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Impacts of increasing levels of canola meal in diets of high producing Holstein cows on their productive performance

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ABSTRACT

Ingredient substitution studies are common in the animal science literature. However such studies often confound changes of ingredient and nutrient levels, thereby begging the question as to whether responses measured among diets represent known differences among diets in measured nutrient levels, or to changes in unknown dietary factors/nutrients. Our objective was to determine if formulating diets to contain the same levels of nutrients, concomitant with increasing the dietary canola meal (CM) level from 50 to 170 g/kg of diet dry matter (DM), while mainly reducing levels of distillers dried grains (DDG), would result in dissimilar performance by lactating dairy cattle – thereby suggesting nutritional factors/nutrients of CM and/or DDG exist which are not known and so not included in diet formulation. This differs from Swanepoel et al. (2014; Anim. Feed Sci. Technol. 189, 41–53) wherein increasing levels of CM were confounded with modest changes in dietary levels of some proximate nutrients. The experiment was a 4 × 4 Latin square using 4 pens of about 315 early lactation multiparous cows/pen with four 21 day periods. The DM intake was not affected (30.0 ± 0.09 kg/d) by increased dietary levels of CM, but milk, milk lactose and milk energy outputs all declined ($P < 0.01$) linearly, as did milk somatic cell counts. Change in body condition score (BCS) declined linearly ($P < 0.01$), with a quadratic component ($P < 0.01$), suggesting maximum BCS gain at about 80 g/kg CM inclusion. Plasma concentrations of most essential amino acids increased linearly ($P < 0.01$) with higher dietary levels of CM – exceptions being Met and Phe (unaffected) and Leu (declined). As a result of lower milk energy output and lower accretion of energy in BCS gain, as well as similar DM intake, estimated net energy for lactation (NE_l) of the diet declined linearly as inclusion of CM increased. While our objective of creating diets with no changes in dietary nutrient levels and biological measures was mainly met, there was an unexpected linear ($P < 0.01$) decrease of 6.3 g/kg DM in the crude fat level of the diets concomitant with the increase in CM inclusion. However the calculated decrease of diet NE_l as a direct result of this difference in diet crude fat only accounted for about 40% of the decline in the estimated NE_l density of the diet (*i.e.,* 0.08 MJ/kg DM of NE_l *versus* the actual decline of 0.21 MJ/kg DM of NE_l). This suggests that if the diets had achieved equal fat levels, as well as other nutrients, concomitant with increasing levels of CM, that NE_l output of the cows would have still declined. Thus diets formulated with 170 g/kg of CM in diet DM (from 50 g/kg DM of CM) in substitution for primarily corn based DDG, but with equal levels of primary nutrients, resulted in a small reduction in performance of

Abbreviations: AA, amino acid; ADF, acid detergent fiber; ADICP, acid detergent insoluble CP; AL, allantoin; aNDF, amylase-treated NDF with residual ash; BCP, bacterial CP; BCS, body condition score; CM, canola meal; CP, crude protein; DDGS, dried distillers grains with solubles; DIM, days in milk; DIP, degraded intake protein; EE, ether extract; DM, dry matter; HPDDG, high protein DDG; LSD, least square difference; MCP, microbial CP; MP, metabolizable protein; ND, neutral detergent; NDF, ND fiber (in general); NE_L, net energy (NE) for lactation; OM, organic matter; RDP, ruminally degraded CP; SBM, soybean meal; SCC, somatic cell count; TMR, total mixed ration; UDP, ruminally undegraded CP; UIP, undegraded intake protein

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lactating dairy cows for reasons which are unknown, but may relate to lower conversion of digestible to metabolizable energy of the soluble carbohydrate fraction of CM *versus* DDG.

