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Feeding canola meal to dairy cows: A meta-analysis on lactational responses

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ABSTRACT

The objective of this meta-analysis was to determine the effects of the substitution of a protein source by canola meal (CM) on lactational responses (CM minus control) in dairy cows. The study included 49 comparisons of isonitrogenous (±1.0% dietary CP content) dietary treatments published since 1975 (27 experiments). The CM intake ranged from 1.0 to 4.0 kg/d (standard deviation = 0.65). Regressions were forced through the origin, weighted by sample size, and controlled for changes in dry matter intake and in dietary concentrations of CP and ether extract. Milk yield and milk protein yield responded positively to the substitution of a protein source by CM. The response in milk protein yield was affected by the type of protein source that was substituted; the positive response was half less when CM was substituted for soybean meal compared with substitution of CM for other protein sources. The latter effect was in part related to a positive response on milk protein percentage when CM replaced protein sources other than soybean meal. The response in efficiency of N utilization (milk N yield/N intake) was positive to the substitution of a protein source by CM. Negative changes in supply of metabolizable protein (MP) estimated from the 2001 National Research Council model were associated with positive responses in milk protein yield with CM substitution, a finding contrary to the expected positive relationship between supply of MP and milk protein yield. In conclusion, a protein supplement can be substituted by CM with positive effects on milk and milk protein production. These data also indicate an underestimation of MP supply associated with CM inclusion in dairy rations using the National Research Council model.
Key words: canola meal, meta-analysis, metabolizable protein, milk

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INTRODUCTION

Cruciferous seeds and plants contain glucosinolates, which can yield breakdown products potentially goitrogenic, hepatotoxic, or pungent (Fenwick, 1982). Goitrogenic compounds reduce the availability of iodine to the animal and diminish the synthesis of thyroxine, which is involved in the hormonal mechanisms of milk production (Grenet and Journet, 1971). A lower grain intake was also reported with diets containing rapeseed meal high in glucosinolate, tannin, or phytate content (Papas et al., 1978; Thomke, 1981). Therefore, this type of rapeseed meal was not considered a suitable feedstuff for livestock (Abbadi and Leckband, 2011).

In 1969, a low-glucosinolate trait was identified in the Polish rapeseed spring variety Bronowski and that discovery started an international backcrossing breeding program to introduce the new trait into high-yielding erucic acid-free rapeseed varieties (Abbadi and Leckband, 2011). A few years later, Canadian plant breeders were able to license the first rapeseed cultivar with low levels of both glucosinolates and erucic acid (Tower; Stefansson and Kondra, 1975). The term canola was coined to specifically identify rapeseed varieties containing less than 2% erucic acid in the oil portion and less than 30 μmol of glucosinolates/g in the meal portion (i.e., double-zero or double-low rapeseed; Bell, 1984; Newkirk, 2009).

Since the mid 1980s, Canadian canola producers have consistently grown more canola in a greater area than ever before (Harker et al., 2012). Consequently, the use of its coproduct, canola meal (**CM**), also increased tremendously as a ruminant feed in Canada (Christensen and McKinnon, 1989) as well as in other countries (Emanuelson, 1989; Tuori, 1992; Huhtanen, 1998; Moss, 2002; Tan et al., 2011). In Western Canada and parts of the United States, CM is the principal source of protein for dairy cow diets because it is readily available and provides a high-quality protein (Hickling, 2008; Mulrooney et al., 2009).

Over the years, many manuscripts have been published comparing lactational performances of dairy cattle obtained with CM and other protein supplements, especially soybean meal (**SBM**). In an extensive review, Hill (1991) concluded that rapeseed meal low in glucosinolates could be used as freely as SBM and that milk production and composition were equally satisfactory from either protein supplement. More recently, Huhtanen et al. (2011) provided evidence that milk production was as good or better and that milk protein secretion was higher with CM compared with SBM in grass silage-based diets. Positive responses in milk protein yield might be related to an improved efficiency of microbial synthesis and reduced ruminal CP degradability, based on the findings of a meta-analysis on omasal studies (Broderick et al., 2010). As suggested by NRC (2001), the estimated supply of MP, either from RUP or microbial protein, is the main factor that determines milk protein secretion in lactating dairy cows.

