Final Report to the
Fats and Proteins Research Foundation, Inc.

Title of Project: Effects of supplemental fat on growth performance and quality of beef from steers fed corn finishing diets

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Summary

Supplemental fat in finishing diets 1) decreases ruminal fiber fermentation so we may be able to decrease forage in the diet, 2) decreases energy lost as methane which increases diet ME, 3) decreases heat increment which increases diet NE so steers may eat less DM, gain more and be more efficient. However, supplemental fat also alters the fat composition of beef including increasing conjugated linoleic acid content and its effects on beef quality and consumer acceptance is known for barley-fed beef but not corn-fed beef. Therefore, we fed 126 steers a corn-based diet containing 15% potato byproduct with either 3.5 or 7% alfalfa and 0, 3 or 6% yellow grease. Steers DM intake and ADG were not affected by dietary treatment. However, gain-to-feed and diet NE content increased linearly ($P < 0.10$) with increased yellow grease. Increased yellow grease increased carcass fatness, altered muscle fatty acid content which increased beef flavor. Moisture retention, shelf-life, and cooking properties of the beef were not affected. Beef from corn plus yellow grease-fed steers was more tender and had slightly less saturated fatty acid content than of beef from barley plus tallow-fed steers. All the 2.75 billion pounds of yellow grease currently produced (Pearl, 2000) could be fed to finishing cattle if 4% fat were added to finishing diets.

Objectives: Determine effects of fat and forage level on

1) growth performance and
2) appearance, composition and eating quality of beef.

Procedures

One hundred twenty-six crossbred beef steers (321.1 ± 0.57 kg) were vaccinated against *Haemophilus sommus*, blackleg, malignant edema, black disease, enterotoxemia, cytopathic and noncytopathic bovine viral diarrhea, infectious bovine rhinotracheitis virus, parainfluenza-3 virus and bovine respiratory syncytial viruses, treated for parasites with IVOMEC-plus® (MSD-Ag Vet, Rahway, NJ), and implanted. Steers were blocked by weight and randomly assigned within block to a randomized complete block design (Steel and Torrie, 1980) with a 2 x 3 + 1 factorial arrangement of dietary treatments. Main effects were level of alfalfa hay (3.5 or 7%) and level of yellow grease (0, 3 or 6%) in corn-based diets containing 15% potato byproduct. The added treatment was 7% alfalfa and 6% yellow grease in a barley-based diet to be able to compare with our previous study. Diets met the nutrient requirements of the steers (NRC, 1996).

Diet composition

	Yellow grease						
	0		3		6		
	Forage, % DM						
Ingredient	3.5	7	3.5	7	3.5	7	7
	% DM						
Barley[a]							65
Corn[b]	74.5	71	71.5	68	68.5	65	
Potato by-product	15	15	15	15	15	15	15
Yellow grease	0	0	3	3	6	6	6
Supplement[c]	7	7	7	7	7	7	7
Alfalfa hay	3.5	7	3.5	7	3.5	7	7

[a]Steam rolled Baroness cultivar.
[b]Steam rolled Pioneer Hibred cultivar.
[c]Table 1.

Initial steer liveweight was measured on two consecutive days (1 d after 12 h without feed, 1 d without feed restriction). Steers were adapted over a 28 d period to the final finishers. All diets were fed ad libitum once a day. The heaviest weight block was fed for 134 d and the lightest two replicates were fed for 155 d.

Results and Discussion

The composition of the feedstuffs fed (Table 2) were similar to those fed in our previous studies. The yellow grease and tallow contained 0.94 and 0.02% moisture, 0.41 and < 0.01% insoluble matter, 0.32 and 0.44% unsaponifiable matter, and fat advisory committee colors of not darker than 21 and 15, respectively.