1. Introduction

High production efficiency of lactating dairy cows is important because it is associated with high performance and reduced environmental impacts per unit milk produced. While differences among protein sources in their susceptibility to degradation in the rumen, and the amino acid (AA) profiles of the fraction escaping the rumen intact, are well understood conceptually, it has long been unclear if such differences can be reliably predicted quantitatively and if those fractions really matter. For example, Santos et al. (1998) evaluated numerous studies where the proportion of dietary RDP (ruminally degraded protein) to UDP (ruminally undegraded protein) differed, and concluded that the dietary RDP/UDP ratio had little value in predicting performance or efficiency of lactating dairy cows. It seems likely that this reflects a trade-off in that, as the RDP/UDP ratio rises, there is more microbial crude protein (MCP) produced thereby countering the decline in UDP, whereas when the RDP/UDP ratio declines there is less MCP produced, which is countered by more UDP. Indeed this was demonstrated by Robinson et al. (1994) where diets with dramatically different RDP/UDP ratios resulted in similar total protein flow to the small intestine, and animal performance, even though the bacterial CP (BCP) to dietary protein ratio varied dramatically. Indeed Lebzien and Voigt (1999) later found that: "… prediction of utilizable crude protein at the duodenum by regression with digested organic matter and undegraded feed protein as predicting variables, was more accurate than the value given by microbial protein synthesis and rumen protein degradability.". It is also notable that in the almost 20 years since Santos et al. (1998), no publication has challenged their findings, even though the importance of RDP and UDP in formulation of rations for dairy cattle has become near dogma, at least in North America.

Yet in spite of the RDP/UDP findings of Santos et al. (1998), it seems clear that dairy cattle performance can be impacted by changing the levels of protein meals in their diet. In four studies with Holstein cows (Piepenbrink et al., 1998; Brito and Broderick, 2007; Christen et al., 2010; Oba et al., 2010) where soybean meal (SBM) was substituted by canola meal (CM) at levels of CM ranging from 98 to 161 g/kg of diet dry matter (DM), this changed net energy for lactation (NE_l) output of the cows by −2.9, 2.2, −1.2 and −5.4% respectively (average: −1.8%). In contrast, in four studies with Holstein cows (Christen et al., 2010 (2 comparisons); Oba et al., 2010; Swanepoel et al., 2014) where high protein distillers dried grains (HPDDG) or distillers dried grains with solubles (DDGS) was substituted by CM at levels ranging from 127 to 130 g/kg of diet DM, this changed NE_l output of the cows by 0.8, 0.2, 6.2 and 6.1% respectively (average: +3.3%). In these studies all authors were largely successful in maintaining pairs of diets with very similar levels of CP, ash and ether extract (EE), yet in all four SBM to CM substitutions the diet neutral detergent fiber (NDF) level was higher with CM inclusion, whereas in all four DDG to CM substitutions the diet NDF level was lower with CM inclusion. While interpreting ingredient substitution studies is often fraught with peril, this begs the question as to whether the responses measured by these authors had anything to do with protein characteristics and/or quality of the protein meals, and everything to do with differences in the NE_l densities of the diets, likely driven largely by changes in the dietary NDF levels, between treatments.

The main protein sources used in contemporary dairy rations in western areas of North America are CM and DDGS. Due to the continuing increase in CM production in Western Canada (Canola Council of Canada Annual Report, 2016), so will the pressure to use more CM as a protein meal in dairy cattle rations. However Swanepoel et al. (2014) showed that dairy cattle performance declined as the proportion of CM in the ration exceeded about 130 g/kg DM in contemporary California total mixed rations (TMR), while to meet full protein needs (*i.e.,* no need to feed any DDGS) would require about 200 g/kg of diet DM to be CM.

The objective was to determine if formulating diets to contain the same levels of proximate nutrients, while increasing the CM level of the diet from 50 to 170 g/kg of DM in replacement of DDG, would result in dissimilar performance by lactating dairy cows thereby suggesting that there are unknown nutritional aspects of CM and/or DDG which are not included in diet formulation. This study differs from a previous study (Swanepoel et al., 2014), wherein increasing levels of CM were confounded with modest changes in dietary levels of aNDF, acid detergent insoluble CP (ADICP) and non-fiber carbohydrate levels due to unit/unit substitution of HPDDG for CM. However in the current study ration formulation used principles used in practice, which allowed levels of other ingredients to change slightly among diets in order to maintain equality in the levels of nutrients among the diets.

2. Materials and methods

The experimental design was a 'Williams' *(i.e.,* where every treatment follows every treatment) 4 × 4 Latin square, with 4 pens of about 315 early lactation cows/pen in four 21 day experimental periods, such that each treatment followed each other treatment once. The study took place during winter (28 October 2016–19 January 2017) with temperatures between −2.5 and 18.5 °C and humidity between 31 and 100%. All cows were cared for relative to applicable laws of the state of California and the USA.

2.1. Research site and management

The commercial dairy farm selected near Hanford (CA, USA) was the same as used in Swanepoel et al. (2015), and was specifically selected for management and pen structures required to support this type of study. As per normal farm practices, cows were randomly allocated each week to one of four early lactation multiparity pens of dairy cows from a single fresh cow pen and, once confirmed