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CRAMBE MEAL AS A SOURCE OF SUPPLEMENTAL PROTEIN FOR GROWING-FINISHING BEEF CATTLE[1,2]

T. W. Perry[3], W. F. Kwolek[4], H. L. Tookey[4], L. H. Princen[4], W. M. Beeson[3] and M. T. Mohler[3]

Purdue University, West Lafayette, IN 47907 and Northern Regional Research Center, Agricultural Research Service, United States Department of Agriculture, Peoria, IL 61604

SUMMARY

A series of four experiments were conducted with growing beef cattle to evaluate crambe (*Crambe abyssinica*) seed meal as a source of supplemental protein. The crambe meal contained hulls and from 25 to 31% protein. In two of the experiments, nonsignificant increases in gain were associated with additions of good quality crambe meal. In the other two experiments where nonsignificant decreases in gain were obtained, the crambe meals were of lower quality as indicated by analytical data and lower apparent acceptability to the cattle.

In one of the experiments, cattle fed higher levels of crambe meal required less ($P<.05$) feed per kilogram gain.

(*Key Words:* Crambe Meal, Beef Cattle, Protein.)

INTRODUCTION

Crambe (*Crambe abyssinica*) is a member of the crucifer plant family. All species of Cruciferae examined contain one or more glucosinolates which are precursors of isothiocyanates, thiocyanates, organic nitriles or goitrins (Daxenbichler *et al.*, 1965; VanEtten *et al.*, 1969). Crambe seed contains the glucosinolate *epi*-progoitrin, a stereoisomer of progoitrin found in rapeseed (Tallent, 1972) in amounts that are not desirable for feed for all animals. *Epi*-Progoitrin in the absence of hydrolytic enzyme is relatively nontoxic (VanEtten *et al.*, 1969). Goitrin leads to enlarged thyroids particularly in monogastric animals but is less toxic than the nitrile (VanEtten *et al.*, 1969; VanEtten, 1969). A good quality crambe meal contains a high amount of unhydrolyzed *epi*-progoitrin, no enzyme and a low amount of nitrile (table 1). Nitrogen extracted by .5 M NaCl should be high if the protein has not been heat-damaged during processing.

Hesketh *et al.* (1963) reported increased thyroid weights in chicks fed crambe meal, indicating a goitrogenic effect, but Lambert *et al.* (1970) showed no such effect in cattle. Lambert *et al.* (1970) reported some acceptability problems with cattle offered crambe-supplemented diets and reported poorer performance of cattle fed diets in which crambe meal was the total source of supplemental protein.

VanEtten *et al.* (1977) demonstrated no detectable residues in tissues of beef cattle fed up to 10% dehulled crambe meal in their diet. Samples of kidney, liver, fat and muscle contained no *epi*-progoitrin, unsaturated nitrile or goitrin by a method sensitive to 1 ppm.

The objective of the research reported herein was to study further the potential of crambe meal as a source of supplemental protein for growing and finishing beef cattle.

EXPERIMENTAL PROCEDURE

A series of four feeding trials were conducted with growing-finishing beef cattle in which crambe meal was tested as a source of supplemental protein. Composition of the crambe meals is shown in table 1. Each trial was a minimum of 150 days duration, after which all cattle were withdrawn from crambe treatments for a minimum of 60 days prior to marketing.

Experiment I. Eight lots of six Hereford steer calves, averaging 280 kg initially, were fed a 10.3% protein high-energy diet (table 2). Replicated

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[3]Purdue University, Department of Animal Sciences.

[4]Agricultural Research Service, USDA, Peoria, IL 61604. The authors thank K. D. Carlson, J. F. Cavins, M. E. Daxenbichler, C. C. Mustakas, W. H. Tallent and G. H. VanEtten for their assistance in various phases of this study.

TABLE 1. ANALYSES OF CRAMBE MEALS, PERCENTAGE OF AIR-DRY

Component	Exp. 1[a]	Exp. 2[b]	Exp. 3[c]	Exp. 4[d]
Crude protein	27	31	28	25
Crude fiber	25	21	24	22
Ash	8.0	7.2	6.2	7.5
Fat	3.8	3.8	4.0	2.1
Moisture	11.0	8.3	6.0	7.6
Enzyme hydrolyzing *epi*-PG[e]	None	None	None	None
Epi-PG	1.1	3.7	1.9	1.6
Goitrin [f]	0	.1	0	0
Nitrile (l-cyano-2-hydroxy-3-butene)[f]	1.5	.6	1.4	1.4
Nitrogen extracted, .5 M NaCl[g]	0	72	36	50

[a]Prepress solvent-extracted meal prepared from seed partially heat-damaged during storage. Meal was darker in color than other three meals.
[b]Solvent-extracted meal.
[c]Prepress solvent-extracted meal from seed containing 3% white mustard (*Brassica hirta*).
[d]Prepress solvent-extracted meal.
[e]*Epi*-Progoitrin.
[f]Calculated as *epi*-progoitrin.
[g]Percentage of total nitrogen; a measure of protein solubility.