Diet digestibilities. On d 116, 117, and 118, level of yellow grease linearly decreased ($P < 0.05$) DMI from 10.6 to 9.2 ± 0.32 kg/d probably due to diet energy content (Table 3). Linear yellow grease x alfalfa hay interactions were detected ($P < 0.05$) for digestibilities of DM, OM, cell solubles, NDF, and hemicellulose due to increased alfalfa hay decreasing digestibility in diets containing yellow grease. This was most likely due to encrusting of fiber and/or decreased gram-positive bacteria in the rumen. Yellow grease was more digestible ($P < 0.01$) than tallow (cell soluble digestibility) but decreased ($P < 0.01$) NDF and hemicellulose digestibility more than tallow did. Level of yellow grease linearly increased ($P < .05$) ADF digestibility and quadratically increased ($P < 0.05$) GE digestibility.

Feedlot performance. Dry matter intake and average daily gain were not affected by diet (Table 4). However, gain to feed (0.175 to 0.188 ± 0.005) and diet NE content increased linearly ($P < 0.10$) as yellow grease increased.

Carcass characteristics. Most carcass characteristics were not affected by diet except kidney, pelvic, and heart fat (2.0 to 2.3 ± 0.07), and yield grade (2.8 to 3.1 ± 0.09) which were increased linearly ($P < 0.05$) as yellow grease increased.

Carcass beef and fat characteristics. Beef color score and beef brightness score were not affected by diet. However, yellow grease fed steers had lower ($P < 0.05$) beef firmness and beef texture scores but greater ($P < 0.01$) fat color score than those fed tallow. Quadratic yellow grease x alfalfa hay interactions ($P < 0.05$) were detected for beef firmness score and fat color score due to very small numeric changes.

Beef characteristics. Moisture retention of beef was not affected by dietary treatment (Table 5) except purge score during retail storage was linearly decreased ($P < 0.01$) by yellow grease from 2.1 to 1.6 ± 0.06. Retail shelf-life (Tables 5 and 6) and cooking measurements (Table 5) were not affected by dietary treatment. Unexplicably, steaks from barley plus tallow-fed steers had greater ($P < 0.05$) shear force than those from steers fed corn plus yellow grease (3.1 vs 2.6 ± 0.14 kg). However, dietary treatment did not affect sensory panel measurements of tenderness, juiciness, or off-flavor. Interestingly, beef flavor increased linearly ($P < 0.05$) from 6.2 to 6.7 ± 0.11 as dietary yellow grease increased suggesting altered fatty acid content. Therefore, dietary yellow grease had positive effects on beef quality.

Longissimus muscle composition. As expected, DM, fat, and total fatty acid content were affected oppositely to DM and all had significant alfalfa hay x yellow grease interactions. These were mainly due to increased fat with increased alfalfa hay with 3% yellow grease. These results agree with the slightly greater energy intake, KPH, and marbling score of steers fed 7% vs 3.5% alfalfa hay and 3% yellow grease. Beef fatty acid content was not substantially altered by dietary treatment. However, trans-vaccenic increased ($P < 0.01$) and oleic decreased ($P < 0.01$) as yellow grease increased. Additionally, beef from barley plus tallow fed steers had less ($P < 0.01$) trans-vaccenic (3.6 vs 9.3 ± 0.72 mol/100 ml) but more ($P < 0.01$) oleic (39.8 vs 34.1 ± 1.1 mol/100 mol) than beef from corn plus yellow grease fed-steers.

Therefore, feeding yellow grease increased diet energy content which increased carcass fatness, altered the muscle fatty acid content which increased beef flavor without affecting moisture retention, shelf-life, or cooking properties of the beef. Additionally, beef from corn plus yellow grease fed-steers was more tender and had more unsaturated fatty acid content than of beef from barley plus tallow fed-steers.

Table 1. Supplement composition

Ingredient	% DM
Corn	63.09
Limestone	17.42
Urea	14.57
Trace mineral salt[a]	2.91
Dynamate[b]	1.36
Rumensin 80	0.26
Tylan 40	0.14
Vitamin A premix[c]	0.11
Vitamin E premix[d]	0.11

[a]97% NaCl, 0.002% Se, 0.005% Co, 0.007% Z, 0.03% Cu, 0.20% Fe, 0.20% Mn, 0.15% Mg, and 0.35% Zn (DM basis).
[b]18% K, 11% Mg, 22% S.
[c]30,000 IU/g (DM basis).
[d]500 IU/g (DM basis).

