.69
Polyunsaturated fatty acid	5.84	6.16	6.12	0.28	0.53
n-6	4.89	5.14	5.10	0.19	0.64
n-3	0.68	0.75	0.75	0.09	0.34
PUFA/SFA	0.13	0.14	0.13	0.01	0.40
n-6/n-3	7.18	6.88	6.80	0.04	0.06

[1]Control diet, [2]Diet with propolis inclusion, [3]Diet with essential oils inclusion, [4]Standard error of mean.

5. EFFECT OF CASTRATION AGE, PROTEIN LEVEL AND LYSINE/METHIONINE RATIO IN THE FEED ON ANIMAL PERFORMANCE, CARCASS AND MEAT QUALITY OF FRIESIAN STEERS REARED INTENSIVELY

5.1. Abstract

This work was carried out to study the effect of castration age, protein level and lysine/methionine (lys/met) ratio in the diet on animal performance, carcass characteristics and meat quality parameters of Friesian steers reared intensively. Sixty four steers were randomly assigned in factorial system to eight treatments: two castration ages (15 days and. 5 months), two protein levels (13 and. 15%) and two lys/met ratio (3.0 and. 3.4). Feeding treatments started when animals were 3 months old and 92.9 $\pm$ 0.65 kg of live weight. The final live weight, average daily gain, and hot carcass weights were similar among treatments. Castration age did not affect any parameter, not even fat percentage or fatty acid composition, except the ratio PUFA/SFA and *n*-6/*n*-3 that increased with late castration. Protein level increased the percentage of muscle in the animal, as well as increased the lys/met ratio.

Keywords: productive indexes, chemical composition, fatty acid profile, water losses

5.2. Introduction

In Spain, carcass and meat quality from Friesian bulls (66.8% of total bulls produced) need to be improved since 62.7% of carcass conformation are classed as ‘O’,

and 32.5% of carcass are classed as ‘2’ using the EU fatness regulation (Mach, Bach, Velarde & Devant, 2008), having in some areas a negative image of quality.

Castration is an important tool in beef cattle for enhancing meat quality, it reduces aggressive and sexual behaviour, improves animal handling, and reduces carcass bruising (Mach et al., 2009). However, castration of bulls reduces average daily gain and worsens feed efficiency (Rotta et al., 2009). Otherwise, the castration of bulls increases carcass fatness, intramuscular fat content and tenderness, but reduces the incidence of high final meat pH, changing the chemical composition and fatty acid profile on *Longissimus* muscle (Aricetti et al., 2008; Wood et al., 2008). The differences in performance between bulls and steers are mainly expressed after puberty as a consequence of a greater production of anabolic hormones by the testicles (Adams, Daley, Adams & Sakurai, 1996), which happens at an age of 6–9 months in Friesian bulls (Lunstra, Ford & Echternkamp, 1978). Knight, Cosgrove, Death and Anderson (1999) have proposed post-pubertal castration of bulls (13 months of age), as a way to maintain the performance advantages of bulls until 13 months, and the benefits of castration on meat quality characteristics afterwards, but this time is too late in markets that slaughter animals at younger ages.

Methods to increase meat production through dietary changes have been extensively studied and it is generally accepted that meat production increases with increased dietary crude protein level (NRC, 2000). However, a number of factors affecting performance, carcass characteristics, and meat quality are not included in the NRC (2000) systems. Both genetic type and nutritional systems could affect body composition and subsequent growth and requirements (Rotta et al., 2009; Webb & O’Neill, 2008). Trends to larger cattle breeds, selection within traditional beef breeds and the introduction of dairy breed have altered the cattle population and meat quality

(Campo et al., 2000; Campo, Sañudo, Panea, Alberti & Santolaria, 1999; Monsón, Sañudo & Sierra, 2004).

Large-framed cattle finished directly after weaning have rapid and efficient gains, depositing a large percentage of protein as lean tissue (Wood et al., 2008). These cattle have high metabolizable protein requirements that may exceed their supply of microbial and dietary escape protein (Hussein & Berger, 1995; Klemesrud, Klopfenstein & Lewis, 2000a; Klemesrud, Klopfenstein, Stock, Lewis & Herold, 2000b). Supplementing with escape protein has improved feed efficiency, especially in the early feeding period (Sindt, Stock, Klopfenstein & Shain, 1993). There is, however, no single source of rumen undergradable crude protein which provides an ideal balance of essential amino acids that matches the amino acids profile of cattle (Robinson, 2010). Thus, is difficult to formulate rations to provide all required amino acids concentrations using currently available feed sources and metabolic models. Lysine and methionine seem to be the two amino acids limiting growth in microbial protein (Komarek, Jandzinski & Ames, 1983). To be effective, escape protein should, therefore, supply adequate amounts of these two amino acids.

There is a lack of information concerning the effect of pre-pubertal castration, and higher protein level and lys/met ratio in diet on carcass composition and meat quality of Friesian bulls slaughtered around 12 months old. Therefore, the aim of this study was to determine the effects of pre-pubertal (15 days) or late castration (5 months), and protein levels (13 and. 15% of DM) and ratio lys/met (3.0/1.0 and. 3.4/1.0) on animal performance, carcass characteristics, pH, water losses and chemical composition of Friesian steers finished with high-concentrate diets.

5.3. Materials and methods

5.3..1. Animals and treatments

Sixty four Friesian steers were used in a complete factorial design. While animals were part of a same flock, half of the animals of each treatment were castrated at 15 days of age: the scrotum was shortened by stretching while the testicles were pressed next to the animal's body, and the securing them in place by slipping a rubber ring over the scrotum below the testicles. The rest of the animals were castrated at 5 months of age with a standard Burdizzo instrument (La Burdizzo, Corso Sebastopoli 187, Turin, Italy) as described by (Fisher, Crowe, Varga & Enright, 1996), under anaesthesia conditions. At 90 days of age, the animals were weighed and distributed in four similar pens in the same farm. Each pen was randomly assigned to one eight treatments, following the factorial design with the levels: Castration [pre-pubertal castration (15 days) or late castration (5 months)], protein level in the feed (13% or 15% crude protein), and ratio lys/met [low (3.0) and high (3.4)]. The average initial live weight (LW) was 92.9 ± 0.65 kg, and it was balanced within treatments at the beginning of the experimental feeding period. Animals were fed concentrate (Table 1) and barley straw *ad libitum* in separate feeders per diet.