TABLE 2. EFFECT OF REPLACEMENT OF SOYBEAN MEAL WITH CRAMBE MEAL ON FEEDLOT PERFORMANCE OF BEEF CATTLE. EXPERIMENT I. (1972 to 1973). 152 DAYS

	Lot no.				
	I, V	II, VI	III, VII	IV, VIII	
Level of soybean meal, %	7.5	5.0	2.5	0	
Level of crambe meal, %	0	4.2	8.4	12.6	SEM[c]
No. of lots	2	2	2	2	
No. of cattle	12	12	12	12	
Avg initial weight, kg	281	280	279	280	
Avg final weight, kg	448	444	439	421	
Avg gain per animal, kg	167	164	160	141	
Avg daily gain[a]					
First 56 days, kg	1.08	1.03	1.00	.96	.05
Total 152 days, kg	1.10	1.08	1.05	.93	.06
Daily feed consumption, kg[a]	8.3	8.0	7.8	7.4	
Feed per 100 kg gain, kg[a]	758	539	742	800	38
Composition of diets (air-dry basis), %					
Ground shelled corn (corn, yellow, grain, grnd (4) Ref. No. 4-02-992)	70.7	70.7	70.7	70.7	
Ground corn cobs (corn cobs, grnd (1) Ref. No. 1-02-782)	17.7	16.0	14.3	12.6	
Soybean meal (soybean seeds, solv. extd. grnd. (5) Ref. No. 5-04-605)	7.5	5.0	2.5	0	
Crambe (crambe, seeds with hulls, prepress solv. extd., grnd., Ref. No. 5-08-167)	0	4.2	8.4	12.6	
Additional ingredients[b]	4.1	4.1	4.1	4.1	

[a]The supplements were pelleted for cattle in lots I, II, III and IV and unpelleted for cattle in treatment replicate lots V, VI, VII and VIII. Comparative daily gains were 1.08 *vs* 1.01 kg; daily feed consumption was 7.83 *vs* 7.98 kg per day; feed conversion efficiencies were 728 *vs* 791 kg feed per 100 kg gain, respectively, for cattle fed pelleted supplement *vs* those fed unpelleted supplement.

[b]Cane molasses (sugar cane, molasses, mn 48% invert sugar (4) Ref. No. 4-04-696) 1.6%; dehydrated alfalfa meal (alfalfa, aerial part, dehy, grnd. (1) Ref. No. 1-00-025) 1.6%; dicalcium phosphate .7%; iodized salt .2%; vitamin A 3,300 IU per kg.)

[c]Standard error of the mean based on two lots per treatment.

treatments consisted of replacing 1/3, 2/3 or all of the soybean meal with the protein equivalent of crambe meal. Adjustments in levels of ground shelled corn and ground corn cobs were necessary among treatment formulations in order to maintain comparable crude fiber levels (table 2). The supplements (all of the diet except ground shelled corn and ground corn cobs) were pelleted for one replicate of treatment lots and unpelleted in the other replicate.

The duration of the trial was 152 days; and since a withdrawal from treatment of 60 days followed, no attempt was made to study treatment effect on carcass quality.

Experiments II and III. Treatments were comparable in these two experiments. A control, 9% protein diet utilizing urea was formulated to be protein-borderline. Three levels of added crambe were compared in diets formulated to contain 9.6, 10.3 and 11% crude protein. Each experiment consisted of eight lots of six cattle each, with two lots of cattle assigned to each of the four treatments. In experiment II, 48 Hereford steer calves averaging 215 kg initially were utilized in a 182-day study. In experiment III, the 48 Hereford steer calves weighed 243 kg initially and the length of the comparison was 159 days.