Table 2. Composition of feedstuffs

Item	Barley	Corn	Potato by-products	Supple-ment	Alfalfa hay	Tallow	Yellow grease
				% DM			
CP	10.4	8.1	6.5	45.5	14.8	-	-
Starch	61.3	71.0	70.9	44.7	4.4	-	-
Ether extract	1.1	3.8	4.9	2.2	0.3	97.8	94.5
NDF	16.2	15.0	10.8	14.9	43.9	-	-
ADF	9.4	2.9	4.2	3.2	32.5	-	-
ADL	3.0	1.3	2.0	1.5	13.2	-	-
Ash	3.6	1.6	2.7	17.3	9.1	-	-
Total fatty acids	1.8	4.3	2.5	2.2	1.5	96.1	92.5
				% of total fatty acids, mol/100 mol			
Capric acid (C10:0)	0.0	0.0	0.0	0.0	0.2	0.1	0.0
Lauric acid (C12:0)	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Myristic acid (C14:0)	0.0	0.1	0.4	0.0	1.0	2.8	0.5
Myristoleic acid (C14:1n5)	0.0	0.2	0.0	0.0	0.6	0.5	0.1
Pentadecanoic acid (C15:0)	0.1	0.0	0.0	0.0	0.5	0.6	0.1
Palmitic acid (C16:0)	18.9	12.2	14.7	15.8	24.6	24.8	13.4
Palmitoleic acid (C16:1n7)	0.4	0.0	0.9	0.2	0.4	2.8	0.8
Heptadecanoic acid (C17:0)	0.0	0.0	0.3	0.1	0.5	1.3	0.3
Heptadecenoic acid (C17:1n7)	0.0	0.0	0.2	0.0	0.0	0.6	0.1
Stearic acid (C18:0)	0.0	1.9	13.0	2.8	4.4	18.8	8.0
Elaidic acid (C18:1n9t)	0.0	0.0	27.8	0.0	0.6	0.0	0.0
Trans-vaccenic acid (C18:1n11t)	0.0	0.6	11.1	1.1	5.3	4.5	9.1
Oleic acid (C18:1n9)	12.4	26.5	19.3	27.8	1.5	33.8	33.0
Linolelaidic acid (C18:2n6t)	0.2	0.3	0.4	0.3	0.0	0.2	0.8
Linoleic acid (C18:2n6)	61.4	53.8	4.8	43.7	18.6	4.8	27.1
Arachidic acid (C20:0)	0.6	0.2	0.4	0.3	1.0	0.2	0.5
Gamma-Linolenic acid (C18:3n6)	0.1	0.0	0.0	0.0	0.5	0.1	0.4
Eicosenoic acid (20:1n9)	1.1	0.2	0.0	0.2	0.6	0.3	0.6
Linolenic acid (C18:3n3)	4.5	1.4	1.8	1.5	28.2	1.0	2.7
CLA (C18:2c9,t11)	0.0	0.0	0.0	0.0	0.0	0.4	0.1
Arachidonic acid (C20:4n6)	0.0	0.0	0.0	0.0	0.6	0.1	0.1
Docosapentaenoic acid (C22:5n3)	0.0	0.0	0.0	0.0	0.0	0.1	0.0

Table 3. Feed intake and diet digestibilities by steers on d 116, 117 and 118, fed corn-yellow grease diets or a barley-tallow diet

	Yellow grease, %						Tallow, %	
	0		3		6		6	
	Alfalfa hay, %							
Item	3.5	7.0	3.5	7.0	3.5	7.0	7.0	SE
DMI, kg/d[a]	10.9	10.2	9.3	10.5	8.7	9.8	10.0	0.45
Diet digestibility, %								
DM[b]	84.2	82.1	82.0	79.0	87.2	82.2	79.2	1.28
OM[bc]	80.1	82.2	79.4	75.7	85.6	79.8	74.4	1.69
Cell solubles[bde]	86.0	87.2	85.5	83.0	89.8	85.7	79.6	1.09
NDF[be]	61.0	68.2	62.0	56.4	72.3	62.5	78.4	2.81
Hemicellulose[efg]	68.3	79.0	70.0	61.3	75.2	65.6	88.2	3.04
ADF[a]	54.4	50.6	51.4	50.2	68.2	58.6	59.6	4.79
GE[hi]	81.2	83.5	81.2	77.6	86.2	81.7	78.3	1.66