When steers reached 414.6 ± 38.6 kg live weight, they were slaughtered. All steers were without feed before slaughter for less than 24 h and had free access to water; transportation did not exceed 2 h.

5.3.2. Carcass measurements and sampling

The animals were transported to a commercial slaughterhouse (Friusa, Gerona, Spain). Steers were stunned using a captive-bolt pistol and dressed according to commercial practices. No electrical stimulation of carcasses was performed.

After chilling the carcasses at 2^{o} C for 24 h, cold carcass weight (CCW) was obtained.

- Carcass yield was calculated as the cold carcass weight divided by the live weight 24 h before slaughter;

- Carcass classification was performed using the SEUROP classification scale (Anonymous, 1981) for conformation (CONF), scoring from 18 (for S+) to 1 (for P-) and for fatness score (FS) ranking from 15 (for 5+) to 1 (for 1-).

- Carcass length was recorded according to the method of De Boer, Dumont, Pomeroy and Weniger (1974).

At 24 h *post-mortem* the 6^{th} rib and *Longissimus dorsi* (LD) were obtained from the left side of carcass for sampling. The 6^{th} rib was used for tissue composition analysis. At 48 h after slaughter, the sample of *Longissimus thoracis* (LT) from the 6^{th} rib was obtained and used for the fatty acid profile. Similarly, the rest of LT was removed, sliced into 3.5 cm thick steaks, which were used for water-holding capacity analysis.

5.3.3. Tissue composition

After thawing (overnight at 4 ^{o}C $\pm$ 1 ^{o}C) the muscle, fat, bone and waste were physically separated from the 6^{th} rib, and individually weighed for percentage determinations each tissue.

5.3.4. pH and Water-holding capacity

The pH was measured 48 h *post-mortem*. A portable CRISSON 503 pH-meter equipped with a penetrating electrode probe was used to measure the pH of the left *Longissimus thoracis* (LT) at the level of the 6th rib.

For the cooking losses (performed at 3, 7, 14 and 21 days of ageing in vacuum polyethylene packaged samples that were kept frozen at -18 ºC after ageing), samples were thawed overnight at 4 ^{o}C $\pm$ 1 ^{o}C and cooked in a water bath at 75 $\pm$ 2 ^{o}C until reaching an internal temperature of 70 ^{o}C. Sample internal temperature was monitored with a thermocouple probe (JENWAY, 2000) inserted horizontally at the steak midpoint. Cooking loss was calculated as the difference between thawed and cooked weight (% CL = [(thawed weight – cooked weight)/thawed weight] x 100).

5.3.5. Chemical analysis

Laboratory beef analyses were carried out four months after sampling. The samples of LT were thawed at 4 $\pm$ 1 ^{o}C grounded, homogenized, and analyzed in duplicate. Meat moisture and ash content were determined according to ISO R-1442 (1997) and ISO-R-936 (1998). Crude protein content was obtained through ISO-R-937 (1978). Total fat was determined following ISO-R-1443 (1973).

For fatty acid determination, the samples were fast-thawed in tap water (1 h) without losing vacuum, the meat was ground and the fat was extracted in chloroform–methanol, with BHT as an antioxidant (Bligh & Dyer, 1959). All of the samples were analysed in duplicates. The methyl esters from fatty acids (FAMES) were formed using a KOH solution in methanol. The FAMES were analysed in a gas chromatograph HP-6890 II, with a capillary column SP-2380 (100 mx0.25 mmx0.20 μm), using nitrogen as the carrier gas (Carrilho, López & Campo, 2009).

5.3.6. Statistical analysis

For the animal performance, carcass characteristics, pH, water hold capacity, tissue percentages and fatty acid composition, the effect of treatment (castration age, protein level and lys/met ratio) was assessed with the following model:

Yijk = μ + Ci + Pj + Rk + Ci*Pj + Ci*Rk + Pj*Rk + Ci*Rj*Lk + eijk, where:

Yijk is the dependent variable;μ is the population average; Ci is the fixed effect of castration age; Pj is the protein level; Rk is the lysine/methionine ratio; Ci*Pj is the interaction between castration age and protein level; Ci*Rk is the interaction between castration age and lysine/methionine ratio; Pj*Rk is the interaction between protein level and lysine/methionine ratio; Ci*Pj*Rk is the interaction among castration age, protein level and lys/met ratio and eijk is the error. When the effect was significant, differences between mean values were obtained by Duncan.

5.4. Results and discussion

5.4.1. Animal performance and carcass characteristics

For animal performance and carcass characteristics, there were no significant interactions among castration age, protein level and lys/met ratio; thus the effects of treatments were evaluated, showed and discussed as main effects (Table 2).

Average daily gain, final live weight, carcass weight, carcass conformation and fatness scores were not affected by castration age. Castration is a tool in beef cattle to enhance meat quality and reduces aggressive behaviour (Mach et al., 2009; Purchas, Burnham & Morris, 2002). However, castration of bulls reduces average daily gain (Rotta et al., 2009).

Supporting the current results, some studies conducted with Holstein steers castrated at 5.5 months of age (Fisher et al., 1996) have reported no negative effects on ADG and feed intake in the first 35 d after castration. Bagley, Morrison, Feazel and Saxton (1989) indicate that the practise of castration calves at birth did not reduce suckling calf weight at weaning compared with delaying castration until 4 months of age. Similarly, no advantages were found in carcass conformation or fatness scores, meat yield, and commercial cuts after adopting late castration on calves of the Piemontese breed, instead of the traditional practice to castrate calves before puberty (Lazzaroni & Biagini, 2008). In fact, the difference between the two groups of castrated animals seems to be slight, at least in the quantitative performance, particularly for the commercial dissection. On the other hand, the differences in performance between bulls and steers are mainly manifested after puberty as a consequence of a greater production of anabolic hormones by the testicles (Adams et al., 1996), which is attained at an age of 9 months in Holstein bulls (Lunstra et al., 1978). Therefore, Knight et al. (1999) have proposed post-pubertal castration of bulls (13 months of age), as a means to maintain the performance advantages of bulls until 13 months, and the benefits of castration on meat quality characteristics afterwards. Nevertheless, in Spain Friesian bulls are slaughtered at an average age of 12 months (Mach et al., 2008).

