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Effect of processing conditions on nutrient disappearance of cold-pressed and hexane-extracted camelina and carinata meals *in vitro*[1]

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SUMMARY

Camelina and carinata are oilseed crops that have recently gained increasing attention as biofuel sources. The meals remaining after oil extraction contain relatively high concentration of protein and, because of this, there is interest in using them in livestock diets. However, the nutritional qualities of these meals are not well defined and may vary with processing conditions. In our experiment, we evaluated meals from cold-pressed and solvent-extracted camelina and carinata meals manufactured using 6 different processing conditions. Estimates of total *in vitro* OM and CP disappearance of each meal were determined according to a modified 2-phase procedure of Tilley and Terry (1963). We detected no differences in CP disappearance of camelina meal manufactured under cold-pressed extraction. In contrast, we noted differences in OM disappearance of camelina and carinata meals which had undergone different cold-press processing conditions. Differences were also observed in OM and CP disappearance of oilseed meals under varied hexane extraction conditions. Our data suggests that hexane extraction produced, on average, meals with greater OM disappearance than cold-pressing, but there were interactions by oilseed type. Hexane extraction performed under a temperature of 80°C for 90 min resulted in camelina meals with the greatest CP disappearance, whereas a temperature of 120°C for 65 min resulted in meals with the lowest CP disappearance.

INTRODUCTION

Camelina *(Camelina sativa*) and carinata (*Brassica carinata*) oilseed meals have been gradually gaining entry into the livestock feed industry as the search for alternate fuel sources has been gaining momentum. These oilseed meals are the byproducts that remain from processes that remove oil from oilseeds for biofuel. Currently, an increased attention has been given to camelina meals because they are not only economically efficient but are good source of protein and polyunsaturated fatty acids (Bonjean and Le Goffic, 1999; Hurtaud and Peyraud, 2007). Because of this, camelina meals have been used as part of livestock diets. Carinata oilseed meals have similar nutritional qualities but are not as widely used because of higher glucosinolate content compare to camelina meals. As novel feed resources, our knowledge of how the nutritional qualities of these meals vary with processing conditions is still unknown, therefore, we evaluated *in vitro* nutrient disappearance of these oilseed meals under a modified 2-phase procedure of Tilley and Terry (1963). Evaluating feeds *in vitro* is an efficient technique that allows prediction of a feed's ruminal digestibility. Our objectives were to evaluate meals manufactured from cold-pressed and solvent-extracted camelina and carinata seeds under 6 different processing conditions in order to determine the effect of processing condition on OM and CP disappearance. We hypothesize that processing condition affects nutritional quality of oilseed meals.

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MATERIALS AND METHODS

Meals from cold-pressed and hexane-extracted non-food oilseeds (camelina and carinata) obtained from the same source and manufactured using 6 different processing conditions were analyzed for OM and CP disappearance. Cold-pressed extraction conditions evaluated for each meal varied by die nozzle size and screw speed; 0.22 inch at 15 Hz, 0.22 inch at 20 Hz, 0.22 inch at 25 Hz, 0.25 inch at 15 Hz, 0.25 inch at 20 Hz and 0.25 inch at 25 Hz, respectively. Hexane extraction conditions evaluated varied by temperature and duration of extraction: 80 °C for 90 min, 100 °C for 65 min, 100 °C for 90 min, 120 °C for 40 min, 120 °C for 65 min and 120 °C for 90 min, respectively.