[a]Linear effect of yellow grease ($P < 0.05$).
[b]Linear yellow grease x alfalfa hay interaction ($P < 0.05$).
[c]Yellow grease vs tallow ($P < 0.05$).
[d]Calculated as DM minus NDF in feed, and fecal samples.
[e]Yellow grease vs tallow ($P < 0.01$).
[f]Calculated as NDF minus ADF in feed and fecal samples.
[g]Linear yellow grease x alfalfa hay interaction ($P < 0.01$).
[h]Quadratic effect of yellow grease ($P < 0.05$).
[i]Effect of alfalfa hay level ($P < 0.05$).

Table 4. Effects of supplemental fat on feedlot performance and on characteristics of the carcass, beef and fat of steers fed finishing diets

	Yellow grease, %						Tallow, %[a]	
	0		3		6		6	
	Alfalfa hay, %							
Item	3.5	7.0	3.5	7.0	3.5	7.0	7.0	SE
Feedlot performance								
DMI, kg/d	9.61	9.15	9.23	9.34	8.94	9.06	8.74	0.28
ADG, kg/d	1.66	1.59	1.76	1.61	1.66	1.69	1.59	0.07
G/F[b]	0.174	0.176	0.191	0.172	0.188	0.187	0.184	0.007
Calculated diet energy content								
NEm[b]	2.20	2.22	2.31	2.20	2.36	2.33	2.32	0.07
NEg[b]	1.52	1.53	1.61	1.52	1.66	1.63	1.62	0.06
Carcass characteristics								
Hot carcass wt, kg	357.8	348.9	362.8	352.5	359.5	358.7	352.1	6.69
LM area, cm^2	85.9	83.2	85.4	84.8	82.7	82.1	82.1	1.52
12^{th} rib fat thickness, cm	1.2	1.1	1.2	1.2	1.2	1.3	1.2	0.07
Kidney, pelvic, and heart fat, %[c]	2.1	2.0	2.1	2.2	2.2	2.4	2.4	0.10
Marbling score[d]	462.2	468.3	454.4	481.7	459.4	422.2	475.6	25.96
USDA choice, %	94.4	66.7	77.8	77.8	72.2	61.1	72.2	12.57
Yield grade[c]	2.8	2.8	2.9	2.9	3.0	3.2	3.1	0.13
Beef and fat characteristics[e]								
Beef color score	2.7	2.6	2.6	2.9	3.0	2.6	2.3	0.15
Beef brightness score	3.0	2.7	2.8	2.9	2.6	2.9	3.2	0.26
Beef firmness score[fg]	3.2	3.0	3.0	3.3	3.0	2.8	3.1	0.08
Beef texture score[g]	3.1	2.6	2.8	2.9	2.8	2.6	3.0	0.14
Fat color score[fg]	2.9	2.9	2.7	3.1	3.0	3.1	2.7	0.08
Fat luster score[hi]	3.0	3.1	2.9	2.8	3.0	3.2	2.9	0.10

[a]Barley was fed in this treatment; in all others corn was fed.
[b]Linear effect of yellow grease, $P < 0.10$.
[c]Linear effect of yellow grease, $P < 0.05$.
[d]300=Slight[00]; 400 = Small[00]; and 500 = Modest[00].
[e]Beef color score (1=very pale to 7=very dark); beef brightness score (1=very dull to 5=very bright); beef firmness score (1=very soft to 5=very firm); beef texture score (1=very coarse to 5=very fine); fat color (1=very white to 7=very yellow); and fat luster score (1=very dull to 5= very lustrous).
[f]Quadratic yellow grease x alfalfa hay interaction, $P < 0.01$.
[g]Yellow grease vs tallow, $P < 0.05$.
[h]Quadratic yellow grease x alfalfa hay interaction, $P < 0.10$.
[i]Yellow grease vs tallow, $P < 0.10$.