Animal performance and carcass characteristics were not different between steers fed with low-protein level (13% of CP; DM basis) and those fed with high-protein level (15%). Then, results suggest that high-protein diet can be replaced with a cheaper diet, without compromising feedlot performance and carcass characteristics. It is generally accepted that meat production increases with increased dietary crude protein level (NRC, 1996). Cattle finished directly after weaning make rapid gains, depositing a large percentage of protein as lean tissue (Wood et al., 2004).

Animal performance and carcass characteristics were not different between steers fed the low and high ratio lys/met (3.0 and. 3.4). Lysine and methionine frequently have been identified as the first- and second-limiting amino acid for growing cattle (Hussein & Berger, 1995; Klemesrud et al., 2000a; Klemesrud et al., 2000b). Ruminant's requirements for these limiting amino acids have been estimated from studies in which the amino acid were infused postruminally in a protected form to allow escape from the ruminal microbial deamination, but availability for digestion and absorption in the small intestine (Schroeder & Titgemeyer, 2008). However, growth response to supplementation of diets with protected protein has been inconsistent (Klemesrud et al., 2000a; Klemesrud et al., 2000b; Schroeder & Titgemeyer, 2008).

Total muscle, total fat and bone percentages did not differ between castration age (early *vs.* late, Table 2). Usually, the castration of bulls increases carcass fatness and intramuscular fat content (Knight et al., 1999; Purchas et al., 2002). To our knowledge, there are not studies that evaluated changes in muscle, fat and bone percentages of calves castrated at 15 days old.

On the other hand, muscle percentage was higher due to high protein level ($P < 0.05$) and high lys/met ratio ($P < 0.001$). Bone percentage was lower ($P < 0.05$) due to high level protein. Thus, high protein level and high lys/met ratio increased muscle deposition without affecting carcass fatness.

5.4.2. pH and water-holding capacity

The ultimate pH (at 48 h) did not differ among the treatments and ranged 5.36 to 5.41, indicating that animals were not stressed at the time of slaughter, as noted by Serra et al. (2008) and Christensen et al. (2011) in some European cattle breeds. Final pH can

be considered as normal, assuming that an ultimate pH greater than 5.8 is regarded as undesirable.

Cooking losses were not affected by castration age, protein level and lys/met ratio (Table 3). Mean values of the cooking losses reported in this study are similar (21.5%) to those reported in the literature (Oliván et al., 2004; Serra et al., 2008). Cooking losses were affected by ageing time ($P > 0.05$). On all treatments, they decreased when ageing time increased, especially between 3 days and the other ageing times. It is known that cooking denatures the muscle proteins, which directly influences the structural characteristics (Tornberg, 2005) and thereby also the water distribution of the meat (Pearce, Rosenvold, Andersen & Hopkins, 2011). Such structural changes lead to substantial loss of water (cooking loss) in the range of 15 to 35%. Higher water loss has been shown to occur during early *post mortem* storage which corresponds with decreased WHC from one day *post mortem*. Kristensen and Purslow (2001) found that the WHC of pork gradually decreased immediately *post rigour* followed by an increase as ageing continued. It is not clear whether the water loss is directly associated with the cytoskeletal proteins or whether degradation of the protein contributes to the appearance of muscle water over time (Pearce et al., 2011).

5.4.3. Chemical composition

There were some interactions ($P < 0.05$) among castration age, protein levels and lys/met ratio. Thus, effects were analyzed as 8 treatments (Table 4). The moisture percentage was higher ($P < 0.05$) in meat from steers late castrated (73.26%) than in meat from early steers castrated (72.83%). However, protein level and lys/met ratio did not affect moisture percentage in meat. Moisture percentage in meat from steers early castrated and fed high protein level and high lys/met ratio was lower ($P < 0.05$) than

moisture percentage in meat from animals early castrated, fed high protein level and low lys/met ratio, and in meat from steers late castrated, fed low or high protein level and low lys/met ratio and in meat from steers late castrated and fed high protein and high lys/met ratio. However, the moisture percentages in meat from steers all treatments were low (from 72.19 to 73.65%). Variations in moisture percentage in meat from animals intensively reared occur when there is a variation in lipid percentage in meat (Rotta et al., 2009).

Ashes percentages were higher ($P < 0.05$) in meat from steers fed high protein level and similar in meat from steers castrated at 15 days or 5 months of age and steers fed low or high lys/met ratio in the diets. On the other hand, ashes percentages were higher ($P < 0.05$) in meat from steers early castrated, fed high protein and high lys/met ratio than the meat from animals early castrated and fed low protein level. The ashes percentages for others treatments were similar. In fact, ashes percentage is little influenced by age of castration or nutrition system (Padre et al., 2007; Padre et al., 2006).

Protein percentage was similar between castration ages. However, protein percentage was lower ($P < 0.05$) in meat from steers fed high protein level and high lys/met ratio too. The protein percentage in meat from steers ranged from 21.52 to 22.77%. Some authors (Aricetti et al., 2008; Rotta et al., 2009) reported that crude protein percentage in *Longissimus* muscle varied little with age of castration and nutrition status and varied between 21 and 24%.

Lipid percentages were similar among three treatments. Lipid percentage in meat was higher ($P < 0.01$) in meat from steers late castrated and fed high protein level and low lys/met ratio than in that from the other treatments. In this study, lipids percentages varied from 4.43 to 6.86%. Total lipids in *Longissimus* muscle of beef cattle finished in

feed-lot system can vary from 2 to 6% (Padre et al., 2007; Padre et al., 2006; Rotta et al., 2009). This is the parameter that is most influenced by nutrition. Thus, the lipids percentages in meat from these steers were high.

5.4.4. Fatty acid profile

Castration age, protein level and lys/met ratio had a limited effect on intramuscular fatty acid (IMF) composition (Table 5). There was significant difference in only one fatty acid due to castration age (C18:2 *n*-6, linoleic acid) of all the individual fatty detected, with late castrated animals showing higher percentage of linoleic acid. In the same way, only 3 minor fatty acids showed significant differences due to the effect of the protein level (C17:1,; tC18:1 *n*-7, and CLA) and only one between lys/met ratio (C18:1 *n*-11). The level of the palmitic acid (C16:0) was high in all animals (27%). This acid is considered non-beneficial to human health (Pensel, 1997). The levels of stearic acid (C18:0) considered neutral to human health (Pensel, 1997) did not suffer influence by any treatment. Similarly, the levels of linoleic (C18:2 *n*-6) and α-linolenic (C18:3 *n*-3) acids were not altered by castration age, protein level and lys/met ratio. Thus, the castration and diet studied did not influence the levels of fatty acid considered beneficial to human health.