Two ruminally cannulated steers accustomed to being fed chopped hay twice daily were used in this study. Ruminal fluid was collected from each steer 4 h after feeding and after 2 h without water and transferred into separate pre-warmed thermos flasks. Evacuated ruminal contents were hand-squeezed and the associated fluid was blended for 1 min and strained through 4 layers of cheesecloth. Filtered ruminal fluid was maintained at 39°C under a constant flow of CO_2. Ruminal fluid (50 mL) from each steer was transferred to separate *in vitro* tubes in duplicate, each containing 4 g of the sample to be evaluated and 150 mL of degassed McDougall's buffer without urea. *In vitro* tubes were flushed with CO_2, capped with lids equipped with a vent to allow release of gases, and incubated for 48 h. After 48 h of incubation, *in vitro* tubes were removed from the incubator and placed in an ice bath to stop fermentation, followed by centrifugation at 2,000 x g for 15 min, after which supernatant was suctioned off. Pepsin solution (140 mL) was added to each tube and incubated for 48 h at 39 °C. *In vitro* tubes were again centrifuged for 15 min at 2,000 x g and supernatant suctioned off. Samples were lyophilized, placed into desiccator overnight and weighed to determine DM disappearance. A 0.5 g was sampled for ash determination to calculate OM disappearance. Residue of each *in vitro* tube was also analyzed for N by combustion analysis using Elementar Rapid N III for determination of CP disappearance.

All analyses were conducted at the South Dakota State University ruminant nutrition laboratory.

Statistical analysis

All data were analyzed using the PROC MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Initially, effects of processing condition on *in vitro* OM and CP disappearance were analyzed with a model that included oilseed and processing condition and the interactions between them. A second analysis was conducted separately for each extraction method using a model that included oilseed and processing conditions. Steer was considered a random effect in all models. Differences were considered significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

Hexane extraction processing conditions produced the greatest mean CP and OM disappearance in both oilseed types ($P < 0.05$). Carinata meal had greater CP and OM disappearance than camelina meal ($P < 0.05$). However, we observed an interaction ($P < 0.05$) between oilseeds and processing condition for both OM and CP disappearance.

Hexane extraction processing conditions

Differences in CP and OM disappearance in both oilseed types due to hexane extraction processing conditions were noted (Table 1). We observed difference in OM disappearance of camelina meal between hexane extraction processing condition of 120°C for 65 min and 120°C 90 min but the 120°C for 65 min processing condition was, however, not significantly different from any other processing conditions.

Hexane extraction performed under 80°C for 90 min produced camelina meal with the greatest CP disappearance, whereas a temperature of 120°C for 65 min resulted in meals with the least CP disappearance. Hexane extraction performed under temperature and time combinations of 100°C for 65 min, 100°C for 90 min, 120°C for 40 min and 120°C for 90 min, however, did not differ in CP disappearance.

We noted no difference in OM disappearance of hexane extracted carinata meal between 80°C for 90 min and 100°C for 65 min. Similarly, processing condition at 100°C for 90 min resulted in OM disappearance of hexane extracted carinata meal that only compares with processing at 120°C for 65 min. Similar OM disappearance of hexane extracted carinata meal was observed between processing at 120°C for 90 min and 120°C for 40 min.

Crude protein disappearance of carinata meal manufactured under a hexane extraction processing temperature of 100°C for 90 min was significantly greater than all other hexane processing conditions except processing at 120°C for 65 min. Disappearance of CP of carinata meals manufactured at a temperature of 120°C for 65 min also did not differ from that produced at 100°C for 65 min and 120°C for 40 min, as well. No difference in the CP disappearance of hexane extracted carinata meals was observed among meals manufactured under 80°C for 90 min, 100°C for 65 min, 120°C for 40 min and 120°C for 90 min.

Cold-press processing conditions

Organic matter disappearance of cold pressed camelina meal observed under a die nozzle of 0.22 inch and screw speed of 20 Hz was significantly greater than that of 0.25 inch die nozzle and either a 20 or 25 Hz screw speed (Table 2). No significant differences in the OM disappearance of cold-pressed camelina meal were, however, detected when processing conditions of die nozzle and screw size of 0.22 inch at 15 Hz, 0.22 inch at 20 Hz, 0.22 inch at 25Hz and 0.25 inch at 15 Hz, respectively were used. A die nozzle of 0.25 inch with a screw speed of 25 Hz resulted in the lowest OM disappearance of cold pressed camelina meal. No significant differences in CP disappearance among cold-pressed camelina meals were noted.

Cold-pressed extraction performed under a die nozzle and screw size of 0.22 inch at 15 Hz resulted in the greatest OM disappearance of carinata meal, whereas a die nozzle and screw speed of 0.22 inch at 20Hz or 0.25 inch at either or 25 Hz and resulted in meals with the lowest OM disappearance. No significant differences in OM disappearance of carinata meals manufactured under cold-pressed processing conditions of 0.22 inch at 25 Hz and 0.25 inch at 15Hz were noted.