Table 5. Moisture retention, color, cooking, and palatability attributes of beef from steers fed corn-yellow grease or barley-tallow finishing diets

	Yellow grease, %						Tallow, %	
	0		3		6		6	
	Alfalfa hay, %							
Item	3.5	7.0	3.5	7.0	3.5	7.0	7.0	SE
Purge, %	1.2	1.2	1.4	1.2	1.2	1.1	1.0	0.29
pH[a]	5.60	5.61	5.58	5.60	5.59	5.57	5.57	0.02
Drip loss, %	0.6	0.4	0.6	0.5	0.5	0.8	0.7	0.12
Thaw drip, %	5.7	5.3	5.3	5.4	5.2	5.1	5.2	0.66
Retail storage								
Purge score[bc]	2.1	2.0	1.9	1.6	1.6	1.7	1.7	0.09
Color score[d]	5.1	5.0	5.0	5.0	5.0	5.1	5.0	0.06
L*[e]	44.1	44.0	43.1	51.3	43.9	44.2	44.0	2.32
a*[e]	26.6	23.2	23.8	23.3	23.1	23.5	24.7	1.22
b*[e]	19.1	19.5	19.6	19.7	19.2	20.1	20.3	0.22
Cook time, min	39.4	31.9	35.8	28.4	34.6	36.6	44.7	6.03
Cook loss, %	23.9	19.8	19.8	20.0	22.1	21.8	23.8	1.77
Shear force, kg[f]	2.6	2.7	2.5	2.6	2.6	2.6	3.1	0.14
Sensory panel								
Tenderness								
Initial	7.8	6.9	7.7	7.3	7.8	7.2	7.0	0.42
Sustained	7.5	6.4	7.5	7.2	7.6	7.2	6.7	0.43
Juiciness								
Initial	6.7	7.0	6.3	6.6	6.8	6.2	6.1	0.46
Sustained	6.2	6.1	5.8	6.3	6.4	5.7	5.7	0.39
Beef flavor[g]	6.2	6.3	6.6	6.4	6.9	6.5	6.3	0.18
Off-flavor	0.5	0.8	0.4	0.4	0.4	0.5	0.7	0.15

[a]Linear effect of yellow grease, $P < 0.10$.

[b]Purge score 0 = no purge and 6 = abundant purge.

[c]Linear effect of yellow grease, $P < 0.01$.

[d]Color score 6 = bright cherry red and 1 = very brown.

[e]L* = Measurement of lightness to darkness (higher L* value indicates a lighter color; a* = measurement of redness (higher a* value indicates a redder color); and b* = measurement of yellowness (higher b* values indicates a more yellow color).

[f]Yellow grease vs tallow, $P < 0.05$.

[g]Linear effect of yellow grease $P < 0.05$.

Table 6. Purge score, color score, and L*, a*, b* values during retail storage

	Day of retail storage					
Item	0	2	4	6	8	SE
Purge score[a]	1.2	1.5	1.9	2.3	2.2	0.08
Color score[bc]	5.8	5.4	5.0	4.5	4.5	0.05
L*[de]	45.9	49.2	43.7	43.1	42.7	1.97
a*[df]	27.0	24.0	23.2	23.4	22.6	1.10
b*[cd]	19.3	19.9	19.8	19.7	19.6	0.15

[a]Purge score 0 = no purge and 6 = abundant purge.
[b]Color score 6 = bright cherry red, and 1 = very brown (AMSA, 1991).
[c]Quadratic effect of day, $P < 0.05$.
[d]L* = Measurement of lightness to darkness (higher L* value indicates a lighter color; a* = measurement of redness (higher a* value indicates a redder color; and b* = measurement of yellowness (higher b* value indicates a more yellow color).
[e]Linear effect of day, $P < 0.05$.
[f]Linear effect of day, $P < 0.01$.