However, castration by itself may influence the intramuscular fatty acid composition (Rotta et al., 2009), differences that can be explained by differences in carcass fatness (De Smet, Raes & Demeyer, 2004; Wood et al., 2008) and associated changes in triacylglycerol/phospholipid ratio (Eichorn, Baily & Blomquist, 1985).

Castration age and protein level did not have an influence ($P > 0.05$) on SFA percentage in meat from steers reared intensively (Table 6). However, SFA percentage was higher ($P < 0.05$) in meat from steers fed low lys/met ratio than in meat from steers

fed high lys/met ratio. MUFA percentage was only higher ($P < 0.05$) in meat from steers fed high protein level than in meat from steers fed low protein, without being affected by castration age or protein level. None of the studied effect had an influence in PUFA percentage in meat from steers reared intensively. The fatty acid percentages found in this study are similar to those observed among bovines finished in feed-lot (Padre et al., 2007; Padre et al., 2006; Rotta et al., 2009).

Although castration age, protein level and lys/met ratio did not change ($P > 0.05$) *n*-3 and *n*-6 percentages in meat from steers reared intensively (Table 6), PUFA/SFA and *n*-6/*n*3 were higher in meat from steers castrated at 5 mo in relation to steers castrated at 15 days old. On the other hand, protein level and lys/met ratio did not influence ($P > 0.05$) the PUFA/SFA and *n*-6/*n*-3 ratio in meat from Friesian steers. The PUFA/SFA ratio was low (0.13) possibly because the steers were slaughtered at a young age and had not accumulated enough fat; otherwise they would have increased the level of SFA, and it was within the normal range for cattle (Padre et al., 2007; Padre et al., 2006) specially for animals that are intensively fed cereal-based diets (Scollan et al., 2006). However, the PUFA/SFA ratio remained below 0.4 which is the limit recommended by HMSO (1994) as being healthy. The *n*-6/*n*-3 ratio is recommended to be near 4. In this manner, all the animals showed *n*-6/*n*-3 ratio (10.7) since the diets contained high proportions of barley, corn, and soybean meal, which are very rich in linoleic acid. Overall, these results suggest that the influence of castration and protein quality in the fatty acid profile of meat is relatively small.

5.5. Conclusions

Animal performance, carcass conformation and chemical composition of *Longissimus dorsi* were not affected by castration age. On the other hand, results support the substitution of high-protein (15% CP of DM) level for an extended period by low protein level (13% CP of DM) in the diet of growing-finishing Friesian steers without compromising feedlot performance or carcass characteristics. An increase of methionine in the diet to produce a ration lysine/methionine of 3.0 did not enhance feedlot performance or carcass characteristics of the steers, indicating that the diets were not limiting in lysine or methionine, and that the ratio 3.4 by reducing the amount of methionine could be recommended. Higher level of protein increased monounsaturated fatty acids and a higher ratio of lisinna:methionine decrease the amount of saturated fatty acids

5.6. Acknowledgements

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5.7. References (Journal Meat Science)

Adams, T. E., Daley, C. A., Adams, B. M., & Sakurai, H. (1996). Testes function and feedlot performance of bulls actively immunized against gonadotropin-releasing hormone: effect of age at immunization. *Journal of Animal Science, 74*(5), 950-954.

Anonymous. (1981). Community scale for the classification of carcass of adult bovine animals. R. (CEE) no. 2930/81. *Office for Official Publications of the European Communities, L-2985 Luxemburg*.

Aricetti, J. A., Rotta, P. P., Prado, R. M., Perotto, D., Moletta, J. L., Matsushita, M., & Prado, I. N. (2008). Carcass characteristics, chemical composition and fatty acid profile of *Longissimus* muscle of bulls and steers finished in a pasture system. *Asian-Australasian Journal of Animal Science, 21*(10), 1441-1448.

Bagley, C., Morrison, D., Feazel, J., & Saxton, A. (1989). Growth and sexual characteristics of suckling beef calves as influenced by age at castration and growth implants. *Journal of Animal Science, 67*(5), 1258-1264.

Bligh, E. G., & Dyer, W. J. (1959). A rapid method of total lipid extraction and purification. *Canadian Journal Biochemistry and Physiology, 37*(8), 911-917.

Campo, M. M., Santolaria, P., Sañudo, C., Lepetit, J., Olleta, J. L., Panea, B., & Albertí, P. (2000). Assessment of breed type and ageing time effects on beef meat quality using two different texture devices. *Meat Science, 55*(4), 371-378.

Campo, M. M., Sañudo, C., Panea, B., Alberti, P., & Santolaria, P. (1999). Breed type and ageing time effects on sensory characteristics of beef strip loin steaks. *Meat Science, 51*(4), 383-390.

Carrilho, M., López, M., & Campo, M. (2009). Effect of the fattening diet on the development of the fatty acid profile in rabbits from weaning. *Meat Science, 83*(1), 88-95.

Christensen, M., Ertbjerg, P., Failla, S., Sañudo, C., Richardson, R. I., Nute, G. R., Olleta, J. L., Panea, B., Albertí, P., Juárez, M., Hocquette, J.-F., & Williams, J. L. (2011). Relationship between collagen characteristics, lipid content and raw and cooked texture of meat from young bulls of fifteen European breeds. *Meat Science, 87*(1), 61-65.

De Boer, H., Dumont, B. L., Pomeroy, R. W., & Weniger, J. H. (1974). Manual on EAAP reference methods for the assessment of carcass characteristics in cattle. *Livestock Production Science, 1*(2), 151-164.

De Smet, S., Raes, K., & Demeyer, D. (2004). Meat fatty acid composition as affected by fatness and genetic factors: a review. *Animal Research, 53*(2), 81-98.

Eichorn, J. M., Baily, C. M., & Blomquist, G. J. (1985). Fatty acid composition of muscle and adipose tissue from crossbred bulls and steers. *Journal of Animal Science, 61*(4), 892-904.

Fisher, A. D., Crowe, M. A., Varga, M. E. A., & Enright, W. (1996). Effect of castration method and the provision of local anesthesia on plasma cortisol, scrotal circumference, growth, and feed intake of bull calves. *Journal of Animal Science, 74*(10), 2336-2343.