Therefore, the first objective of this meta-analysis was to evaluate lactational performances when CM substituted another protein source in dairy rations. The second objective was to determine if lactational responses were affected by experimental conditions or factors such as the type of forage in the diet or the protein source that was substituted. A third objective was to evaluate if changes in milk protein yield were in line with changes in estimated supply of MP (NRC, 2001).

MATERIALS AND METHODS

Database

A comprehensive literature review was conducted in October 2011 and updated in February 2012 to track experiments in which CM (or a low-glucosinolate rapeseed meal) was replaced by another protein supplement in dairy cows. A large body of literature was compiled after a thorough search of computerized-stored databases [e.g., Scopus (http://www.scopus.com/home.url), PubMed (http://www.ncbi.nlm.nih.gov/pubmed), and Canola Council database (http://www.canolacouncil.org/research/)]. References in articles and review manuscripts were scrutinized in the search for new articles. The literature search was not limited to studies published in North American journals or to publications in the English language.

Four a priori criteria were used to select eligible studies: (1) N intake reported, (2) isonitrogenous diets [i.e. difference in dietary CP concentration not exceeding 1.0% (DM basis) between the control and the CM diets], (3) no CM in the control diet and a proportion of CM of 0.05 (DM basis) or more in the treated diet, and (4) treated diets with a high proportion of CM in the protein supplement portion of the diet. For the latter criterion, a protein supplement was defined as a concentrate feed with a CP concentration of 20% or more (DM basis) and a high proportion of CM was defined as 0.85 or more (weight basis) or 0.75 or more (N basis). The breakpoint was set at 0.85 to ensure a minimal bias of responses by the complementary protein source in the treated diets.

Among the eligible studies, some were deemed outliers and excluded from the database for the reasons outlined below. The heat-damaged and dark-colored CM used in the study of Fisher and Walsh (1976) was excluded because it depressed the apparent DM digestibility and the lactational performances. Initial milk production was low (i.e., 13.5 kg/cow per day) in the study of Khorasani et al. (1994) and diets had a low CP concentration (i.e., 12.5%) in the study of Munger (1996) compared with the other studies in the database; therefore, these 2 studies were also excluded from the eligible database. The study of Mancuso et al. (2002) had a large gap between its dietary proportion of CM (i.e., 30%) and the upper proportion of CM in the database (i.e., 17.2%; Table 1); therefore, that study was not included in the database. Finally, the urea-based diet (1.9% DM) in Brito and Broderick (2007) reduced DMI and lactational performances compared with other diets based on true protein sources; that urea-based diet was also excluded from the database.

With the exception of Rinne et al. (2006), authors of all eligible manuscripts were contacted to confirm the use of CM before inclusion of the experiment in the database if the glucosinolate concentration of the rapeseed meal was not specified in the article. The final database contained 27 experiments (88 diets) reported in 22 publications using these exclusion criteria: Ingalls and Sharma (1975), Laarveld and Christensen (1976), Sharma et al. (1977), Papas et al. (1978), DePeters and Bath (1986), Robinson and Kennelly (1988), Huhtanen et al. (1991), Macleod (1991), McClean and Laarveld (1991), Tuori (1992), Emanuelson et al. (1993), Huhtanen et al. (1995), Piepenbrink et al. (1998), Dewhurst et al. (1999), Khalili et al. (2001), Shingfield et al. (2001), Vanhatalo et al. (2003), Rinne et al. (2006), Brito and Broderick (2007), Mulrooney et al. (2009), Christen et al. (2010), and Oba et al. (2010).

Rations and Nitrogen Fractions of Canola Meal

Dietary characteristics of rations were estimated using the NRC (2001) model with feed ingredients as similar as possible to those reported in the publications. The chemical composition of each feed ingredient was used when reported [e.g., CP, NDF, ADF, ether extract (**EE**), ash, and N fractions]; otherwise, table values of NRC (2001) were used.

Nitrogen fractions of CM were required to estimate MP supply. The oil extraction process affects the N fractions and the rumen CP degradability of CM. The