Experiment IV. Twelve lots of six Hereford steer calves averaging 217 kg at the start were used in this 153-day experiment. Five lots of cattle were fed the 9% protein control diet, five lots were fed a 10.3% protein diet in which crambe meal was used for the added protein, and two lots were fed a 10.3% protein diet in which soybean meal was used as the source of added protein. The crambe meal contained 25% protein and 22% crude fiber.

Average daily gains per animal and feed per kg gain were examined by analysis of variance. Significance of treatment differences was tested at the 95% level. Variation among pen means provided the basis for testing treatment differences.

RESULTS AND DISCUSSION

Crambe meal was evaluated as a source of supplemental protein for growing beef cattle in a basic diet containing 17 to 18% corn cobs and 71 to 78% ground shelled corn and fortified with minerals and vitamin A. The crambe meals contained 25 to 31% protein and 22 to 26% crude fiber, the latter derived largely from hull material.

In experiment I, crambe meal was substituted for soybean meal and ground corn cobs to maintain a 10.3% protein level and a constant crude fiber level. At the highest level of crambe meal (12.6% of the diet), there was nonsignificant 15% depression in rate of gain and a 5.5% reduction in efficiency of feed conversion (table 2).

In this experiment, as well as the other three, daily gain for the respective treatments is listed for the first 55 or 56 days to show whether an early response in gain might have differed from the total response. The early gain data are quite similar to the overall gain data for all four of the trials. Apparent lowered feed consumption with increasing levels of crambe suggests less acceptability of crambe-containing diets, which is in agreement with the report of Lambert *et al.* (1970). The crambe meal fed in this experiment contained less *epi*-progoitrin and more nitrile than the other meals and was, therefore, of poorer quality. In one replication for each treatment, the supplement was pelleted. The effect of pelleting the supplement was not statistically significant (see table 2) but suggested that pelleting was desirable. The supplements were pelleted for the remaining experiments.

Experiments II and III were designed to study the value of added crambe to a low protein diet containing 9% protein (NRC, 1976). In experiment II, adding 2.5 and 5.4% crambe meal to raise the total protein to 9.6 and 10.3%, respectively, resulted in nonsignificant increases in rate of gain; the addition of 8.3% crambe to make an 11% protein diet did not result in additional gain (table 3). Increasing levels of crambe meal resulted in significantly improved feed conversion of 3.6, 9.1 and 12%. In experiment III, the addition of 2.6 to 8.5% crambe meal to a 9% protein diet did not result in either improvement in rate of gain or efficiency of feed conversion (table 4). Thus, the trends of experiments II and III correlated with meal quality. Daily feed consumption was comparable for all treatments in experiment II, but feed consumption tended to decline in ex-

TABLE 3. VALUE OF CRAMBE MEAL AS A SOURCE OF SUPPLEMENTAL PROTEIN FOR GROWING AND FINISHING BEEF CATTLE. EXPERIMENT II. (1973 to 1974). 182 DAYS

	Lot no.				
	I, V	II, VI	III, VII	IV, VIII	
Level of protein, %	9.0	9.6	10.3	11.0	
Level of crambe meal, %	0	2.5	5.4	8.3	SEM[f]
No. of lots	2	2	2	2	
No. of cattle	12	12	12	12	
Avg initial weight, kg	215	216	215	216	
Avg final weight, kg	396	407	420	423	
Avg gain per animal, kg	181	191	205	207	
Avg daily gain					
First 56 days, kg	1.02	1.09	1.12	1.15	.06
Total 182 days, kg	1.00	1.05	1.13	1.14	.07
Daily feed consumption, kg	7.8	7.9	8.0	7.9	
Feed per 100 kg gain, kg	786[a]	757[ab]	714[bc]	691[c]	14
Composition of diets (air-dry basis), %					
Ground shelled corn[d]	77.9	77.3	76.5	75.8	
Ground corn cobs	17.0	15.1	13.0	10.8	
Urea	.4	.4	.4	.4	
Crambe meal	0	2.5	5.4	8.3	
Remainder[e]	4.7	4.7	4.7	4.7	

[a b c]Values on the same line with different superscripts are significantly different ($P<.05$).

[d]For NRC names, see table 2.

[e]Cane molasses, .6%; dehydrated alfalfa meal, 3.2%; dicalcium phosphate, .7%; iodized salt, .2%; vitamin A, 3,300 IU per kg.)

[f]Standard error of the mean based on two lots per treatment.