HMSO. (1994). England Department of Health Nutritional. Aspects of cardiovascular disease. *Report on Health and Social Subjects, 46*, 37-46.

Hussein, H. S., & Berger, L. L. (1995). Feedlot performance and carcass characteristics of Holstein steers as affected by source of dietary protein and level of ruminally protected lysine and methionine. *Journal of Animal Science, 73*(12), 3503-3509.

ISO-R-936. (1998). Meat and meat products - Determination of total ash content. Method ISO R-936. *International Organization for Standardization, Geneva, Switzerland*.

ISO-R-937. (1978). Meat and meat products - Determination of nitrogen content. Method ISO R-937. *International Organization for Standardization, Geneva, Switzerland*.

ISO-R-1442. (1997). Meat and meat products - Determination of moisture content. Method ISO R-1442. *International Organization for Standardization, Geneva, Switzerland*.

ISO-R-1443. (1973). Meat and meat products - Determination of total fat content. Method ISO R-1442. *International Organization for Standardization, Geneva, Switzerland*.

Klemesrud, M. J., Klopfenstein, T. J., & Lewis, A. J. (2000a). Metabolize methionine and lysine requirements of growing cattle. *Journal of Animal Science, 78*(1), 199-206.

Klemesrud, M. J., Klopfenstein, T. J., Stock, R. A., Lewis, A. J., & Herold, D. W. (2000b). Effect of dietary concentration of metabolizable lysine on finishing cattle performance. *Journal of Animal Science, 78*(4), 1060-1066.

Knight, T. W., Cosgrove, G. P., Death, A. F., & Anderson, C. B. (1999). Effect of interval from castration of bulls to slaughter on carcass characteristics and meat quality. *New Zealand Journal of Agricultural Research, 42*(3), 269-277.

Komarek, R. J., Jandzinski, R. A., & Ames, S. R. (1983). Effect of diet upon the postruminal supplies of amino acids in the steer. *Journal of Animal Science, 57*(Suppl 1), 447-448.

Kristensen, L., & Purslow, P. P. (2001). The effect of ageing on the water-holding capacity of pork: role of cytoskeletal proteins. *Meat Science, 58*(1), 17-23.

Lazzaroni, C., & Biagini, D. (2008). Effect of pre-and post-pubertal castration on Piemontese male cattle. II: Carcass measures and meat yield. *Meat Science, 80*(2), 442-448.

Lunstra, D. D., Ford, J. J., & Echternkamp, S. E. (1978). Puberty in beef bulls: hormone concentrations, growth, testicular development, sperm production and sexual aggressiveness in bulls of different breeds. *Journal of Animal Science, 46*(4), 1054-1062.

Mach, N., Bach, A., Realini, C., Font i Furnols, M., Velarde, A., & Devant, M. (2009). Burdizzo pre-pubertal castration effects on performance, behaviour, carcass characteristics, and meat quality of Holstein bulls fed high-concentrate diets. *Meat Science, 81*(2), 329-334.

Mach, N., Bach, A., Velarde, A., & Devant, M. (2008). Association between animal, transportation, slaughterhouse practices, and meat pH in beef. *Meat Science, 78*(3), 232-238.

Monsón, F., Sañudo, C., & Sierra, I. (2004). Influence of cattle breed and ageing time on textural meat quality. *Meat Science, 68*(4), 595-602.

NRC. (2000). *Nutrient Requirements of Beef Cattle*: 7th ed. Natl. Acad. Press, Washington, DC.

Oliván, M., Martínez, A., Osoro, K., Sañudo, C., Panea, B., Olleta, J. L., Campo, M. M., Oliver, M. À., Serra, X., Gil, M., & Piedrafita, J. (2004). Effect of muscular hypertrophy on physico-chemical, biochemical and texture traits of meat from yearling bulls. *Meat Science, 68*(4), 567-575.

Padre, R. G., Aricetti, J. A., Gomes, S. T. M., Goes, R. H. T. B., Moreira, F. B., Prado, I. N., Visentainer, J. V., Souza, N. E., & Matsushita, M. (2007). Analysis of fatty acids in *Longissimus* muscle of steers of different genetic breeds finished in pasture systems. *Livestock Science, 110*(1), 57-63.

Padre, R. G., Aricetti, J. A., Moreira, F. B., Mizubuti, I. Y., Prado, I. N., Visentainer, J. V., Souza, N. E., & Matsushita, M. (2006). Fatty acid profile, and chemical composition of Longissimus muscle of bovine steers and bulls finished in pasture system. *Meat Science, 74*(2), 242-248.

Pearce, K. L., Rosenvold, K., Andersen, H. J., & Hopkins, D. L. (2011). Water distribution and mobility in meat during the conversion of muscle to meat and ageing and the impacts on fresh meat quality attributes — A review. *Meat Science, 89*(2), 111-124.

Pensel, N. (1997). The future for red meat in human diets. *Outlook on Agriculture, 26*(3), 159-164.

Purchas, R., Burnham, D., & Morris, S. (2002). Effects of growth potential and growth path on tenderness of beef longissimus muscle from bulls and steers. *Journal of Animal Science, 80*(12), 3211-3221.

Robinson, P. H. (2010). Impacts of manipulating ration metabolizable lysine and methionine levels on the performance of lactating dairy cows: A systematic review of the literature. *Livestock Science, 127*(2), 115-126.

Rotta, P. P., Prado, R. M., Prado, I. N., Valero, M. V., Visentainer, J. V., & Silva, R. R. (2009). The effects of genetic groups, nutrition, finishing systems and gender of Brazilian cattle on carcass characteristics and beef composition and appearance: a review. *Asian-Australasian Journal of Animal Sciences, 22*(12), 1718-1734.

Schroeder, G. F., & Titgemeyer, E. C. (2008). Interaction between protein and energy supply on protein utilization in growing cattle: a review. *Livestock Science, 114*(1), 1-10.

Scollan, N., Hocquette, J. F., Nuernberg, K., Dannenberger, D., Richardson, I., & Moloney, A. (2006). Innovations in beef production systems that enhance the nutritional and health value of beef lipids and their relationship with meat quality. *Meat Science, 74*(1), 17-33.