Table 7. Fatty acid (FA) content (dry tissue basis) and composition of longissimus muscle from steers fed corn-potato product finishing diets with supplemental yellow grease or tallow-potato product finishing diet with supplemental tallow

	Yellow grease, %						Tallow, %[a]	
	0		3		6		6	
	Alfalfa hay, %							
Item	3.5	7.0	3.5	7.0	3.5	7.0	7.0	SE
DM, %[a]	28.6	28.3	28.3	29.4	28.9	28.4	28.8	0.34
CP, %[a]	78.4	79.3	81.4	76.5	78.5	79.2	78.3	1.43
Fat, %[a]	16.4	15.4	14.4	18.8	16.7	15.8	17.4	1.13
Ash, %	3.8	3.7	3.7	3.5	3.6	3.6	3.5	0.11
Total FA, mg/g[b]	171.7	166.0	141.9	185.9	163.4	157.8	192.0	15.42
CLA, mg/g	0.2	0.4	0.3	0.2	0.3	0.4	0.3	0.06
	FA composition, mol/100 mol of FA							
Capric acid (C10:0)	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.01
Lauric acid (C12:0)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.01
Myristic acid (C14:0)	3.3	3.1	3.2	3.2	3.6	3.3	3.2	0.20
Myristoleic acid (C14:1n5)[c]	0.7	0.6	0.7	0.7	0.7	0.6	0.8	0.06
Pentadecanoic acid (C15:0)	0.7	0.7	0.7	0.7	0.8	0.7	0.6	0.03
Palmitic acid (C16:0)	25.9	26.1	25.4	25.6	25.8	24.4	26.0	0.64
Palmitoleic acid (C16:1n7)	3.7	3.6	3.3	3.3	3.4	3.3	4.0	0.12
Heptadecanoic acid (C17:0)[e]	1.8	1.9	1.7	1.9	1.7	1.6	1.7	0.08
Heptadecenoic acid (C17:1n7)[d]	1.4	1.5	1.2	1.3	1.2	1.2	1.3	0.07
Stearic acid (C18:0)[f]	11.6	12.4	11.8	12.9	12.4	12.8	12.9	0.31

Trans-vaccenic acid (C18:1n11t)[dg]	5.3	3.6	7.2	6.0	8.5	9.3	3.6	0.72
Oleic acid (C18:1n9t) [dg]	36.9	38.1	34.8	36.6	32.7	34.1	39.8	1.10
Linoledaidic acid (C18:2n6t)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.03
Linoleic acid (C18:2n6)[g]	4.8	4.3	5.3	4.2	4.9	4.5	2.5	0.36
Arachidic acid (C20:0)[e]	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.01
Gamma-Linolenic acid (C18:3n6)[e]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.01
Eicosenoic acid (C20:1n9)[f]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.02
Linolenic acid (C18:3n3)[d]	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.02
CLA (C18:2c9,t11)[a]	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.04
Eicosatrienoic acid (C20:3n6)[ah]	0.3	0.3	0.3	0.2	0.3	0.3	0.2	0.02
Arachidonic acid (C20:4n6)	0.9	0.9	0.9	0.7	0.8	0.8	0.6	0.12
Eicosapentaenoic acid (C20:5n3)[a]	0.1	0.2	0.2	0.1	0.2	0.2	0.1	0.03
Docosatetraenoic acid (C22:4n6)[e]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.01
Docosapentaenoic acid (C22:5n3)	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.03

[a]Quadratic yellow grease x alfalfa hay, $P < 0.05$.
[b]Quadratic yellow grease x alfalfa hay, $P < 0.10$.
[c]Yellow grease vs tallow, $P < 0.05$.
[d]Linear effect of yellow grease, $P < 0.01$.
[e]Linear effect of yellow grease, $P < 0.05$.
[f]Linear effect of yellow grease, $P < 0.10$.
[g]Yellow grease vs tallow, $P < 0.01$.
[f]Yellow grease vs tallow, $P < 0.10$.