TABLE 4. VALUE OF CRAMBE MEAL AS A SOURCE OF SUPPLEMENTAL PROTEIN FOR GROWING AND FINISHING BEEF CATTLE. EXPERIMENT III. (1974 to 1975). 159 DAYS

	Lot no.				
	I, V	II, VI	III, VII	IV, VIII	
Level of protein, %	9.0	9.6	10.3	11.0	
Level of crambe meal, %	0	2.6	5.4	8.5	SEM[c]
No. of lots	2	2	2	2	
No. of cattle	12	12	12	12	
Avg initial weight, kg	243	243	243	242	
Avg final weight, kg	396	381	378	380	
Avg gain per animal, kg	153	138	135	138	
Avg daily gain					
First 56 days	1.04	.96	1.01	.97	.05
Total 159 days	.96	.87	.85	.87	.05
Daily feed consumption, kg	7.9	7.7	7.2	7.3	
Feed per 100 kg gain, kg	825	882	844	845	64
Composition of diets (air-dry basis), %					
Ground shelled corn[a]	77.4	76.3	75.4	74.2	
Ground corn cobs	17.0	15.5	13.6	11.7	
Urea	.9	.9	.9	.9	
Crambe meal	0	2.6	5.4	8.5	
Remainder[b]	4.7	4.7	4.7	4.7	

[a]For NRC names, see table 2.
[b]For remainder of ingredients, see footnote b, table 3.
[c]Standard error of the mean based on two lots per treatment.

periment III as the level of crambe meal was increased.

Experiment IV was designed to determine whether crambe meal would fortify a 9% protein cattle diet to a 10.3% protein level as efficiently as soybean meal. Addition of either crambe meal or soybean meal resulted in a nonsignificant increase in rate of gain (7.2%) and improvement in feed conversion (3.7%) (table 5). The crambe meal used in this experiment was of intermediate quality,

TABLE 5. VALUE OF CRAMBE MEAL AS A SOURCE OF SUPPLEMENTAL PROTEIN AND COMPARED WITH SOYBEAN MEAL FOR GROWING AND FINISHING BEEF CATTLE. EXPERIMENT IV. (1976 to 1977). 153 DAYS

	Lot no.			
	I, II, III, IV, V	VI, VII, VIII, IX, X	XI, XII	
Level of protein	9.0	10.3	10.3	
Level of crambe meal	0	5.5	0	
Level of soybean meal	0	0	3.1	SEM[c]
No. of lots	5	5	2	
No. of cattle	30	29	12	
Avg initial weight, kg	216	216	216	
Avg final weight, kg	364	377	374	
Avg gain, kg	148	161	158	
Avg daily gain				
First 55 days	.87	.93	.92	.06
Total 153 days	.97	1.05	1.03	.05
Daily feed consumption, kg	6.9	7.2	7.1	
Feed per 100 kg gain, kg	716	686	692	26
Composition of diets (air-dry basis), %				
Ground shelled corn[a]	77.5	74.8	74.5	
Ground corn cobs	17.0	13.4	16.5	
Urea	.8	.8	.8	
Crambe meal	0	6.3	0	
Soybean meal	0	0	3.5	
Remainder[b]	4.7	4.7	4.7	

[a]For NRC names, see table 2.
[b]For remainder of ingredients, see footnote b, table 3.
[c]Standard error of the mean based on two lots per treatment.

having a high amount of nitrile.

Average daily gains per animal and feed per kilogram gain were examined by analysis of variance. Differences between means were tested by Duncan's procedure (Steel and Torrie). Variation between pen means within each experiment provided the basis for testing differences. For average daily gain, 10% of the variation per animal was attributable to pen variation and the remainder to animal variation. The standard error of the mean average daily gain per pen combining all four experiments was .08 kg.) The standard error per pen for feed per 100 kg gain was 40.

Animal size is an additional factor that may be involved in the acceptability of crambe. In experiments II and IV, the cattle were smaller (younger) and maintained daily feed consumption with increasing amounts of crambe in the diet. In experiments I and III where the animals were larger (older), the daily feed consumption declined with increasing crambe meal. These trends suggest that crambe meal might be more acceptable to smaller (younger) animals.

Overall results of the four experiments show no adverse response to the feeding of crambe meal to finishing beef cattle at 8.5% or less of the diet. Crambe appears to be compatible with the use of urea. The results suggest that if crambe seed is processed for minimal loss of *epi*-progoitrin and minimal heat damage, the resultant meal should be an acceptable cattle feed ingredient.

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