Serra, X., Guerrero, L., Guàrdia, M. D., Gil, M., Sañudo, C., Panea, B., Campo, M. M., Olleta, J. L., García-Cachán, M. D., Piedrafita, J., & Oliver, M. A. (2008). Eating quality of young bulls from three Spanish beef breed-production systems and its relationships with chemical and instrumental meat quality. *Meat Science, 79*(1), 98-104.

Sindt, M. H., Stock, R. A., Klopfenstein, T. J., & Shain, D. H. (1993). Effect of protein source and grain type on finishing calf performance and ruminal metabolism. *Journal of Animal Science, 71*(4), 1047-1056.

Tornberg, E. (2005). Effects of heat on meat proteins–Implications on structure and quality of meat products. *Meat Science, 70*(3), 493-508.

Webb, E. C., & O'Neill, H. A. (2008). The animal fat paradox and meat quality. *Meat Science, 80*(1), 28-36.

Wood, J. D., Enser, M., Fisher, A. V., Nute, G. R., Sheard, P. R., Richardson, R. I., Hughes, S. I., & Whittington, F. M. (2008). Fat deposition, fatty acid composition and meat quality: A review. *Meat Science, 78*(4), 343-358.

Wood, J. D., Richardson, R. I., Nute, G. R., Fisher, A. V., Campo, M. M., Kasapidou, E., Sheard, P. R., & Enser, M. (2004). Effects of fatty acids on meat quality: a review. *Meat Science, 66*(1), 21-32.

Table 1
Ingredient composition of the diets (% of Dry Matter)

	Low protein		High protein	
Raw material (%)	Low Lys/Met	High Lys/Met	Low Lys/Met	High Lys/Met
Barley grain (ground)	42.04	42.04	36.11	36.11
Corn grain (ground)	35.00	35.00	35.00	35.00
Soybean meal 44% (CP)	4.72	5.05	10.69	11.05
Rapessed meal	3.00	3.00	3.00	3.00
Sunflower meal	3.00	3.00	3.00	3.00
Wheat middling	6.00	6.00	6.00	6.00
Palm calcium soap	1.59	1.48	1.60	1.48
Palm oil	1.20	1.20	1.20	1.20
Urea	0.20	0.18	0.21	0.19
Calcium carbonate	1.58	1.61	1.60	1.63
Salt	0.40	0.40	0.40	0.40
Bicarbonate	0.40	0.40	0.40	0.40
Dicalcium phosphate	0.29	0.28	0.21	0.20
Magnesium oxide	0.15	0.15	0.15	0.15
Vitamin-mineral premix	0.20	0.20	0.20	0.20
Chemical composition*				
Dry matter	89.08	89.05	89.92	88.88
Crude protein	13.00	13.00	15.00	15.00
Crude fat	5.12	5.03	5.11	5.01
Metabolizable energy[1]	2798.99	2787.04	2798.67	2785.74
Ash	5.39	5.37	5.53	5.50
Neutral detergent fibre	40.88	40.95	40.24	40.32
Non-fibre carbohydrates	50.48	50.52	48.46	48.50
Calcium	0.95	0.95	0.95	0.95
Phosporus	0.45	0.45	0.45	0.45
Lysine	6.08	6.10	6.08	6.11
Methionine	2.03	1.81	2.03	1.79
Lys/met, ratio	3.00	3.38	3.00	3.40

*NRC (1996). [1]Mcal/kg.

Table 2
Effect of castration age (early and. late), protein level (13 and. 15%) and (Lys/Met) ratio (3.0 and. 3.4) on animal performance and carcass characteristics from Friesian steers intensively reared

Parameters	Treatments						SED	Sign		
	Castration		Protein level		Lys/met ratio					
	Early	Late	Low	High	Low	High		Cast	Prot	Lys/Met
Initial weight, kg	93.6	92.2	92.7	93.1	92.8	93.0	0.65	NS	NS	NS
Final weight, kg	444.9	442.3	444.0	443.1	443.6	443.5	4.35	NS	NS	NS
Average daily gain, kg	0.98	1.01	1.01	0.98	1.00	0.99	0.02	NS	NS	NS
Cold carcass weight, kg	231.6	230.0	230.2	231.2	229.0	232.4	1.38	NS	NS	NS
Carcass dressing, %	52.1	52.0	51.8	52.2	51.6	52.4	3.21	NS	NS	NS
Carcass lenght, cm	127.4	127.5	127.5	127.4	126.7	128.1	0.56	NS	NS	NS
Carcass conformation[1]	13.5	13.5	13.4	13.6	13.6	13.4	0.09	NS	NS	NS
Fat score[2]	5.14	5.06	5.11	5.08	5.07	5.10	0.07	NS	NS	NS
Deboning losses, %	1.41	1.40	1.50	1.31	1.50	1.31	0.62	NS	NS	NS
Thawing losses, %	0.97	1.00	1.07	0.90	0.95	1.02	0.47	NS	NS	NS
[§]Muscle, %	56.3	56.7	55.6b	57.4a	55.8b	57.2a	0.49	NS	*	***
[§]Subcutaneous fat, %	4.46	4.75	4.81	4.41	4.58	4.64	1.05	NS	NS	NS
[§]Intramuscular fat, %	17.9	17.1	17.4	17.6	17.9	17.1	2.05	NS	NS	NS
[§]Total fat, %	22.4	21.8	22.2	22.0	22.5	21.7	2.57	NS	NS	NS
[§]Bone, %	16.8	16.8	17.7a	15.8b	17.0	16.6	0.39	NS	*	NS
[§]Others, %	4.56	4.72	4.54	4.79	4.71	4.57	0.06	NS	NS	NS

[1](1 to 18). [2](1 to 15). NS= not significant. *P $\leq$ 0.05. ***P $\leq$ 0.001. No significant interactions between effects have been found.
Means with different letters (a, b) within a row are statistically different.
[§]Carcass composition from the dissection of the 6th rib.
SED: standard error of the difference.

Table 3
Effect of castration age (early and. late), protein level (13 and. 15%) and Lys/Met ratio (3.0 and. 3.4) on cooking losses (%) from Friesian steers intensively reared throughout ageing

Days	Treatments						SED	Sign		
	Castration		Protein level		Lys/Met ratio					
	Early	Late	Low	High	Low	High		Cast	Prot	Lys/Met
3	20.75a	20.88a	20.60a	21.04a	20.16	21.47a	1.32	NS	NS	NS
7	19.54ab	19.51b	19.02b	20.02ab	19.46	19.58b	1.12	NS	NS	NS
14	19.96ab	19.42b	19.39b	20.00ab	19.51	19.87b	1.14	NS	NS	NS
21	18.65b	19.55b	19.16b	19.04b	19.06	19.14b	0.94	NS	NS	NS
SED	1.04	1.26	1.19	1.12	1.17	1.14				
Sign	*	*	*	*	NS	*				

NS – not significant. *P < 0.05. No significant interactions between effects have been found.
Means with different letters (a, b) within a column are statistically different.
SED: standard error of the difference.

