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Determining the optimal ratio of canola meal and high protein dried distillers grain protein in diets of high producing Holstein dairy cows

N. Swanepoel[a,b,*], P.H. Robinson[b], L.J. Erasmus[a]

[a] Department of Animal and Wildlife Sciences, University of Pretoria, 0001, South Africa
[b] Department of Animal Science, University of California, Davis, CA 95616, USA

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ABSTRACT

Use of canola meal (CM) and dried corn distillers grains with solubles (DDGS) as major supplemental protein sources are common practice in North American dairy rations and usage of both is projected to increase in the future. Since limited data is available on performance of cows fed diets with different ratios of CM and DDGS, our objective was to determine the optimal ratio of CM to DDGS protein in a contemporary lactation dairy ration by feeding combinations of CM and high protein DDG (HPDDG) to early lactation multiparity dairy cows. The experiment was a 4×4 Latin square with 28 d periods using four pens of ~320 high producing cows/pen. Treatments were created by varying the amounts of CM and HPDDG added on a DM basis to be: (1) 0 g/kg CM and 200 g/kg HPDDG, (2) 65 g/kg CM and 135 g/kg HPDDG, (3) 135 g/kg CM and 65 g/kg HPDDG, (4) 200 g/kg CM and 0 g/kg HPDDG. Dry matter intake was not affected by the CM/HPDDG ratio in the ration. Milk and lactose yield, true protein (TP) content and yield, milk fat yield as well as milk energy output increased at a decreasing rate with a higher CM/HPDDG ratio. Maximum values for milk and TP yield were at ~135 g/kg CM, while lactose, TP content and milk energy were maximized at ~120 g/kg CM inclusion. Milk fat content and milk energy density decreased linearly with higher CM inclusion. Body condition score change responded quadratically with the highest gain at ~120 g/kg CM inclusion. The purine derivative to creatinine index increased linearly with higher CM inclusion levels, suggesting that microbial protein production (MCP) was limited in the 0 g/kg CM ration and was progressively stimulated by higher feeding levels of CM. Plasma AA levels suggest that the reduction in lysine in dietary protein, together with the decrease in MCP production, resulted in a substantial reduction in lysine available for milk production, thereby limiting performance in the higher HPDDG ration. The only AA which decreased in plasma with higher CM feeding levels were phenylalanine, leucine and methionine. That the level of leucine in the plasma was still decreasing linearly, while methionine and phenylalanine responded quadratically at the 200 g/kg CM treatment, was interpreted to suggest that the leucine supply remained higher than its requirement at the highest CM

Abbreviations: AA, amino acids; ADF, acid detergent fiber; ADICP, AD insoluble CP; AL, allantoin; aNDF, amylase-treated NDF; aNDFom, aNDF free of residual ash; AP, absorbable protein; BCS, body condition score; BUN, blood urea N; BW, body weight; CM, canola meal; CP, crude protein; CR, creatinine; DC305, DairyComp 305 management system; DDGS, dried distillers grains with solubles; DHIA, Dairy Herd Improvement Association; DIM, days in milk; DM, dry matter; EAA, essential AA; HPDDG, high protein DDG; MCP, microbial CP; NDF, neutral detergent fiber; NE_L, net energy for lactation; OM, organic matter; PD, purine derivatives; PDC index, PD to creatinine index; RDP, rumen degradable CP; RUP, rumen undegradable CP; SCC, somatic cell counts; TMR, total mixed ration; TP, true protein.

* Corresponding author at: University of California, 2251 Meyer Hall, Davis, CA 95616, USA. Tel.: +1 530 752 7076; mobile: +27 79 891 8920.
E-mail address: nanswanepoel@gmail.com (N. Swanepoel).

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inclusion level, but that phenylalanine and/or methionine was limiting production in the highest CM ration. Overall, results suggest that the optimum ratio of CM to HPDDG in these diets was with 120–135 g/kg of diet DM from CM.

1. Introduction

Protein nutrition is critical for high production efficiency of lactating dairy cows because it impacts their performance and the environment. Sufficient dietary protein is required to optimize production while an excess has negative effects on the environment, primarily when excreted as urea in urine. The major protein sources used in western areas of North America include high quality alfalfa hay, whole cottonseed or cottonseed meal, dried distillers grains with solubles (DDGS) and canola meal (CM). Due to the variable quality and high price of alfalfa hay, and the presence of secondary compounds (*i.e.*, tannins and gossypol) in cottonseed, their inclusion levels in dairy rations are limited. Therefore, use of CM and DDGS as major supplemental protein sources is currently very high in many US dairy rations.