Crude protein disappearance was not different when cold-pressed carinata meals were manufactured under a die nozzle and screw speed of 0.22 inch at 20 Hz or 0.25 inch at 25 Hz. Observed CP disappearance among these 2 processing conditions, however, differed from 0.22 inch at 15 Hz. Crude protein disappearance of carinata meals manufactured under cold-pressed processing conditions of 0.22 inch at 15 Hz, and 0.22 inch at 25 Hz and 0.25 inch at 15 Hz were similar. Observed CP disappearance of carinata meal processed under a processing condition of 0.22 inch at 15 Hz was, however, significantly greater than carinata meal manufactured under a processing condition of 0.25 inch at 20 Hz.

Implications

Our data suggest that hexane extraction performed under a temperature of 80°C for 90 min will result in camelina meals with the greatest CP disappearance, whereas a temperature of 120°C for 65 min will results in camelina meal with the lowest CP disappearance. Cold-press processing pressure had no effect on CP disappearance of camelina meal but differences were observed for carinata meals. A die nozzle and a screw speed of 0.22 inch at 15Hz will lead to the greatest OM disappearance and one of the greatest CP disappearances for carinata meal. Given that there were limited differences in OM disappearance and no difference in CP of cold-pressed camelina, cost involved as well as other factors such as oil quality and quantity extracted should be considered when choosing between processing camelina oilseeds under a die nozzle and screw sizes of 0.22 inch at 15 Hz, 0.22 inch at 20 Hz, 0.22 inch at 25 Hz, or 0.25 inch at 15 Hz. The same consideration should be applied in choosing between processing carinata oilseed meals at 100°C for 90 min or 120°C for 65 min.

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Table 1. Effect of temperature and time during hexane extraction of camelina and carinata seeds on organic matter (OM) and crude protein (CP) disappearance of their meals *in vitro*.

Oilseed	**Processing Temperatures**						SE
	80°C 90 min	**100°C 65min**	**100°C 90 min**	**120°C 40 min**	**120°C 65 min**	**120°C 90 min**	
	------------------------Disappearance, %-------------------------------						
Camelina							
OM	65.7^{ab}	65.8^{ab}	65.8^{ab}	65.5^{ab}	64.0^{b}	67.5^{a}	1.19
CP	82.4^{a}	79.6^{b}	78.8^{b}	79.7^{b}	76.4^{c}	79.0^{b}	0.78
Carinata							
OM	78.4^{d}	78.6^{d}	86.8^{a}	84.0^{bc}	85.5^{ab}	82.5^{c}	1.19
CP	87.5^{c}	87.9^{bc}	91.5^{a}	88.6^{bc}	89.7^{ab}	86.7^{c}	0.78

Means with differing superscript are significantly different from each other (P < 0.05).

Table 2. Effect of pressure during cold-press extraction of camelina and carinata seeds on organic matter (OM) and crude protein (CP) disappearance of their meals *in vitro*.

Oilseed	**Processing Pressure**						**SE**
	0.22inch 15Hz	**0.22inch 20Hz**	**0.22inch 25Hz**	**0.25inch 15Hz**	**0.25inch 20Hz**	**0.25inch 25Hz**	
	-------------------------------Disappearance, %----------------------------						
Camelina							
OM	66.1^{ab}	67.5^{a}	66.0^{ab}	65.9^{ab}	65.1^{b}	63.2^{c}	0.97
CP	81.2	82.7	81.6	82.5	81.2	81.7	0.75
Carinata							
OM	79.1^{a}	72.4^{c}	75.3^{b}	75.7^{b}	72.2^{c}	73.2^{c}	0.97
CP	89.9^{a}	85.2^{c}	87.8^{ab}	88.1^{ab}	87.7^{b}	87.0^{bc}	0.75

Means with differing superscript are significantly different from each other (P < 0.05).
SE is the largest SE observed for that treatment.