Table 4

Effect of castration age (early and. late), protein level (13 and. 15%) and Lys/Met ratio (3.0 and. 3.4) on chemical composition of *Longissimus thocacis* from Friesian steers intensively reared

	Castration early				Castration late										
	Low protein		High protein		Low protein		High protein		SED	Cast	Prot	Lys	Cast Prot	Cast Lys	Prot Lys
Item	Low Lys	High Lys	Low Lys	High Lys	Low Lys	High Lys	Low Lys	High Lys							
Moisture, %	72.94abc	72.74bc	73.45ab	72.19c	73.65a	73.37ab	72.70bc	73.32ab	0.13	**	NS	NS	NS	*	NS
Ashes, %	1.02b	1.02b	1.05ab	1.08a	1.04ab	1.03ab	1.03ab	1.07ab	0.03	NS	*	NS	NS	NS	NS
Protein, %	22.20abc	22.01bc	22.26ab	21.84bc	22.77a	22.04bc	21.62bc	21.52c	0.11	NS	**	*	*	NS	NS
Lipids, %	4.79b	5.61b	4.99b	4.73b	5.22b	4.73b	6.86a	4.43b	0.22	NS	NS	NS	NS	**	*

a-d: values in rows with different letters are significantly different ($p \leq 0.05$).
SED: standard error of the difference.

Table 5

Effect of castration age (early and. late), protein level (13 and. 15%) and Lys/Met ratio (3.0 and. 3.4) on *Longissimus* muscle fatty acid composition from Friesian steers intensively reared

Fatty acid	Treatments						SED	Sign		
	Castration		Protein level		Lys/Met ratio					
	Early	Late	Low	High	Low	High		Cast	Prot	Lys/Met
C10:0	0.05	0.05	0.05	0.05	0.05	0.05	0.003	NS	NS	NS
C12:0	0.07	0.06	0.06	0.06	0.06	0.06	0.005	NS	NS	NS
C14:0	2.95	2.66	2.74	2.82	2.74	2.87	0.205	NS	NS	NS
C14:1	0.53	0.48	0.46	0.54	0.50	0.51	0.068	NS	NS	NS
C15:0	0.37	0.37	0.36	0.37	0.37	0.36	0.022	NS	NS	NS
C15:1	0.01	0.01	0.01	0.01	0.01	0.01	0.001	NS	NS	NS
C16:0	27.51	27.36	27.72	26.96	27.80	27.08	0.517	NS	NS	NS
C16:1	3.18	2.97	2.92	3.26	3.07	3.08	0.225	NS	NS	NS
C17:0	1.09	1.12	1.07	1.13	1.10	1.10	0.053	NS	NS	NS
C17:1	0.69	0.70	0.65b	0.76a	0.67	0.72	0.051	NS	*	NS
C18:0	15.91	15.79	16.12	15.29	16.07	15.62	0.604	NS	NS	NS
tC18:1-*n*9	2.50	2.61	2.47	2.64	2.49	2.63	0.274	NS	NS	NS
C18:1-*n*9	35.12	34.89	34.70	35.69	34.64	35.37	0.757	NS	NS	NS
C18:1-*n*11	1.46	1.50	1.45	1.53	1.43b	1.52a	0.052	NS	NS	**
tC18:1-*n7*	0.25	0.25	0.23b	0.28a	0.25	0.26	0.028	NS	*	NS
tC18:2-*n*6	0.11	0.11	0.11	0.11	0.11	0.11	0.007	NS	NS	NS
C18:2-*n*6	4.03b	4.77a	4.56	4.32	4.34	4.46	0.513	*	NS	NS
CLA	0.06	0.06	0.05b	0.07a	0.06	0.06	0.007	NS	*	NS
C18:3-*n*3	0.13	0.12	0.13	0.13	0.12	0.12	0.008	NS	NS	NS
C18:3-*n*6	0.06	0.06	0.06	0.06	0.06	0.06	0.005	NS	NS	NS
C20:0	0.09	0.09	0.09	0.09	0.09	0.09	0.005	NS	NS	NS
C20:1	0.20	0.20	0.20	0.20	0.21	0.19	0.015	NS	NS	NS
C20:2-*n*3	0.35	0.36	0.37	0.35	0.35	0.35	0.043	NS	NS	NS
C20:2-*n*6	0.04	0.04	0.04	0.04	0.04	0.04	0.008	NS	NS	NS
C20:3-*n*3	0.01	0.01	0.01	0.01	0.01	0.01	0.002	NS	NS	NS
C20:3-*n*6	0.03	0.03	0.03	0.03	0.03	0.03	0.008	NS	NS	NS
C20:4-*n*6	1.13	1.29	1.25	1.20	1.19	1.23	0.175	NS	NS	NS
C20:5-*n*3	0.04	0.04	0.04	0.04	0.04	0.04	0.007	NS	NS	NS
C22:0	0.05	0.05	0.05	0.05	0.05	0.05	0.008	NS	NS	NS
C22:6-*n*3	0.02	0.02	0.02	0.02	0.02	0.02	0.003	NS	NS	NS

NS – not significant. *P < 0.05. **P < 0.01. No significant interactions between effects have been found.
CLA: sum of isomers.
Means with different letters (a, b) within a row are statistically different.
SED: standard error of the difference.