The Canola Council of Canada developed an initiative (Growing Great 2015) which aims to double 2011 production of CM by 2015 through increased crushing capacity in Canada (Canola Council of Canada Annual Reports, 2010, 2011). The USA is the main market for CM exports from Canada, receiving over 50% of their total CM exports with over 90% of this imported CM being utilized by the California dairy industry (USDA, 2011; Nernberg, 2012). Due to steadily increasing crude oil prices, the corn ethanol production industry in the Midwestern USA has been expanding rapidly since 2000, and increased production of corn distiller's grains, the major by-product of the corn–starch ethanol industry, is projected to continue in coming years, at least as long as government subsidies persist (Wisner, 2010). As supplies of CM and DDGS increase, so will pressure to use these products as major protein supplements in dairy cattle rations. However, with as much as 400 g/kg of the crude protein (CP) in contemporary California total mixed ration (TMR) already coming from corn products, which is known to be limiting for milk protein synthesis in some amino acids (AA), particularly lysine, inclusion of even more corn DDGS protein could have a detrimental effect on production due to AA imbalances at the intestinal absorptive site, as well as by adding excess corn oil to already corn oil rich rations.

Studies comparing CM to DDGS have reported that higher proportions of CM, included at up to 66 and 120 g/kg DM respectively, tended to have higher absolute values for milk and protein yields (Mulrooney et al., 2009). However, negative effects of high levels of unsaturated fatty acids in corn oil on milk production, often reducing milk fat concentration and yield (Hollmann et al., 2011; Liu and Rosentrater, 2011), necessitates use of a low oil alternative to conventional DDGS when experimentally comparing dietary protein sources involving corn based DDGS. High protein DDG products (HPDDG) provide the opportunity to do this as they have a very similar proximate nutrient profile to CM (Table 1). Christen et al. (2010)

Table 1
Chemical analysis (+ standard errors[a]) of ingredients used in the total mixed rations (g/kg dry matter) fed to cows.

	Dry matter	Organic matter	Crude protein	aNDF[b]	aNDFom[c]	Fat
Alfalfa, hay	912	889	195	391	380	20.6
	(1.1)	(3.4)	(2.8)	(10.1)	(10.7)	(0.98)
Almond, hulls	981	928	48.9	332	319	24.3
	(0.8)	(2.4)	(2.74)	(21.4)	(18.5)	(0.61)
Oat, hay	918	890	109	560	542	24.3
	(0.6)	(3.6)	(6.1)	(3.2)	(2.4)	(0.75)
Corn, steam flaked grain	857	986	84.4	85.0	84.5	34.6
	(5.3)	(0.3)	(1.11)	(2.86)	(3.12)	(1.17)
Cottonseed, cracked Pima	915	953	218	403	385	223
	(3.4)	(0.8)	(9.8)	(8.9)	(8.1)	(3.2)
Canola meal, pellets (380 g/kg CP, solvent)	893	924	410	271	237	26.4
	(5.1)	(1.0)	(2.3)	(5.3)	(7.6)	(1.54)
Distillers grains, high CP (corn with solubles)	915	978	395	338	331	54.5
	(1.9)	(7.1)	(6.1)	(30.0)	(29.3)	(2.18)
Wheat, silage	321	881	82.2	537	495	29.4
	(6.4)	(1.5)	(6.34)	(8.4)	(6.5)	(0.87)
Corn, silage	331	926	80.0	459	447	24.8
	(5.4)	(4.4)	(1.87)	(5.8)	(4.5)	(1.42)
Citrus, pulp	158	954	72.1	189	185	15.7
	(4.3)	(3.5)	(3.56)	(10.8)	(9.3)	(0.90)
Potatoes, tubers (whole)	197	955	79.8	57.0	55.0	<2.5
	(3.7)	(2.1)	(4.22)	(2.00)	(1.30)	(–)
Pomegranate, pulp waste	251	955	99.2	301	293	59.5
	(19.0)	(2.3)	(17.97)	(46.5)	(46.3)	(11.13)

[a] Means and (SE) with a 95% confidence level. $n = 4$, except citrus pulp = 3, potatoes = 2, pomegranate = 2.
[b] Neutral detergent fiber assayed with heat stable amylase, expressed inclusive of residual ash.
[c] Neutral detergent fiber assayed with heat stable amylase, expressed exclusive of residual ash.