Table 6

Effect of castration age (early and. late), protein level (13 and. 15%) and Lys/Met ratio (3.0 and. 3.4) on *Longissimus* muscle fatty acid composition sum from Friesian steers intensively reared

Fatty acid	Treatments									
	Castration		Protein level		Lys/met ratio			Sign		
	Early	Late	Low	High	Low	High	SED	Cast	Prot	Lys/Met
SFA[1]	48.24	47.69	48.40	46.97	48.49a	47.44b	0.66	NS	NS	*
MUFA[2]	43.94	43.62	43.10b	44.46a	43.28	44.28	0.87	NS	*	NS
PUFA[3]	6.01	6.92	6.68	6.25	6.37	6.56	0.72	NS	NS	NS
n-6	5.41	6.32	6.06	5.66	5.78	5.95	0.68	NS	NS	NS
n-3	0.54	0.55	0.56	0.52	0.54	0.55	0.05	NS	NS	NS
PUFA/SFA	0.12b	0.15a	0.14	0.13	0.13	0.14	0.02	*	NS	NS
n-6/*n*-3	10.05b	10.73a	10.68	10.77	10.77	10.69	0.62	**	NS	NS

[1]SFA – Saturated fatty acids [2]MUFA – Monounsaturated fatty acids; [3]PUFA – Polyunsaturated fatty acids.

NS – not significant. *P < 0.05. **P < 0.01.

Means with different letters (a, b) within a row are statistically different.

SED: standard error of the difference.

6. CONSIDERAÇÕES FINAIS

O uso do sistema de confinamento possibilita melhora no desempenho animal e qualidade da carne. Todavia, este sistema exige animais de boa qualidade genética e uso racional de dietas balanceadas. As dietas dos animais confinados são compostas por volumosos tais como silagem de milho, silagem de sorgo, capineiras, cana-de-açúcar, bagaço de cana-de-açúcar, entre outros e concentrados chamados convencionais que são milho em grão e farelo de soja ou algodão, e os alternativos que dependem das regiões de produção. Além desses alimentos, os co-produtos do setor agro alimentar também estão sendo usados em escala crescente.

Para atingir ganhos de pesos máximos de bovinos em confinamento (entre 1,5 e 1,8 kg/animal/dia) é necessário o uso de dietas com alta densidade energética. A energia das dietas dos bovinos também pode ser fornecida por fontes de lipídeos: grãos de oleaginosas ou gordura animal. No entanto, o uso destes produtos com fonte de energia é limitado pela inclusão de gordura na dieta de ruminantes (7% da MS). Acima deste limite, ocorre redução na digestibilidade da fibra. Desta forma, o uso dos grãos de cereais e co produtos do setor agro alimentar são usados sistematicamente. Em ruminantes, o uso excessivo de fontes de carboidratos causa distúrbios na modulação ruminal. Os distúrbios na modulação ruminal podem ser controlados com uso de sais orgânicos, antibióticos e ionóforos. Sais orgânicos são caros e o uso de antibióticos e ionóforos estão sendo proibidos na União Europeia e no Japão. Deste modo, várias pesquisas estão sendo realizadas para viabilizar o uso de novas substâncias naturais nas dietas de bovinos de alto rendimento.

De acordo com resultados preliminares obtidos por grupos de pesquisa do Departamento de Zootecnia da Universidade Estadual de Maringá, o extrato de própolis poderia ser uma substância interessante a ser adicionada à dieta de bovinos em confinamento uma vez que melhora o desempenho

animal, eficiência alimentar e qualidade da carne. Todavia, a produção em escala do extrato de própolis é limitada pelas características particulares do produto. A própolis apresenta uma variação muito grande em sua composição básica, uma vez que a mesma é dependente da flora local de produção. Desta forma, o produto não apresenta composição homogênea nos diferentes locais de produção. Da mesma forma, sua produção em escala é dificultada porque a mesma não é produzida e replicada em laboratórios, mas depende da produção das colmeias. Apesar dos bons resultados observados com produtos a base de própolis sobre o desempenho animal, modulação ruminal e eficiência alimentar sua produção seria finita para atender a demanda. Assim sendo, outras fontes com melhor posibilidade de atendimento da demanda estão sendo investigados, entre elas os óleos vegetais.

O Brasil, em razão da sua localização geográfica privilegiada, tem flora interessante a ser estudada na alimentação animal. Alguns resultados observados na França, Espanha, Canadá e USA demonstraram que a adição de óleos essenciais à dieta de ruminantes apresenta efeitos semelhantes aos antibióticos e ionóforos

Nosso objetivo nos dois primeiros trabalhos foi estudar a adição de óleos essenciais (óleos de mamona e da casca da castanha de caju) na dieta, a base de glicerina como fonte de energia, de bovinos mestiços, não castrados, com 18 meses de idade, em confinamento sobre o desempenho animal e digestão. No terceiro trabalho o objetivo foi estudar o efeito destes mesmos aditivos sobre qualidade da carne em substituição aos ionóforos. Os animais foram alimentados em duas fases distintas: crescimento e terminação. No período de crescimento foi observado que a adição dos óleos vegetais melhorou o desempenho animal e eficiência alimentar, embora não tenha tido efeito na digestibilidade aparente dos nutrientes. Em ensaio adicional, foram usados os mesmo animais do experimento anterior com uso dos mesmos aditivos sobre o desempenho animal, digestibilidade dos nutrientes e características de carcaça até o peso de abate (470 kg). Como observado no ensaio de crescimento, a adição de óleos vegetais continuaram melhorando o desempenho animal e a eficiência alimentar. Por outro lado, a própolis não alterou o crescimento dos animais, mas na fase de terminação melhorou o desempenho destes. No terceiro trabalho foi observado que as características da carne, a composição química não sofreram efeito dos aditivos. De modo geral, de acordo com os parâmetros

usados, a carne apresentou de forma adequada e satisfatória para atender a demanda do mercado brasileiro e para exportação.

No quarto estudo realizado na Espanha, o objetivo foi estudar a idade de castração (15 dias ou 5 meses), níveis de proteína (13 ou 15%) e a razão lisina/metionia (3.0 ou 3.4) sobre o desempenho animal e qualidade da carne de bovinos holandeses terminados em confinamento e abatidos aos 420 kg de peso vivo. A quantidade de músculo na carcaça e a composição de ácidos graxos monoinsaturados na carne de bovinos holandeses foram maiores quando a dieta continha alto nível de proteína (15%/MS) Por outro lado, um aumento da razão de lisina:metionina na dieta diminuiu a quantidade de ácidos saturados na carne destes bovinos. Em conclusão a idade de castração, níveis de 13 e 15% de proteína e razão 3.0 ou 3.4 de lisina:metionina não alteram o desempenho dos bovinos holandeses, mas os níveis de maiores de proteína e razão maior de Lisina:metionina melhoram a composição de musculo da carcaça e a quantidade de ácidos graxos da carne.